GAS TURBINE MODELING WITH PEPSE®

Thomas W. McColloch

Rochester Gas & Electric Corporation

Abstract

Gas turbines have become an attractive alternative for small base loaded electric generation units. Simple cycle, advanced design gas turbines have efficiencies approaching that of conventional regenerative steam cycles, and combined cycle (gas turbine with heat recovery steam generator and steam turbine) have efficiencies exceeding those of steam cycles. PEPSE can be used to model simple cycle, simple cycle with regenerator, steam injection cycle and combined cycle gas turbine plants.

PEPSE sub models were developed to analyze the various configurations of gas turbine cycles. The sub models were then combined with larger models to analyze full combined cycle plants. Electric generation, heat rates and thermal efficiency were calculated from the PEPSE model output.

Introduction

Rochester Gas and Electric serves the Upstate New York area, with corporate headquarters in Rochester, New York. Electric generation consists of a 500MW nuclear plant, five (5) coal units with a total output of 350MW, hydro-electric stations along the Genesee River with a total output of 50MW, and two (2) 15MW gas turbines. RG&E is also a partner with neighbor utilities for 200MW of oil fired generation and 150MW of nuclear. RG&E is a member of the New York Power Pool and will supply the pool or draw from the pool, depending upon the generating units available. Currently the nuclear plants are base loaded, the hydro plants will produce based upon the river flow, and the coal units will load swing on economic reserve.

RG&E currently has studies underway in several areas where gas turbines are being considered. The first is in the evaluation of new generating units, where gas turbines are being considered for the next increment of electric generation. Also under study is the repowering of one of the existing pulverized coal units with a gas turbine and heat recovery steam generator, making a combined cycle plant. Cogeneration using gas turbines is also being studied, with a third party providing steam and electricity to current RG&E customers. PEPSE is being used to help evaluate all of these gas turbine applications.

PEPSE Gas Turbine Models

A number of PEPSE gas turbine sub models were developed to cover a wide range of gas turbine cycles, as follows:

- Simple cycle
- Regenerative cycle
- Simple cycle with Heat Recovery Steam Generator
- Simple cycle with Steam Injection
- Combined cycle

* Simple Cycle

The simple cycle gas turbine heat balance for a typical 30MW machine is shown in Attachment 1A. Air at atmospheric conditions is compressed by the shaft driven air compressor. Natural gas fuel is compressed and then fired in the combustor. The high temperature and pressure exhaust is then expanded through the turbine and exhausted at atmospheric pressure. The pressure in the combustor varies upon application, from 100 PSIG to 450 PSIG. The combustion temperature varies from 1400°F to 2300°F. The higher temperatures and pressure result in a cycle with higher efficiency. The air to fuel ratio will determine the combustion temperature. On a mass basis, 55 to 1 air to fuel will result in a combustion temperature of approximately 1800°F. The exhaust temperature is typically 900-1000°F, and represents most of the thermal losses from the cycle. Simple cycle heat rates are typically 12,500 BTU/KWH with a cycle thermal efficiency of 27%.

The PEPSE schematic for this cycle is shown in Attachment 1B. The gas turbine is a component type 9, with the exhaust pressure and temperature specified to allow

PEPSE to calculate turbine efficiency. The combustor is a component type 70. The fuel compressor is a type 43 (motor driven) and the air compressor a type 44 (shaft driven). A type 61 fixed flow splitter is included to adjust the air to fuel ratio. A control is included to adjust the splitter "B" port flow to obtain the desired combustion temperature. Operations are included to calculate a heat rate and cycle efficiency.

* Regenerative Cycle

The next sub model includes a regenerator to recover some of the exhaust heat, as shown in the heat balance on Attachment 2A. In this cycle the air leaving the compressor is pre-heated by the exhaust gases prior to entering the combustor, thereby reducing the fuel required to obtain the desired combustion temperature. The exhaust gases typically are reduced in temperature by 300°F, which improves the heat rate to 9300 BTU/KWH and raises efficiency to 36%. A measure of performance of the regenerator is the effectiveness, which is the ratio of the actual temperature rise of the air divided by the maximum available temperature rise. This value is typically 85%.

The PEPSE schematic for this cycle is shown in Attachment 2B. The regenerator is a type 20 heat exchanger, with the exhaust gases on the tube side, the air from the compressor entering the "S" port and the heated air leaving at the "D" port. This allows the air temperature leaving the regenerator to be specified. To help the model converge, a double ended source is included between the regenerator outlet and the combustor inlet. This source provides the expected air temperature for the first few PEPSE iterations, then passes through the calculated temperature. The air flow rate is fixed at a value calculated from the simple cycle run, and fuel flow varied to obtain the desired combustion temperature. An operation is included to calculate the regenerator effectiveness.

* Simple Cycle with Heat Recovery Steam Generator

A heat recovery steam generator is next added to the simple cycle, as shown on the heat balance in Attachment 3A. The exhaust products are used to produce steam, thereby utilizing the heat and lowering the cycle exit temperature to 300°F. This improves overall cycle efficiency to 77%.

The PEPSE schematic is shown in Attachment 3B. The HRSG is a type 20 heat exchanger, with the exhaust gases on the tube side, the feedwater entering at the "S" port and the steam exiting at the "D" port. The heat exchanger is in the performance mode, which allows the steam conditions leaving the heat exchanger to be specified. A control is added to adjust the flow leaving the source component to produce the desired exhaust gas exit temperature.

* Simple Cycle with Steam Injection

The output of the gas turbine can be improved by increasing the mass flow through the turbine. This can be done by injecting steam into the turbine inlet to augment the exhaust flow from the combustor, as shown in the heat balance on Attachment 4A. This is done in applications where excess steam is available. The addition of approximately 6% steam (by mass) to the flow going to the turbine improves the heat rate to 11,200 BTU/KWH.

The PEPSE schematic is shown is Attachment 4B. A type 50 mixer is used to mix the injection steam and the gases, with the combustor exhaust going to the "IA" port and the steam to the "IB" part. The addition of steam reduces the temperature of the stream going to the turbine, so additional fuel is fired to provide a higher temperature leaving the combustor. A control on fuel flow is added to produce the desired 1800°F temperature at the mixer outlet versus the combustor outlet.

* Simple Cycle with HRSG in Design Mode

The HRSG can be separated into a three (3) zone heat exchanger, with separate economizer, evaporator and superheater sections. To simplify the analysis, the feedwater leaving the economizer is a saturated liquid, the steam leaving the evaporator is a saturated vapor and all of the superheat is added in the superheater. The heat balance is shown on Attachment 5A.

The PEPSE schematic, shown in Attachment 5B, uses type 28 heat exchangers to model each of the 3 zones. The physical dimensions and characteristics of each of the zones is input. Each zone has extended surface tubes, so the heat transfer area can be varied with the same outside unit dimensions. Additional double ended sources are added to help the model converge.

* Combined Cycle

The last cycle considered is a combined cycle, as shown in the heat balance in Attachment 6A. The steam produced in the HRSG is expanded through a steam turbine to generate additional electricity. This cycle maximizes the electrical production. With a condensing steam turbine, the cycle heat rate is 8800 BTU/KWH with a cycle efficiency of 38%.

The PEPSE schematic is shown in Attachment 6B. A splitter is included to direct steam to the turbine or to a process consumer. The steam turbine is modeled as a type 8 turbine, and a surface condenser is included. Operations are included to calculate heat rate and cycle efficiency.

Applications

These models were applied to two studies currently underway at RG&E. This first is a re-powering study of Unit 1 at RG&E Russell Station. Unit 1 is a 46MW, non-reheat, pulverized coal boiler which went on line in 1948. The study considers replacing the boiler with a gas turbine and HRSG, thereby supplying steam at the present conditions to the steam turbine (375,000 lb/hour, 1260 PSIA, 950F). The heat balance is shown in Attachment 7A, and the PEPSE schematic in Attachment 7B. This requires a gas turbine of 103MW, resulting in total unit output of 149MW. The heat rate of the combined cycle is 7500 BTU/KWH, versus 8800 for the steam cycle only. One interesting feature is that both heat rate and output are improved by removing feedwater heaters from service. The colder feedwater to the HRSG allows the exhaust gases to be cooled to a lower temperature, and the steam turbine output increases with the reduced extraction flow. The heat rate improves to 7200 BTU/KWH with generation of 153 MW when bypassing heaters 2 through 5.

A cogeneration combined cycle was also analyzed using PEPSE. Attachment 8A shows the heat balance proposed by a vendor who wants to sell electricity to RG&E and steam/hot water to a local process consumer. The schematic shown in Attachment 8B was developed to help analyze the cycle and determine the potential electric/steam/hot water production.

Conclusions

The PEPSE output for various cycles was compared with data from gas turbine vendors. In general, PEPSE predicts approximately 10% less exhaust flow than that in the published vendor data. Often the cycle is not fully characterized by the vendor, so the comparison of stream conditions is difficult. Further study of the vendor data may be required to reconcile the differences in predicted cycle performance.

A summary of the various cycles is as follows:

Cycle Description	Gross Heat Rate BTU/KWH	Thermal Efficiency, %	Exhaust Temp, °F	Output MW
Simple	12,500	27	1,000	29.9
Regenerator	9,300	36	670	28.9
Simple w/HRSG	12,500	77 (1)	300	29.9
Steam Injection	11,200	63 (1,2)	300	35.0
Combined	8,800	38 (3)	300	42.6

Notes:

1) Assumes all steam produced is utilized.

2) Assumes 6% steam injection.

3) Assumes all steam is expanded through condensing turbine.

List of Attachments

Number	Description	
1A	Simple Cycle	- Heat Balance
1B		- PEPSE Schematic
1C		- PEPSE Input File
2A	Regenerative Cycle	- Heat Balance
2B		- PEPSE Schematic
2C		- PEPSE Input File
3A	Heat Recovery Cycle	- Heat Balance
3B		- PEPSE Schematic
3C		- PEPSE Input File
4A	Steam Injection Cycle	- Heat Balance
4B		- PEPSE Schematic
4C		- PEPSE Input File
5A	Design Mode HRSG	- Heat Balance
5B		- PEPSE Schematic
5C		- PEPSE Input File
6A	Combined Cycle	- Heat Balance
6B		- PEPSE Schematic
6C		- PEPSE Input File
7A	Repowering Study	- Heat Balance
7B		- PEPSE Schematic
7C		- PEPSE Input File
8A	Cogeneration Study	- Heat Balance
8B		- PEPSE Schematic
8C		- PEPSE Input File

