The Development of a Design Mode Fluidized Bed Plant Model Using the PEPSE® Heat Balance Code

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ABSTRACT

The use of a fluidized bed combustor in an electric utility power plant offers several potential benefits. This paper discusses the benefits that were the motivating factors to the choice of such a system for the lignite fueled Heskett Station of Montana-Dakota Utilities. In brief there are advantages relating to atmospheric pollution control, combustion-zone heat transfer, and capabilities to combust poor-grade fuels.

In the Heskett Station, the fluidized bed combustor replaced a more conventional boiler furnace for the production of superheated steam to a steam turbine generator cycle. Early operation of the new system revealed shortcomings in attaining the needed main steam set point temperature. This paper discusses the development of a PEPSE analysis model of the new Heskett Station to aid in the understanding of the problem and to calculate performance behavior of considered improvements to the system.

INTRODUCTION

Coal combustion in a fluidized bed for steam generation to a steam turbine generator cycle is a relatively recent application. As such, the analysis, diagnosis, and remediation of troublesome operation is in a state of development.

The staffs of Montana-Dakota Utilities and of the HALLIBURTON NUS Environmental Corporation have collaborated to enhance the PEPSE® heat balance computer program for analyses of fluidized bed steam generators. These enhancements have added two new components to PEPSE's existing library. These are the fluidized bed combustor and the in-bed heat exchanger components. The added computations for these components include performance and/or design mode capabilities and embody such effects as bed depth and chemical reactions of limestone for flue gas pollution control.

With the new components in place, it is now possible to analyze the performance of a complete power generation system that employs the fluidized bed for fuel combustion. Such a complete system analysis was necessary in order to investigate scenarios for remedying a shortfall of superheat temperature for the MDU Heskett Power Station.

A PEPSE model has been developed, making extensive use of design mode capabilities for the heat source and the turbine cycle for this station. Discussed here are the background, the highlights of the model development, and conclusions from the work. Also mentioned, in passing, are some observations from experiences of using the 386 machine version on a 486 PC.

Montana-Dakota Utilities

Montana-Dakota Utilities is a relatively small Electric and Natural gas utility. "MDU COUNTRY", as it is called, occupies eastern Montana, most of North Dakota, north western South Dakota, and north central Wyoming. That is 168,100 square miles, or 5 1/4% of the continental United States. The actual peak obligation in 1990 was about 450 mW.

Generation capabilities include the Heskett Station in Mandan, North Dakota, Lewis and Clark Station in Sidney, Montana, Coyote Station in Beulah, North Dakota, Big Stone Plant in Milbank, South Dakota, and 4 gas turbines located in Miles City, Montana, Glendive, Montana, and Wiliston, North Dakota.

The system obviously spans extensive territory.

Fluidized Bed Combustion

The Electric Utility industry has for many years had to address many environmental problems. Currently these include acid rain and global warming from the "greenhouse effect". Both of these are a result of increased emissions of nitrous oxides, and sulfur dioxide. In addition, carbon dioxide is a major contributor to the "greenhouse effect". Utility boilers burning hydrocarbons, such as coal, are a major contributor to these emissions.

Atmospheric Fluidized Bed Combustion continues to be proven as a viable method for burning coal with reduced emissions of NO_x and SO_2. In AFBC, air for combustion is forced upward through a mixture of limestone (or other material) and fuel (normally coal) at a velocity great enough to suspend, or fluidize the material. The presence of the limestone introduces chemical reactions that reduce the emissions of SO_2. NO_x is reduced due to lower combustion temperatures.

The fluidization phenomenon is achieved by blowing a gas (air) up through the particulate from the bottom of the bed. The gas velocity at which fluidization first occurs is referred to as "the minimum fluidization velocity" (see Figure 1). At this velocity, the particles are just suspended in the gas stream, with no relative motion observed. As the gas velocity is increased, bubbles, or pockets, of air begin to form in the dense phase of the bed and the particles begin to move about. This is known as a bubbling bed.

As the gas velocity is increased further, the bubbling action becomes more violent, and the bed enters a turbulent mode. In this mode, more of the bed particles are carried out of the

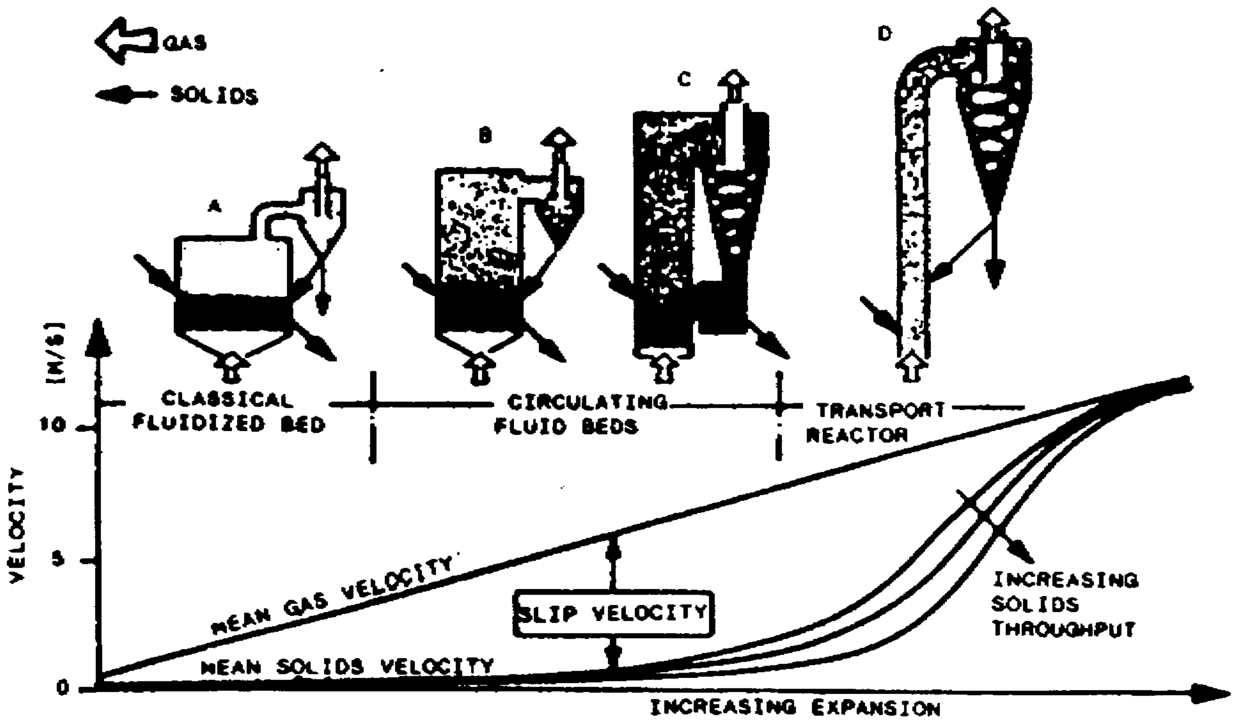

Figure 1

Modes of fluidization of fine particles [1] bed by the gas stream. These particles are then captured and returned to the bed. This mode is referred to as a Circulating Fluidized Bed.

In a fluidized bed, a portion of the fuel is burned within the dense phase and the rest is burned in the "freeboard" region above the dense region. The heat is removed through immersed heat exchange surfaces within the dense phase of the bed. The agitated movement of material in the bed results in a uniform temperature throughout the bed.

MDU Heskett Station

Montana-Dakota Utilities Heskett Station, Unit 1 (see Figure 2) uses a Riley Spreader Stoker boiler to burn lignite fuel for steam generation. It is a small unit at 25 mW. Since its construction in 1953, it has proved to be a very dependable unit. Unit 1 has been so dependable, in fact, that in 1963, when Unit 2 was built, the same basic design was used, on a larger scale. It was to be rated at 66 mW.

Using the same lignite fuel as Unit 1, Unit 2 (see Figure 3) did not operate nearly as well. Even after major convection pass surface changes, the boiler had severe fouling and slagging problems in the convection pass. It was not uncommon to totally foul the boiler in a period of only 2 months.

The decision to convert the boiler to fluidized bed combustion was made in 1986. This conversion offered many advantages for the future such as: reduced temperatures leaving the furnace, reduced sootblowing, reduced NO_x and SO_2, and generation increased up to 80 mW.

The conversion project proceeded very quickly (see Figure 4). Demolition in the existing boiler proceeded in December of 1986, and first fire was achieved in May of 1987.

Operation to date has not been without problems. However, the availability of the unit for 1990 was greater than 90% (see Figure 5). The major problem has been deficient superheat

