TRANSITION METAL-GRAPHITE CATALYSTS FOR PRODUCTION OF LIGHT HYDROCARBONS FROM SYNTHESIS GAS. QUARTERLY REPORT, FEBRUARY 1, 1978--APRIL 30, 1978

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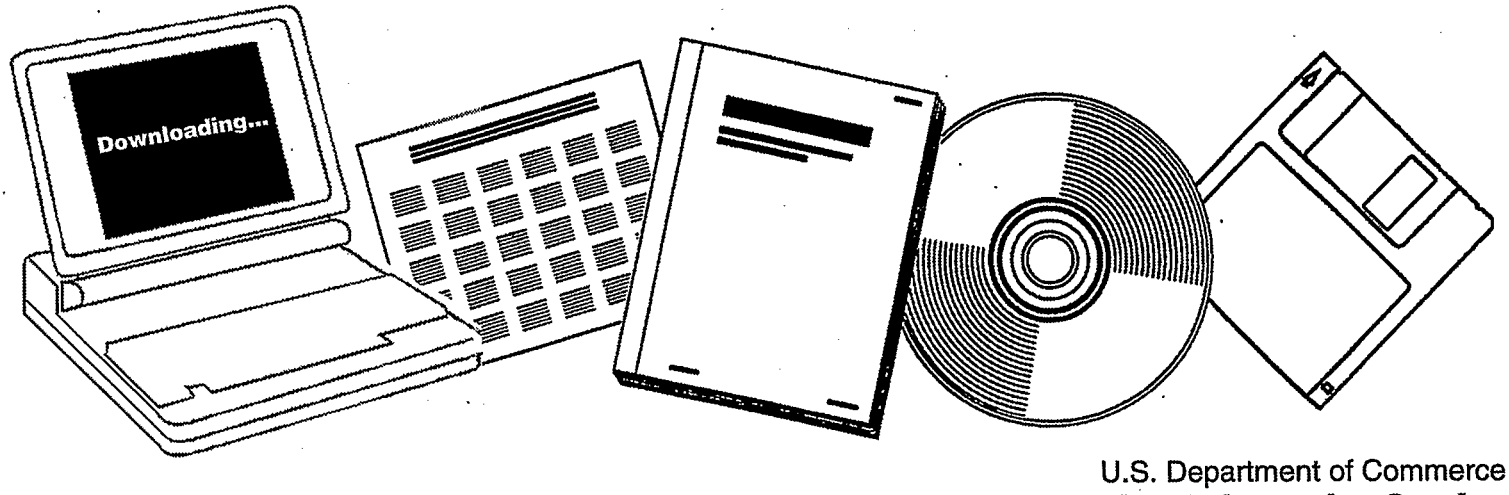

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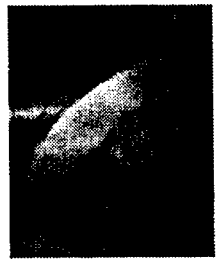

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TRANSITION METAL-GRAPHITE CATALYSTS FOR PRODUCTION OF LIGHT HYDROCARBONS FROM SYNTHESIS GAS

Quarterly Report for the Period

February 1, 1978 - April 30, 1978

Michael P. Rosynek

Texas A & M University
Department of Chemistry
College Station, Texas 77843

Date Submitted - May 1978

PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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REA

ABSTRACT

Cobalt-graphite intercalates, when used as catalysts for the hydrogenation of carbon monoxide at one atmosphere pressure, exhibit a markedly different effect of reaction temperature on product distribution in the range 200-300°C than does a conventional kieselguhr-supported cobalt catalyst under the same conditions. In the latter case, the percentage of all reacted CO involved in methane formation increased from 27% at 200° to 87% at 300°C, while the percentage yielding C_2^+ hydrocarbons decreased proportionately from 69% to 7%. Over cobalt-graphite, on the other hand, methane accounted for a virtually constant 35% of all reacted CO throughout the 200-300°C range, while the C_2+C_3 olefin/paraffin fraction increased slightly from 31% at 200° to 41% at 300°, and C_4^+ hydrocarbons only decreased from 30% to 20% of all converted CO at the same temperatures. The results suggest that interlayer penetration of the graphite intercalate lattice by H_2/CO reactant may be the rate-limiting step of the reaction. Poisoning studies utilizing hydrogen sulfide indicated that only 0.6 to 0.7% of all intercalated cobalt atoms are accessible as catalytically active sites.

I. OBJECTIVE AND SCOPE OF WORK

The objective of this research is the development of a novel process for the production of petrochemical feedstocks based on coal or other carbonaceous materials. Specifically, the project is to investigate the catalytic activities and selectivities of novel alkali and transition metal-graphites in producing light (C_1-C_3) hydrocarbons from H_2/CO synthesis gas via the Fischer-Tropsch process.

II. SUMMARY OF PROGRESS TO DATE

A comparison of actual research progress to date vs. project schedule is contained in the "Project Plan and Progress Chart" shown in Fig. 1. In our previous Quarterly Report (for the period November 1, 1977 to January 31, 1978), we described the design and installation of a microcomputer-based data processing system, as well as the results of preliminary catalytic testing of a commercially-available cobalt-graphite intercalate for the Fischer-Tropsch process at one atmosphere pressure. During the most recent contract quarter, we have completed our evalauation of the activity and selectivity characteristics of this material, for the reaction temperature range 200-300°C, together with a comparison of these properties with those of a commercial cobalt/kieselguhr catalyst under the same reaction conditions. We have also begun to examine the sulfur poisoning behaviors and percentages of metal exposure for both cobalt catalysts by means of *in situ* additions of gaseous hydrogen sulfide. Technical details of research progress during the past quarter are described in the following sections.

III. DETAILED DESCRIPTION OF TECHNICAL PROGRESS

Each experiment described below employed a fresh sample of the cobalt-graphite intercalate (Alfa Chemical Co. No. 89650; 3.4 wt% Co), pretreated by exposure to excess circulating H_2 for 3-4 hrs at 400°C, followed by overnight evacuation at 300°C to a residual pressure of $< 10^{-4}$ torr. All experiments were performed using the stirred-batch reaction system described in a previous report, with an initial H_2/CO reactant ratio of 2/1 and a total initial pressure of 700 torr.

A. Reproducibility of Catalytic Activity

Reproducibility of overall catalytic activity was examined for the cobalt-graphite intercalate at 250° and at 300°C by performing three identical experiments at the former temperature and two at the latter, each employing a separate, freshly-pretreated catalyst sample. The results are contained in Tables I and II. It is evident that, on a per-metal-atom basis, the comparative initial activities for overall CO conversion (summarized in the "% CO Conv" and "Rate" columns) varied over at least an 8- to 9-fold range at both temperatures. However, apart from the apparently anomolous results of Series 4, Run 1-A in Table I, product distributions,

at comparable CO conversion levels for a given reaction temperature, were quite reproducible and relatively unaffected by overall catalystic activity (Compare, for example, the 9.00 and 6.00 hr samples of Series 3, Run 1-A and Series 5, Run 1-A, respectively, and the 4.05 and 0.50 hr samples of Series 6, Run 1-A and Series 7, Run 1-A). Since a fresh catalyst sample was used in each of the tabulated experiments, these results suggest that the batch of cobalt-graphite employed may be inhomogeneous with respect to either the extent of metal intercalation or the accessibility of intercalated metal atoms, or both. Regardless of total activity, however, all "active" metal sites apparently behave similarly with regard to reaction selectivity.

B. Temperature Dependence of Reaction Selectivity

Separate experiments, each employing a fresh catalyst sample, were performed at 25° increments over the reaction temperature range 200-300°C in order to explore the product distribution characteristics of the cobalt-graphite intercalate. Table III contains the tabulated results of the five runs, and Fig. 2 summarizes the temperature-dependence of reaction selectivity at an arbitrarily-selected CO conversion level of 5%. (Apart from the expected increase in olefin → paraffin transformations, little fundamental change in product distribution occurred with increasing CO conversion in a given run.) Here, the mole fraction of each gaseous, carbon-containing product has been corrected to account for the number of carbon atoms/molecule, and the results normalized to 100 moles of CO converted. Thus the region between each adjacent pair of plotted curves corresponds to the percentage of all reacted CO that was involved in forming the indicated product.

