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User's Instructions for ORCENT II—A Digital Computer Program for the Analysis of Steam Turbine Cycles Supplied by Light-Water-Cooled Reactors

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NOTICE: This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

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USER'S INSTRUCTIONS FOR ORCENT II — A DIGITAL COMPUTER PROGRAM FOR THE ANALYSIS OF STEAM TURBINE CYCLES SUPPLIED BY LIGHT-WATER-COOLED REACTORS

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ABSTRACT

The ORCENT-II digital computer program will perform calculations at valves-wide-open design conditions, maximum guaranteed rating conditions, and an approximation of part-load conditions for steam turbine cycles supplied with throttle steam characteristic of contemporary light-water reactors. Turbine performance calculations are based on a method published by the General Electric Company. Output includes all information normally shown on a turbine-cycle heat balance diagram. The program is written in FORTRAN IV for the IBM System 360 digital computers at the Oak Ridge National Laboratory (ORNL).

Keywords: feedwater heating, heat balance, steam cycle, turbine generator.

1. INTRODUCTION

This report describes ORCENT II, an updated version of the original ORCENT digital computer program for analyzing turbine cycles with large steam turbine generators operating with saturated or low-superheat throttle steam, such as that provided by light-water-cooled nuclear reactors (LWRs). The original ORCENT code[1] was published in January 1969, with turbine performance calculations based on the method presented by the General Electric Company at the 1967 American Power Conference.[2] Turbine performance calculations in ORCENT II are based on a revised method published by the General Electric Company in 1973 (Ref 3), and the ORCENT program has undergone extensive revisions to match the 1973 performance data. In addition, ORCENT II utilizes the 1967 American Society of Mechanical Engineers (ASME) formulations and iterative procedures for the calculation of the properties of steam[4] adapted for use at ORNL by D. W. Altom. These formulations and procedures replace the equations of Keenan and Keyes[5] and algorithms of the Westinghouse Electric Corporation[6] used in the original ORCENT code.

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This report includes (1) a detailed description of input data requirements with recommendations for various parameters, (2) input data and program output for two example problems in Appendices A and B, and (3) a FORTRAN listing of the program in Appendix C. The methodology used is not included because it is covered in detail in Ref. 3. Access to this General Electric Company report is essential for applying and understanding the program. References 7 and 8 are also very helpful.

The ORCENT II computer program is written in FORTRAN IV for the IBM System 360 digital computers at ORNL.

2. APPLICATIONS

The current version of ORCENT permits calculations at valves-wide-open (VWO) design conditions, maximum guaranteed rating conditions, and an approximation of part-load conditions, whereas the 1969 version was limited to calculation of turbine maximum guaranteed conditions. However, the 1978 version of ORCENT is less versatile than the 1969 version in terms of cycle arrangement. Operating conditions (VWO through part-load) have been expanded, and accuracy has been improved. The preparation of input data may be more or less complex now than it was in the previous version, depending on the cycle arrangement and the accuracy requirement.

Example problems 1 and 2 in Appendices A and B demonstrate the application of ORCENT II to boiling-water-reactor (BWR) and pressurized-water-reactor (PWR) cycles, respectively. The ORCENT II program is limited to 1800-rpm tandem-compound turbine generators with single- or double-flow high-pressure sections and one, two, or three double-flow low-pressure turbine sections. Steam supply for LWR cycles is generally in the range of 900 to 1100 psia and slightly wet to 100°F of initial superheat. Normally, LWR cycles will contain a moisture separator and may contain one or two stages of steam reheat. The method is Ref. 3 is intended to be applied to condensing turbines with exhaust pressure of 5 in. Hg abs or less, but ORCENT II will also make calculations at elevated pressures. The code is intended for use on units rated 500 Mw(e) and larger but will run to completion for units rated as low as 100 MW(e). Results should be viewed with some suspicion, because not all mechanical and generator loss functions in Ref. 3 have been plotted for generator ratings below 500 MVA. Numerous warning messages are printed when independent variables exceed their intended limits, but limit checks are by no means complete.

Appendix IV of Ref. 3 provides equations and tabular values representing curves required to determine efficiencies and losses. It also contains tabular listings for limits for throttle flow ratio, stage-group pressure ratio, first-stage bowl pressure, inlet volume flow per end, annulus velocity, generator kVA, and other independent variables.

3. DATA INPUT DESCRIPTION

Input data are entered on cards as described below and as shown in Fig. 1 and in example problems 1 and 2 of Appendices A and B. The first data card for each case must be a title or comment card. A "case" refers to a complete heat balance calculation, whether at VWO design conditions, maximum guaranteed rating conditions, or part-load conditions. Often, calculation of two cases will be required to arrive at a desired result: VWO design for the first case and maximum guaranteed rating or part load for the second case. Seventy-two columns of the first data card are read, and these comments are printed at the top of each page which is part of that case. If the user fails to include a comment card in any case, the next data card will be interpreted as a comment card. The title card may be followed by various data cards containing a flag variable IFLAG, right-adjusted in the first two columns of the card. As each data card is read, the first two columns are checked to determine which variables have been read in the remaining one through six data fields. Columns 73 to 80 are not read and may be used for card identification purposes. The format for the six data fields is F10.0,5F12.0. Integer-type data variables must either be right-adjusted or followed by a decimal point.

A first-time user of ORCENT may see what default input data and sample output look like by entering two blank cards. The first card

ORNL DWG 78 15978

	IFLAG	DATA1	DATA2	DATA3	DATA4	DATA5	DATA6	
COLUMN	NO 2	3	13	25	37	49	61	73

Card							
	COMMENTS (UP TO 72 ALPHANUMERIC CHARACTERS) 72						73
1	TT	PT	AT				
2	QT	PCMU	QCR	TFR	QSGO		
3	WRATE	GC	PF	IH2			
4	EFP	EFF	CP1	CP2			
5	PDGS						
7	NHP						
9	NLP	PBLP	PXLPI	BLS	PCI		
10	MR	PMR (1)	PMR (2)	FMR (3)	PMR (4)	PMR (5)	
11	MS	EMS					
12	NRH	QERH1	TTDRH1	QERH2	TTDRH2	NDRH	
13	NF	NFH	NFL				
14	N	PE (N)	TTD(N)	ND (N)	NDC (N)	TDCA (N)	
15	IP	IFPT					
16	QAE						
17	LK						
0							

Fig. 1. Input data card headings.

is utilized as a title card with 72 blanks. The second card is interpreted as an "end of case" card.

Following are detailed descriptions of each data card and variable. As noted in the discussions, it is often possible to leave selected variable fields blank and use the default values.

1. IFLAG = 1

   TT = throttle steam temperature, °F

   PT = throttle steam pressure, psia

   AT = throttle steam moisture, percent

Throttle temperature TT and pressure PT normally will be known. For wet or dry-and-saturated throttle conditions, either temperature or pressure should be input. If throttle steam temperature TT is input and throttle steam pressure PT is blank, PT will be selected equal to the saturation pressure corresponding to temperature TT. Similarly, PT may be input and TT will be selected as the saturation temperature corresponding to pressure PT. A blank for throttle steam moisture is interpreted as zero. Throttle temperature for LWR cycles should generally be in the range of 532°F through 656°F, with zero through 100°F superheat. Throttle moisture AT should be entered as percent (0.5 for 1/2 percent). BWR throttle conditions will generally be at or near saturation; PWR cycles may include modest superheat.

2. IFLAG = 2

   QT = estimated throttle steam flow, lb/hr

   PCMU = feedwater makeup rate, percent of throttle steam flow

   QCR = condensate flow bypassed to steam generator, lb/hr

   TFR = throttle flow ratio

   QSGO = required steam generator outlet flow, lb/hr

Estimated throttle steam flow QT is required information to provide a starting point for iteration. Rapid convergence does not require a close estimate of throttle steam flow. Use of the theoretical steam rate will provide adequate estimates of throttle steam flow. In the absence of a better estimate, QT may be set equal to 10,000 times the generator output in MW(e). This will be close enough for VWO through half of rated load heat balances.

The feedwater makeup rate PCMU is normally left blank (interpreted as zero) unless modeling a system with makeup. Condensate flow bypassed to the steam generator QCR represents flow to a condensate storage tank, as shown in Fig. 22 of Ref. 3. The ORCENT program does not include the option of a separate steam seal system employing sealing steam raised in a steam seal evaporator. When modeling this type of system, the heat rate will be more accurate if an estimate of sealing steam is included as part or all of QCR.

The first stage of the high-pressure turbine section is normally designed for multiadmission governing control. The number of admissions is determined from the turbine rating and throttle steam conditions. For ratings through 1250 MW(e), three admissions are normally used for multiadmission governing control, according to Ref. 3. For ratings greater than 1250 MW(e) to the largest sizes offered, two admissions are used. For abnormally low pressures, a single admission (full throttling) is used. Only the three-admission option is included in the present code, with the first admission occurring at a throttle flow ratio of 0.6. For a VWO heat balance, TFR should be set euqal to one. For a maximum guaranteed rating heat balance, TFR should be set equal to 0.95238. This constant results from the 5% flow margin provided above the flow required to meet guaranteed output (0.95238 = 1./1.05). For cases where generator output or steam generator outlet flow is known, TFR must be estimated for low-load cases. Throttle flow is not a linear function of generator output. It is advisable to estimate TFR, converge on the required generator output, then modify TFR and rerun if the ratio of throttle flow to VWO throttle flow differs appreciably from the input TFR. To summarize, it is desirable, but not mandatory, that any case at a throttle flow ratio TFR of less than one be preceded by a case at VWO design (TFR = 1.). Any case not preceded by such must have a TFR value input as 1. This with all other input data corresponding to maximum guaranteed rating condition, will produce a heat rate in error by <0.3%.

If steam generator flow QSGO is known and the user wishes to solve for generator electrical output, QSGO must be input. For all other cases, QSGO should be left blank.

3. IFLAG = 3

   WRATE = gross electrical output, MW(e)

   GC = generator capability, MVA

   PF = generator power factor

   IH2 = index for generator hydrogen pressure

If required steam generator outlet flow QSGO is input on the previous card, there is still a need for an estimate of electrical output WRATE and generator capability GC. If required steam-generator outlet flow has been input but generator capability has not, then the code will calculate generator capability as electrical output divided by power factor, making use of the last iteration of electrical output. The BLOCK DATA subprogram contains a value of gross electrical output that will be used as a first guess unless it is erroneously input as blank. If the gross electrical output WRATE is input and the required steam generator output QSGO is not, the program will iterate until steam flow is sufficient to obtain the required electrical output WRATE. If generator capability GC is input, it should be set equal to electrical output at VWO divided by the power factor PF (which normally will be 0.9).

Flag variable IH2 is normally left blank or input as zero. This indicates that the generator is operated at rated hydrogen pressure. Setting IH2 equal to one reduces generator operating pressure to 15 psi below rated pressure. Generator hydrogen pressure is not continuously variable; only rated pressure or a 15-psi reduction in pressure may be selected.

4. IFLAG = 4

   EFP = feedwater pump isentropic efficiency, decimal fraction

   EFF = feedwater pump turbine efficiency, decimal fraction

   CP1 = pressure of feedwater pump inlet above condenser pressure, psi

   CP2 = ratio of feedwater pump discharge pressure to turbine throttle pressure, decimal value greater than one

To match heat balance calculations by others, ORCENT includes feedwater pump isentropic efficiency EFP, feedwater pump turbine efficiency EFF, pressure constants for feedwater pump inlet pressure above condenser pressure CP1, and ratio of feedwater pump discharge pressure to turbine throttle pressure CP2 as input data variables. The default value of pump efficiency EFP is 0.878. A 10% change in pump efficiency will result in a heat rate change of about 13 Btu/kWhr. The default value of feedwater pump turbine efficiency EFF is 0.77. A 10% change in turbine efficiency will result in about a 21-Btu/kWhr change in heat rate. For calculation purposes, it is assumed that the feedwater pump takes suction from the discharge of a hotwell or condensate pump with no intermediate feedwater booster pump. The default value of inlet pressure above condenser pressure CP1 is 220 psi, and the ratio of discharge pressure to turbine throttle pressure CP2 is 1.31.

5. IFLAG = 5

PDGS = pitch diameter of the governing stage, in.

One does not normally have sufficient detail on turbine design to use anything but a default value for the pitch diameter of the governing stage PDGS of the high-pressure turbine. Example problems in Ref. 3 indicate a value of 65 in. for PDGS, which is the value set by ORCENT II if it is not input.

6. IFLAG = 6 is not used.

7. IFLAG = 7

NHP = number of parallel high-pressure turbine sections

Reference 3 indicates that the high-pressure turbine casing is normally single flow for ratings through ∿575 MW(e) and double flow at larger ratings. The number of parallel high-pressure turbine sections NHP will be set at these values by ORCENT if NHP is not input on this data card.

8. IFLAG = 8 is not used.

9. IFLAG = 9

NLP = number of parallel low-pressure turbine sections; NLP = 2 for one double-flow section, NLP = 4 for two double-flow sections, and NLP = 6 for three double-flow sections

PBLP = bowl pressure in the low pressure turbine, psia

PXLPI = low-pressure turbine exhaust pressure, in. Hg abs

PXLP = low-pressure turbine exhaust pressure, psia

BLS = length of last stage buckets in the low-pressure turbine, in.

PCI = condenser pressure, in. Hg abs

PC = condenser pressure, psia

The number of parallel low-pressure turbine sections NLP should be determined by reference to the vendor's exhaust loading limit information. The General Electric Company specifies exhaust loading limits at 3.5 in. Hg abs exhaust pressure with zero makeup as follows:[9]

Last stage bucket length (in.)	Exhaust flow (lb/hr per row LSB)
35	1,260,000
38	1,585,000
43	1,857,000

Up to the exhaust loading limit, it is possible to select turbines with considerable variation in exhaust loss and efficiency. Some utilities accept a high exhaust loss in return for a turbine of lower capital cost, while others select a lower exhaust loss with higher capital cost in return for higher efficiency. It is difficult to come up with a rule of thumb, but 10- to 30-Btu/lb exhaust loss at turbine maximum guaranteed rating is not uncommon. In general, the exhaust loss should be minimized over the expected operating load range.

The bowl pressure PBLP of the low-pressure turbine should be ∿200 psia. Reference 7 indicates that optimum intermediate pressures for nonreheat, single-stage, and two-stage steam reheat cycles are ∿10, 20, and 15% of initial pressure, respectively.

The user has the option of entering the low-pressure turbine section exhaust pressure in in. Hg abs or in psia. If the pressure entered in the data field is preceded by a minus sign, pressure is interpreted as PXLP, exhaust pressure in psia. A positive sign or no sign interprets the pressure as PXLPI, exhaust pressure in in. Hg abs.

The length of the last-stage buckets BLS in the low-pressure section must be input if it is other than the default value, 43 in.

Previous applications of the ORCENT code to desalination studies required location of a heat exchanger in place of the condenser at a location remote from the low-pressure turbine exhaust. This resulted in significant pressure drop from the turbine exhaust to the "condenser" (actually a brine heater). For this application, a variable PCI may be input in in. Hg abs or psia (preceded by a minus sign for psia). If this feature is not required, the data field should be left blank, and it will be assumed that the turbine exhausts directly to the condenser with no pressure drop.

10. IFLAG = 10

MR = number of moisture removal stages in each low-pressure turbine section

PMR = moisture removal stage pressure psia

The number of moisture removal stages MR in the low-pressure turbine section and the moisture removal stage pressures PMR often require some trial and error. In general, moisture removal stages should be included in all turbine stages with a shell pressure of <60 psia and shell moisture of >4% before removal. The maximum number of moisture removal stages is five. Because the actual stage pressures are not normally known except by the turbine supplier, it is customary to select approximate stage pressures of 50, 30, 20, 10, and 5 psia for nonreheat cycles and 20, 10, and 5 psia for reheat cycles. Moisture-removal pressures should be listed in descending order. Each moisture-removal point will drain to the same or to the next lower pressure feedwater heater shell, or it will drain to the condenser if there are no intervening feedwater heaters.

11. IFLAG = 11

MS = moisture-separator index; MS = 0 for no moisture separator, MS = N if separator drains to feedwater heater No. N, and MS = NF + 1 if separator drains to condenser where NF = total number of feedwater heaters (see IFLAG = 13)

EMS = moisture-separator effectiveness, percent

The moisture-separator index (MS) indicates the number of the feedwater heater to which the external moisture separator drains. The moisture separator can drain to a feedwater heater fed from the exhaust of the high-pressure turbine section, to any lower pressure feedwater heater, or to the condenser by setting MS equal to the total number of feedwater heaters plus one. The efficiency of the moisture separator is assumed to be 100% unless another value is input. Efficiency is defined as the percentage of entering moisture removed, calculated at the moisture-separator discharge pressure.

12. IFLAG = 12

NRH = number of stages of steam reheat

QERH1 = estimated steam flow to first-stage reheater, lb/hr

TTDRH1 = terminal temperature difference for first-stage reheater, °F

QERH2 = estimated steam flow to second-stage reheater, lb/hr

TTDRH2 = terminal temperature difference for second-stage reheater, °F

NDRH = feedwater heater number for first-stage reheater drain

Optionally, one or two stages of steam reheat may be specified; NRH is set equal to 0, 1, or 2 to indicate the number of stages of steam reheat. Steam flow to the first-stage steam reheater QERH1 may be estimated as 2 to 3% of steam generator outlet flow. Steam flow to the second-stage reheater may be estimated as 8 to 9% of steam generator outlet flow. There is no incentive to make a very close estimate; the calculation converges rapidly with very poor estimates. In the absence of other information, full-load terminal temperature differences TTDRH1 and TTDRH2 should be set at 25°F. These parameters decrease somewhat in proportion to throttle flow ratio for part-load conditions.

13. IFLAG = 13

NF = total number of feedwater heaters

NFH = number of feedwater heaters supplied from the high-pressure turbine

NFL = number of feedwater heaters supplied from the low-pressure turbine

There is no simple set of rules for selection of feedwater heater parameters. The user is referred to Chapters 10 and 11 of Ref. 8 for information on heater types, cycle arrangements, and choice of extraction stages. In addition, existing nuclear cycle heat balarce diagrams might be consulted for typical configurations. The user must input total number of feedwater heaters NF, number of feedwater heaters supplied from the high-pressure turbine section NFH, and number of feedwater heaters supplied from the low-pressure turbine section NFL, unless one is willing to accept the default values of 6, 2, and 4. ORCENT will accept as many as 12 feedwater heaters. The pressure drop between inside the shell of the turbine and the heater shell is assumed to be 8% of the pressure in the turbine shell, except that 5% is assumed when the heater is fed from the high-pressure exhaust or the moisture-separator outlet.

14. IFLAG = 14

N = feedwater heater number

PE(N) = extraction steam pressure, psia

TTD(N) = feedwater heater terminal temperature difference, °F

ND(N) = index for feedwater neater drain; ND = 0 for flashed drain and ND = 1 for pumped drain

NDC(N) = index for drain cooler; NDC = 0 for no drain cooler and NDC = 1 for drain cooler

TDCA(N) = drain cooler approach temperature difference, °F

Feedwater heaters are numbered from one through NF with No. 1 being the highest pressure heater. A separate IFLAG = 14 card is required for each feedwater heater. The extraction steam pressure PE(N) must be input except where a heater is fed from the exhaust of the high-pressure turbine or from the outlet of the moisture separator. If PE(N) is left blank and there is no moisture separator, then the high-pressure turbine exhaust pressure is used; if there is a moisture separator, its outlet pressure is used. ORCENT will accept feedwater heater terminal temperature differences that are positive, zero, or negative. A negative terminal temperature difference means only that feedwater outlet temperature exceeds saturation temperature at heater shell pressure. Inlet steam temperature will still be higher than feedwater outlet temperature because of extraction steam superheat. A direct-contact or deaerating heater may be specified by letting TTD(N) equal zero and ND(N) equal one. Normally, the boiler feedwater pump is connected to the discharge of the deaerator. If ND(N) is zero, the feedwater heater drain is flashed to the next lower pressure feedwater heater or to the condenser, and a drain cooler approach temperature TDCA(N) should be input. If the heater drain is flashed and the user has not input TDCA(N), ORCENT will set the drain cooler approach temperature at 10°F. For pumped drains [ND(N) = 1], no drain cooler [NDC(N) = 0] and no drain cooler approach temperature [TDCA(N) = 0] should be indicated. Flashed drains with or without drain coolers result in higher thermodynamic loss than pumped drains but result in a less complex operating system.

15. IFLAG = 15

IP = index for feedwater pump location

IFPT = index for type of feedwater pump drive

The feedwater pump location relative to the feedwater heater train is specified by index IP, which can take on any value between zero and the total number of feedwater heaters NF. If IP = 0, the feedwater pump is located at the outlet of feedwater heater No. 1, the heater supplied with the highest pressure steam; if IP = 1, the feedwater pump is located at the inlet of feedwater heater No. 1; if IP = 2, it is located at the inlet of feedwater heater No. 2, and so on. If a deaerating heater is used as a means of boiling condensate to eliminate entrained gases, it is frequently the second feedwater heater above the condenser hot well, and the feedwater pump suction is taken from this heater. Reference to typical heat balance diagrams or flow schematics for similar cycles may provide the best guide for normal practice in cycle arrangement.

The user has the option of specifying motor-driven or turbine-driven feedwater pumps. In the absence of other information, it is suggested that motor-driven feedwater pumps be used for cycles with an electrical output below 250 MW(e), motor- or turbine-driven pumps in the range of 250 through 400 MW(e), and turbine-driven pumps above 400 MW(e). Turbine drive shows a significant increase in efficiency over motor drive. The ORCENT code does not contain provisions for shaft-driven pumps. The flag variable IFPT = 0 indicates motor drive and IFPT = 1 for turbine drive with flows and enthalpies calculated by the program.

16. IFLAG = 16

QAE = steam flow to steam jet air ejector, lb/hr

Steam flow to the steam jet air ejector QAE should be left blank or set equal to zero if there is no air ejector. A value of 15,000 lb/hr is stored in the BLOCK DATA subprogram and will be assumed if this card is omitted.

17. IFLAG = 17

LK = index for steam seal leakage calculations

If the user wants ORCENT to calculate throttle valve stem and turbine shaft leakage flows, no action is necessary. The flag variable LK is set equal to one in the BLOCK DATA subroutine. To suppress leakage calculations, LK must be set equal to zero on this card.

18. IFLAG = 0 (or blank card)

The last data card for a case must either be blank or have a zero in column 2, which will terminate reading of input data for that case. Input data will be printed, and control will be returned to the main program where the calculations will be started.

Each subsequent case must have a title card and an end-of-case card. Only the additional cards containing data to be revised from the previous case must be input.

4. PROGRAM OUT

Output from the program includes all information normally shown on a steam turbine cycle heat balance diagram. The input data are printed first by subroutine DATAIN before control is returned to the main program and before the calculations are performed. If iteration limits or independent variable limits for the turbine performance functions are exceeded, warning messages will be printed next. Results of the calculations are printed by subroutine RESULT and are summarized in ten tables, each headed by the information read from the comment card. Output for two example problems is included in Appendices A and B.

REFERENCES

1. H. I. Bowers, *ORCENT: A Digital Computer Program for Saturated and Low Superheat Steam Turbine Cycle Analysis*, ORNL/TM-2395 (January 1969).

2. F. G. Baily, K. C. Cotton, and R. C. Spencer, *Predicting the Performance of Large Steam Turbine Generators Operating with Saturated and Low Superheat Steam Conditions*, General Electric Company, GER-2454A, American Power Conference, Chicago, April 25–27, 1967.

3. F. G. Baily et al., *Predicting the Performance of 1800-rpm Large Steam Turbine Generators Operating with Light-Water-Cooled Reactors*, General Electric Company, GET-6020 (February 1973).

4. R. B. McClintock and G. J. Silvestri, *Formulations and Iterative Procedures for the Calculation of Properties of Steam*, American Society of Mechanical Engineers, New York, 1967.

5. J. H. Keenan and F. G. Keyes, *Thermodynamic Properties of Steam*, John Wiley and Sons, New York, 1936.

6. W. G. Steltz and G. J. Silvestri, "The Formulation of Steam Properties for Digital Computer Applications," *Trans. ASME* 80(4), 967 (May 1958).

7. R. C. Spencer and J. A. Booth, *Heat Rate Performance of Nuclear Steam Turbine Generators*, General Electric Company, GER-2533, American Power Conference, Chicago, April 23–25, 1968.

8. J. K. Salisbury, *Steam Turbines and Their Cycles*, Robert E. Krieger Publishing Company, Huntington, N.Y., 1974.

9. General Electric Company Apparatus Handbook, *Large Steam Turbine Generator Units for Nuclear Applications Using Dry and Saturated Steam*, Sect. 4712, p. 12, Jan. 19, 1976.

APPENDICES

Appendix A

EXAMPLE PROBLEM 1 — BWR CYCLE

Example problem No. 1 is intended to model the BWR cycle shown in Fig. 22 of Ref. 3. The ORCENT program requires two cases to be run for any condition other than VWO conditions. Because the BWR cycle of Ref. 3 was made at maximum guaranteed rating flow, example problem 1 contains a VWO case followed by a maximum guaranteed rating case. There are minor differences in the cycle configurations, but these have no significant effect on results. The turbine cycle analyzed is shown schematically in Fig. 2, and the input data for both cases, entered on coding forms ready for keypunching, are shown in Fig. 3. The complete program output listing for both cases follows. Example problem No. 1 required less than 5 sec on the IBM 360/91 for both VWO and maximum guaranteed conditions.

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ORNL-DWG 78-12693

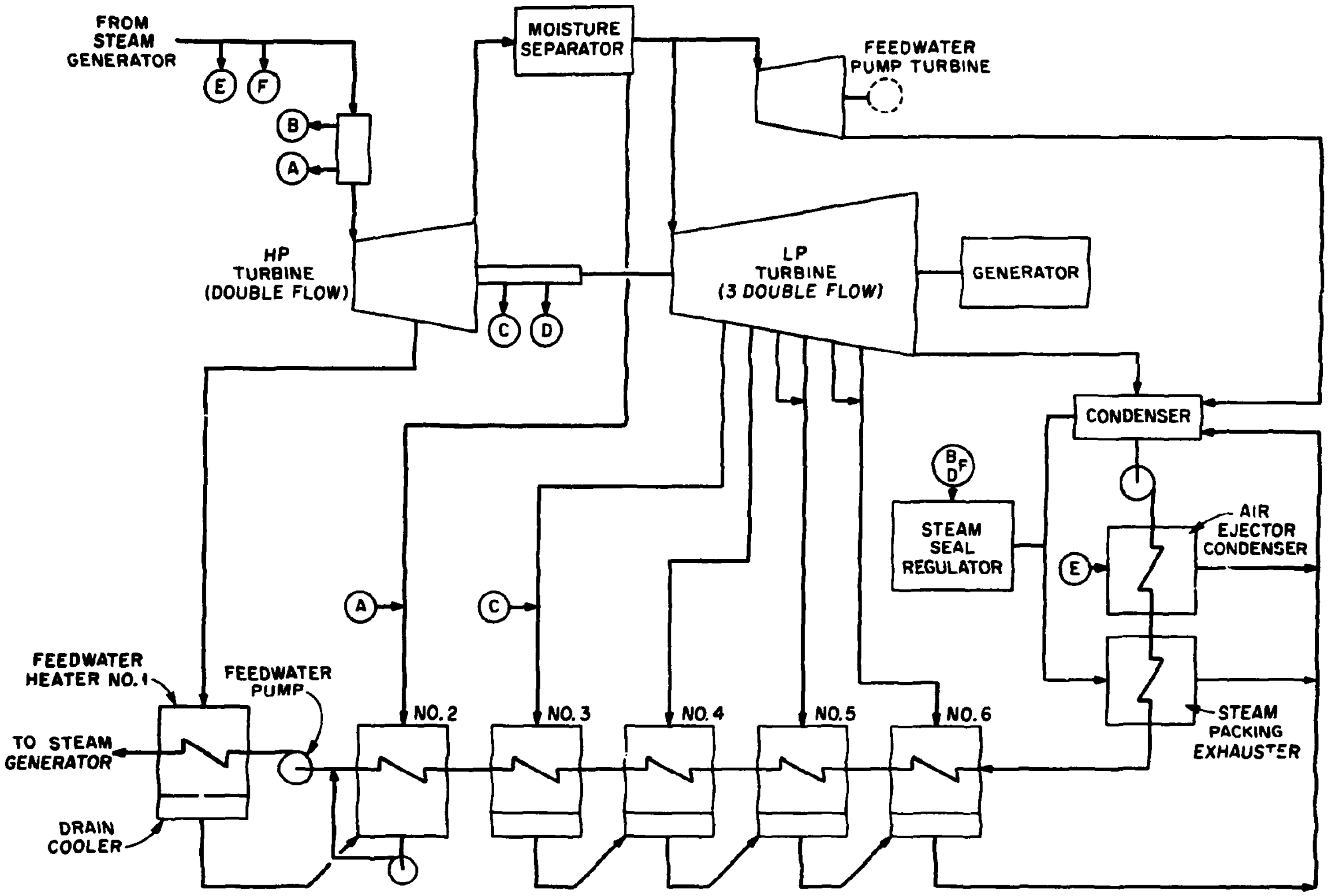
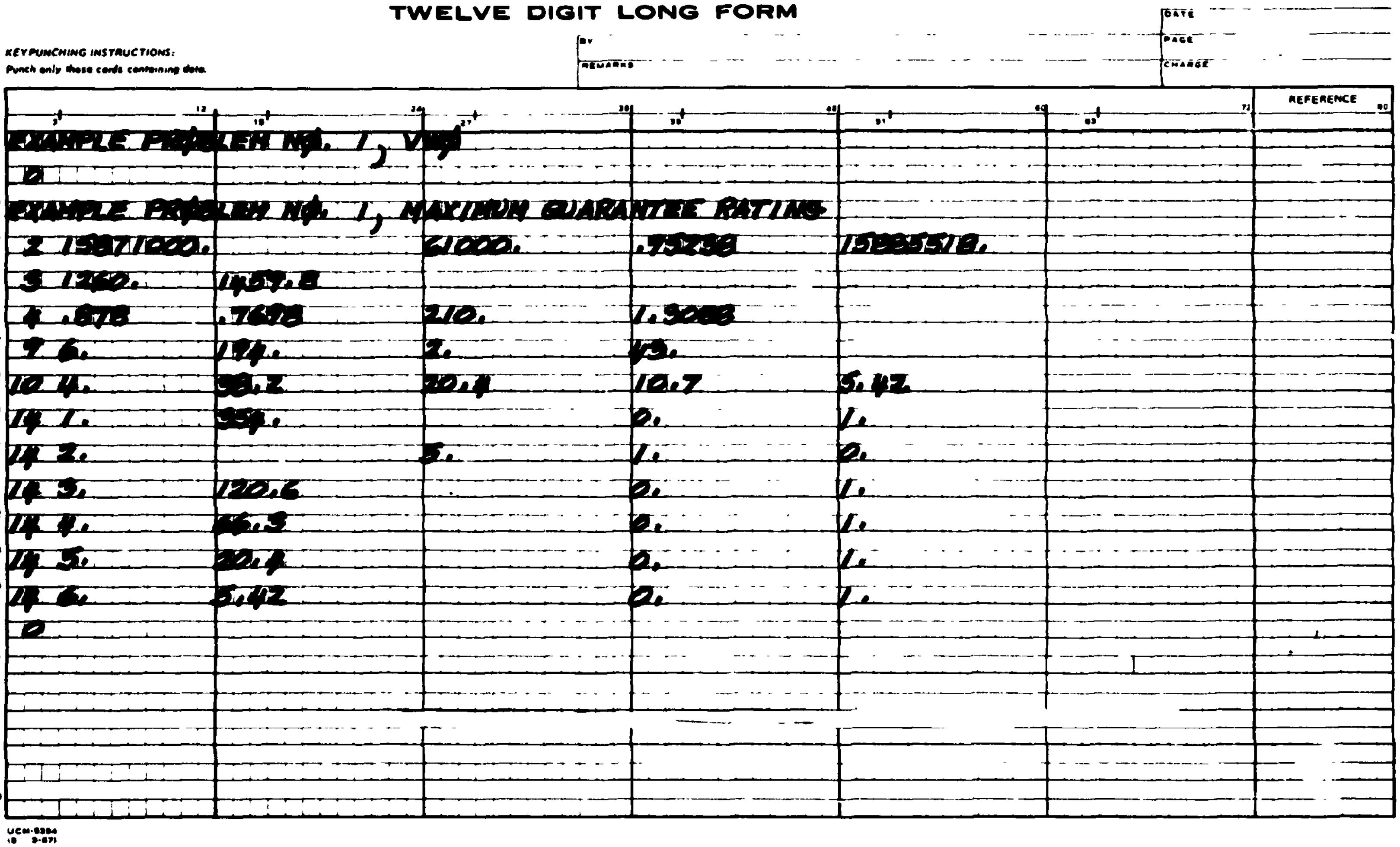


Fig. 2. BWR turbine cycle for example problem No. 1.



