SECTION 16

PROJECTED PERFORMANCE

16.1 INTRODUCTION

The conceptual POGO coal refinery contains four primary coal conversion units, which are:

- Hydroliquefaction using SRC II techniques; this is Unit 12.
- Pressurized flash pyrolysis of a mixture of coal and a vacuum distillation bottoms containing the coal ash and unreacted coal constituents from the hydroliquefaction unit; this is Unit 15.
- A two-stage pressurized entrained slagging process gasifier to produce syngas as precursor of hydrogen for use in the hydroliquefaction and hydrotreating units; this is Unit 18.
- A two-stage pressurized entrained fuel gas gasifier to produce an intermediate Btu gas for use in power generation; this is Unit 33.

The fixed capital investment for these coal conversion units represent approximately 20% of the total fixed capital investment for the complex.

In addition, the following three units process coal-derived liquids; there is a limited design base for these units.

- Heavy liquids hydrotreating, Unit 21.
- Thermal cracking, Unit 22.
- Coking, Unit 23.

These three units comprise approximately 10% of the complex's fixed capital investment.

A third category consists of units that have significant commercial experience in existing industries, such as coal mining, coal preparation, oil refineries, petrochemical plants, and power plants. These are:

- Coal mine, Unit 8.
- Coal preparation, Unit 9.
- Coal storage, grinding, and drying, Unit 10.

- Oxygen plant, Unit 11.
- SRC atmospheric distillation, Unit 13.
- SRC vacuum distillation, Unit 14.
- Pyrolysis atmospheric distillation, Unit 16.
- Sour gas compression, Unit 17.
- Shift conversion, Unit 19.
- Selective acid gas removal, Unit 20.
- Naphtha hydrotreating, Unit 24.
- Naphtha reforming, Unit 25.
- Olefinic gas/acid gas removal, Unit 26.
- Saturate gas/acid gas removal, Unit 27.
- Olefin recovery and polymerization, Unit 28
- Hydrogen recovery and purification, Unit 29.
- SNG purification, Unit 30.
- LPG fractionation, Unit 31.
- Sulfur plant, Unit 32.
- Fuel gas/acid gas removal, Unit 34.
- Steam and power generation, Unit 35.
- Process waste water treating, Unit 36.

The fixed capital investment for these 22 units plus related ancillaries represents about 65% of the total.

The projected performance of the four key coal conversion and three heavy liquids processing units will be emphasized in the following discussion.

16.2 GENERAL

The design is considered workable while recognizing that commercialization will require additional development and pilot plant work. This additional development will provide the data needed to confirm the projected operations and lead to confidence in final design, construction, and operation of efficient commercial plants. A number of these areas will be discussed below.

The selection of materials of construction for the high temperature and corrosive services consists of high alloy corrosion resistant materials specified to provide confidence they will perform suitably.

16.3 HYDROLIQUEFACTION; SRC II TECHNOLOGY

The DOE Tacoma, Washington, 50-ton-per-day pilot plant has been operating successfully in the SRC II mode during the latter half of 1977. It has operated relatively continuously for more than 60 days at the time of this writing. Sulfur contents in the range of 0.3 to 0.4 wt% for the distillate oil produced have been achieved.

Results to date indicate that this coal conversion unit will perform satisfactorily.

16.4 PYROLYZER

The basis for the conceptual design of the pressurized flash pyrolyzer has been described in Section 15 of this report. The incentive for use of this process step was defined during the course of predesign analysis efforts. Incentives included the ability to eliminate the troublesome filtration step from the hydroliquefaction unit plus the recovery of a significant amount of the liquids as saleable liquid products from the vacuum fractionator bottoms, which contain the solids scheduled for rejection.

Simultaneously, with the definition of incentives and the development of the pyrolyzer design procedures for this project, a recommendation was made to ERDA (DOE) to obtain experimental data to confirm the design. A small scale confirmatory program is underway under DOE sponsorship at Oak Ridge National Laboratory at the time of this writing. Very preliminary results to date indicate general corroboration of the yields employed in this design.