The highly unusual and unexpected selectivity behavior of the cobalt-graphite intercalate can best be appreciated by comparing it to the corresponding behavior of a "conventional" kieselguhr-supported cobalt catalyst, data for which have been drawn from a previous report in this series and presented in Table IV and Fig. 3. Although the amount of carbon dioxide produced, primarily via a water-gas shift process, is similar and relatively constant over both catalysts (accounting for ~ 5% of all converted CO), the temperature-dependence of hydrocarbon selectivity is dramatically different for the two materials. Over the supported cobalt catalyst, the percentage of all reacted CO involved in methane formation increased from 27% at 200° to 87% at 300°C, while the percentage yielding C_2^+ hydrocarbons decreased correspondingly from 69% to only 7%. In particular, the C_4^+ hydrocarbon fraction accounted for 35% of all converted CO at 200°, but had decreased to < 10% at 250°, and was entirely absent at 300°C. This overall behavior is typical of that normally observed over supported, unpromoted cobalt catalysts in this temperature range.

The outstanding and atypical selectivity feature exhibited by the cobalt-graphite intercalate, on the other hand, is the relative insensitivity of product distribution to reaction temperature variations. Methane accounted for a virtually constant 35% of all converted CO over the entire temperature range investigated, while the C_2+C_3 olefin/paraffin fraction

increased slightly from 31% at 200° to 41% at 300°C, and C_4^+ hydrocarbons only decreased from 30% to 20% of all converted CO over the same temperature range.

This unusual behavior may be due to the unique structural nature of the metal-graphite system. Active cobalt sites are located between graphitic planes that are spaced ~ 3.5 to 4.0 Å apart. Thus, unlike the situation with a conventional supported catalyst, CO and H_2 reactant molecules must not only diffuse through the gas phase to the catalyst surface, but must then penetrate between the narrowly-spaced layers of the graphite lattice in order to reach the metallic sites and allow adsorption and subsequent reaction to occur. If the average depth of intercalation of the reduced cobalt atoms is sufficiently large, it is conceivable that the overall rate-limiting step of the process may be the interlayer diffusion of reactants. Such a restriction on molecular movement at or near the catalytically active sites could result in carbon chain growth that is larger than would otherwise be the case, and cause the observed selectivity behavior. Indeed, although the reaction rate data presented in Table III may be viewed as only semi-quantitative, they indicate, nevertheless, an apparent activation energy for CO conversion of ~ 10-12 kcal/mole in the temperature range 225-275°C. This value is considerably lower than the one (~ 25 kcal/mole) that is normally observed for H_2/CO reactions over supported metal catalysts, and is consistent with the postulate of a diffusion-controlled process. We have previously reported, for example, an apparent activation energy of 23.8 kcal/mole for CO hydrogenation over the cobalt/kieselguhr comparison catalyst. It should be noted, however, that the interlayer diffusion rates of CO and H_2 should increase with increasing temperature, and, hence, the virtual constancy of product distribution over a 100° range of reaction temperature is still unclear. Nevertheless, selectivity effects exhibited by the cobalt-graphite intercalation system may be of considerable importance and warrant further investigation, particularly at elevated pressures, in order to more fully characterize this behavior.

C. Sulfur Poisoning Effects

In situ poisoning experiments, employing gaseous hydrogen sulfide, have been initiated during the past quarter in an effort to assess both the sulfur tolerance behaviors and the percentages of accessible metal atoms in the cobalt-graphite catalyst. Additions of H_2S aliquots during reaction were made by filling a calibrated doser volume to a known pressure and then injecting the doser contents, by means of appropriate stopcock manipulations, into the circulating reaction mixture at pre-selected time intervals. The preliminary results for two such experiments at 300°C, using separate cobalt-graphite samples pretreated in the usual manner, are presented in Table V. In each case, the percentages noted for the H_2S doses in the catalyst description correspond to the percentage of catalytic activity that could be poisoned by each successive H_2S addition, if it is assumed that all cobalt atoms are accessible as catalytic sites.

As shown by the conversion and rate data for the two runs, the catalyst

displayed no unusual resistance to sulfur poisoning. In Series 11, Run 1-A, addition of a 10% dose of H_2S immediately following the 2.50 hr sample destroyed virtually all activity for C_2^+ hydrocarbon formation, but the sample apparently retained a very small capacity for methane formation. The latter was removed by another 10% addition of H_2S following the 13.00 hr sample. In Series 13, Run 1-A, smaller H_2S doses were employed in an effort to determine the percentage of catalytically accessible cobalt atoms in the intercalate. The approximately 20% of original activity for formation of all hydrocarbon products that was retained after addition of a 0.5% H_2S dose at 0.73 hrs of reaction indicates that only 0.6-0.7% of all cobalt atoms in the catalyst are accessible to the H_2/CO reactant mixture. An additional 1% dose of H_2S, added at 1.77 hrs, destroyed virtually all remaining catalytic activity.

More detailed experiments, aimed at further characterizing the sulfur poisoning responses of iron- and cobalt-graphites and the iron/alumina and cobalt/kieselguhr comparison catalysts, are currently in progress. Particular emphasis is being placed on evaluating the potential reversibility of sulfur-induced deactivation, as well as investigating the alterations in reaction selectivity that are brought about by sulfur poisoning.

IV. CONCLUSIONS

Cobalt-graphite intercalate, when used as a catalyst for CO hydrogenation at one atmosphere pressure, exhibits a markedly different response of reaction selectivity to temperature variations in the range 200-300°C than does a conventional kieselguhr-supported cobalt catalyst under the same conditions. In the latter case, the percentage of all reacted CO that is involved in methane formation increases from 27% at 200° to 87% at 300°C, while the percentage yielding C_2^+ hydrocarbons decreases correspondingly from 69% to only 7%. Over cobalt-graphite, however, methane accounts for a virtually constant 35% of all converted CO over the entire 200-300°C range, while the C_2+C_3 olefin/paraffin fraction increases from 31% at 200° to 41% at 300°, with the C_4^+ materials decreasing proportionately.

The results suggest that interlayer penetration of the graphite intercalate lattice by H_2/CO reactant may be the rate-limiting step of the overall reaction.

Poisoning studies with hydrogen sulfide indicate that only 0.6-0.7% of all cobalt atoms in the intercalate are accessible as catalytically active sites.