TWELVE DIGIT LONG FORM

KEYPUNCHING INSTRUCTIONS:
Punch only those cards containing data.

BY | REMARKS | DATE | PAGE | CHARGE

	1–12	13–24	25–36	37–48	49–60	61–72	REFERENCE 73–80
1	EXAMPLE PROBLEM NO. 1, V[illegible]						
2	0						
3	EXAMPLE PROBLEM NO. 1, MAXIMUM GUARANTEE RATING						
4	2 15871000.		61000.	.75238	15885518.		
5	3 1260.	1459.8					
6	4 .878	.7678	210.	1.3088			
7	9 6.	174.	2.	43.			
8	10 4.	38.2	20.4	10.7	5.42		
9	14 1.	354.		0.	1.		
10	14 2.		5.	1.	0.		
11	14 3.	120.6		0.	1.		
12	14 4.	66.3		0.	1.		
13	14 5.	20.4		0.	1.		
14	14 6.	5.42		0.	1.		
15	0						
16							
17							
18							
19							
20							

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(8 9-67)

Fig. 3. Input data for example problem No. 1 ready for keypunching.

EXAMPLE PROBLEM NO. 1, TWO
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

INPUT DATA

THROTTLE STEAM TEMPERATURE	540.3	F			
THROTTLE STEAM PRESSURE	965.0	PSIA			
THROTTLE STEAM MOISTURE	0.52	PER CENT			
ESTIMATED THROTTLE STEAM FLOW	16664044.	LB/HR			
FW MAKE-UP RATE (TO CONDENSER HOTWELL)	0.0	PER CENT			
CONDENSATE BY-PASSED TO STEAM GENERATOR	61000.	LB/HR			
THROTTLE FLOW RATIO	1.00000				
REQUIRED STEAM GENERATOR OUTLET FLOW	16679080.	LB/HR			
REQUIRED ELECTRICAL OUTPUT	1313.820	MWE			
GENERATOR RATED CAPABILITY	1459.800	MVA			
GENERATOR POWER FACTOR	0.90				
GENERATOR OPERATION AT RATED HYDROGEN PRESSURE, IH2= 0					
ROTATIONAL SPEED OF TURBINE-GENERATOR	1800	RPM			
FEEDWATER PUMP ISENTROPIC EFFICIENCY	0.8780				
FEEDWATER PUMP TURBINE EFFICIENCY	0.7698				
PRESSURE OF FWP INLET ABOVE COND. PRESSURE	220.00	PSIA			
RATIO OF FWP DISCH. PRESS. TO H-P THROTTLE	1.31				
PITCH DIAMETER OF GOVERNING STAGE	65.00	IN.			
NUMBER OF PARALLEL H-P SECTIONS	2				
NUMBER OF PARALLEL L-P SECTIONS	6				
BOWL PRESSURE L-P SECTION	203.7	PSIA			
EXHAUST PRESSURE L-P SECTION	0.98231	PSIA	=	2.00	IN. HGA
CONDENSER PRESSURE	0.98231	PSIA	=	2.00	IN. HGA
PITCH DIAMETER OF LAST STAGE L-P SECTION	132.00	IN.			
LENGTH OF LAST STAGE BUCKETS L-P SECTION	43.00	IN.			
NO. OF MOISTURE REMOVAL STAGES LP SECTION	4				
MOISTURE REMOVAL STAGE NO. 1					
MOISTURE REMOVAL STAGE PRESSURE	40.1	PSIA			
MOISTURE REMOVAL STAGE NO. 2					
MOISTURE REMOVAL STAGE PRESSURE	21.4	PSIA			
MOISTURE REMOVAL STAGE NO. 3					
MOISTURE REMOVAL STAGE PRESSURE	11.2	PSIA			
MOISTURE REMOVAL STAGE NO. 4					
MOISTURE REMOVAL STAGE PRESSURE	5.7	PSIA			
EXTERNAL MOISTURE SEPARATOR DRAINS TO FW HEATER NO. 2, MS= 2					
MOISTURE SEPARATOR EFFECTIVENESS	100.	PER CENT			
NUMBER OF STAGES OF REHEAT	0				
TOTAL NO. OF FW HEATERS	6				
NO. OF FW HEATERS HP SECTION	2				
NO. OF FW HEATERS LP SECTION	4				
FW HEATER NO. 1					
EXTRACTION STAGE PRESSURE	371.7	PSIA			
TERMINAL TEMPERATURE DIFFERENCE	5.0	F			

```
  DRAIN IS FLASHED, ND( 1)= 0
  THERE IS A DRAIN COOLER SECTION, NDC( 1)= 1
  DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE              10.0      F
FW HEATER NO.  2
  EXTRACTION STEAM FROM MOISTURE SEPARATOR VESSEL
  TERMINAL TEMPERATURE DIFFERENCE                            5.0      F
  DRAIN IS PUMPED, ND( 2)= 1
  THERE IS NO DRAIN COOLER SECTION, NDC( 2)= 0
FW HEATER NO.  3
  EXTRACTION STAGE PRESSURE                                126.6      PSIA
  TERMINAL TEMPERATURE DIFFERENCE                            5.0      F
  DRAIN IS FLASHED, ND( 3)= 0
  THERE IS A DRAIN COOLER SECTION, NDC( 3)= 1
  DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE              10.0      F
FW HEATER NO.  4
  EXTRACTION STAGE PRESSURE                                 69.5      PSIA
  TERMINAL TEMPERATURE DIFFERENCE                            5.0      F
  DRAIN IS FLASHED, ND( 4)= 0
  THERE IS A DRAIN COOLER SECTION, NDC( 4)= 1
  DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE              10.0      F
FW HEATER NO.  5
  EXTRACTION STAGE PRESSURE                                 21.4      PSIA
  TERMINAL TEMPERATURE DIFFERENCE                            5.0      F
  DRAIN IS FLASHED, ND( 5)= 0
  THERE IS A DRAIN COOLER SECTION, NDC( 5)= 1
  DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE              10.0      F
FW HEATER NO.  6
  EXTRACTION STAGE PRESSURE                                  5.7      PSIA
  TERMINAL TEMPERATURE DIFFERENCE                            5.0      F
  DRAIN IS FLASHED, ND( 6)= 0
  THERE IS A DRAIN COOLER SECTION, NDC( 6)= 1
  DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE              10.0      F
FW PUMP IS LOCATED BEFORE FW HEATER NO.  1, IP=  1
FW PUMP IS TURBINE DRIVEN, IFPT=  1
STEAM FLOW TO FW PUMP TURBINE WILL BE CALCULATED
STEAM FLOW TO STEAM JET AIR EJECTOR                      15000.       LB/HR
VALVE STEM AND PACKING LEAKAGES WILL BE CALCULATED, LK= 1
```

EXAMPLE PROBLEM NO. 1, VWO
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 1

TABLE I OVERALL PERFORMANCE

NET TURBINE CYCLE HEAT RATE, BTU/KW-HR	10007.
NET TURBINE CYCLE EFFICIENCY, PER CENT	34.10
GROSS TURBINE CYCLE HEAT RATE, BTU/KW-HR	9859.
GROSS TURBINE CYCLE EFFICIENCY, PER CENT	34.61
GENERATOR OUTPUT, MWE	1315.646
POWER REQUIRED BY TURBINE-DRIVEN FW PUMP, MW	19.789
GENERATOR OUTPUT PLUS FW PUMP POWER, MW	1335.435
MECHANICAL LOSSES, KW	6168.
GENERATOR LOSSES, KW	16283.

EXAMPLE PROBLEM NO. 1, VWO
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 2

TABLE II TURBINE EXPANSION LINE

	STEAM FLOW LB/HR	PRESSURE PSIA	TEMPERATURE F	MOISTURE PER CENT	ENTHALPY BTU/LB	ENTROPY BTU/LB-F
TURBINE THROTTLE	16664080.	965.0	540.3	0.52	1190.9	
GOVERNING STAGE BOWL	16647416.	926.4	535.4	0.71	1190.9	1.3952
GOVERNING STAGE SHELL	16647416.	718.5	506.0	3.96	1173.5	1.3988
HP SECTION ELEP	15638729.	218.7	389.3	12.51	1094.9	1.4147
HP SECTION UEEP		218.7			1096.4	
EXTERNAL MOISTURE SEPARATOR INLET	15613671.	217.1			1096.4	
EXTERNAL MOISTURE SEPARATOR OUTLET	13698991.	213.0	387.1	0.0	1199.2	
LP SECTION BOWL	12752120.	203.7	384.2	0.0	1199.2	1.5446
BEFORE MOISTURE REMOVAL NO. 1		40.1	267.4	8.80	1087.7	1.5633
AFTER MOISTURE REMOVAL NO. 1		40.1	267.4	8.36	1091.7	1.5689
BEFORE MOISTURE REMOVAL NO. 2		21.4	231.6	10.66	1055.6	1.5789
AFTER MOISTURE REMOVAL NO. 2		21.4	231.6	9.74	1064.3	1.5916
BEFORE MOISTURE REMOVAL NO. 3		11.2	198.6	11.83	1029.6	1.6027
AFTER MOISTURE REMOVAL NO. 3		11.2	198.6	9.97	1047.8	1.6304
BEFORE MOISTURE REMOVAL NO. 4		5.7	167.5	12.05	1013.0	1.6424
AFTER MOISTURE REMOVAL NO. 4		5.7	167.5	9.50	1038.4	1.6829
LP SECTION ELEP	9170924.	0.98231	101.1	14.39	956.4	1.7137
LP SECTION UEEP		0.98231			975.1	

EXAMPLE PROBLEM NO. 1, VWO
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 3

TABLE III STEAM JET AIR EJECTOR

STEAM FLOW, LB/HR	15000.
STEAM ENTHALPY IN, BTU/LB	1190.9
STEAM ENTHALPY OUT, BTU/LB	180.2

TABLE IV EXTERNAL MOISTURE SEPARATOR DRAINS TO FW HEATER NO. 2

DRAIN FLOW, LB/HR	1914680.
DRAIN PRESSURE, PSIA	213.0
DRAIN TEMPERATURE, F	387.1
DRAIN ENTHALPY, BTU/LB	361.2

TABLE V THERE IS NO REHEATER

TABLE VI MOISTURE REMOVAL STAGES

MOISTURE REMOVAL STAGE NO.	1	2	3	4
DRAINS TO FW HEATER NO.	5	5	6	6
STAGE PRESSURE, PSIA	40.1	21.4	11.2	5.7
TEMPERATURE, F	267.4	231.6	198.6	167.5
WATER REMOVED, LB/HR	51004.	112182.	211924.	281091.
WATER ENTHALPY, BTU/LB	236.3	199.9	166.7	135.5
STEAM REMOVED, LB/HR	55843.	0.	51187.	0.
STEAM ENTHALPY, BTU/LB	1091.7	0.0	1047.8	0.0

EXAMPLE PROBLEM NO. 1, VWO
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 4

TABLE VII FW HEATERS

FW HEATER NO.	1	2	3	4	5	6
FW FLOW, LB/HR	16618080.	13003455.	13003455.	13003455.	13003455.	13003455.
FW TEMPERATURE OUT, F	424.5	377.8	334.0	291.9	222.1	159.0
FW ENTHALPY OUT, BTU/LB	402.7	351.2	305.0	261.4	190.4	126.9
FW TEMPERATURE IN, F	381.3	334.0	291.9	222.1	159.0	102.8
FW ENTHALPY IN, BTU/LB	356.4	305.0	261.4	190.4	126.9	70.8
EXTRACTION STAGE PRESSURE, PSIA	371.7	213.0	126.6	69.5	21.4	5.7
EXTRACTION STEAM FLOW, LB/HR	1008687.	678272.	630977.	952627.	710095.	522266.
EXTRACTION STEAM ENTHALPY, BTU/LB	1128.3	1199.2	1163.1	1121.9	1064.3	1038.4
SHELL PRESSURE, PSIA	342.0	202.3	116.5	63.9	19.7	5.2
SHELL TEMPERATURE, F	429.5	382.8	339.0	296.9	227.1	164.0
SHELL DRAIN FLOW, LB/HR	1008687.	3614625.	637046.	1589673.	2520797.	3591931.
SHELL DRAIN TEMPERATURE, F	391.3	382.8	301.9	232.1	169.0	112.8
SHELL DRAIN ENTHALPY, BTU/LB	365.7	356.5	271.7	200.5	136.9	80.8

TABLE VIII CONDENSER

CONDENSER PRESSURE, PSIA	0.98231	=	2.00	IN. HGA
CONDENSATE FLOW, LB/HR	13064455.			
CONDENSATE TEMPERATURE, F	101.1			
CONDENSATE ENTHALPY, BTU/LB	69.1			

EXAMPLE PROBLEM NO. 1, VWO
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 5

TABLE II CONDENSATE AND FEEDWATER

CONDENSATE FLOW BY-PASSED TO STEAM GENERATOR, LB/HR	61000.			
CONDENSATE ENTHALPY BY-PASSED TO STEAM GENERATOR, BTU/LB	70.8			
FW FLOW TO FW PUMP, LB/HR	16618080.			
FW TEMPERATURE TO FW PUMP, F	378.9			
FW ENTHALPY TO FW PUMP, BTU/LB	352.4			
FW ENTHALPY RISE ACROSS FW PUMP, BTU/LB	4.1			
FW PRESSURE INCREASE ACROSS FW PUMP, PSI	1042.			
FW FLOW TO STEAM GENERATOR, LB/HR	16618080.			
FW TEMPERATURE TO STEAM GENERATOR, F	424.5			
FW ENTHALPY TO STEAM GENERATOR, BTU/LB	402.7			
MAKE-UP TO CONDENSER HOTWELL, LB/HR	0.			
STEAM FLOW FROM STEAM GENERATOR, LB/HR	16679080.			
STEAM ENTHALPY FROM STEAM GENERATOR, BTU/LB	1190.9			
THROTTLE STEAM FLOW FW PUMP TURBINE, LB/HR	266600.			
THROTTLE PRESSURE FW PUMP TURBINE, PSIA	202.1			
THROTTLE ENTHALPY FW PUMP TURBINE, BTU/LB	1199.2			
EXHAUST PRESSURE FW PUMP TURBINE, PSIA	1.22789	=	2.50	IN. HGA
EXHAUST ENTHALPY FW PUMP TURBINE, BTU/LB	947.8			

EXAMPLE PROBLEM NO. 1, VWO
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 6

TABLE X VALVE STEM AND SHAFT LEAKAGES

STEAM SEAL REGULATOR	
FLOW TO SSR, LB/HR	22666.
ENTHALPY AT SSR, BTU/LB	1111.7
FLOW FROM SSR TO MAIN CONDENSER, LB/HR	10800.
FLOW FROM SSR TO STEAM PACKING EXHAUSTER, LB/HR	7200.
FLOW FROM SSR TO FW HEATER NO. 6, LB/HR	4666.
MAKE-UP FROM THROTTLE STEAM, LB/HR	0.
ENTHALPY OF MAKE-UP STEAM, BTU/LB	0.0
THROTTLE VALVE STEM	
LEAK NO. 1 (DRAINS TO FW HEATER NO. 2), LB/HR	12986.
ENTHALPY LEAK NO. 1, BTU/LB	1190.9
LEAK NO. 2 (DRAINS TO SSR), LB/HR	3678.
ENTHALPY LEAK NO. 2, BTU/LB	1190.9
GOVERNING STAGE SECTION	
LEAK NO. 3 (DRAINS TO FW HEATER NO. 0), LB/HR	0.
ENTHALPY LEAK NO. 3, BTU/LB	0.0
LEAK NO. 4 (DRAINS TO SSR), LB/HR	0.
ENTHALPY LEAK NO. 4, BTU/LB	0.0
HP TURBINE SECTION	
TOTAL LEAK NO. 5 (DRAINS TO FW HEATER NO. 3), LB/HR	6069.
ENTHALPY LEAK NO. 5, BTU/LB	1096.4
TOTAL LEAK NO. 6 (DRAINS TO SSR), LB/HR	18988.
ENTHALPY LEAK NO. 6, BTU/LB	1096.4

EXAMPLE PROBLEM NO. 1, MAXIMUM GUARANTEE RATING
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

INPUT DATA

THROTTLE STEAM TEMPERATURE	540.3	F	
THROTTLE STEAM PRESSURE	965.0	PSIA	
THROTTLE STEAM MOISTURE	0.52	PER CENT	
ESTIMATED THROTTLE STEAM FLOW	15871000.	LB/HR	
FW MAKE-UP RATE (TO CONDENSER HOTWELL)	0.0	PER CENT	
CONDENSATE BY-PASSED TO STEAM GENERATOR	61000.	LB/HR	
THROTTLE FLOW RATIO	0.95238		
REQUIRED STEAM GENERATOR OUTLET FLOW	15885518.	LB/HR	
REQUIRED ELECTRICAL OUTPUT	1260.000	MWE	
GENERATOR RATED CAPABILITY	1459.800	MVA	
GENERATOR POWER FACTOR	0.90		
GENERATOR OPERATION AT RATED HYDROGEN PRESSURE, IH2= 0			
ROTATIONAL SPEED OF TURBINE-GENERATOR	1800	RPM	
FEEDWATER PUMP ISENTROPIC EFFICIENCY	0.8780		
FEEDWATER PUMP TURBINE EFFICIENCY	0.7698		
PRESSURE OF FWP INLET ABOVE COND. PRESSURE	210.00	PSIA	
RATIO OF FWP DISCH. PRESS. TO H-P THROTTLE	1.31		
PITCH DIAMETER OF GOVERNING STAGE	65.00	IN.	
NUMBER OF PARALLEL H-P SECTIONS	2		
NUMBER OF PARALLEL L-P SECTIONS	6		
BOWL PRESSURE L-P SECTION	194.0	PSIA	
EXHAUST PRESSURE L-P SECTION	0.98231	PSIA	= 2.00 IN. HGA
CONDENSER PRESSURE	0.98231	PSIA	= 2.00 IN. HGA
PITCH DIAMETER OF LAST STAGE L-P SECTION	132.00	IN.	
LENGTH OF LAST STAGE BUCKETS L-P SECTION	43.00	IN.	
NO. OF MOISTURE REMOVAL STAGES LP SECTION	4		
MOISTURE REMOVAL STAGE NO. 1			
MOISTURE REMOVAL STAGE PRESSURE	38.2	PSIA	
MOISTURE REMOVAL STAGE NO. 2			
MOISTURE REMOVAL STAGE PRESSURE	20.4	PSIA	
MOISTURE REMOVAL STAGE NO. 3			
MOISTURE REMOVAL STAGE PRESSURE	10.7	PSIA	
MOISTURE REMOVAL STAGE NO. 4			
MOISTURE REMOVAL STAGE PRESSURE	5.4	PSIA	
EXTERNAL MOISTURE SEPARATOR DRAINS TO FW HEATER NO. 2, MS= 2			
MOISTURE SEPARATOR EFFECTIVENESS	100.	PER CENT	
NUMBER OF STAGES OF REHEAT	0		
TOTAL NO. OF FW HEATERS	6		
NO. OF FW HEATERS HP SECTION	2		
NO. OF FW HEATERS LP SECTION	4		
FW HEATER NO. 1			
EXTRACTION STAGE PRESSURE	354.0	PSIA	
TERMINAL TEMPERATURE DIFFERENCE	5.0	F	

```
  DRAIN IS FLASHED, ND( 1)= 0
  THERE IS A DRAIN COOLER SECTION, NDC( 1)= 1
  DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE              10.0      F
FW HEATER NO.  2
  EXTRACTION STEAM FROM MOISTURE SEPARATOR VESSEL
  TERMINAL TEMPERATURE DIFFERENCE                           5.0      F
  DRAIN IS PUMPED, ND( 2)= 1
  THERE IS NO DRAIN COOLER SECTION, NDC( 2)= 0
FW HEATER NO.  3
  EXTRACTION STAGE PRESSURE                               120.6      PSIA
  TERMINAL TEMPERATURE DIFFERENCE                           5.0      F
  DRAIN IS FLASHED, ND( 3)= 0
  THERE IS A DRAIN COOLER SECTION, NDC( 3)= 1
  DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE              10.0      F
FW HEATER NO.  4
  EXTRACTION STAGE PRESSURE                                66.3      PSIA
  TERMINAL TEMPERATURE DIFFERENCE                           5.0      F
  DRAIN IS FLASHED, ND( 4)= 0
  THERE IS A DRAIN COOLER SECTION, NDC( 4)= 1
  DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE              10.0      F
FW HEATER NO.  5
  EXTRACTION STAGE PRESSURE                                20.4      PSIA
  TERMINAL TEMPERATURE DIFFERENCE                           5.0      F
  DRAIN IS FLASHED, ND( 5)= 0
  THERE IS A DRAIN COOLER SECTION, NDC( 5)= 1
  DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE              10.0      F
FW HEATER NO.  6
  EXTRACTION STAGE PRESSURE                                 5.4      PSIA
  TERMINAL TEMPERATURE DIFFERENCE                           5.0      F
  DRAIN IS FLASHED, ND( 6)= 0
  THERE IS A DRAIN COOLER SECTION, NDC( 6)= 1
  DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE              10.0      F
FW PUMP IS LOCATED BEFORE FW HEATER NO.  1, IP=  1
FW PUMP IS TURBINE DRIVEN, IFPT=  1
STEAM FLOW TO FW PUMP TURBINE WILL BE CALCULATED
STEAM FLOW TO STEAM JET AIR EJECTOR                     15000.       LB/HR
VALVE STEM AND PACKING LEAKAGES WILL BE CALCULATED, LK= 1
```

EXAMPLE PROBLEM NO. 1, MAXIMUM GUARANTEE RATING
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 1

TABLE I OVERALL PERFORMANCE

NET TURBINE CYCLE HEAT RATE, BTU/KW-HR	10002.
NET TURBINE CYCLE EFFICIENCY, PER CENT	34.11
GROSS TURBINE CYCLE HEAT RATE, BTU/KW-HR	9854.
GROSS TURBINE CYCLE EFFICIENCY, PER CENT	34.63
GENERATOR OUTPUT, MWE	1261.678
POWER REQUIRED BY TURBINE-DRIVEN FW PUMP, MW	18.969
GENERATOR OUTPUT PLUS FW PUMP POWER, MW	1280.649
MECHANICAL LOSSES, KW	6168.
GENERATOR LOSSES, KW	15304.

EXAMPLE PROBLEM NO. 1, MAXIMUM GUARANTEE RATING
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 2

TABLE II TURBINE EXPANSION LINE

	STEAM FLOW LB/HR	PRESSURE PSIA	TEMPERATURE F	MOISTURE PER CENT	ENTHALPY BTU/LB	ENTROPY BTU/LB-F
TURBINE THROTTLE	15870518.	965.0	540.3	0.52	1190.9	
GOVERNING STAGE BOWL	15853854.	918.0	534.3	0.75	1190.9	1.3960
GOVERNING STAGE SHELL	15853854.	683.6	500.5	4.31	1171.4	1.4009
HP SECTION ELEP	14909832.	208.2	385.2	12.60	1093.0	1.4168
HP SECTION UEEP		208.2			1094.5	
EXTERNAL MOISTURE SEPARATOR INLET	14885935.	206.8			1094.5	
EXTERNAL MOISTURE SEPARATOR OUTLET	13047203.	202.9	383.0	0.0	1198.5	
LP SECTION BOWL	12152792.	194.0	380.2	0.0	1198.5	1.5487
BEFORE MOISTURE REMOVAL NO. 1		38.2	264.5	8.73	1087.2	1.5674
AFTER MOISTURE REMOVAL NO. 1		38.2	264.5	8.28	1091.4	1.5732
BEFORE MOISTURE REMOVAL NO. 2		20.4	229.0	10.56	1055.3	1.5832
AFTER MOISTURE REMOVAL NO. 2		20.4	229.0	9.61	1064.5	1.5965
BEFORE MOISTURE REMOVAL NO. 3		10.7	196.4	11.70	1029.9	1.6075
AFTER MOISTURE REMOVAL NO. 3		10.7	196.4	9.79	1048.6	1.6361
BEFORE MOISTURE REMOVAL NO. 4		5.4	165.7	11.88	1013.8	1.6479
AFTER MOISTURE REMOVAL NO. 4		5.4	165.7	9.35	1039.1	1.6883
LP SECTION ELEP	8776141.	0.98231	101.1	14.15	958.9	1.7181
LP SECTION UEEP		0.98231			976.0	

EXAMPLE PROBLEM NO. 1, MAXIMUM GUARANTEE RATING
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 3

TABLE III STEAM JET AIR EJECTOR

STEAM FLOW, LB/HR	15000.
STEAM ENTHALPY IN, BTU/LB	1190.9
STEAM ENTHALPY OUT, BTU/LB	180.2

TABLE IV EXTERNAL MOISTURE SEPARATOR DRAINS TO FW HEATER NO. 2

DRAIN FLOW, LB/HR	1838732.
DRAIN PRESSURE, PSIA	202.9
DRAIN TEMPERATURE, F	383.0
DRAIN ENTHALPY, BTU/LB	356.8

TABLE V THERE IS NO REHEATER

TABLE VI MOISTURE REMOVAL STAGES

MOISTURE REMOVAL STAGE NO.	1	2	3	4
DRAINS TO FW HEATER NO.	5	5	6	6
STAGE PRESSURE, PSIA	38.2	20.4	10.7	5.4
TEMPERATURE, F	264.5	229.0	196.4	165.7
WATER REMOVED, LB/HR	52249.	111253.	207393.	265379.
WATER ENTHALPY, BTU/LB	233.3	197.3	164.5	133.6
STEAM REMOVED, LB/HR	53313.	0.	48890.	0.
STEAM ENTHALPY, BTU/LB	1091.4	0.0	1048.6	0.0

EXAMPLE PROBLEM NO. 1, MAXIMUM GUARANTEE RATING
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 4

TABLE VII FW HEATERS

FW HEATER NO.	1	2	3	4	5	6
FW FLOW, LB/HR	15824518.	12394059.	12394059.	12394059.	12394059.	12394059.
FW TEMPERATURE OUT, F	419.9	373.7	330.4	288.8	219.6	157.1
FW ENTHALPY OUT, BTU/LB	397.7	346.8	301.2	258.2	187.8	125.1
FW TEMPERATURE IN, F	377.2	330.4	288.8	219.6	157.1	102.9
FW ENTHALPY IN, BTU/LB	352.1	301.2	258.2	187.8	125.1	70.9
EXTRACTION STAGE PRESSURE, PSIA	354.0	202.9	120.6	66.3	20.4	5.4
EXTRACTION STEAM FLOW, LB/HR	944021.	634544.	591630.	898536.	667830.	480178.
EXTRACTION STEAM ENTHALPY, BTU/LB	1126.4	1198.5	1162.6	1121.5	1064.5	1039.1
SHELL PRESSURE, PSIA	325.7	192.7	111.0	61.0	18.6	5.0
SHELL TEMPERATURE, F	424.9	378.7	335.4	293.8	224.6	162.1
SHELL DRAIN FLOW, LB/HR	944021.	3430459.	597408.	1495944.	2380589.	3386051.
SHELL DRAIN TEMPERATURE, F	387.2	378.7	298.8	229.6	167.1	112.9
SHELL DRAIN ENTHALPY, BTU/LB	361.3	352.2	268.5	197.9	135.1	80.9

TABLE VIII CONDENSER

CONDENSER PRESSURE, PSIA	0.98231	=	2.00	IN. HGA
CONDENSATE FLOW, LB/HR	12455059.			
CONDENSATE TEMPERATURE, F	101.1			
CONDENSATE ENTHALPY, BTU/LB	69.1			

EXAMPLE PROBLEM NO. 1, MAXIMUM GUARANTEE RATING
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 5

TABLE IX CONDENSATE AND FEEDWATER

CONDENSATE FLOW BY-PASSED TO STEAM GENERATOR, LB/HR	61000.			
CONDENSATE ENTHALPY BY-PASSED TO STEAM GENERATOR, BTU/LB	70.9			
FW FLOW TO FW PUMP, LB/HR	15824518.			
FW TEMPERATURE TO FW PUMP, F	374.8			
FW ENTHALPY TO FW PUMP, BTU/LB	348.0			
FW ENTHALPY RISE ACROSS FW PUMP, BTU/LB	4.1			
FW PRESSURE INCREASE ACROSS FW PUMP, PSI	1052.			
FW FLOW TO STEAM GENERATOR, LB/HR	15824519.			
FW TEMPERATURE TO STEAM GENERATOR, F	419.9			
FW ENTHALPY TO STEAM GENERATOR, BTU/LB	397.7			
MAKE-UP TO CONDENSER HOTWELL, LB/HR	0.			
STEAM FLOW FROM STEAM GENERATOR, LB/HR	15885519.			
STEAM ENTHALPY FROM STEAM GENERATOR, BTU/LB	1190.9			
THROTTLE STEAM FLOW FW PUMP TURBINE, LB/HR	259867.			
THROTTLE PRESSURE FW PUMP TURBINE, PSIA	192.6			
THROTTLE ENTHALPY FW PUMP TURBINE, BTU/LB	1198.5			
EXHAUST PRESSURE FW PUMP TURBINE, PSIA	1.22789	=	2.50	IN. HGA
EXHAUST ENTHALPY FW PUMP TURBINE, BTU/LB	349.4			

EXAMPLE PROBLEM NO. 1, MAXIMUM GUARANTEE RATING
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 6

TABLE X VALVE STEM AND SHAFT LEAKAGES

STEAM SEAL REGULATOR	
FLOW TO SSR, LB/HR	21621.
ENTHALPY AT SSR, BTU/LB	1110.2
FLOW FROM SSR TO MAIN CONDENSER, LB/HR	10800.
FLOW FROM SSR TO STEAM PACKING EXHAUSTER, LB/HR	7200.
FLOW FROM SSR TO FW HEATER NO. 6, LB/HR	3621.
MAKE-UP FROM THROTTLE STEAM, LB/HR	0.
ENTHALPY OF MAKE-UP STEAM, BTU/LB	0.0
THROTTLE VALVE STEM	
LEAK NO. 1 (DRAINS TO FW HEATER NO. 2), LB/HR	13161.
ENTHALPY LEAK NO. 1, BTU/LB	1190.9
LEAK NO. 2 (DRAINS TO SSR), LB/HR	3503.
ENTHALPY LEAK NO. 2, BTU/LB	1190.9
GOVERNING STAGE SECTION	
LEAK NO. 3 (DRAINS TO FW HEATER NO. 0), LB/HR	0.
ENTHALPY LEAK NO. 3, BTU/LB	0.0
LEAK NO. 4 (DRAINS TO SSR), LB/HR	0.
ENTHALPY LEAK NO. 4, BTU/LB	0.0
HP TURBINE SECTION	
TOTAL LEAK NO. 5 (DRAINS TO FW HEATER NO. 3), LB/HR	5779.
ENTHALPY LEAK NO. 5, BTU/LB	1094.5
TOTAL LEAK NO. 6 (DRAINS TO SSR), LB/HR	18118.
ENTHALPY LEAK NO. 6, BTU/LB	1094.5

Appendix B

EXAMPLE PROBLEM 2 — PWR CYCLE

Example problem No. 2 is intended to model the PWR cycle shown in Fig. 24 of Ref. 3. The cycle of Ref. 3 is a two-stage steam reheat cycle supplied with slightly superheated steam from a PWR employing once-through steam generators. Because the calculation is made at half-rated load, both a VWO case and a half-rated load case are required. The turbine cycle analyzed is shown schematically in Fig. 4, and the input data for both the VWO case and the half-rated load case, entered on coding forms ready for keypunching, are shown in Fig. 5. The complete program output listing for both cases follows. Example problem No. 2 required about 15 sec on the IBM 360/91 for both VWO and half-rated load conditions.

