PRELIMINARY DESIGN SERVICES RESEARCH AND DEVELOPMENT REPORT NO. 114, JULY--SEPTEMBER 1975. INTERIM REPORT NO. 2

PARSONS (RALPH M.) CO., PASADENA, CALIF

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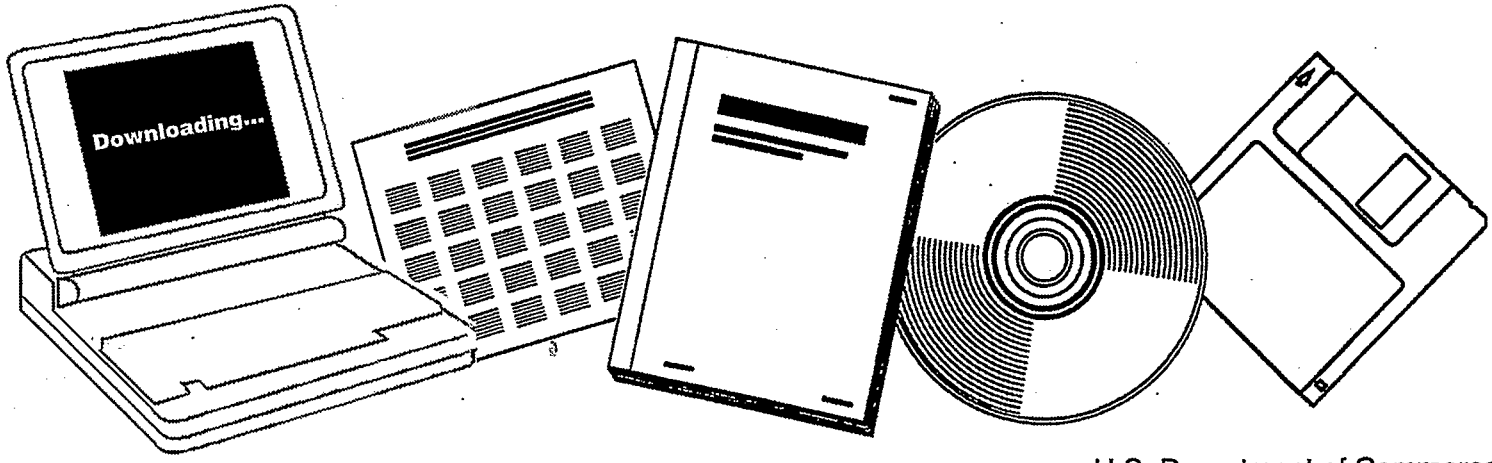

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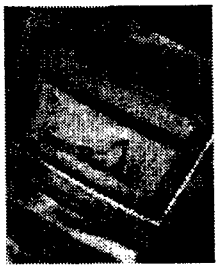

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PRELIMINARY DESIGN SERVICES

RESEARCH AND DEVELOPMENT REPORT NO. 114

INTERIM REPORT NO. 2

For the Period: July-September 1975

Prepared by:

The Ralph M. Parsons Company
100 W. Walnut Street
Pasadena, California 91124

For:

Energy Research and Development Administration
Washington, D.C. 20545

Under Contract No. E(49-18)-1775

November 1975

I. OBJECTIVE AND SCOPE OF WORK

The objective of the work is to develop preliminary designs and economic evaluations for a number of coal conversion plants. The following designs are included in the scope of work:

- A conceptual commercial plant for a Coal-Oil-Energy-Development (COED) plant.
- An Oil/Gas plant to produce liquid fuels plus substitute natural gas (SNG).
- A commercial-scale Fischer-Tropsch plant with motor fuel and SNG as the main products.
- A commercial-scale plant for the production of solvent-refined coal (SRC).
- A Coal Oil Gas Refinery (COG) to produce clean liquids, gas and electrical power generating capacity.
- A facilities complex capable of demonstrating the commercial feasibility of a variety of coal conversion processes that show promise during pilot plant operations.