FIGURE CAPTIONS

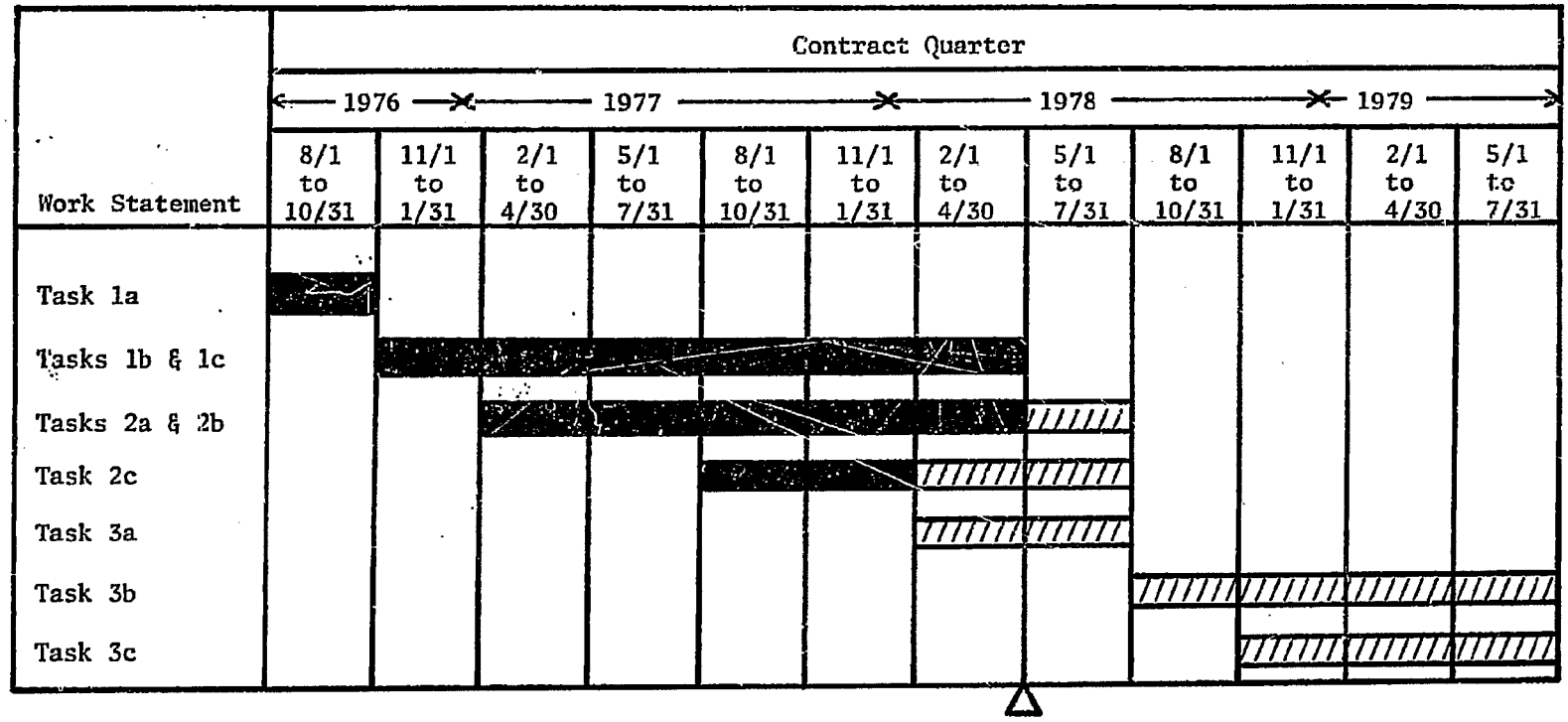
Fig. 1 Project Plan and Progress Chart

Fig. 2 Variation of Carbon-Containing Product Distribution with Reaction Temperature at 5% CO Conversion over Cobalt-Graphite Intercalate.

Fig. 3 Variation of Carbon-Containing Product Distribution with Reaction Temperature at 5% CO Conversion over Kieselguhr-Supported Cobalt.

FIGURE 1

Project Plan and Progress Chart



LEGEND

Scheduled

Completed

End of Reporting Period

FIGURE 2

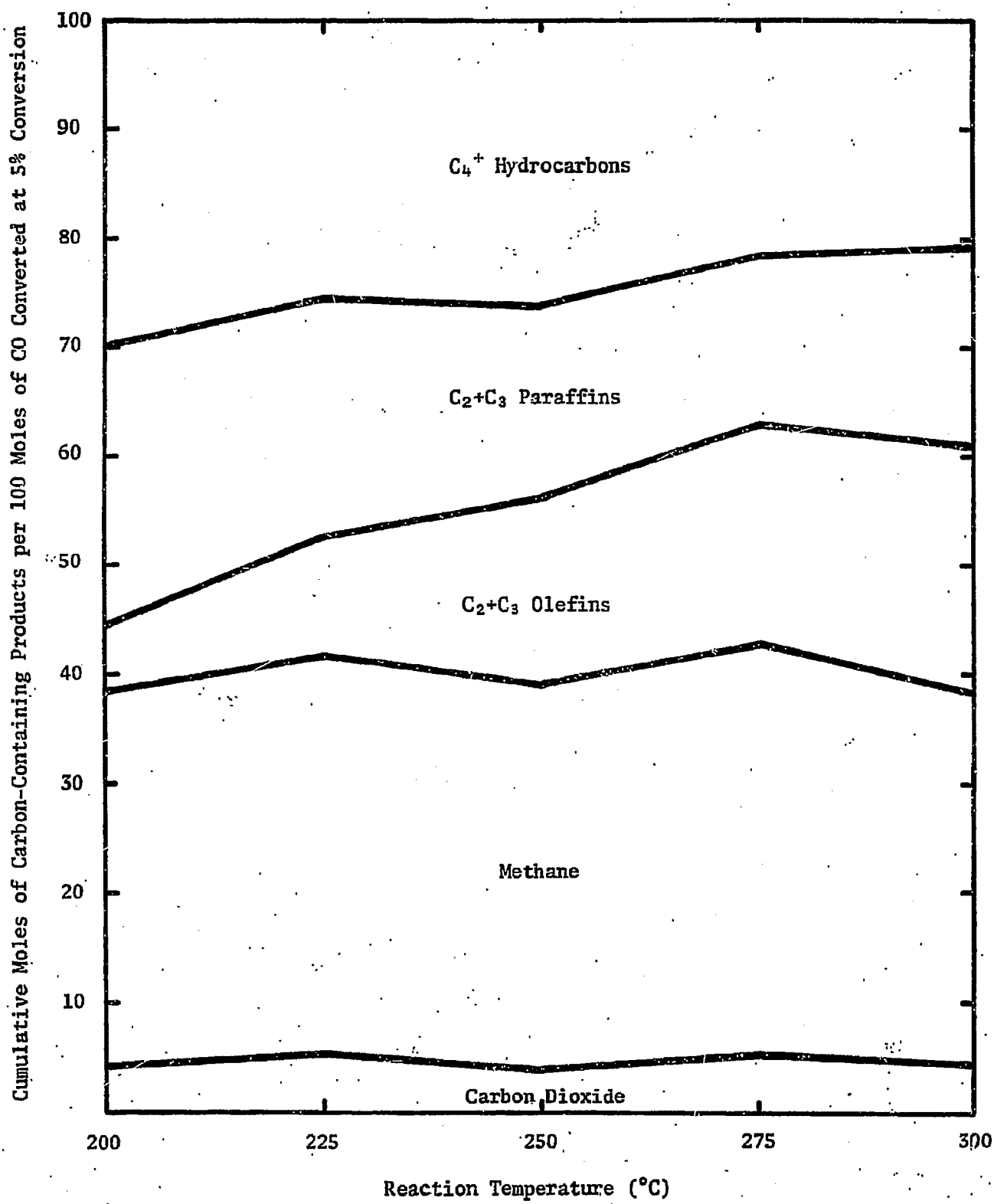

Cumulative Moles of Carbon-Containing Products per 100 Moles of CO Converted at 5% Conversion
100
90
80
70
60
50
40
30
20
10
C_4^+ Hydrocarbons
C_2+C_3 Paraffins
C_2+C_3 Olefins
Methane
Carbon Dioxide
200
225
250
275
300
Reaction Temperature (°C)