At this time, the flash pyrolyzer is expected to perform approximately as described in flow sheet R-15/16-FS-1. This performance should be confirmed in small scale and pilot plant operations.

To provide continuity of operation, two pyrolyzers are installed in parallel. Thus, in case of coking due to thermal upsets, operation could be switched to the standby unit while the other pyrolyzer is being decoked.

16.4.1 COAL FEED SIZE

The 70% minus 200 mesh coal feed size was selected as that which would be most likely to result in immediate flashing of volatiles with some assurance of recovery in the high energy cyclone systems. The piloting of a slightly coarser grind would be advisable in the interest of easier solids recovery with acceptable pyrolysis results.

16.4.2 COAL FEEDING

The pyrolizer is fed with dry coal by compression screw feeders. Screw feeders, and also alternate types, that will transfer ground coal from atmospheric conditions into reactors operating at moderate to high pressures are under development. The design anticipates that success will be achieved. The power requirement used in this design was estimated and extrapolated from similar operations at lower pressure.

16.5 PROCESS AND FUEL GAS GASIFIERS

Both gasifiers are the entrained bed type. Following preliminary process development unit (PDU) work, this type gasifier is currently being pilot-plant tested.

16.5.1 CHAR FEEDING

The feeding of char into the upper and lower stages of the process gasifier is by gravity flow aided by a small pressure differential. In addition, injection into the gasifier will be further assisted by eductors using reaction steam as the carrying fluid.

16.5.2 SLAG DISPOSAL

The slag disposal system provided in the gasifier design is of the type used successfully with slagging coal-fired boilers. These systems are also available for pressurized boiler operation.

16.6 SYNGAS HEAT RECOVERY

Syngas flows from the top of the gasifier through three parallel pairs of two-stage, high efficiency, hot cyclone systems for separation of the bulk of the char particles. The series of steam superheaters, steam generators are vertical straight tube heat exchangers. Ducts are refractory lined and abrasion resistant ceramic ferrules are fitted in the tube inlets. Thus, the turbulent entry area of the high temperature service tubes will be protected. The selection of special alloy tubes and shells was made to suit each level of temperature. Removal of better than 98% of the entrained abrasive char/ash solids by the hot cyclones from the raw gas stream immediately on leaving the gasifier minimizes the downstream erosion problem in the heat exchangers.

16.7 SYNGAS SOLIDS REMOVAL

Proper operation of the catalytic shift conversion reactors requires a clean gas feed virtually free of solids contaminants.

The two-stage, high efficiency, hot cyclones render the raw gas sufficiently clean for handling in the downstream heat exchangers. Further solids removal is accomplished in an electrostatic ionizer unit before the gas enters the shift conversion reactors. This is a relatively new type of electrostatic precipitation and collection device that has a higher charge intensity and is capable of handling greater gas velocities than conventional precipitators. This process has been successfully demonstrated on boiler stack gas cleaning service by TVA. Testing on gases containing entrained fine char/ash particulates is included in future test plans by the manufacturer, Air Pollution Systems, Inc.

16.8 HYDROTREATING AND REFORMING

These processes as applied in Units 21, 24, and 25 have been practiced successfully on crude oil sourced streams by the petroleum industry. The analyses of feedstocks produced in the POGO complex indicate them to be amenable to these catalytic processing methods.

Hydrotreating of coal-derived liquids has been practiced at the COED pilot plant located in Princeton, New Jersey. Considerable additional experimental work is underway by at least three DOE development contractors. Additional data is required regarding catalyst life, space velocities, and conversions. Flow sheet performance is expected, but should be confirmed by laboratory and pilot plant work on the specific feed stock involved.

16.9 THERMAL CRACKING AND DELAYED COKING

These operations are based on proven technology for crude oil sourced liquids in the petroleum industry. The coke calcining and purification system included in the design comprises proprietary equipment and processes provided by Kennedy Van Saun Corporation.

The thermal cracking and coking conceptual designs should be confirmed by laboratory and pilot plant work using specific feed stock of coal origin. Data from such developmental work will ensure an acceptable plant design.