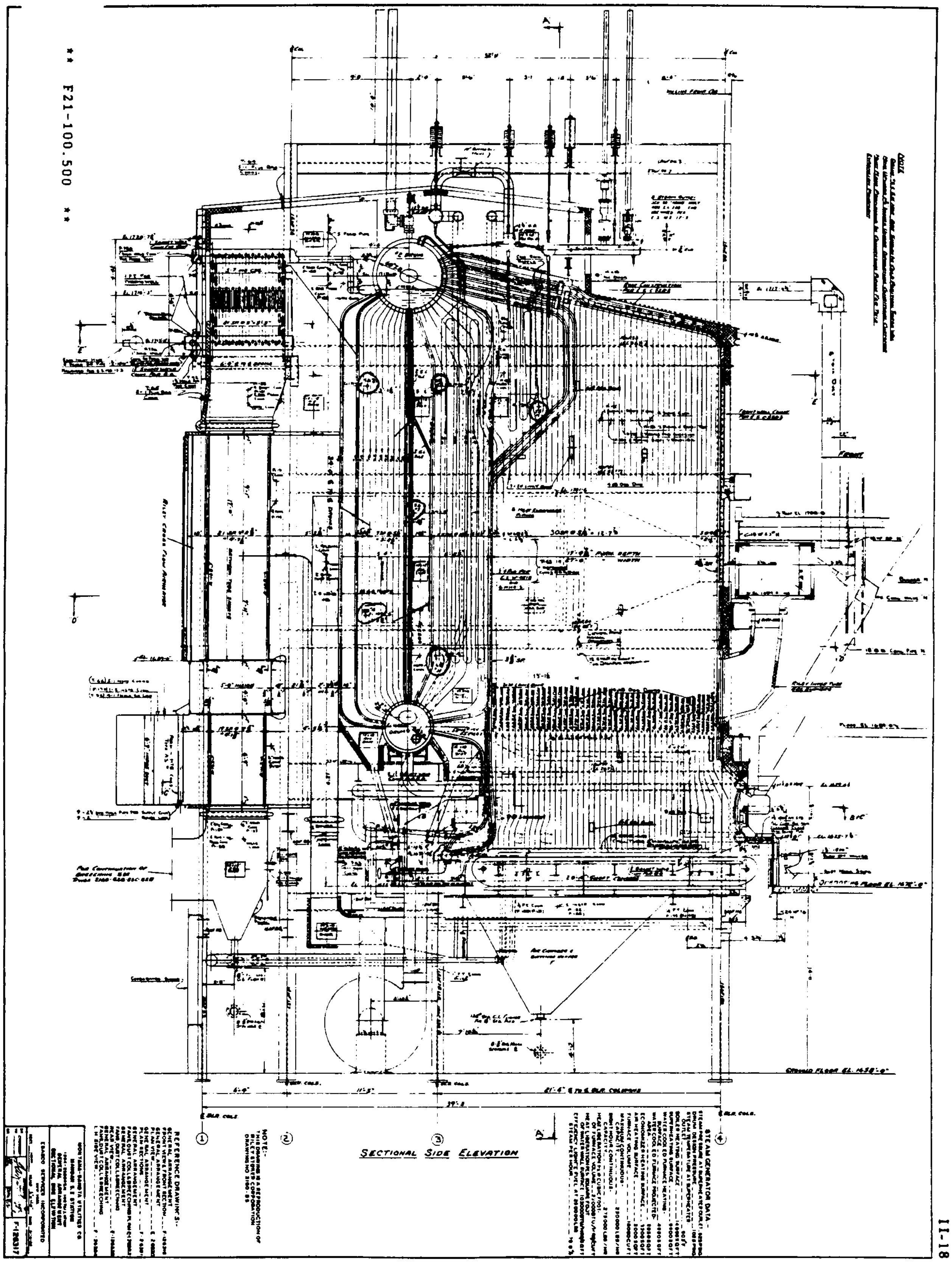

FIGURE 2

MONTANA-DAKOTA UTILITIES
HESKETT STATION UNIT 1

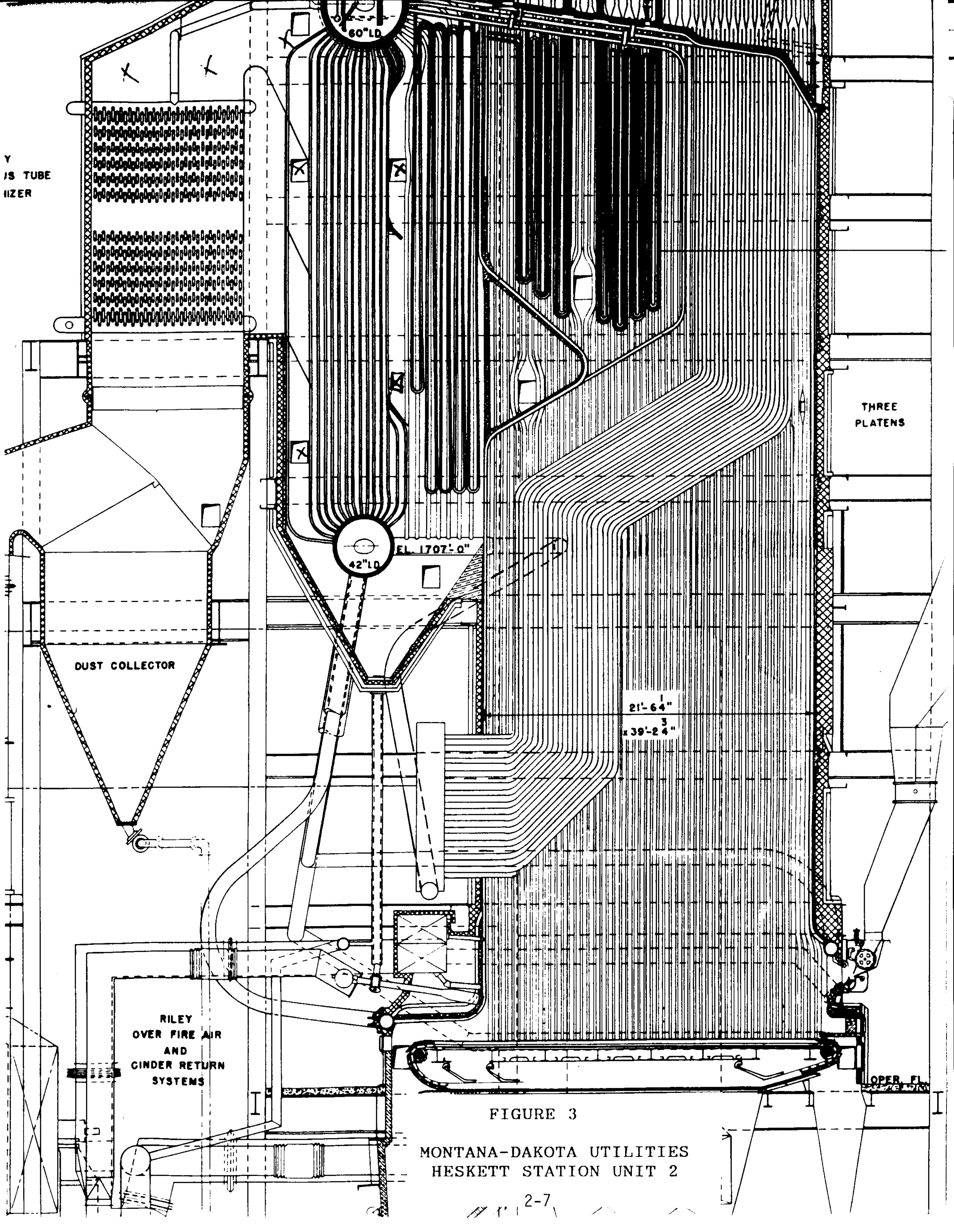

FIGURE 3

MONTANA-DAKOTA UTILITIES
HESKETT STATION UNIT 2

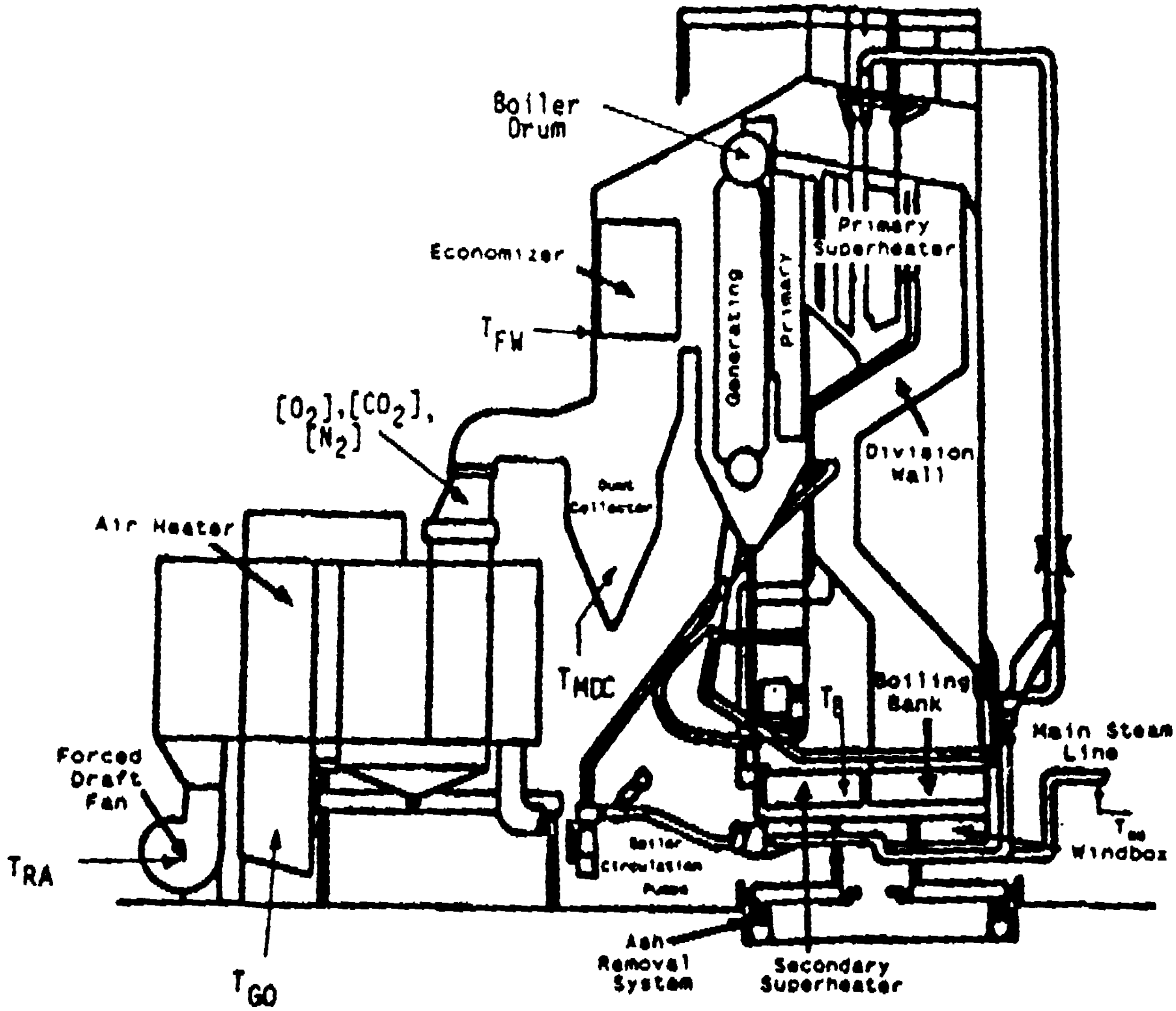

Figure 4

Heskett Unit Side View

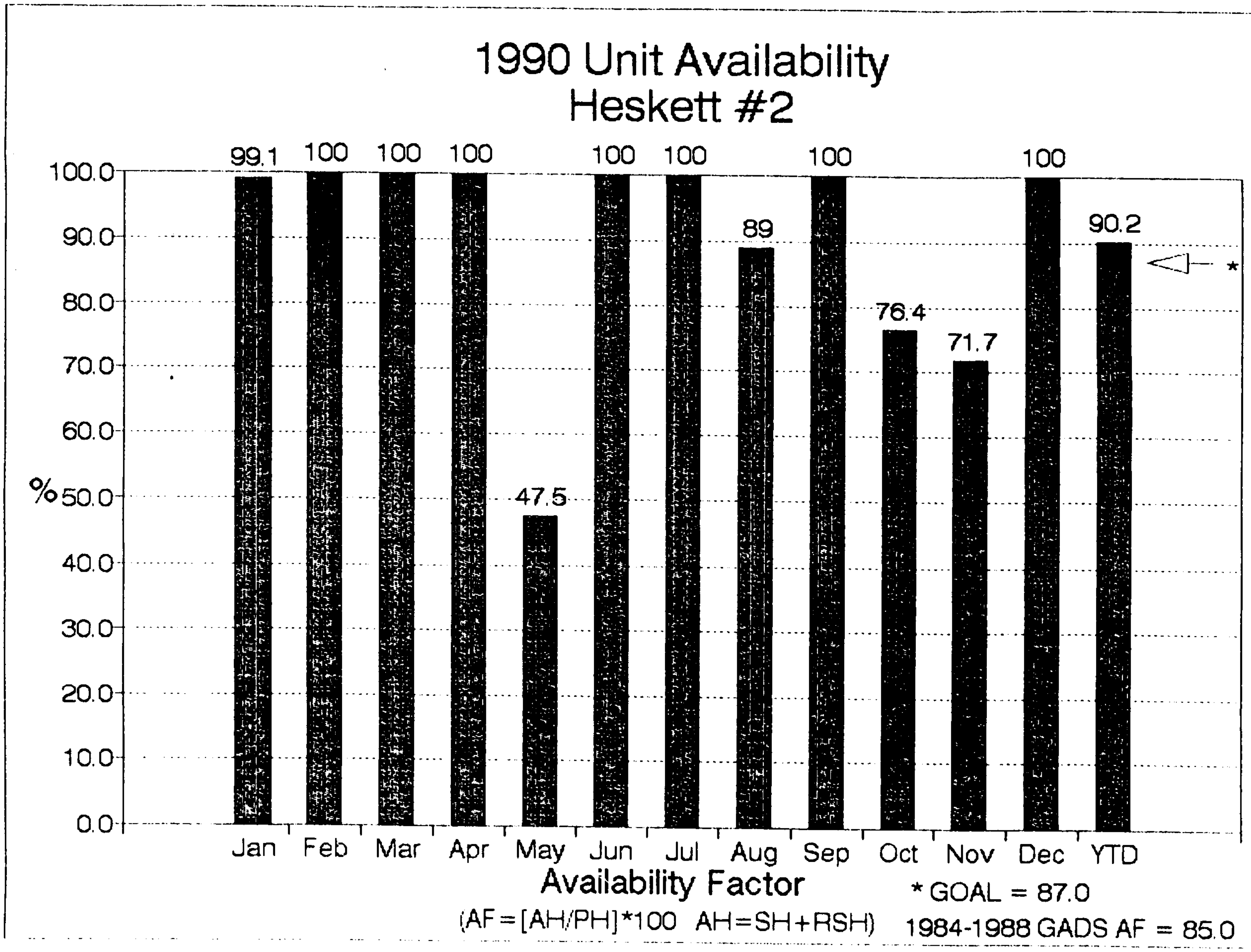

FIGURE 5

HESKETT STATION UNIT 2
1990 AVAILABILITY

leaving the bed. Presently, additional superheat surface is being installed in the convection pass of the original boiler. This should solve the problem. But will it? An analysis should provide an answer to this question.

PEPSE Design Mode Plant Model

To best evaluate this problem, it was felt that a full plant model would be needed. Such a model includes a complete turbine and design mode condenser and feedwater heaters, and a complete design mode fluidized bed boiler. The design mode components were necessary so that each section would properly float and reflect the impacts of the changes that occur with the new surface addition.

The entire model schematic was initially drawn and input to the PEPSE Graphics/Database program of the PC Version 56. Figure 6 shows this system schematic. The initial component descriptions were specified in performance mode. This model was based on sketchy heat balances from the original 650,000 lb/hr turbine information, new fluidized bed boiler design information, and operational data. Therefore, there was much information that was missing and thus needed to be determined. The performance mode model was then tuned and some of the unknowns were determined.

The design mode components were each built using submodels (see Figure 7). The HEI condenser and each of the feedwater heaters were quite easy to model. These components were then installed one by one in the plant model. This process occurred smoothly without significant problems.

Next, the boiler portion of the model was developed (see Figure 8). The submodel was relatively more complex than the earlier design mode feedwater heaters because several components were needed in combination including a Type 71 fluidized bed component and the two enclosed in-bed heat exchangers. Unlike the normal Type 70 combustor, the Type 71 Fluidized Bed Combustor can intermingle the performance and design modes for the resident heat exchanger components. This capability made the submodeling of each of these