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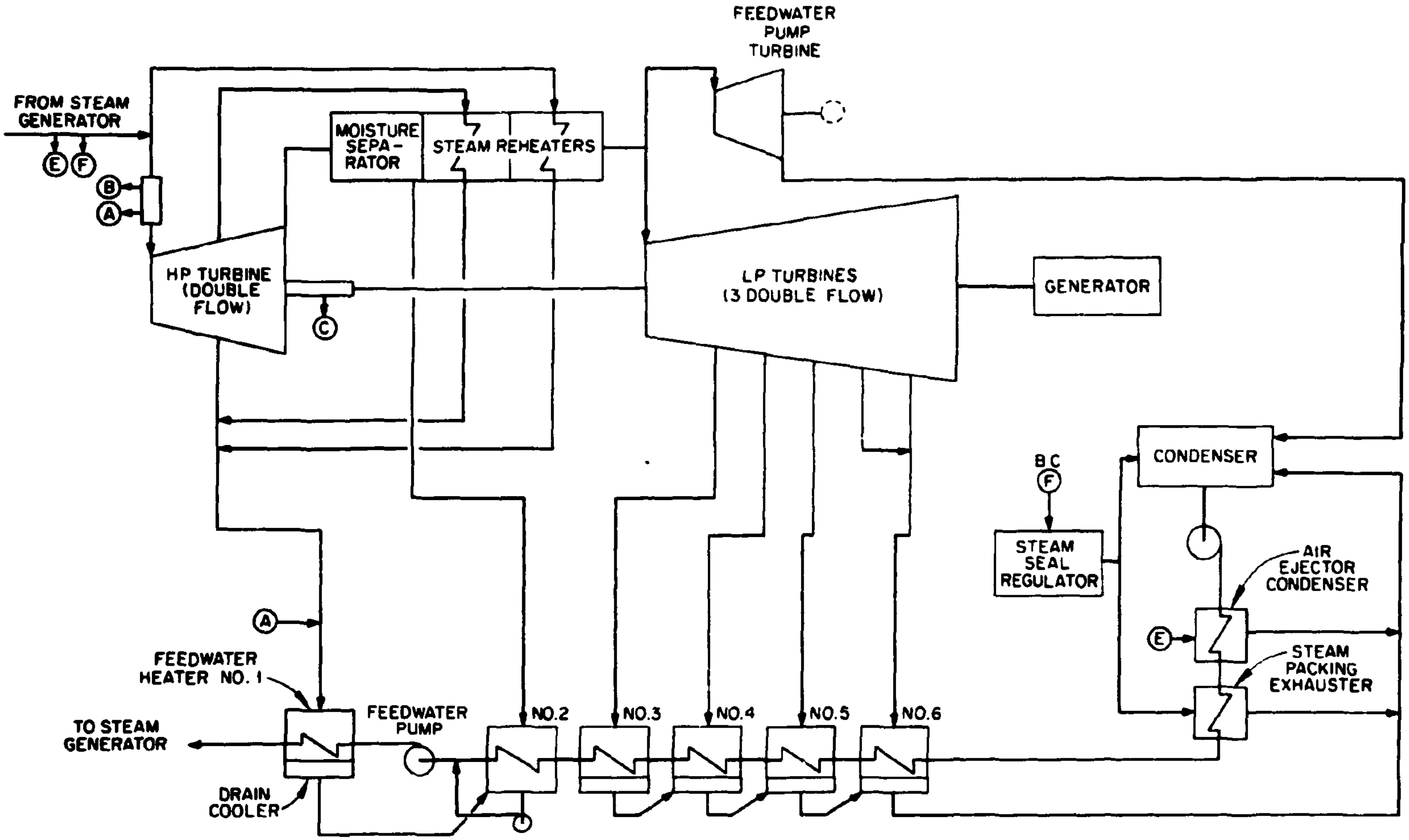

Fig. 4. PWR turbine cycle for example problem No. 2.

TWELVE DIGIT LONG FORM

KEYPUNCHING INSTRUCTIONS
Punch only those cards containing data

REMARKS

						REFERENCE
EXAMPLE PROBLEM NO. 2, YHO						
1 594.6	1000.					
2 14542000.			1.0	15381973.		
3 1323.	1456.6					
4 .878	.77	100.	1.262			
9 6.	173.2	2.	43.			
10 3.	19.5	10.2	5.2			
11 2.	100.					
12 2.	484000.	25.	192000.	25.	1.	
13 6.	2.	4.				
14 1.	457.6		0.	1.		
14 2.		5.	1.	0.		
14 3.	106.7		0.	1.		
14 4.	64.1		0.	1.		
14 5.	19.5		0.	1.		
14 6.	5.2		0.	1.		
15 1.	1.					
16 1500.						
17 1.						
0						

Fig. 5. Input data for example problem No. 2 ready for keypunching.

TWELVE DIGIT LONG FORM

DATE
BY
PAGE
REMARKS
CHARGE

KEYPUNCHING INSTRUCTIONS
Punch only those cards containing data

						REFERENCE
EXAMPLE PROBLEM NO. 2, HALF RATED LOAD						
2 6580500.	0.	0.	.4525	7213868.		
3 630.	1456.6					
4 .878	.77	100.	1.262			
9 6.	84.5	2.	43.			
10 3.	9.57	5.01	2.66			
12 2.	188000.	11.9	624000.	11.9	1.	
14 1.	214.		0.	1.		
14 2.		5.	1.	0.		
14 3.	52.5		0.	1.		
14 4.	52.		0.	1.		
14 5.	9.57		0.	1.		
14 6.	2.66		0.	1.		
0						

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(3 3-67)

Fig. 5 (continued)

PROBLEM NO. 2, WMO
RBINE CYCLE HEAT BALANCE
'ERSION 10-9-78

.ROTTLE STEAM TEMPERATURE	594.6	F				
THROTTLE STEAM PRESSURE	1000.0	PSIA				
THROTTLE STEAM MOISTURE	0.0	PER CENT				
ESTIMATED THROTTLE STEAM FLOW	14542000.	LB/HR				
FW MAKE-UP RATE (TO CONDENSER HOTWELL)	0.0	PER CENT				
CONDENSATE BY-PASSED TO STEAM GENERATOR	0.	LB/HR				
THROTTLE FLOW RATIO	1.00000					
REQUIRED STEAM GENERATOR OUTLET FLOW	15381973.	LB/HR				
REQUIRED ELECTRICAL OUTPUT	1310.930	MWE				
GENERATOR RATED CAPABILITY	1456.600	MVA				
GENERATOR POWER FACTOR	0.90					
GENERATOR OPERATION AT RATED HYDROGEN PRESSURE, IH2= 0						
ROTATIONAL SPEED OF TURBINE-GENERATOR	1800	RPM				
FEEDWATER PUMP ISENTROPIC EFFICIENCY	0.8780					
FEEDWATER PUMP TURBINE EFFICIENCY	0.7700					
PRESSURE OF FWP INLET ABOVE COND. PRESSURE	100.00	PSIA				
RATIO OF FWP DISCH. PRESS. TO H-P THROTTLE	1.26					
PITCH DIAMETER OF GOVERNING STAGE	65.00	IN.				
NUMBER OF PARALLEL H-P SECTIONS	2					
NUMBER OF PARALLEL L-P SECTIONS	6					
BOWL PRESSURE L-P SECTION	173.2	PSIA				
EXHAUST PRESSURE L-P SECTION	0.98231	PSIA	=	2.00	IN. HGA	
CONDENSER PRESSURE	0.98231	PSIA	=	2.00	IN. HGA	
PITCH DIAMETER OF LAST STAGE L-P SECTION	132.00	IN.				
LENGTH OF LAST STAGE BUCKETS L-P SECTION	43.00	IN.				
NO. OF MOISTURE REMOVAL STAGES LP SECTION	3					
MOISTURE REMOVAL STAGE NO. 1						
MOISTURE REMOVAL STAGE PRESSURE	19.5	PSIA				
MOISTURE REMOVAL STAGE NO. 2						
MOISTURE REMOVAL STAGE PRESSURE	10.2	PSIA				
MOISTURE REMOVAL STAGE NO. 3						
MOISTURE REMOVAL STAGE PRESSURE	5.2	PSIA				
EXTERNAL MOISTURE SEPARATOR DRAINS TO FW HEATER NO. 2, MS= 2						
MOISTURE SEPARATOR EFFECTIVENESS	100.	PER CENT				
NUMBER OF STAGES OF REHEAT	2					
ESTIMATED STEAM FLOW TO 1ST STAGE REHEATER	484000.	LB/HR				
TERMINAL TEMPERATURE DIFFERENCE 1ST STAGE REHEATER	25.0	F				
1ST STAGE REHEATER DRAINS TO FW HEATER NO. 1, NDRH= 1						
ESTIMATED STEAM FLOW TO 2ND STAGE REHEATER	792000.	LB/HR				
TERMINAL TEMPERATURE DIFFERENCE 2ND STAGE REHEATER	25.0	F				
2ND STAGE REHEATER DRAINS TO FW HEATER NO. 1						
TOTAL NO. OF FW HEATERS	6					
NO. OF FW HEATERS HP SECTION	2					

NO. OF FW HEATERS LP SECTION	4	
FW HEATER NO. 1		
EXTRACTION STAGE PRESSURE	457.6	PSIA
TERMINAL TEMPERATURE DIFFERENCE	5.0	F
DRAIN IS FLASHED, ND(1)= 0		
THERE IS A DRAIN COOLER SECTION, NDC(1)= 1		
DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE	10.0	F
FW HEATER NO. 2		
EXTRACTION STEAM FROM MOISTURE SEPARATOR VESSEL		
TERMINAL TEMPERATURE DIFFERENCE	5.0	F
DRAIN IS PUMPED, ND(2)= 1		
THERE IS NO DRAIN COOLER SECTION, NDC(2)= 0		
FW HEATER NO. 3		
EXTRACTION STAGE PRESSURE	106.7	PSIA
TERMINAL TEMPERATURE DIFFERENCE	5.0	F
DRAIN IS FLASHED, ND(3)= 0		
THERE IS A DRAIN COOLER SECTION, NDC(3)= 1		
DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE	10.0	F
FW HEATER NO. 4		
EXTRACTION STAGE PRESSURE	64.1	PSIA
TERMINAL TEMPERATURE DIFFERENCE	5.0	F
DRAIN IS FLASHED, ND(4)= 0		
THERE IS A DRAIN COOLER SECTION, NDC(4)= 1		
DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE	10.0	F
FW HEATER NO. 5		
EXTRACTION STAGE PRESSURE	19.5	PSIA
TERMINAL TEMPERATURE DIFFERENCE	5.0	F
DRAIN IS FLASHED, ND(5)= 0		
THERE IS A DRAIN COOLER SECTION, NDC(5)= 1		
DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE	10.0	F
FW HEATER NO. 6		
EXTRACTION STAGE PRESSURE	5.2	PSIA
TERMINAL TEMPERATURE DIFFERENCE	5.0	F
DRAIN IS FLASHED, ND(6)= 0		
THERE IS A DRAIN COOLER SECTION, NDC(6)= 1		
DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE	10.0	F
FW PUMP IS LOCATED BEFORE FW HEATER NO. 1, IP= 1		
FW PUMP IS TURBINE DRIVEN, IFPT= 1		
STEAM FLOW TO FW PUMP TURBINE WILL BE CALCULATED		
STEAM FLOW TO STEAM JET AIR EJECTOR	1500.	LB/HR
VALVE STEM AND PACKING LEAKAGES WILL BE CALCULATED, LK= 1		

EXAMPLE PROBLEM NO. 2, VWO
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 1

TABLE I OVERALL PERFORMANCE

NET TURBINE CYCLE HEAT RATE, BTU/KW-HR	9595.
NET TURBINE CYCLE EFFICIENCY, PER CENT	35.56
GROSS TURBINE CYCLE HEAT RATE, BTU/KW-HR	9450.
GROSS TURBINE CYCLE EFFICIENCY, PER CENT	36.09
GENERATOR OUTPUT, MWE	1114.201
POWER REQUIRED BY TURBINE-DRIVEN FW PUMP, MW	19.577
GENERATOR OUTPUT PLUS FW PUMP POWER, MW	1133.778
MECHANICAL LOSSES, KW	6148.
GENERATOR LOSSES, KW	16271.

EXAMPLE PROBLEM NO. 2, VWO
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 2

TABLE II TURBINE EXPANSION LINE

	STEAM FLOW LB/HR	PRESSURE PSIA	TEMPERATURE F	MOISTURE PER CENT	ENTHALPY BTU/LB	ENTROPY BTU/LB-F
TURBINE THROTTLE	14980512.	1000.0	594.6	0.0	1244.5	
GOVERNING STAGE BOWL	14565951.	960.0	589.2	0.0	1244.4	1.4448
GOVERNING STAGE SHELL	14565951.	765.9	540.7	0.0	1226.6	1.4476
HP SECTION ELEP	12810241.	189.7	377.4	8.52	1125.5	1.4618
HP SECTION UEEP		189.7			1127.0	
EXTERNAL MOISTURE SEPARATOR INLET	12808922.	188.4			1127.0	
EXTERNAL MOISTURE SEPARATOR OUTLET	11746425.	186.1	375.9	0.0	1197.1	
1ST STAGE REHEATER INLET	11170157.	186.1			1197.1	
1ST STAGE REHEATER OUTLET	11170157.	181.9	428.4		1230.1	
2ND STAGE REHEATER INLET	11170157.	181.9			1230.1	
2ND STAGE REHEATER OUTLET	11170157.	181.1	517.8		1280.7	
LP SECTION BOWL	10920176.	171.2	516.3	0.0	1280.7	1.6515
BEFORE MOISTURE REMOVAL NO. 1		19.5	226.6	4.40	1111.5	1.6724
AFTER MOISTURE REMOVAL NO. 1		19.5	226.6	3.96	1117.8	1.6785
BEFORE MOISTURE REMOVAL NO. 2		10.2	194.1	6.62	1078.8	1.6869
AFTER MOISTURE REMOVAL NO. 2		10.2	194.1	5.44	1090.3	1.7046
BEFORE MOISTURE REMOVAL NO. 3		5.2	163.9	7.91	1052.7	1.7342
AFTER MOISTURE REMOVAL NO. 3		5.2	163.9	6.37	1070.1	1.7422
LP SECTION ELEP	8312671.	0.98211	101.1	11.45	986.9	1.7680
LP SECTION UEEP		0.98211			1001.9	

EXAMPLE PROBLEM NO. 2, TWO
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 3

TABLE III STEAM JET AIR EJECTOR

STEAM FLOW, LB/HR	1500.
STEAM ENTHALPY IN, BTU/LB	1288.5
STEAM ENTHALPY OUT, BTU/LB	180.2

TABLE IV EXTERNAL MOISTURE SEPARATOR DRAINS TO FW HEATER NO. 2

DRAIN FLOW, LB/HR	1062497.
DRAIN PRESSURE, PSIA	186.3
DRAIN TEMPERATURE, F	375.9
DRAIN ENTHALPY, BTU/LB	349.2

TABLE V LIVE STEAM REHEATER

1ST STAGE DRAINS TO FW HEATER NO. 1	
1ST STAGE STEAM FLOW, LB/HR	489126.
1ST STAGE STEAM ENTHALPY, BTU/LB	1185.6
1ST STAGE PRESSURE, PSIA	437.2
1ST STAGE DRAIN TEMPERATURE, F	451.4
1ST STAGE DRAIN ENTHALPY, BTU/LB	434.1
2ND STAGE DRAINS TO FW HEATER NO. 1	
2ND STAGE STEAM FLOW, LB/HR	799981.
2ND STAGE STEAM ENTHALPY, BTU/LB	1288.5
2ND STAGE PRESSURE, PSIA	985.1
2ND STAGE DRAIN TEMPERATURE, F	542.8
2ND STAGE DRAIN ENTHALPY, BTU/LB	540.1

TABLE VI MOISTURE REMOVAL STAGES

MOISTURE REMOVAL STAGE NO.	1	2	3
DRAINS TO FW HEATER NO.	5	6	6
STAGE PRESSURE, PSIA	19.5	10.2	5.2
TEMPERATURE, F	226.6	194.1	161.9
WATER REMOVED, LB/HR	44751.	112669.	165974.
WATER ENTHALPY, BTU/LB	194.9	162.2	131.9
STEAM REMOVED, LB/HR	0.	45380.	0.
STEAM ENTHALPY, BTU/LB	0.0	1090.3	0.0

EXAMPLE PROBLEM NO. 2, TWO
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE 4

TABLE VII FW HEATERS

FW HEATER NO.	1	2	3	4	5	6
FW FLOW, LB/HR	15381971.	11195692.	11195692.	11195692.	11195692.	11195692.
FW TEMPERATURE OUT, F	444.6	366.7	321.5	286.6	217.2	155.4
FW ENTHALPY OUT, BTU/LB	424.8	339.4	291.9	255.9	185.4	123.1
FW TEMPERATURE IN, F	370.7	321.5	286.6	217.2	155.4	101.9
FW ENTHALPY IN, BTU/LB	345.2	291.9	255.9	185.4	123.1	69.9
EXTRACTION STAGE PRESSURE, PSIA	457.6	186.3	106.7	64.1	19.5	5.2
EXTRACTION STEAM FLOW, LB/HR	1246588.	576269.	410674.	759660.	629280.	439314.
EXTRACTION STEAM ENTHALPY, BTU/LB	1185.6	1197.3	1216.5	1195.6	1137.8	1070.1
SHELL PRESSURE, PSIA	421.0	177.0	98.2	59.0	17.9	4.8
SHELL TEMPERATURE, F	449.6	371.7	326.5	291.6	222.2	162.4
SHELL DRAIN FLOW, LB/HR	2535651.	4088281.	416260.	1175920.	1849951.	2613740.
SHELL DRAIN TEMPERATURE, F	380.7	331.7	296.6	227.2	165.4	111.9
SHELL DRAIN ENTHALPY, BTU/LB	354.1	304.7	266.2	195.5	133.3	79.9

TABLE VIII CONDENSER

CONDENSER PRESSURE, PSIA	0.98211	=	2.00	IN. HGA
CONDENSATE FLOW, LB/HR	11195692.			
CONDENSATE TEMPERATURE, F	101.1			
CONDENSATE ENTHALPY, BTU/LB	69.1			

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EXAMPLE PROBLEM NO. 2, VWO
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE  5



TABLE IX  CONDENSATE AND FEEDWATER

FW FLOW TO FW PUMP, LB/HR                                   1518371.
FW TEMPERATURE TO FW PUMP, F                                   368.0
FW ENTHALPY TO FW PUMP, BTU/LB                                 340.8
FW ENTHALPY RISE ACROSS FW PUMP, BTU/LB                          4.1
FW PRESSURE INCREASE ACROSS FW PUMP, PSI                       1163.

FW FLOW TO STEAM GENERATOR, LB/HR                           1518371.
FW TEMPERATURE TO STEAM GENERATOR, F                           444.6
FW ENTHALPY TO STEAM GENERATOR, BTU/LB                         424.0

MAKE-UP TO CONDENSER HOTWELL, LB/HR                               0.

STEAM FLOW FROM STEAM GENERATOR, LB/HR                      1518371.
STEAM ENTHALPY FROM STEAM GENERATOR, BTU/LB                   1200.5

THROTTLE STEAM FLOW FW PUMP TURBINE, LB/HR                   249781.
THROTTLE PRESSURE FW PUMP TURBINE, PSIA                        172.0
THROTTLE ENTHALPY FW PUMP TURBINE, BTU/LB                     1200.7
EXHAUST PRESSURE FW PUMP TURBINE, PSIA                        1.22709    =     2.50   IN. HGA
EXHAUST ENTHALPY FW PUMP TURBINE, BTU/LB                      1011.1




EXAMPLE PROBLEM NO. 2, VWO
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

CALCULATED RESULTS, PAGE  6



TABLE X   VALVE STEM AND SHAFT LEAKAGES

STEAM SEAL REGULATOR
   FLOW TO SSR, LB/HR                                          18449.
   ENTHALPY AT SSR, BTU/LB                                     1144.1
   FLOW FROM SSR TO MAIN CONDENSER, LB/HR                      16800.
   FLOW FROM SSR TO STEAM PACKING EXHAUSTER, LB/HR              1200.
   FLOW FROM SSR TO FW HEATER NO.  6, LB/HR                      449.
   MAKE-UP FROM THROTTLE STEAM, LB/HR                              0.
   ENTHALPY OF MAKE-UP STEAM, BTU/LB                              0.0

THROTTLE VALVE STEM
   LEAK NO. 1 (DRAINS TO FW HEATER NO.  2), LB/HR              11868.
   ENTHALPY LEAK NO. 1, BTU/LB                                 1200.5
   LEAK NO. 2 (DRAINS TO SSR), LB/HR                            2716.
   ENTHALPY LEAK NO. 2, BTU/LB                                 1200.5

GOVERNING STAGE SECTION
   LEAK NO. 3 (DRAINS TO FW HEATER NO.  0), LB/HR                  0.
   ENTHALPY LEAK NO. 3, BTU/LB                                    0.0
   LEAK NO. 4 (DRAINS TO SSR), LB/HR                               0.
   ENTHALPY LEAK NO. 4, BTU/LB                                    0.0

HP TURBINE SECTION
   TOTAL LEAK NO. 5 (DRAINS TO FW HEATER NO.  1), LB/HR      5586.
   ENTHALPY LEAK NO. 5, BTU/LB                               1127.0
   TOTAL LEAK NO. 6 (DRAINS TO SSR), LB/HR                  15731.
   ENTHALPY LEAK NO. 6, BTU/LB                               1127.0
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EXAMPLE PROBLEM NO. 2, HALF RATED LOAD
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

INPUT DATA

THROTTLE STEAM TEMPERATURE	594.6	F		
THROTTLE STEAM PRESSURE	1000.0	PSIA		
THROTTLE STEAM MOISTURE	0.0	PER CENT		
ESTIMATED THROTTLE STEAM FLOW	6580500.	LB/HR		
FW MAKE-UP RATE (TO CONDENSER HOTWELL)	0.0	PER CENT		
CONDENSATE BY-PASSED TO STEAM GENERATOR	0.	LB/HR		
THROTTLE FLOW RATIO	0.45250			
REQUIRED STEAM GENERATOR OUTLET FLOW	7213868.	LB/HR		
REQUIRED ELECTRICAL OUTPUT	630.000	MWE		
GENERATOR RATED CAPABILITY	1456.600	MVA		
GENERATOR POWER FACTOR	0.90			
GENERATOR OPERATION AT RATED HYDROGEN PRESSURE, IH2= 0				
ROTATIONAL SPEED OF TURBINE-GENERATOR	1800	RPM		
FEEDWATER PUMP ISENTROPIC EFFICIENCY	0.8780			
FEEDWATER PUMP TURBINE EFFICIENCY	0.7700			
PRESSURE OF FWP INLET ABOVE COND. PRESSURE	100.00	PSIA		
RATIO OF FWP DISCH. PRESS. TO H-P THROTTLE	1.26			
PITCH DIAMETER OF GOVERNING STAGE	65.00	IN.		
NUMBER OF PARALLEL H-P SECTIONS	2			
NUMBER OF PARALLEL L-P SECTIONS	6			
BOWL PRESSURE L-P SECTION	84.5	PSIA		
EXHAUST PRESSURE L-P SECTION	0.98231	PSIA	=	2.00 IN. HGA
CONDENSER PRESSURE	0.98231	PSIA	=	2.00 IN. HGA
PITCH DIAMETER OF LAST STAGE L-P SECTION	132.00	IN.		
LENGTH OF LAST STAGE BUCKETS L-P SECTION	43.00	IN.		
NO. OF MOISTURE REMOVAL STAGES LP SECTION	3			
MOISTURE REMOVAL STAGE NO. 1				
MOISTURE REMOVAL STAGE PRESSURE	9.6	PSIA		
MOISTURE REMOVAL STAGE NO. 2				
MOISTURE REMOVAL STAGE PRESSURE	5.0	PSIA		
MOISTURE REMOVAL STAGE NO. 3				
MOISTURE REMOVAL STAGE PRESSURE	2.7	PSIA		
EXTERNAL MOISTURE SEPARATOR DRAINS TO FW HEATER NO. 2, NS= 2				
MOISTURE SEPARATOR EFFECTIVENESS	100.	PER CENT		
NUMBER OF STAGES OF REHEAT	2			
ESTIMATED STEAM FLOW TO 1ST STAGE REHEATER	189000.	LB/HR		
TERMINAL TEMPERATURE DIFFERENCE 1ST STAGE REHEATER	11.9	F		
1ST STAGE REHEATER DRAINS TO FW HEATER NO. 1, NDRH= 1				
ESTIMATED STEAM FLOW TO 2ND STAGE REHEATER	624000.	LB/HR		
TERMINAL TEMPERATURE DIFFERENCE 2ND STAGE REHEATER	11.9	F		
2ND STAGE REHEATER DRAINS TO FW HEATER NO. 1				
TOTAL NO. OF FW HEATERS	6			
NO. OF FW HEATERS HP SECTION	2			

NO. OF FW HEATERS LP SECTION	4	
FW HEATER NO. 1		
EXTRACTION STAGE PRESSURE	214.0	PSIA
TERMINAL TEMPERATURE DIFFERENCE	5.0	F
DRAIN IS FLASHED, ND(1)= 0		
THERE IS A DRAIN COOLER SECTION, NDC(1)= 1		
DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE	10.0	F
FW HEATER NO. 2		
EXTRACTION STEAM FROM MOISTURE SEPARATOR VESSEL		
TERMINAL TEMPERATURE DIFFERENCE	5.0	F
DRAIN IS PUMPED, ND(2)= 1		
THERE IS NO DRAIN COOLER SECTION, NDC(2)= 0		
FW HEATER NO. 3		
EXTRACTION STAGE PRESSURE	52.5	PSIA
TERMINAL TEMPERATURE DIFFERENCE	5.0	F
DRAIN IS FLASHED, ND(3)= 0		
THERE IS A DRAIN COOLER SECTION, NDC(3)= 1		
DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE	10.0	F
FW HEATER NO. 4		
EXTRACTION STAGE PRESSURE	32.0	PSIA
TERMINAL TEMPERATURE DIFFERENCE	5.0	F
DRAIN IS FLASHED, ND(4)= 0		
THERE IS A DRAIN COOLER SECTION, NDC(4)= 1		
DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE	10.0	F
FW HEATER NO. 5		
EXTRACTION STAGE PRESSURE	9.6	PSIA
TERMINAL TEMPERATURE DIFFERENCE	5.0	F
DRAIN IS FLASHED, ND(5)= 0		
THERE IS A DRAIN COOLER SECTION, NDC(5)= 1		
DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE	10.0	F
FW HEATER NO. 6		
EXTRACTION STAGE PRESSURE	2.7	PSIA
TERMINAL TEMPERATURE DIFFERENCE	5.0	F
DRAIN IS FLASHED, ND(6)= 0		
THERE IS A DRAIN COOLER SECTION, NDC(6)= 1		
DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE	10.0	F
FW PUMP IS LOCATED BEFORE FW HEATER NO. 1, IP= 1		
FW PUMP IS TURBINE DRIVEN, IFPT= 1		
STEAM FLOW TO FW PUMP TURBINE WILL BE CALCULATED		
STEAM FLOW TO STEAM JET AIR EJECTOR	1500.	LB/HR
VALVE STEM AND PACKING LEAKAGES WILL BE CALCULATED, LK= 1		

EXAMPLE PROBLEM NO. 2, HALF RATED LOAD
STEAM TURBINE CYCLE HEAT BALANCE
ORCENT, VERSION 10-9-78

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TABLE I OVERALL PERFORMANCE

NET TURBINE CYCLE HEAT RATE, BTU/KW-HR	10230.
NET TURBINE CYCLE EFFICIENCY, PER CENT	33.35
GROSS TURBINE CYCLE HEAT RATE, BTU/KW-HR	10084.
GROSS TURBINE CYCLE EFFICIENCY, PER CENT	33.84
GENERATOR OUTPUT, MWE	630.590
POWER REQUIRED BY TURBINE-DRIVEN FW PUMP, MW	9.181
GENERATOR OUTPUT PLUS FW PUMP POWER, MW	639.772
MECHANICAL LOSSES, KW	6148.
GENERATOR LOSSES, KW	7629.