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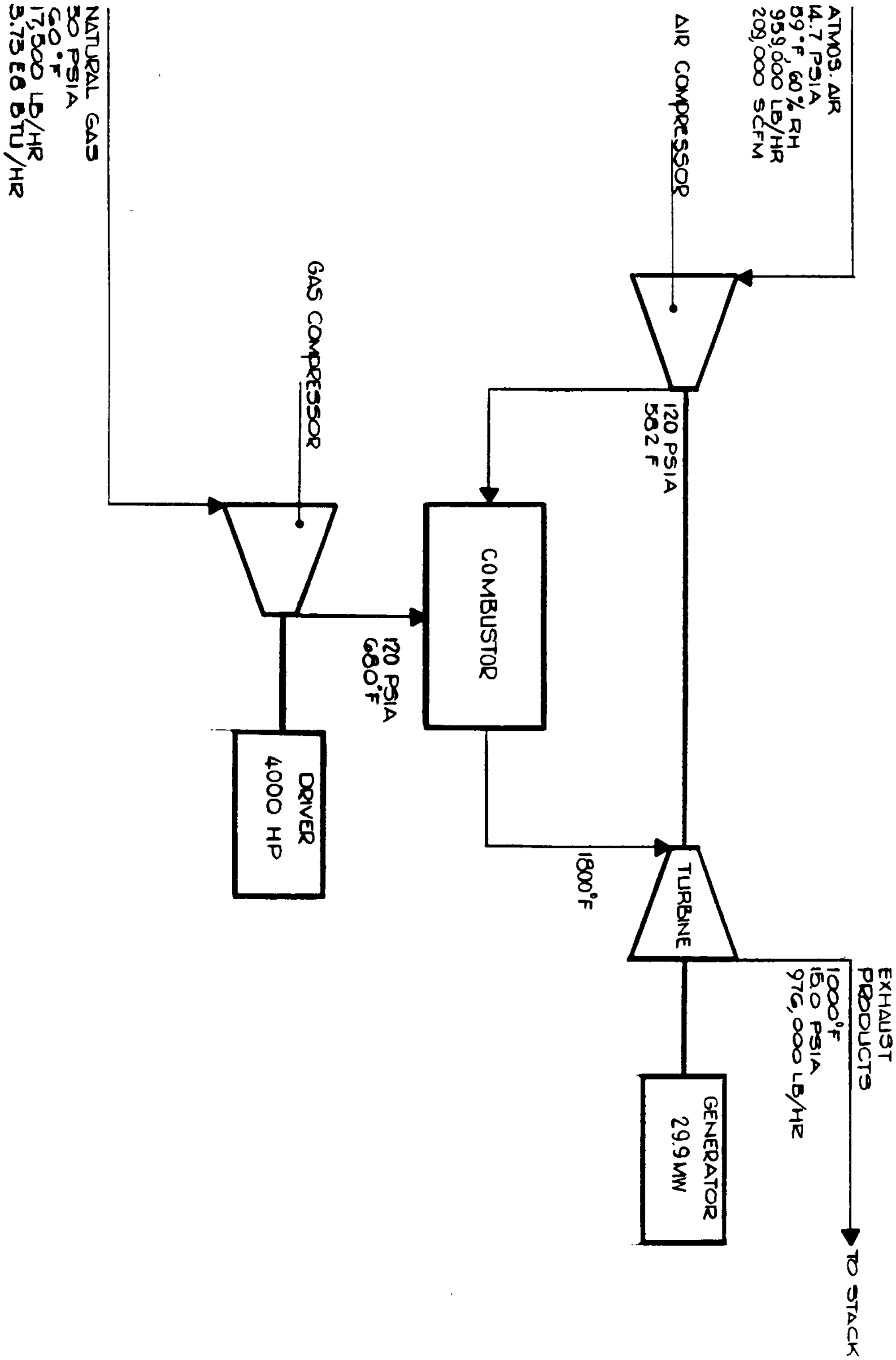
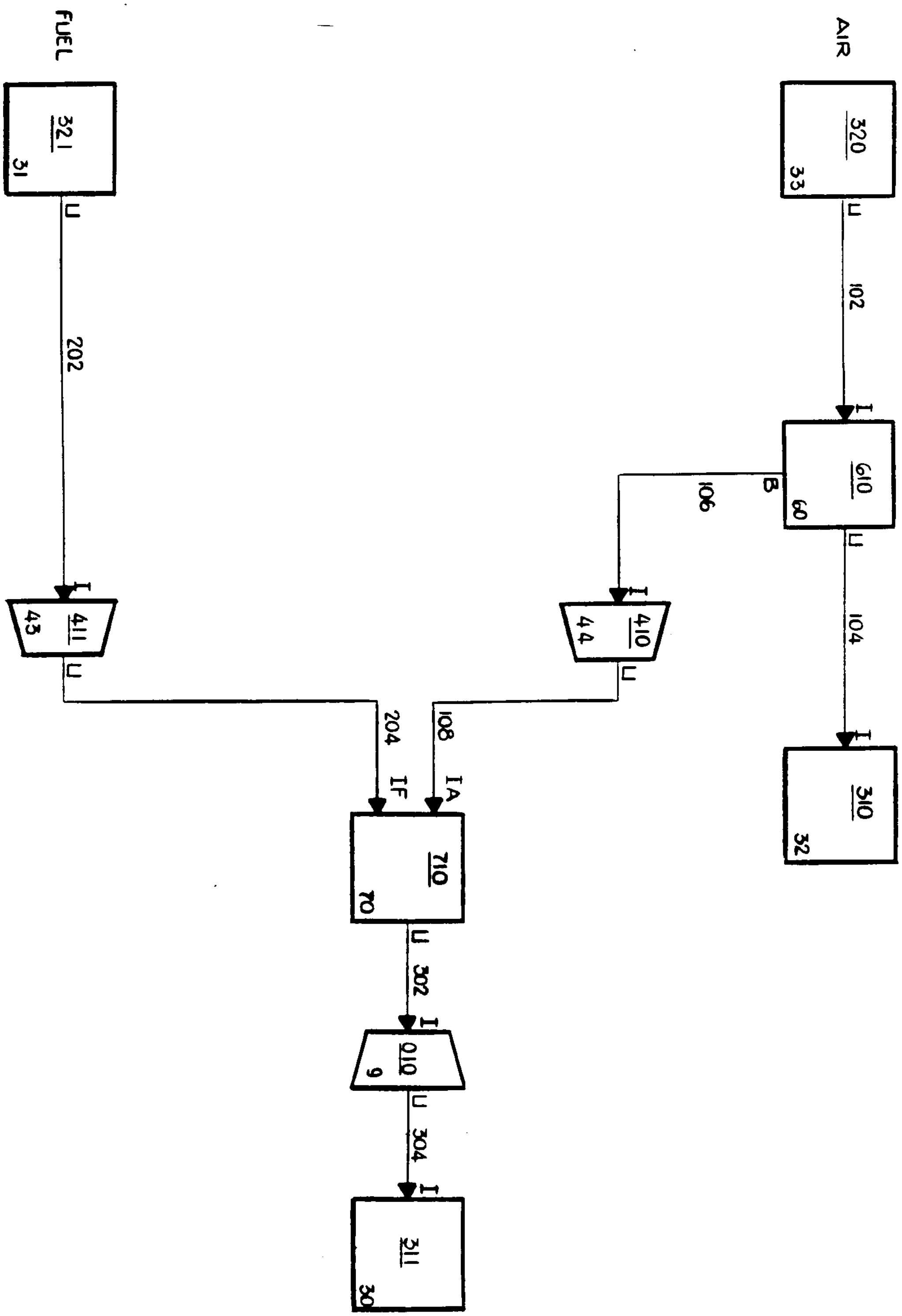


HEAT BALANCE
GAS TURBINE CYCLE



PEPSE SCHEMATIC
GAS TURBINE CYCLE

LISTING OF INPUT DATA FOR CASE 1

```
  SIMPLE CYCLE GAS TURBINE (EXAMPLE NUMBER 1)
* CONTROL ON AIR FLOW TO PROVIDE 1800F TURBINE INLET TEMP
012000 25
010200 3,0,1,0,0
011010 1,2,5,0,3600,32000.,.85,45.,45.
011011 200. 350.
* TABLE SUPPRESSION
020001 NOPRNT
020002 NOPRNT
020004 NOPRNT
020005 NOPRNT
020012 NOPRNT
020013 NOPRNT
020016 NOPRNT
020020 NOPRNT
020021 NOPRNT
020022 NOPRNT
020023 NOPRNT
020025 NOPRNT
020026 NOPRNT
020028 NOPRNT
020034 NOPRNT
020037 NOPRNT
020042 NOPRNT
* GEOMETRY INPUT
501020 320, U, 610, I
501040 610, U, 310, I
501060 610, B, 410, I
501080 410, U, 710, IA
502020 321, U, 411, I
502040 411, U, 710, IF
503020 710, U,  10, I
503040  10, U, 311, I
* TURBINE DATA
700100 9 1 2 1 6
700106 15. 1000.
* SOURCE AND SINK DATA
703100 32
703110 30
703200 33 59. 14.7 2.E6
703203 AIR .6
703210 31 60. 30. 17500.
703213 FUEL 21300. SSVL 44.5 C .754 H2 .234 N2 .012
* COMPRESSOR DATA
704100 44 1 120. 1. .8
704110 43 120. 1. 1. .8
* SPLITTER DATA
706100 61 0. 1.E6
* COMBUSTOR DATA
707100 70 0 2 0 0.
* CONTROL ON EXCESS AIR TO PRODUCE DESIRED GAS TEMP
840100 WWFIXB 610 1800. 0. 1. TT 302
* OPERATIONAL VARIABLES
870010 21300.
870020 1000.
870030 3412.
* CALCULATE GROSS CYCLE HEAT RATE
880010 WW 202 MUL OPVB 1 OPVB 4
880020 BKGRO 1 MUL OPVB 2 OPVB 5
880030 OPVB 4 DIV OPVB 5 OPVB 6
* CALCULATE OVERALL CYCLE EFFICIENCY
880040 OPVB 5 MUL OPVB 3 OPVB 7
880050 OPVB 7 DIV OPVB 4 OPVB 8
* PRINT OUTPUT VARIABLES
890100 'GENERATOR ELECTRICAL OUTPUT, MW'
890101 BKGRO 1
890200 'GROSS CYCLE HEAT RATE, BTU/KWH'
890201 OPVB 6
890300 'CYCLE THERMAL EFFICIENCY'
890301 OPVB 8
*
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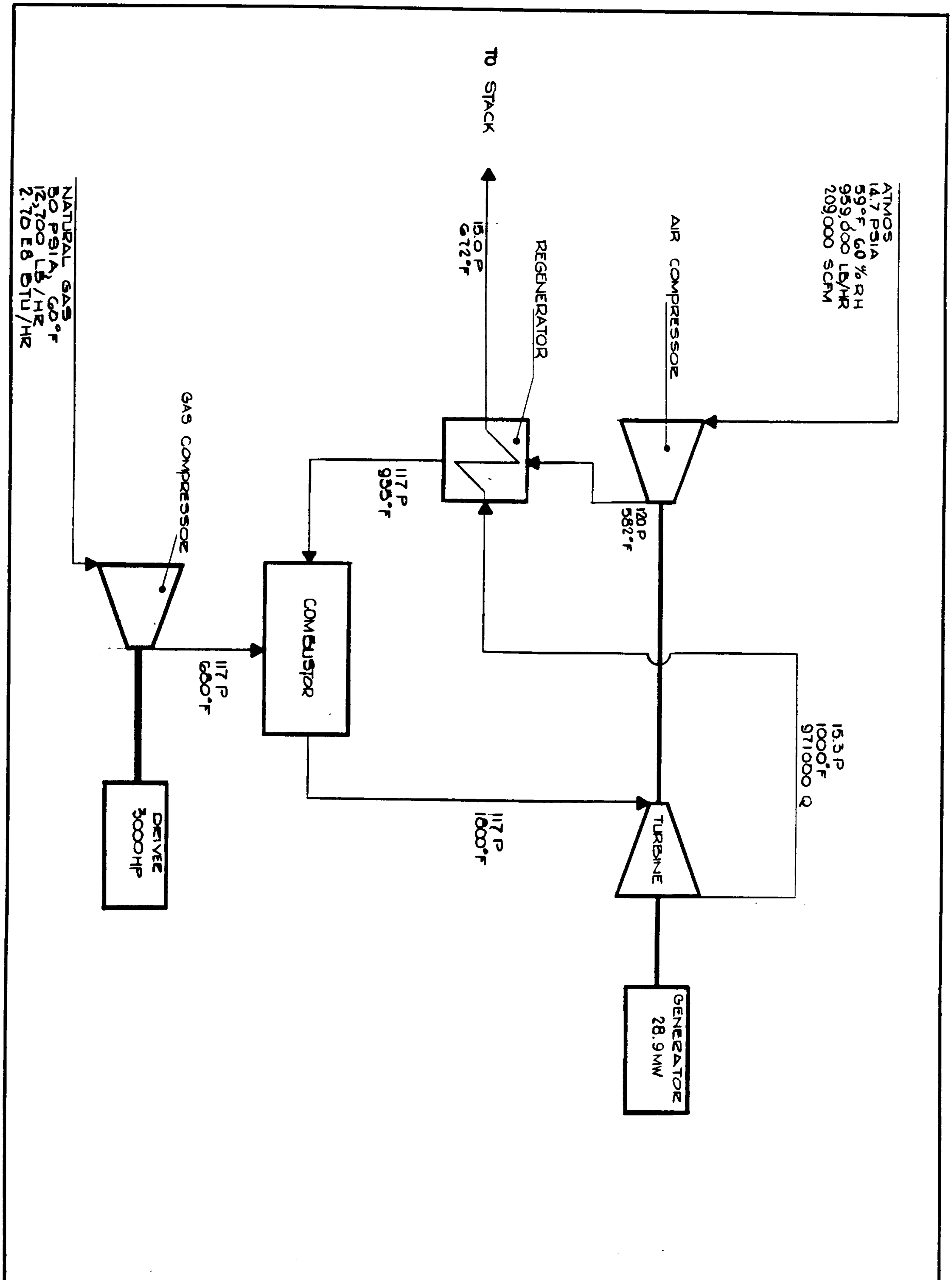
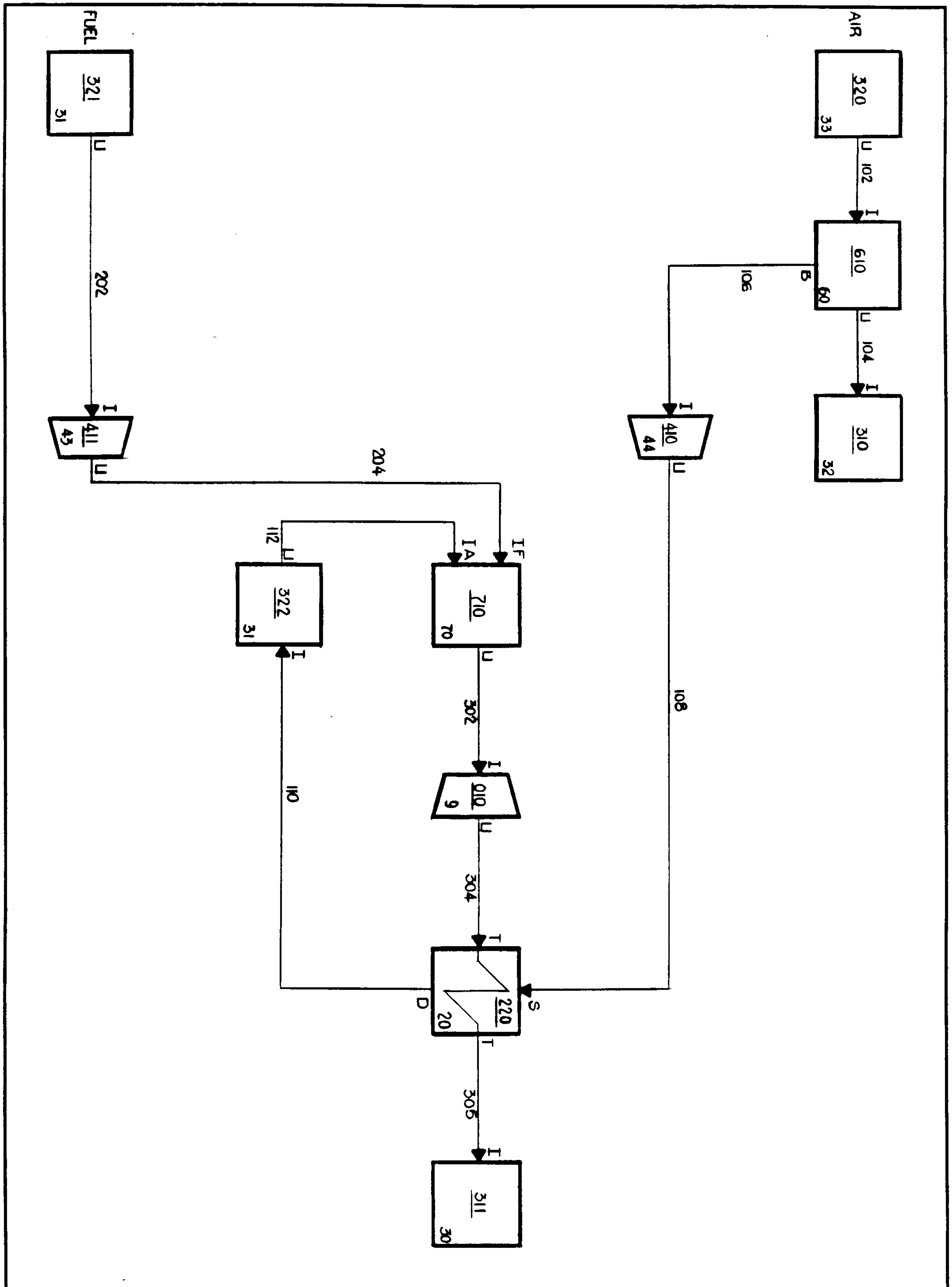


HEAT BALANCE
GAS TURBINE W/REGENERATION



PEPSE SCHEMATIC
GAS TURBINE CYCLE W/REGENERATOR

LISTING OF INPUT DATA FOR CASE 1