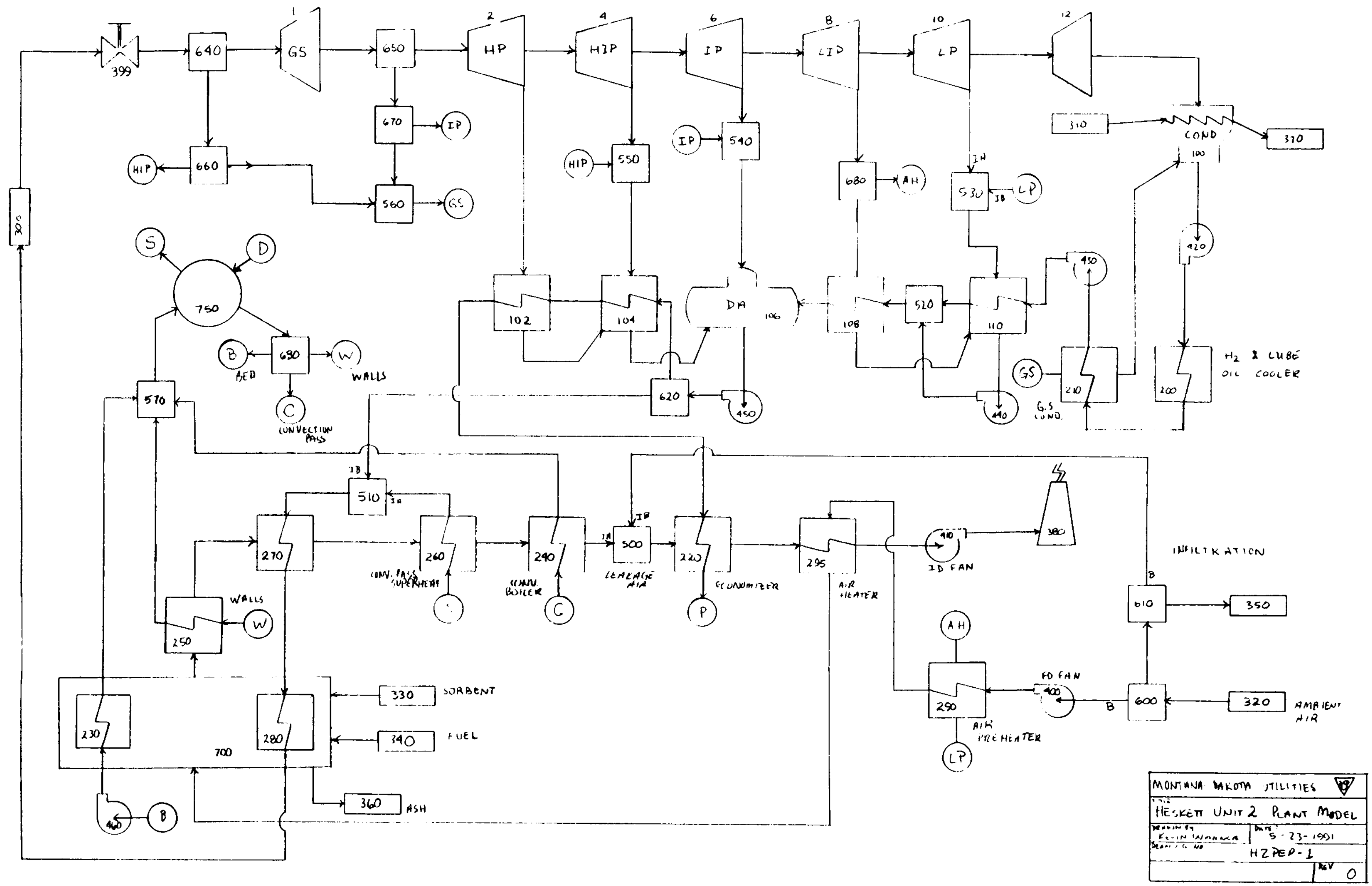

FIGURE 6

HESKETT STATION UNIT 2
PLANT MODEL

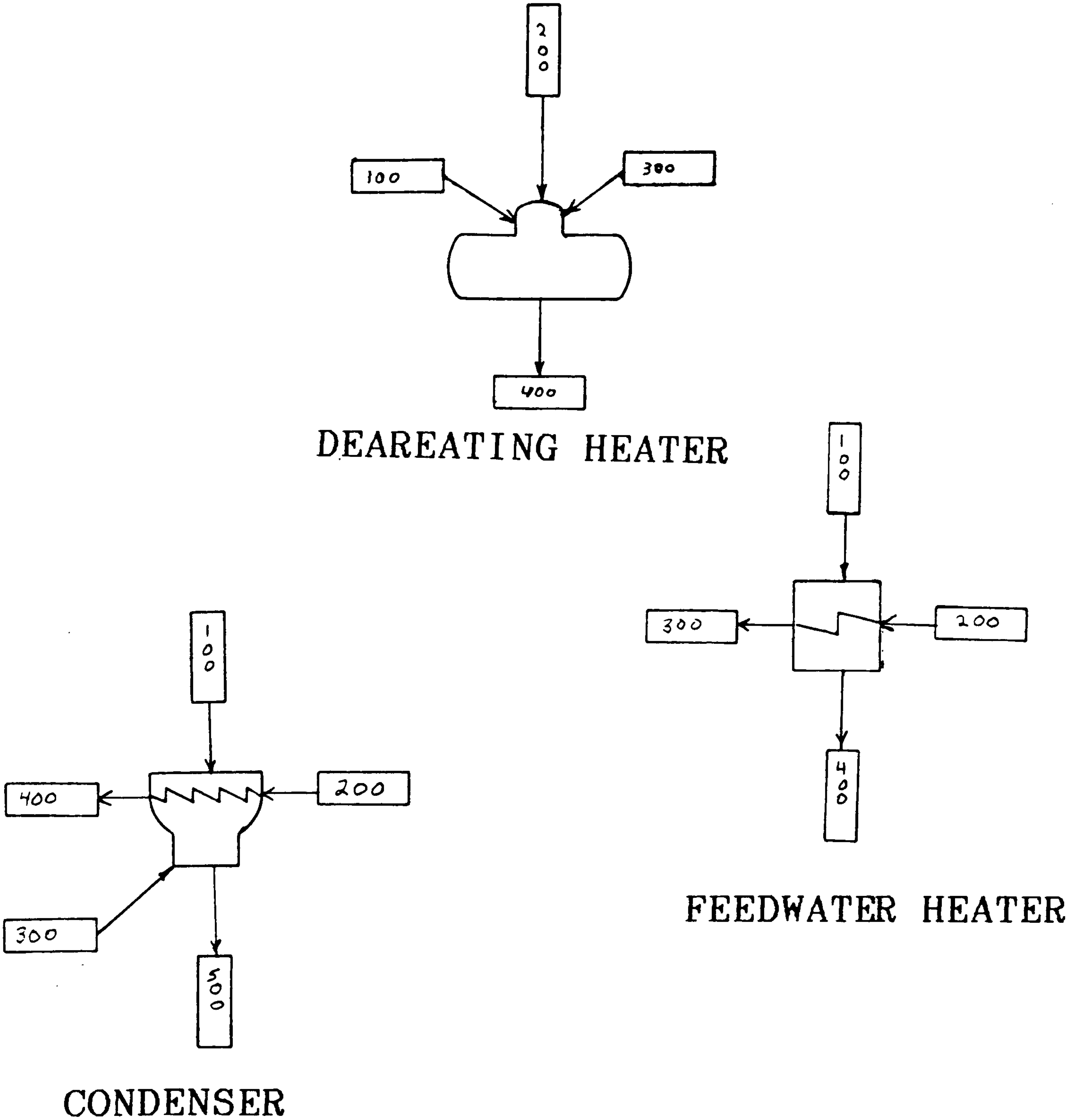

FIGURE 7

HESKETT STATION UNIT 2
PLANT MODEL
SUB-MODEL EXAMPLES

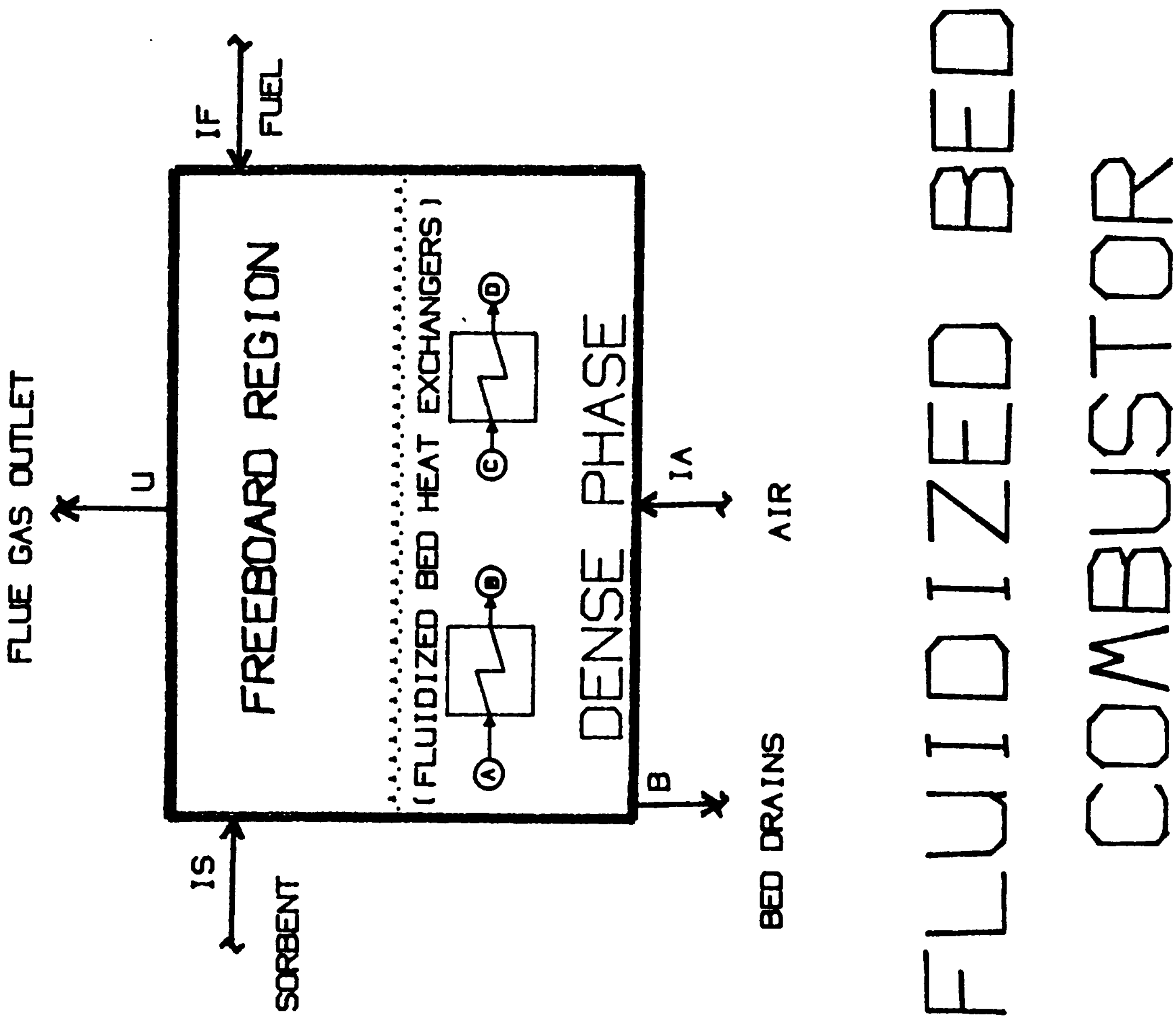

FIGURE 8

HESKETT STATION UNIT 2
PLANT MODEL
FLUIDIZED BED SUB-MODEL

two much easier. After these were properly tuned, they were inserted into the plant model and tested.

The design walls were then developed in a submodel. This component was a little awkward because the Type 28 heat exchanger was not designed to model a wall arrangement. The Type 28 had to be customized to emulate the walls even though the input geometry looks nothing like a wall description. This took many tries to find one that yielded the desired performance simulation. The result of this effort was then inserted into the full model.

The rest of the boiler sections were then modeled individually, and inserted, one at a time, into the plant model. The model was ready to go after a minor amount of tuning.

The input data set for the full design model is included as Attachment 1. It was very pleasing that the model construction was preceding so quickly, and without major problems. At this point the running of the model had gone from about 34 iterations, to 128 iterations. This compared favorably with past experiences with complete plant models.

Next the added surface was included in the convection pass superheat component. The number of iterations for the calculation did not change, but the final steam temperature was too high now (as it should have been). Now the attemperator needed to be activated in order to reduce the steam temperature.

The attemperator modeling included a single control on the flow from the feedwater splitter to obtain a desired superheat outlet temperature. When this was activated, the number of iterations jumped to about 375 for convergence of $1.0X10^{-3}$. On the 486-33 this run took only about 45 minutes.

The next obvious step, was to reduce the run time. A considerable amount of time was spent changing iteration initiations, interval of applications, relaxation factors and other parameters to finally reduce the iterations to 139 (or about 15 minutes). The study was completed, indicating that YES the surface addition was adequate to raise the superheat to 955 degrees Fahrenheit.

Conclusions

Some of the key points in successfully building a plant model are:

1. It helps to begin with a simplified model, with components initially represented in performance mode. Design components are often easily developed in submodels.

2. Install a steam flow stabilizer in the main steam line after the last boiler superheat stage, and before the throttle valve.

3. Use only one envelope. The use of more envelopes caused no improvement in run time.

4. Good initial construction of the performance mode plant model. Make it as complete and refined as you can initially.

5. Patience - as shown by this work, such a complex model can be made to converge.

PEPSE-386 Operation Using a 486 Machine

The PEPSE 386 Version 56 operated extremely well and quickly on the 486 machine, and it offers many advantages over the mainframe version:

1. Speed. A model run on the PC runs about 10 times faster than on the PRIME mainframe.

2. Ability to observe the convergence criteria change from iterate to iterate. This allows the user to interrupt the run at any time when he feels that the run is diverging.

