BITUMINOUS COAL RESEARCH, INC.
OCR/AGA-SPONSORED RESEARCH PROGRAM

PIPELINE GAS GENERATOR RESEARCH AND DEVELOPMENT

Progress Report No. 15

(BCR Report L-499)

I. INTRODUCTION

This report summarizes progress achieved during November, 1972, on a part of the program, "Gas Generator Research and Development," being conducted by Bituminous Coal Research, Inc., for the Office of Coal Research. The overall program was initiated under Contract No. 14-01-0001-324, December 20, 1963, and was transferred to Contract No. 14-32-0001-1207 on August 19, 1971. Under the new prime contract, a portion of the work is being sponsored jointly by OCR and the American Gas Association. Thus, this report represents the fifteenth report of progress on the jointly-sponsored OCR/AGA program.

The objective of this part of the program continues to be to develop processes for gasifying coal to produce high-Btu pipeline gas.

Laboratory-scale coal gasification experimentation is to be continued together with process and equipment development. With the aid of engineering subcontractor(s), a multipurpose research pilot plant facility is to be designed, constructed, and test operated.

A. Work Schedule

Work on the project is being conducted according to a schedule reflecting the program outlined under the new prime contract. This schedule was shown in Figure 1, page 2, Progress Report No. 1 and revised as shown in Figure 160, Progress Report No. 13, to reflect only that part of the overall program sponsored by both OCR and AGA.

B. Monthly Progress Charts

Monthly progress charts reflecting proposed rate of effort and expenditures on that part of the contract sponsored jointly by OCR and AGA, through Fiscal Year 1974, are shown in Appendixes A-1 and A-2. The projected costs are quarterly costs divided by three to obtain monthly costs, and will be adjusted when anticipated monthly expenditures are received from Stearns-Roger. These progress charts will be further revised to reflect the complete contract period when project planning and expenditure estimates for the period beginning with Fiscal Year 1975 are complete.

II. PHASE II PROGRESS ACHIEVED DURING MONTH ENDING NOVEMBER 25, 1972

A. Laboratory-scale Process Studies

1. Gas Processing (M. S. Graboski): This report summarizes progress achieved in the bench-scale and PEDU gas processing programs during November. Gas processing studies continued in accordance with the updated time schedule presented in Figure 163, Progress Report No. 14.

a. Bench-scale Studies: The purpose of the bench-scale program is to investigate methanation catalysts under conditions imposed by the BI-GAS process. These include high carbon monoxide concentrations, high pressure, and a nominal 3/1 hydrogen to carbon monoxide ratio.

Three processing schemes are currently under investigation. These are summarized in Figure 164, Progress Report No. 14. Scheme A reflects current planning where methanation follows shift conversion and acid gas removal; Scheme B considers hydrogen sulfide removal before and carbon dioxide removal after methanation; and Scheme C is based on methanation of the synthesis gas containing all acid gas components. The purpose of both the bench-scale and PEDU programs is to determine the feasibility of the schemes for the BI-GAS process.

(1) Harshaw Catalysts: In Progress Report No. 12, physical properties were reported for four new methanation catalysts, BCR Lots 3049 through 3052, obtained from Harshaw. During September, October, and November, work covered activity testing of these catalysts in direct comparison to Lot 2903 molybdenum oxide catalyst.

As reported in September (Progress Report No. 13), only catalyst Lots 3049 and 3051 showed stable activity for any length of time. In October, charges of Lots 3049, 3051, and 2903 were placed in the life tester, as reported in OCR Progress Report No. 14. Data are available for 1000 hours of testing through November. The test has been terminated in order to analyze the catalysts after the exposure period while they still have some degree of activity.

Data for the four catalyst charges are shown in Figures 178 through 185. For each catalyst, graphs are presented depicting conversion as a function of time, and yield of hydrocarbons as a function of time. The conversion-time trends for all catalysts are similar. Below 650 hours, when the feed gas consisted of a nominal 3/1 hydrogen to carbon monoxide ratio, the conversion level was stable, but lower than for the period above about 650 hours when a feed gas with a 1/1 hydrogen to carbon monoxide ratio was used. The yield-time plots indicate catalyst stability over the 1000-hour test period. Catalyst Lot 2903 is the most stable of the three tested. The other two catalysts tested, which contain nickel and molybdenum, showed rapid initial deactivation with no stabilization of activity until about 500 hours. Catalyst Lots 2903 and 3049 have the same molybdenum content and use the same

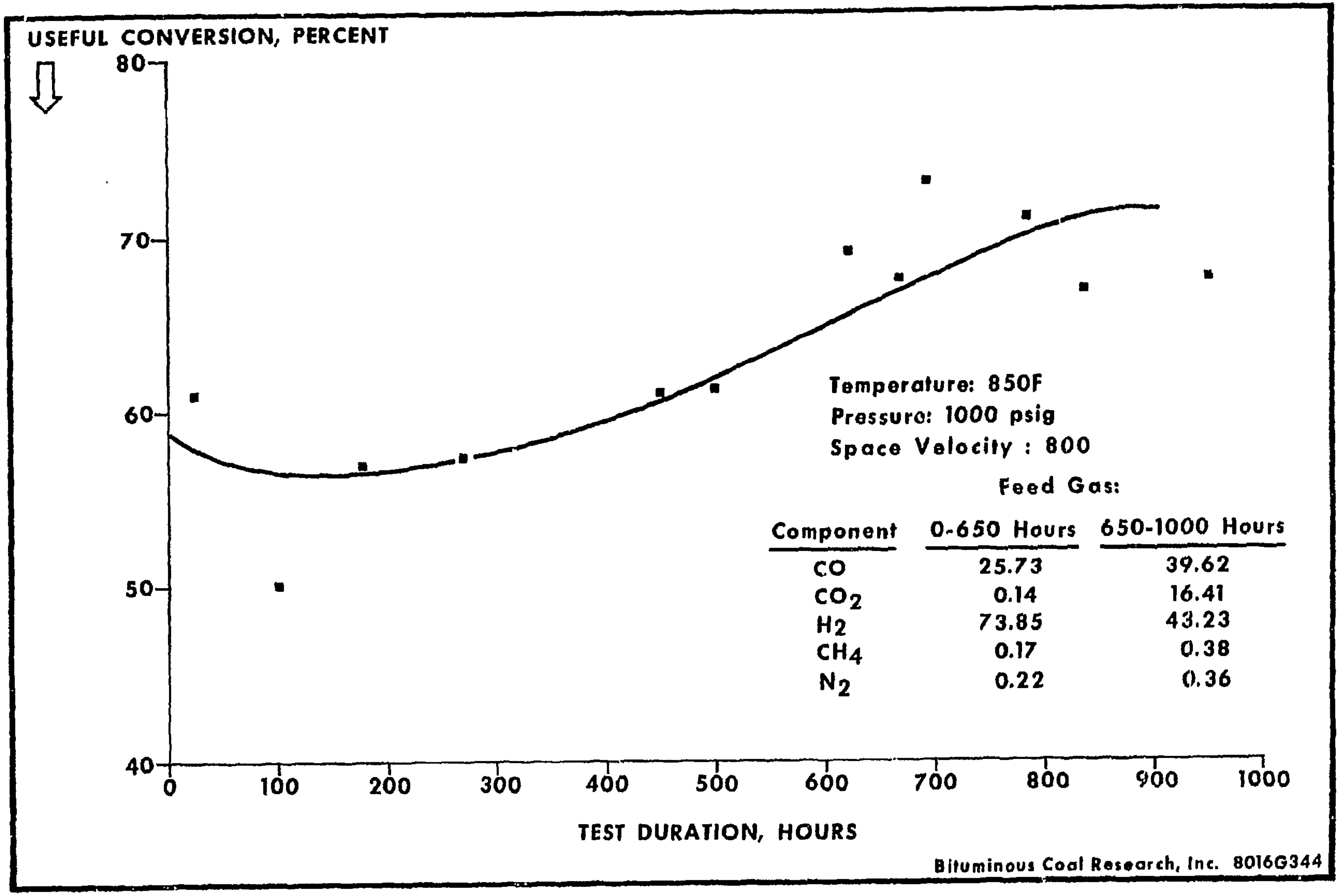


Figure 178. Useful Conversion as a Function of Time for BCR Lot 2903 Molybdenum Oxide Catalyst