```
   SIMPLE CYCLE GAS TURBINE WITH REGENERATOR (EXAMPLE NUMBER 2)
 * AIR FLOW RATE EQUALS THAT OF SIMPLE CYCLE W/O REGEN
 * CONTROL ON FUEL FLOW TO PROVIDE 1800F TURBINE INLET TEMP
 012000 25
 010200 3,0,1,0,0
 011010 1,2,5,0,3600,32000.,.85,45.,45.
 011011 200. 350.
 * TABLE SUPPRESSION
 020001 NOPRNT
 020002 NOPRNT
 020004 NOPRNT
 020005 NOPRNT
 020013 NOPRNT
 020016 NOPRNT
 020020 NOPRNT
 020021 NOPRNT
 020022 NOPRNT
 020023 NOPRNT
 020025 NOPRNT
 020026 NOPRNT
 020028 NOPRNT
 020034 NOPRNT
 020037 NOPRNT
 020042 NOPRNT
 * GEOMETRY INPUT
 501020 320, U, 610, I
 501040 610, U, 310, I
 501060 610, B, 410, I
 501080 410, U, 220, S
 501100 220, D, 322, I
 501120 322, U, 710, IA
 502020 321, U, 411, I
 502040 411, U, 710, IF
 503020 710, U,  10, I
 503040  10, U, 220, T
 503050 220, T, 311, I
 * TURBINE DATA
 700100 9 1 2 1 6
 700106 15.3 1000.
 * REGENERATOR DATA
 702200 20 935. .02 .02 .02
 * SOURCE AND SINK DATA
 703100 32
 703110 30
 703200 33 59. 14.7 2.E6
 703203 AIR .6
 703210 31 60. 30. 13200.
 703213 FUEL 21300. SSVL 44.5 C .754 H2 .234 N2 .012
 703220 31 900. 115. 9.58562E5
 703223 AIR
 703222 5
 * COMPRESSOR DATA
 704100 44 1 120. 1. .8
 704110 43 120. 1. 1. .8
 * SPLITTER DATA
 706100 61 0. 9.58562E5
 * COMBUSTOR DATA
 707100 70 0 2 0 0.
 * CONTROL ON FUEL FLOW TO PRODUCE DESIRED GAS TEMP
 840100 WWVSC 321 1800. 0. 1. TT 302
 * OPERATIONAL VARIABLES
 870010 21300.
 870020 1000.
 870030 3412.
 * CALCULATE CYCLE HEAT RATE
 880010 WW 202 MUL OPVB 1 OPVB 4
 880020 BKGRD 1 MUL OPVB 2 OPVB 5
 880030 OPVB 4 DIV OPVB 5 OPVB 6
 * CALCULATE OVERALL CYCLE EFFICIENCY
 880040 OPVB 5 MUL OPVB 3 OPVB 7
 880050 OPVB 7 DIV OPVB 4 OPVB 8
 * CALCULATE REGENERATOR EFFECTIVENESS
 880060 TT 110 SUB TT 108 OPVB 9
 880070 TT 304 SUB TT 108 OPVB 10
 880080 OPVB 9 DIV OPVB 10 OPVB 11
 * PRINT OUTPUT VARIABLES
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```
890100 'GENERATOR ELECTRICAL OUTPUT, MW'
890101 BKGRD 1
890200 'REGENERATOR EFFECTIVENESS'
890201 OPVB 11
890300 'GROSS CYCLE HEAT RATE, BTU/KWH'
890301 OPVB 6
890400 'CYCLE THERMAL EFFICIENCY'
890401 OPVB 8
*
.
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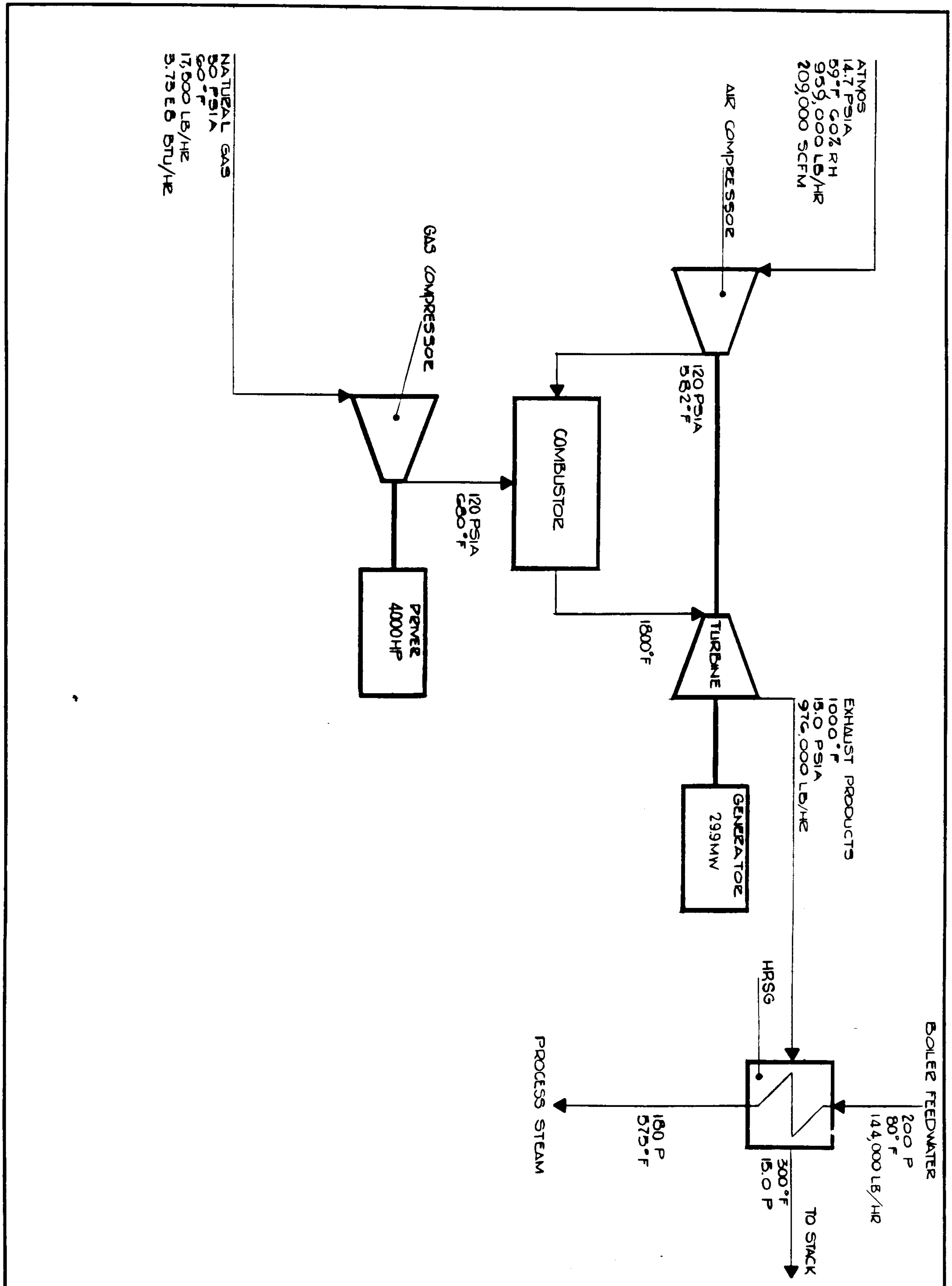
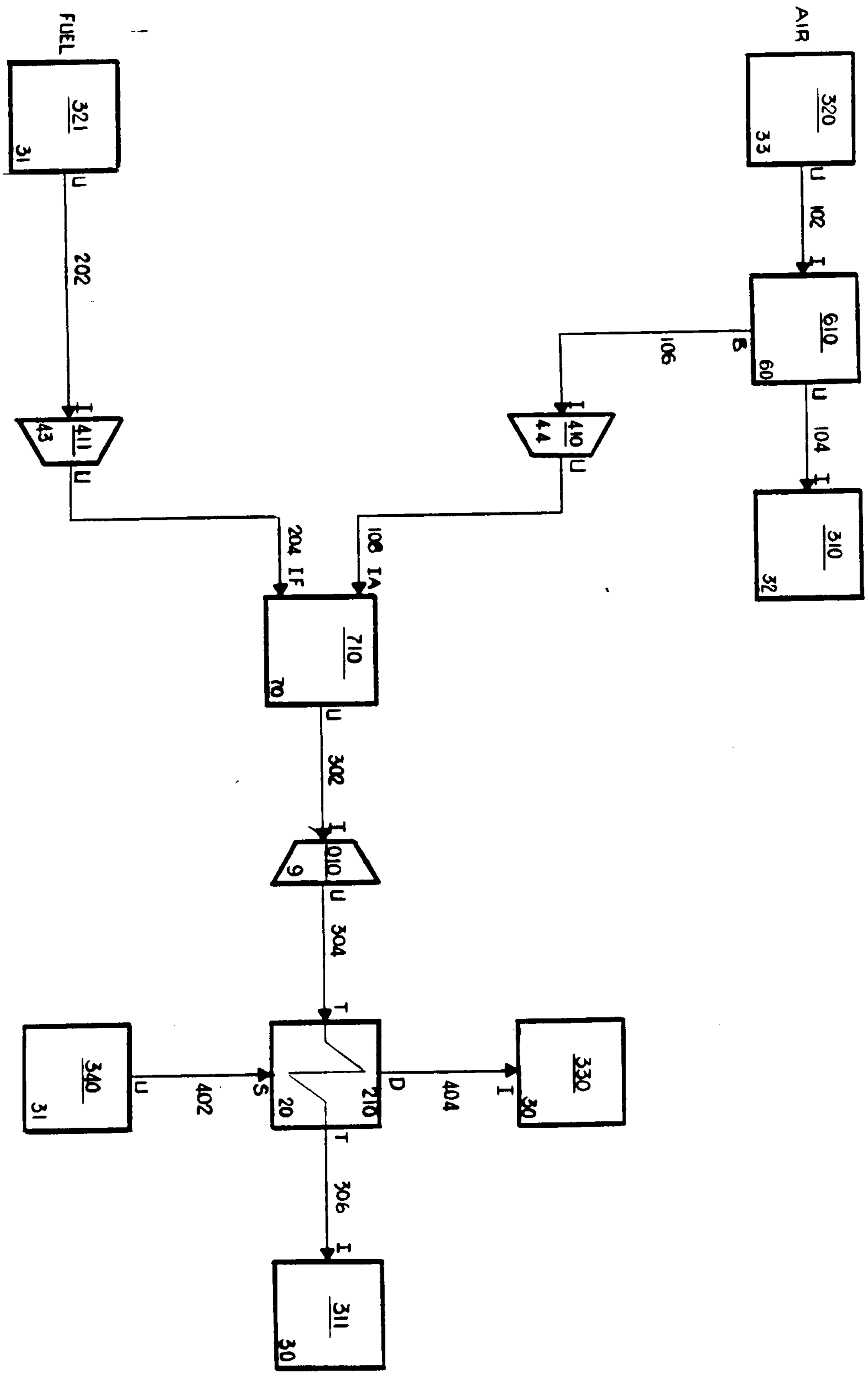