FIGURE 3

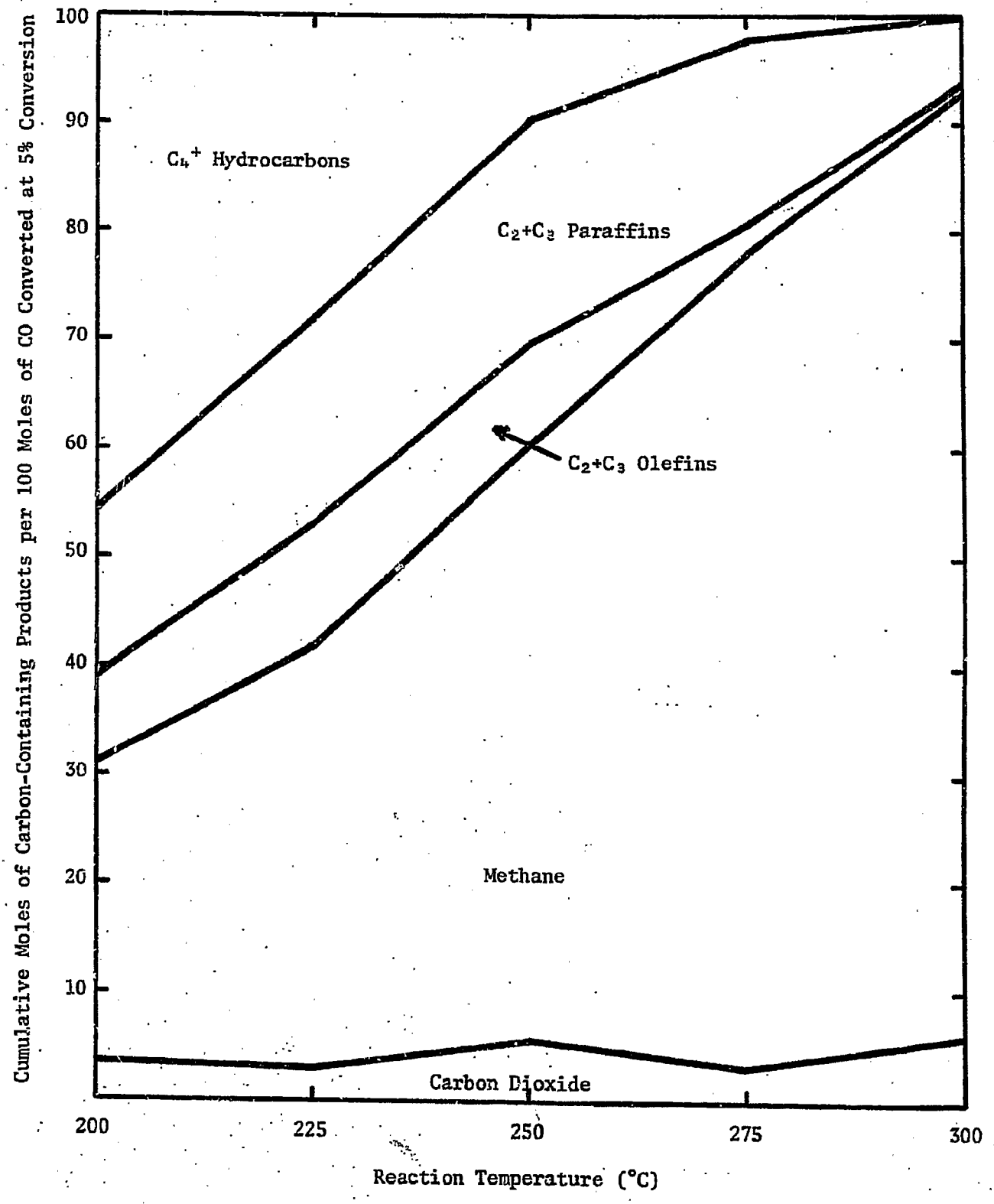

Cumulative Moles of Carbon-Containing Products per 100 Moles of CO Converted at 5% Conversion
100
90
80
70
60
50
40
30
20
10
C_4^+ Hydrocarbons
C_2+C_3 Paraffins
C_2+C_3 Olefins
Methane
Carbon Dioxide
200
225
250
275
300
Reaction Temperature (°C)

Table I

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 3, RUN 1-A

CATALYST - COBALT-GRAPHITE (3.4 WT% CO); VENTRON CORP. 'GRAPHIMET' NO. 89650; PRETREATED (PROGRAM TO 400 C IN H2 FOR 3 HRS) EVACUATED FOR 16 HRS AT 300 C.

WEIGHT - 0.8 G TOTAL

REACTION TEMPERATURE = 250 C
INITIAL TOTAL PRESSURE = 701 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 339 CC

- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE -

REACTION TIME (HRS)	CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
0.25	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.00	13.1	63.2	9.8	5.6	8.4	0.0	0.0	0.0
2.00	10.4	66.6	8.7	5.5	8.8	0.0	0.0	0.0
3.00	9.4	67.3	7.7	6.3	7.8	1.5	0.0	0.0
4.00	8.0	60.9	6.1	5.9	9.0	3.4	3.5	3.2
7.05	8.1	61.4	4.9	6.8	7.6	3.2	4.8	3.1
9.00	8.4	61.4	4.3	7.5	7.3	3.2	4.3	3.7
11.00	8.6	60.5	3.8	7.8	6.8	3.3	5.3	4.0
22.25	9.8	59.4	2.2	8.8	6.2	4.3	5.2	4.1

---- MOLES PER 100 MOLES OF CO CONVERTED -----

REXN TIME (HR)	CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
0.25	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	99
1.00	9.9	47.8	14.8	8.4	19.0	0.0	0.0	0.0	0.2	12	98
2.00	7.9	50.6	13.2	8.3	20.0	0.0	0.0	0.0	0.4	9	98
3.00	7.1	50.8	11.6	9.4	17.7	3.4	0.0	0.0	0.7	10	98
4.00	5.0	38.0	7.7	7.4	16.8	6.3	8.7	10.2	1.3	26	97
7.05	5.1	38.4	6.1	8.5	14.2	6.0	12.0	9.8	2.4	16	94
9.00	5.2	38.3	5.3	9.3	13.6	5.9	10.8	11.6	3.2	17	94
11.0	5.2	37.0	4.6	9.6	12.5	6.1	12.9	12.1	4.0	18	93
22.3	6.0	36.3	2.7	10.8	11.4	7.8	12.6	12.5	8.4	16	91

Table I (cont.)

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 4, RUN 1-A

CATALYST - COBALT-GRAPHITE (3.4 WT% CO); VENTRON CORP. "GRAPHIMET" NO. 89650; PRETREATED (PROGRAM TO 400 C IN H2 FOR 3 HRS) EVACUATED FOR 6 HRS AT 400 C.

WEIGHT - 1.0 G TOTAL

REACTION TEMPERATURE = 250 C
INITIAL TOTAL PRESSURE = 701 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 339 CC

REACTION TIME (HRS)	- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE - CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
2.00	6.5	83.4	1.2	8.8	0.0	0.0	0.0	0.0
3.00	6.5	75.0	1.1	9.8	1.6	6.0	0.0	0.0
4.00	6.1	74.7	1.5	9.9	1.5	6.2	0.0	0.0
5.00	5.2	76.5	1.6	9.3	2.2	5.2	0.0	0.0
27.00	3.8	71.8	0.7	9.4	1.6	7.8	2.2	2.7

REXN TIME (HR)	---- MOLES PER 100 MOLES OF CO CONVERTED ----- CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
2.00	5.9	75.8	2.3	16.0	0.0	0.0	0.0	0.0	0.2	4	97
3.00	5.1	59.4	1.7	15.6	3.8	14.3	0.0	0.0	0.3	5	99
4.00	4.8	58.8	2.4	15.6	3.6	14.7	0.0	0.0	0.4	6	97
5.00	4.2	60.8	2.5	14.8	5.2	12.4	0.0	0.0	0.6	6	97
27.0	2.6	49.1	0.9	12.9	3.3	15.9	5.9	9.3	3.7	6	95

Table I (cont.)

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 5, RUN 1-A

CATALYST - COBALT-GRAPHITE (3.4 WT% CO); VENTRON CORP. 'GRAPHIMET' NO. 89650; PRETREATED (PROGRAM TO 400 C IN H2 FOR 3 HRS) EVACUATED FOR 11 HRS AT 300 C.

WEIGHT - 0.5 G TOTAL

REACTION TEMPERATURE = 250 C
INITIAL TOTAL PRESSURE = 697 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 341 CC

REACTION TIME (HRS)	- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE - CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
1.08	8.5	64.7	9.5	6.0	11.3	0.0	0.0	0.0
2.00	7.9	63.6	8.0	6.7	9.9	0.0	2.3	1.6
3.00	7.0	63.1	6.8	7.0	9.2	3.0	2.7	1.3
4.00	6.6	60.4	5.5	6.9	8.7	3.2	5.1	3.6
6.00	6.7	60.7	4.6	7.8	8.5	3.7	4.6	3.5
9.00	6.8	59.8	3.3	8.4	7.5	4.3	5.4	4.6
23.00	7.7	59.0	1.4	9.8	5.5	6.0	5.8	4.7

REXN TIME (HR)	---- MOLES PER 100 MOLES OF CO CONVERTED ----- CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
1.08	6.2	46.8	13.7	8.6	24.6	0.0	0.0	0.0	0.3	13	100
2.00	5.3	43.0	10.9	9.0	20.1	0.0	6.3	5.4	0.7	20	100
3.00	4.6	41.7	9.0	9.2	18.2	5.9	7.0	4.3	1.3	25	95
4.00	4.0	36.4	6.6	8.3	15.8	5.8	12.3	10.9	2.0	35	96
6.00	4.1	36.9	5.6	9.5	15.5	6.7	11.1	10.6	3.1	25	97
9.00	4.0	35.2	3.9	9.8	13.3	7.6	12.7	13.6	5.0	30	96
23.0	4.5	34.6	1.6	11.5	9.7	10.6	13.5	13.8	12.7	25	92

Table II

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 6, RUN 1-A

CATALYST - COBALT-GRAPHITE (3.4 WT% CO); VENTRON CORP. 'GRAPHIMET' NO. 89650; PRETREATED (PROGRAM TO 400 C IN H2 FOR 3 HRS) EVACUATED FOR 16 HRS AT 300 C.