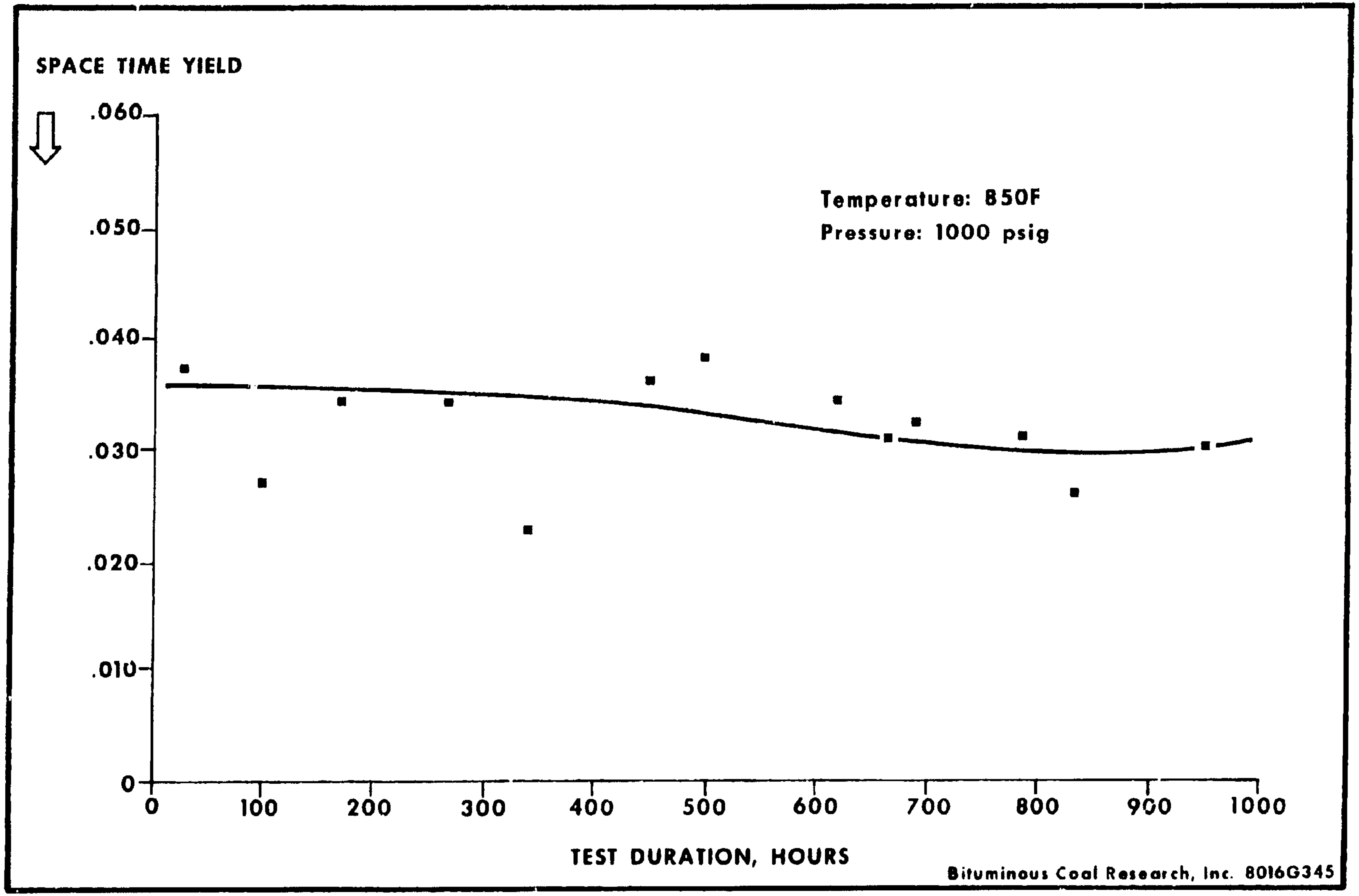


Figure 179. Yield of Hydrocarbons as a Function of Time for BCR Lot 2903

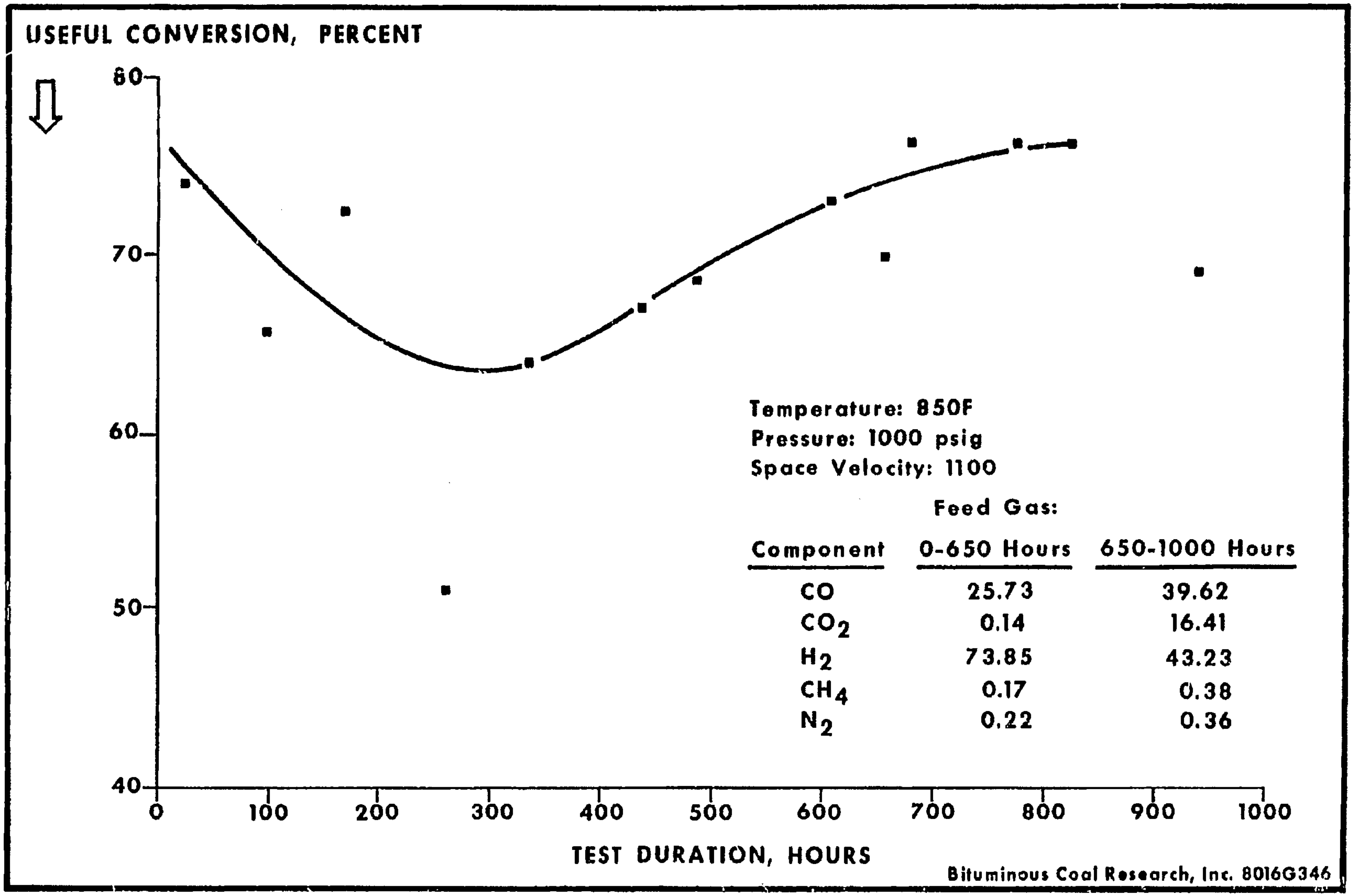


Figure 180. Useful Conversion as a Function of Time for BCR Lot 3049A

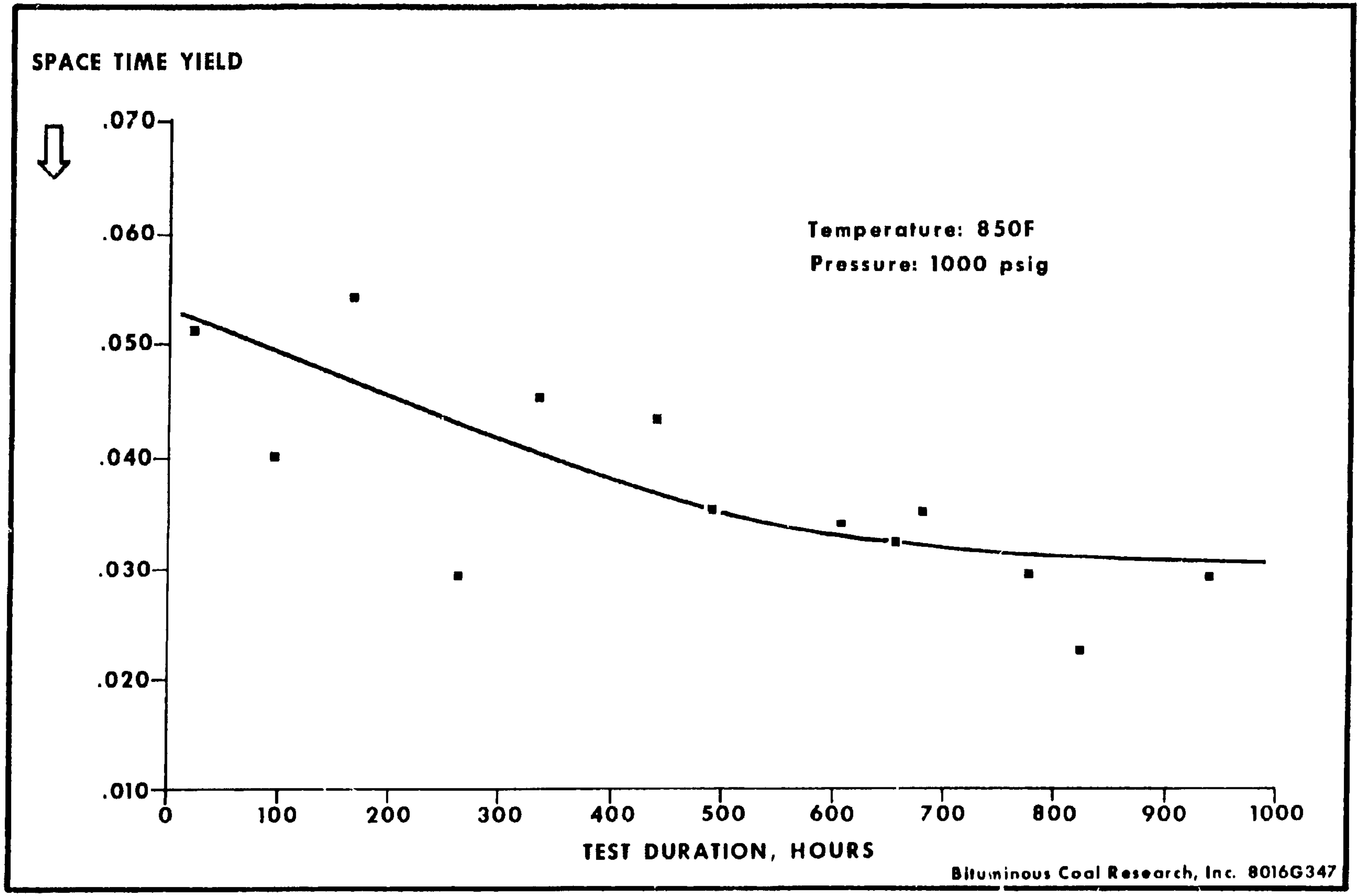


Figure 181. Yield of Hydrocarbons as a Function of Time for BCR Lot 3049A

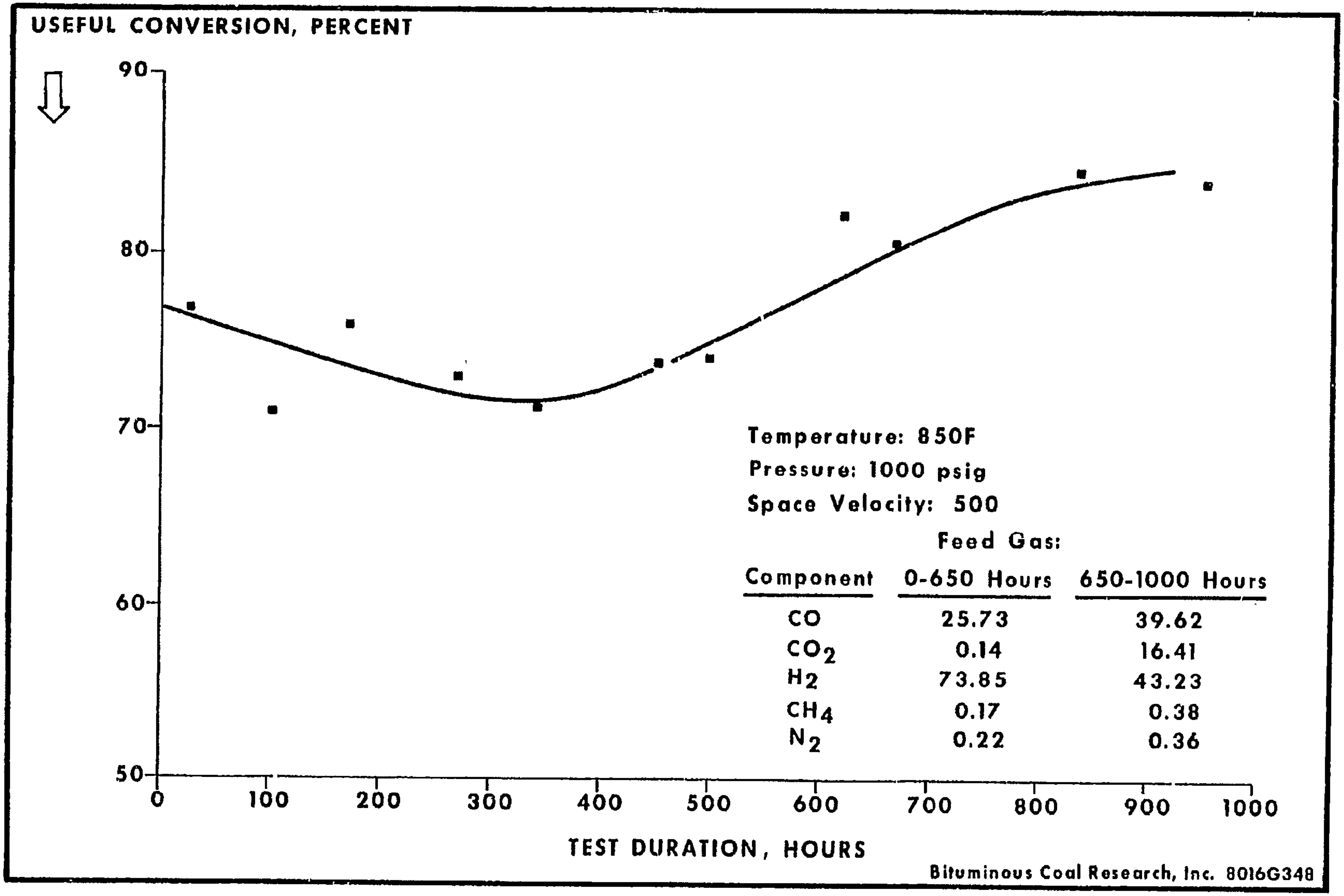


Figure 182. Useful Conversion as a Function of Time for BCR Lot 3049B

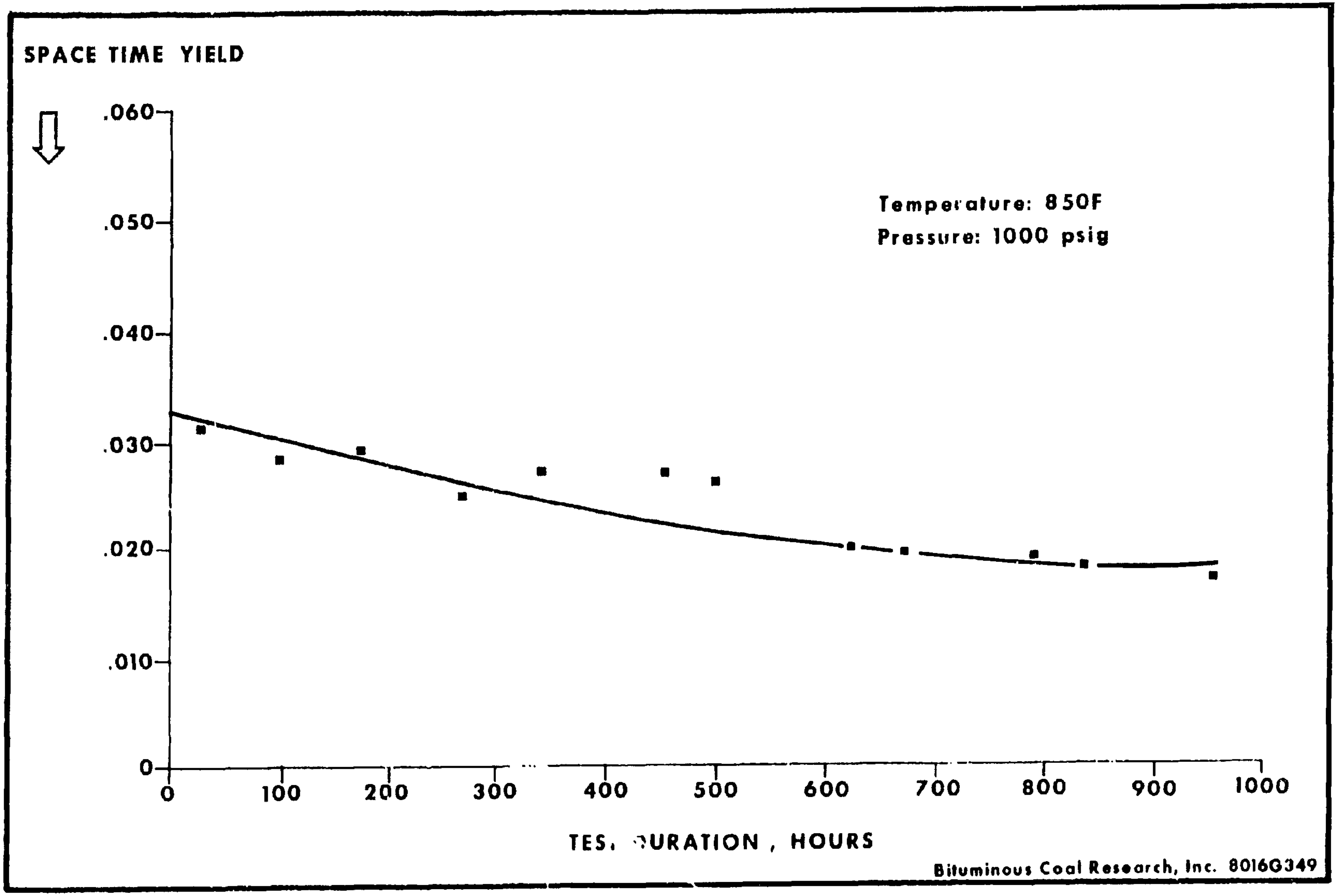


Figure 183. Yield of Hydrocarbons as a Function of Time for BCR Lot 3049B

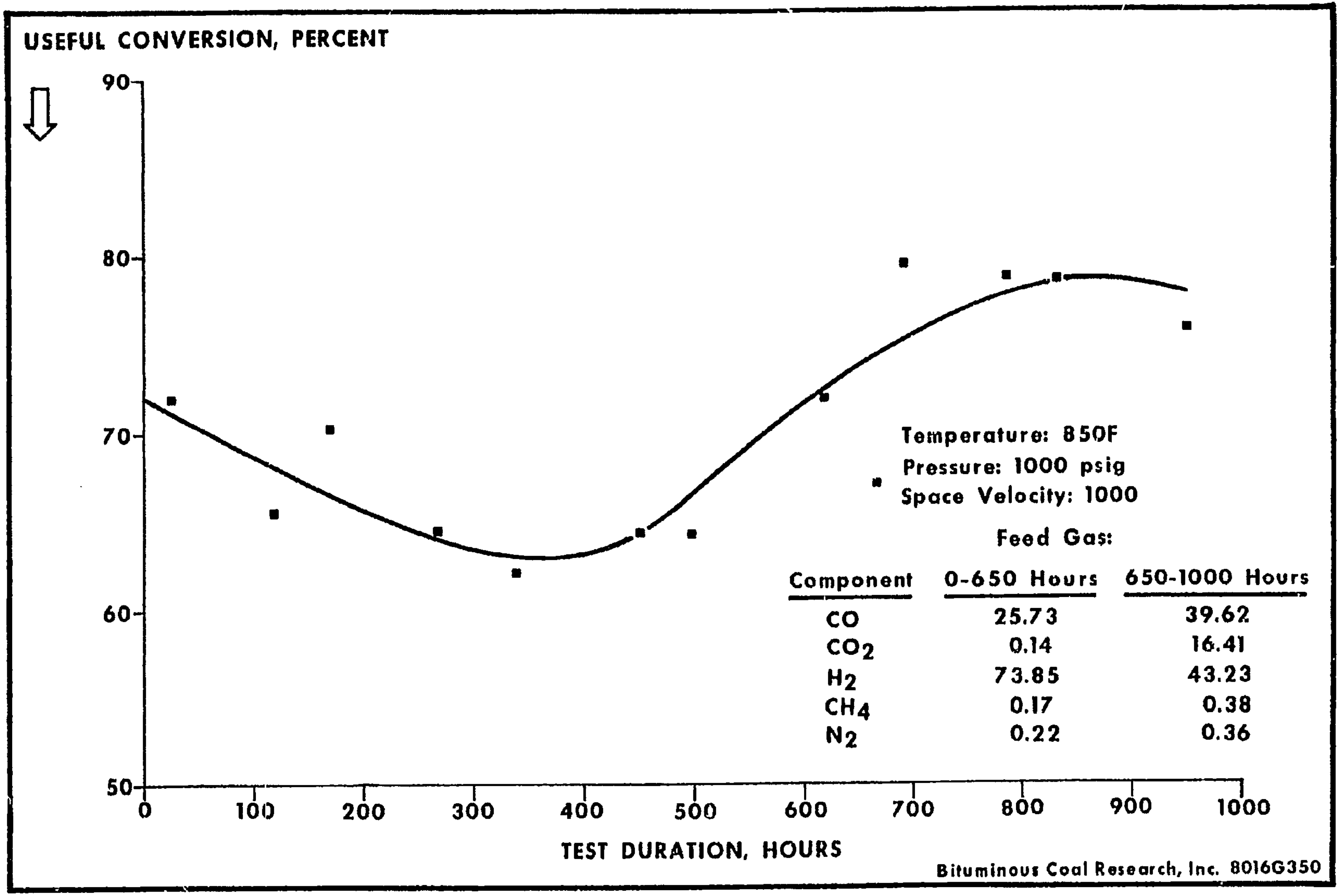


Figure 184. Useful Conversion as a Function of Time for BCR Lot 3051

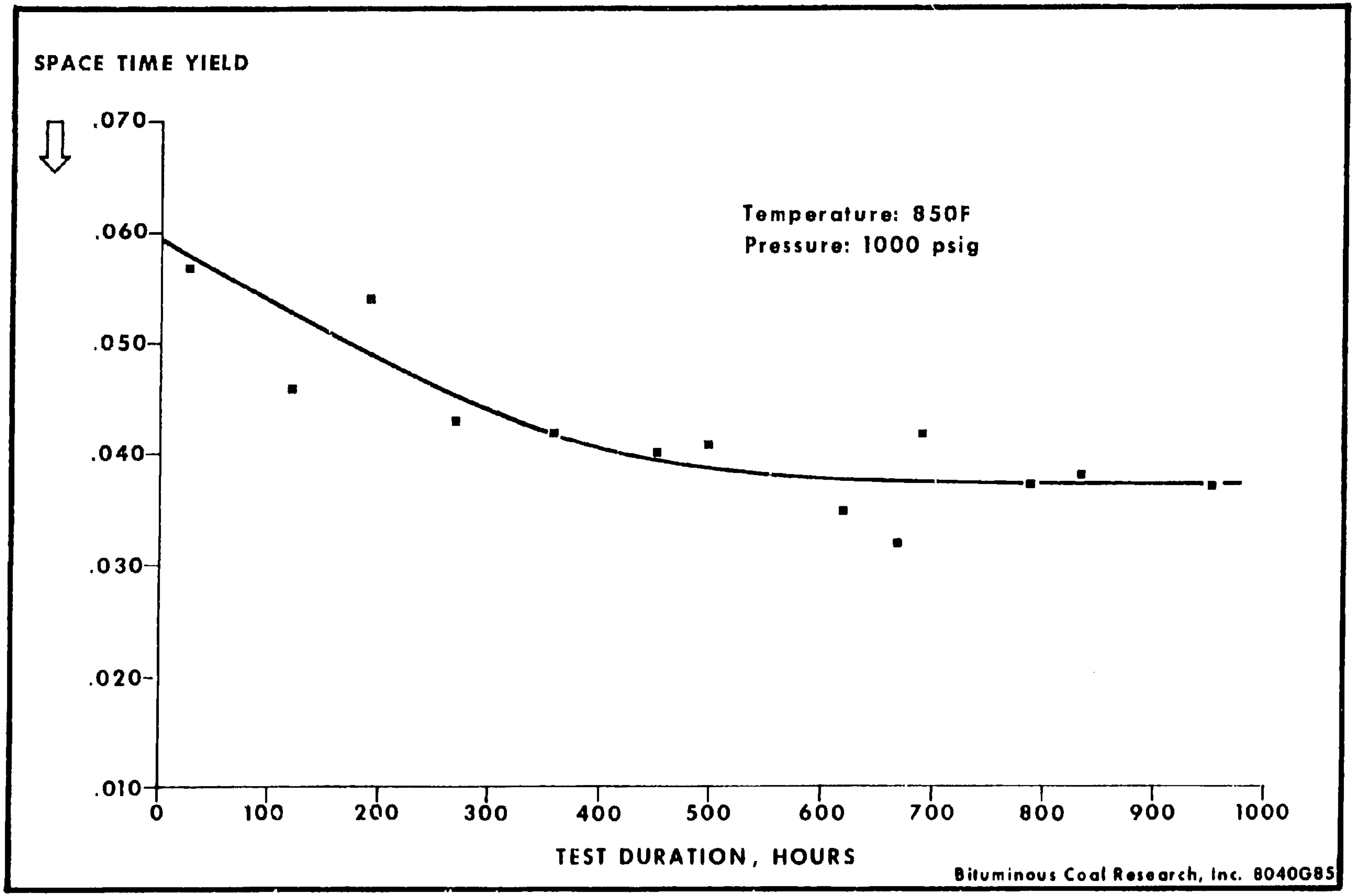


Figure 185. Yield of Hydrocarbons as a Function of Time for BCR Lot 3051

alumina support. Catalyst Lot 3049 is promoted with nickel. Catalyst Lot 3051 contains less molybdenum but more nickel in comparison to catalyst Lot 3049 and utilizes the same support. The stabilized activity levels are as follows:

Sample No.	Final Space Velocity	Yield
3049A	850	0.030
3049B	350	0.018
3051	900	0.037
2903	850	0.030

Comparison of the yield data from catalyst Lots 3049A and 2903 indicates that the catalysts have the same activity. The product distribution tends toward more methane and less ethane for the catalyst with nickel. Catalyst Lot 3051 appears to be more active than either Lots 2903 and 3049A; however, the increase in activity is not great. At the low space velocity, Lot 3049B is converting more than 85 percent of ($CO + H_2$) to hydrocarbons at test conditions.

During the test, some evidence of carbon formation was present. Flow rates for Lots 3049A, 3049B, and 3051 continually declined, indicating increased pressure drop in the reactor. No such decrease in flow occurred for Lot 2903. Since the gas being treated for the final portion of the test had a great potential for carbon formation, this is an important result. The low hydrogen to carbon monoxide ratio in the feed, in addition, does not tend to produce higher hydrocarbons at test conditions. However, it does improve the conversion level.

(2) Chemetron Catalysts: Chemetron has indicated that several catalyst samples are being prepared for test. These samples are scheduled for delivery in early December.

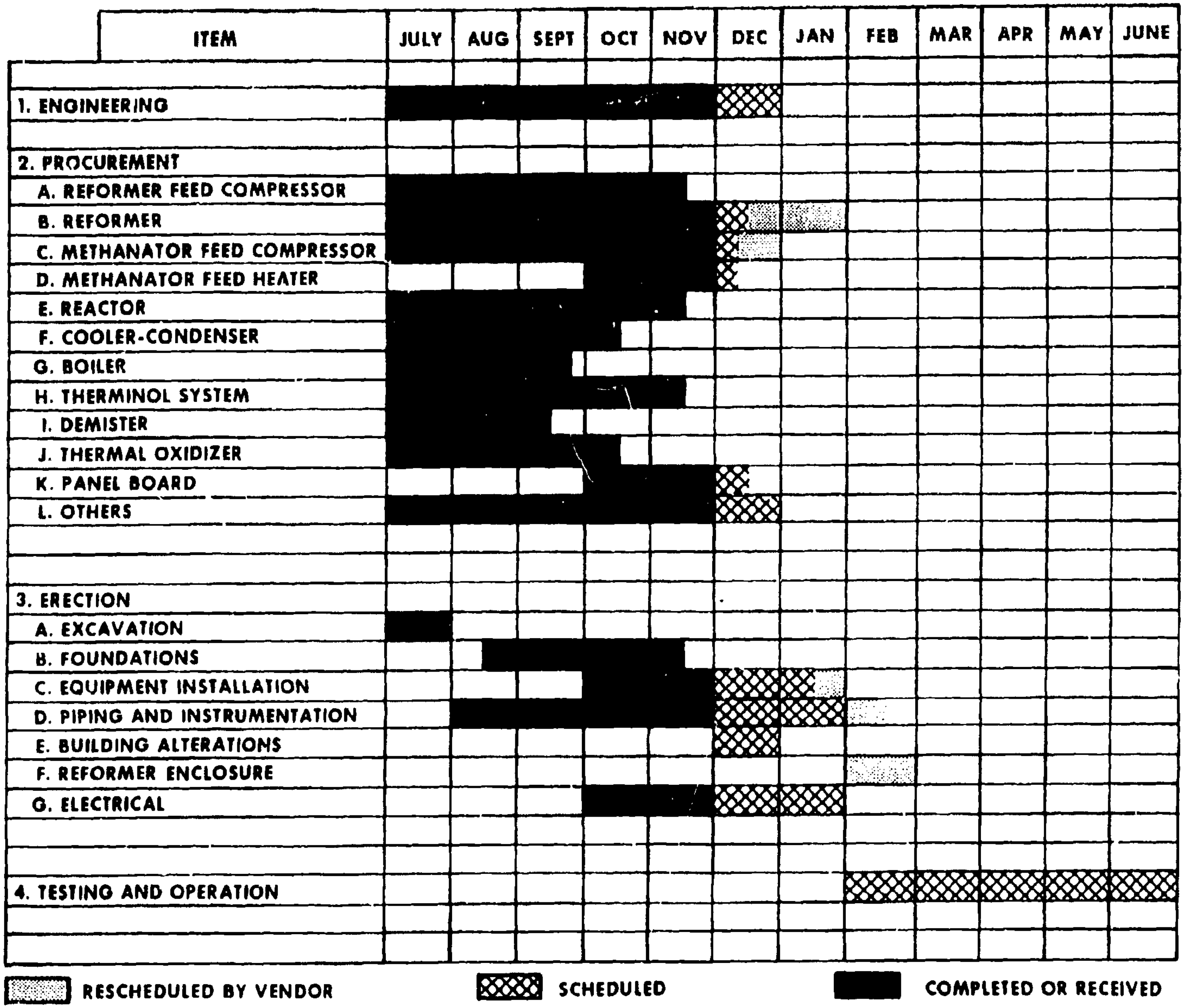
b. PEDU Studies: Progress continued on construction of the methanation PEDU during November. The updated construction schedule for the project, based on currently available delivery data, is given in Figure 186.