HEAT BALANCE
GAS TURBINE CYCLE W/HRSG

CONTACT SUPPLY



PEPSE SCHEMATIC
GAS TURBINE W/HRSG

LISTING OF INPUT DATA FOR CASE 1

```
  SIMPLE CYCLE GAS TURBINE WITH HRSG (EXAMPLE NUMBER 3)
* HRSG IN PERFORMANCE MODE
* CONTROL ON EXCESS AIR TO PROVIDE 1800F TURBINE INLET TEMP
* CONTROL ON BFW FLOW TO PRODUCE 300F HRSG GAS EXIT TEMP
012000 25
010200 3,0,1,0,0
011010 1,2,5,0,3600,32000.,.85,45.,45.
011011 200. 350.
* TABLE SUPPRESSION
020001 NOPRNT
020002 NOPRNT
020004 NOPRNT
020005 NOPRNT
020013 NOPRNT
020016 NOPRNT
020020 NOPRNT
020021 NOPRNT
020022 NOPRNT
020023 NOPRNT
020025 NOPRNT
020026 NOPRNT
020028 NOPRNT
020034 NOPRNT
020037 NOPRNT
020042 NOPRNT
* GEOMETRY INPUT
501020 320, U, 610, I
501040 610, U, 310, I
501060 610, B, 410, I
501080 410, U, 710, IA
502020 321, U, 411, I
502040 411, U, 710, IF
503020 710, U,  10, I
503040  10, U, 210, T
503060 210, T, 311, I
504020 340, U, 210, S
504040 210, D, 330, I
* TURBINE DATA
700100 9 1 2 1 6
700106 15.3 1000.
* HRSG DATA
702100 20 575. 0. .1 .02
* SOURCE AND SINK DATA
703100 32
703110 30
703200 33 59. 14.7 2.E6
703203 AIR .6
703210 31 60. 30. 17500.
703213 FUEL 21300. SSVL 44.5 C .754 H2 .234 N2 .012
703300 30
703400 31 80. 200. 150000.
* COMPRESSOR DATA
704100 44 1 120. 1. .8
704110 43 120. 1. 1. .8
* SPLITTER DATA
706100 61 0. 1.E6
* COMBUSTOR DATA
707100 70 0 2 0 0.
* CONTROL ON EXCESS AIR TO PRODUCE DESIRED GAS TEMP
840100 WWFIXB 610 1800. 0. 1. TT 302
840109 8.E5 1.3E6
* CONTROL ON BFW FLOW TO PRODUCE HRSG OUTLET TEMP
840200 WWVSC 340 300. 0. 1. TT 306
840209 1.E5 2.E5
* OPERATIONAL VARIABLES
870010 21300.
870020 1000.
870030 3412.
* CALCULATE CYCLE HEAT RATE
880010 WW 202 MUL OPVB 1 OPVB 4
880020 BKGRD 1 MUL OPVB 2 OPVB 5
880030 OPVB 4 DIV OPVB 5 OPVB 6
* CALCULATE OVERALL CYCLE EFFICIENCY
880040 BBSTRM 402 ADD OPVB 4 OPVB 7
880050 OPVB 5 MUL OPVB 3 OPVB 8
880060 BBSTRM 404 ADD OPVB 8 OPVB 9
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880070 OPVB 9 DIV OPVB 7 OPVB 10
* PRINT OUTPUT VARIABLES
890100 'GENERATOR ELECTRICAL OUTPUT, MW'
890101 BKGRD 1
890200 'GROSS CYCLE HEAT RATE, BTU/KWH'
890201 OPVB 6
890300 'CYCLE THERMAL EFFICIENCY'
890301 OPVB 10
*
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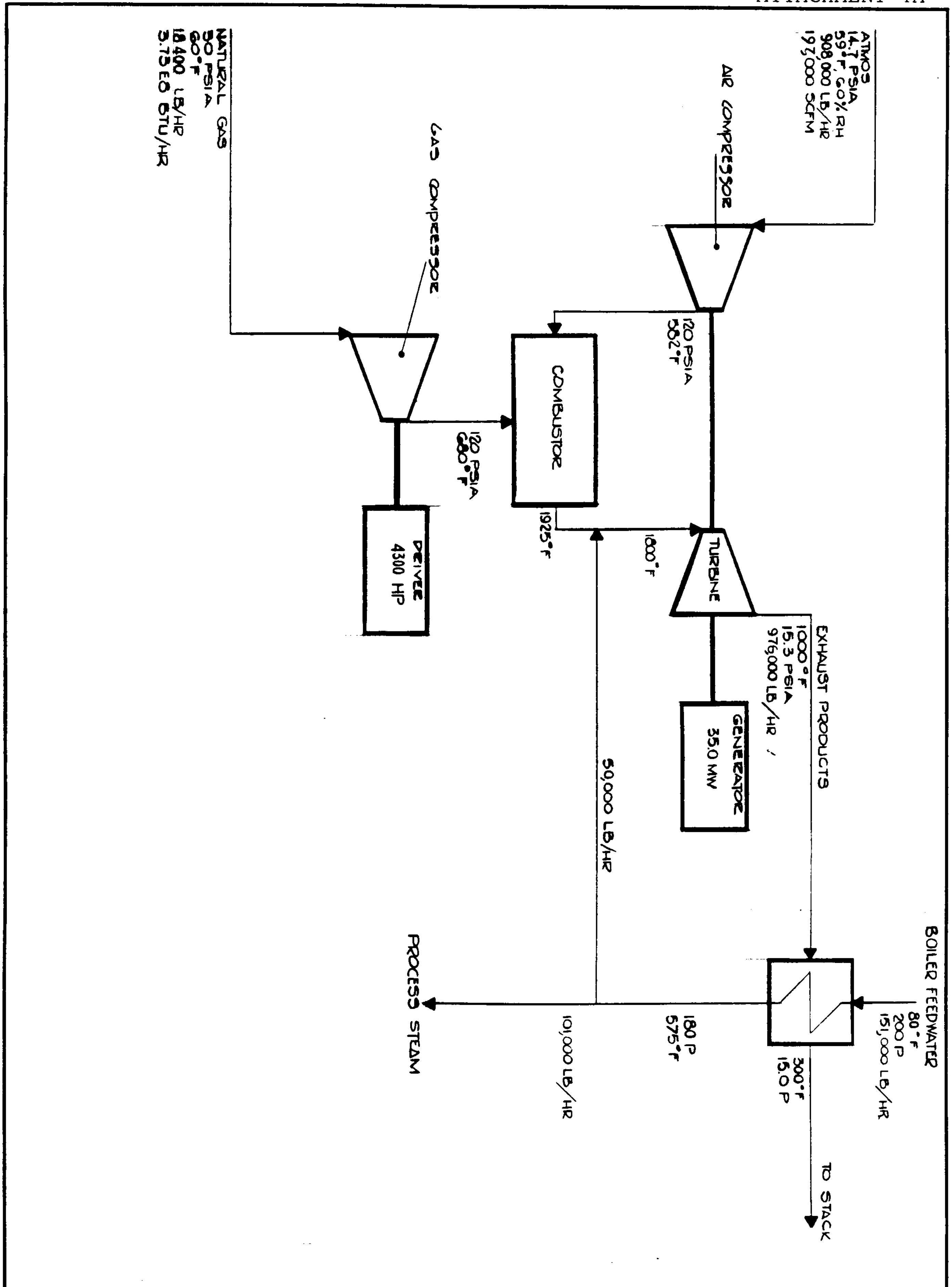
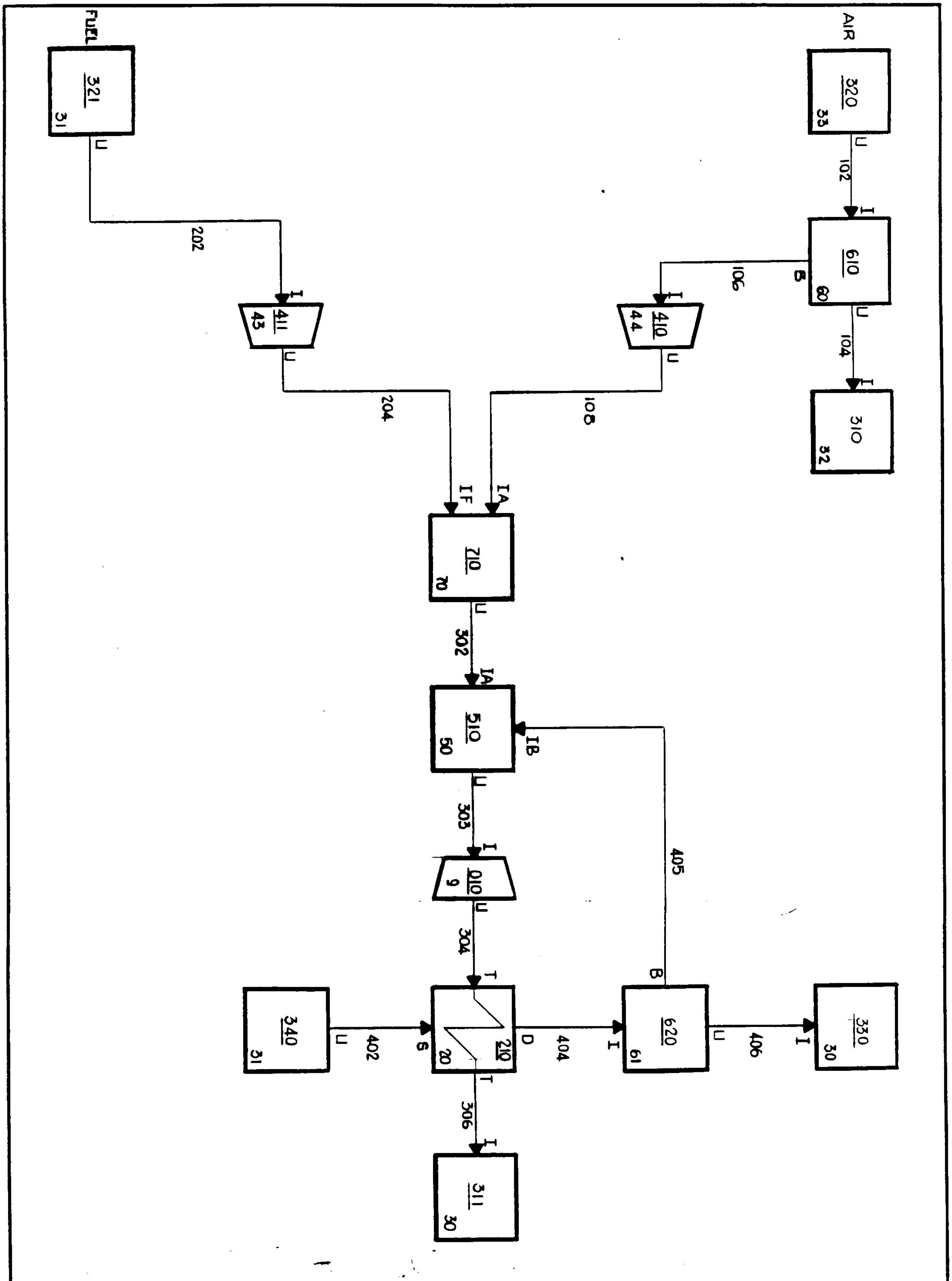


HEAT BALANCE
GAS TURBINE CYCLE W/HRSG & STEAM INJECTION



PEPSE SCHEMATIC
GAS TURBINE CYCLE - STEAM INJECTION

LISTING OF INPUT DATA FOR CASE 1