  The following facilities will be considered; conversion of coal to:

  (1) Low to high Btu fuel gas.

  (2) Methanol/motor fuel by Fischer-Tropsch process.

  (3) Clean liquid fuels by alternate liquefaction processes.

In addition, supporting efforts will be provided to the above activities. These efforts include planning and progress monitoring, equipment development, and environmental factors.

II. SUMMARY OF PROGRESS TO DATE

Some portions of the work on Contract No. E(49-18)-1775, were initiated under Contract No. 14-32-0001-1234 which was awarded by the Office of Coal Research, Department of the Interior in 1972. OCR R&D Report No. 82, Interim Report No. 1, "Demonstration Plant, Preliminary Design/Economic Evaluation, Clean Boiler Fuels From Coal," and a significant part of the COED design were completed under Contract-1234. Also a number of technical Evaluation Contractor Services have been, and are being supplied to ERDA-FE.

In addition, two preliminary assessments of the Fischer-Tropsch Synthesis process for production of liquid fuels and substitute natural gas were completed and reported.

The work effort for Contract E(49-18)-1775 is divided into twelve tasks. These tasks and their schedules are shown in Figure 1 - Overall Program

Schedule. A brief synopsis of the status of the major active design efforts is given below, followed by a more detailed reporting on progress for the separate tasks.

The first task, to complete the conceptual design of the COED process and issue the final report, has been completed. Multiple copies of the report were transmitted to ERDA by our letter PN-74 dated October 3, 1975. The Oil/Gas plant design is underway; a number of studies that compare the technical and economic performance of various process operations have been completed. The results of these studies have been incorporated into the process design that has been reviewed with ERDA. The remaining studies are well underway, and will be completed during the coming quarter.

The Fischer-Tropsch plant design is also well underway. The design basis and process block diagrams have been reviewed with ERDA personnel. The detailed design of equipment is underway.

Work on the COG design is underway. Computer simulation capability is being used to assist in defining the capabilities of a number of liquefaction technologies.

Activities continue on the metallurgical support, equipment development, and environmental factor efforts.

III. DETAILED DESCRIPTION OF TECHNICAL PROGRESS

A. COED Conceptual Commercial Plant

1. Objectives:

   To develop a conceptual design and cost estimate for a commercial-size plant.

2. Activity This Quarter:

   Forty copies of the final report describing the conceptual design investment and economic evaluation was transmitted to ERDA on October 3, 1975. This is ERDA R&D Report No. 114 Interim Report No. 1 "Commercial Complex, Conceptual Design/Economic Analysis, Oil and Power by COED Based Coal Conversion."

   The economic section of the report includes a complete parametric economic analysis. Review comments received from ERDA were incorporated into the final report.

3. Activity Forecast Next Quarter:

   Transmit additional copies of R&D Report No. 114 Interim Report No. 1 to ERDA.

B. Coal Mining/Coal Preparation

1. Objectives:

a. Initially to develop a conceptual design and economic evaluation for facilities to (1) mine a minimum of 35,000 TPD of Illinois No. 6 seam coal, and (2) prepare it in a form suitable for use as feed to various coal conversion process plants. The initial mine conceptual design will be used for the COED project.

b. The long-range objective is development of conceptual designs and economic evaluations for mines in four additional geographic areas. These include the Appalachian area, the Feather River (Western) area, the Four Corners area, and the Utah deposits. Mine costs will be developed to supply feed to the various conceptual plant designs including those based on SRC, Cresap-Development processes, COG, and others that may be defined in the course of the program. Mines with capacities up to 100,000 TPD will be considered.

2. Activity This Quarter:

We continued to assemble information regarding reserves and mining characteristics for the various coal sources to be used in our work as described under the objectives.

We completed a major portion of the conceptual design for a 40,000-TPD coal mine for use in the Fischer-Tropsch plant complex. The mine location is in the Eastern Interior Coal Region.