(1) Engineering: Koppers continued minor detail engineering effort during November. All work will be completed by the end of December.

During November, the work performed by Koppers included the following:

1. Evaluation of control valve quotes.
2. Evaluation of self-acting control valve quotes.
3. Review of graphic panel detail drawings.
4. Preparation of analyzer panel drawings.

(2) Procurement: Table 144 shows the revised status of major PEDU equipment items.



Bituminous Coal Research, Inc. 8040G86

Figure 186. Current Methanation PEDU Schedule for Fiscal 1973

TABLE 144. SUMMARY OF STATUS OF PEDU EQUIPMENT ITEMS

Index	Equipment Item	Status[1]	Estimated Delivery Date
ME-405	Feed Gas Preheater	P	12/15/72
ME-410	Filter Blowback Heater	P/A	R
ME-605	Cooler Condenser	P/A	R
ME-700	Water Cooler	P/A	R
MF-420	Catalyst Filters	Q	--
MK-102	Natural Gas Compressor	P/A	R
MK-305	Methanator Feed Gas Compressor	P/A	12/29/72
ME-305	Bypass Cooler	P/A	12/29/72
MK-770	Air Compressor	P/A	R
MP-710	Cooling Water Pump	P/A	R
MR-420	Fluid Bed Methanator	P/A	R
MV-104	Reformer Feed Gas Receiver	P/A	R
MV-260	H_2S Flash Tank	P/A	R
MV-307	Oil Separator	P/A	R
MV-310	Methanator Feed Gas Receiver	P/A	R
MV-610	Water Metering Tank	P/A	R
MV-615	Water Letdown Tank	P/A	10/15/72[2]
MV-620	Demister	P/A	R
MV-710	Cooling Water Tank	P/A	R
MV-763 A & B	H_2S Removal Towers	P/A	R
MV-764	Drip Pot	P	R
MV-766	Water Break Tank	P/A	10/15/72[2]
MX-100	Reformer	P/A	01/31/73
MX-500	Therminol System	P/A	R
MX-720	Steam Boiler	P/A	R
MX-750	Demineralizer	P/A	--
MX-770	Thermal Oxidizer	P	R
MY-700	Reformer Enclosure	P	01/31/73
	Panel	P	12/15/72
MX-210	CO_2 Storage Tank		R

[1] Q Quote Stage
P Procurement Stage
P/A Procured and Vendors Drawings Approved
R Received

[2] Vendor delay; delivery date to be revised

During November, visits were made to Gas Atmospheres, Cleveland, Ohio, to inspect fabrication of the reformer, Item MX-100, and to Nooter Corporation, St. Louis, Missouri, for final inspection of MR-420, the methanator.

During November, the natural gas compressor, Item MK-102, the fluid-bed methanator, Item MR-420, and the therminol system, Item MX-500, were received. All engineering drawings for the reformer, Item MX-100, were acquired from Gas Atmospheres. Purchasing of all equipment and instrument items except for the catalyst filters, analyzer panel, purgemeters, and thermocouples, is completed. Supplies are being procured for piping the high pressure portion of the process.

(3) Construction: PEDU construction is proceeding according to the schedule shown in Figure 187. Steelbilt has not yet altered Building 3. Some construction photographs are shown in Figures 187 through 196.

(a) Piping Installation: Piping work by BCR personnel continued during November. During this period, the following work was completed:

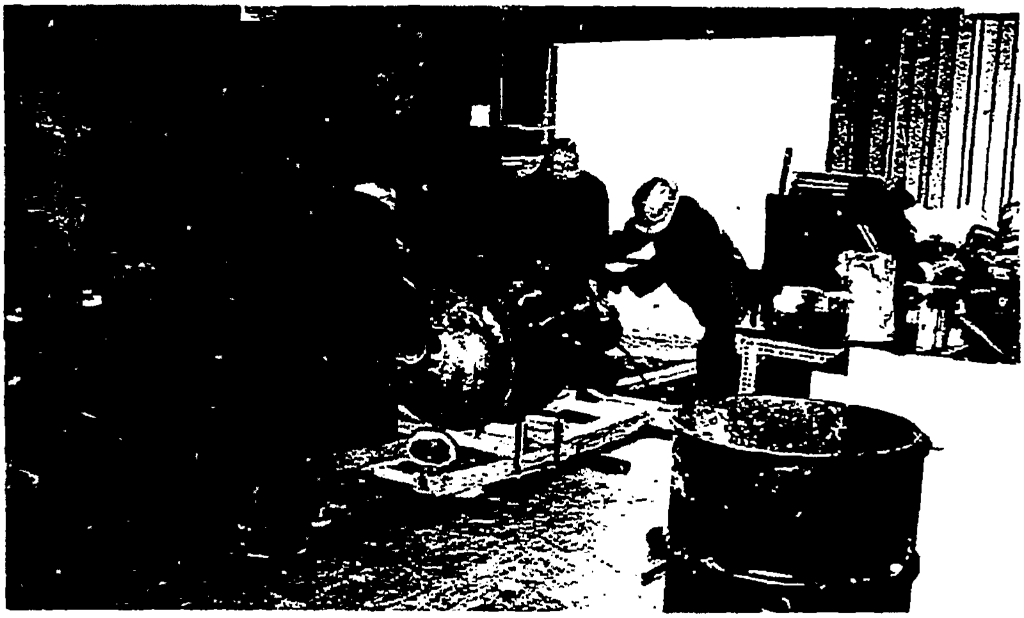
1. Main cooling water circuit piping.
2. H_2S removal tower piping.
3. Relief valve installation on Mv-104, MV-763A & B, MV-764.
4. Insulation of steam and CO_2 lines.
5. Fabrication of valve control house and structural supports.

(b) Structural Construction Work: During November, Mellon-Stuart performed the following work:

1. Completed all foundations.
2. Located the thermal oxidizer, Item MX-770.
3. Located cooling tower, Item ME-700.
4. Located boiler, Item MX-720.
5. Located therminol system, Item MX-500.
6. Installed structural steel in high pressure stall and located reactor, Item MR-420, nitrogen blowback heater, Item ME-410, demister, Item MV-620, cooler condenser, Item ME-605, and methanator feed gas receiver, Item MV-310.
7. Located cooling water tank, Item MV-710.

(c) Electrical Construction Work: During November the electrical construction progressed satisfactorily. The work included the following:

1. Setting of the electrical equipment in the methanation electrical area. The electrical equipment in this area consisted of the motor control center "M", power panel "M", distribution panels and distribution transformers.



8040P29

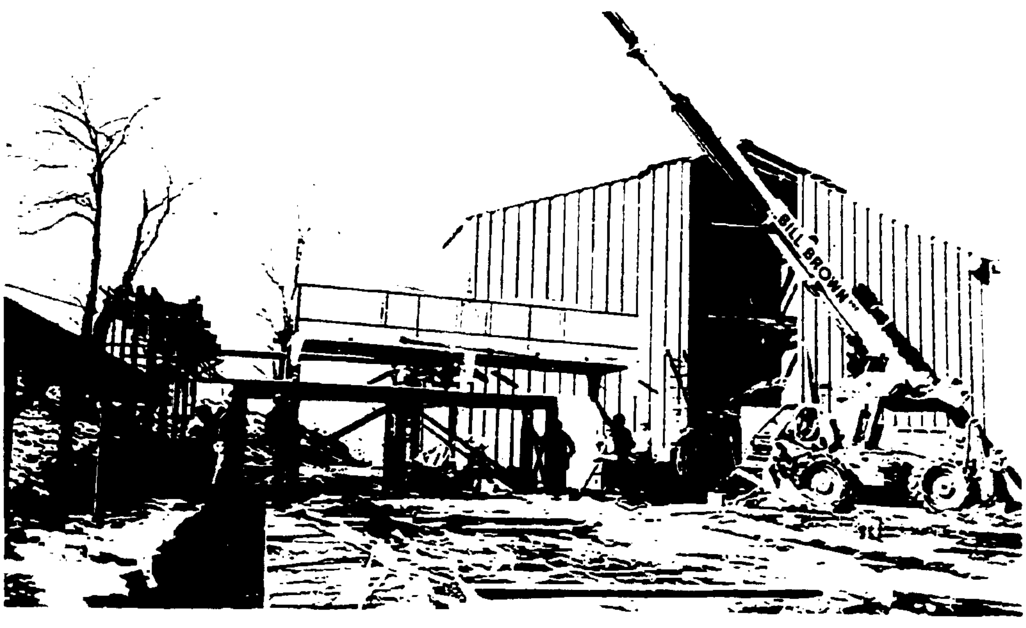
Figure 187. Unloading the Methanator

8040P30

Figure 188. Locating the Methanator in the High-pressure Stall

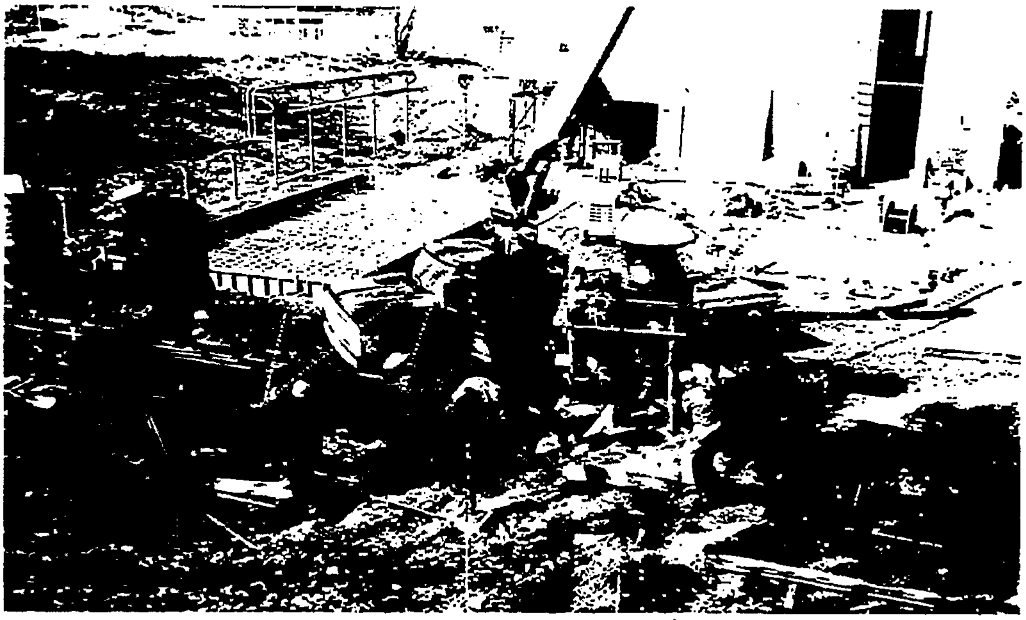
8040P31

Figure 189. Locating the Demister in the High-pressure Stall



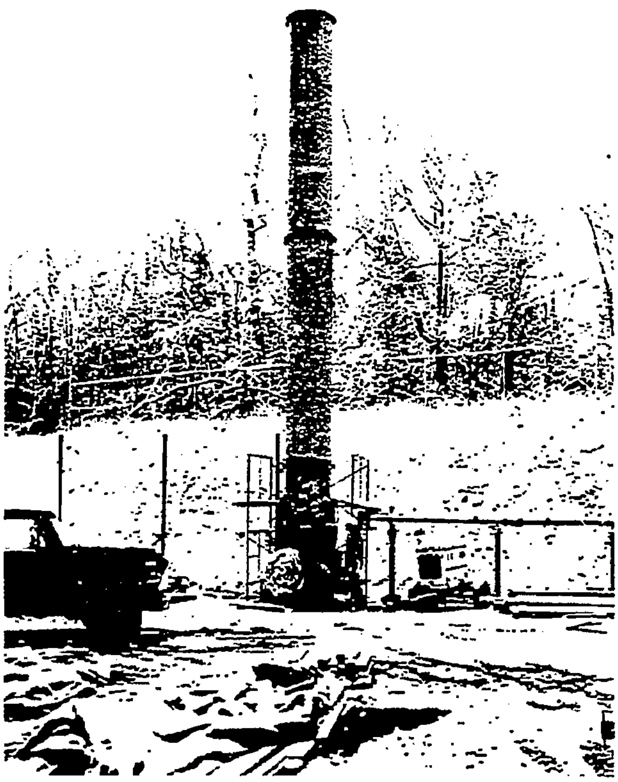
8040P32

Figure 190. Raising the Cooling Tower



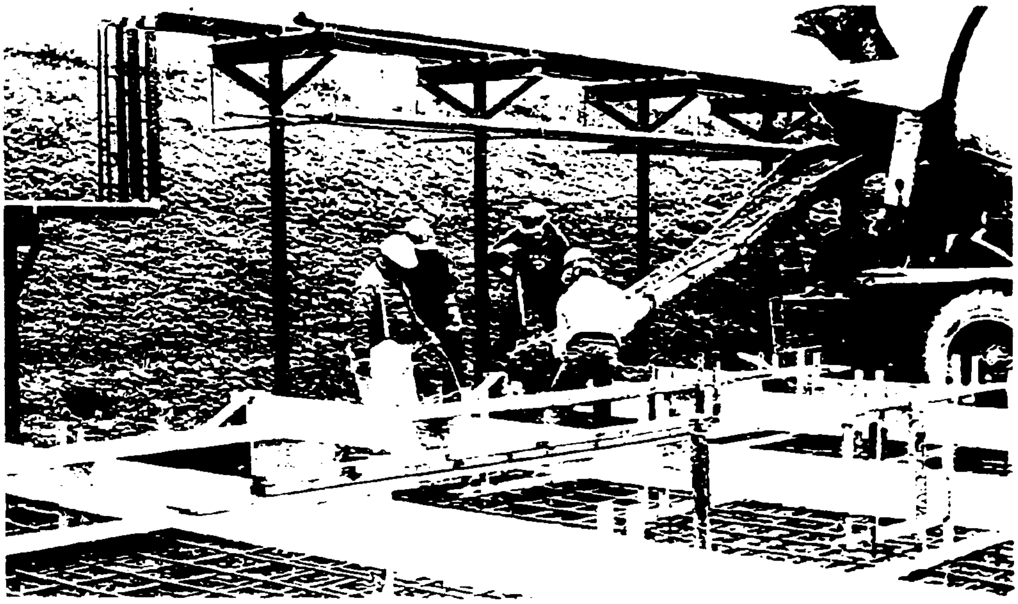
8040P33

Figure 191. Erecting the Thermal Oxidizer Base



8040P34

Figure 192. Thermal Oxidizer

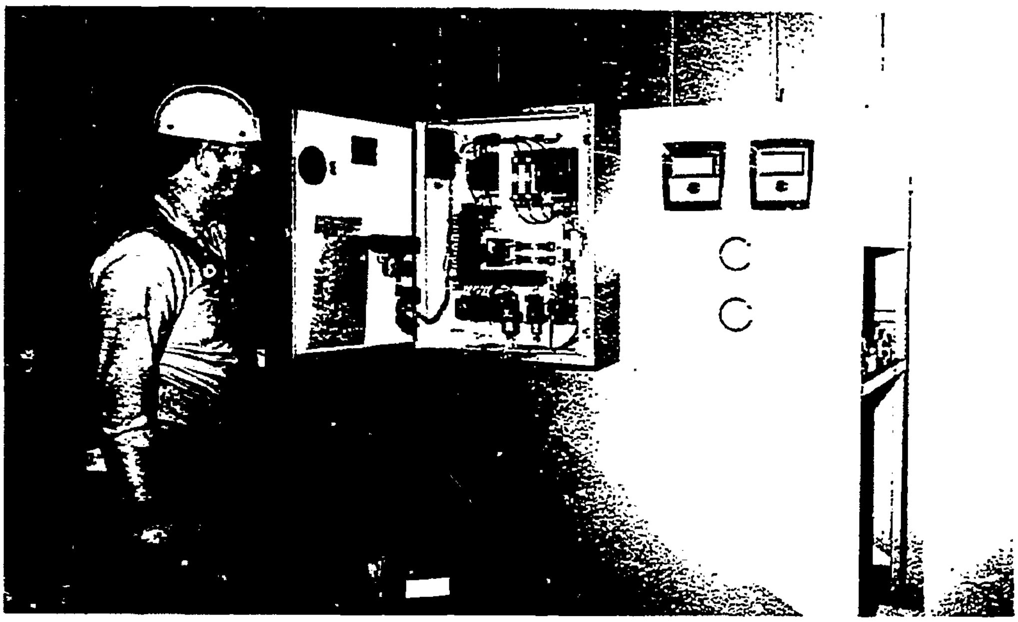


8040P35

Figure 193. Pouring the Reformer Slab

8040P36

Figure 194. Methanation Electrical Controls Area



8040P37

Figure 195. Therminol System

8040P38

Figure 196. Steam Boiler

2. Installation of the exposed conduit which begins at the methanation electrical area and goes to the gas storage area.

3. Installation of the exposed conduit run which is initiated at the gasification control room and runs along the yard pipe rack to the reformer enclosure. This conduit run consisted of fifteen (15) conduits.

4. Work was continued on grounding for the methanation system.

Lord Electric Company, Inc., submitted a work schedule to BCR on November 1. This schedule is shown in Figure 197.

(d) Other: During November, the gas company made changes in the delivery system to supply BCR with the necessary gas capacity for the PEDU system.

The electric company was contacted with respect to transformer delivery. Installation of transformer and poles is scheduled for mid-December.

(e) Work Scheduled: During December, construction work planned includes:

1. Continued piping effort on therminol system and steam boiler.
2. Completion of structural steel installation.
3. Installation of electrical conduit.
4. Installation of switch gear.
5. Installation of yard lighting.

c. Model Studies: No model work was conducted in November.

d. Future Work: Work for December includes the following:

1. Bench-scale testing of methanation catalysts.
2. Continued PEDU construction.

2. Analytical Services (J. E. Noll): During the past month, forty (40) samples from the methanation unit were analyzed by gas chromatography.

3. Gas Chromatographic Procedures (J. E. Noll): The system for automatic gas analysis for the methanation PEDU was tested using neon as a carrier gas. No work was done on the flame ionization detector gas chromatograph.

4. Automated Gas Analysis System (J. E. Noll): The system was tested using neon as a carrier gas to obtain retention times for the various gases. Work was completed on the Porapak Q column, but not on the molecular sieve column. These retention times are necessary for writing the program for the computer to control the system. The other time values required will be determined next month.