16.10 OLEFIN RECOVERY AND POLYMERIZATION

The deethanization and oil absorption operations in this unit have their successful counterparts in the petroleum industry. This also applies to the catalytic condensation system, which is a proprietary process furnished by Universal Oil Products.

16.11 STEAM AND POWER GENERATION

The selected combined cycle mode system, utilizing gas turbines and unfired heat recovery steam generators, uses state-of-the-art equipment. Identical equipment is presently in production service by utility power firms. No developmental work should be necessary for this unit.

The system was selected as the result of comparing seven candidate power generation cycles. Three basic systems were involved in the studies; these are depicted in Figures 16-1, 16-2, and 16-3, and described as follows:

CYCLE I — Seventeen gas turbines, zero supplementary firing of 17 steam boilers, 4 steam turbines, and variable air extraction from the gas turbine compressors. This system is illustrated in Figure 16-1.

CYCLE II Thirteen gas turbines with supplementary firing of 13 steam boilers, 4 steam turbines, and variable air extraction from the gas turbine compressors (see Figure 16-2).

CYCLE III Four gas turbines, 4 fully fired waste heat steam generators, two steam turbines, and zero air extraction from the gas turbine compressors. The system uses the highest Rankine cycle efficiency currently available (see Figure 16-3).

Comparisons of the power cycle characteristics of the systems considered are tabulated in Table 16-1. Table 16-2 summarizes the power production and heat rate preference studies. Table 16-3 compares electrical power production costs. System I-C was selected as the optimum case for the POGO complex. This case proved to have the lowest heat rate, 7810 Btu/kWh, based on fuel gas feed, and the lowest production cost. System I-C is that diagrammed in Figure 16-1.