3. Activity Forecast Next Quarter:

Complete the design and fixed capital estimate for the 40,000 TPD coal mines for the Fischer-Tropsch plant and Oil/Gas complexes.

C. Oil/Gas Plant Design

1. Objectives:

To develop a preliminary design and economic evaluation for a commercial Oil/Gas plant to produce synthetic liquid fuels and SNG from coal. To define the maximum practical capacity single-train plant using the process.

2. Activity This Quarter:

A preliminary block flow diagram incorporating the currently available results of the process alternative studies described below

was prepared and discussed with ERDA personnel. Modifications to this process design will be made as the results of the continuing studies indicate appropriate need.

Work proceeded on development of preliminary material balances to allow sizing of equipment for the separate plant units to begin.

We continued work to finalize the design basis. Predesign studies to select the elements of a preferred design consist of economic and technical comparisons of a number of process alternatives. These alternatives include:

a. Hydrogen vs Syngas: Process designs and equipment data were developed for use in preparing capital cost estimates for the two alternate feeds to the dissolvers. The capital cost comparison for the two alternate feeds is being estimated.

b. Filter Cake Washing and Drying: Process designs and equipment data were developed for preparation of capital cost estimates for this process alternative. The estimation of the capital cost effect of this process alternative is in progress.

c. Dissolver Design Basis: Data from the Tacoma SRC Pilot Plant progress reports was used to determine a preliminary basis for dissolver calculations. These reports gave us details of yields, approximate stream properties, and elemental analysis of all streams; the elemental balance data was rationalized for consistency.

   A preliminary evaluation of the economic impact of dissolver residence time indicated that reduction of the dissolver nominal residence time from 1 hour to 15 minutes would be economically attractive. The annual revenue requirements for a 10,000-TPD coal feed plant would be reduced by approximately $2 million at a 12% discounted cash flow rate of return (DCF).

d. Power Recovery Turbines: A preliminary economic evaluation of this equipment alternative shows that the power savings that make use of power recovery turbines are economically attractive.

e. NH_3 - H_2S Separation: The addition of this unit changes the sulfur removal plant design basis. A revised process stream specification was prepared for these sulfur plant requirements, heat and material balances were prepared and capital cost estimates are being developed.

   A technical and economic comparison has been made of the commercial separation processes. Preliminary estimates were received from the vendors of each of these processes.

f. High Pressure Gasification: We are working on the material and energy balance for a 1000-psig gasifier responding specifically to the Oil/Gas Plant requirements. Design of the gasifier, shift and acid gas removal units has begun.

g. SNG Production: We continued to assemble material required to estimate the effects of various levels of SNG production.

The SNG production potential from the Oil/Gas Plant was analyzed and two cases were selected for current consideration: (1) cryogenic extraction of methane plus LPG and purification of LPGs as products, and (2) cryogenic extraction of methane and LPG followed by steam reforming of LPG to produce additional methane. The design results for these two cases were summarized and are being used as the basis for estimating the economic impacts.

h. Sour Shift: We completed work on process calculations, equipment data sheets, specifications, and process flowsheets for this process alternative. The engineering disciplines are developing equipment data for use in capital cost estimates.

i. Alternative H_2S Removal Processes: A technical and economic comparison of the three processes has been completed and the results are being summarized. Two of the processes used physical absorption solvents. The work included development of performance specifications, and of material and utility balances.

j. Omit Slurry Recycle: A design basis was established for this study so that the coal conversion simulator program originally developed under the COG task assignment could be used for process and economic evaluation.

Material balance calculations were completed for this study. In order to allow selection of the desired option for the design basis, a preliminary estimate of equipment and operating cost differences was made. The economics for the two options - slurry and nonslurry recycle - appeared nearly equal, and the nonslurry case was chosen to permit use of the available pilot plant data.

k. Solids Separation-Coking: A study of coking has been completed and the results are being summarized. A preliminary estimate of the magnitude of plant changes required to incorporate coking and the resulting products was made to evaluate its potential.

l. Solids Separation-Vacuum Flash: Material balance calculations were completed for the vacuum flash treating of

dissolver effluent to carry out solids/liquid separation. We analyzed studies previously performed on vacuum flashing of SRC product.