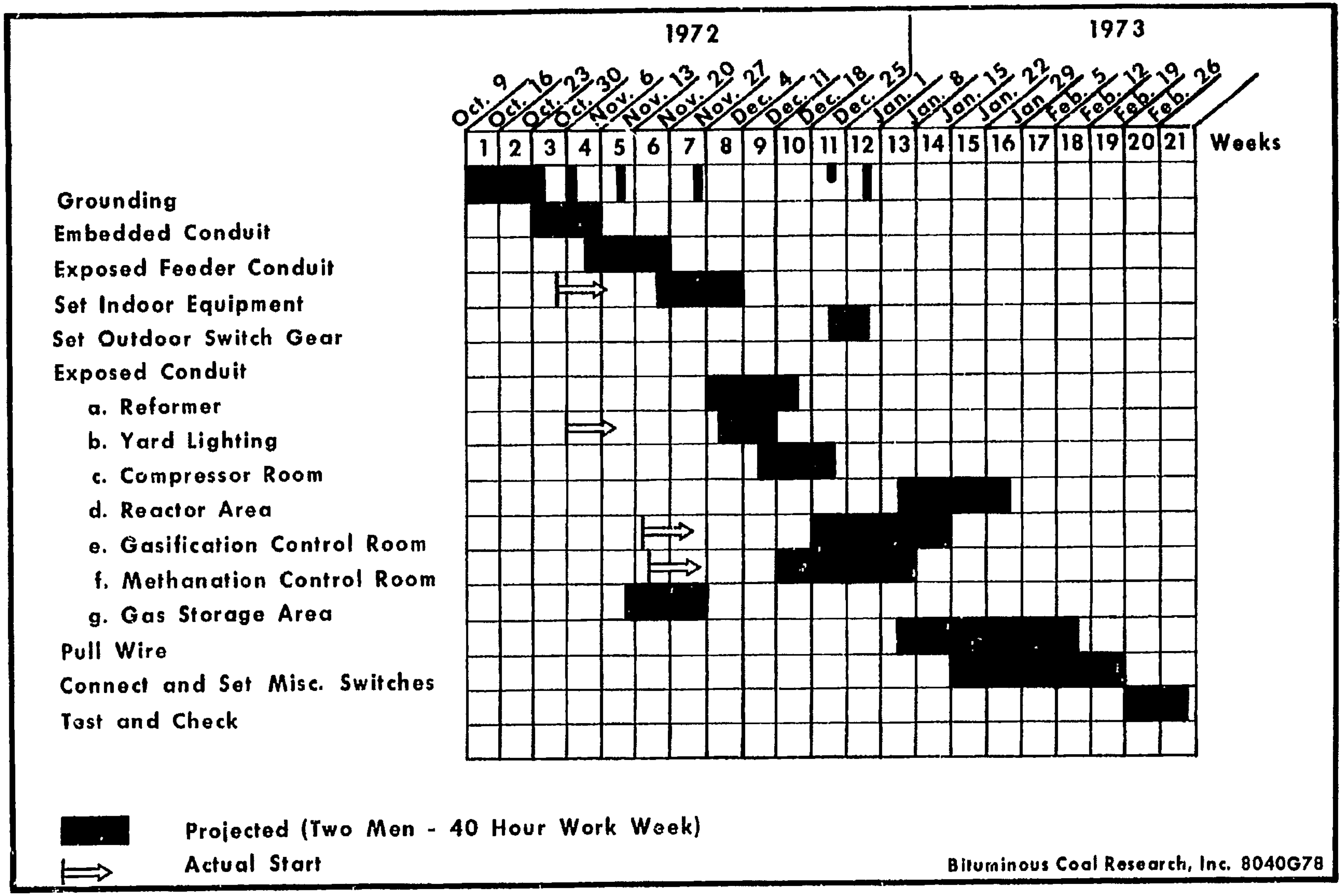


Figure 197. Electrical Sub-contractor's Work Schedule

B. Cold Flow Model Studies - 5 ton/hr Two-stage Gasifier (R. J. Grace, R. D. Harris, R. L. Zahradnik, and E. E. Donath)

The summary report on the cold flow model studies is being final typed and will be issued in December as Special Report No. 3. The model equipment is being maintained in working condition for occasional demonstrations in anticipation of future modeling programs.

C. Data Processing (R. K. Young and D. R. Hauck)

1. Automated Data Acquisition: As indicated in the previous report, the BCR real time software system and the bench-scale methanator data acquisition program have been utilized to acquire, store, and report the data from BSM Test 78. These programs will be used in all future BSM tests.

Complete descriptions of the BCR real time software system and the BSM data acquisition program are included in this report as Appendixes B and C.

2. BI-GAS Process: No gasifier simulation runs were requested during this period.

3. Future Work: Plans for the next report period include:

a. Logging and processing data from the bench-scale methanation unit.

b. Generation of simulation runs with subroutine GASIFY as requested and authorized.

c. Investigation of possible problem areas in interfacing the PDP8/E computer with the methanation PEDU.

d. Determine materials necessary for interfacing the computer with the methanation PEDU.

D. Multipurpose Research Pilot Plant Facility (MPRF)

1. Pilot Plant: Site work, initiated in October, is progressing. The legal survey and site clearing have been completed and topography work started. The location of a Plant Base Line will be established; locations of the initial test holes will be spotted at the site, and soils testing is expected to begin soon.

On November 3, 1972, BCR submitted information regarding the water supply for the Homer City pilot plant for OCR/AGA consideration. We concur with Stearns-Roger's recommendation that the Homer City Municipal Plant be used for water service to the plant and any plans for alternate water supply be suspended. Stearns-Roger estimates that use of city water will reduce plant costs $400,000.00.

A general project review meeting was held in Denver on November 7-8 with BCR, Blaw-Knox, and Stearns-Roger staff. On November 9-10, 1972, discussions were held, with C. F. Braun also participating, to review and approve in principal the process and mechanical flow diagrams which were issued previously. These diagrams are currently being modified to reflect results of the discussions. The next project review meeting is scheduled in the latter half of December, 1972, in Denver.

a. Stearns-Roger, Inc: Current engineering effort by Stearns-Roger, Inc., is reported in their Project Status Report No. 4, Appendix D of this report.

b. Blaw-Knox Chemical Plants, Inc: Blaw-Knox continues to provide surveillance services in connection with the Homer City pilot plant. Assistance has been provided in reviewing and commenting on proposed subcontracts. In addition, Blaw-Knox has been reviewing and approving documents issued by Stearns-Roger, as well as providing assistance concerning the various changes to the project recommended by Stearns-Roger.

2. Materials Evaluation Program: A meeting of the Task Group on Materials Design Data for Coal Gasification Equipment was held on November 21, 1972, in Chicago, Illinois.

The purpose of the meeting was to review the field evaluation programs as submitted by C. F. Braun in relation to installing corrosion test specimens in both the Rapid City pilot plant and the IGT pilot plant. Simplified flow diagrams showing material test specimen locations within the existing operating pilot plants were reviewed by the Task Group. C. F. Braun will prepare and submit to the Task Group a proposal outlining the scope of work to carry on this test program for 1973. Subsequently, C. F. Braun will prepare similar proposals for pilot plants that are presently being designed, such as the BI-GAS pilot plant, as well as future pilot plants.

A subcommittee group will evaluate a refractories test program at a future meeting date. The next Task Group meeting is scheduled for December 20, 1972, in Chicago to review the C. F. Braun proposal on the field evaluation programs.

3. Pressure Optimization Study: In relation to a pressure optimization study of the BI-GAS process which C. F. Braun is conducting for OCR/AGA, they requested by letter dated October 20, 1972, that BCR supply test data on different coals and different pressure levels. This information was transmitted to C. F. Braun, with copies to OCR and AGA, on November 8, 1972. Additional information, including BCR reports "Direct Methanation of Coal in a 100 lb/hr Process and Equipment Development Unit - Summary Report" and "GASIFY: A Computer Simulation of the BCR Two-stage Super-pressure Coal Gasifier," was forwarded to C. F. Braun on November 20, 1972.

E. Literature Search (V. E. Gleason)

Annotated literature references completed during the month are listed in Appendix E.

F. Outside Engineering and Services

1. Koppers Company, Inc: Koppers continues to provide engineering assistance as required and as reported in their Progress Report No. 40, Appendix F of this report.

G. Other

1. Patent Matters: Worthwhile ideas continue to be written as invention disclosures for submission to OCR for consideration. Status of the various disclosures is as follows:

a. OCR-866 and OCR-1078: A U.S. patent application entitled "Gasification of Carbonaceous Solids," containing nine claims, was filed together with the Assignment on September 22, 1971, and given Serial No. 182,652.

Patent applications have been filed in Australia, India, South Africa, Canada, Great Britain, and West Germany. On September 20, 1972, an application was filed in Japan under Serial No. 94477/72. On September 22, 1972, an application was filed in France under Serial No. 72 33 761. Confirmatory license to the government was executed by BCR on January 12, 1972.

b. OCR-1860 and OCR-1861: These disclosures were combined into a single patent application entitled "Two-stage Gasification of Pretreated Coal." This application, containing 12 claims, was filed together with Assignment on March 23, 1972, and given Serial No. 237,332.

Patent applications are being prepared for filing in France, West Germany, and Japan. Confirmatory license was executed by BCR on May 8, 1972.

c. OCR-1862: A U.S. patent application entitled "Three Stage Gasification of Coal," containing eight claims, was filed together with Assignment on March 23, 1972, and assigned Serial No. 237,333.

Patent applications are being prepared for filing in France, West Germany, and Japan. Confirmatory license was executed by BCR on May 8, 1972.

d. OCR-1863: A U.S. patent application was prepared for this disclosure entitled "Two-stage Downflow Gasification of Coal." This application, containing seven claims, was filed together with Assignment on March 23, 1972, and given Serial No. 237,454.

Applications are being prepared for filing in France, West Germany, and Japan. Confirmatory license was executed by BCR on May 8, 1972.

e. OCR-1864: A U.S. patent application entitled "Two-stage Gasification of coal with Forced Reactant Mixing and Steam Treatment of Recycled Char," was prepared for this disclosure. The application contains 13 claims and was filed on March 23, 1972, together with the Assignment, and assigned Serial No. 237,360.

This patent application has been examined by the U.S. Patent Office Examiner and the First Office Action was issued November 9, 1972. All thirteen claims have been rejected by the Examiner. References cited by the Examiner will be reviewed to determine whether foreign applications should be filed.

f. OCR-2044: An Invention Disclosure (Form DI 1217) entitled "Combined Methanation - Shift Reaction Process," was submitted to OCR for consideration on June 14, 1972. Use of this process simplifies and reduces the cost of making synthetic pipeline gas, especially from coal, using the BI-GAS or other coal gasification processes.

In a memorandum dated July 20, 1972, Mr. M. Howard Silverstein, Branch of Patents, notified OCR that this Invention Disclosure had been assigned Interior Case No. OCR-2044. BCR will prepare and file a U.S. patent application for this disclosure as authorized in OCR letter of August 14, 1972, to Mr. S. J. Price, BCR's patent attorney. A draft of the application has been prepared and is currently being reviewed by the inventors. After their review, an application will be prepared in final form for filing in the U.S. Patent Office.

2. Reports and Papers: OCR letter dated November 24, 1972, granted approval for presentation of the paper entitled "Chemistry and Physics of Entrained High Pressure Coal Gasification" by R. J. Grace and R. L. Zahradnik at the Symposium on Gasification, Division of Fuel Chemistry, American Chemical Society, to be held in April, 1973, in Dallas, Texas.

In accordance with OCR request, a draft copy of material for inclusion in the OCR Annual Report was forwarded to OCR on November 13, 1972. Glossy prints and illustrations were submitted on November 15, 1972.

H. Visitors During November, 1972

November 3, 1972

Mr. R. J. Ailsmiller
Mr. R. C. Fritz
Chemetron Corporation
P. O. Box 337
Louisville, Kentucky 40201

November 15, 1972

Mr. Arel L. Langston
Stearns-Roger, Inc.
P. O. Box 5888
Denver, Colorado 80217

November 22, 1972

Mr. R. W. Whiteacre
Koppers Company, Inc.
Koppers Building
Pittsburgh, Pa. 15219

I. Trips and Meetings During November, 1972

November 6, 1972	Nooter Corporation St. Louis, Missouri	M. S. Graboski
November 7-8, 1972	Stearns-Roger, Inc. Denver, Colorado	J. P. Tassoney R. K. Young
November 8, 1972	Stearns-Roger, Inc. Denver, Colorado	E. J. Colborn
November 9-10, 1972	Stearns-Roger, Inc. Denver, Colorado	R. J. Grace J. P. Tassoney R. K. Young
November 14, 1972	OCR Contractors Meeting Princeton, New Jersey	J. P. Tassoney
November 15, 1972	Gas Atmospheres Cleveland, Ohio	M. S. Graboski
November 21, 1972	Meeting of Task Group on Materials Design Data for Coal Gasification Equipment Chicago, Illinois	J. P. Tassoney
November 28-30, 1972	AIChE Meeting New York, N. Y.	J. P. Tassoney

J. Requests for Information

Mr. Evan B. Alderfer
718 Roberts Avenue
Drexel Hill, Pennsylvania 19026

Mr. Dominick Chain
Canadian Liquid Air Co.
1210 Sherbrooke West
Montreal 10, Canada

Dr. David S. Mitchell
Chevron Research Company
576 Standard Avenue
Richmond, California 94802

Mr. John S. Bell
Manager - Marketing & Research
Chemetron Corporation
111 E. Wacker Drive
Chicago, Illinois 60601

III. WORK PLANNED FOR DECEMBER, 1972

The work planned for December will basically be a continuation of the on-going program which has been underway for the past few months.

Bench-scale testing of methanation catalysts will continue. Work on the methanation PEDU will continue. Building alterations, yard rack piping, and most foundations will be completed. The electrical work will be continued.

Special Report No. 3 will be issued.

The data acquisition program for the bench-scale methanator will be continued. Work will begin to determine the materials necessary for interfacing the computer with the methanation PEDU.

Meetings with Stearns-Roger and Blaw-Knox will continue to discuss various technical details.

A. Trips and Meetings Planned

December, 1972	Stearns-Roger, Inc. Denver, Colorado	J. P. Tassoney R. K. Young
December 13, 1972	Meeting with OCR Washington, D. C.	J. W. Igoe R. K. Young
December 19, 1972	Office of Coal Research U.S. Department of the Interior Washington, D. C.	J. W. Igoe R. K. Young
December 20, 1972	Meeting of Task Group on Materials Design Data for Coal Gasification Equipment Chicago, Illinois	J. P. Tassoney

B. Papers to be Presented

December 7-8, 1972	Annual Meeting of the Coal Mining Institute of America Pittsburgh, Pennsylvania	"New Markets - Coal Gasification" J. W. Tieman
April, 1973	National Meeting of American Chemical Society Division of Fuel Chemistry Dallas, Texas	"Chemistry and Physics of Entrained High Pressure Coal Gasification" R. L. Zahradnik R. J. Grace

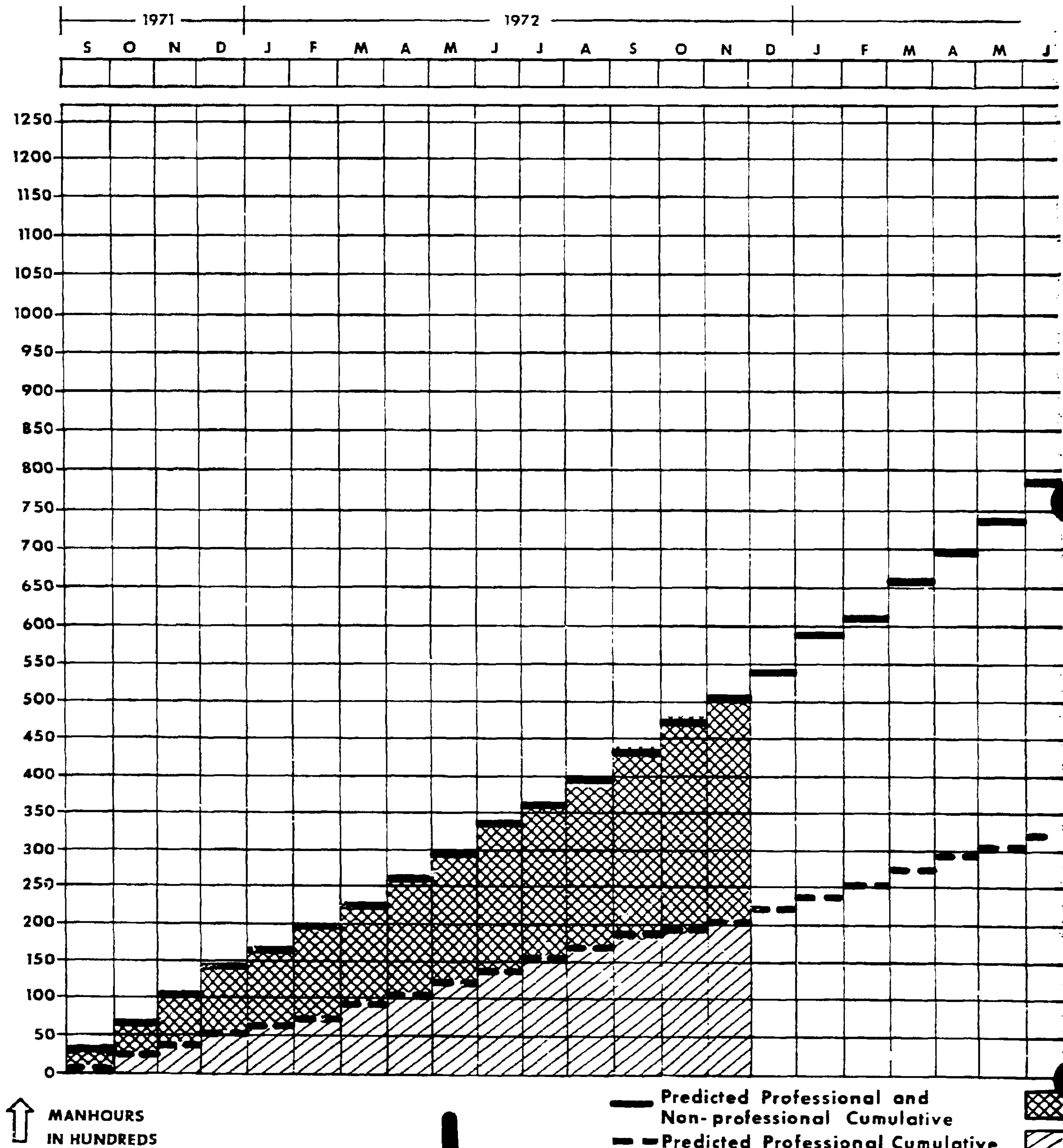
July, 1973

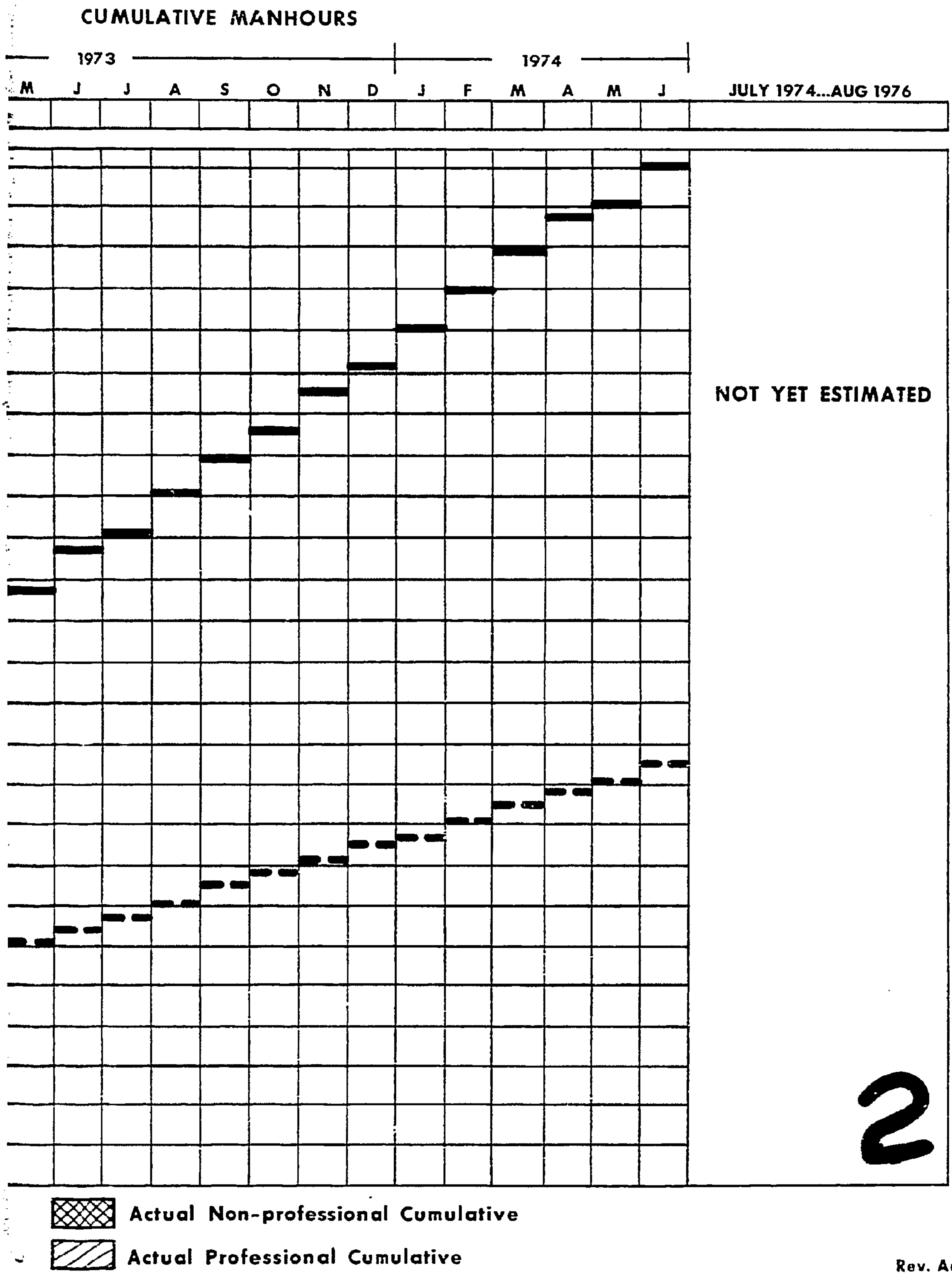
Presentation to be made at 1973 Gordon Conference on Coal Science