3. Ability to interrupt the run at any time and check to see values throughout the model, and then resume the run.

ATTACHMENT 1

PEPSE Data Set
and Output Results

LISTING OF INPUT DATA FOR CASE 1

```
010001     80    *  80 column output
*
*        PEPSE USER : ADMIN
*              DATE : 05/10/91
*              TIME : 12:17
*     MODEL FILE ID : H2P
*       JOB FILE ID : \EASEPLUS\DEMO\H2P.JOB
*   RESULTS FILE ID : \EASEPLUS\DEMO\H2P.OUT
*
= Heskett Unit 2 Plant Model
*
*  This is a plant model of Heskett Unit 2 Fluidized Bed Boiler and
*  its corresponding turbine cycle. This will be used for the NUS
*  Performance Software Users Group meeting in New York.
*  Now it is all Design Mode.
*
*
**************************************************************
*      GENERIC INPUT DATA
**************************************************************
*
*  UNITS FLAGS
010000  ENGLISH   ENGLISH
*
*  CYCLE FLAGS                            NDEBUG
010200    2     3     1     1     0    0     0.     0.
*
*  GENERATOR #1 FLAGS AND DATA
011010    1     2     1     1   3600  88235.  0.85   30.    30.     0.
011011    0.    0.    0.
*
*  CYCLE CONVERGENCE DATA
012000  500     0.    0.    0.    0.    0.    0     0.
*
*  NONCONVERGED CASE CONTINUATION CARD
030000   1
*
*  SPECIAL FEATURES INITIATION DATA
012001    0     0     0     0     0     0
*
*  SPECIAL FEATURES CALCULATIONAL ORDER DATA
012002    0     0     0
*
*  PEPSE OUTPUT SUPPRESSION CARDS
021000  2 4 5 6 7 8 11 12 13 14 15 16 19 21 22 23 24 25 26 28
*
```

```
*
****************************************************************
*        GEOMETRY CARDS
****************************************************************
*
500010     1       U   650   I
500020     2       U     4   I
500030     2       E   102   S
500040     4       U     6   I
500050     4       E   550   IA
500060     6       U     8   I
500070     6       E   540   IA
500080     8       U    10   I
500090     8       E   680   I
500100    10       U    12   I
500110    10       E   530   IA
500120    12       U   100   S
501000   100       T   370   I
501030   100       D   420   I
501020   102       T   220   T
501050   102       D   104   D
501040   104       T   102   T
501060   104       D   106   D
501090   106       D   450   I
501080   108       T   106   FW
501110   108       D   110   D
501100   110       T   520   IA
501120   110       D   440   I
502000   200       T   210   T
502100   210       T   430   I
502120   210       D   100   D
502200   220       T   750   FW
502220   220       D   295   T
502300   230       T   570   IB
502400   240       T   570   IC
502420   240       D   500   IA
502500   250       T   570   IA
502520   250       D   270   S
502600   260       T   510   IA
502620   260       D   240   S
502700   270       T   280   T
502720   270       D   260   S
502800   280       T   300   I
502900   290       T   295   S
502920   290       D   530   IB
502950   295       T   410   I
502970   295       D   700   IA
503000   300       U   399   I
503100   310       U   100   T
503200   320       U   600   I
503300   330       U   700   IS
503400   340       U   700   IF
503990   399       U   640   I
504000   400       U   290   T
```

```
504100   410        U   380   I
504200   420        U   200   T
504300   430        U   110   T
504400   440        U   520   IB
504500   450        U   620   I
505000   500        U   220   S
505100   510        U   270   T
505200   520        U   108   T
505300   530        U   110   S
505400   540        U   106   S
505500   550        U   104   S
505600   560        U   210   S
505700   570        U   750   RI
506000   600        U   610   I
506010   600        B   400   I
506100   610        U   350   I
506110   610        B   500   IB
506200   620        U   104   T
506210   620        B   510   IB
506300   630        U   250   T
506310   630        B   460   I
504600   460        U   230   T
506320   630        C   240   T
506400   640        U     1   I
506410   640        B   660   I
506500   650        U     2   I
506510   650        B   670   I
506600   660        U   550   IB
506610   660        B   560   IA
506700   670        U   560   IB
506710   670        B   540   IB
506800   680        U   108   S
506810   680        B   290   S
507000   700        U   250   S
507010   700        B   360   I
507500   750       ST   260   T
507510   750       DC   630   I
*
*
*****************************************************************
*       SPECIAL STREAM SPECIFICATIONS
*****************************************************************
*
*************** STREAM TYPES 1 - 6
*
*  Initialization flow for Bed Outlet Gasse
607000    6    1    1   3100.   14.7   948098.
607001  AIRB  -0.013
*
```

```
*
**************************************************************
*      COMPONENT DATA
**************************************************************
*
*************** TURBINES
*
*        Governing Stage
700010    4     1     2     1     2     1
700011    8     0   32.849998
700012    0.    0.    0.    0.
*        HP Turbine Stage
700020    7     0     1     1     1     1     0.03
700021  804.  1424.0  640600.   376.299988  44800.    0.
700022    0.    0.    0.    0.    0.
700023    0     0.    0.
*        HIP Turbine Section
700040    7     1     1     1     1     1     0.03
700041  355.700012  1354.   595800.   188.199997  42500.    0.
700042    0.    0.    0.    0.    0.
700043    0     0.    0.
*        IP Turbine Stage
700060    7     1     1     1     1     1     0.03
700061  188.199997  1289.   553300.   72.5  17700.    0.
700062    0.    0.    0.    0.    0.
700063    0     0.    0.
*        LIP Turbine Stage
700080    7     1     1     1     1     1     0.03
700081  72.5  1211.   535600.   30.299999   40100.    0.
700082    0.    0.    0.    0.    0.
700083    0     0.    0.
*        LP Turbine Section
700100    7     1     1     1     1     2     0.03
700101  30.299999   1152.   495500.   10.4  41500.    0.
700102    0.    0.    0.    0.    0.
700103    0     0.    0.
*        Final LP Stage group
700120    7     1     3     0     1     2     0.
700121  10.4  1088.   454000.   -1.5    0.  26.200001
700122    0.    0.    0.    0.    0.
700123    0     0.    0.
*
*************** CONDENSERS AND FEEDWATER HEATERS
*
*  Main Condenser
701000   10     1     5     0.  -1.5
701005  1  .777  .875  312.  5870.  2  -.85  * HEI Mode condenser
*  HP Feedwater Heater
701020   18     0     2    -4     0.   0.0   0.0
701021  0.495  0.625  384.8  326.  17.  1.5  10.0  10.0  6.0  4.0 * Cond.
701023  0.0  0.0  0.0  -0.8  * Mult. for HTC.
701024  71.2  35.0  6.0  0.0  0.0  0.0  0.0  0.0  -0.8  * Desuperheat
701026  48.0  6.0  4.0  * Subcooling Section
*  HIP Feedwater Heater
```

```
701040   18     1     4    -4     0.  0.0    0.0
701041  0.495  0.625  348.  317.  17.  1.5  10.  10.  8.  6. * Cond.
701043    0.     0.     0.    -0.8  * Mult. on HTC.
701044  38.0  50.0  2.0  0.0  0.0  0.0  0.0  0.0  -0.8  * Desuperheat
701046  75.0  10.0  6.0  * Subcooling Section
*  LIP Feedwater Heater
701080   16     0     8    -4     0.
701081  .527  .625  181.  367.  64.  1.5  8.0  8.0  12.  4. * Cond.
701083  0.    0.    0.  -1.0
701086  35.  10.  3.  0.0  0.0  0.0  0.0  0.0  -1.0  * Subcool
*  LP Feedwater Heater
701100   14     1    10    -4     0.
701101  0.527  0.625  337.  226.  64.  1.5  8.0  8.0  20.0  6.0 * Cond.
701103  0.0  0.0  0.0  -0.8
*  Deareating Heater (IP)
701060   15     1     6     0.    0.
701061    0.    0.    0.    0.    0.    0
701062    0.    0.    0.    0.    0     0.    0.
*
*************** HEAT EXCHANGERS
*
*  Boiler Walls
702500   28     1   700000.   1400.  -0.049
702504  3  1  1  400.  200.  66.  1.  300.  1.  2.1  2.5
702505  3.0  3.0  0.0  66.0  0.95 27.0  0.0  0.0  0.0
702506  5.0  25000.0  * HTC and Area
*  Gland Steam Condenser
702100   20     0.
702101    0.    0.    0.    0.    0.    0.    14.2
*  Economizer
702200   28     1   700000.   1785.   433.
702204  3  0  2  39.333333  14.25  38.666667  24.0
702205  36.  24.  1.6  2.  6.  3.  1713.  1719.5
702206  0.95 27.
*  Convection Pass Boiling Surface
702400   28     1   700000.   1400.  -0.049
702404  3  0  2  30.75  39.229  40.75  18.0  96.0
702405  1.0  2.1  2.5  5.5  6.0  1707.0  1742.0
702406  0.95 27.0
*  Convection Pass Primary Superheat
702600   28     1   700000.   1400.     1.
702604  3  0  2  25.0  39.0  18.0  16.0  93.0  16.0  2.1  2.5
702605  9.0  5.0  0.0  0.0  0.80 20.0
*  Convection Pass Secondary Superheater
702700   28     1   700000.   1355.   650.
702704  3  0  2  18.0  39.0  17.0  8.0  46.0  8.0  2.1  2.5
702705  9.0 10.0  0.0  0.0  0.80 20.0
*  Air Pre-heater
702900   20   0.
702901    0.    0.    0.    0.    0.    0.    0.
*  Air Heater
702950   20
702955  2  1.8  2.0  4.0  4.0  340.0  16430.0  1.0  2.0  20.0  1.0
702956  20.0  0.0  0.0  0.0  -0.8
```

```
*  H2 and Lube Oil Cooler
702000   26     3     1.
702001    0.    0.    0.    0.
*  In-Bed Boiling Surface
702300   24     1   700
702304  0.2  39.0  200.0  5.0  1.7  2.5  20.0  0.95  0.75  0.55
702305  2.0  1.0  6.0
*  In-Bed Superheater
702800   24     1   700
702804  955.0  39.0  150.0  2.0  1.65  2.25  20.0  0.85  0.55  0.45
702805  2.0  1.0  6.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
* 702806  0.0  0.0  0.0  0.0  2500.0  * Area
*
*************** SOURCES, SINKS, AND VALVES
*
*  Flow Stabilizers
703000   31   950.  1300.   700000.     0.     0.
703002   1    1
*  Circulating Water Source
703100   31    50.   20.  1.52E+7     0.     0.
*  Ambient Air Source
703200   33    90.  14.7  1500000.    0.     0.
703203   AIR, -0.013
*  Sorbent Source
703300   31   100.  14.7  5060.     0.     0.
703303   CO2, 0., H2O, 0., SO2, 0.,  O2, 0.
703304    N2, 0.,  CO, 0.,  H2, 0.,   C, 0.
703305     S, 0., ASH, 1.
*  Fuel Source
703400   31    50.  14.7  137149.    0.     0.
703403  FUEL, 6680., SSVL, 0., CO2, 0., H2O, 0.374
703404   SO2, 0.,   O2, 0.112,  N2, 0.006,  CO, 0.
703405    H2, 0.028,    C, 0.396,   S, 0.009, ASH, 0.075
*  Sink for Unused Combustion Air
703500  30
*  Sink for Bed Ash
703600  30
*  Sink for Circulating Water
703700  30
*  Stack (Outlet Component)
703800  32
*  Throttle Valve
703990   35    -2.   -2.   -2.  0.250081  1265.   1468.   700000.
*
*************** PUMPS, COMPRESSORS, AND FANS
*
*  Condensate Pump
704200   41    40.    0.    0.    0.
704201    0.    0.    0.    0.    0.    0.
*  Condensate Booster Pump
704300   41    80.    0.    0.    0.
704301    0.    0.    0.    0.    0.    0.
*  LP heater Drain Pump
704400   41    80.    0.    0.    0.
```

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704401    0.    0.     0.     0.     0.     0.
*  Boiler Feed Pump
704500    41   1800.     0.     0.     0.
704501    0.    0.     0.     0.     0.     0.
*  Boiler Circ. Pumps
704600    41   1800.  0.  0.  0.  0.  0.  0.  75.0    * Pressure Rise
*  Forced Draft Fan
704000    43   17.6    0.     0.     0.
704001    0.    0.     0.
*  Induced Draft Fan
704100    43   14.7    0.     0.     0.
704101    0.    0.     0.
*
*************** MIXERS
*
*  Mixer to accept infiltration Air
705000    51     1     0.
*  Mixer for Attemperator water
705100    50     1     0.
*  Mixer for Gov.Stg. Leakage to IP
705400    51     3     0.
*  Mixer for Throttle Valve Leakage to HIP
705500    51     3     0.
*  Leakage Mixer Prior to Gland Steam Conde
705600    51     4     0.
*  LP Heater drain pump Mixer
705200    50     0     0.
*  Mixer for Air Preheater Condensate to LP
705300    51     4     0.
*  Mixer Prior to Drum, after circulation
705700    54     0     0.
*
*************** SPLITTERS
*
*  Splitter for Air Infiltration
706100    61     0.    100000.0
*  Combustion Air Demand Splitter
706000    60     0.  814434.     0.     0     0.
*  Splitter for Attemporater
706200    61     0.    0.
*  Throttle Valve Total Leakage Splitter
706400    68     0.    0.    0.
*  Shaft Packing Total Leakage Splitter
706500    64   260.888763    0.    0.
*
706600    68     0.    0.    0.
*  Final Shaft Packing Leakage Splitter
706700    64   245.0    0.    0.
*  Spltr. for Air Preheater
706800    61     0.    0.
*  Drum Downcommer Triple Spliter
706300    63     0.  0.45
706301     1     0.    0.3
*
```