WEIGHT - 0.5 G TOTAL

REACTION TEMPERATURE = 300 C
INITIAL TOTAL PRESSURE = 697 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 341 CC

	- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE -							
REACTION TIME (HRS)	CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
0.50	10.8	57.4	12.2	6.2	12.7	0.0	0.7	0.0
1.00	10.4	58.3	9.9	6.8	11.7	1.7	0.8	0.4
2.00	9.7	55.4	7.0	7.5	10.1	2.6	4.9	2.9
3.00	10.0	55.1	5.6	8.3	9.2	3.1	4.9	3.8
4.05	10.5	55.5	4.6	8.9	8.5	3.3	5.0	3.6
6.00	11.5	56.7	3.5	9.7	7.6	3.8	4.2	2.8
9.02	12.6	56.7	2.6	10.1	6.4	4.4	4.4	2.9
12.00	13.4	57.0	2.1	10.3	5.7	4.7	4.2	2.6
24.00	15.8	57.5	1.1	10.4	3.9	5.3	3.7	2.3
26.00	16.7	59.5	1.1	10.8	3.8	5.6	0.4	2.2
28.00	16.4	57.6	0.9	10.4	3.4	5.5	3.6	2.1
30.00	16.7	57.6	0.9	10.4	3.3	5.6	3.5	2.1
32.00	16.9	57.6	0.8	10.4	3.1	5.6	3.5	2.0

	---- MOLES PER 100 MOLES OF CO CONVERTED -----										
REXN TIME (HR)	CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
0.50	7.4	39.3	16.7	8.5	26.1	0.0	2.0	0.0	0.8	69	99
1.00	7.0	39.5	13.4	9.3	23.9	3.4	2.1	1.3	1.8	87	95
2.00	5.8	33.3	8.4	9.0	18.2	4.7	11.8	8.8	4.4	112	96
3.00	5.9	32.7	6.6	9.8	16.4	5.6	11.7	11.3	6.6	93	93
4.05	6.3	33.3	5.6	10.7	15.3	5.9	12.1	10.8	8.5	79	92
6.00	7.2	35.4	4.4	12.1	14.3	7.1	10.6	8.9	11.2	58	93
9.02	7.9	35.7	3.3	12.7	12.2	8.3	11.0	9.0	15.5	61	92
12.0	8.6	36.5	2.7	13.2	10.9	9.0	10.8	8.3	19.0	50	91
24.0	10.5	38.3	1.5	13.9	7.7	10.7	9.8	7.5	31.4	44	87
26.0	11.9	42.3	1.5	15.3	8.1	12.0	1.0	7.8	30.3	-24	83
28.0	11.1	38.8	1.3	14.1	7.0	11.0	9.6	7.1	34.9	100	85
30.0	11.3	39.0	1.2	14.1	6.6	11.3	9.5	7.1	36.6	36	85
32.0	11.5	39.1	1.1	14.2	6.3	11.4	9.6	6.9	38.1	32	84

Table II (cont.)

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 7, RUN 1-A

CATALYST - COBALT-GRAPHITE (3.4 WT% CO); VENTRON CORP. 'GRAPHIMET' NO. 89650; PRETREATED (PROGRAM TO 400 C IN H2 FOR 4.3 HR) EVACUATED FOR 16 HRS AT 300 C.

WEIGHT - 0.5 G TOTAL

REACTION TEMPERATURE = 300 C
INITIAL TOTAL PRESSURE = 697 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 341 CC

	- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE -							
REACTION TIME (HRS)	CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
0.50	7.5	57.1	3.9	9.4	10.1	4.0	5.2	2.8
1.00	9.2	58.5	2.2	10.3	7.4	5.3	4.3	2.3
1.50	10.4	59.0	1.5	10.6	5.6	5.9	4.7	2.3
2.00	11.4	59.2	1.2	10.8	4.6	6.2	4.5	2.2
4.00	13.9	59.3	0.7	10.8	2.7	7.0	3.8	1.8
5.00	14.7	59.2	0.6	10.8	2.2	7.0	3.6	1.7
5.50	15.1	59.1	0.6	10.8	2.1	7.1	3.5	1.7
7.00	15.9	59.0	0.5	10.8	1.8	7.1	3.3	1.6
9.00	16.8	58.6	0.5	10.7	1.5	7.0	3.3	1.6
11.00	17.6	58.3	0.4	10.6	1.3	7.1	3.1	1.5

	----- MOLES PER 100 MOLES OF CO CONVERTED -----										
REXN TIME (HR)	CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
0.50	4.5	33.9	4.7	11.2	18.0	7.1	12.5	8.3	7.8	658	96
1.00	5.7	36.3	2.7	12.8	13.7	9.8	11.9	7.1	12.8	423	95
1.50	6.6	37.2	1.9	13.4	10.7	11.1	11.8	7.3	16.4	311	94
2.00	7.3	38.0	1.5	13.8	8.8	12.0	11.5	7.0	19.2	236	94
4.00	9.3	39.6	1.0	14.5	5.4	14.0	10.2	6.1	27.1	166	93
5.00	10.0	40.1	0.8	14.7	4.5	14.2	9.7	5.9	29.8	114	92
5.50	10.2	40.2	0.8	14.7	4.2	14.5	9.4	5.9	31.0	103	92
7.00	11.0	40.5	0.7	14.8	3.6	14.6	9.1	5.6	34.2	92	92
9.00	11.6	40.5	0.6	14.8	3.1	14.6	9.2	5.5	38.3	87	91
11.0	12.3	40.6	0.6	14.8	2.8	14.9	8.6	5.4	41.5	66	90

Table III

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 10, RUN 1-A

CATALYST - : COBALT-GRAPHITE (3.4 WT% CO); VENTRON CORP. 'GRAPHINET' NO. 89650; PRETREATED (PROGRAM TO 400 C IN H2 FOR 4.0 HR) EVACUATED FOR 16 HRS AT 300 C.

WEIGHT - 0.5 G TOTAL

REACTION TEMPERATURE = 200 C
INITIAL TOTAL PRESSURE = 697 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 341 CC

REACTION TIME (HRS)	- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE - CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
2.00	9.0	79.1	3.2	3.3	5.4	0.0	0.0	0.0
8.02	7.3	57.8	2.6	7.4	6.1	7.6	6.1	5.1
24.50	6.9	60.1	1.0	8.5	3.9	8.5	6.0	5.1
28.00	7.2	59.9	0.8	8.7	3.7	9.3	5.6	4.9
31.00	7.4	59.4	0.9	8.7	3.5	8.9	6.3	4.9
38.25	7.7	59.3	0.7	8.8	2.9	9.0	6.2	5.3
50.00	7.8	58.7	0.6	8.7	2.4	9.6	6.5	5.7

REXN TIME (HR)	---- MOLES PER 100 MOLES OF CO CONVERTED ----- CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
2.00	7.7	67.4	5.4	5.6	13.9	0.0	0.0	0.0	0.2	4	95
8.02	4.1	32.8	3.0	8.4	10.4	13.0	13.8	14.4	0.8	4	94
24.5	4.0	34.8	1.2	9.9	6.7	14.8	13.9	14.7	3.0	6	95
28.0	4.2	34.8	1.0	10.1	6.4	16.3	13.0	14.3	3.5	6	94
31.0	4.3	34.4	1.0	10.1	6.1	15.4	14.6	14.2	4.0	7	92
38.3	4.4	34.2	0.8	10.2	5.0	15.6	14.4	15.4	5.2	7	94
50.0	4.5	33.4	0.6	10.0	4.1	16.4	14.8	16.2	7.0	7	91

Table III (cont.)

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 9, RUN 1-A

CATALYST - COBALT-GRAPHITE (3.4 WT% CO); VENTRON COPP. 'GRAPHIMET' NO. 89650; PRETREATED (PROGPAM TO 400 C IN H2 FOR 3.3 HR) EVACUATED FOR 16 HRS AT 300 C.