"Chemistry and Physics of Entrained Coal Gasification"

R. L. Zahradnik
R. J. Grace

OCR/AGA PIPELINE GAS GENERATOR RESEARCH AND DEVELOPMENT



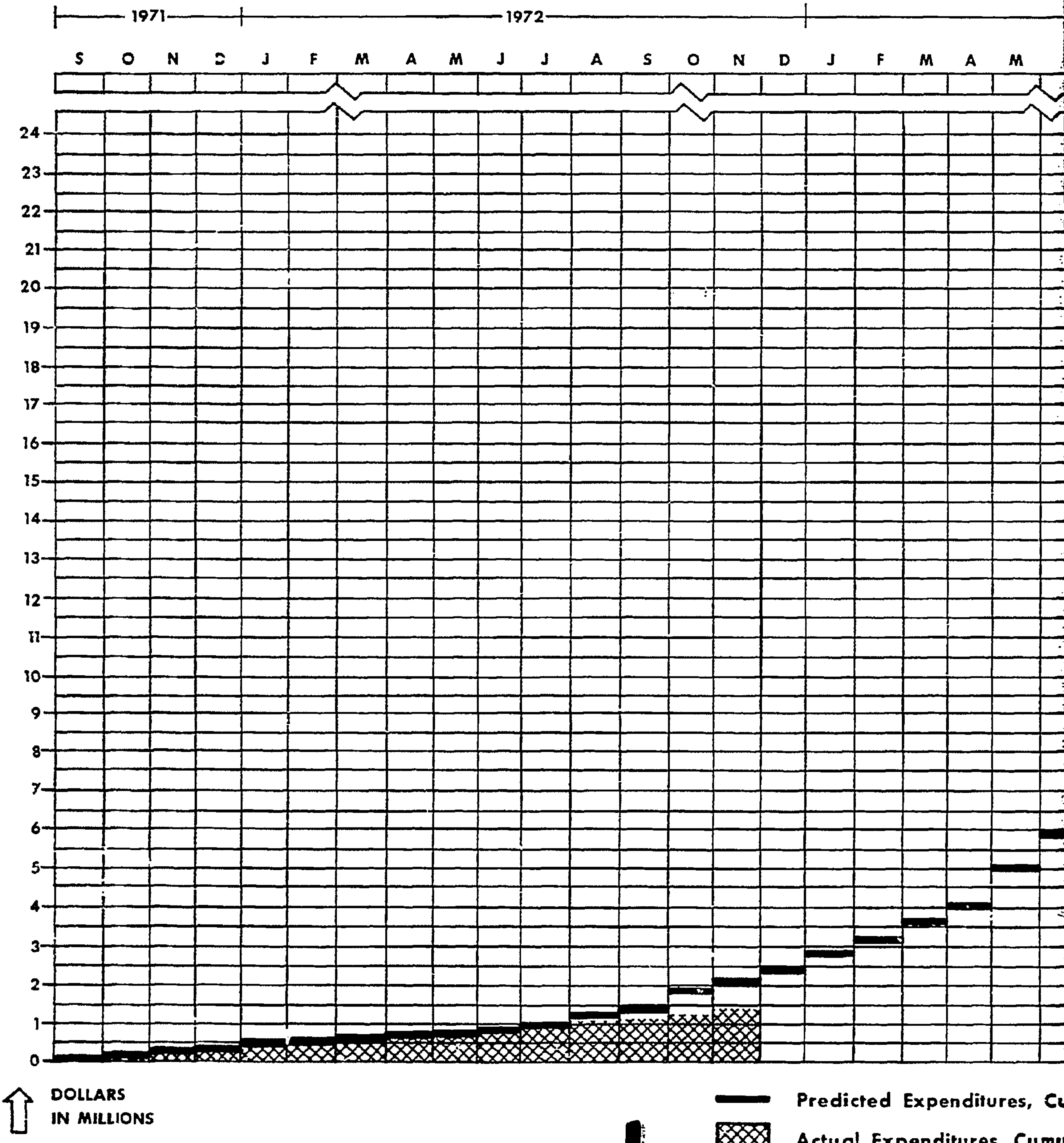

CUMULATIVE MANHOURS
1973
1974
M J J A S O N D J F M A M J
JULY 1974...AUG 1976
NOT YET ESTIMATED
2
Actual Non-professional Cumulative
Actual Professional Cumulative

OCR/AGA PIPELINE GAS GENERATOR RESEARCH AND DEVELOPMENT
Schedule of Predicted and Actual Manhours

	This Month				Cumulative			
	Professional		Non-Professional		Professional		Non-Professional	
Month	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual
Sept. '71		1,606.5		2,253.5		1,606.5		2,253.5
Oct. '71		1,144.0		1,716.0		2,750.5		3,969.5
Nov. '71		1,490.0		2,126.5		4,240.5		6,096.0
Dec. '71		1,290.5		1,875.5		5,531.0		7,971.5
Jan. '72		1,465.0		1,612.5		6,996.0		9,584.0
Feb. '72		1,285.0		1,656.5		8,281.0		11,240.5
Mar. '72		1,337.0		2,042.5		9,618.0		13,283.0
Apr. '72		1,400.0		2,026.0		11,018.0		15,309.0
May '72		1,506.0		1,884.5		12,524.0		17,193.5
June '72		1,555.0		2,054.0		14,079.0		19,247.5
July '72		1,224.5		1,370.0		15,303.5		20,617.5
Aug. '72	1,432.0	1,193.0	2,136.0	1,573.5	16,735.5	16,496.5	22,753.5	22,191.0
Sept. '72	1,544.0	1,301.5	2,152.0	1,549.5	18,279.5	17,798.0	24,905.5	26,455.0
Oct. '72	1,456.0	1,535.5	2,144.0	1,794.5	19,735.5	19,333.5	27,049.5	28,249.5
Nov. '72	1,448.0	1,241.5*	2,136.0	1,866.0*	21,183.5	20,575.0*	29,185.5	30,115.5*
Dec. '72	1,440.0		2,048.0		22,623.5		31,233.5	
Jan. '73	1,664.0		2,328.0		24,287.5		33,561.5	
Feb. '73	1,664.0		2,336.0		25,951.5		35,897.5	
Mar. '73	1,672.0		2,344.0		27,623.5		38,241.5	
Apr. '73	1,624.0		2,280.0		29,247.5		40,521.5	
May '73	1,632.0		2,280.0		30,879.5		42,801.5	
June '73	1,632.0		2,288.0		32,511.5		45,089.5	
July '73	1,656.0		2,328.0		34,167.5		47,417.5	
Aug. '73	1,656.0		2,320.0		35,823.5		49,737.5	
Sept. '73	1,656.0		2,320.0		37,479.5		52,057.5	
Oct. '73	1,640.0		2,288.0		39,119.5		54,345.5	
Nov. '73	1,656.0		2,288.0		40,775.5		56,633.5	
Dec. '73	1,656.0		2,264.0		42,431.5		58,897.5	
Jan. '74	1,672.0		2,328.0		44,103.5		61,225.5	
Feb. '74	1,656.0		2,320.0		45,759.5		63,545.5	
Mar. '74	1,640.0		2,320.0		47,399.5		65,865.5	
Apr. '74	1,640.0		2,280.0		49,039.5		68,145.5	
May '74	1,656.0		2,288.0		50,695.5		70,433.5	
June '74	1,656.0		2,272.0		52,351.5		72,705.5	
July '74 to Aug. '76	N O T Y E T E S T I M A T E D							

* Estimated

OCR/AGA PIPELINE GAS GENERATOR RESEARCH AND DEVELOPMENT



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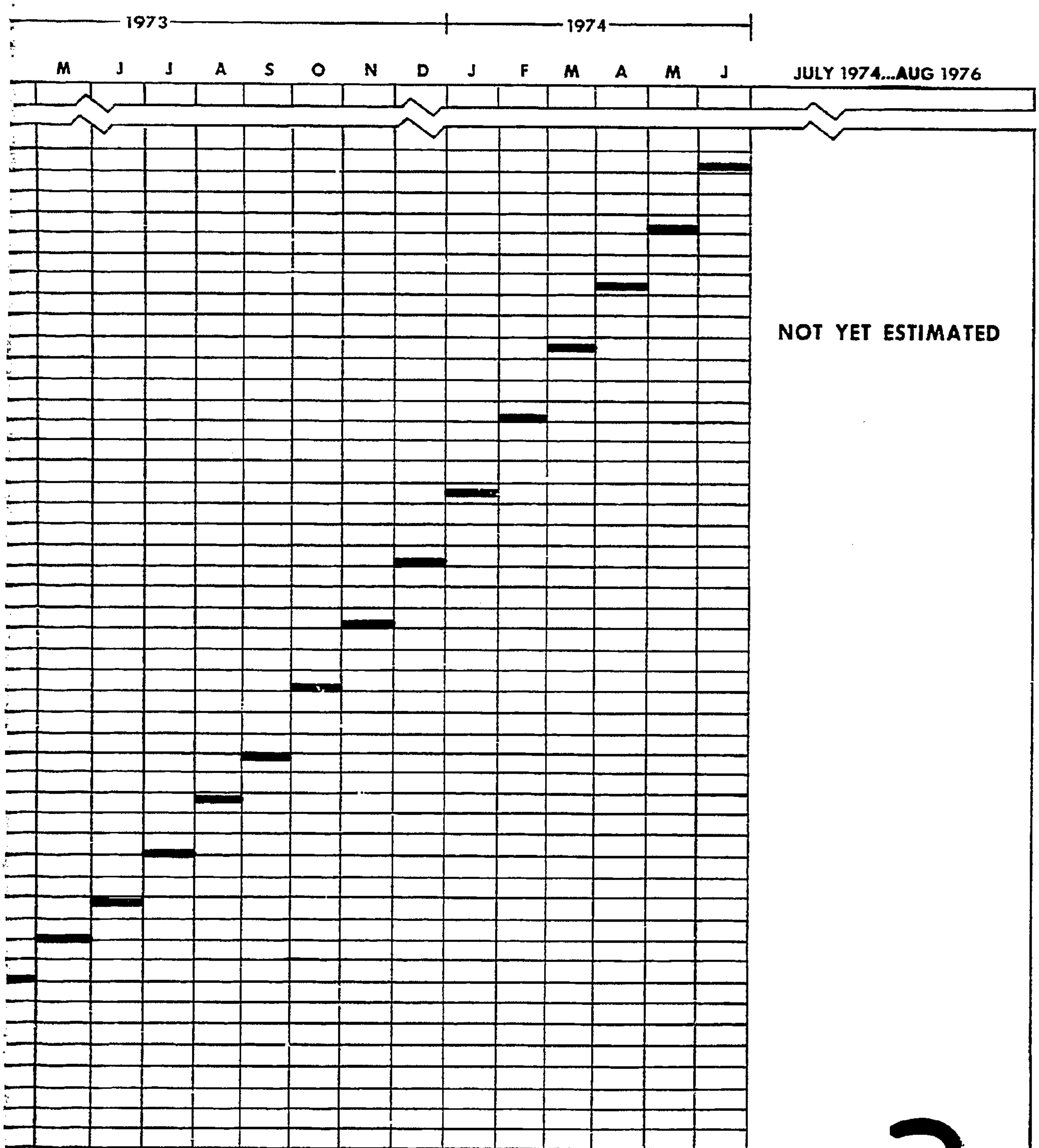


"·ures, Cumulative

·es, Cumulative

OCR/AGA PIPELINE GAS GENERATOR RESEARCH AND DEVELOPMENT
Schedule of Predicted and Actual Expenditures

	Current Month		Cumulative to Date	
Month	Predicted	Actual	Predicted	Actual
1971				
Sept.		57,900		57,900
Oct.		98,983		156,883
Nov.		129,083		285,966
Dec.		138,572		424,538
1972				
Jan.		95,161		519,699
Feb.		71,459		591,158
March		96,682		687,840
April		47,253		735,093
May		73,220		808,313
June		78,521		886,834
July		79,366		966,200
Aug.	205,974	79,220	1,172,174	1,045,420
Sept.	296,974	79,036	1,469,148	1,124,456
Oct.	335,032	130,050	1,804,180	1,254,425
Nov.	335,031	168,013*	2,139,211	1,422,438*
Dec.	331,672		2,470,883	
1973				
Jan.	357,220		2,828,103	
Feb.	357,220		3,184,423	
March	357,219		3,542,542	
April	758,369		4,300,911	
May	758,389		5,059,300	
June	758,400		5,817,700	
July	1,219,816		7,037,516	
Aug.	1,219,816		8,257,332	
Sept.	1,219,818		9,477,150	
Oct.	1,531,333		11,008,483	
Nov.	1,531,333		12,539,816	
Dec.	1,531,284		14,071,100	
1974				
Jan.	1,720,869		15,791,969	
Feb.	1,720,866		17,512,835	
March	1,720,865		19,233,700	
April	1,456,866		20,690,566	
May	1,456,866		22,147,432	
June	1,456,868		23,604,300	
July to Aug. '76	N O T Y E T E S T I M A T E D			

* Estimated

APPENDIX B

BCR REAL TIME SYSTEM

I. INTRODUCTION

The BCR Real Time System (BCRRTS) is a computer program which facilitates the writing and operation of real time data acquisition programs. The system does this by performing the following services for a data acquisition program: (1) schedules and initiates work according to its level of importance or priority, and (2) makes available certain service routines which allow the data acquisition program to accomplish lengthy tasks with a single command.

II. SCHEDULING AND INITIATION OF WORK

A data acquisition program is a multi-task program. The three main tasks are data sampling, data storage, and data reporting. Each of these would be required to perform their function when particular events occurred. For example, the event causing the initiation of the sample routine and storage routine could be clock time; that is, the sample routine might start every 10 seconds while the storage routine starts every 2 minutes. The report task might also be initiated on a time basis or by operator command through a teletype. In order to facilitate this type of multi-task program, the system must allow for a variety of task initiation methods.

Since it is possible that two or more tasks could be initiated by the same event, the system must also allow the programmer some method of assigning a priority to each task so that the most important task is done first.

Both the task initiation and task priority problems are handled by the system through its task table. (See Figure 198.) This matrix-type table contains a row of information about each task in computer memory with room for a maximum of 24 tasks. In each task row, there are eight pieces of information about that task as follows:

(1) STATUS - The task status word contains two numbers, S_1 and S_2. S_1 is the initiation status; it indicates the type of event which initiates that task. The S_1 status numbers and their meanings are as follows:

- 0 - No task in this row of table.
- 1_8 - Task is initiated on a time basis.
- 10_8 - Task is initiated by a message from teletype 0.
- 11_8 - Task is initiated by a message from teletype 1.

S_2 is the current status of the individual tasks. The S_2 status numbers and their meanings are as follows:

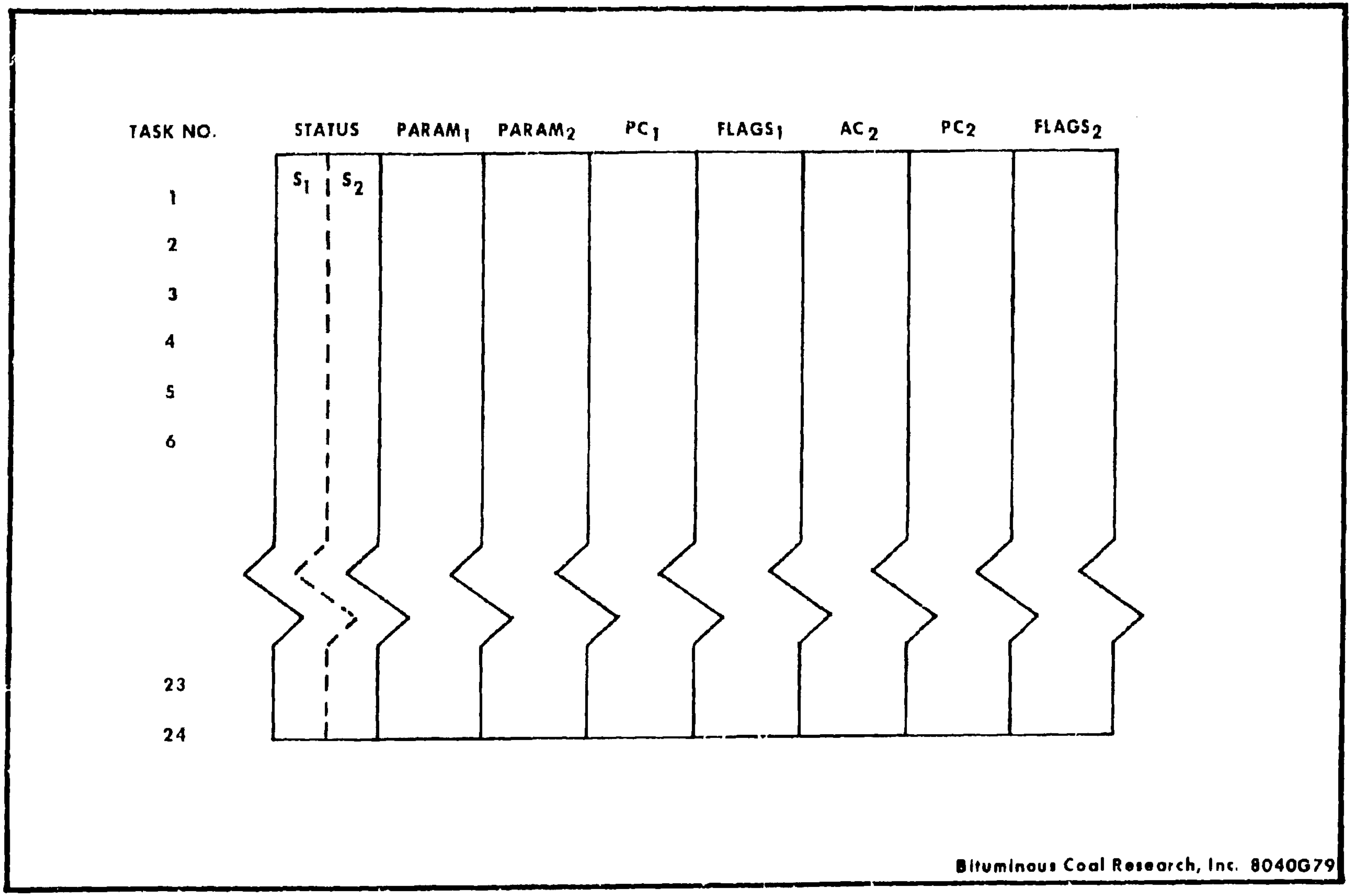


Figure 198. BCRRTS Task Table

0 - Task is waiting for initiation (i.e., task is presently idle).

1_8-37_8 - Task is waiting for, or using a system service routine.

40_8 - Task is waiting for execution time or is in execution.

(2) $PARAM_1$ - Depending on the initiation status, S_1, the contents of $PARAM_1$ vary. If S_1 indicates that the task's initiation is on a time basis, $PARAM_1$ contains the negative number of seconds before the task's next initiation. If S_1 indicates that the task's initiation is by a message from a teletype, $PARAM_1$ contains the address where the system should put that message.

(3) $PARAM_2$ - This is used only if the task is on timed initiation. In this case, it contains the negative number of seconds between initiations.

(4) PC_1 - Contains that task's starting address minus one.

(5) $FLAGS_1$ - Contains the flag values (computer status) to be used when starting that task.

(6) AC_2 - When this task is temporarily interrupted, or halted to permit execution of higher priority tasks, the value of this task's accumulator is put in AC_2. Saving the accumulator will allow the task to be restarted without loss of information.

(7) PC_2 - Contains the task's restart address minus one. This address is saved by the system when the task is interrupted to permit execution of higher priority tasks.

(8) $FLAGS_2$ - Contains the flag values needed to restart this task if interrupted.