3. Activity Forecast Next Quarter:

The prime thrust will be the preparation of the final plant design.

Process information for completed predesign studies will continue to be supplied to the engineering disciplines and to estimating. Work will continue to complete additional optimization studies as time allows. The economic impact of process alternatives will be evaluated.

D. Fischer-Tropsch Plant Design

1. Objectives:

To develop a preliminary commercial plant design and economic evaluation for a plant using Fischer-Tropsch technology to produce pipeline gas and motor fuel.

2. Activity This Quarter:

a. Design Basis: A preliminary design basis has been prepared. The Btu value of the total plant products was set at 500 billion Btu per day, the plant will consist of two trains of 250 billion Btu per day each. The design basis was reviewed with ERDA representatives during a progress review meeting held September 16 and 17.

b. Process Block Flow Diagram: A preliminary process block flow diagram has been completed, this diagram was reviewed with ERDA representatives.

c. Plant Visit: Parsons and ERDA personnel visited the SASOL plant located at Sasolburg, Republic of South Africa. Information obtained will be used as background for Fischer-Tropsch studies.

d. Gasifiers: The development of the design for large-scale gasifiers suitable for production of feed gas for the Fischer-Tropsch synthesis continued.

e. Gas-Solids Separation: The study of alternative means for removal of solid particulates from the hot, pressurized gas stream leaving the gasifier was continued. Contacts were made with vendors to determine the suitability of their equipment.

f. Acid Gas Removal: Criteria were developed for the purity of the feed gas to the Fischer-Tropsch synthesis units. Process specifications were prepared for acid gas removal and compared with published information on the subject for SASOL plant. These specifications were issued to potential process licensors for their proposals. We reviewed with them their concern on the removal of the acid gases to the required low concentration level.

g. Fischer-Tropsch Reactor: Work was continued on the detailed conceptual design of the reactor as applied to the USA Fischer-Tropsch plant. A patent disclosure has been prepared on the details of this reactor design.

h. Coal Feed System: We developed a lock hopper feed system for coal injection into the gasifier. Preliminary capital investment estimates were obtained on this feed system.

i. Gasification System: We continued our efforts to develop a gasification system suitable for a United States Fischer-Tropsch design. This involves the specific steps of (1) how to remove solids particulates, (2) whether or not the shift conversion should operate on sour (H_2S-containing) gases, (3) the extent and method of cooling the gasifier product gases, and (4) how much steam is required to accomplish the necessary gas and carbon reactions. Since our requirements are not to make high purity hydrogen, the last question has a serious impact on economics and plant operation as it affects the plant steam requirements.

j. Overall Process Flow Diagram: We prepared a preliminary overall process flow diagram. This will be used in preparation of equipment lists and assigning equipment numbers.

k. Process Flow Diagram: Preliminary process flow diagrams for units 12-Process Gasification, 13-Gas Cleaning, 15-Shift Conversion, 16-Fischer-Tropsch Synthesis, 17-Methanation, 18-Liquid Product Recovery, and 19-Chemical Recovery were prepared.

3. Activities Forecast for Next Quarter:

The mine, coal preparation, and process design will be completed with flowsheets and capital cost estimates during the next quarter. Services, utilities, and waste treatment facilities design and estimations will begin and be well underway next quarter.

E. Preliminary Design Commercial SRC-Type Plant

1. Objective:

Prepare a preliminary design for a commercial-scale plant for the production of Solvent-Refined Coal (SRC). Information developed from actual pilot plant operations will be furnished by the Government and is to be utilized in the plant design.

2. Activity This Quarter:

None; scheduled to begin in October 1976.