EXAMPLE PROBLEM NO. 2, HALF RATED LOAD
STEAM TURBINE CYCLE HEAT BALANCE
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TABLE II TURBINE EXPANSION LINE

	STEAM FLOW LB/HR	PRESSURE PSIA	TEMPERATURE F	MOISTURE PER CENT	ENTHALPY BTU/LB	ENTROPY BTU/LB-F
TURBINE THROTTLE	6588248.	1000.0	594.6	0.0	1244.5	
GOVERNING STAGE BOWL	6572559.	702.7	551.8	0.0	1244.4	1.4734
GOVERNING STAGE SHELL	6572559.	334.8	429.0	0.0	1204.8	1.5020
HP SECTION ELEP	6072154.	92.5	322.3	8.09	1113.5	1.5166
HP SECTION UEEP		92.5			1115.0	
EXTERNAL MOISTURE SEPARATOR INLET	6058383.	91.9			1115.0	
EXTERNAL MOISTURE SEPARATOR OUTLET	5581254.	90.9	321.0	0.0	1185.4	
1ST STAGE REHEATER INLET	5357213.	90.9			1185.4	
1ST STAGE REHEATER OUTLET	5357213.	89.7	371.8		1213.9	
2ND STAGE REHEATER INLET	5357213.	89.7			1213.9	
2ND STAGE REHEATER OUTLET	5357213.	88.4	530.9		1295.9	
LP SECTION BOWL	5225938.	84.5	530.2	0.0	1295.9	1.7441
BEFORE MOISTURE REMOVAL NO. 1		9.6	191.1	1.76	1125.3	1.7648
AFTER MOISTURE REMOVAL NO. 1		9.6	191.1	1.42	1128.6	1.7700
BEFORE MOISTURE REMOVAL NO. 2		5.0	162.3	4.16	1089.5	1.7772
AFTER MOISTURE REMOVAL NO. 2		5.0	162.3	3.21	1099.0	1.7924
BEFORE MOISTURE REMOVAL NO. 3		2.7	136.8	5.62	1063.5	1.8005
AFTER MOISTURE REMOVAL NO. 3		2.7	136.8	4.34	1076.6	1.8223
LP SECTION ELEP	4264627.	0.98231	101.1	7.80	1024.7	1.8356
LP SECTION UEEP		0.98231			1030.1	

EXAMPLE PROBLEM NO. 2, HALF RATED LOAD
STEAM TURBINE CYCLE HEAT BALANCE
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CALCULATED RESULTS, PAGE 3

TABLE III STEAM JET AIR EJECTOR

STEAM FLOW, LB/HR	1500.
STEAM ENTHALPY IN, BTU/LB	1244.5
STEAM ENTHALPY OUT, BTU/LB	180.2

TABLE IV EXTERNAL MOISTURE SEPARATOR DRAINS TO FW HEATER NO. 2

DRAIN FLOW, LB/HR	477129.
DRAIN PRESSURE, PSIA	90.9
DRAIN TEMPERATURE, F	321.0
DRAIN ENTHALPY, BTU/LB	291.4

TABLE V LIVE STEAM REHEATER

1ST STAGE DRAINS TO FW HEATER NO. 1	
1ST STAGE STEAM FLOW, LB/HR	187557.
1ST STAGE STEAM ENTHALPY, BTU/LB	1170.6
1ST STAGE PRESSURE, PSIA	204.5
1ST STAGE DRAIN TEMPERATURE, F	383.7
1ST STAGE DRAIN ENTHALPY, BTU/LB	357.5
2ND STAGE DRAINS TO FW HEATER NO. 1	
2ND STAGE STEAM FLOW, LB/HR	624120.
2ND STAGE STEAM ENTHALPY, BTU/LB	1244.5
2ND STAGE PRESSURE, PSIA	985.1
2ND STAGE DRAIN TEMPERATURE, F	542.8
2ND STAGE DRAIN ENTHALPY, BTU/LB	540.3

TABLE VI MOISTURE REMOVAL STAGES

MOISTURE REMOVAL STAGE NO.	1	2	3
DRAINS TO FW HEATER NO.	5	6	6
STAGE PRESSURE, PSIA	9.6	5.0	2.7
TEMPERATURE, F	191.1	162.3	136.8
WATER REMOVED, LB/HR	16387.	43957.	59113.
WATER ENTHALPY, BTU/LB	159.2	130.3	104.8
STEAM REMOVED, LB/HR	0.	22419.	0.
STEAM ENTHALPY, BTU/LB	0.0	1099.0	0.0

EXAMPLE PROBLEM NO. 2, HALF RATED LOAD
STEAM TURBINE CYCLE HEAT BALANCE
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TABLE VII FW HEATERS

FW HEATER NO.	1	2	3	4	5	6
FW FLOW, LB/HR	7213868.	5376713.	5376713.	5376713.	5376713.	5376713.
FW TEMPERATURE OUT, F	375.5	312.4	273.8	244.3	182.3	128.6
FW ENTHALPY OUT, BTU/LB	350.2	282.5	242.9	212.8	150.3	96.6
FW TEMPERATURE IN, F	315.8	273.8	244.3	182.3	128.6	102.7
FW ENTHALPY IN, BTU/LB	288.1	242.9	212.8	150.3	96.6	70.7
EXTRACTION STAGE PRESSURE, PSIA	214.0	90.9	52.5	32.0	9.6	2.7
EXTRACTION STEAM FLOW, LB/HR	312848.	224041.	157579.	311158.	256934.	93764.
EXTRACTION STEAM ENTHALPY, BTU/LB	1170.6	1185.4	1250.3	1208.6	1128.6	1076.6
SHELL PRESSURE, PSIA	196.9	86.3	48.3	29.4	8.8	2.4
SHELL TEMPERATURE, F	380.5	317.4	278.8	249.3	187.3	133.6
SHELL DRAIN FLOW, LB/HR	1135985.	1837155.	157579.	468737.	742057.	961310.
SHELL DRAIN TEMPERATURE, F	325.8	317.4	254.3	192.3	138.6	112.7
SHELL DRAIN ENTHALPY, BTU/LB	296.4	287.7	222.9	160.3	106.6	80.7

TABLE VIII CONDENSER

CONDENSER PRESSURE, PSIA	0.98231	=	2.00	IN. HGA
CONDENSATE FLOW, LB/HR	5376713.			
CONDENSATE TEMPERATURE, F	101.1			
CONDENSATE ENTHALPY, BTU/LB	69.1			

EXAMPLE PROBLEM NO. 2, HALF RATED LOAD
STEAM TURBINE CYCLE HEAT BALANCE
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TABLE IX CONDENSATE AND FEEDWATER

FW FLOW TO FW PUMP, LB/HR	7213868.		
FW TEMPERATURE TO FW PUMP, F	313.6		
FW ENTHALPY TO FW PUMP, BTU/LB	283.8		
FW ENTHALPY RISE ACROSS FW PUMP, BTU/LB	4.3		
FW PRESSURE INCREASE ACROSS FW PUMP, PSI	1161.		
FW FLOW TO STEAM GENERATOR, LB/HR	7213868.		
FW TEMPERATURE TO STEAM GENERATOR, F	375.5		
FW ENTHALPY TO STEAM GENERATOR, BTU/LB	350.2		
MAKE-UP TO CONDENSER HOTWELL, LB/HR	0.		
STEAM FLOW FROM STEAM GENERATOR, LB/HR	7213868.		
STEAM ENTHALPY FROM STEAM GENERATOR, BTU/LB	1244.5		
THROTTLE STEAM FLOW FW PUMP TURBINE, LB/HR	131275.		
THROTTLE PRESSURE FW PUMP TURBINE, PSIA	83.9		
THROTTLE ENTHALPY FW PUMP TURBINE, BTU/LB	1295.9		
EXHAUST PRESSURE FW PUMP TURBINE, PSIA	1.22789	= 2.50	IN. HGA
EXHAUST ENTHALPY FW PUMP TURBINE, BTU/LB	1057.3		

EXAMPLE PROBLEM NO. 2, HALF RATED LOAD
STEAM TURBINE CYCLE HEAT BALANCE
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TABLE X VALVE STEM AND SHAFT LEAKAGES

STEAM SEAL REGULATOR	
FLOW TO SSR, LB/HR	18000.
ENTHALPY AT SSR, BTU/LB	1145.4
FLOW FROM SSR TO MAIN CONDENSER, LB/HR	10800.
FLOW FROM SSR TO STEAM PACKING EXHAUSTER, LB/HR	7200.
FLOW FROM SSR TO FW HEATER NO. 6, LB/HR	0.
MAKE-UP FROM THROTTLE STEAM, LB/HR	1109.
ENTHALPY OF MAKE-UP STEAM, BTU/LB	1244.5
THROTTLE VALVE STEM	
LEAK NO. 1 (DRAINS TO FW HEATER NO. 1), LB/HR	11460.
ENTHALPY LEAK NO. 1, BTU/LB	1244.5
LEAK NO. 2 (DRAINS TO SSR), LB/HR	3120.
ENTHALPY LEAK NO. 2, BTU/LB	1244.5
GOVERNING STAGE SECTION	
LEAK NO. 3 (DRAINS TO FW HEATER NO. 0), LB/HR	0.
ENTHALPY LEAK NO. 3, BTU/LB	0.0
LEAK NO. 4 (DRAINS TO SSR), LB/HR	0.
ENTHALPY LEAK NO. 4, BTU/LB	0.0
HP TURBINE SECTION	
TOTAL LEAK NO. 5 (DRAINS TO FW HEATER NO. 0), LB/HR	0.
ENTHALPY LEAK NO. 5, BTU/LB	0.0
TOTAL LEAK NO. 6 (DRAINS TO SSR), LB/HR	13771.
ENTHALPY LEAK NO. 6, BTU/LB	1115.0

Appendix C

FORTRAN LISTING

This appendix contains a brief description and a complete FORTRAN listing of the main program and subroutines. The steam properties subroutines from Ref. 4 are not listed. The primary function of the main program is to control the order of calculations and to call the subroutines required by the cycle specified by the input data. It also performs some calculations. There are no programmed stops or exits. If a convergence criterion is not satisfied or if the allowable range of an independent variable is exceeded, a warning message will be printed and calculations will continue.

The following subroutines perform the input and output functions and the analysis of the specified turbine cycle.

AMOIST	performs internal moisture removal calculations for the low-pressure turbine section
BLOCK DATA	contains default input data to simulate VWO conditions for the cycle of Fig. 22 in Ref. 3
CROSS	calculates average group moisture for the high-pressure turbine section
DATAIN	reads input data cards, sets values by default if not input, and writes input data before returning control to MAIN
FWHEAT	performs heat and mass balance calculations for the feedwater heaters
FWHPAR	calculates the following feedwater heater parameters: shell pressure, shell drain temperature, feedwater inlet temperature, and feedwater outlet temperature
FWPT	calculates steam flow to the feedwater pump turbine
HXTRAC	calculates feedwater heater extraction steam enthalpy after the turbine expansion line has been determined
HPTURB	calculates high-pressure section efficiency including governing-type stages and single stages
INDEX	calculates integer indices for keeping track of steam flows and enthalpies in the low-pressure turbine section
PRDROP	calculates intermediate system pressure drops

RESULT	writes results of calculations for each case before proceeding to the next case
SGROUP	calculates low-pressure turbine section performance
SLEAK1	calculates valve stem packing leakages
SLEAK2	calculates bowl end turbine shaft packing leakages
SLEAK3	calculates exhaust end turbine shaft leakages
SSRE	calculates steam seal regulator flows and enthalpies
STER	produces a traceback to a steam property subroutine as a result of a division by zero
STRATE	calculates enthalpy and entropy at a given pressure on a straight line between two state points on a steam Mollier chart
XLOSS	calculates exhaust loss and used energy end point for the low-pressure turbine when exhaust pressure is less than 3 psia
XSEP	performs heat and mass balance calculations for external moisture separator

The following subroutines perform the calculations required to determine turbine efficiencies and losses. The names of the subroutines correspond to the figure numbers in Ref. 3.

F1A	high-pressure turbine efficiency corrections for governing stage — correction at design conditions VWO
F1B	high-pressure turbine efficiency corrections for governing stage — correction for partial load
F1C	high-pressure turbine efficiency corrections for governing stage — adjustment to correction for partial load for wheel speed
F2	high-pressure turbine efficiency correction for moisture
F3	stage group efficiency, superheat region
F4	stage group efficiency, moisture region
FIG5	stage group efficiency, moisture region — correction for inlet volume flow
FIG7	stage group efficiency, moisture region — correction for inlet moisture
FIG8	noncondensing stage group end point correction for exhaust loss
F10	moisture removal stage effectiveness