```
*************** CLASS 7 COMPONENTS
*
*  Fluid Bed Combustor
707000   71   600   150.  0.059   0.15  0.8
707001  980.    0.    0.    1.    0.    0.
707002  0.008     0.  0.04    0.  0.4     0.
707003  2.9     0.
707009  1500.0   1   1.0
*  Boiler Drum    ID
707500   73   0   340  1400.     0.     0.     0.
707509   10     3  1.0   100000.    150000.
*
***************** CONTROLS
* ATEMPERATOR
706200  61  0.  10000.0               * Guess the attemperator flow
                                      *** CARD ABOVE IS A REPLACEMENT CARD. ***
* 840108  DELETE                                 * Control Deletion Card
840100  WWFIXB  620    955.0   0.001  1.0     TT  280  * Attemperator
840105  2                                      * Interval of aplication
840106  10                                     * 1st time on Itt.#
840107  0.90                                   * Relaxation Fact.
840109  0.0  50000.0                           * Limits on control
* DRUM
* 840200  WWVSC  340  0.0  1.0E3  1.0  BBEIBC 750
* 840205  10
* 840206  10
* 840207  1.0
* 840209  80000.0   150000.0
*  CONTROL BLOCK
* 845100  1  2
* 845106  10
****************** OPERATIONS
* HEAT RATE DEFINITION
873000  1000.0
880010  WW 340   MUL   FUEL 340  OPVB 1
880020  OPVB 1   DIV   BKGRO 1   OPVB 1
880030  OPVB 1   DIV   OPVB 300  OPVB 1
890010  'Gross Plant Heat Rate, BTU/KWH'
890011  OPVB 1
.
```

CONTROLS INPUT
(CALCULATIONS BEGIN AT ITRCON = 10)

CONT SET	VALUE OF GOAL(Y) VARIABLE	FRACT. CONV. CRIT.	GOAL(Y) VARIABLE COMBINATION	CONTROL(X) VARIABLE	CONT LIMITS XCLO/ XCHI	INIT./ INTRVL/ RELAX
1	9.55000E+02	1.0E-03	(1.00E+00)*TT	(280) WWFIXB(620)	0.00E+00 5.00E+04	10 2 0.9000

DEFINITIONS OF SPECIAL OPERATIONS SPECIFIED
(CALCULATIONS BEGIN AT ITROPS = 2)

SET	FIRST VARIABLE (ID)	OPERATION	SECOND VARIABLE (ID)	=	RESULT VARIABLE(ID)	INTERVAL/ SPCL INIT*
1	WW (340)	MUL	FUEL (340)	=	OPVB (1)	1/NO
2	OPVB (1)	DIV	BKGRO (1)	=	OPVB (1)	1/NO
3	OPVB (1)	DIV	OPVB (300)	=	OPVB (1)	1/NO

* SPCL INITIATION (YES) - PRIOR TO FIRST ITERATE AT USER OPTION

OPERATION SET VALUES CALCULATED
AT THE START OF ITERATION 139

SET	VARIABLE (ID) VALUE	OPERATION	VARIABLE (ID) VALUE	=	VARIABLE (ID) VALUE
1	WW (340) 1.38802E+05	MUL	FUEL (340) 6.68000E+03	=	OPVB (1) 9.27198E+08
2	OPVB (1) 9.27198E+08	DIV	BKGRO (1) 6.75778E+01	=	OPVB (1) 1.37205E+07
3	OPVB (1) 1.37205E+07	DIV	OPVB (300) 1.00000E+03	=	OPVB (1) 1.37205E+04

CONTROLLED VARIABLE VALUES CALCULATED

CONTROL SET	Y VARIABLE/ VALUE FROM ITERATE 139	FRAC(ABS) DEVIATION FROM GOAL	Y VARIABLE GOAL VALUE	X VARIABLE/ VALUE USED AT ITERATE 139	CONVG	LAST ITN X LIMTD
1	1.0E+00 * TT (280)			WWFIXB(620)		
	9.55526E+02	-5.5E-04	9.55000E+02	3.10687E+04	YES	

TABLE OF NON-ZERO OPERATIONAL VARIABLES
(PRESENTATION IS: ID, VALUE; ID, ...)

1, 1.37205E+04; 300, 1.00000E+03

FLAG SETTINGS AND DATA FOR SYSTEM

```
NTGCYC =   2, FOSSIL TURBINE GENERATOR CYCLE CALCULATION

NTIMES = 139, NUMBER OF SYSTEM ITERATIONS
              (ITRMAX = 500, ITRMIN =   5)

NCMP   =  60, NUMBER OF COMPONENTS USED IN THIS CASE
              (MXCMP = 250, MAXIMUM NUMBER ALLOWED)

NSTR   =  86, NUMBER OF STREAMS USED IN THIS CASE
              (MXSTR = 360, MAXIMUM NUMBER ALLOWED)

NRHEAT =   0, NON-REHEAT TURBINE PLANT DESIGN

CONVERGENCE DATA:

       EXTERR =  1.00000E+00 LBM/HR, EXTRACTION FLOW CONVERGENCE
       CIRERR =  1.00000E+00 LBM/HR, TOTAL SYSTEM MASS FLOW CONVERGENCE
       TERROR =  5.00000E-06 - ,     COMPONENT CONVERGENCE
       PERROR =  1.00000E-03 - ,     STREAM CONVERGENCE
       GENERR =  1.00000E+00 KW,     GENERATOR CONVERGENCE
       ENEROR =  1.00000E+03 BTU/HR, ENERGY CONVERGENCE

REFERENCE DATA:

       TTDEAD =    50.00 DEG F, DEAD STATE TEMPERATURE
       PPDEAD =    14.70 PSIA,  DEAD STATE PRESSURE
       ZZDEAD =     0.00 FT,    DEAD STATE ELEVATION
       TTAIR  =    50.00 DEG F, AMBIENT TEMPERATURE

STEAM TURBINE DATA:

       NTURB  = 1,        GENERAL ELECTRIC TURBINES
       NGEPRO = 3,        TURBINES SOLVED, G.E. FOSSIL PROCEDURE GER-2007C
       TFREQ  = 0.940254, EQUIVALENT THROTTLE FLOW RATIO
       TFR1ST = 0.250081, FIRST ADMISSION THROTTLE FLOW RATIO

GENERATOR DATA:

       NGNTYP =  2,           CONDUCTOR COOLED GENERATOR
       NGENER =  1,           GENERAL ELECTRIC GENERATOR
       NGNCOL =  1,           LOSSES ARE PARTIALLY RECOVERABLE THROUGH
```

COOLERS

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ISPEED =  3600 RPM,     GENERATOR SPEED
BKGRAT =   88235  KVA,  RATED GENERATOR CAPACITY
POWFAC =  0.850,        GENERATOR POWER FACTOR
PPGNH2 =  30.00 PSIA,   ACTUAL HYDROGEN GENERATOR PRESSURE
PPGNHR =  30.00 PSIA,   RATED HYDROGEN GENERATOR PRESSURE
```

COMPONENT PROPERTIES

COMP	STREAM /PORT	FLU ID	MASS FLOW (LBM/HR)	TEMP (F)	PRESS (PSIA)	QUALITY (-)	ENTH (B/LB)	ENTRPY (B/LB-F)	SPEC. VOLUME (FT3/LBM)
1 TFGS	640/I	0	698077.	952.4	1291.94	1.483	1468.6	1.60076	6.07E-01
	1/U	0	698077.	858.9	880.48	1.345	1429.5	1.61160	8.38E-01
2 TFLP	650/I	0	689619.	858.9	880.48	1.345	1429.5	1.61160	8.38E-01
	2/U	0	641357.	673.1	406.43	1.184	1348.3	1.62572	1.58E+00
	3/E	0	48262.	671.7	394.24	1.183	1348.3	1.62891	1.63E+00
4 TFLP	2/I	0	641357.	673.1	406.43	1.184	1348.3	1.62572	1.58E+00
	4/U	0	600355.	529.6	205.11	1.102	1284.8	1.63769	2.75E+00
	5/E	0	41002.	528.5	198.96	1.102	1284.8	1.64091	2.84E+00
6 TFLP	4/I	0	600355.	529.6	205.11	1.102	1284.8	1.63769	2.75E+00
	6/U	0	573536.	355.2	77.90	1.027	1207.2	1.65407	6.01E+00
	7/E	0	26819.	354.3	75.56	1.027	1207.2	1.65730	6.19E+00
8 TFLP	6/I	0	573536.	355.2	77.90	1.027	1207.2	1.65407	6.01E+00
	8/U	0	539839.	256.1	33.13	0.982	1149.3	1.66817	1.23E+01
	9/E	0	33698.	254.3	32.14	0.982	1149.3	1.67138	1.27E+01
10 TFLP	8/I	0	539839.	256.1	33.13	0.982	1149.3	1.66817	1.23E+01
	10/U	0	495250.	199.4	11.38	0.938	1085.8	1.68646	3.19E+01
	11/E	0	44589.	197.9	11.04	0.939	1085.8	1.68957	3.29E+01
12 TFLP	10/I	0	495250.	199.4	11.38	0.938	1085.8	1.68646	3.19E+01
	12/U	0	495250.	94.7	0.81	0.880	978.0	1.77119	3.59E+02
100 COND	12/S	0	495250.	94.7	0.81	0.880	978.0	1.77119	3.59E+02
	310/T	0	15200000.	50.0	20.00	-0.185	18.1	0.03604	1.60E-02
	212/D	0	869.	210.3	14.20	0.000	178.5	0.30946	1.67E-02
	103/D	0	496119.	94.7	0.81	0.000	62.7	0.11999	1.61E-02
	100/T	0	15200000.	79.9	20.00	-0.154	48.0	0.09291	1.61E-02
102 FWH	104/T	0	668931.	376.2	1792.93	-0.585	351.8	0.53279	1.82E-02
	3/S	0	48262.	671.7	394.24	1.183	1348.3	1.62891	1.63E+00
	102/T	0	668931.	442.4	1785.62	-0.442	422.7	0.61435	1.91E-02
	105/D	0	48262.	391.0	384.66	-0.069	365.7	0.55483	1.85E-02
104 FWH	620/T	0	668931.	310.5	1800.00	-0.724	283.7	0.44795	1.74E-02
	550/S	0	42572.	541.1	198.96	1.110	1291.5	1.64773	2.88E+00
	105/D	0	48262.	391.0	384.66	-0.069	365.7	0.55483	1.85E-02
	104/T	0	668931.	376.2	1792.93	-0.585	351.8	0.53279	1.82E-02
	106/D	0	90833.	327.0	193.01	-0.064	297.9	0.47290	1.77E-02