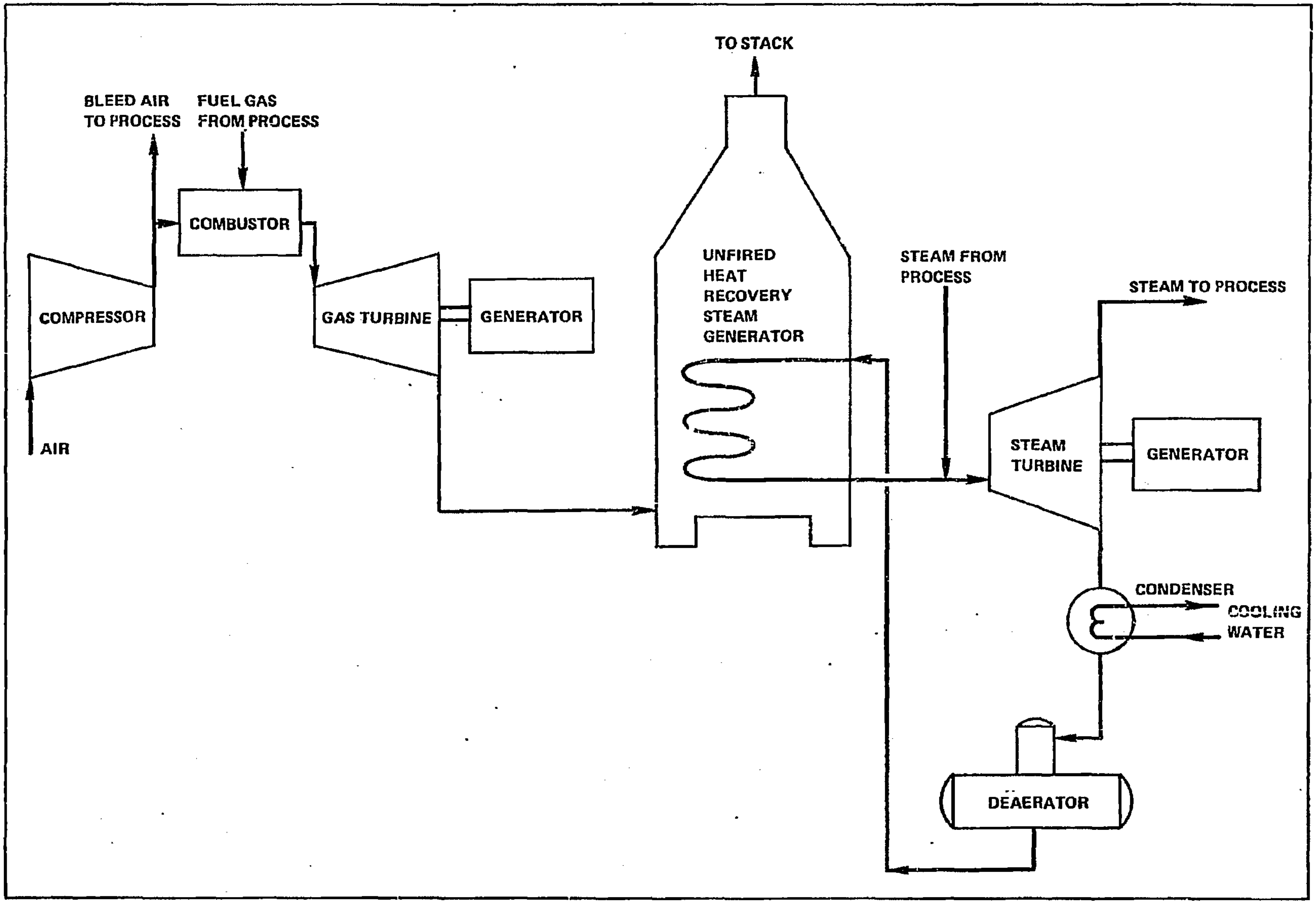

Figure 16-1 - Schematic of Power Cycle No. I

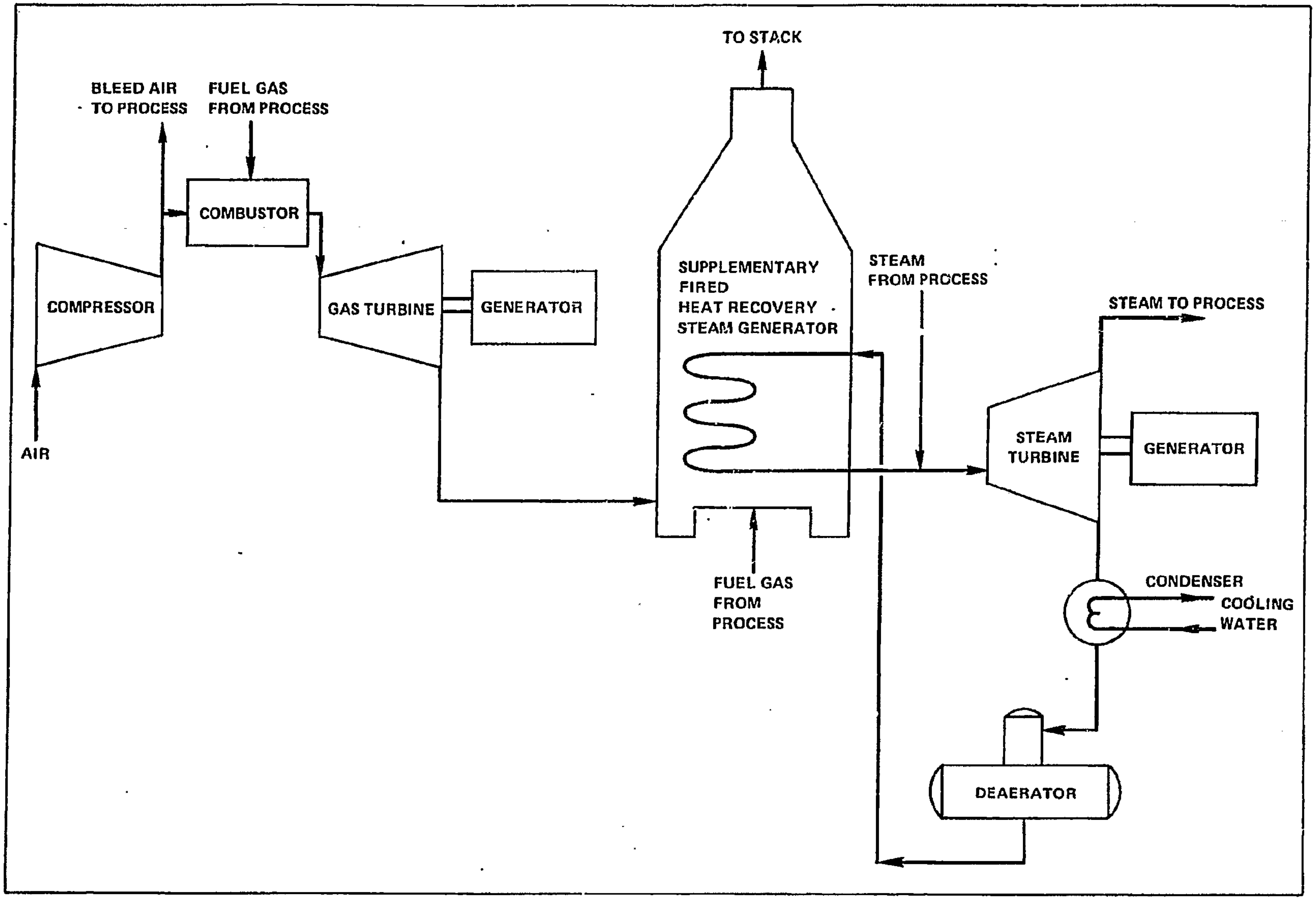

Figure 16-2 - Schematic of Power Cycle No. II

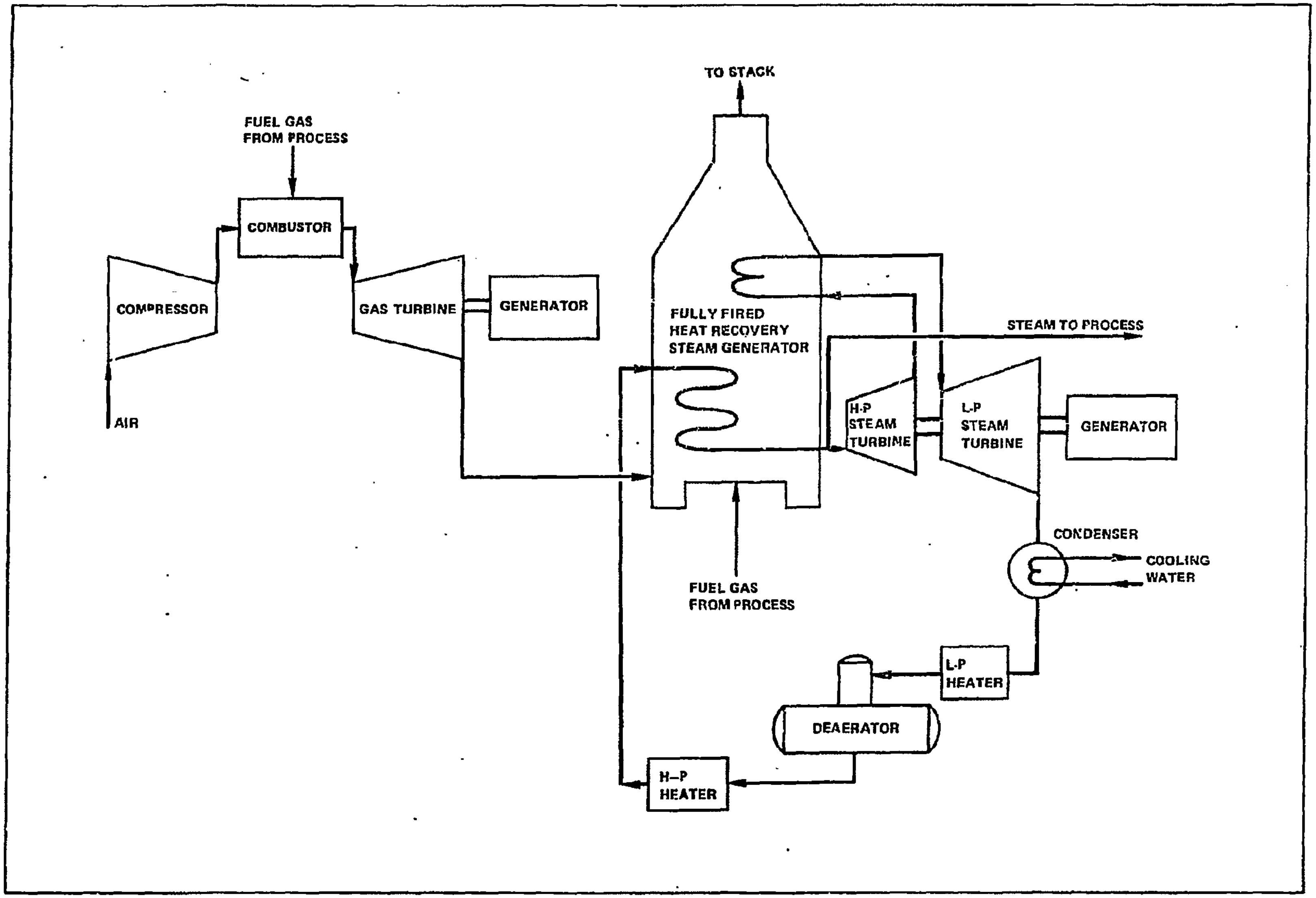

Figure 16-3 - Schematic of Power Cycle No. III

Table 16-1 - Power Cycle Characteristics

System Number	Number of Gas Turbines with Steam Boilers	Number of Steam Turbines	Percent Air Extraction (Feed to Oxygen Plant)	Supplementary Firing
I-a	17	4	0	No
I-b	17	4	5	No
I-c	17	4	10	No
II-a	13	4	0	Yes
II-b	13	4	5	Yes
II-c	13	4	10	Yes
III	4	2	0	Yes

Table 16-2 - Summary of Power Production and Heat Rate Preference Studies