```
  SIMPLE CYCLE GAS TURBINE WITH HRSG AND STEAM INJECTION
* (EXAMPLE NUMBER 4)
* TOTAL MASS FLOW RATE THROUGH TURBINE EQUAL TO SIMPLE CYCLE
* CONTROL ON FUEL TO PROVIDE 1800F TURBINE INLET TEMP
* CONTROL ON BFW FLOW TO PRODUCE 300F HRSG GAS EXIT TEMP
012000 25
010200 3,0,1,0,0
011010 1,2,5,0,3600,32000.,.85,45.,45.
011011 200. 350.
* TABLE SUPPRESSION
020001 NOPRNT
020002 NOPRNT
020004 NOPRNT
020005 NOPRNT
020013 NOPRNT
020016 NOPRNT
020020 NOPRNT
020021 NOPRNT
020022 NOPRNT
020023 NOPRNT
020025 NOPRNT
020026 NOPRNT
020028 NOPRNT
020034 NOPRNT
020037 NOPRNT
020042 NOPRNT
* GEOMETRY INPUT
501020 320, U, 610, I
501040 610, U, 310, I
501060 610, B, 410, I
501080 410, U, 710, IA
502020 321, U, 411, I
502040 411, U, 710, IF
503020 710, U, 510, IA
503030 510, U,  10, I
503040  10, U, 210, T
503060 210, T, 311, I
504020 340, U, 210, S
504040 210, D, 620, I
504050 620, B, 510, IB
504060 620, U, 330, I
* TURBINE DATA
700100 9 1 2 1 6
700106 15.3 1000.
* HRSG DATA
702100 20 575. 0. .1 .02
* SOURCE AND SINK DATA
703100 32
703110 30
703200 33 59. 14.7 2.E6
703203 AIR .6
703210 31 60. 30. 17500.
703213 FUEL 21300. SSVL 44.5 C .754 H2 .234 N2 .012
703300 30
703400 31 80. 200. 150000.
* COMPRESSOR DATA
704100 44 1 120. 1. .8
704110 43 120. 1. 1. .8
* MIXER DATA
705100 50 1
* SPLITTER DATA
706100 61 0. .9077E6
706200 61 0. 5.E4
* COMBUSTOR DATA
707100 70 0 2 0 0.
* CONTROL ON FUEL TO PRODUCE DESIRED GAS TEMP
840100 WWVSC 321 1800. 0. 1. TT 303
* CONTROL ON BFW FLOW TO PRODUCE HRSG OUTLET TEMP
840200 WWVSC 340 300. 0. 1. TT 306
840209 1.E5 3.E5
* OPERATIONAL VARIABLES
870010 21300.
870020 1000.
870030 3412.
* CALCULATE CYCLE HEAT RATE
880010 WW 202 MUL OPVB 1 OPVB 4
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880020 BKGRO 1 MUL OPVB 2 OPVB 5
880030 OPVB 4 DIV OPVB 5 OPVB 6
* CALCULATE OVERALL CYCLE EFFICIENCY
880040 BBSTRM 402 ADD OPVB 4 OPVB 7
880050 OPVB 5 MUL OPVB 3 OPVB 8
880060 OPVB 8 ADD BBSTRM 406 OPVB 9
880070 OPVB 9 DIV OPVB 7 OPVB 10
* PRINT OUTPUT VARIABLES
890100 'GENERATOR ELECTRICAL OUTPUT, MW'
890101 BKGRO 1
890200 'GROSS CYCLE HEAT RATE, BTU/KWH'
890201 OPVB 6
890300 'CYCLE THERMAL EFFICIENCY'
890301 OPVB 10
*
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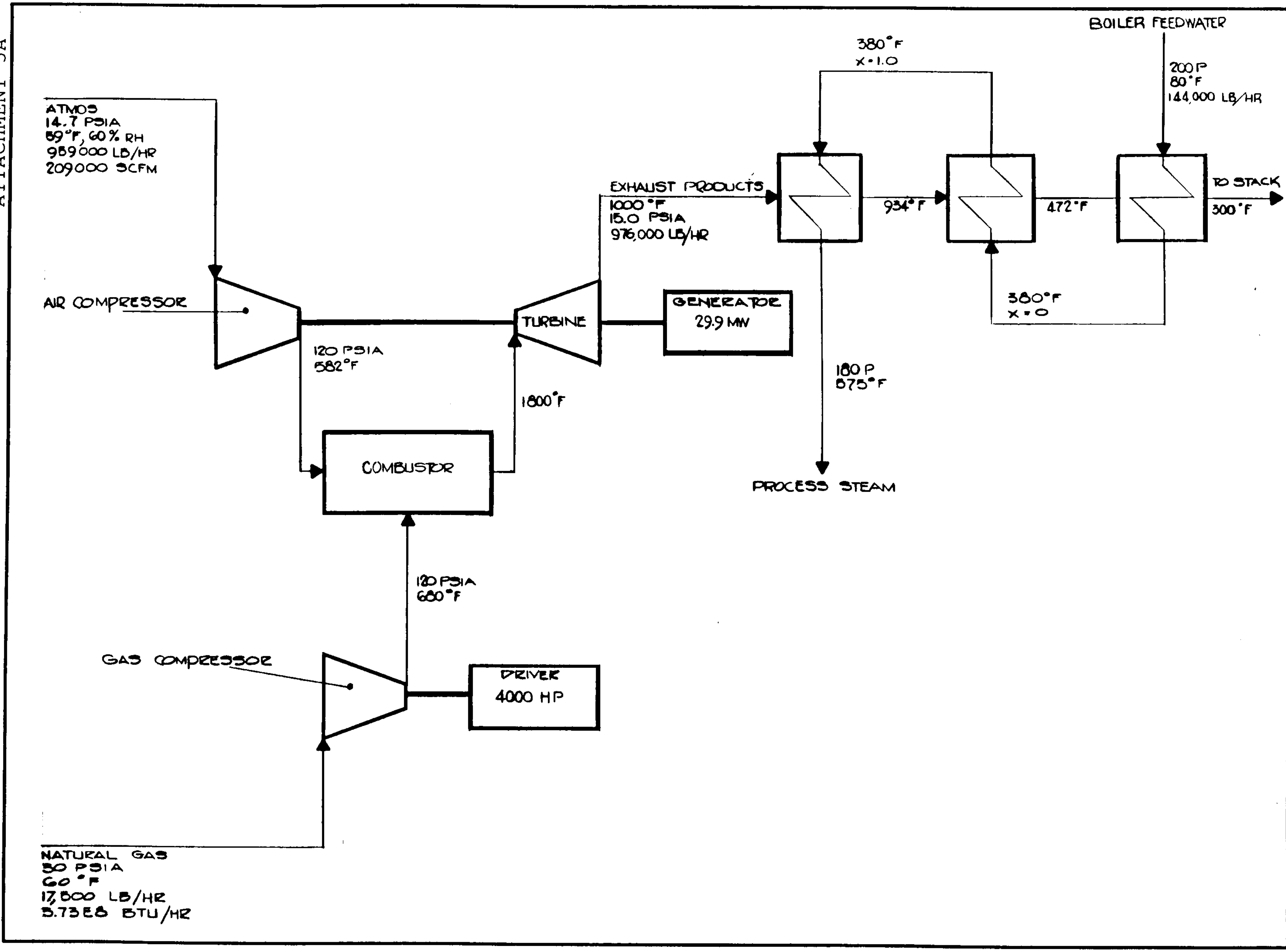
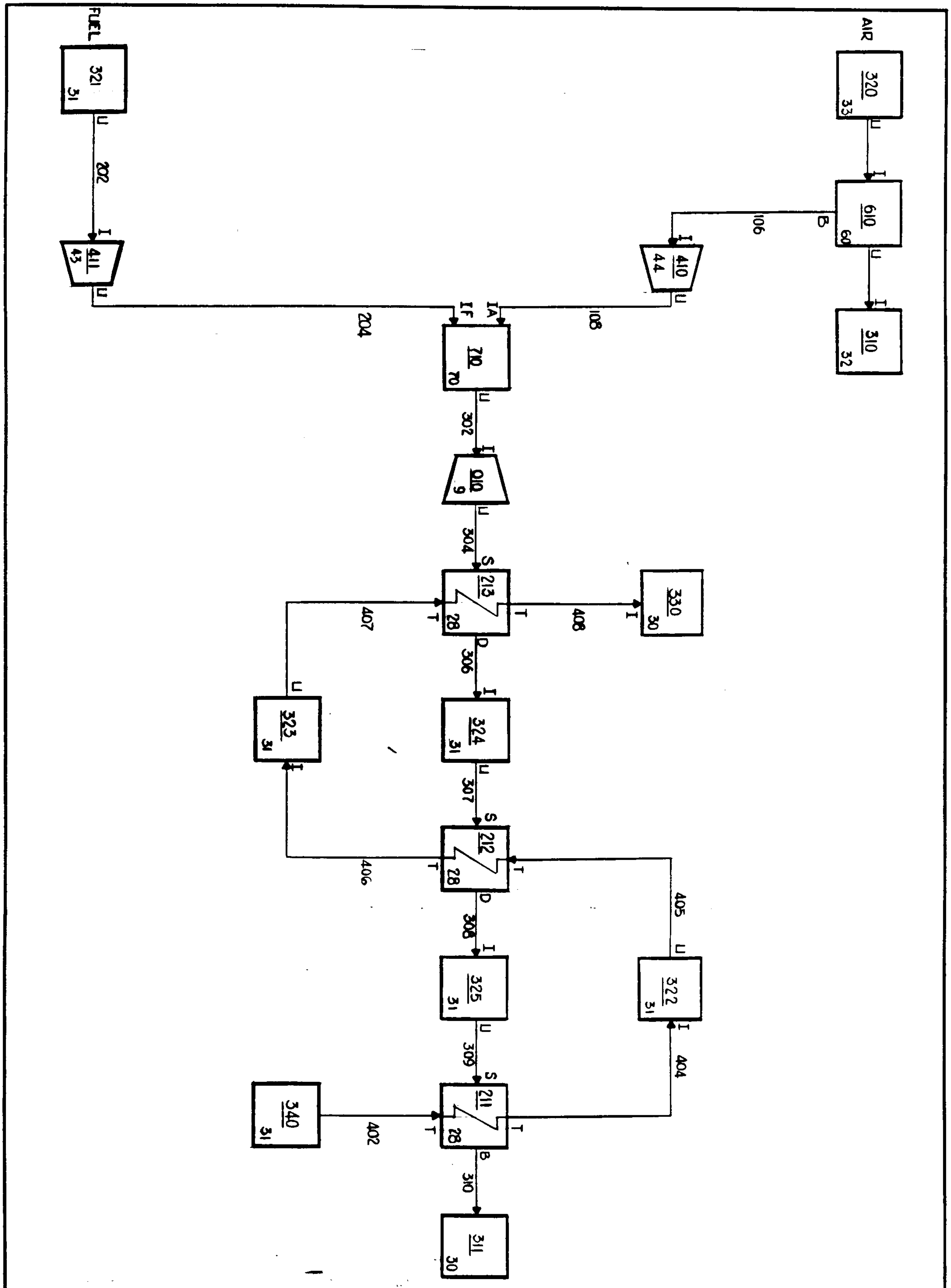