The system can now control all tasks in the core by manipulating the information in the task table. The actual procedure by which the system does this is contained in the logic of four system routines--the task save routine, the task restart routine, the clock routine, and the teletype monitor routine.

A. Task Save Routine

See Figure 199 for the save routine flow chart. When an external device such as a teletype or the time clock is used to make the computer aware of some event, it interrupts the computer. This event might be the time clock indicating the elapse of some time interval, or the teletype indicating that a key has been punched. When these interrupts occur, the task save routine takes control. This routine first determines which task was in execution when the interrupt occurred. It then puts that task's accumulator value in AC_2, the address of the last instruction executed in PC_2, and the current flag values (computer status) in $FLAGS_2$. It then determines which device interrupted and gives control to the routine responsible for servicing that device. When the device

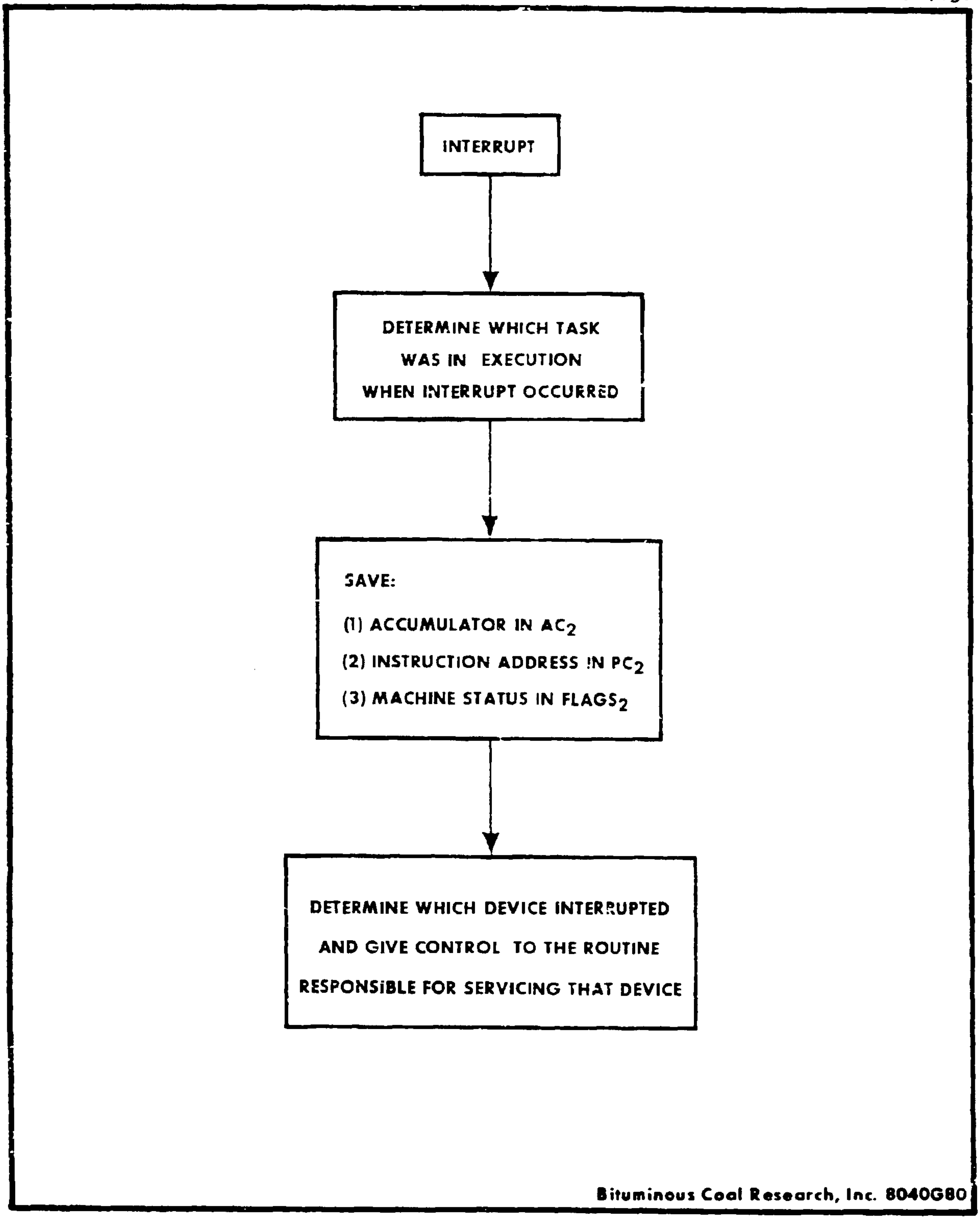


Figure 199. Save Routine Flow Chart

service routine has completed its work, it returns control to the task restart routine.

B. Task Restart Routine

See Figure 200 for the restart routine flow chart. The task restart routine gives control of the computer to the highest priority task. The priority of each task is determined by its location in the task table. That is, the task in the first row of the table has the highest priority while the task in the 24th row has the lowest priority. The restart routine then searches down the status word column for the first task that is waiting for execution time ($S_2 = 40_8$). When such a task is found, the restart routine resets the machine status according to $FLAGS_2$, puts the value of AC_2 in the accumulator, and begins execution of instructions at the core location indicated by PC_2.

C. Clock Routine

See Figure 201 for the clock routine flow chart. The real time clock in the computer is set to interrupt the computer every one-hundredth of a second. When these interrupts occur, the task save routine performs its function and gives control to the clock routine. The clock routine then increments its counter to determine whether a second has elapsed. If a second has not elapsed, control is returned to the task restart routine. If a second has elapsed, the clock routine searches through the task table for tasks on timed initiation ($S_1 = 1$). These tasks' $PARAM_1$ values are incremented by one to indicate the new time until initiation. If $PARAM_1$ is now zero for any of these tasks, the following manipulations are made on their task row:

(1) The present status, S_2, is set to 40_8 to indicate that the task is waiting for execution time.

(2) The value of $PARAM_2$ is put into $PARAM_1$. This resets the timer for the task's next initiation.

(3) The value of PC_1 is put into PC_2.

(4) The value of $FLAGS_1$ is put into $FLAGS_2$.

(5) AC_2 is set to zero.

These steps allow the restart routine to give these tasks execution time as though they were a previously interrupted task. Upon completion of these manipulations in the appropriate task rows, control is given to the restart routine.

D. Teletype Monitor Routine

See Figure 202 for the monitor routine flow chart. Like the clock routine, the teletype monitor routine is given control from the task save routine after a teletype interrupt has occurred. The monitor routine then searches for the task waiting for initiation by message from that teletype. When this task is found, the following manipulations are made on that task row:

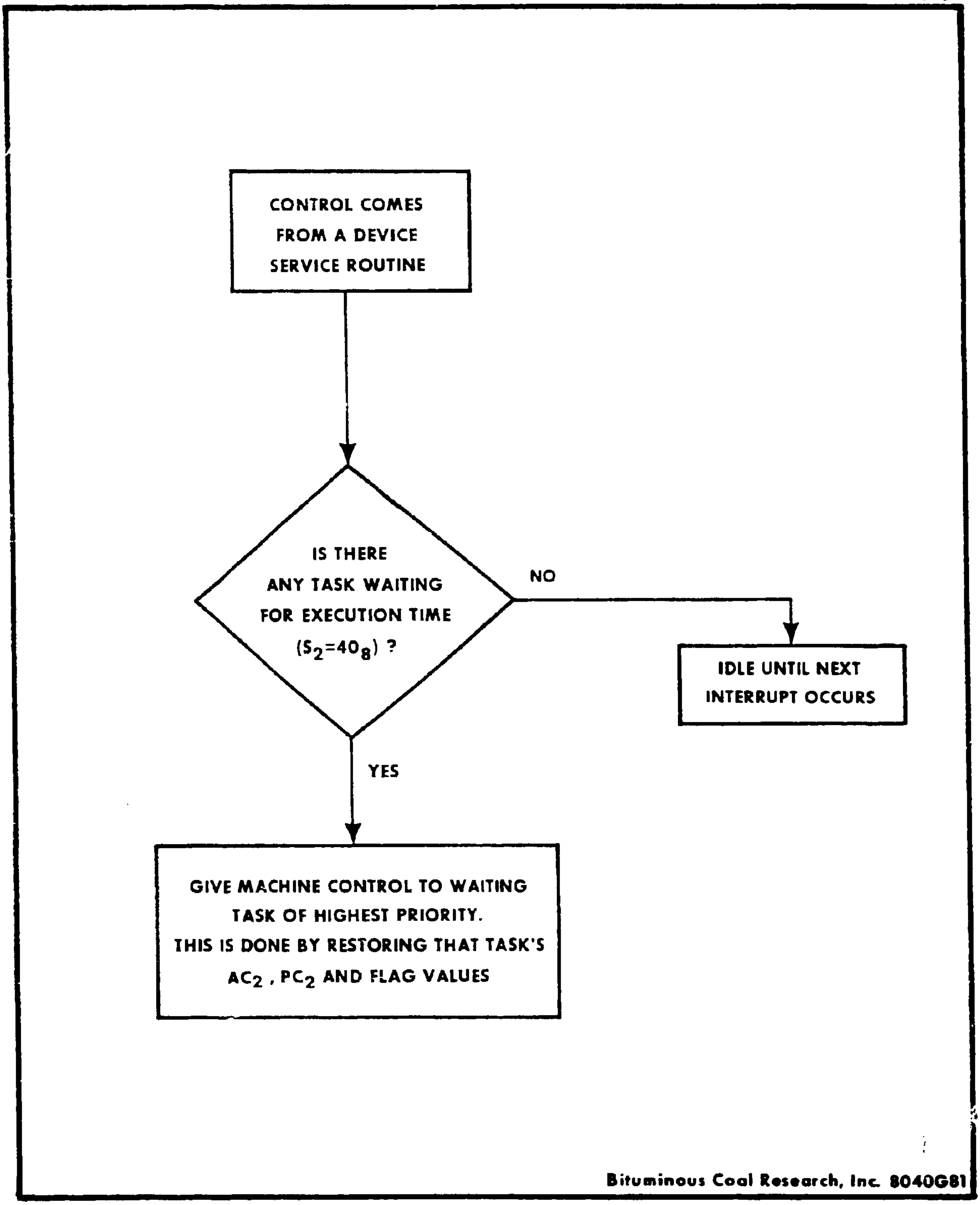
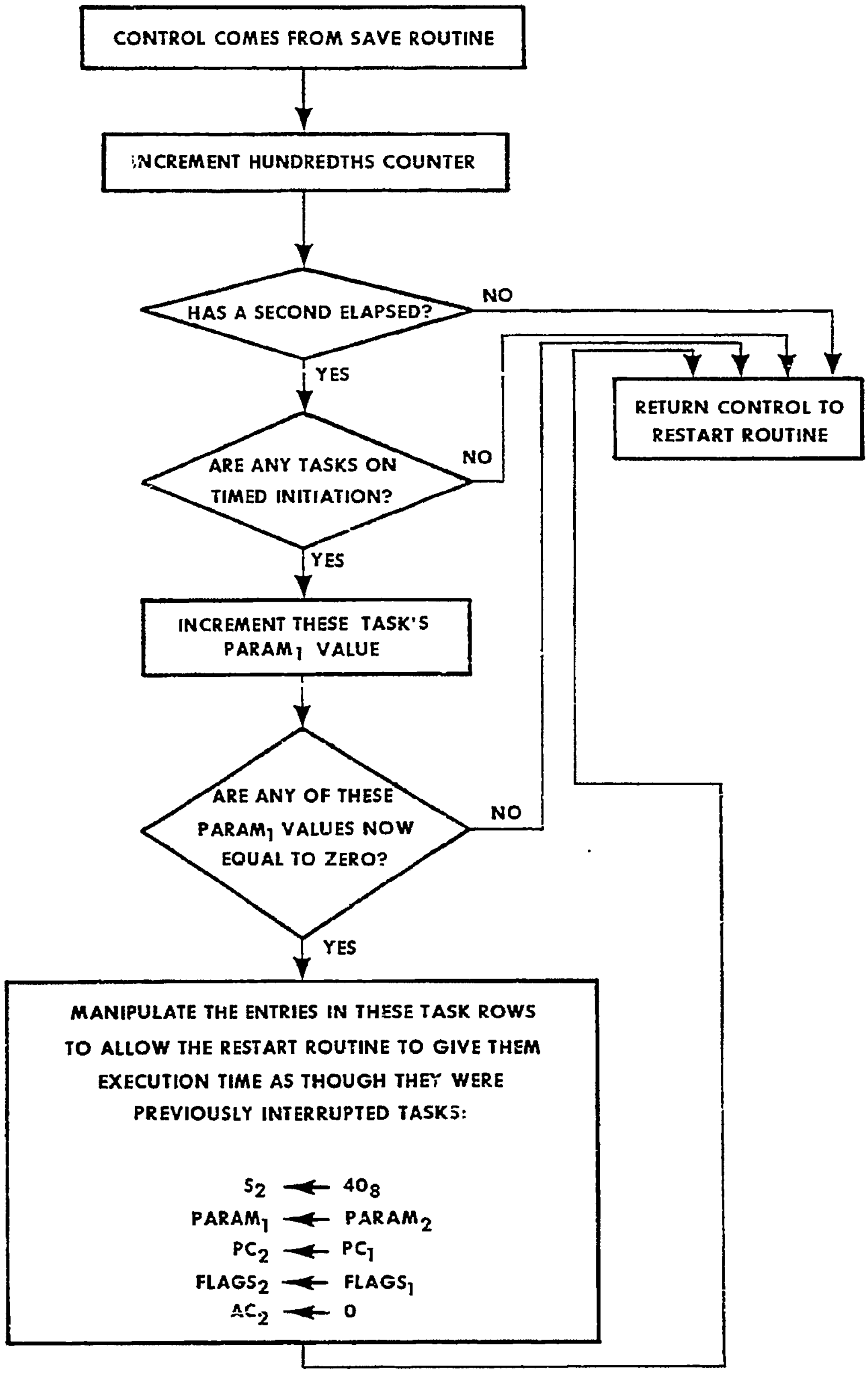


Figure 200. Restart Routine Flow Chart



Bituminous Coal Research, Inc. 8040G82

Figure 201. Clock Routine Flow Chart

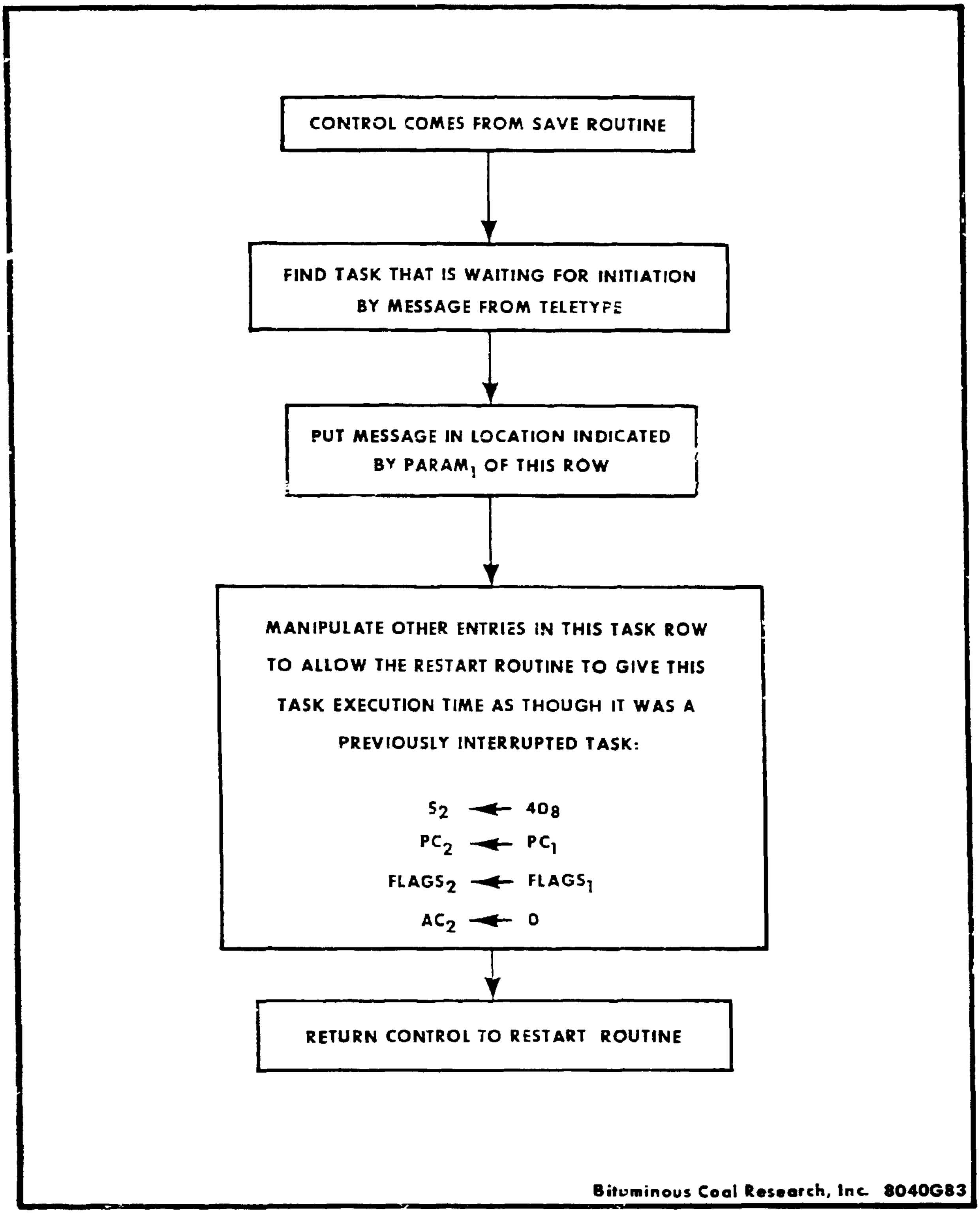


Figure 202. Teletype Monitor Flow Chart

(1) The present status, S_2, is set to indicate that the task is waiting for execution time (40_8).

(2) The message is put at the location indicated by $PARAM_1$.

(3) The value of PC_1 is put into PC_2.

(4) The value of $FLAGS_1$ is put into $FLAGS_2$.

(5) AC_2 is set to zero.

These steps allow the restart routine to give this task execution time as though it was a previously interrupted task. Upon completion of these manipulations, control is given to the restart routine.

III. SYSTEM COMMANDS

Before any program can utilize the BCR real time system, that program must be loaded into computer memory and the pertinent information about that program's tasks entered into the task table. This job and several others are accomplished by commands to the BCR real time system through a teletype.

To accommodate these commands, two system revisions must be made. The first revision is that some row of the task table must be reserved for system use so that it can execute these system commands. This revision is accomplished by merely stating that no program or task is permitted to use the first row of the task table since it will be used exclusively by the system command task.

The second system revision is that the teletype monitor must be able to distinguish between system commands and messages to other tasks in computer memory. This revision is accomplished by stating that all commands intended for the system must begin with a dollar sign ($) and all other commands or messages must not begin with a dollar sign ($). Thus, the logic in the teletype monitor routine is revised to give dollar sign messages to Task 1 and then initiate Task 1 and give all other messages to the appropriate tasks as previously defined. The revised flow chart for the teletype monitor is given in Figure 203.

Presently, the BCR real time system has only two system or dollar sign commands--the run command and the clock command. The form of these commands is as follows:

$R PROGRAM NAME

$C YEAR:DAY:HOUR:MINUTE

The clock command ($C) allows the computer operator to set the clock in the computer to the appropriate date and time of day. The operator merely types the $C command as shown above and the computer will keep accurate time from then on. It should be noted that the day is typed as some number from 1 to 365, and the hour is some number between 0 and 23.