System Number	Net Power Produced (MW)			Power to Process (MW)	Power for Sale (MW)	Compressed Air to Oxygen Plant		Net Power Produced (Electricity + Air) (MW)	Heat Rate(a) in Btu/kWh Produced, Based on	
	Gas Turbine	Steam Turbine	Total			MM PPH	MW Equivalent		Coal to Fuel Gasifier	Fuel Gas to Power Plant
I-a	1069	463	1532	532	1000	0	0	1532	8890	7815
I-b	993	463	1465	456	1000	1.6	71	1527	8915	7835
I-c	905	470	1375	375	1000	3.3	147	1522	8885	7810
II-a	832	702	1534	534	1000	0	0	1534	9365	8235
II-b	779	693	1472	472	1000	1.3	55	1527	9345	8215
II-c	714	692	1406	406	1000	2.5	116	1522	9280	8160
III	247	1295	1542	542	1000	0	0	1542	10,000	8795

(a) Includes credit for power equivalent for compressed air to process.

Table 16-3 - Preliminary Economics Summary - Power Plant Preference Studies

System Number	Net Power[a] Produced (MW)	Fixed Capital Investment ($000)	Operating Costs (mils/kWh)					Fixed[d] Charges (mils/kWh)	Total Cost (mils/kWh)
			Fuel[b]	Labor	Maintenance	Other[c]	Total		
I-a	1532	405	19.54	1.5	2.0	0.20	23.24	5.4	28.6
I-b	1527	405	19.59	1.5	2.0	0.20	23.29	5.4	28.7
I-c	1522	405	19.53	1.5	2.0	0.20	23.23	5.4	28.6
II-a	1534	389	20.59	1.5	2.1	0.24	24.43	5.1	29.5
II-b	1527	389	20.54	1.5	2.1	0.24	24.38	5.1	29.5
II-c	1522	389	20.40	1.5	2.1	0.24	24.24	5.1	29.3
II	1542	575	21.99	1.5	3.0	0.36	26.85	7.5	34.4

[a] From Table 16-2.

[b] Fuel Gas at $2.50 per million Btu.

[c] Includes cost of water at $0.20 per 1000 gallons.

[d] 16% fixed charges.