F12AC	construction of typical high-pressure section expansion line and typical low-pressure section moisture region expansion line
F12B	construction of typical low-pressure section superheat region expansion line
FIG15	correction to expansion line end point for exhaust pressure
F16	1800-rpm condensing group exhaust loss for 35-, 38-, and 43-in. last-stage buckets
F17	effects of pressure feedback of VWO throttle flow
F18	mechanical losses
F19	generator loss factor, K_1
F20	generator loss factor, K_2
F21	change in generator loss with hydrogen pressure, at constant kVA
UNIPOL	univariate polynomial
BIVPOL	bivariate polynomial
LAGRAN	fourth-order (five-point) Lagrange interpolation
RATFUN	rational function

```
C
C     PROGRAM ORCENT
      IMPLICIT REAL*8(A-H,O-Z)
C  QR        FEEDWATER FLOW TO STEAM GENERATOR
C  QT        TURBINE THROTTLE FLOW
C  QAE       STEAM JET AIR EJECTOR STEAM FLOW
C  QCR       CONDENSATE FLOW BY-PASSED TO STEAM GENERATOR
C  QGS       GOVERNING STAGE FLOW
C  QMC       FLOW FROM SSR TO MAIN CONDENSER
C  QMU       MAKE-UP FLOW TO CONDENSER HOTWELL
C  QRO       STEAM FLOW FROM STEAM GENERATOR
C  QRH1      LIVE STEAM REHEATER, FIRST STAGE STEAM FLOW
C  QRH2      LIVE STEAM REHEATER, SECOND STAGE STEAM FLOW
C  QSPE      FLOW FROM SSR TO STEAM PACKING EXHAUSTER
C  QXGS      GOVERNING STAGE EXHAUST FLOW
C  QERH1     ESTIMATED LIVE STEAM REHEATER FIRST STAGE STEAM FLOW
C  QERH2     ESTIMATED LIVE STEAM REHEATER SECOND STAGE STEAM FLOW
C  QSSRMU    STEAM SEAL REGULATOR MAKE-UP FROM THROTTLE STEAM
      COMMON /BLCK/AMBMR(5),AMAMR(5),TMR(6),MR,IDUM
     *          ,QBLP,PBLP,TBLP,AMBLP,HBLP,SBLP,QXLP,PXLP,TXLP,AMXLP,
     *HXLP,SXLP,UEEPLP
     *          ,CMTS(18),     TC,TFP,TR,HR,WRATE,GC,WML,WGL,QMU,QPP,
     *DP,WGEN,WPWP,HTRTN,HTRTG,CEFFN,CEFFG,PC
      COMMON /CONV/HCON,UERCON,AMCON,RHCON,WCON,PCON,SSRCON,XSPCON
      COMMON /FPT/QFPT,PBFPT,HBFPT,PXFPT,HXFPT,IFPT
      COMMON /FWH/HAEI,HAEO,QR,QFS(20),HFS(20),HES(20),QMF(5),HMF(5),
     *QMG(5),HMG(5),QD(12),QF(12),QE(12),QCR,HCR,QRO,QC,I1LP,M
      COMMON /FWPTRB/ EPP, EFF, CP1, CP2
      COMMON /GS/QGS,HBGS,PBGS, ABGS,SBGS,VBGS,TBGS,PXGS, AXGS,SXGS,
     *VXGS,TXGS,HXGS,PDGS,     MBGS,MXGS,NCGS,      NGS
     *          ,QT,PT,TT, AT,HT
      COMMON /HP/QBHP,PBHP,TBHP,AMBHP,HBHP,SBHP,QXHP,TXHP,AMXHP,HXHP,
     *SXHP,UEEPHP
      COMMON /HX1/PE(12),PMR(5)
      COMMON /HX2/HE(12),HE1(12),HAMR(5),HBMR(5),SAMR(5),SBMR(5),PCWD(5)
      COMMON /LEAK/QLK1,HLK1,QLK2,HLK2,QLK3,HLK3,QLK4,HLK4,QLK5,HLK5,
     *QLK6,HLK6,QLK7,HLK7,QLK8,HLK8,QLK9,HLK9,QLK10,HLK10,LK,LK1,LK3,
     *LK5,LK7,LK9
      COMMON /PAR1/HO(12),HI(12),QAE,HC,HFP,DHP,TI(12),TD(12),TDCA(12),
     *HD(12),PLA,PLB,ND(12),NDC(12),IP,NF
      COMMON /PAR2/PSH(12),TSH(12),TO(12),TTD(12),PXHP,PXIP
      COMMON /RH1/PXRH2,PIRH2,PXRH1,PIRH1,PFPT
      COMMON /RH2/QRH1,HCRH1,QRH2,HCRH2,NRH,NDRH1,NDRH2
      COMMON /RH3/TTDRH1,TTDRH2,HRH1,HRH2,PCRH1,TCRH1,PCRH2,TCRH2,TXRH1,
     *HXRH1,TXRH2,HXRH2,HIRH2,HIRH1,QRH
      COMMON /SSR/QSPE,QMC,QSSR,HSSR,PSSR,QFWH,QSSRMU,HSSRMU
      COMMON /XS1/ PSX,PSI
      COMMON /XS2/HPSI,QMR
      COMMON /XS3/QSI,HSI,TSX,QSX,HSX,AMSX,EMS,MS
      COMMON /XX1/ PCHU, PDLS, BLS, QERH1, QERH2, PF, QSGO
      COMMON /XX2/ NHP, IR  , NLP,                   NFH, NFL, IH2
      COMMON /XX3/ AMIHP, HIHP, PIHP, SIHP, TIHP, VIHP
      COMMON /Z/ TFR,SLOPE,QTKEEP,PKEEP,QGKEEP,PGKEEP,VGKEEP,GCKEEP,DUME
      FIG6(TFR)=8.5D0-(0.9D0)/(1.2D0-TFR)
      FIG14(XMOIST)=.87D0*(1.D0-.01D0*XMOIST)*(1.D0-.65D-2*XMOIST)
      NAMELIST /NAM1/ ADI, QRO
      DATA VERS/'11-1-78 '/
      DATA BLANK/0.0D0/
      DATA IW/6/
C  DEFINE CONVERGENCE CRITERIA
C  HCON=ENTHALPY, BTU/LB
C  UERCON=USED ENERGY RATIO
C  AMCON=MOISTURE FRACTION
C  RHCON=REHEATER MOTIVE STEAM FLOW, (DELTA Q)/Q
C  WCON=REQUIRED ELECTRICAL OUTPUT, (DELTA W)/W
C  PCON=GOVERNING STAGE EXHAUST PRESSURE, (DELTA P)/P
C  SSRCON=STEAM SEAL REGULATOR MAKE-UP, (DELTA Q)/Q
C  XSPCON=MOISTURE REMOVED BY EXTERNAL MOISTURE SEPARATOR, (DELTA Q)/Q
  100 CONTINUE
      DO 3 I=1,12
```

```
    3 QE(I)=0.0D0
      CALL DATAIN(VERS)
      NGS=NHP
      NAIN=0
      ICONV=0
C  START CALCULATIONS
C  THROTTLE STEAM ENTHALPY
      HT=HPS(PT,SPTD(PT,TT))
      IF(AT .LE.1.D-10) GO TO 1210
      AMT1=AT *0.01D0
      HT=(1.0D0-AMT1)*HT+AMT1*HPT(TT)
C  GOVERNING STAGE PARAMETERS
 1210 CONTINUE
      HBGS=HT
      IF(TPR.GE. .6D0) PBGS=PT*(1.D0-FIG6(TPR)/100.D0)
      IF(TPR.LT. .6D0) CALL PART
      CALL PROPPH( ABGS,SBGS,VBGS,TBGS,MBGS,PBGS,HBGS)
      NCGS=0
C  INTERMEDIATE SYSTEM PRESSURE DROP AND PXHP
      QMR=0.D0
      HPSX=0.D0
      PB=PBLP
      CALL PRDROP(PXHP,PB,     NRH)
C  CONDENSER HOTWELL PARAMETERS
      TC= TSL(PC)
      HC= HPT(TC)
C  STEAM JET AIR EJECTOR ENTHALPY
      HAEI=HT
      HAEO=180.17D0
C  SET INDICES FOR FW HEATER HEAT BALANCE CALCULATIONS
      I1HP=1
      I2HP=NFH
      I1LP=I2HP+1
      IF(NR.GT.0) GO TO 1340
      I2LP=NF
      GO TO 1350
 1340 I2LP=NF+1
 1350 CALL INDEX(I1LP,I2LP,NPL,NS)
C  FEEDWATER PUMP ENTHALPY RISE
      PLA=PT*CP2
      PLB=PC*CP1
      DP=PLA-PLB
      DHP=DP* VPT( TSL(PLB))*144.D0/778.17D0/EFP
C  FW HEATER PARAMETERS
      IF(NF.EQ.0) GO TO 1400
      IF(NFH.EQ.0)GOTO1390
      IF(PE(I2HP).LE.(PXHP+1.0D0)) GO TO 1381
      I2H=I2HP
      GOTO1390
 1381 IF(NS.EQ.0)PE(I2HP)=PXHP
      IF(NS.GT.0)PE(I2HP)=PSX
      I2H=I2HP-1
 1390 CONTINUE
      CALL PUMPAR(1,NF)
C  STEAM PACKING EXHAUSTER FLOW
 1400 IF(LK.GT.0)GOTO1409
      QSPE=0.D0
      HSSR=0.D0
      GOTO1440
 1409 QSSRHU=0.D0
      QSSRH1=0.D0
      QSPE=1200.0D0*NLP
      QHC=1800.0D0*NLP
C  STEAM SEAL REGULATOR PRESSURE
      IF(PXLP.LE.18.0D0) GO TO 1430
      PSSR=PXLP
      GOTO1440
 1430 PSSR=18.0D0
C  REHEATER
 1440 QRH1=QERH1
```

```
      QRH2=QERH2
      IF(NRH.NE.1) GOTO 1900
      CALL REHEAT(HE(1),PE(1),HT,PT)
 1900 MAIN=MAIN+1
      GCKVA=GC*1000.D0
      GOKVA=1000.D0*WRATE/PF
      FRKVA=GOKVA/GCKVA
C  GENERATOR LOSS (TANDEM COMPOUND)
C  RATED HYDROGEN PRESSURE
      WGL=GOKVA*F19(GCKVA)*F20(FRKVA)*.01D0
C  TEST FOR REDUCED HYDROGEN PRESSURE
      IF(IH2.EQ.0) GO TO 1267
C  REDUCED HYDROGEN PRESSURE
      WGL=WGL-F21(GCKVA)
C  MECHANICAL LOSS
 1267 WML=  F18(GCKVA)
      ITGS=0
      ITHP=0
      NCRH=0
      ITMS=0
      ITSSR=0
C  STEAM FLOW FROM STEAM GENERATOR
      QRO=QT+QAE
      IF(NRH.LT.1) GOTO 1920
      IF(NRH.EQ.1) GOTO 1910
      QRO=QRO+QLH2
      GOTO 1920
 1910 QRO=QRO+QRH1
C  MAKE-UP FLOW
 1920 QMU=QT*PCMU*0.01D0
C  FEEDWATER FLOW TO STEAM GENERATOR
      QR=QRO-QCR+QMU
C  GOVERNING STAGE PERFORMANCE
C  TEST FOR VALVE STEM LEAKAGE CALCULATIONS
      IF(LK.GT.0)GOTO2001
C  GOVERNING STAGE FLOW, NO VALVE STEM LEAKAGE
      QGS=QT
      GOTO2003
C  VALVE STEM LEAKAGE
 2001 CALL SLEAK1(NP, PE,QT,PT,HT,LK1,CLK1,HLK1,QLK2,HLK2,0    )
C  GOVERNING STAGE FLOW WITH VALVE STEM LEAKAGE
 2002 QGS=QT-QLK1-QLK2-QSSRMU
C  GS BOWL AND SHELL CONDITIONS
 2003 CONTINUE
C  TEST FOR GOVERNING STAGE SHAFT LEAKAGE
      IF(LK.GT.0)GOTO2004
C  FLOW TO NEXT STAGE, NO GS SHAFT LEAKAGE
      QNEXT=QGS
      QXGS=QGS
      GOTO2005
C  GS SHAFT LEAKAGE
 2004 CALL SLEAK2(NP, PE,NGS,IR  ,PXGS,VXGS,HXGS,LK3,QLK3,HLK3,QLK4,
     1HLK4,PSSR,0)
C  FLOW TO NEXT STAGE WITH GS SHAFT LEAKAGE
      QNEXT=QGS-QLK3-QLK4
      QXGS=QNEXT
C  TEST FOR FW HEATER AT GS EXHAUST
 2005 CONTINUE
C  HIGH PRESSURE SECTION PERFORMANCE
C  BOWL CONDITIONS (HP SECTION)
      QBHP=QNEXT
      CALL HPTURB(HXHP)
      PBHP=PXGS
      HBHP=HXGS
      SBHP=SXGS
      AMBHP= AXGS
      MBHP=MXGS
      TBHP=TXGS
C  SHELL CONDTIONS (HP SECTION)
```

```
C  EXHAUST LOSS AND UEEP (HP SECTION)
      XLHP=FIG8(PXHP)
      UEEPHP=HXHP+XLHP
      CALL PROPPH(AMUEHP,SUEHP,VUEHP,TUEHP,MUEHP,PXHP,UEEPHP)
C  EXHAUST FLOW (HP SECTION)
      QXHP=QBHP
C  TEST FOR FW HEATERS (HP SECTION)
      IF(NFH.EQ.0) GOTO3031
C  FW HEATER HEAT BALANCE (HP SECTION)
      I1=I1HP
      CALL HXTRAC(0,I1HP,I2HP,MBHP,HBHP,SBHP,MXHP,HXHP,SXHP,PIHP,HIHP,
     1SIHP,PXHP,UEEPHP)
      IF(NRH.LT.2) GO TO 3025
      CALL REHEAT(HE(1),PE(1),HT,PT)
      GOTO3025
 3020 I1=N
 3025 CALL FWHEAT(I1,I2HP,0,0,MS,ITGS)
      ITHP=ITHP+1
C  TEST FOR ONLY ONE FW HEATER (HP SECTION)
C  TEST FOR FW HEATER AT EXHAUST (HP SECTION)
      IF(NFH.EQ. 1.AND. I2H.LT. I2HP) GOTO3031
C  EXHAUST FLOW, MORE THAN ONE FW HEATER HP SECTION,
C  OR ONLY ONE FW HEATER AND NOT LOCATED AT HP EXHAUST
      QXHP=QBHP
      DO3030 K=I1HP,I2H
 3030 QXHP=QXHP-QE(K)
C  TEST FOR REHEATER STEAM EXTRACTION (HP SECTION)
 3031 IF(NRH.LT.2) GO TO 3032
      QXHP=QXHP-QRH1
C  FLOW TO NEXT SECTION
 3032 QNEXT=QXHP
C  TEST FOR SHAFT LEAKAGE CALCULATIONS
      IF(LK.EQ.0)GOTO3033
C  SHAFT LEAKAGE FROM EXHAUST END (HP SECTION)
      CALL SLEAK3(NP,PE,NHP,IR  ,PXHP,VUEHP,UEEPHP,LK5,QLK5,HLK5,QLK6,
     1HLK6,PSSR)
C  FLOW TO NEXT SECTION
      QNEXT=QNEXT-QLK5-QLK6
C  TEST FOR FW HEATER AT HP EXHAUST
 3033 IF(NFH.EQ.0.OR.I2H.EQ.I2HP)GOTO3040
C  FLOW TO NEXT SECTION, FW HEATER AT HP EXHAUST
      IF(MS.EQ.0)QNEXT=QNEXT-QE(I2HP)
C  TEST FOR EXTERNAL MOISTURE SEPARATOR
 3040 IF(MS.GT.0                 )GOTO4000
C  TEST FOR REHEATER
      IF(NRH.NE.0) GOTO4205
C  ENTHALPY TO NEXT SECTION (NO MOISTURE SEPARATOR OR REHEATER)
      HNEXT=UEEPHP
      GOTO4300
C  EXTERNAL MOISTURE SEPARATOR PERFORMANCE (2-SECTION MACHINE)
C  INLET FLOW AND ENTHALPY
 4000 QSI=QNEXT
      HSI=UEEPHP
      ITMS=ITMS+1
C  HEAT AND MASS BALANCE CALCULATION
      QMR1=QMR
      CALL XSEP
C  TEST FOR MOISTURE FLOW TO FW HEATER AT HP SECTION EXHAUST
      IF(MS.GT.I2HP)GOTO4010
C  TEST FOR MOISTURE REMOVAL CONVERGENCE
      ADQMR=DABS((QMR-QMR1)/QMR)
      IF(ADQMR.LE.XSPCON)GOTO4010
      IF(ITMS.GT.50)GOTO4008
      I1=I2HP
      GOTO3025
 4008 WRITE(IW,4009) ADQMR
 4009 FORMAT('0-MAIN PROGRAM-EXTERNAL MOISTURE SEPARATOR DRAIN CALCULATI
     1ONS DID NOT CONVERGE, ADQMR =',G15.7)
C  TEST FOR REHEATER
 4010 IF(NRH.NE.0) GOTO4200
```

```
C  FLOW AND ENTHALPY TO NEXT SECTION (NO REHEATER, 2-SECTION MACHINE)
      IF(NS.GT.0)QNEXT=QSX-QE(I2HP)
      HNEXT=HSX
      GOTO4300
C  REHEATER PERFORMANCE
C  FLOW AND ENTHALPY TO REHEATER (EXTERNAL MOISTURE SEPARATOR)
 4200 QRH=QSX-QE(I2HP)
      HIRH1=HSX
      GOTO4210
C  FLOW AND ENTHALPY TO REHEATER (NO MOISTURE SEPARATOR)
 4205 QRH=QNEXT
      HIRH1=UEEPHP
C  1ST STAGE HEAT BALANCE
 4210 NCRH=NCRH+1
C  LIVE STEAM REHEATER
      QRH1=QRH*(HXRH1-HIRH1)/(HRH1-HCRH1)
C  TEST FOR 2ND STAGE
      IF(NRH.EQ.2) GOTO4225
C  TEST FOR 1ST STAGE DRAIN LOCATION
      IF(NDRH1.GT.NPH) GO TO 4224
C  TEST FOR FW HEATER IN GS OR HP SECTION
      IF(NPH.GT.0) GO TO 4230
C  RE-CALCULATE REACTOR STEAM AND FW FLOW
 4224 QERH1=QRH1
      QRO=QT+QAE+QRH1
      QR=QRO-QCR+QMO
      GOTO4250
C  2ND STAGE HEAT BALANCE
 4225 QRH2=QRH*(HXRH2-HIRH2)/(HRH2-HCRH2)
C  TEST FOR 2ND STAGE DRAIN LOCATION
      IF(NDRH2.LT.NPH) GO TO 4226
      QERH2=QRH2
      GOTO4230
C  TEST FOR 2ND STAGE CONVERGENCE
 4226 ADQ2=DABS((QRH2-QERH2)/QRH2)
      IF(ADQ2.LE.RHCON)GOTO4230
      QERH2=QRH2
      GOTO4240
C  TEST FOR 1ST STAGE CONVERGENCE
 4230 ADQ1=DABS((QRH1-QERH1)/QRH1)
      IF(ADQ1.LE.RHCON)GOTO4250
 4240 QERH1=QRH1
      IF(NCRH.LE.50)GOTO4242
      WRITE(IW,4241) ADQ1, ADQ2
 4241 FORMAT('0-MAIN PROGRAM-REHEATER CALCULATIONS DID NOT CONVERGE, ADQ
     11 =',G15.7  ,5X,'ADQ2 =',G15.7)
      GOTO4250
C  RE-CALCULATE REACTOR STEAM AND FW FLOW
 4242 IF(NRH.EQ.1)GOTO4243
      QRO=QT+QAE+QRH2
      GOTO4244
 4243 QRO=QT+QAE+QRH1
 4244 QR=QRO-QCR+QMO
      I1=I1HP
      GOTO3025
C  FLOW TO NEXT SECTION
 4250 QNEXT=QRH
C  TEST FOR 2ND STAGE
      IF(NRH.LT.2) GOTO4260
C  ENTHALPY TO NEXT TURBINE SECTION (2-STAGE REHEATER)
      HNEXT=HXRH2
      GOTO4300
C  ENTHALPY TO NEXT TURBINE SECTION (1-STAGE REHEATER)
 4260 HNEXT=HXRH1
C  TEST FOR FW PUMP TURBINE CALCULATIONS
 4300 IF(IFPT)4320,4400,4310
C  FW PUMP TURBINE THROTTLE STEAM FLOW
 4310 CALL FWPT(PFPT,HNEXT,  PC,DHP,QR)
```

```
C  FLOW TO NEXT TURBINE SECTION                                          ORCE3440
 4320 QNEXT=QNEXT-QFPT                                                   ORCE3450
 4400 CONTINUE                                                           ORCE3460
C  TEST FOR STEAM SEAL REGULATOR                                         ORCE3470
      IF(LK.EQ.0)GOTO7008                                                ORCE3480
C  STEAM SEAL REGULATOR ENTHALPY AND MAKEUP                              ORCE3490
      CALL SSRE(PSH,HT,PXLP        ,NP)                                  ORCE3500
C  TEST FOR SSR MAKE-UP CONVERGENCE                                      ORCE3510
      IF(QSSRMU.EQ.QSSRM1)GOTO7008                                       ORCE3520
      ADMU=DABS((QSSRMU-QSSRM1)/QSSRMU)                                  ORCE3530
      IF(ADMU.LE.SSRCON)GOTO7008                                         ORCE3540
      IF(ITSSR.GT.50)GOTO7006                                            ORCE3550
      QSSRM1=QSSRMU                                                      ORCE3560
      GOTO2002                                                           ORCE3570
 7006 WRITE(IW,7007) ADMU                                                ORCE3580
 7007 FORMAT('0-MAIN PROGRAM-STEAM SEAL REGULATOR MAKE-UP CALCULATIONS DORCE3590
     1ID NOT CONVERGE, ADMU =',G15.7)                                    ORCE3600
C  LOW PRESSURE SECTION PERFORMANCE                                      ORCE3610
C  BOWL CONDITIONS (LP SECTION)                                          ORCE3620
 7008 QBLP=QNEXT                                                         ORCE3630
      HBLP=HNEXT                                                         ORCE3640
      CALLPROPPH(AMBLP,SBLP,VBLP,TBLP,MBLP,PBLP,HBLP)                    ORCE3650
C  BASE EXPANSION LINE (LP SECTION)                                      ORCE3660
      IF(PXLP.GE.3.D0) GO TO 7010                                        ORCE3670
      PX1=0.7367306D0                                                    ORCE3680
      GOTO7020                                                           ORCE3690
 7010 PX1=PXLP                                                           ORCE3700
 7020 CALL SGROUP(PBLP,TBLP,HBLP,SBLP,VBLP,AMBLP,MBLP,QBLP,NLP,PX1,      ORCE3710
     1TX1,HX1,SX1,VX1,AMX1,MX1,PILP,TILP,HILP,SILP,VILP,AMILP,MILP,PXLP)ORCE3720
C  TEST FOR MOISTURE REMOVAL STAGES (LP SECTION)                         ORCE3730
      IF(MR.GT.0)GOTO7029                                                ORCE3740
      HEP=HX1                                                            ORCE3750
      AMEP=AMX1                                                          ORCE3760
      GOTO7050                                                           ORCE3770
C  MOISTURE REMOVAL CALCULATIONS (LP SECTION)                            ORCE3780
 7029 IF(MBLP.EQ.3)GOTO7030                                              ORCE3790
      PB=PBLP                                                            ORCE3800
      HB=HBLP                                                            ORCE3810
      SB=SBLP                                                            ORCE3820
      GOTO7040                                                           ORCE3830
 7030 PB=PILP                                                            ORCE3840
      HB=HILP                                                            ORCE3850
      SB=SILP                                                            ORCE3860
 7040 CALL AMOIST(MR,PMR,PB,HB,SB,PX1,HX1,SX1,HBMR,HAMR,HEP,AMBMR,AMAMR,ORCE3870
     1AMEP,SBMR,SAMR,PCWD,TMR)                                           ORCE3880
C  SHELL CONDITIONS (LP SECTION)                                         ORCE3890
 7050 IF(PXLP.GE.3.D0) GO TO 7060                                        ORCE3900
      HXLP=HEP+FIG15(PXLP*2.0360234D0)*FIG14(AMEP*100.D0)                ORCE3910
      GOTO7070                                                           ORCE3920
 7060 IF(MR.EQ.0)GOTO7080                                                ORCE3930
      HXLP=HEP                                                           ORCE3940
 7070 CALLPROPPH(AMXLP,SXLP,VXLP,TXLP,MXLP,PXLP,HXLP)                    ORCE3950
      GOTO7090                                                           ORCE3960
 7080 HXLP=HX1                                                           ORCE3970
      TXLP=TX1                                                           ORCE3980
      SXLP=SX1                                                           ORCE3990
      VXLP=VX1                                                           ORCE4000
      AMXLP=AMX1                                                         ORCE4010
      MXLP=MX1                                                           ORCE4020
 7090 CONTINUE                                                           ORCE4030
C  FW HEATER HEAT BALANCE (LP SECTION)                                   ORCE4040
      KL=1                                                               ORCE4050
      QPS(KL)=QBLP                                                       ORCE4060
      HPS(KL)=HBLP                                                       ORCE4070
      IF(NPL.GT.0)GOTO7110                                               ORCE4080
      IF(MR.EQ.0)GOTO7160                                                ORCE4090
      GOTO7120                                                           ORCE4100
 7110 CALL EXTRAC(MR,I1LP,NF,MBLP,HBLP,SBLP,MXLP,HXLP,SXLP,PILP,HILP,    ORCE4110
     1SILP,PXLP,UEEPLP)                                                  ORCE4120
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 7120 CONTINUE                                                          ORCE4130
      IT=ITHP                                                           ORCE4140
      CALL  FWHEAT(I1LP,I2LP,MP,KL,MS,IT)                               ORCE4150
C  TEST FOR REGRESSIVE FW HEATER HEAT BALANCE CALCULATIONS              ORCE4160
      IF(M.EQ.I2HP.AND.NFH.GT.0) GOTO 3020                              ORCE4170
C  EXHAUST FLOW (LP SECTION)                                            ORCE4180
 7150 KLT=KL                                                            ORCE4190
      QXLP=QFS(KLT)                                                     ORCE4200
C  TEST EXHAUST PRESSURE (LP SECTION)                                   ORCE4210
      IF(PXLP.GE.3.D0) GO TO 7170                                       ORCE4220
C  CONDENSING EXHAUST LOSS AND UEEP (LP SECTION)                        ORCE4230
      CALL  XLOSS(PXLP,TXLP,HEP,HXLP,QXLP,AHEP,ANXLP,NLP,BLS,POLS, IR,  ORCE4240
     1UEEPLP,XLLP)                                                      ORCE4250
      GOTO7180                                                          ORCE4260
C  BACK-PRESSURE EXHAUST LOSS AND UEEP (LP SECTION)                     ORCE4270
 7170 XLLP=FIG8(PXLP)                                                   ORCE4280
      UEEPLP=HXLP+XLLP                                                  ORCE4290
 7180 HES(KLT)=UEEPLP                                                   ORCE4300
C  GENERATOR OUTPUT                                                     ORCE4310
      WHP=0.D0                                                          ORCE4320
      WLP=0.D0                                                          ORCE4330
C  GS SECTION                                                           ORCE4340
      WBTU=1.D0/3412.14D0                                               ORCE4350
      WGS=QGS*(HB3S-HXGS)*WBTU                                          ORCE4360
C  HP SECTION                                                           ORCE4370
      WHP=QBHP*(HBHP-UEEPHP)*WBTU                                       ORCE4380
C  TEST FOR FW HEATERS (HP SECTION)                                     ORCE4390
      IF(NFH.EQ.0) GOTO8050                                             ORCE4400
C  TEST FOR REHEATER EXTRACTION STEAM (HP SECTION)                      ORCE4410
      IF(NRH.LT.2) GO TO 8039                                           ORCE4420
C  SUBTRACT REHEATER EXTRACTION STEAM (HP SECTION)                      ORCE4430
      WHP=WHP-QRH1*(HE(1)-UEEPHP)*WBTU                                  ORCE4440
C  SUBTRACT FW HEATER EXTRACTION STEAM (HP SECTION)                     ORCE4450
 8039 DO8040 I=I1HP,I2H                                                 ORCE4460
 8040 WHP=WHP-QE(I)*(HE(I)-UEEPHP)*WBTU                                 ORCE4470
C  LP SECTION                                                           ORCE4480
 8050 DO8060 KL=1,KLT                                                   ORCE4490
 8060 WLP=WLP+QFS(KL)*(HFS(KL)-HES(KL))*WBTU                            ORCE4500
C  NET GENERATOR OUTPUT                                                 ORCE4510
      WGEN=(WGS+WHP+     WLP-WML-WGL)*0.001D0                           ORCE4520
      IF(QSGO.NE.BLANK) GO TO 1                                         ORCE4530
C  TEST NET ELECTRICAL GENERATION CONVERGENCE                           ORCE4540
      ADW=DABS((WGEN-WRATE)/WRATE)                                      ORCE4550
      IF(ADW.LE.WCON)GOTO8200                                           ORCE4560
C  CHECK NUMBER OF ITERATIONS THROUGH MAIN PROGRAM                      ORCE4570
      IF(MAIN.LT.25)GOTO8100                                            ORCE4580
      WRITE(IW,8090) ADW, WGEN                                          ORCE4590
 8090 FORMAT('0-MAIN PROGRAM-REQUIRED ELECTRICAL GENERATION DID NOT CONVORCE4600
     1ERGE, ADW =',G15.7  ,5X,'WGEN =',G15.7)                           ORCE4610
      GOTO8200                                                          ORCE4620
C  CORRECT THROTTLE FLOW RATE                                           ORCE4630
 8100 QT=QT*WRATE/WGEN                                                  ORCE4640
      GOTO1900                                                          ORCE4650
    1 ADX=DABS((QRO-QSGO)/QSGO)                                         ORCE4660
      IF(ADX.LE.WHCON) ICONV = ICONV + 1
      IF(ICONV.EQ.2) GO TO 8200
      IF(MAIN.LT.25) GO TO 2                                            ORCE4680
      WRITE(IW,800)                                                     ORCE4690
  800 FORMAT('0','MAIN PROGRAM - REQUIRED STEAM GENERATOR OUTLET FLOW DIORCE4700
     *D NOT CONVERGE')                                                  ORCE4710
      WRITE(6,MAN1)                                                     ORCE4720
      GO TO 8200                                                        ORCE4730
    2 QT=QT*QSGO/QRO                                                    ORCE4740
      WRATE=WGEN                                                        ORCE4750
      GO TO 1900                                                        ORCE4770
C  STEAM GENERATOR INLET ENTHALPY AND TEMPERATURE                       ORCE4780
C  TEST FOR FW HEATERS                                                  ORCE4790
 8200 IF(NF.GT.0)GOTO8210                                               ORCE4800
C  CONDENSER HOTWELL FLOW (NO FW HEATERS)                               ORCE4810
      QC=QR+QCR                                                         ORCE4820
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C  NO FW HEATERS
      HCR=HC+QAE*(HAEI-HAEO)/QC+QSPE*(HSSR-HAEO)/QC
      HR=HCR
      GOTO8240
C  TEST DRAIN FROM FW HEATER NO. 1
 8210 IF(ND(1).EQ.0)GOTO8220
C
C  DRAIN IS PUMPED
      HR=(QD(1)*HD(1)+QF(1)*HO(1))/QR
      GOTO8230
C  DRAIN IS FLASHED
 8220 HR=HO(1)
C  TEST FOR FW PUMP LOCATION
 8230 IF(IP.GT.0)GOTO8250
C  FW PUMP IS AFTER FW HEATER NO. 1
 8240 HPP=HR
      QPP=QR
      HR=HR+DHP
      GOTO8251
C  FW TEMPERATURE TO FW PUMP AND TO STEAM GENERATOR
 8250 QPP=QF(IP)
 8251 TPP= TSLH(HPP)
      TR=TPHL(PLA,HR)
      RHCORR=0.D0
C  TEST FOR MOTOR-DRIVEN FW PUMP
      IF(IFPT.NE.0)GOTO8260
C  KW FOR MOTOR DRIVE
      EFMCG=0.8075D0
      WFWP=DHP*QPP/(EFMCG*3412.14D0)
      GOTO8270
C  KW FOR TURBINE DRIVE
 8260 WFWP=QFPT*(HBFPT-HXFPT)*WHTU
C  NET AND GROSS CYCLE HEAT RATES (TURBINE-DRIVEN FW PUMP)
      HTRTN=(QHO*(HT-HR)+QCH*(HR-HCR)+QHU*(HT-HR)+RHCORR)/(WGEN*1000.D0)
      HTRTG=HTRTN*WGEN/(WGEN+WFWP*0.001D0)
      GOTO8280
C  GROSS AND NET CYCLE HEAT RATES (MOTOR-DRIVEN FW PUMP)
 8270 HTRTG=(QHO*(HT-HR)+QCH*(HR-HCR)+QHU*(HT-HR)+RHCORR)/(WGEN*1000.D0)
      HTRTN=HTRTG*WGEN/(WGEN-WFWP*0.001D0)
C  NET AND GROSS CYCLE EFFICIENCIES
 8280 CEFFN=341214.D0/HTRTN
      CEFFG=341214.D0/HTRTG
      IF(TFR.LT.1.0D0) GO TO 2525
      SLOPE=(HEGS-HEHP)/(SEGS-SEHP)
      QTKEEP=QT
      PKEEP=PEHP
      QGKEEP=QGS
      PGKEEP=PEGS
      VGKEEP=VEGS
      GCKEEP=GC
 2525 CONTINUE
C  WRITE RESULTS OF CALCULATIONS
      CALL RESULT(VERS)
      GOTO100
      END
```

```
C
      SUBROUTINE AMOIST(K,P,PB,HB,SB,PX,HX,SX,HBMR,HAMR,HEP,AM,
     *AM225,AMEP,  SBMR,S225,PCWD,TE)
      IMPLICIT REAL*8(A-H,O-Z)
C SUBPROGRAM FOR MOISTURE REMOVAL CALCULATIONS
      DIMENSION
     *PE(6),TE(6),HF(6),HFG(6),HG(6),H2S1(6),HSL(6),H2BE(6),P(5),
     *AM210(6),UE(5),S210(5),HS313(5),AE(5),BE(5),SBMR(5),
     *BGMLP(5),AMRE(5),AM(5),PCWD(5),PCPR(5),HBMR(5),HAMR(5),S225(5),
     *HS326(5),AEN(5),AM225(5),       AMLP(5),CGE(5),UEN(5),HGEP(5),
     *EPM(5)
      COMMON /CONV/HCON,UERCON,AMCON,RHCON,WCON,PCON,SSRCON,XSPCON
      DATA IW/6/
C  K=NUMBER OF MOISTURE REMOVAL POINTS
C  HBMR=ENTHALPY BEFORE MOISTURE REMOVAL
C  HAMR=ENTHALPY AFTER MOISTURE REMOVAL