COMPONENT PROPERTIES

COMP	STREAM /PORT	FLU ID	MASS FLOW (LBM/HR)	TEMP (F)	PRESS (PSIA)	QUALITY (-)	ENTH (B/LB)	ENTRPY (B/LB-F)	SPEC. VOLUME (FT3/LBM)
106 D-A	108/FW	0	574406.	247.0	74.00	-0.067	215.7	0.36329	1.70E-02
	540/S	0	34761.	452.7	75.56	1.084	1258.0	1.71624	7.04E+00
	106/D	0	90833.	327.0	193.01	-0.064	297.9	0.47290	1.77E-02
	109/D	0	700000.	308.1	75.56	0.000	278.1	0.44795	1.75E-02
108 FWH	520/T	0	574406.	190.3	75.88	-0.132	158.5	0.27896	1.66E-02
	680/S	0	33698.	254.3	32.14	0.982	1149.3	1.67138	1.27E+01
	108/T	0	574406.	247.0	74.00	-0.067	215.7	0.36329	1.70E-02
	111/D	0	33697.	206.2	31.67	-0.050	174.3	0.30323	1.67E-02
110 FWH	430/T	0	496119.	105.9	80.00	-0.231	74.1	0.13983	1.61E-02
	530/S	0	44589.	197.9	11.04	0.939	1085.8	1.68957	3.29E+01
	111/D	0	33697.	206.2	31.67	-0.050	174.3	0.30323	1.67E-02
	110/T	0	496119.	189.2	75.23	-0.133	157.4	0.27720	1.66E-02
	112/D	0	78286.	197.4	10.92	0.000	165.5	0.29001	1.80E-02
200 HXGC	420/T	0	496119.	94.7	40.00	-0.185	62.8	0.12001	1.61E-02
	200/T	0	496119.	103.6	40.00	-0.176	71.7	0.13590	1.61E-02
210 HXGN	200/T	0	496119.	103.6	40.00	-0.176	71.7	0.13590	1.61E-02
	560/S	0	869.	886.8	880.48	1.368	1445.4	1.62357	8.60E-01
	210/T	0	496119.	105.8	40.00	-0.173	73.9	0.13983	1.61E-02
	212/D	0	869.	210.3	14.20	0.000	178.5	0.30946	1.67E-02
220 HCNV	102/T	0	668931.	442.4	1785.62	-0.442	422.7	0.61435	1.91E-02
	500/S	8	1054686.	636.8	14.68	N.A.	362.7	1.77820	2.80E+01
	220/T	0	668931.	472.1	1748.99	-0.363	455.7	0.65039	1.96E-02
	222/D	8	1054686.	561.3	14.66	N.A.	341.8	1.75856	2.61E+01
230 HXFB	460/T	0	1505095.	566.8	1475.00	-0.067	570.5	0.76861	2.22E-02
	230/T	0	1505095.	588.2	1411.80	0.211	721.6	0.91339	8.13E-02
240 HCNV	632/T	0	1003397.	566.4	1400.00	-0.049	570.2	0.76861	2.22E-02
	262/S	7	954686.	1065.7	14.69	N.A.	496.1	1.86617	3.89E+01
	240/T	0	1003397.	586.5	1394.13	0.134	675.6	0.86959	6.06E-02
	242/D	7	954686.	687.1	14.68	N.A.	385.4	1.78286	2.93E+01
250 HCNV	630/T	0	836164.	566.4	1400.00	-0.049	570.2	0.76861	2.22E-02
	700/S	7	954686.	2009.2	14.70	N.A.	792.0	2.01677	6.29E+01
	250/T	0	836164.	586.3	1392.15	0.258	747.0	0.93798	9.55E-02
	252/D	7	954686.	1522.3	14.70	N.A.	637.1	1.94693	5.05E+01

COMPONENT PROPERTIES

COMP	STREAM /PORT	FLU ID	MASS FLOW (LBM/HR)	TEMP (F)	PRESS (PSIA)	QUALITY (-)	ENTH (B/LB)	ENTRPY (B/LB-F)	SPEC. VOLUME (FT3/LBM)
260 HCNV	750/T	0	668931.	587.1	1400.00	1.000	1175.3	1.34736	3.02E-01
	272/S	7	954686.	1382.9	14.70	N.A.	593.3	1.92403	4.70E+01
	260/T	0	668931.	721.6	1388.95	1.238	1314.1	1.47362	4.25E-01
	262/D	7	954686.	1065.7	14.69	N.A.	496.1	1.86617	3.89E+01
270 HCNV	510/T	0	700000.	666.7	1388.95	1.159	1268.3	1.43396	3.85E-01
	252/S	7	954686.	1522.3	14.70	N.A.	637.1	1.94693	5.05E+01
	270/T	0	700000.	737.8	1362.20	1.258	1328.1	1.48720	4.46E-01
	272/D	7	954686.	1382.9	14.70	N.A.	593.3	1.92403	4.70E+01
280 HXFB	270/T	0	700000.	737.8	1362.20	1.258	1328.1	1.48720	4.46E-01
	280/T	0	700000.	955.5	1345.77	1.495	1468.6	1.59657	5.82E-01
290 HXGN	400/T	3	820106.	118.8	17.60	N.A.	153.0	1.65314	1.23E+01
	681/S	0	0.	254.3	32.14	0.982	1149.3	1.67138	1.27E+01
	290/T	3	820106.	118.8	17.60	N.A.	153.0	1.65314	1.23E+01
	292/D	0	0.	254.3	32.14	0.982	1149.3	1.67138	1.27E+01
295 HXGN	222/T	8	1054686.	561.3	14.66	N.A.	341.8	1.75856	2.61E+01
	290/S	3	820106.	118.8	17.60	N.A.	153.0	1.65314	1.23E+01
	295/T	8	1054686.	297.7	14.66	N.A.	271.1	1.67853	1.94E+01
	297/D	3	820106.	488.4	17.60	N.A.	243.9	1.77445	2.02E+01
300 SRCE	280/I	0	700000.	955.5	1345.77	1.495	1468.6	1.59657	5.82E-01
	300/U	0	700000.	955.5	1345.77	1.495	1468.6	1.59657	5.82E-01
310 SRCE	310/U	0	15200000.	50.0	20.00	-0.185	18.1	0.03604	1.60E-02
320 IPUT	320/U	3	1500000.	90.0	14.70	N.A.	145.9	1.65314	1.40E+01
330 SRCE	330/U	4	5060.	100.0	14.70	N.A.	4.6	0.00839	N.A.
340 SRCE	340/U	5	138802.	50.0	14.70	N.A.	70.5	0.68771	N.A.
350 SINK	610/I	3	579894.	90.0	14.70	N.A.	145.9	1.65314	1.40E+01
360 SINK	701/I	6	9282.	1511.1	14.70	N.A.	291.4	0.27433	5.02E+01
370 SINK	100/I	0	15200000.	79.9	20.00	-0.154	48.0	0.09291	1.61E-02

COMPONENT PROPERTIES

COMP	STREAM /PORT	FLU ID	MASS FLOW (LBM/HR)	TEMP (F)	PRESS (PSIA)	QUALITY (-)	ENTH (B/LB)	ENTRPY (B/LB-F)	SPEC. VOLUME (FT3/LBM)
380 OPUT	410/I	8	1054686.	298.3	14.70	N.A.	271.2	1.67853	1.93E+01
399 VTHR	300/I	0	700000.	955.5	1345.77	1.495	1468.6	1.59657	5.82E-01
	399/U	0	700000.	952.4	1291.94	1.483	1468.6	1.60076	6.07E-01
400 PMGC	601/I	3	820106.	90.0	14.70	N.A.	145.9	1.65314	1.40E+01
	400/U	3	820106.	118.8	17.60	N.A.	153.0	1.65314	1.23E+01
410 PMGC	295/I	8	1054686.	297.7	14.66	N.A.	271.1	1.67853	1.94E+01
	410/U	8	1054686.	298.3	14.70	N.A.	271.2	1.67853	1.93E+01
420 PMEL	103/I	0	496119.	94.7	0.81	0.000	62.7	0.11999	1.61E-02
	420/U	0	496119.	94.7	40.00	-0.185	62.8	0.12001	1.61E-02
430 PMEL	210/I	0	496119.	105.8	40.00	-0.173	73.9	0.13983	1.61E-02
	430/U	0	496119.	105.9	80.00	-0.231	74.1	0.13983	1.61E-02
440 PMEL	112/I	0	78286.	197.4	10.92	0.000	165.5	0.29001	1.80E-02
	440/U	0	78286.	197.5	80.00	-0.129	165.8	0.29003	1.66E-02
450 PMEL	109/I	0	700000.	308.1	75.56	0.000	278.1	0.44795	1.75E-02
	450/U	0	700000.	310.5	1800.00	-0.724	283.7	0.44795	1.74E-02
460 PMEL	631/I	0	1505095.	566.4	1400.00	-0.049	570.2	0.76861	2.22E-02
	460/U	0	1505095.	566.8	1475.00	-0.067	570.5	0.76861	2.22E-02
500 MX51	242/IA	7	954686.	687.1	14.68	N.A.	385.4	1.78286	2.93E+01
	611/IB	3	100000.	90.0	14.70	N.A.	145.9	1.65314	1.40E+01
	500/U	8	1054686.	636.8	14.68	N.A.	362.7	1.77820	2.80E+01
510 MIXR	260/IA	0	668931.	721.6	1388.95	1.238	1314.1	1.47362	4.25E-01
	621/IB	0	31069.	310.5	1800.00	-0.724	283.7	0.44795	1.74E-02
	510/U	0	700000.	666.7	1388.95	1.159	1268.3	1.43396	3.85E-01
520 MIXR	110/IA	0	496119.	189.2	75.23	-0.133	157.4	0.27720	1.66E-02
	440/IB	0	78286.	197.5	80.00	-0.129	165.8	0.29003	1.66E-02
	520/U	0	574406.	190.3	75.88	-0.132	158.5	0.27896	1.66E-02
530 MX51	11/IA	0	44589.	197.9	11.04	0.939	1085.8	1.68957	3.29E+01
	292/IB	0	0.	254.3	32.14	0.982	1149.3	1.67138	1.27E+01
	530/U	0	44589.	197.9	11.04	0.939	1085.8	1.68957	3.29E+01

COMPONENT PROPERTIES

COMP	STREAM /PORT	FLU ID	MASS FLOW (LBM/HR)	TEMP (F)	PRESS (PSIA)	QUALITY (-)	ENTH (B/LB)	ENTRPY (B/LB-F)	SPEC. VOLUME (FT3/LBM)
540 MX51	7/IA	0	26819.	354.3	75.56	1.027	1207.2	1.65730	6.19E+00
	671/IB	0	7943.	858.9	880.48	1.345	1429.5	1.61160	8.38E-01
	540/U	0	34761.	452.7	75.56	1.084	1258.0	1.71624	7.04E+00
550 MX51	5/IA	0	41002.	528.5	198.96	1.102	1284.8	1.64091	2.84E+00
	660/IB	0	1569.	952.4	1291.94	1.483	1468.6	1.60076	6.07E-01
	550/U	0	42572.	541.1	198.96	1.110	1291.5	1.64773	2.88E+00
560 MX51	661/IA	0	354.	952.4	1291.94	1.483	1468.6	1.60076	6.07E-01
	670/IB	0	515.	858.9	880.48	1.345	1429.5	1.61160	8.38E-01
	560/U	0	869.	886.8	880.48	1.368	1445.4	1.62357	8.60E-01
570 M3WA	250/IA	0	836164.	586.3	1392.15	0.258	747.0	0.93798	9.55E-02
	230/IB	0	1505095.	588.2	1411.80	0.211	721.6	0.91339	8.13E-02
	240/IC	0	1003397.	586.5	1394.13	0.134	675.6	0.86959	6.06E-02
	570/U	0	3344656.	587.2	1401.74	0.199	714.1	0.90640	7.86E-02
600 SDEM	320/I	3	1500000.	90.0	14.70	N.A.	145.9	1.65314	1.40E+01
	600/U	3	679894.	90.0	14.70	N.A.	145.9	1.65314	1.40E+01
	601/B	3	820106.	90.0	14.70	N.A.	145.9	1.65314	1.40E+01
610 SFIX	600/I	3	679894.	90.0	14.70	N.A.	145.9	1.65314	1.40E+01
	610/U	3	579894.	90.0	14.70	N.A.	145.9	1.65314	1.40E+01
	611/B	3	100000.	90.0	14.70	N.A.	145.9	1.65314	1.40E+01
620 SFIX	450/I	0	700000.	310.5	1800.00	-0.724	283.7	0.44795	1.74E-02
	620/U	0	668931.	310.5	1800.00	-0.724	283.7	0.44795	1.74E-02
	621/B	0	31069.	310.5	1800.00	-0.724	283.7	0.44795	1.74E-02
630 SPCT	751/I	0	3344656.	566.4	1400.00	-0.049	570.2	0.76861	2.22E-02
	630/U	0	836164.	566.4	1400.00	-0.049	570.2	0.76861	2.22E-02
	631/B	0	1505095.	566.4	1400.00	-0.049	570.2	0.76861	2.22E-02
	632/C	0	1003397.	566.4	1400.00	-0.049	570.2	0.76861	2.22E-02
640 SVSL	399/I	0	700000.	952.4	1291.94	1.483	1468.6	1.60076	6.07E-01
	640/U	0	698077.	952.4	1291.94	1.483	1468.6	1.60076	6.07E-01
	641/B	0	1923.	952.4	1291.94	1.483	1468.6	1.60076	6.07E-01
650 SSPL	1/I	0	698077.	858.9	880.48	1.345	1429.5	1.61160	8.38E-01
	650/U	0	689619.	858.9	880.48	1.345	1429.5	1.61160	8.38E-01
	651/B	0	8458.	858.9	880.48	1.345	1429.5	1.61160	8.38E-01