WEIGHT - 0.5 G TOTAL

REACTION TEMPERATURE = 225 C
INITIAL TOTAL PRESSURE = 697 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 341 CC

	- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE -							
REACTION TIME (HRS)	CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
2.00	14.2	64.2	6.3	6.7	8.6	0.0	0.0	0.0
7.05	3.6	62.1	2.8	8.0	5.9	5.2	4.2	3.1
22.00	9.1	58.0	0.9	9.1	3.5	7.5	6.2	5.7
27.00	9.3	58.0	0.8	9.2	3.0	8.0	6.2	5.5
33.33	9.6	57.9	0.6	9.3	2.6	8.4	6.1	5.5

	---- MOLES PER 100 MOLES OF CO CONVERTED -----										
REXN TIME (HR)	CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
2.00	10.9	49.3	9.7	10.2	19.8	0.0	0.0	0.0	0.4	8	99
7.05	5.5	39.3	3.5	10.2	11.3	9.9	10.8	9.7	2.0	14	95
22.0	5.3	33.5	1.0	10.5	6.0	13.0	14.2	16.4	7.6	16	93
27.0	5.4	33.6	0.9	10.7	5.3	14.0	14.3	15.9	9.4	15	90
33.3	5.6	33.6	0.7	10.8	4.5	14.7	14.2	15.9	11.3	13	92

Table III (cont.)

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 5, RUN 1-A

CATALYST - COBALT-GRAPHITE (3.4 WT% CO); VENTRON CORP. "GRAPHIMET" NO. 89650; PRETREATED (PROGRAM TO 400 C IN H2 FOR 3 HRS) EVACUATED FOR 11 HRS AT 300 C.

WEIGHT - 0.5 G TOTAL

REACTION TEMPERATURE = 250 C
INITIAL TOTAL PRESSURE = 697 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 341 CC

	- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE -							
REACTION TIME (HRS)	CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
1.08	8.5	64.7	9.5	6.0	11.3	0.0	0.0	0.0
2.00	7.9	63.6	8.0	6.7	9.9	0.0	2.3	1.6
3.00	7.0	63.1	6.8	7.0	9.2	3.0	2.7	1.3
4.00	6.6	60.4	5.5	6.9	8.7	3.2	5.1	3.6
6.00	6.7	60.7	4.6	7.8	8.5	3.7	4.6	3.5
9.00	6.8	59.8	3.3	8.4	7.5	4.3	5.4	4.6
23.00	7.7	59.0	1.4	9.8	5.5	6.0	5.8	4.7

	---- MOLES PER 100 MOLES OF CO CONVERTED -----										
REXN TIME (HR)	CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
1.08	6.2	46.8	13.7	8.6	24.6	0.0	0.0	0.0	0.3	13	100
2.00	5.3	43.0	10.9	9.0	20.1	0.0	6.3	5.4	0.7	20	100
3.00	4.6	41.7	9.0	9.2	18.2	5.9	7.0	4.3	1.3	25	95
4.00	4.0	36.4	6.6	8.3	15.8	5.8	12.3	10.9	2.0	35	96
6.00	4.1	36.9	5.6	9.5	15.5	6.7	11.1	10.6	3.1	25	97
9.00	4.0	35.2	3.9	9.8	13.3	7.6	12.7	13.6	5.0	30	96
23.0	4.5	34.6	1.6	11.5	9.7	10.6	13.5	13.8	12.7	25	92

Table III (cont.)

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 8, RUN 1-A

CATALYST - COBALT-GRAPHITE (3.4 WT% CO); VENTRON CORP. 'GRAPHIMET' NO. 89650; PRETREATED (PROGRAM TO 400 C IN H2 FOR 3.6 HR) EVACUATED FOR 16 HRS AT 300 C.

WEIGHT - 0.5 G TOTAL

REACTION TEMPERATURE = 275 C
INITIAL TOTAL PRESSURE = 697 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 341 CC

- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE -

REACTION TIME (HRS)	CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
0.50	17.2	57.1	9.1	4.0	9.7	2.9	0.0	0.0
1.00	12.3	59.4	7.8	4.3	8.4	1.8	2.7	3.2
2.00	11.0	59.1	6.8	5.1	8.6	2.6	3.9	2.9
3.00	11.1	60.5	6.0	5.6	8.2	2.4	3.8	2.4
5.00	11.7	59.1	4.7	6.6	7.6	2.7	4.2	3.4
7.00	12.4	59.4	3.8	7.2	7.1	3.0	4.1	2.9
10.00	13.3	59.1	3.0	7.8	6.4	3.2	3.9	3.2
13.00	14.1	59.5	2.5	8.3	5.9	3.4	3.6	2.7
23.00	15.6	59.3	1.6	8.7	4.7	4.0	3.6	2.4
28.00	16.2	59.2	1.4	8.8	4.2	4.5	3.5	2.3
29.00	16.3	59.2	1.3	8.8	4.2	4.4	3.5	2.3
31.00	16.5	59.1	1.2	8.8	4.0	4.4	3.4	2.5

---- MOLES PER 100 MOLES OF CO CONVERTED -----

REXN TIME (HR)	CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
0.50	12.4	41.2	13.1	5.8	21.0	6.4	0.0	0.0	0.4	38	98
1.00	8.0	38.7	10.2	5.6	16.4	3.6	6.9	10.5	1.0	50	98
2.00	7.0	37.5	8.7	6.4	16.5	4.9	9.8	9.2	2.1	44	96
3.00	7.2	39.3	7.8	7.3	16.0	4.6	9.8	7.9	3.0	38	96
5.00	7.4	37.4	5.9	8.4	14.3	5.2	10.7	10.6	4.9	40	94
7.00	8.0	38.2	4.9	9.3	13.8	5.8	10.5	9.5	6.4	32	93
10.0	8.6	38.2	3.8	10.1	12.4	6.2	10.2	10.4	8.5	30	92
13.0	9.3	39.4	3.3	11.0	11.7	6.8	9.6	8.9	10.1	23	92
23.0	10.5	40.0	2.1	11.7	9.5	8.2	9.8	8.2	15.2	21	90
28.0	11.0	40.2	1.8	11.9	8.6	9.2	9.4	7.8	17.6	20	89
29.0	11.1	40.3	1.8	12.0	8.6	9.0	9.5	7.9	17.9	16	88
31.0	11.2	40.2	1.7	12.0	8.2	9.0	9.3	8.4	18.9	20	89

Table III (cont.)

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 7, RUN 1-A

CATALYST - COBALT-GRAPHITE (3.4 WT% CO); VENTRON CORP. 'GRAPHIMET' NO. 89650; PRETREATED (PROGRAM TO 400 C IN H2 FOR 4.3 HR) EVACUATED FOR 16 HRS AT 300 C.

WEIGHT - 0.5 G TOTAL

REACTION TEMPERATURE = 300 C
INITIAL TOTAL PRESSURE = 697 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 341 CC

- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE -

REACTION TIME (HRS)	CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
0.50	7.5	57.1	3.9	9.4	10.1	4.0	5.2	2.8
1.00	9.2	58.5	2.2	10.3	7.4	5.3	4.8	2.3
1.50	10.4	59.0	1.5	10.6	5.6	5.9	4.7	2.3
2.00	11.4	59.2	1.2	10.8	4.6	6.2	4.5	2.0
4.00	13.9	59.3	0.7	10.8	2.7	7.0	3.8	1.8
5.00	14.7	59.2	0.6	10.8	2.2	7.0	3.6	1.7
5.50	15.1	59.1	0.6	10.8	2.1	7.1	3.5	1.7
7.00	15.9	59.0	0.5	10.8	1.8	7.1	3.3	1.6
9.00	16.8	58.6	0.5	10.7	1.5	7.0	3.3	1.6
11.00	17.6	58.3	0.4	10.6	1.3	7.1	3.1	1.5

----- MOLES PER 100 MOLES OF CO CONVERTED -----

REXN TIME (HR)	CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
0.50	4.5	33.9	4.7	11.2	18.0	7.1	12.5	8.3	7.8	658	96
1.00	5.7	36.3	2.7	12.8	13.7	9.8	11.9	7.1	12.8	423	95
1.50	6.6	37.2	1.9	13.4	10.7	11.1	11.8	7.3	16.4	311	94
2.00	7.3	38.0	1.5	13.8	8.8	12.0	11.5	7.0	19.2	236	94
4.00	9.3	39.6	1.0	14.5	5.4	14.0	10.2	6.1	27.1	166	93
5.00	10.0	40.1	0.8	14.7	4.5	14.2	9.7	5.9	29.8	114	92
5.50	10.2	40.2	0.8	14.7	4.2	14.5	9.4	5.9	31.0	103	92
7.00	11.0	40.5	0.7	14.8	3.6	14.6	9.1	5.6	34.2	92	92
9.00	11.6	40.5	0.6	14.8	3.1	14.6	9.2	5.5	38.3	87	91
11.0	12.3	40.6	0.6	14.8	2.8	14.9	8.6	5.4	41.5	66	90

Table IV

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 4, RUN 1-A

CATALYST - COBALT ON KIESELGUHR (39 WT% CO); HARSHAW CHEMICAL CO. NO. CO-0127; PRETREATED IN H2 FOR 8 HRS AT 400 C EVACUATED FOR 16 HRS AT 300 C.