3. Activities Forecast for Next Quarter:

Continue to monitor progress of the Tacoma SRC pilot plant.

F. COG Plant Design

1. Objectives:

To develop a preliminary design of a coal processing plant that will produce both liquid and gaseous fuels as principal products. The processes employed in this plant design shall be the result of an economic selection from the candidate coal conversion processes available.

To develop a model capable of calculating material and heat balances for a number of coal conversion processes using computer capabilities and to estimate the overall utility balance of the complex.

2. Activity This Quarter:

a. Computer Simulation: We have developed the computer process model to the point where it is now operational. We are using it to evaluate various COG candidate processes, while at the same time expanding and adapting the program as the applications are being developed. The program is also being modified for use in other design task assignments such as Oil/Gas, and Fischer-Tropsch.

b. Gasifier: We completed process specifications for a large-scale air-blown entrained-type coal gasifier to supply in-plant fuel gas requirements. We started engineering design of this unit.

c. Process Screening: Our efforts in preparing screening estimates continued. It appears that more detailed information than now available is required to enable us to make even this type of estimate for evaluation of the Consolidation Coal Company process. We have taken steps to obtain this

information. A request has been made to receive current reports for H-Coal development.

3. Activity Forecast Next Quarter:

During the next quarter we plan to continue screening process assessments and estimates. The in-plant fuel gasifier design will be completed. We will prepare preliminary reports for process selections.

G. Preliminary Designs for Complex to Demonstrate the Feasibility of a Variety of Coal Conversion Processes

1. Objectives:

To develop preliminary designs for a facilities complex capable of demonstrating the commercial feasibility of a variety of coal conversion processes that show promise during pilot plant scale operations. This task will consider:

(1) Low to high Btu fuel gas.

(2) Methane/motor fuel by Fischer-Tropsch process.

(3) Clean liquid fuels by alternate gasification processes.

2. Activity Last Quarter:

None; this task scheduled to begin January 1976.

3. Activity Forecast for Next Quarter:

None planned.

H. Commercial Plant Scale Models

1. Objective:

To make scale models of commercial plants as described in activities A through F.

2. Activity This Quarter:

A scale model of the COED-based complex has been supplied to ERDA.

3. Activity Forecast Next Quarter:

None.

I. Equipment Development

1. Objectives:

To define the equipment and control system development program required to assure reliability and viability of coal conversion processes being developed. To recommend appropriate developmental programs to ERDA - Fossil Energy Division.

2. Activity This Quarter:

a. Liquid/Solids Separation: The V.D. Anderson Company of Chicago requested and received a sample of SRC dissolver product for laboratory testing of their screw expeller as a means of separating SRC product from the solids. Testing of the sample is presently underway.

We continued to work on the development of various separation processes with other candidate equipment manufacturers. Samples of nonwoven fine stainless steel fiber filter media were obtained from the Hydraulic Research Inc. This material may hold promise as a direct high temperature filter medium for rotary drum pressure filters. The samples were sent for testing to Goslin-Birmingham.

b. Gas/Solids Separation: We continued contacts with manufacturers of cyclones, wet electrostatic precipitators, sintered metal fiber filters, and granular bed filters to develop data on the applicability, cost, and economic operation parameters of this equipment based on cost information received from manufacturers of such equipment. This information will be used in process design development.

c. Solids Feed to Gasifiers: We investigated the current status of developmental efforts in the field of extrusion coal feed devices. We contacted vendors and development organizations engaged in development work concerning extrusion coal feeding. Their test data were discussed. The vendors stated their belief that the coal particles that are cemented together due to compression will disintegrate to the original granular size upon entry to the gasifier due to gas velocity and the expansion of entrapped moisture in the coal.