HEAT BALANCE
GAS TURBINE CYCLE W/HRSG IN DESIGN MODE

CONTACT SUPPLY



PEPSE SCHEMATIC
GAS TURBINE W/ HRSG
DESIGN MODE

LISTING OF INPUT DATA FOR CASE 1

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   SIMPLE CYCLE GAS TURBINE WITH HRSG (EXAMPLE NUMBER 5)
* CONTROL ON EXCESS AIR TO PROVIDE 1800F TURBINE INLET TEMP
* HRSG IN DESIGN MODE (3 ZONE)
* ADDITONAL DOUBLE ENDED SOURCES ADDED TO HELP CONVERGENCE
* CONTROLS ON HRSG SURFACE AREAS TO PRODUCE DESIRED GAS TEMPS
012000 25
010200 3,0,1,0,0
011010 1,2,5,0,3600,32000.,.85,45.,45.
011011 200. 350.
* TABLE SUPPRESSION
020001 NOPRNT
020002 NOPRNT
020004 NOPRNT
020005 NOPRNT
020013 NOPRNT
020016 NOPRNT
020020 NOPRNT
020021 NOPRNT
020022 NOPRNT
020023 NOPRNT
020025 NOPRNT
020026 NOPRNT
020028 NOPRNT
020034 NOPRNT
020037 NOPRNT
020042 NOPRNT
* GEOMETRY INPUT
501020 320, U, 610, I
501040 610, U, 310, I
501060 610, B, 410, I
501080 410, U, 710, IA
502020 321, U, 411, I
502040 411, U, 710, IF
503020 710, U,  10, I
503040  10, U, 213, S
503060 213, D, 324, I
503070 324, U, 212, S
503080 212, D, 325, I
503090 325, U, 211, S
503100 211, D, 311, I
504020 340, U, 211, T
504040 211, T, 322, I
504050 322, U, 212, T
504060 212, T, 323, I
504070 323, U, 213, T
504080 213, T, 330, I
* TURBINE DATA
700100 9 1 2 1 6
700106 15. 1000.
* HRSG DATA
* ECONOMIZER
702110 28 1 150000. 200. 230.
702114 2 0 3 15. 6. 12. 4. 25. 4. 1.9
702115 2. 12. 2.5 0. 0. .9 25. 0. 0. 0.
702116 0. 30000.
* EVAPORATOR
702120 28 1 150000. 190. 350.
702124 2 0 3 15. 6. 12. 10. 25. 1. 1.9
702125 2. 12. 2.5 0. 0. .9 25. 0. 0. 0.
702126 0. 12000.
* SUPERHEATER
702130 28 1 150000. 180. 375.
702134 2 1 3 15. 6. 12. 4. 25. 4. 1.9
702135 2. 12. 2.5 0. 0. .9 25. 0. 0. 0.
702136 0. 1100.
* SOURCE AND SINK DATA
703100 32
703110 30
703200 33 59. 14.7 2.E6
703203 AIR .6
703210 31 60. 30. 17500.
703213 FUEL 21300. SSVL 44.5 C .754 H2 .234 N2 .012
703220 31 0. 199. 144265.
703222 5
703230 31 1. 198. 144265.
703232 5
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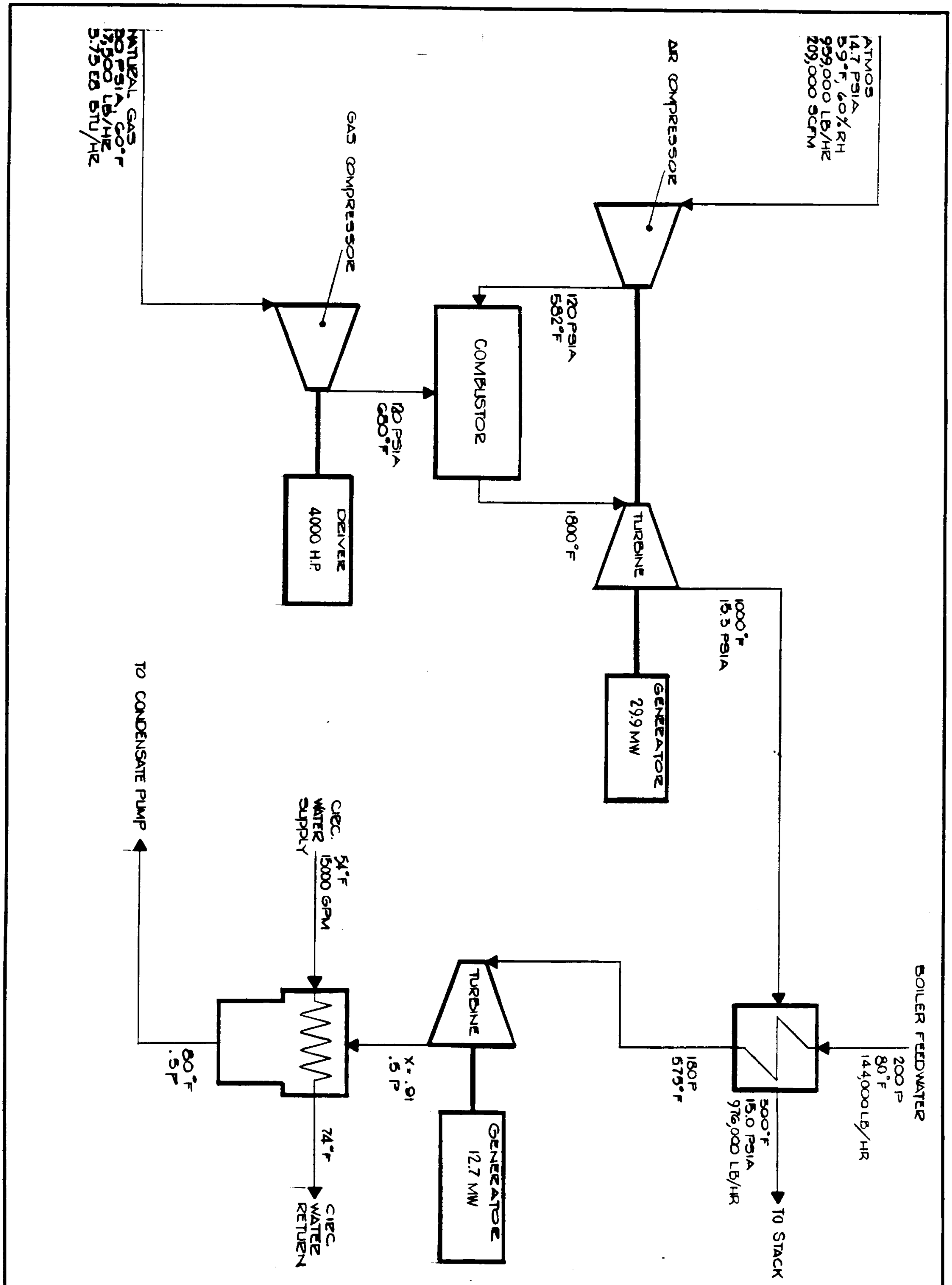
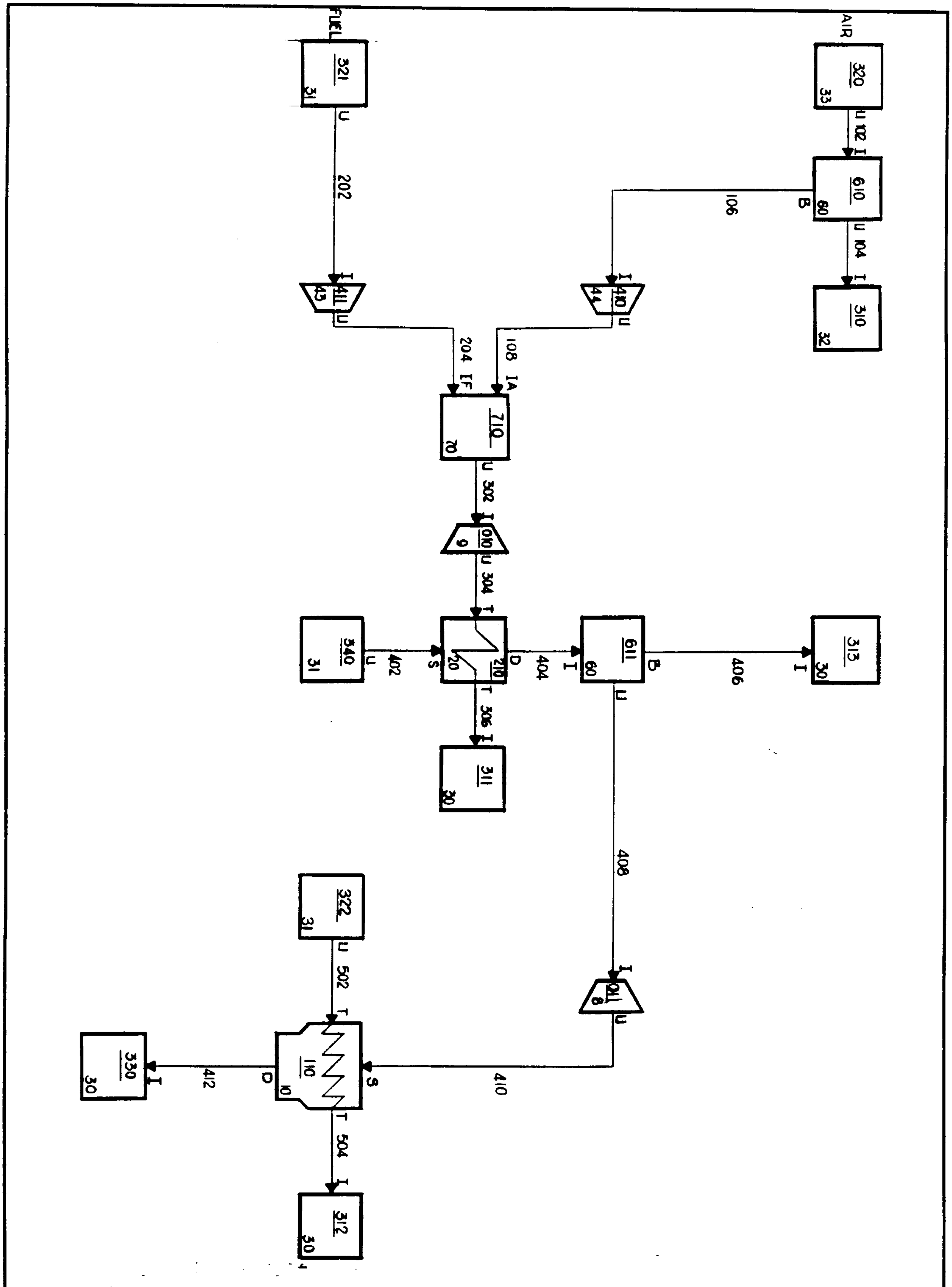
703240 31 934. 15. 976062.
703242 5
703243 CO2 .04953 H2O .04371 O2 .15660 N2 .75016
703250 31 472. 15. 976062.
703252 5
703253 CO2 .04953 H2O .04371 O2 .15660 N2 .75016
703300 30
703400 31 80. 200. 144265.
* COMPRESSOR DATA
704100 44 1 120. 1. .8
704110 43 120. 1. 1. .8
* SPLITTER DATA
706100 61 0. 1.E6
* COMBUSTOR DATA
707100 70 0 2 0 0.
* CONTROL ON EXCESS AIR TO PRODUCE DESIRED GAS TEMP
840100 WWFIXB 610 1800. 0. 1. TT 302
* CONTROL ON SUPERHEATER AREA
840200 AATIRH 213 934. .005 1. TT 306
840209 500. 1500.
* CONTROL ON EVAPORATOR AREA
840300 AATIRH 212 472. .01 1. TT 308
840309 12000. 13000.
* CONTROL ON ECONOMIZER AREA
840400 AATIRH 211 300. .01 1. TT 310
840409 28000. 32000.
* OPERATIONAL VARIABLES
870010 21300.
870020 1000.
870030 3412.
* CALCULATE CYCLE HEAT RATE
880010 WW 202 MUL OPVB 1 OPVB 4
880020 BKGRO 1 MUL OPVB 2 OPVB 5
880030 OPVB 4 DIV OPVB 5 OPVB 6
* CALCULATE OVERALL CYCLE EFFICIENCY
880040 BBSTRM 408 SUB BBSTRM 402 OPVB 7
880050 OPVB 5 MUL OPVB 3 OPVB 8
880060 OPVB 7 ADD OPVB 8 OPVB 9
880070 OPVB 9 DIV OPVB 4 OPVB 10
* CALCULATE HRSG LMTD VALUES
880100 HTTURH 211 MUL AATIRH 211 OPVB 11
880110 BBHXFL 211 DIV OPVB 11 OPVB 12
880120 HTTURH 212 MUL AATIRH 212 OPVB 13
880130 BBHXFL 212 DIV OPVB 13 OPVB 14
880140 HTTURH 213 MUL AATIRH 213 OPVB 15
880150 BBHXFL 213 DIV OPVB 15 OPVB 16
* PRINT OUTPUT VARIABLES
890100 'GENERATOR ELECTRICAL OUTPUT, MW'
890101 BKGRO 1
890200 'GROSS CYCLE HEAT RATE, BTU/KWH'
890201 OPVB 6
890300 'CYCLE THERMAL EFFICIENCY'
890301 OPVB 10
890400 'ECONOMIZER LMTD, F'
890401 OPVB 12
890500 'EVAPORATOR LMTD, F'
890501 OPVB 14
890600 'SUPERHEATER LMTD, F'
890601 OPVB 16
*
.
```



HEAT BALANCE
GAS TURBINE - COMBINED CYCLE



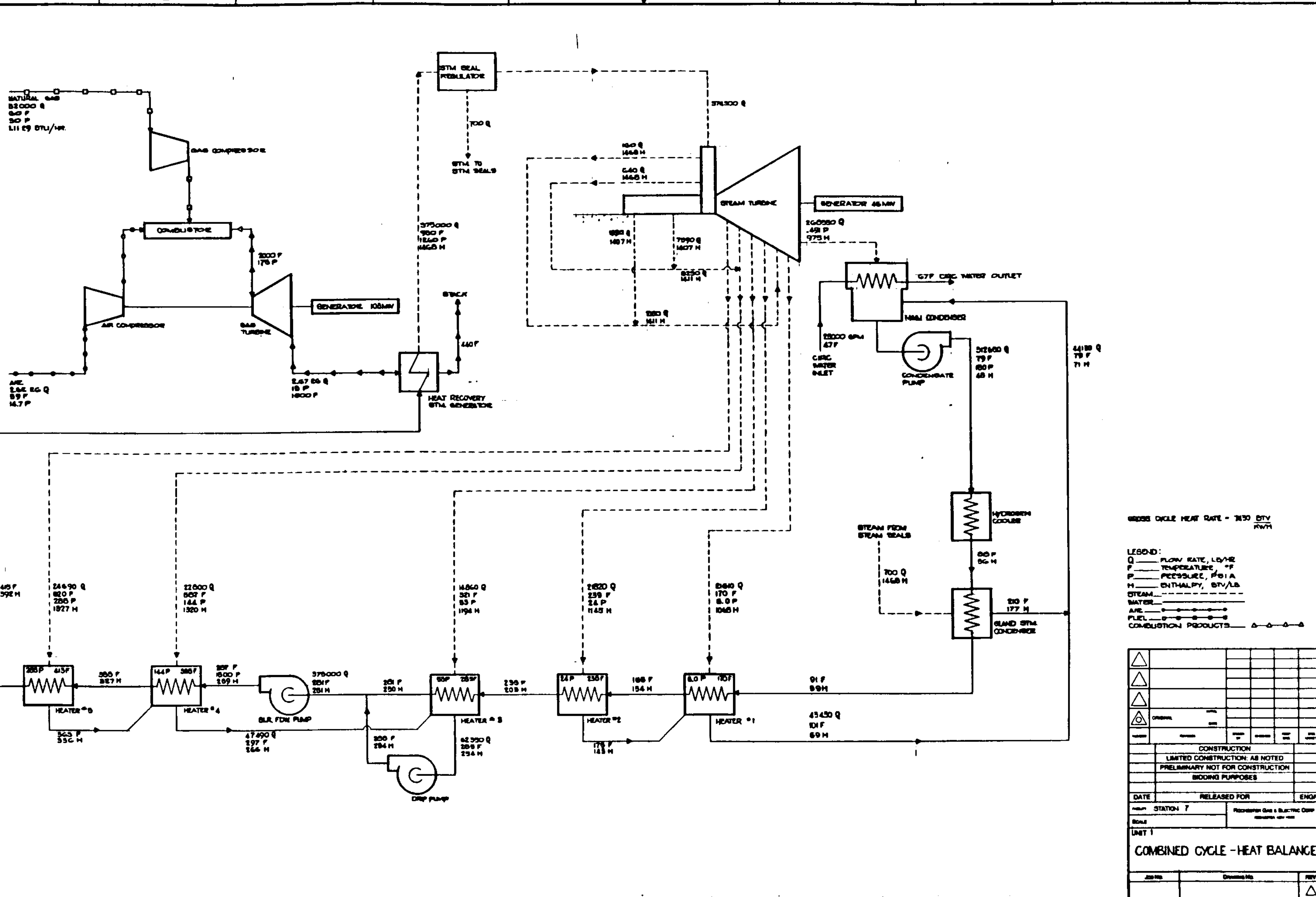
PEPSE SCHEMATIC
COMBINED CYCLE

LISTING OF INPUT DATA FOR CASE 1

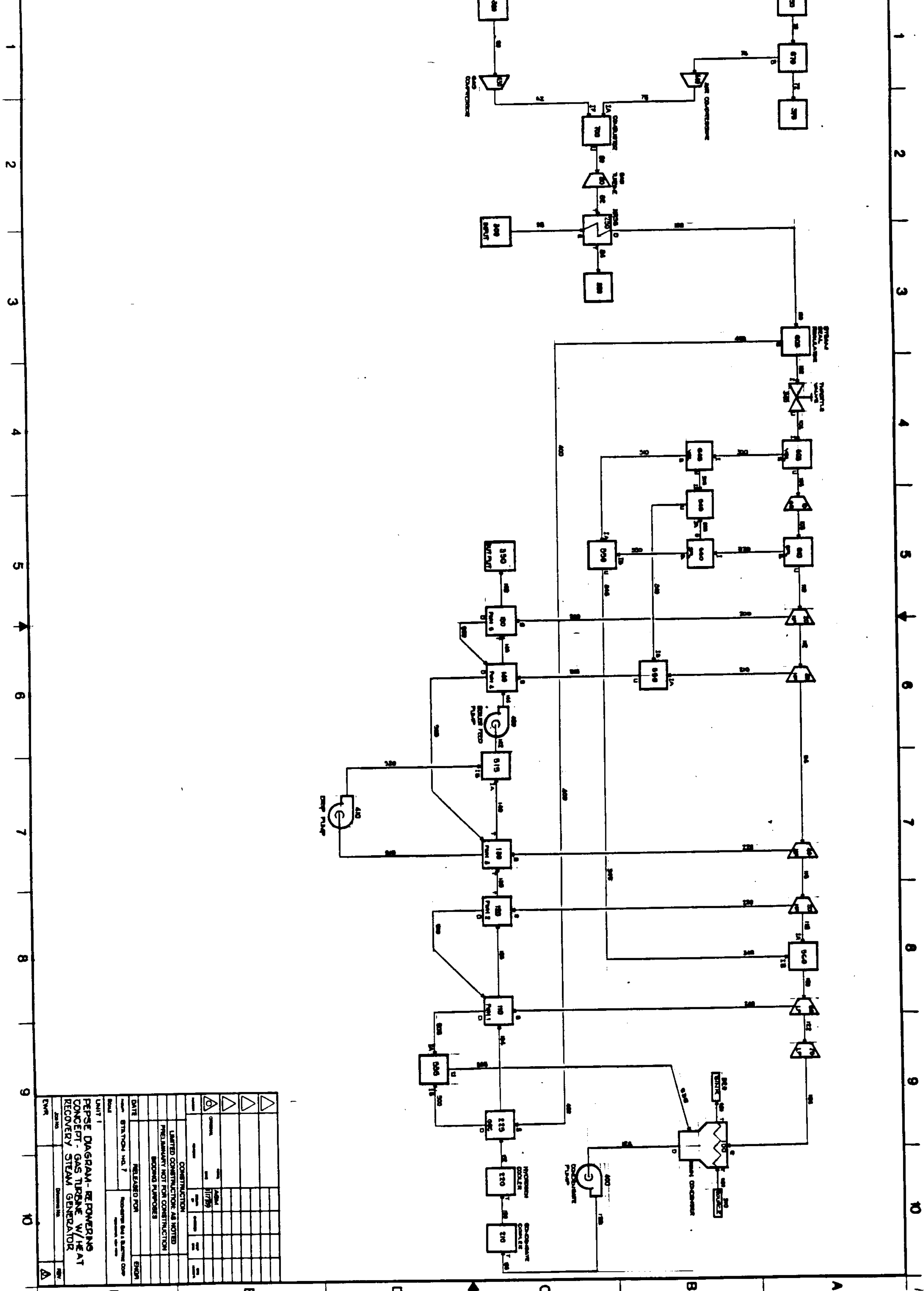
```
  COMBINED CYCLE  (GAS TURBINE WITH HRSG AND STEAM TURBINE)
* (EXAMPLE NUMBER 6)
* GAS TURBINE IS SIMPLE CYCLE (NO REGENERATOR)
* CONTROL ON EXCESS AIR TO PROVIDE 1800F TURBINE INLET TEMP
* CONTROL ON BFW FLOW TO PRODUCE 300F HRSG GAS EXIT TEMP
012000 25
010200 2,3,2,1,0
011010 1,2,5,0,3600,32000.,.85,45.,45.
011011 200. 350.
011020 2,2,5,0,3600,25000.,.85,45.,45.
011021 100. 200.
* TABLE SUPPRESSION
020001 NOPRNT
020002 NOPRNT
020004 NOPRNT
020005 NOPRNT
020013 NOPRNT
020016 NOPRNT
020020 NOPRNT
020021 NOPRNT
020022 NOPRNT
020023 NOPRNT
020025 NOPRNT
020026 NOPRNT
020028 NOPRNT
020034 NOPRNT
020037 NOPRNT
020042 NOPRNT
* GEOMETRY INPUT
501020 320, U, 610, I
501040 610, U, 310, I
501060 610, B, 410, I
501080 410, U, 510, IA
502020 321, U, 411, I
502040 411, U, 510, IF
503020 510, U,  10, I
503040  10, U, 210, T
503060 210, T, 311, I
504020 340, U, 210, S
504040 210, D, 611, I
504060 611, B, 313, I
504080 611, U,  11, I
504100  11, U, 110, S
504120 110, D, 330, I
505020 322, U, 110, T
505040 110, T, 312, I
* GAS TURBINE DATA
700100 9 1 2 1 6
700106 15.3 1000.
* STEAM TURBINE DATA
700110 8 2 2 0 5 0 1 1 0.
700111 .75 .5
* CONDENSER DATA
701100 10 0 2 0. .5
* HRSG DATA
702100 20 575. 0. .1 .02
* SOURCE AND SINK DATA
703100 32
703110 30
703120 30
703130 30
703200 33 59. 14.7 2.E6
703203 AIR .6
703210 31 60. 30. 17500.
703213 FUEL 21300. SSVL 44.5 C .754 H2 .234 N2 .012
703220 31 54. 30. 7.5E6
703300 30
703400 31 80. 200. 150000.
* COMPRESSOR DATA
704100 44 1 120. 1. .8
704110 43 120. 1. 1. .8
* COMBUSTOR DATA
705100 70 0 2 0 0.
* SPLITTER DATA
706100 61 0. 1.E6
706110 61 0. 0.
```