WEIGHT - 0.10 G TOTAL

REACTION TEMPERATURE = 200 C
INITIAL TOTAL PRESSURE = 697 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 341 CC

- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE -

REACTION TIME (HRS)	CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
0.26	87.2	0.0	5.0	0.0	1.2	0.0	2.7	3.9
0.50	42.1	43.2	4.0	4.3	1.4	0.0	2.5	2.5
1.01	20.6	47.7	1.8	5.8	9.1	3.2	5.8	6.0
2.00	11.0	52.6	0.8	5.9	6.5	4.5	8.0	10.6
3.00	8.2	54.8	0.5	6.1	5.6	5.5	8.1	11.1
4.51	6.5	55.1	0.3	6.3	3.9	7.0	9.0	11.9
5.00	6.1	55.6	0.3	6.3	3.6	7.3	9.3	11.5
6.00	5.7	56.1	0.2	6.4	3.1	7.8	9.2	11.6

---- MOLES PER 100 MOLES OF CO CONVERTED -----

REXN TIME (HR)	CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
0.26	66.5	0.0	7.7	0.0	2.7	0.0	8.1	15.1	0.2	26	98
0.50	32.7	33.6	6.2	6.7	3.3	0.0	7.6	9.9	0.3	31	98
1.01	11.9	27.5	2.1	6.7	15.8	5.5	13.3	17.3	1.0	60	97
2.00	5.6	26.9	0.8	6.1	10.0	6.9	16.4	27.2	2.6	68	96
3.00	4.1	27.7	0.6	6.2	8.4	8.4	16.5	28.0	4.1	65	94
4.51	3.2	27.2	0.3	6.2	5.8	10.3	17.8	29.2	6.6	70	93
5.00	3.0	27.5	0.3	6.2	5.3	10.8	18.4	28.4	7.3	62	93
6.00	2.8	27.8	0.2	6.3	4.5	11.5	18.2	28.6	8.9	66	92

Table IV (cont.)

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 5, RUN 1-A

CATALYST - COBALT ON KIESELGUHR (39 WT% CO); HARSHAW CHEMICAL CO. NO. CO-0127; PRETREATED IN H2 FOR 8 HRS AT 400 C EVACUATED FOR 16 HRS AT 330 C.

WEIGHT - 0.10 G TOTAL

REACTION TEMPERATURE = 226 C
INITIAL TOTAL PRESSURE = 701 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 339 CC

- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE -

REACTION TIME (HRS)	CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
0.25	11.3	55.3	2.6	6.3	8.6	2.8	7.0	6.0
0.50	6.8	63.0	1.3	7.2	7.7	4.0	5.7	4.3
1.01	4.6	65.3	0.6	7.8	5.2	6.0	6.1	4.5
2.00	3.6	67.8	0.3	7.8	2.4	7.2	5.1	5.7
3.00	3.3	68.4	0.2	7.9	1.5	7.7	6.0	5.0
4.05	3.2	68.8	0.1	7.8	1.1	7.9	5.8	5.3
5.01	3.2	69.5	0.1	7.8	0.8	7.9	5.7	5.0

----- MOLES PER 100 MOLES OF CO CONVERTED -----

REXN TIME (HR)	CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
0.25	6.4	31.3	3.0	7.1	14.6	4.8	15.9	17.0	1.3	218	99
0.50	4.1	38.0	1.6	8.7	13.8	7.2	13.7	12.8	2.6	228	98
1.01	2.8	39.1	0.7	9.3	9.3	10.7	14.7	13.5	5.7	253	97
2.00	2.2	41.0	0.3	9.4	4.4	13.0	12.3	17.3	11.6	251	94
3.00	2.0	41.5	0.2	9.6	2.8	14.0	14.7	15.2	17.2	240	93
4.05	2.0	41.8	0.1	9.5	2.1	14.4	14.0	16.1	22.9	230	92
5.01	2.0	42.8	0.1	9.6	1.5	14.5	14.0	15.5	27.3	196	91

Table IV (cont.)

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 3, RUN 1-A

CATALYST - COBALT ON KIESELGUHR (39 WT% CO); HARSHAW CHEMICAL CO. NO. CO-0127; PRETREATED IN H2 FOR 8 HRS AT 400 C EVACUATED FOR 16 HRS AT 300 C.

WEIGHT - 0.10 G TOTAL

REACTION TEMPERATURE = 250 C
INITIAL TOTAL PRESSURE = 697 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 341 CC

- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE -

REACTION TIME (HRS)	CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
0.25	8.0	73.1	0.7	7.9	3.6	3.9	1.9	0.9
0.50	5.2	75.2	0.4	8.0	2.0	4.8	3.0	1.4
1.00	4.0	77.7	0.2	8.0	0.9	5.1	2.8	1.2
1.50	3.7	78.8	0.1	7.9	0.6	5.2	2.5	1.2
2.00	3.6	79.4	0.1	7.8	0.4	5.2	2.3	1.2
3.01	3.6	80.3	0.1	7.6	0.3	4.9	2.1	1.1
4.00	3.8	80.7	0.0	7.5	0.2	4.7	2.0	1.1

---- MOLES PER 100 MOLES OF CO CONVERTED -----

REXN TIME (HR)	CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
0.25	6.0	54.9	1.1	11.8	8.2	8.7	5.8	3.5	4.4	747	100
0.50	3.8	55.0	0.5	11.7	4.4	10.6	8.9	5.1	9.0	783	96
1.00	3.0	58.2	0.3	12.0	2.1	11.5	8.5	4.5	16.7	664	95
1.50	2.8	59.6	0.2	12.0	1.3	11.9	7.6	4.6	23.7	591	95
2.00	2.7	60.6	0.1	11.9	1.0	11.8	7.1	4.7	29.8	525	95
3.01	2.8	62.4	0.1	11.9	0.6	11.4	6.6	4.2	39.8	424	96
4.00	3.0	63.2	0.1	11.8	0.5	11.0	6.3	4.1	47.1	314	96

Table IV (cont.)

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIER 6, RUN 1-A

CATALYST - COBALT ON KIESELGUHR (39 WT% CO); HARSHAW CHEMICAL CO. NO. CO-0127; PRETREATED IN H2 FOR 8 HRS AT 400 C EVACUATED FOR 16 HRS AT 300 C.

WEIGHT - 0.10 G TOTAL

REACTION TEMPERATURE = 275 C
INITIAL TOTAL PRESSURE = 697 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 341 CC

REACTION TIME (HRS)	- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE - CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
0.25	3.6	87.4	0.2	5.9	0.5	1.9	0.4	0.0
0.50	3.5	88.0	0.1	5.7	0.2	1.9	0.4	0.1
0.75	3.6	88.5	0.1	5.5	0.1	1.8	0.3	0.1
1.00	3.8	88.5	0.1	5.4	0.1	1.7	0.4	0.1
1.50	4.2	88.5	0.0	5.2	0.1	1.6	0.3	0.0
2.02	4.8	87.9	0.0	5.2	0.1	1.6	0.3	0.0

REXN TIME (HR)	---- MOLES PER 100 MOLES OF CO CONVERTED ---- CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
0.25	3.2	77.8	0.4	10.6	1.4	5.2	1.5	0.0	12.1	2069	99
0.50	3.1	78.7	0.2	10.2	0.7	5.2	1.4	0.6	22.7	1800	100
0.75	3.3	80.0	0.1	9.9	0.4	4.8	1.1	0.4	31.3	1462	100
1.00	3.4	80.0	0.1	9.7	0.2	4.7	1.3	0.5	38.3	1200	100
1.50	3.9	80.8	0.1	9.5	0.2	4.5	1.0	0.2	48.6	873	99
2.02	4.4	80.1	0.1	9.4	0.2	4.5	1.1	0.2	54.8	510	99

Table IV (cont.)

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 7, RUN 1-A

CATALYST - COBALT ON KIESELGUHR (39 WT% CO); HARSHAW CHEMICAL CO. NO CO-0127; PRETREATED IN H2 FOR 8 HRS AT 400 C EVACUATED FOR 16 HRS AT 300 C.