C  HEP    =ENTHALPY AT END POINT AFTER MOISTURE REMOVAL
C  AM=MOISTURE BEFORE MOISTURE REMOVAL
C  AM225=MOISTURE AFTER MOISTURE REMOVAL
C  AMEP  =MOISTURE AT END POINT AFTER MOISTURE REMOVAL
C  SBMR=ENTROPY BEFORE MOISTURE REMOVAL
C  S225=ENTROPY AFTER MOISTURE REMOVAL
C  PCWD=PER CENT WATER DRAINED
C  STEAM PROPERTIES
      L=K+1
      DO 100 I=1,K
  100 PE(I)=P(I)
      PE(L)=PX
      DO 110 I=1,L
      TE(I)= TSL(PE(I))
      HF(I)= HFT(TE(I))
      HG(I)=HPS(PE(I),SPTD(PE(I),TE(I)))
      HFG(I)=HG(I)-HF(I)
      SG=SPTD(PE(I),TE(I))
      AM2S1=(SG-1.0)/(SG- SFT(TE(I)))
      H2S1(I)=HG(I)-AM2S1*HFG(I)
  110 HSL(I)=TE(I)+459.7
C  BASE EXPANSION ANALYSIS
      DO 121 I=1,K
  121 CALL P12AC (PE(I),HB,SB,HX,SX,H2BE(I),S)
      H2BE(L)=HX
      DO 122 I=1,L
  122 AM210(I)=1.0-(H2BE(I)-HF(I))/HFG(I)
      DO 130 I=1,K
      UE(I)=H2BE(I)-H2BE(I+1)
      S210(I)=1.0+(H2BE(I)-H2S1(I))/HSL(I)
      HS313(I)=H2S1(I+1)+HSL(I+1)*(S210(I)-1.0)
      AE(I)=H2BE(I)-HS313(I)
      BE(I)=100.0*UE(I)/AE(I)
  130 BGMLP(I)=1.0-0.435*(AM210(I)+AM210(I+1))
C  MOISTURE REMOVAL CALCULATION AND NEW EXPANSION FOLLOWING MOISTURE
C  REMOVAL
      DO 150 I=1,K
      AMRE(I)=  F10(PE(I))
      IF(I.GT.1)GO TO 141
      AM(I)=AM210(I)
      GO TO 142
  141 AM(I)=EPM(I-1)
  142 PCWD(I)=AMRE(I)*AM(I)
      PCPR(I)=100.0-PCWD(I)
      IF(I.GT.1)GO TO 143
      HBMR(I)=H2BE(I)
      GO TO 144
  143 HBMR(I)=HGEP(I-1)
  144 SBMR(I)=1.0+(HBMR(I)-H2S1(I))/HSL(I)
      HAMR(I)=(HBMR(I)*100.0-HF(I)*PCWD(I))/PCPR(I)
      S225(I)=1.0+(HAMR(I)-H2S1(I))/HSL(I)
      HS326(I)=H2S1(I+1)+HSL(I+1)*(S225(I)-1.0)
      AEN(I)=HAMR(I)-HS326(I)
      AM225(I)=1.0-(HAMR(I)-HF(I))/HFG(I)
```

```
      EPMA=0.1
      DO 145 IT=1,100
      AMLP(I)=1.0-0.435*(AM225(I)+EPMA)
      CGE(I)=BE(I)*AMLP(I)/BGMLP(I)
      UEN(I)=AEN(I)*CGE(I)*0.01
      HGEP(I)=HAMR(I)-UEN(I)
      EPM(I)=1.0-(HGEP(I)-HF(I+1))/HFG(I+1)
      ADM=DABS(EPM(I)-EPMA)
      IF(ADM.LE.AMCON)GO TO 150
  145 EPMA=EPM(I)
      WRITE(IW,145) ADM,I
  146 FORMAT('0-SUBROUTINE AMOIST-END POINT NOISTURE DID NOT CONVERGE, A
     1DM =',1PD14.6,5X,'I =',I2)
  150 CONTINUE
      HEP=HGEP(K)
      AMEP=EPM(K)
      RETURN
      END
```

```
C
      SUBROUTINE BIVPOL(A,X,Y,Z,I,J)
C  A  TWO DIMENSIONAL ARRAY OF POLYNOMIAL COEFS.
C  X  INDEPENDENT VARIABLE
C  Y  INDEPENDENT VARIABLE
C  Z  DEPENDENT VARIABLE
C  I  DEGREE OF X
C  J  DEGREE OF Y
      IMPLICIT REAL*8(A-H,K-Z)
      DIMENSION A(6,7)
C     INCREASE THE ROW AND COLUMN DIMENSION EACH
C     BY ONE BECAUSE ZERO SUBSCRIPTS ARE ILLEGAL.
C     INCREMENT BELOW BASED ON ASSUMPTION DATA
C     IN CALLING ROUTINE IMPLICITLY LISTS A
C     ARRAY AS A(J,I) IN ORDER TO CONFORM
C     TO DEFINITION IN APPENDIX 1.
      II=J+1
      JJ=I+1
C     INITIALIZE Z
      Z=0.0
      DO 1 J1=1,JJ
      DO 1 I1=1,II
    1 Z=Z+A(J1,I1)*(X**(I1-1))*(Y**(J1-1))
      RETURN
      END
```

```
      BLOCK DATA
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /BLCK/AMBMR(5),AMAMR(5),TMR(6),MR,IDUM
     *            ,QBLP,PBLP,TBLP,AMBLP,HBLP,SBLP,QXLP,PXLP,TXLP,AMXLP,
     *HXLP,SXLP,UPEPLP
     *             ,CMTS(18),      TC,TFP,TB,HR,WRATE,GC,WML,WGL,QMU,QPP,
     *DP,WGEN,WPWP,HTRTN,HTRTG,CEFFN,CEFFG,PC
      COMMON /CONV/HCON,UERCON,AMCON,RHCON,WCON,PCON,SSRCON,XSPCON
      COMMON /DEFALT/ PXLPI, PCI
      COMMON /FPT/QFPT,PBFPT,HBFPT,PXFPT,HXFPT,IFPT
      COMMON /FWH/HAEI,HAEO,QR,QPS(20),HPS(20),HES(20),QMF(5),HMF(5),
     *QMG(5),HMG(5),OD(12),OF(12),QE(12),OCR,HCR,ORO,QC,I1LP,I
      COMMON /FWPTBB/ EPP, EFF, CP1, CP2
      COMMON /GS/QGS,HBGS,PBGS,AMBGS,SBGS,VBGS,TBGS,PXGS,AMXGS,SXGS,
     *VXGS,TXGS,HXGS,PDGS,      MBGS,MXGS,NCGS,       NGS
     *           ,QT,PT,TT, AT,HT
      COMMON /HX1/PE(12),PMR(5)
      COMMON /LEAK/QLK1,HLK1,QLK2,HLK2,QLK3,HLK3,QLK4,HLK4,QLK5,HLK5,
     *QLK6,HLK6,QLK7,HLK7,QLK8,HLK8,QLK9,HLK9,QLK10,HLK10,LK,LK1,LK3,
     *LK5,LK7,LK9
      COMMON /PAR1/HO(12),HI(12),QAE,HC,HPP,DHP,TI(12),TD(12),TDCA(12),
     *HD(12),PLA,PLB,ND(12),NDC(12),IP,NF
      COMMON /PAR2/PSH(12),TSH(12),TO(12),TTD(12),PXHP,PXIP
      COMMON /RH2/QRH1,HCRH1,QRH2,HCRH2,NRH,NDRH1,NDRH2
      COMMON /XS3/QSI,HSI,TSX,QSX,HSX,AMSX,EMS,MS
      COMMON /XX1/ PCMU, PDLS, BLS, QERH1, QERH2, PF, QSGO
      COMMON /XX2/ NHP, IR  , NLP,                  NFH, NFL, IH2
      COMMON /Z/ TPR,SLOPE,QTKEEP,PKEEP,QGKEEP,PGKEEP,VGKEEP,GCKEEP,DUME
       DATA  AT/.52D0/
       DATA BLS/43.D0/
       DATA CP1/220.D0/, CP2/1.3088D0/
       DATA EPP/.7698D0/
       DATA EFP/.878D0/
       DATA GC/1459.8D0/
       DATA IH2/0/
       DATA IP/1/, IFPT/1/
       DATA IR/1800/
       DATA LK/1/
       DATA MR/4/, PMR/40.1D0, 21.4D0, 11.2D0, 5.66D0, 0.D0/
       DATA MS/2/, EMS/100.D0/
       DATA ND/0,1,4*0/
       DATA NDC/1,0,4*1/
       DATA NF/6/, NFH/2/, NFL/4/
       DATA NHP/2/
       DATA NLP/6/
       DATA NRH/0/
       DATA PBLP/233.7D0/
       DATA PCI/2.D0/
       DATA PCMU/0.D0/
       DATA PDGS/65.D0/
       DATA PE/371.7D0, 0.D0, 126.6D0, 69.5D0, 21.4D0, 5.66D0/
       DATA PF/.9D0/
       DATA PT/965.D0/
       DATA PXLPI/2.D0/
       DATA QAE/1.5D4/
       DATA QCR/61000.D0/
       DATA QSGO/16679080.D0/
       DATA QT/16664044.D0/
       DATA TDCA/10.D0,0.D0,4*10.D0/
       DATA TPR/1.D0/
       DATA TT/540.325D0/
       DATA TTD/6*5.D0/
       DATA WRATE/1313.620D0/
       DATA HCON/.5D-1/,UERCON/1.D-3/,AMCON/1.D-4/,RHCON/1.D-8/
       DATA WCON/1.D-7/,PCON/1.D-4/,SSRCON/1.D-4/,XSPCON/1.D-6/
       END
```

```
C
      SUBROUTINE CROSS(HIN,SIN,PRATIO,EFFY,AGM)
      IMPLICIT REAL*8(A-H,O-Z)
C  _I   DRY AND SATURATED VAPOR CONDITIONS, P, T, V, H, S, A, M
C  AGM  AVERAGE GROUP MOISTURE
C  _ID  IDEAL CONDITIONS (REVERSIBLE ADIABATIC), P, T, V, H, S, A, M
C  _IN  INLET CONDITIONS, P, T, V, H, S, A, M
C  EFFY  H-P EFFICIENCY AFTER ALL CORRECTIONS
C  _INT  ESTIMATED EXPANSION LINE POINT INTERSECTING SATURATION LINE
C  _OUT  OUTLET CONDITIONS, P, T, V, H, S, A, M
C  PBOT  A PRESSURE BELOW SAT. LINE ITERATIVELY APPROACHING SAT. LINE
C  PTOP  A PRESSURE ABOVE SAT. LINE ITERATIVELY APPROACHING SAT. LINE
C  UETOT  TOTAL USED ENERGY (DELTA H)
C  UEWET  WET USED ENERGY (DELTA H)
C  DELTAH  DELTA H BETWEEN SATURATION LINE AND TRIAL POINT
      COMMON /CONV/HCON,UPRCON,AMCON,RHCON,WCON,PCON,SSRCON,XSPCON
      COMMON /XX3/ AL, HL, PL, SL, TL, VL
      CALL PROPHS(PIN,TIN,VIN,AIN,MIN,HIN,SIN)
      POUT=PIN/PRATIO
      PID=POUT
      SID=SIN
      CALL PROPPS(AID,HID,TID,VID,MID,PID,SID)
      DIDEAL=HIN-HID
      HOUT=HIN-EFFY*DIDEAL
      CALL PROPPH(AOUT,SOUT,VOUT,TOUT,MOUT,POUT,HOUT)
      IF(MOUT.GT.1)AGM=0.D0
      IF((MOUT.EQ.1).AND.(MIN.LT.1)) AGM=(AIN+AOUT)/2.D0
      IF((MOUT.EQ.1).AND.(MIN.EQ.1)) GO TO 610
      GO TO 602
  610 J=0
  640 IF(J.GT.0)GO TO 604
      PTOP=PIN
      PBOT=POUT
      GO TO 605
  604 IF(HL.LT.HINT)PTOP=PINT
      IF(HINT.LT.HL)PBOT=PINT
  605 PL=(PTOP+PBOT)/2.D0
      J=J+1
      CALL F12AC(PL,HIN,SIN,HOUT,SOUT,HINT,SINT)
      CALL PROPHS(PINT,TINT,VINT,AINT,MINT,HINT,SINT)
      TL=TSL(PL)
      HL=HPS(PL,SPTD(PL,TL))
      CALL PROPPH(AL,SL,VL,TL,ML,PL,HL)
      DELTAH=DABS(HL-HINT)
      IF(DELTAH.LE.HCON) GO TO 631
      IF(J.LT.100)GO TO 640
  631 UEWET=HINT-HOUT
      UETOT=HIN-HOUT
      AGM=((AIN+AOUT)/2.D0)*UEWET/UETOT
  602 CONTINUE
      RETURN
      END
```

```
C
      SUBROUTINE DATAIN(VERS)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /BLCK/AMBMP(5),AMAMR(5),TMR(6),MR,IDUM
     *            ,QBLP,PBLP,TBLP,AMBLP,HBLP,SBLP,QXLP,PXLP,TXLP,AMXLP,
     *HXLP,SXLP,UEEPLP
     *            ,CMTS(18),      TT,TFP,TR,HR,WRATE,GC,WML,WGL,QMU,QFP,
     *DP,WGEN,WPWP,HTRTN,HTRTG,CEFFN,CEFFG,PC
      COMMON /DEFALT/ PXLPI, PCI
      COMMON /FPT/QFPT,PBFPT,HBFPT,PXFPT,HXFPT,IFPT
      COMMON /FWH/HAEI,HAEO,QE,QFS(20),HFS(20),HES(20),QMP(5),HMP(5),
     *QMG(5),HMG(5),QD(12),QF(12),QE(12),QCR,HCR,QRO,QC,I1LP,I
      COMMON /FWPTBB/ EFP, EFF, CP1, CP2
      COMMON /GS/QGS,HBGS,PBGS, ABGS,SBGS,VBGS,TBGS,PXGS, AXGS,SXGS,
     *VXGS,TXGS,HXGS,PDGS,      MBGS,MXGS,NCGS,       NGS
     *            ,QT,PT,TT, AT,HT
      COMMON /HX1/PE(12),PMR(5)
      COMMON /LEAK/QLK1,HLK1,QLK2,HLK2,QLK3,HLK3,QLK4,HLK4,QLK5,HLK5,
     *QLK6,HLK6,QLK7,HLK7,QLK8,HLK8,QLK9,HLK9,QLK10,HLK10,LK,LK1,LK3,
     *LK5,LK7,LK9
      COMMON /PAR1/HO(12),HI(12),QAE,HC,HFP,DHP,TI(12),TD(12),TDCA(12),
     *HD(12),PLA,PLB,ND(12),NDC(12),IP,NF
      COMMON /PAR2/PSH(12),TSH(12),TO(12),TTD(12),PXHP,PXIP
      COMMON /RH2/QRH1,HCRH1,QRH2,HCRH2,NRH,NDRH1,NDRH2
      COMMON /RH3/TTDRH1,TTDRH2,HRH1,HRH2,PCRH1,TCRH1,PCRH2,TCRH2,TXRH1,
     *HXRH1,TXRH2,HXRH2,HIRH2,HIRH1,QRH
      COMMON /XS3/QSI,HSI,TSI,QSX,HSX,AMSX,EMS,MS
      COMMON /XX1/ PCMU, PDLS, BLS, QERH1, QERH2, PF, QSGO
      COMMON /XX2/ NHP, IR  , NLP,                  NFH, NFL, IH2
      COMMON /Z/ TFR,SLOPE,QTKEEP,PKEEP,QGKEEP,PGKEEP,VGKEEP,GCKEEP,DUME
      DATA BLANK/0.0D0/, CPSI/2.03602234D0/
C  READ ONE COMMENT CARD (COLUMNS 1-72)
      HSX=1200.D0
      READ(5,201,END=999) (CMTS(J),J=1,18)
  201 FORMAT(18A4)
C  READ DATA CARDS
  200 READ(5,210) IFLAG,DATA1,DATA2,DATA3,DATA4,DATA5,DATA6
  210 FORMAT(I2,D10.0,5D12.0)
      IF(IFLAG.EQ.0)GO TO 300
      GOTO(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17),IFLAG
C  IFLAG=1
C  TT=THROTTLE STEAM TEMPERATURE, F
C  PT=THROTTLE STEAM PRESSURE, PSIA
C  AMT=THROTTLE STEAM MOISTURE, PER CENT
    1 TT=DATA1
      PT=DATA2
      AT=DATA3
      GO TO 200
C  IFLAG=2
C  QT=ESTIMATED THROTTLE STEAM FLOW, LBM/HR
C  PCMU=FW MAKE-UP RATE, PER CENT
C  QCR=CONDENSATE FLOW BY-PASSED TO STEAM GENERATOR, LB/HR
C  TFR=THROTTLE FLOW RATIO
C  QSGO=REQUIRED STEAM GENERATOR OUTLET FLOW
    2 QT=DATA1
      PCMU=DATA2
      QCR=DATA3
      TFR=DATA4
      QSGO=DATA5
      GO TO 200
C  IFLAG=3
C  WRATE=ELECTRICAL OUTPUT, MWE (TURBINE MAXIMUM GUARANTEED RATING)
C  GC=GENERATOR CAPABILITY, MVA
C  PF=GENERATOR POWER FACTOR
C  IH2=0, GENERATOR OPERATION AT RATED HYDROGEN PRESSURE
C  IH2=1, GENERATOR OPERATION AT REDUCED HYDROGEN PRESSURE
    3 WRATE=DATA1
      GC=DATA2
      PF=DATA3
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      IH2=DATA4
      GO TO 200
C   IFLAG=4
C   EFP=FEEDWATER PUMP ISENTROPIC EFFICIENCY
C   EPF=FEEDWATER PUMP TURBINE EFFICIENCY
C   CP1=PRESSURE OF FWP INLET ABOVE CONDENSER PRESSURE, PSI
C   CP2=RATIO OF FWP DISCHARGE PRESSURE TO H-P TURBINE THROTTLE PRESSURE
    4 EFP=DATA1
      EPF=DATA2
      CP1=DATA3
      CP2=DATA4
      GO TO 200
C   IFLAG=5
C   PDGS=PITCH DIAMETER OF GOVERNING STAGE, IN.
    5 PDGS=DATA1
      GO TO 200
C   IFLAG=6 IS NOT USED
    6 CONTINUE
      GO TO 200
C   IFLAG=7
C   NHP=NUMBER OF PARALLEL HP SECTIONS
    7 NHP=DATA1
      GO TO 200
C   IFLAG=8 IS NOT USED
    8 CONTINUE
      GO TO 200
C   IFLAG=9
C   NLP=NUMBER OF PARALLEL LP SECTIONS
C   PBLP=BOWL PRESSURE LP SECTION, PSIA
C   PXLPI=EXHAUST PRESSURE LP SECTION, IN. HGA
C   BLS=LENGTH OF LAST STAGE BUCKETS LP SECTION, IN.
C   PCI=CONDENSER PRESSURE, IN. HGA
C   IF DATA3.GT.0, PXLPI=DATA3 AND PCI=DATA6
C   PXLP=EXHAUST PRESSURE LP SECTION, PSIA
C   PC=CONDENSER PRESSURE, PSIA
C   IF DATA3.LT.0, PXLP=-DATA3 AND PC=-DATA6
C   PDLS=PITCH DIAMETER OF LAST STAGE LP SECTION, IN.
    9 NLP=DATA1
      PBLP=DATA2
      PXLPI=DATA3
      BLS=DATA4
      PCI=DATA5
      GO TO 200
C   IFLAG=10
C   MR=NUMBER OF MOISTURE REMOVAL STAGES LP SECTION
C   PMR(L)=MOISTURE REMOVAL STAGE PRESSURE, PSIA (L=1,MR)
   10 MR=DATA1
      PMR(1)=DATA2
      PMR(2)=DATA3
      PMR(3)=DATA4
      PMR(4)=DATA5
      PMR(5)=DATA6
      GO TO 200
C   IFLAG=11
C   MS=0, NO EXTERNAL MOISTURE SEPARATOR
C   MS=N, EXTERNAL MOISTURE SEPARATOR DRAINS TO FW HEATER NO. N
C   MS=NF+1, EXTERNAL MOISTURE SEPARATOR DRAINS TO CONDENSER
C   EMS=MOISTURE SEPARATOR EFFECTIVENESS, PER CENT
   11 MS=DATA1
      EMS=DATA2
      GO TO 200
C   IFLAG=12
C   NRH=NUMBER OF STAGES OF LIVE STEAM REHEAT
C   QERH1=ESTIMATED STEAM FLOW TO 1ST STAGE REHEATER, LBM/HR
C   TTDRH1=TERMINAL TEMPERATURE DIFFERENCE 1ST STAGE REHEATER, F
C   QERH2=ESTIMATED STEAM FLOW TO 2ND STAGE REHEATER, LBM/HR
C   TTDRH2=TERMINAL TEMPERATURE DIFFERENCE 2ND STAGE REHEATER, F
C   IF NRH=1, REHEATER ALWAYS DRAINS TO FW HEATER NO. 1
C   IF NRH=2 AND NDRH=0, 1ST STAGE DRAINS TO FW HEATER NO. 2
C   IF NRH=2 AND NDRH=1, 1ST STAGE DRAINS TO FW HEATER NO. 1
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C  IF NRH=2, 2ND STAGE ALWAYS DRAINS TO FW HEATER NO. 1                DATA1380
   12 NRH=DATA1                                                        DATA1390
      QERH1=DATA2                                                      DATA1400
      TTDRH1=DATA3                                                     DATA1410
      QERH2=DATA4                                                      DATA1420
      TTDRH2=DATA5                                                     DATA1430
      NDRH=DATA6                                                       DATA1440
      GO TO 200                                                        DATA1450
C  IFLAG=13                                                            DATA1460
C  NF=TOTAL NUMBER OF FW HEATERS                                       DATA1470
C  NFH=NUMBER OF FW HEATERS HP SECTION                                 DATA1480
C  NFL=NUMBER OF FW HEATERS LP SECTION                                 DATA1490
   13 NF=DATA1                                                         DATA1500
      NFH=DATA2                                                        DATA1510
      NFL=DATA3                                                        DATA1520
      GO TO 200                                                        DATA1530
C  IFLAG=14                                                            DATA1540
C  N=FW HEATER NUMBER                                                  DATA1550
C  PE(N)=EXTRACTION STAGE PRESSURE, PSIA                               DATA1560
C  TTD(N)=FW HEATER TERMINAL TEMPERATURE DIFFERENCE, F                 DATA1570
C  ND(N)=0, FW HEATER DRAIN IS FLASHED                                 DATA1580
C  ND(N)=1, FW HEATER DRAIN IS PUMPED                                  DATA1590
C  NDC(N)=0, NO DRAIN COOLER ON FW HEATER                              DATA1600
C  NDC(N)=1, DRAIN COOLER SECTION ON FW HEATER                         DATA1610
C  TDCA(N)=DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE, F             DATA1620
   14 N=DATA1                                                          DATA1630
      PE(N)=DATA2                                                      DATA1640
      TTD(N)=DATA3                                                     DATA1650
      ND(N)=DATA4                                                      DATA1660
      NDC(N)=DATA5                                                     DATA1670
      TDCA(N)=DATA6                                                    DATA1680
      GO TO 200                                                        DATA1690
C  IFLAG=15                                                            DATA1700
C  IP=0,  FW PUMP IS LOCATED AFTER FW HEATER NO. 1                     DATA1710
C  IP=N,  FW PUMP IS LOCATED BEFORE FW HEATER NO. N                    DATA1720
C  IFPT=0, FW PUMP IS MOTOR DRIVEN                                     DATA1730
C  IFPT=1, FW PUMP IS TURBINE DRIVEN                                   DATA1740
   15 IP=DATA1                                                         DATA1810
      IFPT=DATA2                                                       DATA1820
      GO TO 200                                                        DATA1860
C  IFLAG=16                                                            DATA1870
C  QAE=STEAM FLOW TO SJAE, LBM/HR                                      DATA1880
   16 QAE=DATA1                                                        DATA1890
      GOTO200                                                          DATA1900
C  IFLAG=17                                                            DATA1910
C  LK=0, VALVE STEM AND SHAFT LEAKAGES WILL NOT BE CALCULATED          DATA1920
C  LK=1, VALVE STEM AND SHAFT LEAKAGES WILL BE CALCULATED              DATA1930
   17 LK=DATA1                                                         DATA1940
      GO TO 200                                                        DATA1950
  300 CONTINUE                                                         DATA1960
      IF(TT.EQ.BLANK)  TT=TSL(PT)                                      DATA1970
      IF(PT.EQ.BLANK)  PT=PSL(TT)                                      DATA1980
      IF(PF.EQ.BLANK)  PF=.9                                           DATA1990
      IF((GC.EQ.BLANK).AND.(TFR.GE.1.D0))GC=WRATE/PF                   DATA2000
      IF((GC.EQ.BLANK).AND.(TFR.LT.1.D0))GC=GCKEEP                     DATA2010
      IF(PDGS.EQ.BLANK) PDGS=65.                                       DATA2020
      IF(PCI.EQ.BLANK)PCI=PXLPI                                        DATA2030
      IF(PXLPI.LT.0) GO TO 91                                          DATA2040
      PXLP=PXLPI/CPSI                                                  DATA2050
      PC=PCI/CPSI                                                      DATA2060
      GO TO 92                                                         DATA2070
   91 PXLP=-PXLPI                                                      DATA2080
      PXLPI=PXLP*CPSI                                                  DATA2090
      PC=-PCI                                                          DATA2100
      PCI=PC*CPSI                                                      DATA2110
   92 CONTINUE                                                         DATA2120
      ISEVEN=SEVEN                                                     DATA2130
      IF((NHP.EQ.ISEVEN).AND.(WRATE.LE.575.D0))NHP=1                   DATA2140
      IF((NHP.EQ.ISEVEN).AND.(WRATE.GT.575.D0))NHP=2                   DATA2150
      IF(BLS.EQ.35.D0) PDLS=110.0                                      DATA2160
      IF(BLS.EQ.38.D0) PDLS=127.5                                      DATA2170
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      IF(BLS.EQ.43.D0)PDLS=132.0
      IF(EMS.EQ.BLANK) EMS=100.
      IF(NRH.EQ.1) GO TO 2012
      NDRH2=1
      IF(NDRH.NE.0) GO TO 2012
      NDRH1=2
      GO TO 602
 2012 NDRH1=1
  602 CONTINUE
      DO 603 N=1,NF
      IF(TTD(N).EQ.BLANK) TTD(N)=5.0
      IF((ND(N).EQ.BLANK).AND.(TDCA(N).EQ.BLANK)) TDCA(N)=10.
  603 CONTINUE
      PRINT 310,(CMTS(K),K=1,18),VERS
  310 FORMAT('1',T10,18A4/
     *' ',T10,'STEAM TURBINE CYCLE HEAT BALANCE'/
     *' ',T10,'ORCENT, VERSION ',A8)
      WRITE(6,800) TT
  800 FORMAT('0',T10,'INPUT DATA'/
     * '0',T15,'THROTTLE STEAM TEMPERATURE',T74,F7.1,T87,'F')
      WRITE(6,801) PT
  801 FORMAT('0',T15,'THROTTLE STEAM PRESSURE',T74,F7.1,T87,'PSIA')
      WRITE(6,802) AT
  802 FORMAT('0',T15,'THROTTLE STEAM MOISTURE',T76,F6.2,T87,'PER CENT')
      WRITE(6,803) QT
  803 FORMAT('0',T15,'ESTIMATED THROTTLE STEAM FLOW',T70,F10.0,T87,
     * 'LB/HR')
      WRITE(6,804) PCMU
  804 FORMAT('0',T15,'FW MAKE-UP RATE (TO CONDENSER HOTWELL)',T76,F5.1,
     * T87,'PER CENT')
      WRITE(6,805) QCB
  805 FORMAT('0',T15,'CONDENSATE BY-PASSED TO STEAM GENERATOR',T70,
     * F10.0,T87,'LB/HR')
      WRITE(6,899) TFR
  899 FORMAT('0',T15,'THROTTLE FLOW RATIO',T76,F9.5)
      IF(QSGO.NE. BLANK)WRITE(6,851)QSGO
  851 FORMAT('0',T15,'REQUIRED STEAM GENERATOR OUTLET FLOW',T70,
     * F10.0,T87,'LB/HR')
      WRITE(6,806) WRATE
  806 FORMAT('0',T15,'REQUIRED ELECTRICAL OUTPUT',T74,F9.3,T87,'MWE')
      WRITE(6,807) GC
  807 FORMAT('0',T15,'GENERATOR RATED CAPABILITY',T74,F9.3,T87,'MVA')
      WRITE(6,808) PF
  808 FORMAT('0',T15,'GENERATOR POWER FACTOR',T77,F5.2)
      IF(IH2.EQ.0) GO TO 701
      WRITE(6,809) IH2
  809 FORMAT('0',T15,'GENERATOR OPERATION AT REDUCED HYDROGEN PRESSURE,
     *IH2=',I2)
      GO TO 702
  701 WRITE(6,810) IH2
  810 FORMAT('0',T15,'GENERATOR OPERATION AT RATED HYDROGEN PRESSURE, IH
     *2=',I2)
  702 WRITE(6,811) IR
  811 FORMAT('0',T15,'ROTATIONAL SPEED OF TURBINE-GENERATOR',T74,I5,T87,
     * 'RPM')
      WRITE(6,898) EFP
  898 FORMAT('0',T15,'FEEDWATER PUMP ISENTROPIC EFFICIENCY',T75,F9.4)
      WRITE(6,897) EFF
  897 FORMAT('0',T15,'FEEDWATER PUMP TURBINE EFFICIENCY',T75,F9.4)
      WRITE(6,849) CP1
  849 FORMAT('0',T15,'PRESSURE OF FWP INLET ABOVE COND. PRESSURE',T74,
     * F8.2,T87,'PSIA')
      WRITE(6,850) CP2
  850 FORMAT('0',T15,'RATIO OF FWP DISCH. PRESS. TO H-P THROTTLE',T74,
     * F8.2)
      WRITE(6,812) PDGS
  812 FORMAT('0',T15,'PITCH DIAMETER OF GOVERNING STAGE',T74,F8.2,T87,
     * 'IN.')
      WRITE(6,813) NHP
  813 FORMAT('0',T15,'NUMBER OF PARALLEL H-P SECTIONS',T77,I2)
      WRITE(6,814) NLP
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814 FORMAT('0',T15,'NUMBER OF PARALLEL L-P SECTIONS',T77,I2)
    WRITE(6,815) PBLP
815 FORMAT('0',T15,'BOWL PRESSURE L-P SECTION',T75,F6.1,T87,'PSIA')
    WRITE(6,816) PXLP, PXLPI
816 FORMAT('0',T15,'EXHAUST PRESSURE L-P SECTION',T76,F9.5,T87,
   *'PSIA',T95,'=',F8.2,T106,'IN. HGA')
    WRITE(6,817) PC, PCI
817 FORMAT('0',T15,'CONDENSER PRESSURE',T76,F9.5,T87,'PSIA',
   *T95,'=',F8.2,T106,'IN. HGA')
    IF(PXLP.GE. 3.) GO TO 703
    WRITE(6,818) PDLS
818 FORMAT('0',T15,'PITCH DIAMETER OF LAST STAGE L-P SECTION',T75,
   * F7.2,T87,'IN.')
    WRITE(6,819) BLS
819 FORMAT('0',T15,'LENGTH OF LAST STAGE BUCKETS L-P SECTION',T76,
   * F6.2,T87,'IN.')
703 WRITE(6,820) MR
820 FORMAT('0',T15,'NO. OF MOISTURE REMOVAL STAGES LP SECTION',T70,7X,
   *I2)
    IF(MR.EQ.0) GO TO 440
    DO 601 L=1,MR
    WRITE(6,821) L, PMR(L)
821 FORMAT('0',T15,'MOISTURE REMOVAL STAGE NO.',I2/
   *'0',T17,'MOISTURE REMOVAL STAGE PRESSURE',T70,5X,F6.1,T87,'PSIA')
601 CONTINUE
440 IF(MS.EQ.0) GO TO 706
    IF(MS.LE.NP) GO TO 705
    WRITE(6,822) MS
822 FORMAT('0',T15,'EXTERNAL MOISTURE SEPARATOR DRAINS TO CONDENSER, M
   *S=',I3)
    GO TO 704
705 WRITE(6,824) MS, MS
824 FORMAT('0',T15,'EXTERNAL MOISTURE SEPARATOR DRAINS TO FW HEATER NO
   *.',I3,', MS=',I3)
    GO TO 704
706 WRITE(6,827) MS
827 FORMAT('0',T15,'THERE IS NO EXTERNAL MOISTURE SEPARATOR, MS=',I2)
    GO TO 18
704 WRITE(6,823) EMS
823 FORMAT('0',T15,'MOISTURE SEPARATOR EFFECTIVENESS',T70,4X,F6.0,T87,
   *'PER CENT')
 18 INRH=IABS(NRH)
    WRITE(6,825) INRH
825 FORMAT('0',T15,'NUMBER OF STAGES OF REHEAT',T70,7X,I2)
    IF(NRH.EQ.0) GO TO 707
    IF(NRH.GT.0) GO TO 708
    WRITE(6,828) TTDRH1
828 FORMAT('0',T15,'TEMPERATURE OF STEAM LEAVING EXTERNAL REHEATER',
   *T70,4X,F6.0,T87,'F')
    GO TO 707
708 WRITE(6,829) QERH1, TTDRH1, NDRH1, NDRH
829 FORMAT('0',T15,'ESTIMATED STEAM FLOW TO 1ST STAGE REHEATER',T70,
   *2X,F8.0,T87,'LB/HR'/
   *'0',T15,'TERMINAL TEMPERATURE DIFFERENCE 1ST STAGE REHEATER',T70,
   *5X,F6.1,T87,'F'/
   *'0',T15,'1ST STAGE REHEATER DRAINS TO FW HEATER NO.',I2,
   *', NDRH=',I2)
    IF(NRH.EQ.1) GO TO 707
    WRITE(6,830) QERH2, TTDRH2, NDRH2
830 FORMAT('0',T15,'ESTIMATED STEAM FLOW TO 2ND STAGE REHEATER',T70,
   *2X,F8.0,T87,'LB/HR'/
   *'0',T15,'TERMINAL TEMPERATURE DIFFERENCE 2ND STAGE REHEATER',T70,
   *5X,F6.1,T87,'F'/
   *'0',T15,'2ND STAGE REHEATER DRAINS TO FW HEATER NO.',I2)
707 WRITE(6,826) NF
826 FORMAT('0',T15,'TOTAL NO. OF FW HEATERS',T70,6X,I3)
    WRITE(6,831) NFH
831 FORMAT('0',T15,'NO. OF FW HEATERS HP SECTION',T70,7X,I2)
    WRITE(6,832) NFL
832 FORMAT('0',T15,'NO. OF FW HEATERS LP SECTION',T70,7X,I2)
```

```
      IF(NF.EQ.0) GO TO 731                                             DATA3590
      DO 690 N=1,NF                                                     DATA3600
      IF (PE(N).LE.0.0D0 .AND. MS.EQ.0) WRITE(6,611) N, TTD(N)          DATA3610
  611 FORMAT('0',T15,'FW HEATER NO.',I3/                                DATA3620
     * '0',T17,'EXTRACTION STEAM FROM TURBINE EXHAUST'/                 DATA3630
     *'0',T17,'TERMINAL TEMPERATURE DIFFERENCE',T70,6X,F5.1,T87,'F')    DATA3640
      IF (PE(N).LE.0.0D0 .AND. MS.GE.1) WRITE(6,612) N, TTD(N)          DATA3650
  612 FORMAT('0',T15,'FW HEATER NO.',I3/                                DATA3660
     * '0',T17,'EXTRACTION STEAM FROM MOISTURE SEPARATOR VESSEL'/       DATA3670
     *'0',T17,'TERMINAL TEMPERATURE DIFFERENCE',T70,6X,F5.1,T87,'F')    DATA3680
      IF(PE(N).GT. 0.0D0) WRITE( 6,610) N, PE(N), TTD(N)                DATA3690
  610 FORMAT('0',T15,'FW HEATER NO.',I3/                                DATA3700
     *'0',T17,'EXTRACTION STAGE PRESSURE',T70,4X,F7.1,T87,'PSIA'/       DATA3710
     *'0',T17,'TERMINAL TEMPERATURE DIFFERENCE',T70,6X,F5.1,T87,'F')    DATA3720
      IF(ND(N).EQ.0) GO TO 709                                          DATA3730
      WRITE(6,834) N, ND(N)                                             DATA3740
  834 FORMAT('0',T17,'DRAIN IS PUMPED, ND(',I2,')=',I2)                 DATA3750
      GO TO 650                                                         DATA3760
  709 WRITE(6,835) N, ND(N)                                             DATA3770
  835 FORMAT('0',T17,'DRAIN IS FLASHED, ND(',I2,')=',I2)                DATA3780
      IF(NDC(N).EQ.1) GO TO 711                                         DATA3790
  650 WRITE(6,836) N, NDC(N)                                            DATA3800
  836 FORMAT('0',T17,'THERE IS NO DRAIN COOLER SECTION, NDC(',I2,')=',  DATA3810
     *I2)                                                               DATA3820
      GO TO 690                                                         DATA3830