COMPONENT PROPERTIES

COMP	STREAM /PORT	FLU ID	MASS FLOW (LBM/HR)	TEMP (F)	PRESS (PSIA)	QUALITY (-)	ENTH (B/LB)	ENTRPY (B/LB-F)	SPEC. VOLUME (FT3/LBM)
660 SVSL	641/I	0	1923.	952.4	1291.94	1.483	1468.6	1.60076	6.07E-01
	660/U	0	1569.	952.4	1291.94	1.483	1468.6	1.60076	6.07E-01
	661/B	0	354.	952.4	1291.94	1.483	1468.6	1.60076	6.07E-01
670 SSPL	651/I	0	8458.	858.9	880.48	1.345	1429.5	1.61160	8.38E-01
	670/U	0	515.	858.9	880.48	1.345	1429.5	1.61160	8.38E-01
	671/B	0	7943.	858.9	880.48	1.345	1429.5	1.61160	8.38E-01
680 SFIX	9/I	0	33698.	254.3	32.14	0.982	1149.3	1.67138	1.27E+01
	680/U	0	33698.	254.3	32.14	0.982	1149.3	1.67138	1.27E+01
	681/B	0	0.	254.3	32.14	0.982	1149.3	1.67138	1.27E+01
700 FBED	297/IA	3	820106.	488.4	17.60	N.A.	243.9	1.77445	2.02E+01
	340/IF	5	138802.	50.0	14.70	N.A.	70.5	0.68771	N.A.
	330/IS	4	5060.	100.0	14.70	N.A.	4.6	0.00839	N.A.
	700/U	7	954686.	2009.2	14.70	N.A.	792.0	2.01677	6.29E+01
	701/B	6	9282.	1511.1	14.70	N.A.	291.4	0.27433	5.02E+01
750 DRUM	220/FW	0	668931.	472.1	1748.99	-0.363	455.7	0.65039	1.96E-02
	570/RI	0	3344656.	587.2	1401.74	0.199	714.1	0.90640	7.86E-02
	750/ST	0	668931.	587.1	1400.00	1.000	1175.3	1.34736	3.02E-01
	751/DC	0	3344656.	566.4	1400.00	-0.049	570.2	0.76861	2.22E-02

DETAILED FEEDWATER HEATER PERFORMANCE OUTPUT - TABLE A
(EXTRACTION FLOW UPDATING BEGINS AT ITERATION 2)

HTR NO.	COMP NO.	COMPONENT DESCRIPTION	HEAT TRANSFER/DEG* CONDENSING SECTION (BTU/HR-F)	HEAT TRANSFER/DEG* SUBCOOL/MX SECTION (BTU/HR-F)	HEAT# EX PERF INDEX (-)	TERM TEMP DIFF (TTD) (F)	DRAIN COOL DIFF (DCA) (F)	FW OR TUBE PRESS DROP (PSIA)	UPD INT/ (RELAXN) DEMAND REFERENCE (-)
1	102	FW. W/DESUP+COOL	3.53E+05	8.05E+04	0.98	0.80	14.8	7.3	1(1.00)
2	104	FW. W/DESUP+COOL	3.85E+05	1.65E+05	0.97	5.13	16.5	7.1	1(1.00)
3	106	CONTACT HEATER	N.A.	N.A.	0.82	0.00	N.A.	-1.6	1(1.00)
4	108	FWHT. BACK-DRAIN	1.25E+06	4.84E+04	0.98	7.27	15.9	1.9	1(1.00)
5	110	STD. FW. HEATER	1.17E+06	3.24E+03	0.85	8.78	N.A.	4.8	1(1.00)
A	100	STD. CONDENSER	1.67E+07	2.25E+03	9.53	N.A.	N.A.	0.0	N.A.

* HEAT TRANSFER/DEG IS SIMILAR TO UA. SEE VOL 1 OUTPUT DESCRIPTION.
# PERFORMANCE INDEX IS SIMILAR TO EFFECTIVENESS. SEE VOL 1 OUTPUT DESCRIPTION.

DETAILED FEEDWATER HEATER PERFORMANCE OUTPUT - TABLE B

HTR NO.	COMP NO.	COMPONENT DESCRIPTION	HEAT XFER TO FW OR CIRC.H2O (BTU/HR)	ENTHALPY RISE FW.OR CIRC. (BTU/LBM)	ENTHALPY DROP EXT STEAM (BTU/LBM)	MASS FLOWS TO HEATER SHELL (LBM/HR)	MASS FLOWS RATE HEATER DRAIN IN (LBM/HR)	MASS FLOWS RATE THRU TUBES (LBM/HR)
1	102	FW. W/DESUP+COOL	4.74E+07	70.9	982.6	48262.	0.	668931.
2	104	FW. W/DESUP+COOL	4.56E+07	68.1	993.6	42572.	48262.	668931.
3	106	CONTACT HEATER	3.59E+07	62.4	979.9	34761.	90833.	574406.
4	108	FWHT. BACK-DRAIN	3.29E+07	57.2	975.0	33698.	0.	574406.
5	110	STD. FW. HEATER	4.13E+07	83.3	920.3	44589.	33697.	496119.
A	100	STD. CONDENSER	4.53E+08	29.8	915.3	495250.	869.	15200000.

DETAILED HEAT EXCHANGER DESIGN OUTPUT

COMPONENT NUMBER	COMPONENT DESCRIPTION	HEAT TRANS. COEFFICIENT (BTU/HR-FT2-F)	EFFECTIVE HEAT TRANS. AREA (FT2)
220	CONVECTIVE STAGE	9.005	17492.39
230	FLUID BED HT.EX.	47.716	5105.09
240	CONVECTIVE STAGE	8.616	46087.17
250	CONVECTIVE STAGE	5.000	25000.00
260	CONVECTIVE STAGE	9.378	17530.09
270	CONVECTIVE STAGE	13.566	4094.54
280	FLUID BED HT.EX.	43.370	3445.93

DETAILED COMBUSTOR PERFORMANCE OUTPUT

COMP NO.	FUEL FIRING RATE (LBM/HR)	FRACT. EXCESS AIR (-)	AD. FLAME TEMP. (F)	EXIT TEMP. (F)	ENERGY (BTU/HR) IN-AIR/ IN-FUEL	OUT-REFUSE/ OUT-FLU GAS	LOST TO ENVIR.	RESIDENT HX'S
700	1.388E+05	0.1500	0.0	2009.2	8.293E+07 8.346E+08	2.690E+06 5.445E+08	7.418E+06	3.258E+08

FIRST LAW OF THERMODYNAMICS PERFORMANCE - SYSTEM

HEAT SUPPLIED (ALL UNITS ARE BTU/HR) -

BOILER HEAT TO WORKING FLUID	$	-5.54931E+07	
1ST BOILER REHEAT (IN, TYPE 25 COMPONENT)		0.00000E+00	
2ND BOILER REHEAT (IN, TYPE 25 COMPONENT)		0.00000E+00	
UNSPECIFIED HEAT EXCHANGERS (HEAT IN)		0.00000E+00	
GROSS HEAT SUPPLIED	$		-5.54931E+07
MAKEUP HEAT (BY FLOW IN)		-1.52752E+10	
LETDOWN HEAT (BY FLOW OUT)		-1.56518E+10	
CIRC WATER LOAD CREDIT (HEAT IN)		4.53416E+08	
COMPONENT VESSEL LOSSES		0.00000E+00	
PIPE HEAT AND ELEVATION LOSSES		0.00000E+00	
PUMP/COMP/FAN INEFFICIENCY LOSSES		0.00000E+00	
PUMP GLANDS AND SEALS LOSSES		0.00000E+00	
GENERATOR HYD AND OIL COOLER (HEAT IN)		4.40673E+06	
NET HEAT SUPPLIED			7.78975E+08
HEAT IN AS ELECTRIC PUMP/COMP/FAN POWER		1.04309E+07	
NET POWER SUPPLIED			7.89406E+08

POWER OUT (ALL UNITS ARE MWE) -

NET TURBINE WHEEL POWER TO GENERATORS	69.013	
GENERATOR MECHANICAL LOSSES	0.327	
GENERATOR ELECTRICAL LOSSES	1.109	
GROSS GENERATOR POWER		67.578
ELECTRIC POWER USED FOR PUMP/COMP/FAN	3.057	
HOUSE LOAD POWER, EXCLUDING ELEC PUMP/COMP/FAN	0.000	
NET GENERATOR POWER		64.521

SYSTEM PERFORMANCE	THERMAL EFF. (-)	HEAT RATE (BTU/KW-HR)
GROSS ACTUAL TURBINE CYCLE (GROSS HEAT SUPPLIED / GROSS GENERATOR POWER)	-4.15520	$ -821.
NET ACTUAL TURBINE CYCLE (MOD NET POWER SUPPLIED / NET GENERATOR POWER)	0.27889	12235.
TURBINE CYCLE STEAM RATE, LBM/KW-HR		22.1966

NOTE: MOD NET POWER SUPPLIED = NET POWER SUPPLIED + COMPONENT VESSEL LOSSES + PIPE HEAT AND ELEVATION LOSSES + PUMP INEFFICIENCY LOSSES + PUMP GLANDS AND SEALS LOSSES

$ -- CAUTION INTERPRETING BOILER HEAT AND GROSS HEAT RATE AND EFFICIENCY, RE INPUT/OUTPUT MASS DIFFERENCE. SEE VOLUME 1, SECTION 24. ADVISE USER DEFINE HEAT RATE AND EFFICIENCY.

SPECIAL OUTPUT TABLE OF SPECIFIED VARIABLES

INDEX	DESCRIPTION	VARIABLE(ID)	VALUE
1	Gross Plant Heat Rate, BTU/KWH	OPVB (1)	1.372046E+04