WEIGHT - 0.10 G TOTAL

REACTION TEMPERATURE = 300 C
INITIAL TOTAL PRESSURE = 701 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 339 CC

- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE -

REACTION TIME (HRS)	CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
0.25	6.4	90.3	0.1	2.9	0.1	0.3	0.0	0.0
0.52	6.8	89.7	0.0	2.9	0.1	0.4	0.0	0.0
1.00	7.9	88.4	0.1	3.1	0.1	0.4	0.0	0.0
1.50	8.8	87.0	0.1	3.2	0.2	0.5	0.1	0.0

---- MOLES PER 100 MOLES OF CO CONVERTED -----

REXN TIME (HR)	CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
0.25	6.2	86.9	0.1	5.5	0.4	0.9	0.0	0.0	26.2	4444	98
0.52	6.6	86.4	0.1	5.7	0.2	1.1	0.0	0.0	40.1	2220	98
1.00	7.6	84.9	0.1	5.9	0.2	1.2	0.0	0.0	51.9	1034	97
1.50	8.4	82.8	0.3	6.1	0.6	1.4	0.3	0.1	56.6	398	97

Table V

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 11, RUN 1-A

CATALYST - COBALT-GRAPHITE (3.4 WT% CO); VENTRON CORP. 'GRAPHIMET' NO. 89650; PRETREATED (PROGRAM TO 400 C IN H2 FOR 3.5 HR) EVACUATED FOR 16 HRS AT 300 C, H2S DOSE (10%-2%-10%) ADDED AT 2.51, 7.63, AND 13.05 HRS. OF REACTION.

WEIGHT - 0.5 G TOTAL

REACTION TEMPERATURE = 300 C
INITIAL TOTAL PRESSURE = 697 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 341 CC

- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE -

REACTION TIME (HRS)	CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
0.27	6.9	56.5	8.3	7.3	12.5	2.7	4.5	1.3
0.75	7.1	57.8	4.1	9.3	9.5	4.1	5.4	2.6
1.00	7.7	58.6	3.2	9.9	8.5	4.8	4.9	2.3
1.50	8.6	59.7	2.3	10.6	6.8	5.5	4.3	2.2
2.03	9.4	60.0	1.7	11.0	5.5	6.2	4.3	1.9
2.50	9.9	60.3	1.4	11.0	4.7	6.8	3.9	2.0
3.00	9.9	60.7	1.4	10.9	4.6	6.6	4.2	1.8
3.50	9.7	60.8	1.4	10.9	4.5	6.5	4.2	2.0
6.50	9.4	63.7	1.3	10.3	4.3	6.2	3.2	1.6
8.00	9.2	64.1	1.3	10.1	4.1	6.2	3.5	1.5
12.00	8.9	66.5	1.1	9.5	3.6	5.6	3.3	1.4
13.00	8.8	66.4	1.1	9.5	3.6	5.6	3.4	1.6
14.00	8.8	67.0	1.1	9.3	3.6	5.6	3.3	1.4
15.00	8.7	67.3	1.1	9.2	3.5	5.5	3.2	1.5

---- MOLES PER 100 MOLES OF CO CONVERTED -----

	REXN TIME (HR)	CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
	0.27	4.2	34.4	10.1	8.8	22.8	5.0	11.0	3.7	2.4	381	96
	0.75	4.3	34.6	4.9	11.1	17.1	7.4	12.8	7.9	6.3	344	94
	1.00	4.7	35.9	4.0	12.2	15.6	8.8	12.0	6.9	7.6	225	94
	1.50	5.4	37.5	2.8	13.4	12.8	10.4	10.7	7.0	9.9	191	95
	2.03	6.0	38.2	2.2	14.0	10.6	11.9	11.0	6.0	11.9	162	95
H_2S →	2.50	6.3	38.8	1.8	14.1	9.1	13.1	10.1	6.6	13.3	126	93
	3.00	6.4	39.3	1.8	14.1	8.9	12.8	10.9	5.8	13.5	14	93
	3.50	6.3	39.3	1.8	14.0	8.8	12.6	10.8	6.5	13.8	24	93
H_2S →	6.50	6.3	42.9	1.7	13.9	8.6	12.6	8.6	5.4	14.1	5	92
	8.00	6.2	43.1	1.7	13.6	8.3	12.5	9.4	5.2	14.5	11	91
	12.0	6.2	46.0	1.6	13.2	7.4	11.7	9.1	4.8	15.1	6	89
H_2S →	13.0	6.0	45.7	1.6	13.0	7.5	11.6	9.3	5.3	15.5	18	90
	14.0	6.1	46.5	1.5	12.9	7.4	11.6	9.2	4.8	15.4	-4	89
	15.0	6.1	46.8	1.5	12.8	7.3	11.5	8.9	5.1	15.6	7	88

Table V (cont.)

FISCHER-TROPSCH REACTION RESULTS

EXPT. NO. - SERIES 13, RUN 1-A

CATALYST - COBALT-GRAPHITE (3.4 WT% CO); VENTRON CORP. 'GRAPHIMET' NO. 89650; PRETREATED (PROGRAM TO 400 C IN H2 FOR 4.0 HR) EVACUATED FOR 12 HRS AT 300 C, H2S DOSE (.5%-1.0%-1.0%) ADDED AT 0.73, 1.77, AND 3.53 HRS OF REACTION.

WEIGHT - 0.5 G TOTAL

REACTION TEMPERATURE = 300 C
INITIAL TOTAL PRESSURE = 697 TORR (0.92 ATM)
INITIAL H2/CO RATIO = 2.0
REACTOR VOLUME = 341 CC

- MOLE PERCENTS OF CARBON-CONTAINING PRODUCTS IN GAS PHASE -

REACTION TIME (HRS)	CO2	CH4	C2H4	C2H6	C3H6	C3H8	C4'S	C5+
0.25	5.9	57.5	5.5	9.6	10.8	3.5	3.0	4.2
0.50	7.0	59.8	2.9	10.9	8.2	5.0	4.4	1.9
1.00	7.9	60.3	1.9	11.5	5.9	6.2	4.4	2.0
1.50	8.4	60.7	1.5	11.7	5.1	6.6	4.2	1.7
1.75	8.7	60.7	1.4	11.8	4.7	6.8	4.2	1.8
2.25	8.7	60.9	1.4	11.6	4.5	6.8	4.2	1.9
3.00	8.7	61.6	1.3	11.5	4.5	6.7	4.0	1.7
3.50	8.7	61.8	1.3	11.4	4.4	6.7	4.0	1.8
4.25	8.7	62.2	1.3	11.3	4.3	6.7	4.0	1.7
5.00	8.6	62.6	1.3	11.2	4.2	6.6	3.8	1.6
5.50	8.6	63.0	1.2	11.2	4.1	6.5	3.8	1.6

----- MOLES PER 100 MOLES OF CO CONVERTED -----

	REXN TIME (HR)	CO2 (X1)	CH4 (X1)	C2H4 (X2)	C2H6 (X2)	C3H6 (X3)	C3H8 (X3)	C4'S (X4)	C5+ (X5)	% CO CONV	RATE MMOL /HR	% C MASS BAL.
	0.25	3.5	33.9	6.5	11.3	19.2	6.2	7.1	12.3	4.6	788	98
H_2S →	0.50	4.3	37.2	3.6	13.5	15.2	9.3	11.1	5.8	8.5	655	98
	1.00	5.0	38.0	2.3	14.4	11.2	11.7	11.1	6.3	12.6	353	95
	1.50	5.4	38.9	1.9	15.0	9.8	12.7	10.7	5.6	14.2	134	96
H_2S →	1.75	5.6	39.0	1.8	15.1	9.0	13.1	10.8	5.7	15.0	139	95
	2.25	5.6	39.1	1.7	15.0	8.7	13.1	10.7	6.0	15.3	19	93
	3.00	5.7	40.1	1.7	15.0	8.7	13.1	10.3	5.5	15.4	9	94
H_2S →	3.50	5.7	40.1	1.7	14.8	8.5	13.1	10.3	5.8	15.7	19	93
	4.25	5.7	40.6	1.7	14.8	8.4	13.1	10.4	5.5	15.6	-2	93
	5.00	5.7	41.2	1.7	14.8	8.3	13.0	10.1	5.2	15.7	6	92
	5.50	5.7	41.6	1.6	14.7	8.2	12.9	10.0	5.2	15.8	6	92

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