  711 WRITE(6,837) N, NDC(N), TDCA(N)                                   DATA3840
  837 FORMAT('0',T17,'THERE IS A DRAIN COOLER SECTION, NDC(',I2,')=',I2/DATA3850
     *'0',T17,'DRAIN COOLER APPROACH TEMPERATURE DIFFERENCE',T70,6X,    DATA3860
     *F5.1,T87,'F')                                                     DATA3870
  690 CONTINUE                                                          DATA3880
      IF(IP.GT.0) GO TO 720                                             DATA3890
      WRITE(6,838) IP                                                   DATA3900
  838 FORMAT('0',T15,'FW PUMP IS LOCATED AFTER FW HEATER NO. 1, IP=',I3)DATA3910
      GO TO 731                                                         DATA3920
  720 WRITE(6,839) IP, IP                                               DATA3930
  839 FORMAT('0',T15,'FW PUMP IS LOCATED BEFORE FW HEATER NO.',I3,      DATA3940
     *', IP=',I3)                                                       DATA3950
  731 IF(IFPT.EQ.0) GO TO 736                                           DATA3960
      WRITE(6,840) IFPT                                                 DATA3970
  840 FORMAT('0',T15,'FW PUMP IS TURBINE DRIVEN, IFPT=',I3)             DATA3980
      IF(IFPT.LT.0) GO TO 734                                           DATA3990
      WRITE(6,841)                                                      DATA4000
  841 FORMAT('0',T15,'STEAM FLOW TO FW PUMP TURBINE WILL BE CALCULATED')DATA4010
      GO TO 740                                                         DATA4020
  734 WRITE(6,842) QFPT, HBFPT, HEFPT                                   DATA4030
  842 FORMAT('0',T15,'STEAM FLOW TO FW PUMP TURBINE',T70,2X,F8.0,T87,   DATA4040
     *'LB/HR'/                                                          DATA4050
     *'0',T15,'BOWL ENTHALPY FW PUMP TURBINE',T70,F11.1,T87,'BTU/LB'/   DATA4060
     *'0',T15,'EXHAUST ENTHALPY FW PUMP TURBINE',T70,F11.1,T87,'BTU/LB')DATA4070
      GO TO 740                                                         DATA4080
  736 WRITE(6,843) IFPT                                                 DATA4090
  843 FORMAT('0',T15,'FW PUMP IS MOTOR DRIVEN, IFPT='I2)                DATA4100
  740 IF(QAE.GT.0.) GO TO 743                                           DATA4110
  741 WRITE(6,844) QAE                                                  DATA4120
  844 FORMAT('0',T15,'THERE IS NO STEAM JET AIR EJECTOR, QAE =',F10.0)  DATA4130
      GO TO 755                                                         DATA4140
  743 IF(PELP.LT.3.)GO TO 745                                           DATA4150
      WRITE(6,845)                                                      DATA4160
  845 FORMAT('0',T5,'DO NOT USE SJAE WITH B-P TURBINE')                 DATA4170
      QAE=0.                                                            DATA4180
      GO TO 741                                                         DATA4190
  745 WRITE(6,846) QAE                                                  DATA4200
  846 FORMAT(                                                           DATA4210
     *'0',T15,'STEAM FLOW TO STEAM JET AIR EJECTOR',T70,3X,F7.0,T87,    DATA4220
     *'LB/HR')                                                          DATA4230
  755 IF(LK.GT.0) GO TO 760                                             DATA4240
      WRITE(6,847)                                                      DATA4250
  847 FORMAT('0',T15,'VALVE STEM AND PACKING LEAKAGES WILL NOT BE CALCULDATA4260
     *ATED, LK=',I2)                                                    DATA4270
      RETURN                                                            DATA4280
```

```
  760 WRITE(6,848) LK
  848 FORMAT('0',T15,'VALVE STEM AND PACKING LEAKAGES WILL BE CALCULATED
     *, LK=',I2)
      RETURN
  999 STOP 999
      END
```

```
C
      SUBROUTINE FWHPAR(N1,N2)
      IMPLICIT REAL*8(A-H,O-Z)
C
C SUBPROGRAM  FOR FW HEATER PARAMETERS
C  SHELL PRESSURE, DRAIN TEMPERATURE, AND FW IN AND OUT TEMPERATURES
C
      COMMON /HX1/PE(12),PHR(5)
      COMMON /PAR1/HO(12),HI(12),QAE,HC,HFP,DHP,TI(12),TD(12),TDCA(12),
     *HD(12),PLA,PLB,ND(12),NDC(12),IP,NF
      COMMON /PAR2/PSH(12),TSH(12),TO(12),TTD(12),PXHP,PXIP
      COMMON /XS1/ PSX, PSI
      COMMON /XS3/QSI,HSI,TSX,QSX,HSX,AMSX,EMS,MS
C
      DO250 I=N1,N2
C  SHELL PRESSURE
      IF(PE(I).GT.(PXHP+1.0).OR.PE(I).LT.(PSX -1.0))GOTO220
  210 PSH(I)=0.95*PE(I)
      GOTO240
  220 CONTINUE
      PSH(I)=0.92*PE(I)
  240 TSH(I)= TSL(PSH(I))
C  FW OUTLET
      TO(I)=TSH(I)-TTD(I)
      IF(I.LE.IP)GOTO241
      HO(I)= HFT(TO(I))
      GOTO250
  241 HO(I)=HPTL(PLA,TO(I))
  250 CONTINUE
      DO310 I=N1,N2
C  FW INLET
      IF(I.EQ.NF)GOTO260
      HI(I)=HO(I+1)
      IF(ND(I+1).EQ.0)GOTO270
C  CORRECT FW INLET FOR PUMPED DRAIN AT I+1
      HI(I)=HI(I)+1.0
      GOTO270
C  CORRECT FW INLET FOR SJAE ENTHALPY RISE AND SPE ENTHALPY RISE
  260 HI(I)=HC+1.0
  270 IF(IP.NE.I)GOTO280
C  FW PUMP INLET
      HFP=HI(I)
C  CORRECT FW INLET FOR FW PUMP ENTHALPY RISE
      HI(I)=HI(I)+DHP
  280 IF(I.LE.IP)GOTO281
      TI(I)= TSLH(HI(I))
      GOTO282
  281 TI(I)=TPHL(PLA,HI(I))
  282 IF(NDC(I).EQ.0)GOTO290
C  DRAIN WITH DRAIN COOLER
      TD(I)=TI(I)+TDCA(I)
      GOTO300
C  DRAIN WITHOUT DRAIN COOLER
  290 TD(I)=TSH(I)
  300 HD(I)= HFT(TD(I))
  310 CONTINUE
      RETURN
      END
```

```
C
      SUBROUTINE FWHEAT(I1,I2,MR,KL,MS,IT)
      IMPLICIT REAL*8(A-H,O-Z)
C
C SUBPROGRAM  FOR FW HEATER HEAT BALANCE
C
C  QD       DRAIN FLOW FROM PREVIOUS HEATER
C  QRH1     DRAIN FLOW FROM 1ST STAGE REHEATER
C  QRH2     DRAIN FLOW FROM 2ND STAGE REHEATER
C  QMS      DRAIN FLOW FROM EXTERNAL MOIST SEPARATOR
C  QLK1     DRAIN FLOW FROM VALVE STEM LEAKAGES
C  QLK3     DRAIN FLOW FROM TURBINE SHAFT BOWL END
C  QLK5     DRAIN FLOW FROM TURBINE SHAFT EXHAUST END
C  QFWH     DRAIN FLOW FROM STEAM SEAL REGULATOR
C  QMF      DRAIN FLOW FROM TURBINE MOIST REM. STAGE - WATER REMOVAL
C  QMG      DRAIN FLOW FROM TURBINE MOIST REM. STAGE - STEAM REMOVAL
      DIMENSION IT1(13),QMFE(13)
C
      COMMON /CONV/HCON,UERCON,AMCON,BHCON,WCON,PCON,SSRCON,XSPCON
      COMMON /FWH/HAPI,HAPO,QR,QFS(20),HPS(20),HES(20),QMF(5),HMF(5),
     1QMG(5),HMG(5),QD(12),QF(12),QE(12),QCR,HCR,QRO,QC,I1LP,I
      COMMON /HX1/PE(12),PMR(5)
      COMMON /HX2/HE(12),HE1(12),HAMR(5),HBMR(5),SAMR(5),SBMR(5),PCWD(5)
      COMMON /IN/L1(13),L2(13),J1(13),IMR(5)
      COMMON /LEAK/QLK1,HLK1,QLK2,HLK2,QLK3,HLK3,QLK4,HLK4,QLK5,HLK5,
     1QLK6,HLK6,QLK7,HLK7,QLK8,HLK8,QLK9,HLK9,QLK10,HLK10,LK,LK1,LK3,
     2LK5,LK7,LK9
      COMMON /PAR1/HO(12),HI(12),QAE,HC,HPP,DHP,TI(12),TD(12),TDCA(12),
     *HD(12),PLA,PLB,ND(12),NDC(12),IP,NP
      COMMON /RH2/QRH1,HCRH1,QRH2,HCRH2,NRH,NDRH1,NDRH2
      COMMON /SSR/QSPE,QMC,QSSR,HSSR,PSSR,QFWH,QSSRMU,HSSRMU
      COMMON /XS2/HPSX,QMR
C
      I=I1
      IT2=0
      GOTO1910
 1900 I=I+1
 1910 QMFE(I)=0.
      IT1(I)=0
      IF(MR.EQ.0)GOTO2000
      IF(L2(I).LT.L1(I))GOTO1995
C  FIND DRAIN FROM TURBINE MOISTURE REMOVAL STAGE
      M1=L1(I)
      M2=L2(I)
      DO1990 L=M1,M2
      QMF(L)=PCWD(L)*QFS(KL)*0.01
      HMF(L)= HFT( TSL(PMR(L)))
      IF(I.EQ.I2)GOTO1980
      IF(PE(I).LT.(PMR(L)-1.0))GOTO1980
      QMG(L)=0.0
      HMG(L)=0.0
      QMFE(I)=QMF(L)
      GOTO2000
 1980 QMG(L)=0.005*QFS(KL)
      HMG(L)=HAMR(L)
C  FIND FLOW TO FOLLOWING STAGE
      KL=KL+1
      QFS(KL)=QFS(KL-1)-QMF(L)-QMG(L)
      HPS(KL)=HAMR(L)
      HES(KL-1)=HBMR(L)
 1990 CONTINUE
 1995 IF(I.EQ.I2)GOTO2400
C  FIND DRAIN FROM PREVIOUS FW HEATER
 2000 CONTINUE
C  FIND DRAINS TO FW HEATER SHELL
      QSUM=0.0
      SUM=0.0
```

```
C  FIND FW FLOW
      IF(I.GT.1) GOTO2020
      QF1=QR
      GOTO2030
 2020 QF1=QF(I-1)
C  ADD DRAIN FROM PREVIOUS FW HEATER
      IF(ND(I-1).EQ.1) GOTO2030
      QSUM=QSUM+QD(I-1)
      SUM=SUM+QD(I-1)*(HD(I-1)-HD(I))
C  TEST FOR LIVE STEAM REHEATER
 2030 IF(NRH.LT.1) GOTO2040
C  ADD DRAIN FROM 1ST STAGE REHEATER
      IF(NDRH1.NE.I) GOTO2035
      QSUM=QSUM+QRH1
      SUM=SUM+QRH1*(HCRH1-HD(I))
C  TEST FOR 2ND STAGE REHEATER
 2035 IF(NRH.LT.2) GOTO2040
C  ADD DRAIN FROM 2ND STAGE REHEATER
      IF(NDRH2.NE.I) GOTO2040
      QSUM=QSUM+QRH2
      SUM=SUM+QRH2*(HCRH2-HD(I))
C  ADD DRAIN FROM EXTERNAL MOISTURE SEPARATOR
 2040 IF(MS.NE.I) GOTO2050
      QSUM=QSUM+QMR
      SUM=SUM+QMR*(HFSX-HD(I))
C  ADD DRAINS FROM VALVE STEM AND SHAFT LEAKAGES
 2050 IF(LK.EQ.0) GOTO2070
      IF(I.NE.LK1) GOTO2060
      QSUM=QSUM+QLK1
      SUM=SUM+QLK1*(HLK1-HD(I))
 2050 IF(I.NE.LK3) GOTO2061
      QSUM=QSUM+QLK3
      SUM=SUM+QLK3*(HLK3-HD(I))
 2061 CONTINUE
      IF(I.NE.LK5) GOTO2062
      QSUM=QSUM+QLK5
      SUM=SUM+QLK5*(HLK5-HD(I))
 2062 CONTINUE
C  ADD DRAIN FROM STEAM SEAL REGULATOR
 2065 IF(I.LT.NF) GOTO2070
      QSUM=QSUM+QFWH
      SUM=SUM+QFWH*(HSSR-HD(I))
C  ADD DRAINS FROM TURBINE MOISTURE REMOVAL STAGES
 2070 IF(MR.EQ.0) GOTO2090
      IF(L2(I).LT.L1(I)) GOTO2090
C  SUM DRAINS FROM TURBINE MOISTURE REMOVAL STAGES
      M1=L1(I)
      M2=L2(I)
      DO2080 L=M1,M2
      QSUM=QSUM+QMF(L)+QMG(L)
      SUM=SUM+QMF(L)*(HMF(L)-HD(I))+QMG(L)*(HMG(L)-HD(I))
 2080 CONTINUE
 2090 IF(ND(I).EQ.1) GOTO2100
C  HEAT BALANCE (FW HEATER DRAIN IS FLASHED)
      QF(I)=QF1
      QE(I)=(QF(I)*(HO(I)-HI(I))-SUM)/(HE(I)-HD(I))
      QD(I)=QE(I)+QSUM
      GOTO2200
C  HEAT BALANCE (FW HEATER DRAIN IS PUMPED)
 2100 CONTINUE
      QE(I)=((QF1-QSUM)*(HO(I)-HI(I))-SUM)/(HE(I)-HD(I)+HO(I)-HI(I))
      QD(I)=QE(I)+QSUM
      QF(I)=QF1-QD(I)
      IF(I.EQ.1) GOTO2200
      HI1=(QD(I)*HD(I)+QF(I)*HO(I))/QF1
      IF(IP.NE.(I-1)) GOTO2110
C  CORRECT FW PUMP INLET ENTHALPY
      HPP=HI1
      HI1=HI1+DHP
C  TEST FW INLET ENTHALPY
 2110 ADH=DABS(HI1-HI(I-1))
```

```
      IT1(I)=IT1(I)+1                                                   FWHE1380
      IF(ADH.LE.HCON)GOTO2200                                           FWHE1390
      IF(I.GT.I1)GOTO2111                                               FWHE1400
      IF(IT.GT.50)GOTO2112                                              FWHE1410
 2111 IF(IT1(I-1).LE.50)GOTO2114                                        FWHE1420
 2112 IX=I-1                                                            FWHE1430
      PRINT 2113,IX,ADH                                                 FWHE1440
 2113 FORMAT('0-SUBROUTINE FWHEAT-FW HEATER INLET ENTHALPY IN IT1 DID NOFWHE1450
     1T CONVERGE, FW HEATER NO.',I3,4X,'ADH= ',1PD14.6)                 FWHE1460
      GOTO2200                                                          FWHE1470
C  RE-SET INDEX I TO PREVIOUS FW HEATER                                 FWHE1480
 2114 I=I-1                                                             FWHE1490
C  CORRECT FW INLET TEMPERATURE                                         FWHE1500
      HI(I)=HI1                                                         FWHE1510
      IF(I.LE.IP)GOTO2118                                               FWHE1520
      TI(I)= TSLH(HI1)                                                  FWHE1530
      GOTO2119                                                          FWHE1540
 2118 TI(I)=TPHL(PLA,HI1)                                               FWHE1550
 2119 IF(NDC(I).EQ.0)GOTO2120                                           FWHE1560
C  CORRECT FW HEATER DRAIN TEMPERATURE                                  FWHE1570
      TD(I)=TI(I)+TDCA(I)                                               FWHE1580
      HD(I)= HFT(TD(I))                                                 FWHE1590
 2120 IF(I.EQ.(I1LP-1))GOTO2400                                         FWHE1600
      IF(I.LT.I1LP)GOTO2000                                             FWHE1610
C  RE-SET INDEX KL (FLOW TO FOLLOWING STAGE)                            FWHE1620
      KL=I-I1LP+1+L2(I)-J1(I)                                           FWHE1630
      GOTO2000                                                          FWHE1640
 2200 CONTINUE                                                          FWHE1650
      IF(I.LT.I1LP)GOTO2210                                             FWHE1660
C  FIND FLOW TO FOLLOWING STAGE                                         FWHE1670
      KL=KL+1                                                           FWHE1680
      QFS(KL)=QFS(KL-1)-QE(I)-QMFE(I)                                   FWHE1690
      HES(KL-1)=HE1(I)                                                  FWHE1700
      HFS(KL)=HE(I)                                                     FWHE1710
 2210 IF(I.LT.NF)GOTO2300                                               FWHE1720
C  FIND ENTHALPY RISE ACROSS SJAE AFTER-CONDENSER AND SPE               FWHE1730
      QC=QF(I)+QCR                                                      FWHE1740
      DHAE=QAE*(HAEI-HAEO)/QC+QSPE*(HSSR-HAEO)/QC                       FWHE1750
      HI1=HC+DHAE                                                       FWHE1760
      HCR=HI1                                                           FWHE1770
      IF(IP.NE.NF)GOTO2220                                              FWHE1780
C  CORRECT FW PUMP INLET ENTHALPY                                       FWHE1790
      HFP=HI1                                                           FWHE1800
      HI1=HI1+DHP                                                       FWHE1810
C  TEST FW INLET ENTHALPY                                               FWHE1820
 2220 ADH=DABS(HI1-HI(I))                                               FWHE1830
      IT2=IT2+1                                                         FWHE1840
      IF(ADH.LE.HCON)GOTO2300                                           FWHE1850
      IF(IT2.LE.50)GOTO2229                                             FWHE1860
      PRINT 2221,I,ADH                                                  FWHE1870
 2221 FORMAT('0-SUBROUTINE FWHEAT-FW HEATER INLET ENTHALPY IN IT2 DID NOFWHE1880
     1T CONVERGE, FW HEATER NO.',I3,4X,'ADH= ',1PD14.6)                 FWHE1890
      GOTO2300                                                          FWHE1900
 2229 IF(I.LT.I1LP)GOTO2230                                             FWHE1910
C  RE-SET INDEX KL (FLOW TO FOLLOWING STAGE)                            FWHE1920
      KL=KL-1                                                           FWHE1930
C  CORRECT FW INLET TEMPERATURE                                         FWHE1940
 2230 HI(I)=HI1                                                         FWHE1950
      IF(I.LE.IP)GOTO2240                                               FWHE1960
      TI(I)= TSLH(HI1)                                                  FWHE1970
      GOTO2250                                                          FWHE1980
 2240 TI(I)=TPHL(PLA,HI1)                                               FWHE1990
 2250 IF(NDC(I).EQ.0)GOTO2090                                           FWHE2000
C  CORRECT FW HEATER DRAIN TEMPERATURE                                  FWHE2010
      TD(I)=TI(I)+TDCA(I)                                               FWHE2020
      HD(I)= HFT(TD(I))                                                 FWHE2030
      GOTO2090                                                          FWHE2040
 2300 IF(I.LT.I2)GOTO1900                                               FWHE2050
 2400 RETURN                                                            FWHE2060
      END                                                               FWHE2070
```

```
C
      SUBROUTINE FWPT(PB,HB,PX,DHP,QB)
      IMPLICIT REAL*8(A-H,O-Z)
C SUBPROGRAM  FOR CALCULATING THROTTLE STEAM FLOW TO FW PUMP TURBINE
      COMMON /FPT/QFPT,PBFPT,HBFPT,PXFPT,HXFPT,IFPT
      COMMON /FWPTBB/ EFP, EFF, CP1, CP2
C  FIND BOWL ENTROPY
      PBFPT=PB
      HBFPT=HB
      CALL PROPPH(AMB,SB,VB,TB,XB,PBFPT,HBFPT)
C  FIND ISENTROPIC EXHAUST ENTHALPY
      PXFPT=PX+0.24558
      CALL PROPPS(AMXS,HXS,TXS,VXS,XXS,PXFPT,SB)
C  FIND USED ENERGY
      AE=HBFPT-HXS
      UE=AE*EFF
      HXFPT=HBFPT-UE
C  THROTTLE STEAM FLOW TO FW PUMP TURBINE
      QFPT=QB*DHP/UE
      RETURN
      END
```

```
C
      FUNCTION F1A(W,PX,PB)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(6,7)
      DATA IW/6/
      DATA A/9.9701993D-1, -2.8250567D-2, 1.1488895D-1, 3*0.0D0,
     * 1.1225967D-5, 1.1173166D-4, -4.5518203D-4,       3*0.0D0,
     * -1.9041979D-8, -1.3694475D-7, 3.9876404D-7,      3*0.0D0,
     * 24*0.0D0/
      RXB=PX/PB
      RBX=PB/PX
      IF((RBX.GT.8.0).OR.(RBX.LT.2.0)) WRITE(IW,800) RBX
  800 FORMAT(' ','RBX = ',D25.16,' IS A DATA ERROR IN F1A')
      CALL BIVPOL(A,W,RXB,Z,2,2)
      F1A=Z
      RETURN
      END
```

```
C
      FUNCTION F1B(TFR,RBX)
      IMPLICIT REAL*8(A-H, O-Z)
      DIMENSION A(6,7)
      DATA IW/6/
      DATA A/ 2.1161407D-1,  1.1847063D0 ,  -3.9631998D-1,  3*0.0D0,
     *         7.3863399D-2, -5.6665227D-2,  -1.7198355D-2,  3*0.0D0,
     *        -4.5419954D-3,  2.7427505D-3,   1.7992637D-3,  3*0.0D0,
     *                         24*0.0D0/
      IF((RBX.GT.8.0).OR.(RBX.LT.2.0)) WRITE(IW,800) RBX
  800 FORMAT(' ','RBX = ',D25.16,' IS A DATA ERROR IN F1B')
      IF((TFR.GT.1.0).OR.(TFR.LT.0.1)) WRITE(IW,801) TFR
  801 FORMAT(' ','TFR = ',D25.16,' IS A DATA ERROR IN F1B')
      IF(TFR.LT. .6D0) TFX=.6D0
      IF(TFR.GE. .6D0) TFX=TFR
      CALL BIVPOL(A,RBX,TFX,Z,2,2)
      DELTA=Z
      F1B=DELTA*(1.015-0.015*TFX)
      RETURN
      END
```

```
C
      FUNCTION F1C(W,TPR)
      IMPLICIT REAL*8(A-H, O-Z)
      DATA IW/6/
      IF((TPR.GT.1.0).OR.(TPR.LT.0.1)) WRITE(IW,801)TPR
  801 FORMAT(' ','TPR = ',D25.16,' IS A DATA ERROR IN F1C')
      IF(TPR.LT. .6D0) TPX=.6D0
      IF(TPR.GE. .6D0) TPX=TPR
      F1C = 1.0 - (56.0/W - 0.112) * (1.0 - TPX) /0.5
      RETURN
      END
```

```
C
      FUNCTION F2(AGM,PB)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(6)
      DATA I/5/
      DATA IW/6/
      DATA A/+1.0D0, -3.8962559D0, +2.0760751D2, -6.6328180D3,
     * +1.0109593D5, -5.9521194D5/
      IF(AGM.LE.0.06)CALL UNIPOL(A,AGM,GAMMA,I)
      IF(AGM.GT.0.06)GAMMA=.93606550-.9*(AGM-0.06)
      IF((PB.LT.100.0).OR.(PB.GT.2000.0))WRITE(IW,801)PB
  801 FORMAT(' ','PB = ',D25.16,' IS A DATA ERROR IN F2')
      IF(AGM.LT.0.0)WRITE(IW,802)AGM
  802 FORMAT(' ','AGM = ',D25.16,' IS A DATA ERROR IN F2')
      F2=GAMMA+1.5D-5*(AGM/0.08)*(900.0-PB)
      RETURN
      END
```

```
C
      FUNCTION F3(QVN,PR)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION AALPHA(3),ATHETA(3)
      DATA IW/6/
      DATA AALPHA/-0.17387620D1,-0.24241363D0,0.95370576D-2/,ATHETA/
     *   -0.23694637D1,-0.99561861D-1,-0.298893540D-2/,I/2/
      IF(QVN.LT..2D6)GO TO 15
   10 IF(QVN.LE.100.D6)GO TO 20
   15 WRITE(IW,800) QVN
  800 FORMAT(' ','QVN = ',D25.16,' IS OUTSIDE SPECIFIED LIMITS FOR F3')
   20 IF(PR.LT.1.0)GO TO 30
   25 IF(PR.LT.500.)GO TO 35
   30 WRITE(IW,801)PR
  801 FORMAT(' ','PR = ', D25.16,' IS OUTSIDE SPECIFIED LIMITS FOR F3')
   35 X = DLOG(PR)
      CALL UNIPOL(AALPHA,X,ZALPHA,I)
      ALPHA = DEXP(ZALPHA)
      CALL UNIPOL(ATHETA,X,ZTHETA,I)
      THETA = DEXP(ZTHETA)
      PSI=1.006*(1.0-8000./QVN)
      F3    =(1.0-(ALPHA*((THETA-ALPHA)/QVN)*((QVN-250000.)/0.975)))*PSI
      RETURN
      END
```

```
C
      FUNCTION F4(PR,PB,VP)
      IMPLICIT REAL*8(A-H,O-Z)
C     PR IS PB/PX
      DIMENSION A(6,7)
      DATA IW/6/
      DATA A/0.91545965D0,-0.16800190D-1,0.22481349D-2,
     >-0.21178836D-3,0.91380561D-5,0.D0,
     >-0.52509228D-4,0.10910256D-4,-0.20090378D-4,
     >0.49081537D-5,-0.35197958D-6,0.D0,
     >0.27863077D-6,-0.38164297D-6,0.25227588D-6,
     >-0.54516150D-7,0.38424326D-8,0.D0,
     >-0.68155332D-9,0.10184591D-8,-0.63504086D-9,
     >0.13690704D-9,-0.97149103D-11,0.D0,
     >0.69937432D-12,-0.10905080D-11,0.66534494D-12,
     >-0.14337663D-12,0.10204672D-13,0.D0,
     >-0.32231499D-15,0.51336370D-15,-0.30982129D-15,
     >0.66775818D-16,-0.47614905D-17,0.D0,
     >0.54818623D-19,-0.88601007D-19, 0.53145252D-19,
     >-0.11459126D-19,0.81819448D-21,0.D0/
      ALO=DLOG(2.0D0)
      APL=DLOG(PR)
C     CALCULATE ETA1
      ETA1=1.0-(0.16993783-0.08220699*((VP-250000.0)/
     > (0.975*VP)))
C     CHECK TO SEE IF INPUT ARGUMENTS ARE WITHIN SPECIFIED LIMITS
      IF(PB.LE.2000.) GO TO 3
C     IF DATA IS OUTSIDE LIMITS PRINT MESSAGE AND
C     CONTINUE EXECUTION
      WRITE(IW,13) PB
   13 FORMAT(' ','PB = ',D25.16,' IS A DATA ERROR IN F4')
    3 IF(PR-1.0) 29,5,9
   29 WRITE(IW,14) PR
   14 FORMAT(' ','PR = ',D25.16,' IS A DATA ERROR IN F4')
    9 IF(PR.LE.2.0) GO TO 5
      IF(PR-500.0) 6,6,7
C     CALCULATE ETA2 BY CALLING A GENERAL SUBROUTINE
C     TO COMPUTE THE BIVARIATE POLYNOMIAL
    5 CALL BIVPOL(A,PB,ALO,Z,4,6)
      ETA2=Z
C     CALCULATE FIG4 WHERE PR IS BETWEEN 1.0 AND
C     2.0 INCLUSIVE
      F4=ETA1 + (ETA2 - ETA1) * (APL/ALO)
      RETURN
    7 WRITE(IW,14) PR
C     CALCULATE F4 BY CALLING A GENERAL SUBROUTINE
C     TO COMPUTE THE BIVARIATE POLYNOMIAL
    6 CALL BIVPOL(A,PB,APL,Z,4,6)
      F4 = Z
      RETURN
      END
```

```
C
      FUNCTION FIG5(QVN,PB,VP,PR)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(3),B(1)
      DATA A/-0.10239761D0,0.14091440D-1,-0.88660084D-3/,B/0.52514486D0/
     *     ,I/2/,J/1/
      IF((PR.LT.1.0).OR.(PR.GT.500.))WRITE(6,16)PR
   16 FORMAT(5H0PR =,D25.16,38H  IS OUTSIDE SPECIFIED LIMITS FOR FIG5)
      IF(PB.GT.2000.)WRITE(6,31)PB
   31 FORMAT (5H0PB =,D25.16,38H  IS OUTSIDE SPECIFIED LIMITS FOR FIG5)
      X = DLOG(PR)
      CALL RATFUN(A,B,X,XK,I,J)
      CONSTK = 250000.*XK
      FIG5=((CONSTK/QVN)+1.0)/((CONSTK/VP)+1.0)
      RETURN
      END
```

```
C
      FUNCTION FIG7(PR,PB)
      IMPLICIT REAL*8(A-H,O-Z)
C     PR IS PB/PX
      DIMENSION A(6,7)
      DATA A/0.88620962D0,-0.57966163D-1,-0.70547092D-2,
     10.53287932D-2,-0.10834413D-2,0.74799566D-4,0.73023513D-4,
     2-0.90870584D-3,0.51487177D-3,-0.15870788D-3,0.24559973D-4,
     3-0.14649524D-5,-0.93332207D-6,0.45863391D-5,-0.30414566D-5,
     40.98498064D-6,-0.15288021D-6,0.90166692D-8,0.26842196D-8,
     5-0.10384613D-7,0.72972894D-8,-0.24101082D-8,0.37440997D-9,
     6-0.21928984D-10,-0.30566338D-11,0.10644149D-10,-0.77044070D-11,
     70.25741444D-11,-0.40054815D-12,0.23384013D-13,0.15075129D-14,
     8-0.49596233D-14,0.36525359D-14,-0.12292791D-14,0.19154518D-15,
     9-0.11162844D-16,-0.26954610D-18,0.85580517D-18,-0.63735459D-18,
     A0.21556766D-18,-0.33625662D-19,0.19575380D-20/
      AL1=DLOG(2.0D0)
      AP1=DLOG(PR)
C     CHECK TO SEE IF INPUT ARGUMENTS ARE WITHIN SPECIFIED LIMITS
      IF(PB.GT.2000.)WRITE(6,13)PB
   13 FORMAT(6H0PB = ,D25.16,5X,23HIS A DATA ERROR IN FIG7)
      IF(PR-1.0)29,5,9
   29 WRITE(6,14)  PR
   14 FORMAT(6H0PR = ,D25.16,5X,23HIS A DATA ERROR IN FIG7)
    9 IF(PR-2.0)5,6,4
    4 IF(PR-500.0)6,6,7
C     CALCULATE ETA3 BY CALLING A GENERAL SUBROUTINE
    5 CALL BIVPOL(A,PB,AL1,Z,5,6)
      ETA3=Z
C     CALCULATE FIG7 WHERE PR IS BETWEEN 1.0 AND
C     2.0 INCLUDING 1.0 BUT NOT 2.0
      FIG7=0.87+(ETA3-.87)*(AP1/AL1)
      RETURN
    7 PRINT 14,PR
C     CALCULATE FIG7 BY CALLING A GENERAL SUBROUTINE
C     TO COMPUTE THE BIVARIATE POLYNOMIAL
    6 CALL BIVPOL(A,PB,AP1,Z,5,6)
      FIG7=Z
      RETURN
      END
```

```
C
      FUNCTION FIG8(PX)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(5)
      DATA A/0.1304D1,0.1973D2,-0.1118D2,-0.9587D2,0.3148D3/,I/4/
      DATA IW/6/
      IF(PX.LT.3.0 )GO TO 30
      IF(PX.LE.100.)GO TO 35
      FIG8=1.5
      RETURN
   30 WRITE(IW,31) PX
   31 FORMAT(5H0PX =,D25.16,38H  IS OUTSIDE SPECIFIED LIMITS FOR FIG8)
   35 X = 1.0/PX
      CALL UNIPOL(A,X,Z,I)
      FIG8 = Z
      RETURN
      END
```

```
C
      FUNCTION F10(P)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(4), B(3)
      DATA A/1.3725945D-2, 1.3749009D0, -2.9965293D0, 6.1649777D1/
      DATA B/-6.1862609D0, 3.9837738D1, 1.8158351D2/
      IF(P.LE.3.5) X=1./3.5
      IF(P.GT.3.5) X=1./P
      CALL RATFUN(A,B,X,Z,3,3)
      F10=Z*100.D0
      RETURN
      END
```

```
C
      SUBROUTINE F12AC (P,HB,SB,HX,SX,H,S)
       IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 K,L,M,N,LN,MN
      DATA IW/6/
      DATA K/0.16129D5/
      M=50.0*(SB-SX)
      N=0.1*(HB-HX)
      MN=M/N
      L=2500.0*(SB*SB-SX*SX)+0.01*(HB*HB-HX*HX)
      LN=L/N
      A=0.25*(1.0+MN*MN)
      B=50.0*SX+MN*(0.5*LN-0.1*HX)
      C=(50.0*SX)*(50.0*SX)+(0.1*HX)*(0.1*HX)
     >-K+LN*(0.25*LN-0.1*HX)
      SC=(0.25/A)*(B+DSQRT(B*B-4.*A*C))
      HC=0.5*(LN-2.0*MN*SC)
C     INITIALIZE ENTROPY AT END CONDITION SB
      AS=SB
      T= TSL(P)
C     BEGIN ITERATIVE PROCESS ON CONVERGING ENTROPY
      DO 5 I=1,50
      SG=SPTD(P,T)
      M=(SG-AS)/(SG- SPT(T))
      HG=HPS(P,SPTD(P,T))
      H1=HG-M*(HG- HPT(T))
      S=(SC-DSQRT(K-(0.1*H1-HC)*(0.1*H1-HC)))/50.0
      DIFF=S-AS
      IF(DABS(DIFF)-1.D-5)2,2,1
```

```
    1 AS=S
    5 CONTINUE
C     IF ENTROPY DOES NOT CONVERGE IN 50 ITERATIONS THEN PRINT MESSAGE
C     AND RETURN THE LATEST VALUES OF H AND S TO CALLING ROUTINE
      WRITE(IW,800)
  800 FORMAT(' ','ENTROPY IN F12A DID NOT CONVERGE IN 50 ITERATIONS')
    2 H=H1
      RETURN
      END
```

```
C
      SUBROUTINE F12B  (P,HB,SB,HA,SA,H,S)
      IMPLICIT REAL*8(A-H,O-Z)
      DATA IW/6/
C     CALCULATE CONSTANT TERM RO
      RO=((SA-SB)+(0.0177)-(10.**((HB-(HA+650.))/371.)))/(HA-HB)
C     INITIALIZE ENTROPY AT END CONDITION SB
      AS=SB
C     BEGIN ITERATIVE PROCESS ON CONVERGING ENTROPY
      DO 5 I=1,50
      T=TSUPS(P,AS)
      H1= HPS(P,SPTD(P,T))
      S=10.**((HB-(H1+650.))/371.)+RO*(H1-HB)+SB-(0.0177)
      DIFF=S-AS
      IF(DABS(DIFF)-1.D-5) 2,2,1
    1 AS=S