```
* CONTROL ON EXCESS AIR TO PRODUCE DESIRED GAS TEMP
840100 WWFIXB 610 1800. 0. 1. TT 302
* CONTROL ON BFW FLOW TO PRODUCE HRSG OUTLET TEMP
840200 WWVSC 340 300. 0. 1. TT 306
840209 5.E4 2.E5
* OPERATIONAL VARIABLES
870010 21300.
870020 1000.
870030 3412.
* CALCULATE CYCLE HEAT RATE
880010 WW 202 MUL OPVB 1 OPVB 4
880020 BKGRO 1 ADD BKGRO 2 OPVB 5
880030 OPVB 5 MUL OPVB 2 OPVB 6
880040 OPVB 4 DIV OPVB 6 OPVB 7
* CALCULATE CYCLE EFFICIENCY
880050 BBSTRM 402 ADD OPVB 4 OPVB 8
880060 OPVB 6 MUL OPVB 3 OPVB 9
880070 BBSTRM 406 ADD OPVB 9 OPVB 10
880080 OPVB 10 DIV OPVB 8 OPVB 11
* PRINT OUTPUT VARIABLES
890100 'GAS TURBINE GENERATOR OUTPUT, MW'
890101 BKGRO 1
890200 'STEAM TURBINE GENERATOR OUTPUT, MW'
890201 BKGRO 2
890300 'TOTAL ELECTRICAL OUTPUT, MW'
890301 OPVB 5
890400 'GROSS CYCLE HEAT RATE, BTU/KWH'
890401 OPVB 7
890500 'CYCLE THERMAL EFFICIENCY'
890501 OPVB 11
*
.
```

ATTACHMENT 7A



ATTACHMENT 7B



LISTING OF INPUT DATA FOR CASE 1

```
   RG&E RUSSELL STATION UNIT 1 COMBINED CYCLE PLANT
 * MODEL INCLUDES THE FOLLOWING:
 * GAS TURBINE WITH HRSG REPLACES BOILER
 * SCHEDULE FOR HEAT INPUT FROM H2 COOLER
 * SCHEDULE FOR GENERATOR LOSSES
 * SCHEDULE FOR TURBINE EXHAUST LOSS USING ANNULUS VELOCITY AND GE-2007C
 * SPECIFIED COEFFICIENT 'A' FOR EXTRACTION LINE PRESSURE DROP
 * SPECIFIED LEAKAGE COEFFICIENTS SPLITTER FLOWS
 * SPECIFIED TURBINE EFFICIENCY FACTORS
 * CALCULATION FOR CYCLE HEAT RATE
 * Convergence Criteria
 012000 25 50. 50. 0. 0. 0. 0 1.E5
 * Table Suppression
 020001 NOPRNT
 020002 NOPRNT
 020004 NOPRNT
 020005 NOPRNT
 020006 NOPRNT
 020007 NOPRNT
 020009 NOPRNT
 020010 NOPRNT
 020011 NOPRNT
 020012 NOPRNT
 020013 NOPRNT
 020014 NOPRNT
 020015 NOPRNT
 020016 NOPRNT
 020017 NOPRNT
 020018 NOPRNT
 020020 NOPRNT
 020021 NOPRNT
 020022 NOPRNT
 020023 NOPRNT
 020024 NOPRNT
 020025 NOPRNT
 020026 NOPRNT
 020028 NOPRNT
 020031 NOPRNT
 020032 NOPRNT
 020033 NOPRNT
 020034 NOPRNT
 020035 NOPRNT
 020036 NOPRNT
 020037 NOPRNT
 020038 NOPRNT
 020040 NOPRNT
 020042 NOPRNT
 010200 2 3 2 1 0
 010201 3
 011010 1 2 5 0 3600 100000. .85 45. 45.
 011011 600. 1100.
 011020 2 2 1 0 3600 47058. .85 45. 45.
 011021 300. 563.
 * GEOMETRY
 * GAS TURBINE STREAMS
 500600 360, U, 430, I
 500620 430, U, 700, IF
 500700 350, U, 670, I
 500720 670, U, 370, I
 500740 670, B, 440, I
 500760 440, U, 700, IA
 500800 700, U,  80, I
 500820  80, U, 250, T
 500840 250, T, 380, I
 * MAIN STEAM AND FEEDWATER STREAMS
 500980 300, U, 250, S
 501000 250, D, 600, I
 501020 600, U, 340, I
 501040 340, U, 605, I
 501060 605, U,  10, I
 501080  10, U, 610, I
 501100 610, U,  20, I
 501120  20, U,  30, I
 501140  30, U,  40, I
 501160  40, U,  50, I
 501180  50, U, 560, IA
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501200 560, U,  60, I
501220  60, U,  70, I
501240  70, U, 100, S
501260 100, D, 400, I
501280 400, U, 210, T
501300 210, T, 220, T
501320 220, T, 225, T
501340 225, T, 110, T
501360 110, T, 120, T
501380 120, T, 130, T
501400 130, T, 515, IA
501420 515, U, 420, I
501440 420, U, 140, T
501460 140, T, 150, T
501480 150, T, 330, I
* EXTRACTION STREAMS
502000  20, E, 150, S
502100  30, E, 555, IA
502150 555, U, 140, S
502200  40, E, 130, S
502300  50, E, 120, S
502400  60, E, 110, S
* PACKING LEAKOFF LINES
503000 605, B, 645, I
503050 645, U, 545, IB
503100 645, B, 550, IA
503200 610, B, 660, I
503250 660, U, 545, IA
503300 660, B, 550, IB
503400 545, U, 555, IB
503450 550, U, 560, IB
* OTHER SPLITTER LEAKOFFS
504000 600, B, 225, S
* DRAIN LINES
505000 225, D, 535, IB
505050 110, D, 535, IA
505100 120, D, 110, D
505150 130, D, 410, I
505200 410, U, 515, IB
505250 140, D, 130, D
505300 150, D, 140, D
505350 535, U, 100, D
* MISCELLANEOUS LINES
506200 310, U, 100, T
506300 100, T, 320, I
* GAS TURBINE DATA
700800 9 1 2 1 6
700806 15. 1000.
* STEAM TURBINE DATA
700100 4 2 2 1 2 0 0 0 38.01
700108 .982014
700200 7 2 0 1 1 1 0. 1000. 1431. 364600. 307. 24180.
700300 7 2 1 1 1 1 0. 307. 1336.5 340420. 154. 14520.
700400 7 2 1 1 1 1 0. 154. 1275. 325900. 56.5 15380.
700500 7 2 1 1 1 1 0. 56.5 1198.6 306020. 26.1 17430.
700600 7 2 1 1 1 2 0. 26.1 1150.1 290750. 6.45 22210.
700700 7 2 3 0 1 2 0. 6.45 1068. 268540. -1. 0. 20.67 0. 0. 0. 0. 0. 3 21.9
* FW HEATER DATA
701000 10 1 2 0. -1.
701100 16 1 60 2 0. 5. 10.
701200 16 0 50 2 0. 5. 10.
701300 17 1 40 2 0. 5.
701400 18 1 30 2 0. 2. 10.
701500 18 0 20 2 0. -1.5 10.
* HEAT EXCHANGER DATA
702100 27 0.
702200 27 3.04E6
702250 20 0. 0. 0. 0. 0. 0. 0. 14.
702500 20 950. 0. .1
* COMPRESSOR AND PUMP DATA
704000 41 150. 1. 1. 1. 0. 0.
704100 41 150. 1. 1. 1. 0. 0.
704200 41 1500. 1. 1. 1. 0. 8.
704300 43 175. 1. 1. .8
704400 44 1 175. 1. .8
* SOURCE, SINK AND VALVE DATA
703000 33 175. 1400. 375000.
703100 31 47. 33. 1.25E7
703200 30
703300 32
703400 35 -2. -2. -2. .3 1265. 1468.12 376000.
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```
703500 31 59. 14.7 2.E7
703503 AIR
703600 31 60. 100. 52000.
703603 FUEL 21300. SSVL 44.5 C .754 H2 .234 N2 .012
703700 30
703800 30
* MIXER DATA
705150 50 1
705350 51 1
705450 50 1
705500 50 1
705550 50 1
705600 51 1
* SPLITTER DATA
706000 61 0. 700.
706050 68 0. 17.6978
706100 64 362.351
706450 68 0. 31.0595
706600 64 369.474
706700 61 0. 2.62E6
* COMBUSTOR DATA
707000 70 0 2 0 0.
* STREAM DATA
602000 2 .0599
602100 2 .0597
602200 2 .0602
602300 2 .0613
602400 2 .0698
*602006 CLOSE
*602156 CLOSE
*602206 CLOSE
*602306 CLOSE
*602406 CLOSE
* CONTROL ON EXCESS AIR FOR GAS TURBINE INLET TEMP
*840100 WWFIXB 670 2000. 0. 1. TT 80
* CONTROL ON FUEL RATE FOR STEAM TEMPERATURE
*840200 WWVSC 360 950. 0. 1. TT 100
* DEFINE TURBINE EXHAUST LOSS
870310 0.
870320 150300.
870330 .87
870340 1.
870350 .65
880100 OPVB 31 PHG PP 124 OPVB 10
880110 PP 124 PHV OPVB 10 OPVB 11
880120 PP 124 PHX HHACP 70 OPVB 12
880130 WW 124 MUL OPVB 11 OPVB 13
880140 OPVB 13 MUL OPVB 12 OPVB 14
880150 OPVB 14 DIV OPVB 32 OPVB 15
800100 'EXHAUST LOSS VS. ANNULUS VEL'
810101     128. 150. 175. 200. 250. 300. 350. 400. 450. 500.
810111 0. 25.6 20.6 16.1 12.8 8.83 5.53 4.09 3.73 3.95 4.90
810102     550. 600. 650. 700. 800. 900. 1000. 1100. 1200. 1300.
810112     6.57 8.65 10.9 13.6 19.4 25.6 32.0  38.4  44.4  49.9
830100 1 OPVB 16 OPVB 15
880160 OPVB 34 SUB OPVB 12 OPVB 17
880170 OPVB 17 MUL OPVB 35 OPVB 18
880180 OPVB 34 SUB OPVB 18 OPVB 19
880190 OPVB 16 MUL OPVB 33 OPVB 20
880200 OPVB 20 MUL OPVB 12 OPVB 21
880210 OPVB 21 MUL OPVB 19 EXUSLS 70
* DEFINE GENERATOR LOSSES
800200 'GENERATOR LOSSES'
810201       10.  15.  20.  25.  30.  35.  40.  50.
810210 0. 323. 344. 374. 412. 457. 507. 564. 564.
830200 2 BKELEI 2 BKTURB 2
* DEFINE HYDROGEN COOLER HEAT INPUT
800300 'HYDROGEN COOLER HEAT'
810301         9.9   20.9   31.1   40.6   45.6
810310 0. 2.16E6 2.38E6 2.77E6 3.12E6 3.46E6
830300 3 BBHXGR 220 BKGRO 2
* CALCULATE GROSS CYCLE HEAT RATE
870010 21300.
870020 1000.
870030 3412.
880010 WW 60 MUL OPVB 1 OPVB 4
880020 BKGRO 1 ADD BKGRO 2 OPVB 5
880030 OPVB 5 MUL OPVB 2 OPVB 6
880040 OPVB 4 DIV OPVB 6 OPVB 7
890010 'GROSS CYCLE HEAT RATE, BTU/KWH'
890011 OPVB 7
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890020 'GROSS GENERATION, MW'
890021 OPVB 5
*
.
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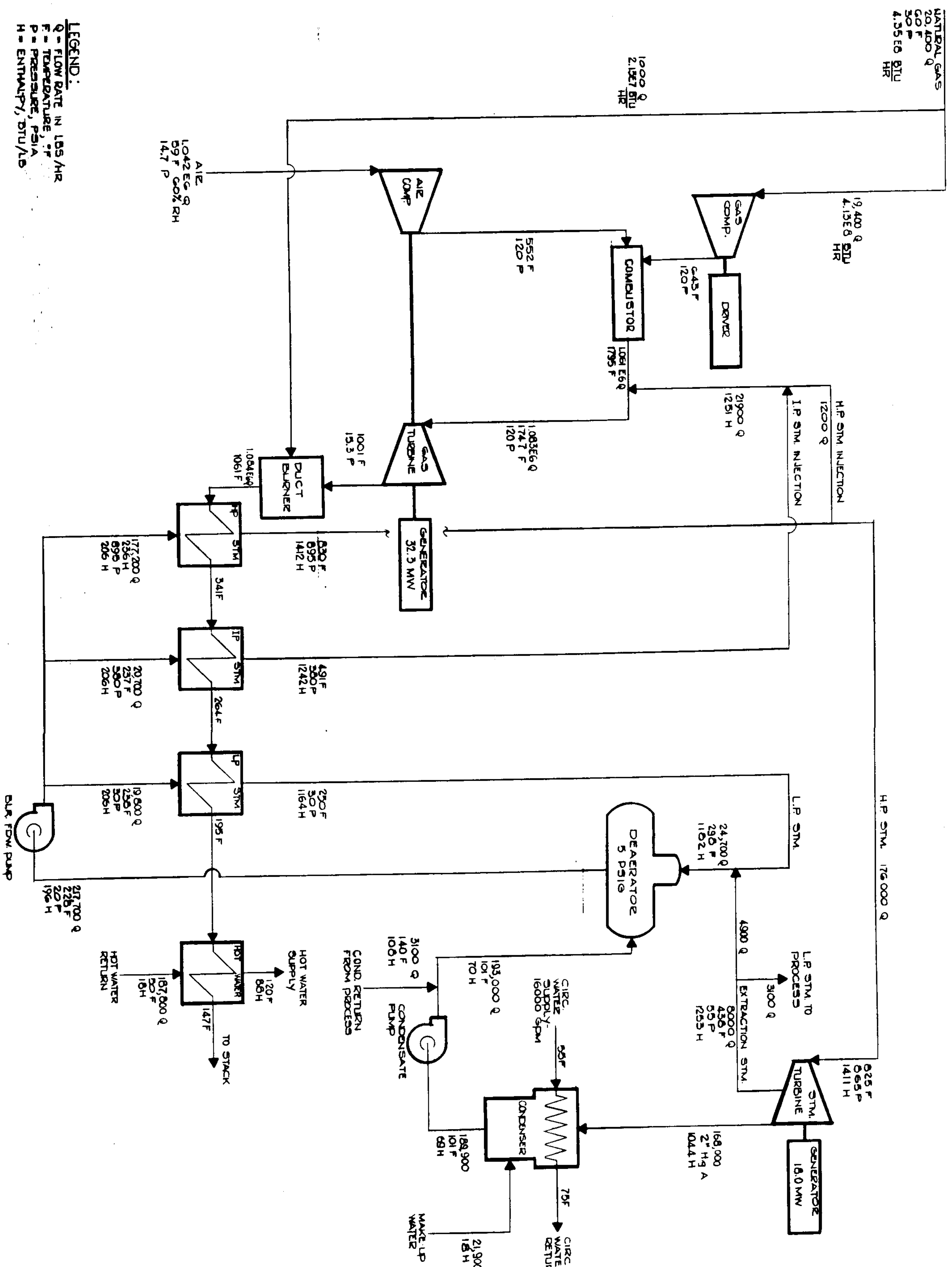
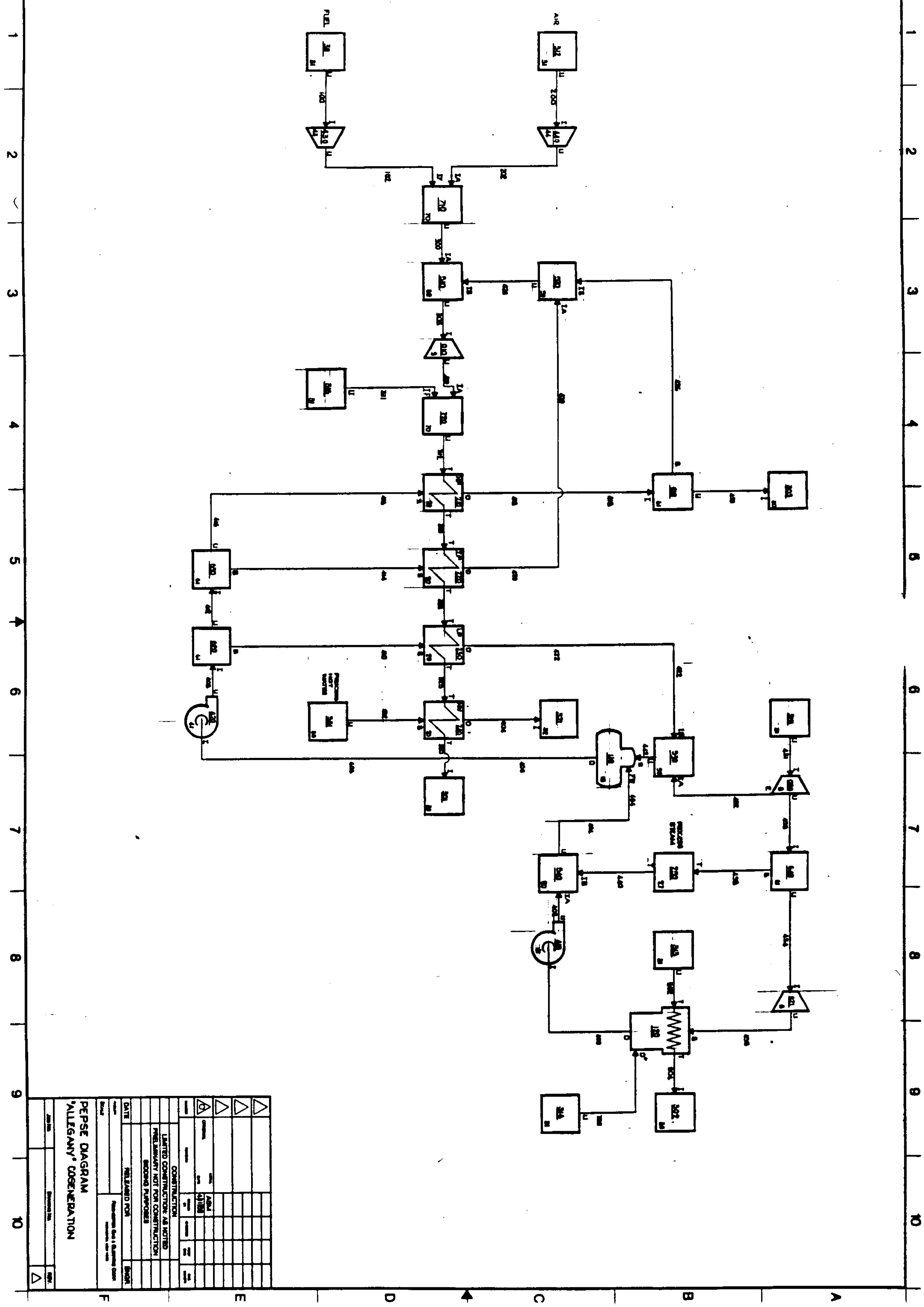