We discussed laboratory experimental work on extrusion coal feeding with the Research Director of the V.D. Anderson Company. This firm is designing and assembling a pressurized test installation for use in extrusion coal feeding test work.

d. Filter Cake Drying: We continued contacts with various manufacturers to develop diverse approaches to the problems of filter cake drying. We received preliminary capital cost information from two kiln manufacturers. We are also reviewing information on other drying methods such as flash drying and wiped film dryers.

e. Valves: We received information regarding the Gemco segmental ball valve. The Gemco standard product is designed for intermediate temperature and low-pressure service. Modifications of this design for heavier duty service appears possible.

3. Activity Forecast Next Quarter:

We anticipate obtaining results from the V.D. Anderson Company's laboratory testing of liquid/solids separation and on extruder coal feeding.

The coal liquefaction slurry filtration tests and filter cake oil and solvent recovery equipment investigations and cost proposals should be completed.

Investigations will be continued in the areas of gas-solids separation and solids feeding techniques.

J. Materials of Construction Assessment

1. Objectives:

To define the preferred materials of construction for use in coal conversion projects.

2. Activity this Quarter:

a. Metals Property Council: We attended a meeting at the Illinois Institute of Technology Research Institute on July 10. We reviewed the status of the Phase I (High Temperature Laboratory Corrosion Test) and made comments concerning the materials to be evaluated. We further reviewed the Phase II (Pilot Plant Corrosion Tests) Summary report and collaborated in the revisions thereto.

We attended a meeting of the Phase V Committee on Engineering Properties of Metals that was held in Los Angeles, California on September 30. We helped to prepare a draft proposal for mechanical testing of candidate alloys suggested by the Phase V Committee.

b. NACE Technical Practices Committee (T-12A): We met with the chairman of committee T-12 of the National Association of Corrosion Engineers to discuss the agenda for an initial

committee meeting to be held at the annual Association meeting in Houston in March 1976. The meeting is planning a two-day program addressing problems of materials selection for coal conversion plants.

c. Pilot Plant Activities: A letter report was transmitted to Project Lignite and ERDA personnel concerning metallurgical investigation of defects and corrosion of the expansion loop between Dissolvers R-1A and R-1B of Project Lignite at the University of North Dakota Pilot Plant.

The design and materials of High Pressure Separators S-1 and S-2 and Dissolvers R-1A and R-1B were also evaluated.

3. Work Forecast For Next Quarter:

We will continue our participation in the ongoing programs of the Metals Property Council and the NACE activities.

K. Environmental Considerations

1. Objectives:

To define environmental factors and required facilities for proposed coal conversion complexes and to define product quality standards to meet environmental regulations for product users.

2. Activity Last Quarter:

We summarized federal and state statutes and regulations concerning coal conversion plants and ancillary facilities.

3. Activity Forecast Next Quarter:

Continue to advise and define environmental requirements as they affect each process. Review the Oil/Gas and Fischer-Tropsch designs as they are developed in order to ensure that environmental control facilities are incorporated.

L. General

1. Objectives:

To plan and define work efforts. Define short-term project objectives and priorities. Prepare recommendations to ERDA on actions to be taken.

2. Activity This Quarter:

a. Review Meeting: A progress review meeting was held at The Ralph M. Parsons Company offices in Pasadena on September 15 to 17 with ERDA representatives.

b. Papers: We prepared two invited papers presented to the 68th National AIChE meeting held in Los Angeles on November 19, 1975. The titles of these papers were "Oil/Gas Design Plant Criteria" and "Fischer-Tropsch Plant Design Criteria."

We presented an invited paper titled "Gaseous Environmental Factors in Coal Pyrolysis Plant Design" at the Joint Power Generation Conference held in Portland, Oregon on September 29 to October 2, 1975.