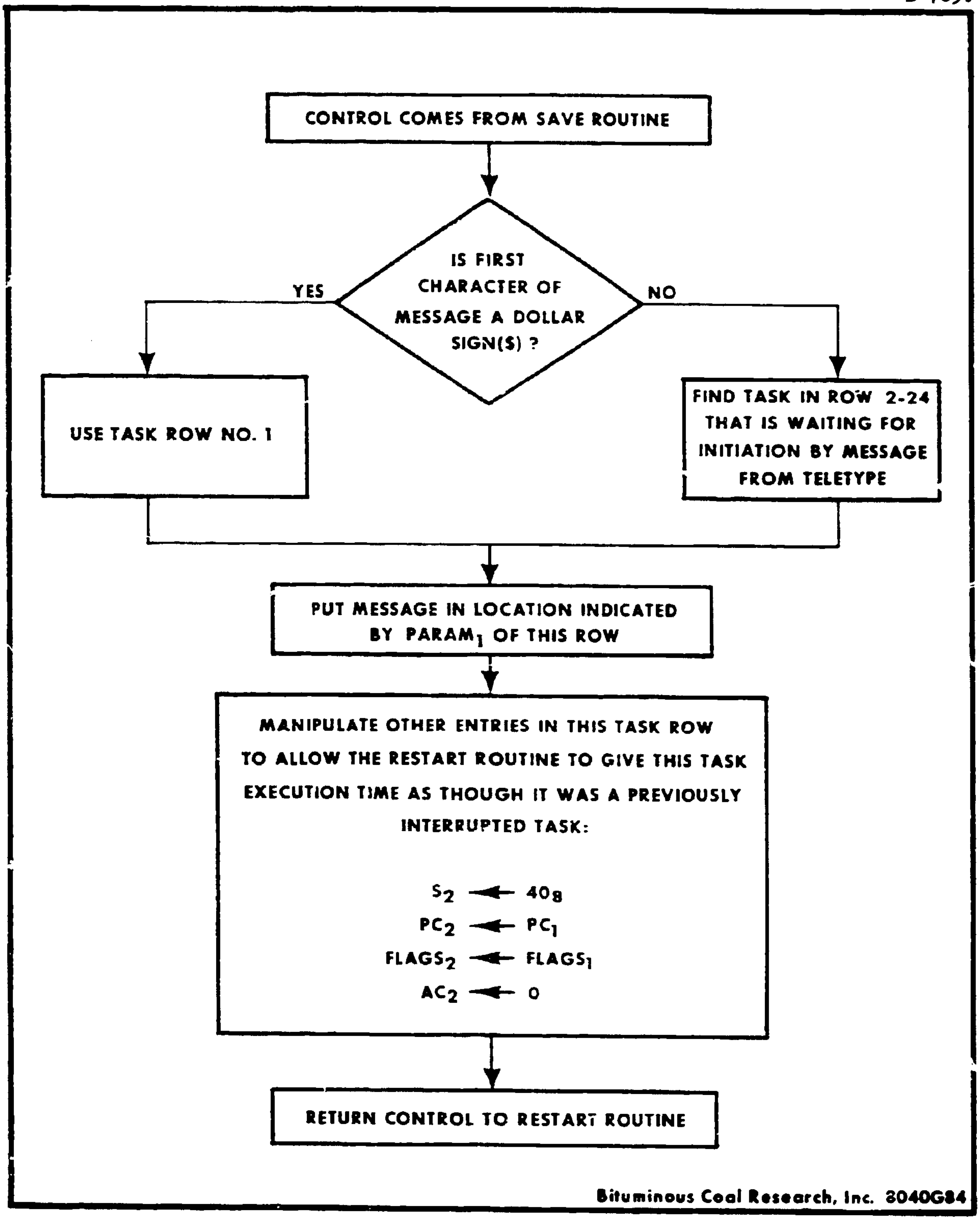


Figure 203. Revised Teletype Monitor Flow Chart

The run command ($R) loads the selected program from DECtape into core memory and allows it to begin execution. The program is then responsible for finding empty rows in the task table and inserting the pertinent information about each of its tasks in the table. The program then returns control to the real time system and each of its tasks will, from then on, be given execution time as indicated by that task's status.

IV. SYSTEM SERVICE ROUTINES

There are certain basic activities or operations such as mathematical calculating, reading from and writing onto magnetic tape, and reading from and writing onto a teletype which are common to almost all data acquisition programs. These operations are generally considered time-consuming to program and costly because of the computer core memory required. To minimize these core requirements and programming time, the BCR real time system has certain routines which are available to any task to accomplish these lengthy and more commonly needed services. A brief description of these system service routines (SSR) is given in Table 145.

TABLE 145. SYSTEM SERVICE ROUTINES

Routine Name	Description	Function Number (Octal)
RETURN	Tells the system to change this task's present status to zero. $S_2 \leftarrow 0$	0
DECTAPE	Reads and writes on DECtape.	1
FORMI	Decodes ASCII input lines.	2
FORMO	Codes ASCII lines for output.	3
MATH	Does arithmetic operations.	4
A2D	Handles the analog to digital converter.	5
WAIT	Delays execution of a task n/100ths of a second.	6
TTY0	Reads and writes on teletype #0.	10
TTY1	Reads and writes on teletype #1.	11

Prior to describing each of the system service routines (SSR's) in detail, the procedure for linking a task to a service routine should be explained. This procedure starts when a task executes the following sequence of instructions:

```
CLA
RIF
CIF 0
IOF
JMS I  (725
n
```

where n is an integer from 0 to 37 (Octal) which indicates the function number of the desired system service routine. This makes the BCR system aware of the request for a service routine. When this routine becomes available, the task will then be linked to it.

Once linkage is made, the service routine will need more specific information about the work it should perform for the task. The task provides this information in the core locations immediately following the SSR linkage instructions:

```
CLA          )
RIF          )
CIF 0        )  SSR linkage instruction
IOF          )
JMS I  (725  )
n            )  SSR number
A            )
B            )  Information about the work to be
C            )
:            )  performed by the service routine.
Z            )
0            )
```

Generally, the last word of information supplied to the service routine is a zero. This indicates that the list of information ends here and the service routine should return control to the location immediately following the zero when it has completed the requested work.

The type and quantity of information contained between the linkage instructions and the zero will vary depending on the routine being used and the amount of work to be performed. The following sections will more completely describe the capabilities of each service routine and the information that must be supplied to that routine to perform the work.

A. SSR No. 0 - RETURN

The RETURN routine is used to change the present status of the calling task to zero ($S_2 = 0$). This prevents the restart routine from giving execution time to this task until it is next initiated and thus indicates to the system that this task has completed its work. The calling sequence is as follows:

```
CLA            )
               )
RIF            )
               )
CIF  0         )  SSR linkage instructions
               )
IOF            )
               )
JMS  I  (725   )

 0             )  SSR No. = 0
```

B. SSR No. 1 - DECTAPE

The DECTAPE routine is actually a collection of five separate functions which perform the operation of opening and closing, and reading and writing on DECtape. These functions and their code numbers are as follows:

Function Code	Function Name	Description
1	IOPEN	Opens a DECtape file for input.
2	READ	Reads the opened input file into core.
3	OOPEN*	Opens a DECtape file for output.
4	WRITE	Writes on the open output file.
5	OCLOSE	Closes the open output file.

* The OOPEN function assumes that the tape to be written on is empty.

To tell the DECTAPE routine to perform any of these five functions, the task must specify the following information after the SSR linking instructions and routine number:

Function	Information	Description
IOPEN	D001	DECtape drive number (D) and function code for IOPEN (1).
	Filename	Filename and extension of file to be opened (8 characters in 6-bit ASCII).
READ	D002	DECtape drive number (D) and function code for READ (2).
	J	Number of blocks to be read (200_8 words/block).
	Buffer	Starting address of buffer.
OOPEN	D003	DECtape drive number (D) and function code for OOPEN (3).
	Filename	Filename and extension of file to be opened (8 characters in 6-bit ASCII).
WRITE	D004	DECtape drive number (D) and function code for WRITE (4).
	J	Number of blocks to be written (200_8 words/block).
	Buffer	Starting address of words to be written.
OCLOSE	D005	DECtape drive number (D) and function code for OCLOSE (5).

Thus, to open the DECtape file named "ABCDEF.DA" for input from DECtape Drive Number 7, the following instructions should be used:

```
CLA                    /SSR linkage instructions

RIF

CIF  0

IOF

JMS  I  (725

0001                   /SSR No. = 1  (DECTAPE routine)
7001                   /DRIVE = 7,  FUNCTION = 1  (IOPEN)
0102                   /FILENAME  AB
0304                   /CD
0506                   /EF
0401                   /DA
0000                   /End of information
```

To then read the first block of 200_8 words of that open DECtape file, the task would use the following instructions:

```
CLA                  /SSR linkage instructions
RIF
CIF  0
IOF
JMS  I  (725
0001                 /SSR No. = 1  (DECTAPE routine)
7002                 /DRIVE = 7, FUNCTION = 1  (READ)
0001                 /Number of blocks = 1
2400                 /Store input at location 2400
0000                 /End of information
```

To perform the IOPEN function and the READ function consecutively, the task would use the following sequence:

```
CLA                  /SSR linkage instructions
RIF
CIF  0
IOF
JMS  I  (725
0001                 /SSR No. = 1  (DECTAPE routine)
7001                 /DRIVE = 7, FUNCTION = 1  (IOPEN)
0102                 /FILENAME  AB
0304                 /CD
0506                 /EF
0401                 /DA
7002                 /DRIVE = 7, FUNCTION = 2  (READ)
0001                 /Number of blocks = 1
2400                 /Store input at location 2400
0000                 /End of information
```

It should be obvious from this example that there is no limit to the number of functions that can be performed in one linkage with the DECTAPE routine. This is accomplished by merely specifying the next function code after the information for the previous function code and specifying a zero function code when all desired work is completed. Thus, zero is considered a function code which means to return control to the calling task.

C. SSR No. 2 - FORMI

The FORMI routine decodes an ASCII input string according to any one or combination of the following formats:

Format	Format Code	Description
I	1	Converts characters in input string to single precision integer (1 word).
J	2	Converts characters in input string to double precision integer (2 words).
F	3	Converts characters in input string to single precision floating point (3 words).
Return	0	Specifies the end of the work and that control should be returned to the next location of the calling sequence.

The sequence that must be given to utilize the input formatter, FORMI, is as follows:

```
CLA                 /SSR linkage instructions
RIF
CIF  0
IOF
JMS  I  (725
0002                /SSR No. = 2  (FORMI routine)
000T                /Teletype # from which the input came
Buffer              /Starting address of the ASCII input string
000N                /Format code (0 - 3 as described above)
AAAA                /Address for decoded input
000N                /Next format code
AAAA                /Address for decoded input
 .
 .
 .
0000                /Next format code (N = 0 specifies end
                        of work)
```

The input formatter (FORMI) uses the following conventions of which the computer operator should be aware:

(1) All leading blanks are ignored.

(2) All conversions will terminate when any unexpected character is found in the ASCII string.

(3) I conversions allow an input value range of $\pm 2047_{10}$.

(4) J conversions allow an input value range of $\pm 8{,}388{,}607_{10}$.

(5) F conversions allow a maximum of 6 digits on each side of the decimal point.

(6) Any error in the input string (usually a violation of convention 3, 4, or 5 above) causes an error message to print on teletype T and the calling task's present status to be set to zero, ($S_2 = 0$).

D. SSR No. 3 - FORMO

This routine sets up 8-bit ASCII code lines for output according to a specified format. The standard instruction sequence for utilization of the output formatter is as follows:

```
CLA                     /SSR linkage instructions
RIF
CIF  0
IOF
JMS  I  (725
0003                    /SSR No. = 3  (FORMO routine)
Buffer                  /Starting address for the ASCII code
OOON                    /Format code - corresponds to a format type
A1                      /Arguments required by that format type
A2
.
OOON                    /Next format code
A1                      /Arguments required by that format type
A2
.
0000                    /Next format code (N = 0 signifies end
                             of work)
```

The FORMO format codes and description for each are as follows:

Format	Format Code	Description
Return	0	Puts a zero in output buffer and returns control to the calling task.
/	1	Puts a line feed and return in the output buffer.
n/	2	Puts a return and any specified number of line feeds in the buffer.
nX	3	Puts a specified number of blanks in the buffer.
A	4	Converts 6-bit ASCII to 8-bit ASCII and puts it in the output buffer.
I	5	Converts a single precision integer to ASCII and puts it in the buffer.
J	6	Converts a double precision integer to ASCII and puts it in the buffer.
F	7	Converts a floating point number to fixed point.
E	10_8	Converts a floating point number to scientific notation.

Arguments following each format code in the task instruction string are as follows:

```
0000        /Format Code = 0 (return), no arguments

0001        /Format Code = 1 (/), no arguments

0002        /Format Code = 2 (n/)
000n        /n = number of line feeds desired

0003        /Format Code = 3 (nX)
000n        /n = number of blanks desired

0004        /Format Code = 4 (A)
ADDRESS     /Address of 6-bit ASCII string to be put in buffer

0005        /Format Code = 5 (I)
ADDRESS     /Address of integer to be converted
W           /W = field width (must include a space for the sign)
```

0006	/Format Code = 6 (J)
ADDRESS	/Address of integer to be converted
W	/W = field width (must include a space for the sign)
7	/Format Code = 7 (F)
ADDRESS	/Address of number to be converted
W	/W = field width (including sign and decimal point)
j	/j = number of digits desired behind the decimal point
10_8	/Format Code = 10_8 (E)
ADDRESS	/Address of number to be converted, field width is assumed to be 15 places

E. SSR No. 4 - MATH

The MATH routine performs the following arithmetic operations:

Function Code	Operation
0	Returns control to calling task.
1	FADD - adds floating point numbers.
2	FSUB - subtracts floating point numbers.
3	FMULT - multiplies floating point numbers.
4	FDIV - divides floating point numbers.
5	FLOGN - calculates the natural log of a floating point number.
6	FEXP - calculates e^x, where x is a floating point number.
7	FLOAT - converts a double precision integer to a floating point number.
10_8	IFIX - converts a floating point number to a double precision integer.

The standard instruction sequence for utilization of the MATH routine is as follows:

```
CLA                     /SSR linkage instructions
RIF
CIF  0
IOF
JMS  I  (725
0004                    /SSR No. = 4  (MATH routine)
000n                    /n = function code of the operation to
                             be performed
A1                      /Addresses of operands and answer
A2
A3
000n                    /Next function code of the operation to
                              be performed
A1                      /Addresses of operands and answer
A2
A3
 .
 .
 .
0000                    /Next function code (n = 0 signifies
                              return control to calling tasks)
```

The arguments following each function code in the task instruction string are as follows:

```
0000          /Function Code = 0 (return), no arguments

0001          /Function Code = 1 (FADD)
 A1           /Address of first floating point operand
 A2           /Address of second floating point operand
 A3           /Address of the floating point answer

0002          /Function Code = 2 (FSUB)
 A1           /Address of floating point minuend
 A2           /Address of floating point subtrahend
 A3           /Address of the floating point answer
```

0003	/Function Code = 3 (FMULT)
A_1	/Address of first floating point multiplier
A_2	/Address of second floating point multiplier
A_3	/Address of the floating point answer
0004	/Function Code = 4 (FDIV)
A_1	/Address of floating point dividend
A_2	/Address of floating point divisor
A_3	/Address of the floating point answer
0005	/Function Code = 5 (FLOGN)
A_1	/Address of floating point number
A_2	/Address of floating point answer
0006	/Function Code = 6 (FEXP)
A_1	/Address of floating point number
A_2	/Address of floating point answer
0007	/Function Code = 7 (FLOAT)
A_1	/Address of double precision integer
A_2	/Address of floating point answer
0010	/Function Code = 10_8 (IFIX)
A_1	/Address of floating point number
A_2	/Address of double precision integer answer

F. SSR No. 5 - A2D

The A2D routine reads any electrical analog signal, converts it to digital, and adds it to the double precision location specified by the calling task. Prior to reading the analog signal, the calling task must also specify the screw terminal number on the A/D converter and the electrical gain number. The standard instruction sequence for utilization of the A2D routine is as follows:

```
CLA                      /SSR linkage instructions
RIF
CIF  0
IOF
JMS  I  (725
0005                     /SSR No. = 5 (A2D routine)
GAIN                     /Electrical gain from 0 to 7
TERMINAL                 /Screw terminal number
ADDRESS                  /Address of double precision integer
GAIN                     /Next gain value
TERMINAL                 /Next screw terminal number
ADDRESS                  /Next address
   .
   :
  -1                     /Gain of -1 indicates end of work and
                            that control should be returned to
                            the calling task.
```

G. SSR No. 6 - WAIT

The WAIT routine delays execution of the calling task until a specified amount of time has elapsed. The standard instruction sequence for utilization of the WAIT routine is as follows:

```
CLA                      /SSR linkage instructions
RIF
CIF  0
IOF
JMS  I  (725
0006                     /SSR No. = 6 (WAIT)
 n                       /n = time delay in 100ths of a second
```

It should be noted that the maximum n value is 4096 for a maximum delay of 40.96 seconds. After any delay, control is returned to the calling task at the location immediately after the n value.

H. SSR No. 10_8 and 11_8 (TTY0 and TTY1)

TTY0 and TTY1 read and write 8-bit ASCII code on teletypes 0 and 1, respectively. The standard instruction sequence for utilization of the TTY routines is as follows:

```
CLA                 /SSR linkage instructions
RIF
CIF 0
IOF
JMS I (725
0010 or 0011        /SSR No. = 10(8) or 11(8) (TTY)
 n                  /Function Code for read or write 8-bit ASCII
ADDRESS             /Starting buffer address
 n                  /Next function code for read or write
ADDRESS             /Starting buffer address
   .
   .
   .
0000                /Next function code (zero specifies
                        return control to calling task)
```

The function codes and the arguments for each are as follows:

```
0001                /Function Code = 1 = read
ADDRESS             /Location for storage of characters read

 -1                 /Function Code = -1 = write
ADDRESS             /Address of characters to be printed

0000                /Function Code = 0 = return control to
                        calling task
```

It should be noted that read function stops when a return key is punched on the teletype and the write function stops when a zero is found in the character string to be printed.

DRH:pjc
8006A

APPENDIX C

BENCH-SCALE METHANATION UNIT DATA ACQUISITION PROGRAM

I. INTRODUCTION

The bench-scale methanation unit data acquisition program (BSM) is a computer program which utilizes the BCR Real Time System to acquire and store data from this unit. The program does this through three main tasks: (1) the monitor task; (2) the data sampling task; and (3) the data conversion and storage task. A description of each of these tasks is given in the following sections.

II. THE MONITOR TASK

The function of the monitor task is to receive and execute commands from the computer operator to start or stop the data sample and storage tasks, print material balances, change ambient conditions, etc.

When the BSM program is loaded and executed, the monitor task requests, through the teletype, the name of the DECtape data storage file to be used for recording the test data. The operator types the filename and the monitor will then open that file for data output. The monitor then enters itself in the BCR Real Time System (BCRRTS) task table with an initiation status of 10, which means that this task is started by a message or command through the teletype. The description of commands which the computer operator can then give to the BSM monitor follows:

AMBIENT T, P, IFLOW, OFLOW

> The AMBIENT command gives the BSM program the ambient temperature (°F), the ambient pressure (psi), the maximum inlet flow (scfh), and the maximum outlet flow (scfh).

FEED %H_2, %N_2, %CO, %CO_2, %CH_4, %H_2O, %C_2H_6

> The FEED command gives the BSM program the feed gas analysis to be used during that test.

WEIGHT W, D

> The WEIGHT command gives the BSM program the catalyst weight (grams) and the catalyst bulk density (gram/cc).

BEGIN

> The BEGIN command tells the BSM monitor to start the sample and storage routines. The monitor does this by inserting the routine status words and starting locations in the BCRRTS task table.

STOP

The STOP command tells the monitor to stop the sample and storage routines. The monitor does this by setting the routine status words to zero.

. The . (dot) command tells the monitor to print the latest one minute average of all the methanator variables.

LIST I:J, M:N

The LIST command tells the BSM monitor to print the one minute averages of all the methanator variables from time I:J (hour:minute) to M:N.

REPORT I:J, M:N

The REPORT command tells the BSM monitor to print a summary report for the time period I:J (hour:minute) to M:N. The report includes: (1) the average of each flow, temperature, and pressure over that time period, (2) a material balance, and (3) gas conversion rates.

CLOSE

The CLOSE command tells the monitor to do a STOP command and then close the DECtape file that was opened when the program was loaded. This insures that the test data will be available for future use.

III. THE SAMPLE TASK

The sample task is initiated when the BEGIN command is given to the BSM monitor. This routine then continuously reads and stores the signals from all the methanator instrumentation every six seconds. The methanator transmitters, their corresponding computer terminal numbers, and electrical ranges are shown in Table 146.