COGENERATION HEAT BALANCE

ATTACHMENT 8B



LISTING OF INPUT DATA FOR CASE 1

```
  COGENERATION HEAT BALANCE
* COMBINED CYCLE MODEL
* AIR AND FUEL RATES EQUAL HEAT BALANCE RATES FROM VENDOR
* COMBUSTOR INCLUDED IN MODEL FOR DUCT BURNER
* SPECIFIED EXTRACTION RATE TO DEAERATOR
012000 25
010200 2,3,2,1,0
011010 1,2,5,0,3600,40000.,.85,45.,45.
011011 200. 600.
011020 2,2,5,0,3600,20000.,.85,45.,45.
011021 100. 300.
* TABLE SUPPRESSION
020001 NOPRNT
020002 NOPRNT
020004 NOPRNT
020005 NOPRNT
020013 NOPRNT
020015 NOPRNT
020016 NOPRNT
020020 NOPRNT
020021 NOPRNT
020022 NOPRNT
020023 NOPRNT
020025 NOPRNT
020026 NOPRNT
020028 NOPRNT
020034 NOPRNT
020037 NOPRNT
020042 NOPRNT
* GEOMETRY INPUT
501000 311, U, 430, I
501020 430, U, 710, IF
502000 312, U, 440, I
502020 440, U, 710, IA
503000 710, U, 510, IA
503050 510, U,  10, I
503100  10, U, 720, IA
503110 316, U, 720, IF
503120 720, U, 210, T
503150 210, T, 220, T
503200 220, T, 230, T
503250 230, T, 240, T
503300 240, T, 310, I
504000 120, D, 410, I
504020 410, U, 540, IA
504040 540, U, 110, FW
504060 110, D, 420, I
504080 420, U, 620, I
504100 620, B, 230, S
504120 620, U, 630, I
504140 630, B, 220, S
504160 630, U, 210, S
504180 210, D, 610, I
504200 220, D, 520, IA
504220 230, D, 530, IA
504240 520, U, 510, IB
504260 610, B, 520, IB
504300 610, U, 303, I
504310 315, U,  20, I
504320  20, E, 530, IB
504330  20, U, 640, I
504340 640, U,  21, I
504350  21, U, 120, S
504380 640, B, 250, T
504400 250, T, 540, IB
504420 530, U, 110, S
505020 313, U, 120, T
505040 120, T, 302, I
506020 331, U, 240, S
506040 240, D, 321, I
507000 314, U, 120, D
* GAS TURBINE DATA
700100 9 1 2 1 6
700106 15.3 1001.
* STEAM TURBINE DATA
700200 8 2 0 1 5 0 1 5 0. 4900.
```

```
700205 55. 1253.
700210 8 2 3 0 5 0 1 1 0.
700211 .75 .982
* DEAERATOR DATA
701100 15 0 20 0. 0. 20. 0.
* CONDENSER DATA
701200 10 1 2 0. .982
* HRSG DATA
* HP SECTION
702100 20 830.
* IP SECTION
702200 20 491.
* LP SECTION
702300 20 1.
* HOT WATER SECTION
702400 20 120.
* PROCESS STEAM CONSUMER
702500 27 -3.55E6
* SOURCE AND SINK DATA
703100 30
703020 30
703030 30
703120 31 59. 14.7 1.0417E6
703123 AIR .6
703110 31 60. 30. 19400.
703113 FUEL 21300. SSVL 44.5 C .754 H2 .234 N2 .012
703130 31 55. 30. 8.E6
703140 31 50. 50. 21900.
703150 31 830. 895. 176000.
703160 31 60. 30. 1014.
703163 FUEL 21300. SSVL 44.5 C .754 H2 .234 N2 .012
703210 32
703310 33 50. 80. 187800.
* PUMP DATA
704100 41 65.
704200 41 1000. 0. 0. 0. 0. 10.
* COMPRESSOR DATA
704300 43 120. 1. 1. .85
704400 44 1 120. 1. .85
* COMBUSTOR DATA
707100 70 0 2 0 0.
707200 70 0 2 0 0.
* MIXER DATA
705100 50 1
705200 50 1
705300 50 2
705400 50 1
* SPLITTER DATA
706100 61 0. 1200.
706200 61 0. 19800.
706300 61 0. 20700.
706400 61 0. 3100.
* ACTIVE STREAMS
604100 5 30.
604140 5 380.
604160 5 895.
604310 5 865. 825.
* OPERATIONAL VARIABLES
870010 21300.
870020 1000.
870030 3412.
* CALCULATE CYCLE HEAT RATE
880010 WW 100 MUL OPVB 1 OPVB 4
880020 WW 311 MUL OPVB 1 OPVB 5
880030 OPVB 4 ADD OPVB 5 OPVB 6
880040 BKGRD 1 ADD BKGRD 2 OPVB 7
880050 OPVB 7 MUL OPVB 2 OPVB 8
880060 OPVB 6 DIV OPVB 8 OPVB 9
* CALCULATE CYCLE EFFICIENCY
880070 BBSTRM 604 SUB BBSTRM 602 OPVB 10
880080 BBSTRM 438 SUB BBSTRM 440 OPVB 11
880090 OPVB 10 ADD OPVB 11 OPVB 12
880100 OPVB 8 MUL OPVB 3 OPVB 13
880110 OPVB 12 ADD OPVB 13 OPVB 14
880120 OPVB 14 DIV OPVB 6 OPVB 15
* PRINT OUTPUT VARIABLES
890100 'GAS TURBINE GENERATOR OUTPUT, MW'
890101 BKGRD 1
890200 'STEAM TURBINE GENERATOR OUTPUT, MW'
890201 BKGRD 2
890300 'TOTAL ELECTRICAL OUTPUT, MW'
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890301 OPVB 7
890400 'GROSS CYCLE HEAT RATE, BTU/KWH'
890401 OPVB 9
890500 'CYCLE THERMAL EFFICIENCY'
890501 OPVB 15
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