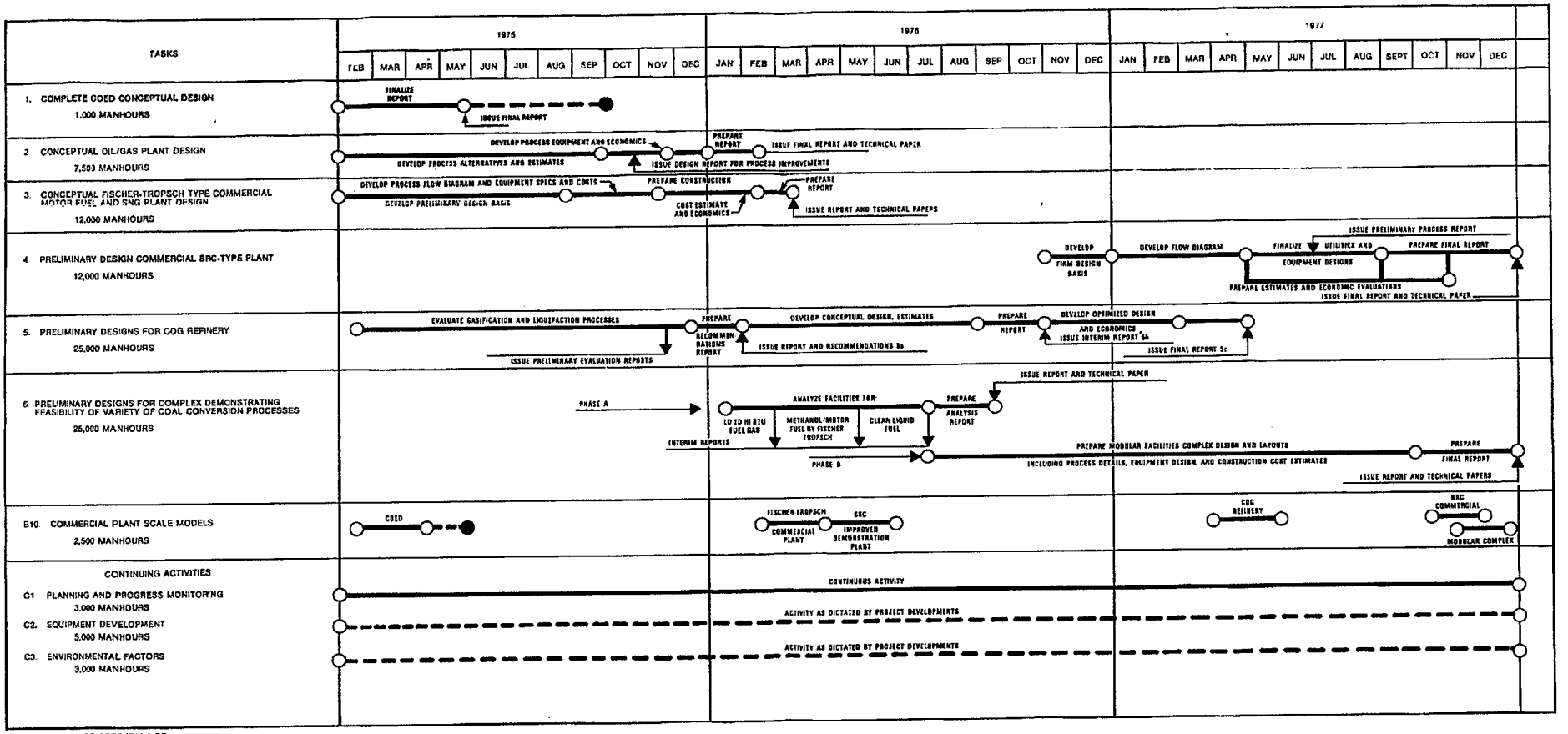
3. Activities Forecast Next Quarter:

a. Continue program surveillance and planning.
b. Present papers to organizations as described under 2b above.
c. Perform such miscellaneous services as requested by ERDA.

V. CONCLUSIONS

The design basis for the Fischer-Tropsch plant has been selected. Design efforts are now well underway.

The Oil/Gas plant design has commenced. Most of the required process studies have been completed. The detailed engineering design effort is now being emphasized.



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○ SCHEDULED

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● ACTUAL

Overall Program Schedule
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