IV. THE DATA CONVERSION AND STORAGE TASK

The data conversion and storage task is initiated when the BEGIN command is given to the BSM monitor. Once a minute, this routine averages the signals read in by the sampling task, converts them to engineering units, and stores them on DECtape. The conversion to engineering units for each methanator variable is as follows:

Thermocouples: millivolts (mv) to °F

$$°F = 42.54036 \times mv + 21.84214 + \text{ambient temperature}$$

CO Lira:

$$\%CO = .0007081368 \times (mv)^2 + 0.226576 \times mv + 0.316229$$

CH_4 Lira:

$$\%CH_4 = .00247088 \times (mv)^2 + 0.352744 \times mv + 0.104229$$

Inlet Flow: conversion from milliampere (ma) to scfh

Inlet flow = (ma - 10.0) x IFLOW/40.0

where IFLOW is the maximum inlet flow.

Outlet Flow: conversion from psi to scfh

Outlet flow = (psi - 3.0) x OFLOW/12.0

where OFLOW is the maximum outlet flow.

Inlet and Outlet Reactor Pressure: conversion from psi to psig

Pressure = (psi - 3.0) x 1500.0/12.0

TABLE 146. METHANATOR TRANSMITTERS

Transmitter	Range	Computer Terminal No. Decimal	Computer Terminal No. Octal
Scanivalve (used to read inlet pressure, outlet pressure and outlet flow)	0-40 mv	1	1
TC-1 (Gas temp., at 6-inch level)	0-50 mv	8	10
TC-2 (Gas temp., at 6-inch level)	0-50 mv	9	11
TC-8 (Gas temp., at preheater outlet)	0-50 mv	10	12
TC-11 (Gas temp., at 18-inch level)	0-50 mv	11	13
TC-19 (Reactor surface temp.)	0-50 mv	12	14
Outlet CO Lira	0-100 mv	16	20
Outlet CH_4 Lira	0-100 mv	17	21
FT-1 (inlet flow)	10-50 ma	24	30

APPENDIX D

HOMER CITY, PENNSYLVANIA
COAL GASIFICATION PILOT PLANT

JOB NO. C-11630

STEARNS-ROGER PROJECT STATUS REPORT
NO. 4
DECEMBER 8, 1972

GENERAL

This report covers job progress from November 2, 1972 to December 7, 1972.

A flow sheet review meeting was held on November 9-10, 1972. Approval of these flow sheets in principle was received by Stearns-Roger on December 5, 1972.

Gasifier design and schedule continues to be the critical problem area. The B&W engineering subcontract has been submitted to BCR for approval. A gasifier schedule based upon the best available information has been included in the report.

Flow sheets at their current state of development will be distributed December 15, 1972. C. F. Braun requested this issue for their use during a planned meeting with the AGA Advisory Committee.

PHYSICAL DESIGN

The concept plot plan has been issued to BCR for approval. Final soil testing boring location will be restricted until approval of the plot plan is received.

Office and laboratory building preliminary layouts have been developed and issued for approval.

External loading analyses have been made for the gasifier. This data has been forwarded to B&W for their use.

The Phase I soil testing boring location drawing has been issued to the field for the mining study.

Recommendations have been made to BCR concerning enclosing the gasifier structure, enclosing the coal preparation facilities, operating floor design, and plant roads and parking areas.

A recommendation has been submitted to BCR concerning the use of a plant model.

GENERAL SPECIFICATIONS

Eleven (11) general specifications were issued for construction. Approximately thirteen (13) additional general specifications have been returned from BCR with their comments. Two (2) specifications have not been returned from BCR.

FIELD PROGRESS

The legal survey has been completed and the certified drawing received. Topographic survey work has been completed and Phase I soil testing core holes have been established.

Site clearing is complete and drilling work has started for the soils analyses. Progress has been somewhat hampered due to the wet weather.

PROCESS ENGINEERING

GENERAL

A flow diagram review meeting was held in Denver on November 9-10, 1972. This meeting was attended by Stearns-Roger, BCR, Blaw-Knox, C. F. Braun, and OCR. The purpose of this meeting was to review flow sheets for "approval in principle" with respect to the basic process scheme and equipment requirements. Minutes and marked flow sheets were subsequently distributed by Stearns-Roger. Stearns-Roger received approval in principle, areas marked "hold" excepted, on December 5, 1972. This type of approval applies to flow sheets 00-1-10 thru 00-1-21.

1. Coal Handling

Preliminary sketches have been prepared for all bins in the coal handling area. These are being designed by Stearns-Roger in the detail required to obtain fabrication quotations.

Vendors' quotations due approximately December 1, 1972 have not been received. Vendors have been expedited and are providing proposals between December 6, 1972 and December 15, 1972.

Basic design problems not recognized in the Koppers design or initial job scope have resulted in addition of approximately 600 manhours required for process - mechanical equipment design. Appropriate cost trends are being developed.

Since the flow sheet review meeting, it has been determined that addition of a slag grinder will be necessary because slag is not available commercially to the required screen anaylsis. Process design of the associated transportation, storage and clsssifying facilities is in progress. Additional manhours for this system have not been included above.

The requirement to dry lignite in an atmosphere containing less than 1% oxygen received October 23, 1972 resulted in a complete new process design for the coal crushing-drying circuit. Work accomplished prior to this date was lost.

2. Coal Feed

Since the last report, vessels in this area were redesigned to provide the 70° slope requested at the November 9-10, 1972 flow sheet meeting. This request resulted in major vessel revisions and will require added structure height, revision of previously calculated purge rates and up-dating of flow sheets. A cost trend is being prepared for this change.

Inquiries for eleven major equipment items have been sent to vendors between 9-27-72 and 11-29-72. Of seven vendors asked to quote coal feeders, one vendor responded. All others declined to quote. One vendor has agreed to reconsider and offer a quotation. Delays are being experienced on quotations for other items, due to specialized design, exceptions to OSHA requirements, etc.

Operational safety features have not been recognized in previous design work. The possibilities and ways to prevent hot vapors backing into the coal feed system are being investigated. Possible overpressure of the coal feed bin due to valve failure must be adequately recognized in design. This problem is directly related to adequate disposition of vent gases. Lock hopper valves are still being researched. As stated in the previous report, basic process design is considered firm.

3. Gasification

The gasifier cooling water flow diagram has been developed and approved in principle. Process information required to size pumps, exchangers, and system surge is still dependent upon final gasifier design.

Efforts to locate a vendor for the slag crusher-grinder have not been successful. Accordingly, the slag removal flow sheet has been revised to show installation of the required lock hoppers. This flow sheet will be issued for approval in principle approximately December 15, 1972.

The other gasifier flow diagrams have been approved in principle.

Major equipment items are being specified for purchase inquiry.

The basic gasifier specification was sent out for approval October 30, 1972. "As Noted" approval was received November 29, 1972. Incorporation and resolution of pertinent approval comments is in progress

GASIFIER

As noted in the last report, B&W had promised to submit an engineering services proposal by November 9, 1972. On November 1, 1972, Stearns-Roger requested B&W to hand carry this proposal to Denver by November 7, 1972. On November 9, 1972 representatives of B&W brought the proposal

GASIFIER - continued

to Denver. November 9 and 10, 1972 were devoted to review of this proposal in detail between Stearns-Roger and B&W and working out the details of a mutually acceptable subcontract document to cover this work. On November 10, 1972, essential agreement was reached and BCR was so advised. The following week Stearns-Roger prepared the B&W subcontract draft. The necessary B&W reimbursement information needed to complete this effort was received on November 16, 1972. Stearns-Roger transmitted the subcontract draft to B&W for final comment on November 17, 1972 with a copy to BCR for information and comment. The document as drafted did not contain the OCR/AGA joint agreement and guidelines. BCR raised questions regarding the OCR/AGA agreement patent clause and data clause. These matters were resolved and on December 4, 1972, Stearns-Roger was advised to submit the B&W subcontract for approval. Final changes were made and the B&W proposal was submitted for BCR approval on December 6, 1972, with a request for immediate action.

4. Gas Wash

Design of the gasifier effluent line has developed into a major problem area. Thermal gradients in the heavy wall pipe necessary for design pressure, results in material stresses which cannot be tolerated. Several alternate solutions are being investigated, but no alternative method has resulted to date. The complexity of this problem was not apparent until detailed stress calculations were run.

Gas washer design is complete, but equipment specifications are being held, pending confirmation by B&W of original BCR gasifier heat loss data or resolution of any different results.

5. Char and Lime Systems

Flow sheets have been approved in principle. Equipment quotations were due November 17, 1972. As with coal feeders, 6 of 7 vendors have declined to quote due to the unusual equipment requirements. Other major equipment is being specified for purchase inquiry. Equipment specifications for the overhead system components are being held until design problems in the overhead line are resolved.

At the November 9-10, 1972 flow sheet meetings, it was decided to inject flux into all three char burners, with an alternate flux injection into the coal injectors. This requires the addition of two additional feeders and revision of flow sheets. A cost trend will be submitted for this change in scope.

6. CO Shift

Process design for CO shift is complete. There are no major problems in this area. Flow sheets have been approved in principle. All major equipment has been released to the mechanical group for preparation of inquiry specifications.

7. Acid Gas Removal

Stearns-Roger recommended selection of the SELEXOL process on November 3, 1972. Approval of this recommendation was received December 5, 1972. Work is now in progress on this basis. The process design was essentially complete at the process recommendation stage. Allied Chemical will visit Stearns-Roger the week of December 13, to finalize process design and equipment requirements. Some major equipment has been released for preparation of inquiry specifications. Before distribution of process information, Allied Chemical secrecy agreement matters need resolution. It is assumed that Allied Chemical will handle this with the interested organizations involved on the project.

8. Methanation

Basic process design is now considered firm. Flow sheets have been approved in principle. Equipment is being specified for purchase inquiry. Water removal facilities have been included in the design, based upon non-availability of a suitable water tolerant catalyst.

9. Utilities

Job design will be based upon use of Homer City water supply. The creek pumping facilities will be eliminated. A cost trend will be submitted for this change.

No further information regarding the availability of commercial fuel gas has been received by Stearns-Roger. This item must be resolved within the next month in order to proceed with design of utilities and properly specify fuel gas using process equipment.

Process design has been started to develop utility and disposal requirements in the areas of oxygen and nitrogen distribution systems, steam system, and effluent water treating.

APPENDIX E

ADDITIONS TO THE ABSTRACT FILE - NOVEMBER, 1972

Grace, R. J. and Zahradnik, R. L., "BI-GAS program enters pilot plant stage," Fourth Synthetic Pipeline Gas Symp., Chicago, Ill., by Am. Gas Assoc. and U.S. Office Coal Res., 1972. 22 pp.

> The focus of this paper is the 5 ton/hr pilot plant to be built in 1973 at Homer City, Pa. (Adapted from authors' introduction)

Inst. Gas Technol., "A survey of R & D projects directed toward the conversion of coal to gaseous and liquid fuels," prepared for Am. Gas Assoc., Inc., Catalog No. H31791 (1971). (129 pp.) 662.6 I 59

> Information has been compiled on all major coal conversion research projects undertaken during the past 10-15 years. The material has been obtained from available published sources and therefore has been presented without discussing technical aspects in great detail. Periodic updates are planned. A bibliography and an index of organizations involved in the work are not given.

Karnavas, J. A., LaRosa, P. J., and Pelczarski, E. A., "ATGAS--a process for gasification of coal in molten iron," Fourth Synthetic Pipeline Gas Symp., Chicago, Ill., by Am. Gas Assoc. and U.S. Office Coal Res., 1972. 12 pp.

540.000 72-8

> Experimental results obtained in gasifying coal with air in an induction melting furnace (27 in. ID) are used as the basis for a discussion of the process used for coal gasification with steam and oxygen. An estimate of process economics is given.

Lee, B. S., Tarman, P. B., and Youngblut, K. C., "Status of HYGAS, electrothermal gasification, and steam-oxygen gasification programs," Fourth Synthetic Pipeline Gas Symp., Chicago, Ill., by Am. Gas Assoc. and U.S. Office Coal Res., 1972.

9 pp. 540.000 72-9

> The progress of IGT's HYGAS program since the report presented at the Third Synthetic Pipeline Gas Symposium is reviewed.

Mills, G. A., "Coal gasification research - Bureau of Mines," Fourth Synthetic Pipeline Gas Symp., Chicago, Ill., by Am. Gas Assoc. and U.S. Office Coal Res., 1972. 21 pp. 540.000 72-10

The projects reviewed are: stirred fixed-bed pilot unit; hydrogasification (Hydrane Process); catalytic gasification; underground gasification; and exploratory gasification.

Rudolph, P.F.H., "The Lurgi process - the route to S.N.G. from coal," Fourth Synthetic Pipeline Gas Symp., Chicago, Ill., by Am. Gas Assoc. and U.S. Office Coal Res., 1972. 26 pp.+ 540.000 72-11

The Lurgi process is described and is presented as a commercially proven up-to-date process.

Schora, F. C. and Matthews, C. W., "Other coal gasification related A.G.A. programs at the Institute of Gas Technology," Fourth Synthetic Pipeline Gas Symp., Chicago, Ill., by Am. Gas Assoc. and U.S. Office Coal Res., 1972. 20 pp.
540.000 72-12

The objectives and status of seven ongoing programs are covered. The programs are variously related to work on the mechanism of coal gasification; aimed at developing basic engineering data necessary for designing high-pressure coal gasification systems; for the purpose of improving gas-cleaning systems; to develop an alternate hydrogasification process; and further work on converting large quantities of oil shale to gas. (From authors' introduction)

Vestal, M. L., Day, A. G., III, Snyderman, J. S., Fergusson, G. J., Lampe, F. W., Essenhigh, R. H., and Johnston, W. H., "Kinetic studies on the pyrolysis, desulfurization, & gasification of coals with emphasis on the non-isothermal kinetic method," Scientific Research Instrument Corp., Rept. No. SRIC 70-14, Final Rept. to U.S. Natl. Air Pollut. Contr. Admin. (1969). 102 pp.
540.000 69-28

These studies on desulfurization of coal during gasification have emphasized the theoretical and experimental application and extension of the new method of non-isothermal kinetic measurements developed originally by Juntgen and coworkers. A substantial amount of basic kinetic data relative to the desulfurization of coal during pyrolysis and gasification has been obtained and has been used to construct a rational mechanistic picture of the process in terms of a set of competing and opposing chemical reactions, the individual rates of which are known under a variety of process conditions. (Adapted from text)

PATENTS

Aldridge, C. L. and Buben, D. (to Esso Research and Engineering Company), "Production of methane rich gases," U.S. Pat. 3,689,240 (Sept. 5, 1972). 2 pp.

540.000 Patent

A process for producing a methane-rich gas wherein carbonaceous material is steam gasified at temperatures between 1100 and 1400 °F. and at pressures between 200 and 2000 p.s.i.g. with steam rates between 0.1 and 1.0 wt. H_2O/wt. carbon/hr. in the presence of an alkali metal salt catalyst composition. (Abstract of the disclosure)

Lorenz, E., Reitz, O., and Ebenhoech, F. L. (to Badische Anilin- & Soda-Fabrik A.-G), "Catalytic conversion of carbon monoxide and steam under pressure to produce hydrogen," U.S. Pat. 3,392,001 (July 9, 1968). 2 pp.

540.000 Patent

A carbon monoxide conversion process using catalysts which consist of oxides and sulfides of transition elements of Groups V to VII of the Periodic System supported on oxide or silicate carriers and contain hydraulic cement binding agents. (Abstract of the disclosure)

Lorenz, E., Wodtcke, F., Eberhoech, F. L., and Giesler, E. (to Badische Anilin- & Soda-Fabrik A.-G.), "Catalytic reaction of carbon monoxide with steam," U.S. Pat. 3,529,935 (Sept. 22, 1972). 4 pp. Certificate of correction.

540.000 Patent

The catalytic reaction of carbon monoxide with steam in the presence of oxidic or sulfidic catalysts containing the transition elements of Group VI of the Periodic System and cobalt and/or nickel on a carrier of aluminum oxide and magnesium oxide. (Abstract of the disclosure)

Slater, W. L. and Schlinger, W. G. (to Texaco, Inc.), "Production of a methane-rich synthesis gas," U.S. Pat. 3,688,438 (Sept. 5, 1972). 3 pp.

540.000 Patent

Methane-rich synthesis gas comprising H_2, CO, CO_2 and 10 to 26 percent by volume of CH_4 (dry basis) is produced by the partial oxidation of a hydrocarbonaceous fuel in a free flow noncatalytic synthesis gas generator at a reaction temperature below 1,700 °F., a pressure in the range of about 15 to 250 atmospheres, and a steam to fuel weight ratio in the range of about 3 to 5. The product gas, after removal of CO_2 and H_2S has a heating value in excess of 400 Btu/scf. (Abstract of the disclosure)

APPENDIX F

F-816.

PROGRESS REPORT #40

Bituminous Coal Research, Inc.
Coal Gasification

November, 1972

Koppers Contract 2415

I. STATUS OF CONTRACT

A. Pilot Plant Engineering Bid Packages

Step No. 1: Pilot Plant for oxygen-blown, two stage coal gasification system, including general facilities: design and models. For additional information see Part II: Contract Evaluation.

(Work Completed)

Step No. 2: Fluidized bed system.

(Work Deferred)

B. Engineering Assistance and Recommendations for PE[illegible] Program Methanation PEDU

The following Fluid Bed Methanation PEDU drawings, bills of material, and specifications were transmitted by Koppers Company, Inc. to BCR:

Drawing No.	Rev. No.	Title	Date Trans.
2415-2A747	1	Instrument Air and Gage Piping Sheet 1 of 2	02NOV72
2415-2A748	1	Instrument Air and Gage Piping Sheet 2 of 2	02NOV72
B/M 2415-2A747	1	Instrument Air and Gage Piping Bill of Materials	02NOV72
2415-2A730	2	H.P. Stall Equipment Gen'l. Arrgm't. and Piping and Steel Design - Sheet 1 of 3	02NOV72
2415-2A731	2	H.P. Stall Equipment Gen'l. Arrgm't. and Piping and Steel Design - Sheet 2 of 3	02NOV72
2415-2A732	2	H.P. Stall Equipment Gen'l. Arrgm't. and Piping and Steel Design - Sheet 3 of 3	02NOV72
B/M 2415-2A730	2	H.P. Stall Equipment Gen'l. Arrgm't. and Piping and Steel Design - Bill of Materials	02NOV72

The following memorandum was transmitted by Koppers Company, Inc. to BCR:

Date	Letter No.	Title	Remarks
16NOV72	2415-C472	Cardox Information	Transmitted Technical bulletins pertaining to Cardox CO_2 Fiberglass Storage and Vaporizer units.

C. Fluid Bed Gasification PEDU

1. BCR's letter of 26JUN72 relieved Koppers of the responsibility for fluidized-bed gasification engineering under Amendment No. 6 and No. 7, Subcontract No. 2, OCR Contract No. 14-32-001-1207.

D. General Engineering Assistance & Consultation

1. Koppers Company, Inc. Inspection Section with personnel from BCR inspected the "Methanator Reactor" (item M-R420) on 06NOV72 at Nooter Corporation, St. Louis, Missouri. An inspection report was transmitted to BCR in a memorandum (2415-C473) dated 16NOV72.

II. CONTRACT EVALUATION

Four (4) copies of Amendment No. 7 to Amended Subcontract No. 2 including Appendices I through VIII, signed by Mr. J. D. Rice, Vice President & Asst. Gen. Mgr. of Engineering and Construction Division, Koppers Company, Inc. were transmitted to BCR in our letter 2415-C183 dated 18OCT71. Receipt of these copies was acknowledged by BCR in their letter dated 18OCT71.

Pilot Plant Engineering Bid Package (Volumes I through VI) was completed in accordance with the scope of work specified under Appendix I-Revised Appendix A, Par. IIIA-5. Step a.: "General Facilities Plus Oxygen-Blown Two-Stage System" of Amendment No. 7 to Amended Subcontract No. 2 (originated under OCR Contract No. 14-01-0001-324 and transferred to OCR Contract No. 14-34-0001-1207) between Bituminous Coal Research, Inc. and Koppers Company, Inc.

J. F. Farnsworth
Project Manager