    5 CONTINUE
C     IF ENTROPY DOES NOT CONVERGE IN 50 ITERATIONS THEN PRINT MESSAGE
C     AND RETURN THE LATEST VALUES OF H AND S TO CALLING ROUTINE
      WRITE(IW,800)
  800 FORMAT(' ','ENTROPY IN F12B DID NOT CONVERGE IN 50 ITERATIONS')
    2 H=H1
      RETURN
      END
```

```
C
      FUNCTION FIG15(INHGA)
      IMPLICIT REAL*8(A-I,O-Z)
      DIMENSION A(3)
      DATA A          /-0.23984811D2,0.57862440D2,0.31849404D1/
C     CHECK TO SEE IF INPUT ARGUMENTS ARE WITHIN SPECIFIED LIMITS
C     IF DATA OUTSIDE LIMITS PRINT MESSAGE AND
C     CONTINUE EXECUTION
      IF((INHGA.LT..25).OR.(INHGA.GT.6.0))WRITE(6,13)INHGA
   13 FORMAT(9H0INHGA = ,D25.16,5X,24HIS A DATA ERROR IN FIG15)
C     CALCULATE FIG15 BY CALLING A GENERAL SUBROUTINE
C     TO COMPUTE THE UNIVARIATE POLYNOMIAL
      AINHGA=DLOG(INHGA)
      CALL UNIPOL(A,AINHGA,Z,2)
      FIG15=Z
      RETURN
      END
```

```
C
      FUNCTION F16(VAN,BLS)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION VANX(21),              F38(21)
      DATA VANX/128.D0,150.D0,175.D0,200.D0,250.D0,300.D0,350.D0,400.D0,
     *   450.D0,500.D0,550.D0,600.D0,650.D0,700.D0,800.D0,900.D0,1000.D0
     *   ,1100.D0,1200.D0,1300.D0,1400.D0/
      DATA F38/51.63D0,45.50D0,38.38D0,32.65D0,23.80D0,17.43D0,12.91D0,
     *   9.80D0,7.97D0,7.07D0,7.02D0,7.72D0,9.00D0,11.00D0,16.25D0,
     *   21.97D0,27.92D0,34.D0,39.92D0,45.25D0,49.85D0/,
     *                                 NPOINT/5/,NORDER/4/
C-----IF VAN .LE. 4TH TABULAR VANX, USE FIRST 5 POINTS TO INTERPOLATE
      IF (VAN - VANX(4)) 15,15,10
C-----IF VAN .GE. 20TH TABULAR VANX, USE LAST 5 POINTS TO INTERPOLATE
   10 IF (VAN - VANX(20)) 20,16,16
   15 I = 1
      GO TO 60
   16 I = 17
      GO TO 60
   20 ILO = 4
      IHI = 20
      DO 25 J=1,4
      IVAN = .5*(ILO + IHI)
      IF (VAN - VANX(IVAN)) 30,30,35
   30 IHI = IVAN
      GO TO 25
   35 ILO = IVAN
   25 CONTINUE
      I = IHI - 3
C     F38 APPLIES TO 35 INCH AND 43 INCH
   60 CONTINUE
      CALL LAGRAN(VAN,VANX,F38,Z,NPOINT,NORDER,I)
      F16=Z
      RETURN
      END
```

```
C
      FUNCTION F17   (PDT,PDD)
C     PDT IS PD/PT
C     PDD IS PD/PD'
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(6,7)
      DATA A/0.10387869D0,0.51016459D-1,0.29102908D1,
     10.27471818D0,-0.21304563D1,0.D0,
     2-0.19802735D1,-0.95190372D1,-0.37135945D2,
     3-0.13560028D2,0.33612332D2,0.D0,
     40.10063291D2,0.20037626D3,0.69547999D2,
     50.98411071D2,-0.17160622D3,0.D0,
     6-0.18538112D2,-0.27829006D3,-0.29449752D3,
     7-0.18258882D3,0.38650991D3,0.D0,
     80.10749035D2,0.20073785D3,0.30482186D3,
     90.48723599D2,-0.29025217D3,0.D0,
     A12*0.D0/
C     CHECK TO SEE IF INPUT ARGUMENTS ARE WITHIN SPECIFIED LIMITS
      PD=1.0/PDT
      IF(PD-1.2) 7,3,8
C     IF DATA OUTSIDE LIMITS PRINT MESSAGE AND
C     CONTINUE EXECUTION
    7 PRINT 13,PDT
    8 IF(PD-10.0)3,3,2
    2 PRINT 13,PDT
    3 PDINV=1.0/PDD
      IF(PDINV-0.5) 9,5,10
    9 PRINT 14,PDD
   10 IF(PDINV-3.3) 5,5,4
    4 PRINT 14,PDD
```

```
C     CALCULATE FIG18 BY CALLING A GENERAL SUBROUTINE
C     TO COMPUTE THE BIVARIATE POLYNOMIAL
    5 APDD=DLOG(PDD)
      CALL BIVPOL(A,PDT,APDD,Z,5,5)
      F17=Z
      RETURN
   13 FORMAT(7HOPDT = ,D25.16,5X,24HIS A DATA ERROR IN F17    )
   14 FORMAT(7HOPDD = ,D25.16,5X,24HIS A DATA ERROR IN F17    )
      END
```

```
C
      FUNCTION F18(KVA)
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 KVA
      DIMENSION A(4)
      DATA IW/6/
      DATA A/6.832580D1, 4.29619D-3, -1.52886D-9, 9.92122D-16/
      DATA I/3/
      IF((KVA.LT.1.D5).OR.(KVA.GT.2.D6)) WRITE(IW,800)KVA
  800 FORMAT('0','KVA= ',D25.16,
     * ' IS OUTSIDE SPECIFIED LIMITS FOR FIGURE 18')
      CALL UNIPOL(A,KVA,Z,I)
      F18 = Z
      RETURN
      END
```

```
C
      FUNCTION F19(KVA)
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 KVA
      DIMENSION      AA(4),B(1)
      DATA AA/1.7479050D0, 6.1637835D-2, -2.6652558D-2, 1.0759713D-3/
      DATA B/-4.9564581D-2/
      ALO=DLOG(KVA)
      CALL RATFUN(AA,B,ALO,Z,3,1)
      F19=Z
      RETURN
      END
```

```
C
      FUNCTION F20(FRKVA)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION ACD18(5),BCD18(1)
      DATA ACD18/-0.22727744D0,-0.24939976D2,0.34283283D2,-0.35808901D2,
     >   0.90544169D1/,BCD18/-0.18638959D2/,I1/4/,J1/1/
      CALL RATFUN (ACD18,BCD18, FRKVA,Z,I1,J1)
      F20 = Z
      RETURN
      END
```

```
C
      FUNCTION F21(KVA)
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 KVA
      DIMENSION AC(2)
      DATA AC                      /0.40D2,0.96D-4/
      CALL UNIPOL(AC,KVA,Z,1)
      F21=Z
      RETURN
      END
```

```
C
      SUBROUTINE HPTURB(NXHP)
      IMPLICIT REAL*8(A-H,O-Z)
C  A   MOISTURE FRACTION
C  M   =1 WET VAPOR, =2 SATURATED VAPOR, =3 SUPERHEATED VAPOR
C  Q   VWO FLOW TO G-S
C  W   WHEEL SPEED, FPS
C  AE   AVAILABLE ENERGY G-S
C  C1   CORRECTION FACTOR FROM F1A
C  C2   CORRECTION FACTOR FROM F1B
C  C3   CORRECTION FACTOR FROM F1C
C  C4   CORRECTION FACTOR FROM F2
C  JJ   INDEX FOR LOOP TO FIND H-P ELEP
C  PR   PRESSURE RATIO -- VWO G-S BOWL/VWO ISENTROPIC EXHAUST H-P
C  AGM   AVERAGE GROUP MOISTURE
C  EFE   H-P EFFICIENCY BEFORE CORRECTIONS HAVE ALL BEEN INCLUDED
C  NHP   NUMBER OF H-P SECTION EXHAUST ENDS
C  QVN   INLET VOLUME FLOW PER END
C  TFR   THROTTLE FLOW RATIO
C  VEL   THEORETICAL VELOCITY CORRESPONDING TO STAGE AE
C  BE3S   BASE EFFICIENCY OF H-P SECTION FROM F3
C  EFFY   H-P EFFICIENCY AFTER ALL CORRECTIONS
C  TEMP   AN EFFICIENCY TEMPORARILY STORED UNTIL CONVERGENCE CHECK
C  PRATIO   PRESSURE RATIO AT PART LOAD
      FIG6(TFR)=8.5D0-(0.9D0)/(1.2D0-TFR)
      COMMON /CONV/HCON,UERCON,AMCON,RHCON,WCON,PCON,SSRCON,XSPCON
      COMMON /GS/QGS,HBGS,PBGS, ABGS,SBGS,VBGS,TBGS,PXGS, AXGS,SXGS,
     *VXGS,TXGS,HXGS,PDGS,      MBGS,MXGS,NCGS,       NGS
     *          ,QT,PT,TT, AT,HT
      COMMON /HP/QBHP,PBHP,TBHP,AMBHP,HBHP,SBHP,QXHP,TXHP,AMXHP,HXHP,
     *SXHP,UEEPHP
      COMMON /PAR2/PSH(12),TSH(12),TO(12),TTD(12),PXHP,PXIP
      COMMON /XX2/ NHP, IR  , WLP,                NPH, NPL, IH2
      COMMON /XX3/ AL,HL,PL,SL,TL,VL
      COMMON /Z/ TFR,SLOPE,QTKEEP,PKEEP,QGKEEP,PGKEEP,VGKEEP,GCKEEP,DUM
      DATA PI/3.14159265400/, XJOULE/778.16926200/, GRAV/32.174048600/
C-----THROTTLE CONDITIONS
C       AT         HT          MT          PT         ST         TT          VT
      HBGS=HT
      IF(TFR.LT.1.D0)Q=QGKEEP
      IF(TFR.GE.1.D0)Q=QGS
C-----VWO G-S BOWL CONDITIONS
C       ABGSO      HBGSO      MBGSO      PBGSO      SBGSO      TBGSO      VBG
      PBGSO=PT    *(1.D0-FIG6(1.D0)/100.D0)
      HBGSO=HT
      CALL PROPPH(ABGSO,SBGSO,VBGSO,TBGSO,MBGSO,PBGSO,HBGSO)
      QVN = Q * VBGSO/NHP
      W = PI * PDGS * IR /12.D0 / 60.D0
      VEL = W / .5D0
      AE = VEL * VEL / 2.D0 / GRAV / XJOULE
C-----VWO ISENTROPIC SHELL G-S
C       AXSGSO     HXSGSO     MXSGSO     PXSGSO     SXSGSO     TXSGSO     VXS
      HXSGSO=HBGSO-AE
      SXSGSO=SBGSO
      CALL PROPHS(PXSGSO,TXSGSO,VXSGSO,AXSGSO,MXSGSO,HXSGSO,SXSGSO)
```

```
C-----G-S BOWL RATED LOAD POINT
C        ABGS      HBGS      MBGS      PBGS      SBGS      TBGS      VBG
C-----TWO ISENTROPIC EXHAUST H-P
C        AXSHPO    HXSHPO    MXSHPO    PXSHPO    SXSHPO    TXSHPO    VXSHP
      IF(TPR.GE. 1.D0) PXSHPO = PXHP
      SXSHPO=SXSGSO
      CALL PROPPS(AXSHPO,HXSHPO,TXSHPO,VXSHPO,MXSHPO,PXSHPO,SXSHPO)
      PR=PBGSO/PXSHPO
C-----H-P ISENTROPIC EXHAUST RATED LOAD
C        AXSHP     HXSHP     MXSHP     PXSHP     SXSHP     TXSHP     VXSH
      PXSHP=PXHP
      SXSHP=SBGS
      CALL PROPPS(AXSHP,HXSHP,TXSHP,VXSHP,MXSHP,PXSHP,SXSHP)
      BEGS=F3(QTW,PR)
      C1=F1A(W,PXSHPO,PBGSO)
      EPE=BEGS*C1
      C2=F1B(TPR,PR)
      C3=F1C(W,TPR)
      EPE=BEGS*C1*C2*C3
      PRATIO=PBGS/PXSHP
      EFFY=EPE
      JJ=0
  612 CONTINUE
      CALL CROSS(HBGS,SBGS,PRATIO,EFFY,AGM)
      TEMP=EFFY
      C4=F2(AGM,PBGS)
      EFFY=EPE*C4
      IF(DABS(TEMP-EFFY).LE..5D-4) GO TO 611
      JJ=JJ+1
      IF(JJ.LT.20) GO TO 612
  611 CONTINUE
C-----ELEP RATED LOAD
C        AXHP      HXHP      MXHP      PXHP      SXHP      TXHP      VXH
      HXHP=HBGS-EFFY*(HBGS-HXSHP)
      CALL PROPPH(AXHP,SXHP,VXHP,TXHP,MXHP,PXHP,HXHP)
C-----G-S SHELL RATED LOAD POINT
      PXGS=PXSGSO*TPR
      IF(TPR.EQ. 1.0D0) GO TO 601
      J=0
      JJJ=0
  610 CALL STRATE(PXGS,HBGS,SBGS,HXHP,SXHP,HXGS,SXGS)
      CALL PROPPS(AXGS,HXGS,TXGS,VXGS,MXGS,PXGS,SXGS)
      JJJ=JJJ+1
      TEMP=PXGS
      PXGS=PGKEEP*(QBHP/QGKEEP)*DSQRT(PXGS*VXGS)/DSQRT(PGKEEP*VGKEEP)
      IF(DABS(PXGS-TEMP).LE..002) GO TO 602
      IF(JJJ.LT.50) GO TO 610
  602 SLOPEG=(HXGS-HXHP)/(SXGS-SXHP)
  600 CONTINUE
      J=J+1
      SXGS=SXHP+(SXGS-SXHP)*SLOPEG/SLOPE
      CALL PROPPS(AXGS,HXGS,TXGS,VXGS,MXGS,PXGS,SXGS)
      SLOPEG=(HXGS-HXHP)/(SXGS-SXHP)
      IF(J.EQ.50) GO TO 601
      IF(DABS((SLOPEG-SLOPE)/SLOPE).LT. 1.D-5) GO TO 601
      GO TO 600
  601 CONTINUE
      IF(TPR.EQ. 1.D0)
     *CALL STRATE(PXGS,HBGS,SBGS,HXHP,SXHP,HXGS,SXGS)
      CALL PROPPS(AXGS,HXGS,TXGS,VXGS,MXGS,PXGS,SXGS)
      IF(TPR.EQ. 1.D0)GO TO 631
      IF((MXGS.LT.3).OR.(MXHP.GT.1))GO TO 631
      K = 0
      PTOP = PXGS
      PBOT = PXHP
      GO TO 605
  604 IF(HL.LT.HINT)PTOP=PINT
      IF(HINT.LT.HL)PBOT=PINT
```

```
605  PL=(PTOP+PBOT)/2.D0
     K = K + 1
     CALL F12AC(PL,HXGS,SXGS,HXHP,SXHP,HINT,SINT)
     CALL PROPHS(PINT,TINT,VINT,AINT,MINT,HINT,SINT)
     TL=TSL(PL)
     HL=HPS(PL,SPTD(PL,TL))
     CALL PROPPH(AL,SL,VL,TL,ML,PL,HL)
     DELTAH=DABS(HL-HINT)
     IF(DELTAH.LE.HCON) GO TO 631
     IF(K.LT.100) GO TO 604
631  CONTINUE
     RETURN
     END
```

```
C
      SUBROUTINE HXTRAC(MR,I1,I2,MBLP,HBLP,SBLP,MXLP,HXLP,SXLP,PIL,HIL,
     1SIL,PX,UEEP)
      IMPLICIT REAL*8(A-H,O-Z)
C
C SUBPROGRAM  FOR FW HEATER EXTRACTION STEAM ENTHALPY
C
C  HE       EXTRACTION STEAM ENTHALPY
C  MR       NUMBER OF MOISTURE REMOVAL STAGES
C  PE       EXTRACTION STEAM PRESSURE
C  PX       TURBINE SECTION EXHAUST PRESSURE
C  HAMR     ENTHALPY AFTER MOISTURE REMOVAL
C  HBMR     ENTHALPY BEFORE MOISTURE REMOVAL
C  HXLP     EXPANSION LINE END POINT, L-P
C  MBLP     =1 BOWL CONDITIONS WET, =2 SAT. VAP., =3 SUPER. VAP.
      COMMON /HX1/PE(12),PMR(5)
      COMMON /HX2/HE(12),HE1(12),HAMR(5),HBMR(5),SAMR(5),SBMR(5),PCWD(5)
      COMMON /XS3/QSI,HSI,TSX,QSX,HSX,AMSX,EMS,MS
C
C  TEST FOR PRESENCE OF MOISTURE REMOVAL STAGES
C-----NOTE:  MAIN CALLS HXTRAC WITH MR=0 FOR H-P TURBINE SECTION
      IF(MR.GT.0) GO TO 4100
C  NO MOISTURE REMOVAL STAGES PRESENT
      DO 4060 I=I1,I2
      IF(PE(I).GT.(PX+1.0)) GO TO 3990
      IF(MS.EQ.0)HE(I)=UEEP
      IF(MS.GT.0)HE(I)=HSX
      GO TO 4050
 3990 IF(MBLP.EQ.3) GO TO 4000
C     BOWL WET OR SATURATED VAPOR
      CALL F12AC (PE(I),HBLP,SBLP,HXLP,SXLP,HE(I),SE)
      GO TO 4050
C     BOWL SUPERHEATED
 4000 IF(MXLP.EQ.1) GO TO 4010
      CALL F12B  (PE(I),HBLP,SBLP,HXLP,SXLP,HE(I),SE)
      GO TO 4050
 4010 IF(PE(I).LT.PIL) GO TO 4040
      CALL F12B  (PE(I),HBLP,SBLP,HIL,SIL,HE(I),SE)
      GO TO 4050
 4040 CALL F12AC (PE(I),HIL,SIL,HXLP,SXLP,HE(I),SE)
 4050 HE1(I)=HE(I)
 4060 CONTINUE
      RETURN
C
C  MOISTURE REMOVAL STAGES PRESENT
 4100 DO 4200 I=I1,I2
      IF(PE(I).GT.(PX+1.0)) GO TO 4110
      HE(I)=UEEP
      GO TO 4195
```

```
4110 DO 4190 J=1,MR
     IF(PE(I).GT.(PMR(J)+1.0).OR.PE(I).LT.(PMR(J)-1.0)) GO TO 4120
     HE(I)=HAMR(J)
     HE1(I)=HBMR(J)
     GO TO 4200
4120 IF(PE(I).GT.PMR(J)) GO TO 4130
     IF(J.LT.MR) GO TO 4190
     HB=HAMR(J)
     SB=SAMR(J)
     HX=HXLP
     SX=SXLP
     GO TO 4180
4130 IF(J.EQ.1) GO TO 4140
     HB=HAMR(J-1)
     SB=SAMR(J-1)
     GO TO 4170
4140 IF(MBLP.EQ.3) GO TO 4150
     HB=HBLP
     SB=SBLP
     GO TO 4170
4150 IF(PE(I).GT.PIL) GO TO 4160
     HB=HIL
     SB=SIL
     GO TO 4170
4160 CALL P12B  (PE(I),HBLP,SBLP,HIL,SIL,HE(I),SE)
     GO TO 4195
4170 HX=HBMR(J)
     SX=SBMR(J)
4180 CALL P12AC (PE(I),HB,SB,HX,SX,HE(I),SE)
     GO TO 4195
4190 CONTINUE
4195 HE1(I)=HE(I)
4200 CONTINUE
     RETURN
     END
```

```
C
      SUBROUTINE INDEX(I1,I2,NFLP,MR)
      IMPLICIT REAL*8(A-H,O-Z)
C SUBPROGRAM  FOR CALCULATING INDICES FOR LP TURBINE
C  I   FEEDWATER HEATER NUMBER
C  L   MOISTURE REMOVAL POINT NUMBER
C  I1  FIRST FEEDWATER HEATER FED FROM L-P TURBINE
C  I2
C  J1(I)     TOTAL NO. OF FW HEATER EXTRACTION AND MOISTURE REMOVAL
C            EXTRACTION POINTS THAT COINCIDE, TO AND INCLUDING FW HEATER
C            EXTRACTION POINT 'I'
C  L1(I)     FIRST MOISTURE REMOVAL EXTRACTION POINT THAT FEEDS FW HTR 'I'
C  L2(I)     LAST MOISTURE REMOVAL EXTRACTION POINT THAT FEEDS FW HTR 'I'
C  MR        NUMBER OF MOISTURE REMOVAL STAGES IN L-P TURBINE
C  NN   I2-1
C  PE        EXTRACTION STAGE PRESSURE
C  IMR(L)    MOISTURE REMOVAL POINT NUMBER L DRAINS TO FEEDWATER HEATER
C            NUMBER IMR(L)
C  JJ1
C  LL1
C  LL2
C  PMR       MOISTURE REMOVAL STAGE PRESSURE
C  NFLP      NUMBER OF FEEDWATER HEATERS FED FROM L-P TURBINE
C            IF L1(I)=1 AND L2(I)=0, THEN NO MOISTURE REMOVAL EXTRACTION
```

```
C         POINTS FEED TO FW HEATER 'I'
      COMMON /HX1/PE(12),PHR(5)
      COMMON /IN/L1(13),L2(13),J1(13),INR(5)
      INR(1)=0
      INR(2)=0
      INR(3)=0
      INR(4)=0
      INR(5)=0
      JJ1=0
      LL1=0
      LL2=0
      IF(NPLP.EQ.0) GO TO 2750
      NN=I2-1
      DO 2740 I=I1,NN
      LL1=LL2+1
      IF(LL1.GT.NR) GO TO 2730
      DO 2710 L=LL1,NR
      IF(PHR(L).LT.(PE(I)-1.0)) GO TO 2730
      INR(L)=I
      LL2=L
      IF(PHR(L).LT.(PE(I)+1.0).AND.PHR(L).GT.(PE(I)-1.0)) GO TO 2720
 2710 CONTINUE
      GO TO 2730
 2720 JJ1=JJ1+1
 2730 J1(I)=JJ1
      L1(I)=LL1
      L2(I)=LL2
 2740 CONTINUE
 2750 J1(I2)=JJ1
      L1(I2)=LL2+1
      L2(I2)=NR
      RETURN
      END
```

```
C
      SUBROUTINE LAGRAN(X,T,F,Z,NPOINT,NORDER,I)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION T(30),F(30),P(30),PNUM(30),PDENOM(30)
C     ADJUSTING NPOINT AND NORDER FOR USE IN DO LOOPS
      NPTI = NPOINT - 1 + I
      NORDI = NORDER - 1 + I
      Z = 0.0
      DO 1 J=I,NPTI
      PNUM(J) = X - T(J)
    1 P(J)=1.0
      DO 2 K=I,NPTI
      DO 3 N=I,NORDI
      IF (K - N) 20,20,10
   10 P(K) = P(K)*PNUM(N)/(T(K) - T(N))
      GO TO 3
   20 P(K) = P(K)*PNUM(N+1)/(T(K) - T(N+1))
    3 CONTINUE
    2 Z=Z+P(K)*F(K)
      RETURN
      END
```

```
C
      SUBROUTINE PART
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /GS/QGS,HBGS,PBGS, ABGS,SBGS,VBGS,TBGS,PXGS, AXGS,SXGS,
     *VXGS,TXGS,HXGS,PDGS,      MBGS,MXGS,NCGS,      NGS
     *          ,QT,PT,TT, AT,HT
      COMMON /Z/ TFR,SLOPE,QTKEEP,PKEEP,QGKEEP,PGKEEP,VGKEEP,GCKEEP,DUME
      FIG6(TFR)=8.5D0-(0.9D0)/(1.2D0-TFR)
      PFIRST=PT*(1.D0-FIG6(.60D0)/100.D0)
      HFIRST=HT
      CALL PROPPH(AFIRST,SFIRST,VFIRST,TFIRST,MFIRST,PFIRST,HFIRST)
C-----FIRST GUESS OF PBGS
      JJJ=0
      PBGS=PFIRST*TFR/.6D0
      HBGS=HFIRST
  610 CALL PROPPH(ABGS,SBGS,VBGS,TBGS,MBGS,PBGS,HBGS)
      TEMP=PBGS
      PBGS=PFIRST*(TFR/.6D0)*
     *             DSQRT(PBGS*VBGS)/DSQRT(PFIRST*VFIRST)
      JJJ=JJJ+1
      IF(DABS(PBGS-TEMP).LE..002) GO TO 611
      IF(JJJ.LT.50) GO TO 610
  611 RETURN
      END
```

```
C
      SUBROUTINE PRDROP(PXHP,PBLP,    NRH)
      IMPLICIT REAL*8(A-H,O-Z)
C SUBPROGRAM  FOR INTERMEDIATE SYSTEM PRESSURE DROP
C  (TABLE III, P. 16, GET-6020)
C  PIV      PRESSURE AT INTERMEDIATE VALVES
C  PSI      SEPARATOR INLET PRESSURE
C  PSX      SEPARATOR OUTLET PRESSURE
C  PBLP     L-P TURBINE BOWL PRESSURE
C  PFPT     FEED PUMP TURBINE BOWL PRESSURE
C  PXHP     H-P TURBINE EXHAUST PRESSURE
C  PIRH1    INLET REHEATER NO. 1 PRESSURE
C  PIRH2    INLET REHEATER NO. 2 PRESSURE
C  PXRH1    OUTLET REHEATER NO. 1 PRESSURE
C  PXRH2    OUTLET REHEATER NO. 2 PRESSURE
      COMMON /RH1/PXRH2,PIRH2,PXRH1,PIRH1,PFPT
      COMMON /XS1/PSX,PSI
      DATA A/.7D0/
      DATA B1/1.9D0/, B2/1.1D0/, B3/1.1D0/
      DATA C2/1.8D0/, C3/1.3D0/
      DATA D3/1.5D0/, E/1.1D0/, F/3.3D0/
C  MOISTURE SEPARATOR
      PIV=PBLP/(1.-F/100.)
      IF(NRH.NE.0) GOTO 40
C  MOISTURE SEPARATOR, NO REHEATER
      PSX=PIV/(1.-E/100.)
      PFPT=(15.*PBLP-2.*PSX  )/13.
      PSI=PSX/(1.-B1/100.)
      PXHP=PSI/(1.-A/100.)
      RETURN
   40 IF(NRH.GT.1) GOTO 50
C  MOISTURE SEPARATOR, 1-STAGE REHEATER
      PXRH1=PIV/(1.-E/100.)
      PFPT=(15.*PBLP-2.*PXRH1)/13.
      PIRH1=PXRH1/(1.-C2/100.)
      PSX=PIRH1
      PSI=PSX/(1.-B2/100.)
      PXHP=PSI/(1.-A/100.)
      RETURN
```

```
C  MOISTURE SEPARATOR, 2-STAGE REHEATER
50 PXRH2=PIV/(1.-E/100.)
      PPPT=(15.*PBLP-2.*PXRH2)/13.
      PIRH2=PXRH2/(1.-D3/100.)
      PXRH1=PIRH2
      PIRH1=PXRH1/(1.-C3/100.)
      PSX=PIRH1
      PSI=PSX/(1.-B3/100.)
      PIHP=PSI/(1.-A/100.)
      RETURN
      END
```

```
C
      SUBROUTINE PROPHS(P,T,V,A,M,H,S)
      IMPLICIT REAL*8 (A-H,O-Z)
      P=PHS(H,S)
      CALL PROPPS(A,H,T,V,M,P,S)
      RETURN
      END
```

```
C
      SUBROUTINE PROPPH(A,S,V,T,M,P,H)
      IMPLICIT REAL*8(A-H,O-Z)
      DATA TC/705.47D0/, PCA/3208.234759D0/
      S=SSSISS(P,H,T,V,X)
      A=1.D0-X
      IF((P.GE.PCA).OR.(T.GE.TC)) GO TO 1
      IF(S.GT.SGP(P))  M=3
      IF(S.EQ.SGP(P))  M=2
      IF(S.LT.SGP(P))  M=1
      RETURN
    1 CONTINUE
      M=3
      RETURN
      END
```

```
C
C  REVISION  10-20-77
      SUBROUTINE PROPPS(A,H,T,V,M,P,S)
      IMPLICIT REAL*8(A-H,O-Z)
      H=HSSISS(P,S,T,V,X)
      DATA TC/705.47D0/, PCA/3208.234759D0/
      A=1.D0-X
      IF((P.GE.PCA).OR.(T.GE.TC)) GO TO 1
      IF(S.GT.SGP(P))  M=3
      IF(S.EQ.SGP(P))  M=2
      IF(S.LT.SGP(P))  M=1
      RETURN
    1 CONTINUE
      M=3
      RETURN
      END
```

```
C
      SUBROUTINE RATFUN(A,B,X,Z,I,J)
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION A(10),B(5)
      ZNUM = 0.0
      ZDENOM = 0.0
      I1 = I + 2
      J1=J + 1
      DO 1 N=1,I
      ZNUM = ZNUM*X
    1 ZNUM = ZNUM + A(I1-N)
      ZNUM = ZNUM *X + A(1)
      DO 2 M=1,J
      ZDENOM = ZDENOM*X
    2 ZDENOM = ZDENOM + B(J1-M)
      ZDENOM = ZDENOM*X + 1.
      Z = ZNUM/ZDENOM
      RETURN
      END
```

```
C
      SUBROUTINE REHEAT(HE,PE,HT,PT)
      IMPLICIT REAL*8 (A-H,O-Z)
C SUBPROGRAM  FOR REHEATER PARAMETERS
      COMMON /RH1/PXRH2,PIRH2,PXRH1,PIRH1,PPPT
      COMMON /RH2/QRH1,HCRH1,QRH2,HCRH2,NRH,NDRH1,NDRH2
      COMMON /RH3/TTDRH1,TTDRH2,HRH1,HRH2,PCRH1,TCRH1,PCRH2,TCRH2,TXRH1,
     1HXRH1,TXRH2,HXRH2,HIRH2,HIRH1,QRH
      DATA IW/6/
C  1ST STAGE
      IF(NRH.EQ.1) GOTO 110
      HRH1=HE
      PCRH1=PE*(1.D0-.03D0)*(1.D0-.007D0)*(1.D0-.008D0)
      GOTO 120
  110 HRH1=HT
      PCRH1=PT*(1.D0-.007D0)*(1.D0-.008D0)
  120 TCRH1= TSL(PCRH1)
      HCRH1= HPT(TCRH1)
      TXRH1=TCRH1-TTDRH1
      T1= TSL(PXRH1)
      IF(TXRH1.GE.T1) GOTO122
      TXRH1=T1
      TTDRH1=TXRH1-TCRH1
      WRITE(IW,121) TTDRH1
  121 FORMAT('0',T10,'THERE IS A DATA ERROR IN SUBROUTINE REHEAT.'/
     1T10,'REHEATER TERMINAL TEMPERATURE DIFFERENCE HAS BEEN CHANGED TO'
     2,F10.2)
  122 HXRH1=HPS(PXRH1,SPTD(PXRH1,TXRH1))
      IF(NRH.EQ.1) GOTO130
C  2ND STAGE
      HRH2=HT
      PCRH2=PT*(1.D0-.007D0)*(1.D0-.008D0)
      TCRH2= TSL(PCRH2)
      HCRH2= HPT(TCRH2)
      TXRH2=TCRH2-TTDRH2
      T2= TSL(PXRH2)
      IF(TXRH2.GE.T2) GOTO124
      TXRH2=T2
      TTDRH2=TXRH2-TCRH2
      WRITE(IW,121) TTDRH2
  124 HXRH2=HPS(PXRH2,SPTD(PXRH2,TXRH2))
      HIRH2=HXRH1
  130 RETURN
      END
```

```
C
      SUBROUTINE RESULT(VERS)
      IMPLICIT REAL*8(A-H,O-Z)
C   THIS SUBPROGRAM PRINTS THE CALCULATED RESULTS
      COMMON /BLCK/AMBMP(5),AMAMR(5),TMR(6),MP,IDUM
     *             ,QBLP,PBLP,TBLP,AMBLP,HBLP,SBLP,QXLP,PXLP,TXLP,AMXLP,
     *HXLP,SXLP,UEEPLP
     *             ,CMTS(18),       TC,TPP,TR,HR,WRATE,GC,WML,WGL,QMU,OPP,
     *DP,WGEN,WFWP,HTRTN,HTRTG,CEFFN,CEFFG,PC
      COMMON /PPT/QPPT,PBPPT,HBPPT,PXPPT,HXPPT,IPPT
      COMMON /PWH/HAEI,HAEO,QR,QPS(20),HPS(20),HES(20),QMP(5),HMP(5),
     *QMG(5),HMG(5),QD(12),QP(12),QE(12),QCR,HCR,QRO,QC,I1LP,I
      COMMON /GS/QGS,HBGS,PBGS, ABGS,SBGS,VBGS,TBGS,PXGS, AXGS,SXGS,
     *VXGS,TXGS,HXGS,PDGS,      MBGS,MXGS,NCGS,       NGS
     *             ,QT,PT,TT, AT,HT
      COMMON /HP/QBHP,PBHP,TBHP,AMBHP,HBHP,SBHP,QXHP,TXHP,AMXHP,HXHP,
     *SXHP,UEEPHP
      COMMON /HX1/PE(12),PMR(5)
      COMMON /HX2/HE(12),HE1(12),HAMP(5),HBMR(5),SAMR(5),SBMR(5),PCWD(5)
      COMMON /IN/L1(13),L2(13),J1(13),IMR(5)
      COMMON /LEAK/QLK1,HLK1,QLK2,HLK2,QLK3,HLK3,QLK4,HLK4,QLK5,HLK5,
     *QLK6,HLK6,QLK7,HLK7,QLK8,HLK8,QLK9,HLK9,QLK10,HLK10,LK,LK1,LK3,
     *LK5,LK7,LK9
      COMMON /PAR1/HO(12),HI(12),QAE,HC,HFP,DHP,TI(12),TD(12),TDCA(12),
     *HD(12),PLA,PLB,ND(12),NDC(12),IP,NP
      COMMON /PAR2/PSH(12),TSH(12),TO(12),TTD(12),PXHP,PXIP
      COMMON /RH1/PXRH2,PIRH2,PXRH1,PIRH1,PFPT
      COMMON /RH2/QRH1,HCRH1,QRH2,HCRH2,NRH,NDRH1,NDRH2
      COMMON /RH3/TTDRH1,TTDRH2,HRH1,HRH2,PCRH1,TCRH1,PCRH2,TCRH2,TXRH1,
     *HXRH1,TXRH2,HXRH2,HIRH2,HIRH1,QRH
      COMMON /SSR/QSPE,QMC,QSSP,HSSR,PSSR,QPWH,QSSRMU,HSSRMU
      COMMON /XS1/PSX,PSI
      COMMON /XS2/HFSX,QMR
      COMMON /XS3/QSI,HSI,TSX,QSX,HSX,AMSX,EMS,MS
      COMMON /Z/ TPR,SLOPE,QTKEEP,PKEEP,QGKEEP,PGKEEP,VGKEEP,GCKEEP,DUMZ
      DATA CPSI/2.036022340D0/
      NPAGE=1
      PRINT 100,(CMTS(K),K=1,18),VERS,NPAGE
  100 FORMAT('1',T10,18A4/
     *' ',T10,'STEAM TURBINE CYCLE HEAT BALANCE'/
     *' ',T10,'ORCENT, VERSION ',A8/
     *'0',T10,'CALCULATED RESULTS, PAGE',I3////)
      PRINT 110,HTRTN,CEFFN,HTRTG,CEFFG,WGEN
  110 FORMAT('0',T10,'TABLE I  OVERALL PERFORMANCE'/
     *'0',T10,'NET TURBINE CYCLE HEAT RATE, BTU/KW-HR',T60,F8.0/
     *' ',T10,'NET TURBINE CYCLE EFFICIENCY, PER CENT',T60,F10.2/
     *'0',T10,'GROSS TURBINE CYCLE HEAT RATE, BTU/KW-HR',T60,F8.0/
     *' ',T10,'GROSS TURBINE CYCLE EFFICIENCY, PER CENT',T60,F10.2/
     *'0',T10,'GENERATOR OUTPUT, MWE',T60,F11.3)
      IF(IPPT.EQ.0)GOTO112
      WG=WGEN+WFWP*0.001D0
      PRINT 111,WFWP,WG
  111 FORMAT('0',T10,'POWER REQUIRED BY TURBINE-DRIVEN FW PUMP, MW',
     *T60,-3PF11.3/
     *' ',T10,'GENERATOR OUTPUT PLUS FW PUMP POWER, MW',T60,0PF11.3)
      GOTO114
  112 WG=WGEN-WFWP*0.001D0
      PRINT 113,WFWP,WG
  113 FORMAT('0',T10,'POWER REQUIRED BY MOTOR-DRIVEN FW PUMP, MW',
     *T60,-3PF11.3/
     *' ',T10,'GENERATOR OUTPUT MINUS FW PUMP POWER, MWE',T60,0PF11.3)
  114 PRINT 115,WML,WGL
  115 FORMAT('0',T10,'MECHANICAL LOSSES, KW',T60,F8.0/
     *' ',T10,'GENERATOR LOSSES, KW',T60,F8.0)
      NPAGE=NPAGE+1
      PRINT 100,(CMTS(K),K=1,18),VERS,NPAGE
      PRINT 120
  120 FORMAT('0',T10,'TABLE II  TURBINE EXPANSION LINE'/
     *'0',T50,'STEAM FLOW    PRESSURE    TEMPERATURE    MOISTURE     ENTH
     *ALPY    ENTROPY'/
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```
   *' ',T50,' LB/HR          PSIA             F            PER CENT     BTU
   */LB     BTU/LB-F')
    PRINT 130,QT,PT,TT,AT ,HT,
   *QGS,PBGS,TBGS, ABGS,HBGS,SBGS,
   *QGS,PIGS,TIGS, AIGS,HIGS,SIGS
130 FORMAT('0',T10,'TURBINE THROTTLE',
   *T50,F10.0,F12.1,F12.1,F14.2,F12.1/
   *' ',T10,'GOVERNING STAGE BOWL',
   *T50,F10.0,F12.1,F12.1,2PF14.2,0PF12.1,F12.4/
   *' ',T10,'GOVERNING STAGE SHELL',
   5T50,F10.0,F12.1,F12.1,2PF14.2,0PF12.1,F12.4)
    WRITE(6,140) QXHP,PXHP,TXHP,AMXHP,HXHP,SXHP,
   2PXHP,UEEPHP
140 FORMAT(' ',T10,'HP SECTION ELEP',
   *T50,F10.0,F12.1,F12.1,2PF14.2,0PF12.1,F12.4/
   *' ',T10,'HP SECTION UEEP',
   *T60,F12.1,T98,F12.1)
139 IF(MS.EQ.0)GOTO151
    PRINT 150,QSI,PSI,HSI,
   *QSX,PSX,TSX,AMSX,HSX
150 FORMAT(' ',T10,'EXTERNAL MOISTURE SEPARATOR INLET',
   *T50,F10.0,F12.1,T98,F12.1/
   *' ',T10,'EXTERNAL MOISTURE SEPARATOR OUTLET',
   *T50,F10.0,F12.1,F12.1,2PF14.2,0PF12.1)
151 CONTINUE
160 IF(NRH.EQ.0) GOTO181
    PRINT 170,QRH,PIRH1,HIRH1,
   *QRH,PXRH1,TXRH1,HXRH1
170 FORMAT(' ',T10,'1ST STAGE REHEATER INLET',
   *T50,F10.0,F12.1,T98,F12.1/
   *' ',T10,'1ST STAGE REHEATER OUTLET',
   *T50,F10.0,F12.1,F12.1,T98,F12.1)
    IF(NRH.LT.2) GOTO181
    PRINT 180,QRH,PIRH2,HIRH2,
   *QRH,PXRH2,TXRH2,HXRH2
180 FORMAT(' ',T10,'2ND STAGE REHEATER INLET',
   *T50,F10.0,F12.1,T98,F12.1/
   *' ',T10,'2ND STAGE REHEATER OUTLET',
   *T50,F10.0,F12.1,F12.1,T98,F12.1)
181 CONTINUE
    PRINT 200,QBLP,PBLP,TBLP,AMBLP,HBLP,SBLP
200 FORMAT(' ',T10,'LP SECTION BOWL',
   *T50,F10.0,F12.1,F12.1,2PF14.2,0PF12.1,F12.4)
    IF(MR.EQ.0)GOTO230
    DO220 L=1,MR
    PRINT 210,L,PMR(L),TMR(L),AMBMR(L),HBMR(L),SBMR(L),
   *L,PMR(L),TMR(L),AMAMR(L),HAMR(L),SAMR(L)
210 FORMAT(' ',T10,'BEFORE MOISTURE REMOVAL NO.',I2,
   1T60,F12.1,F12.1,2PF14.2,0PF12.1,F12.4/
   2' ',T10,'AFTER MOISTURE REMOVAL NO.',I2,
   3T60,F12.1,F12.1,2PF14.2,0PF12.1,F12.4)
220 CONTINUE
230 PRINT 240,QXLP,PXLP,TXLP,AMXLP,HXLP,SXLP,
   1PXLP,UEEPLP
240 FORMAT(' ',T10,'LP SECTION ELEP',
   1T50,F10.0,F16.5, F8.1,2PF14.2,0PF12.1,F12.4/
   2' ',T10,'LP SECTION UEEP',
   3T60,F16.5,T98,F12.1)
    NPAGE=NPAGE+1
    PRINT 100,(CMTS(K),K=1,18),VERS,NPAGE
    IF(QAB.GT.1.0)GOTO260
    PRINT 250
250 FORMAT('0',T10,'TABLE III   THERE IS NO STEAM JET AIR EJECTOR')
    GOTO275
260 PRINT 270,QAB,HABI,HABO
270 FORMAT('0',T10,'TABLE III   STEAM JET AIR EJECTOR'/
   1'0',T10,'STEAM FLOW, LB/HR',T40,F10.0/
   2' ',T10,'STEAM ENTHALPY IN, BTU/LB',T40,F11.1/
   3' ',T10,'STEAM ENTHALPY OUT, BTU/LB',T40,F11.1)
275 CONTINUE
    IF(MS.GT.0)GOTO290
    PRINT 280
```

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280 FORMAT('0',T10,'TABLE IV  THERE IS NO EXTERNAL MOISTURE SEPARATOR'
   1)
    GOTO350
290 IF(MS.LE.NF) GOTO 310
    PRINT 300
300 FORMAT('0',T10,'TABLE IV  EXTERNAL MOISTURE SEPARATOR DRAINS TO CO
   1NDENSER')
    GOTO 330
310 PRINT 320,MS
320 FORMAT('0',T10,'TABLE IV  EXTERNAL MOISTURE SEPARATOR DRAINS TO FW
   1 HEATER NO.',I2)
330 PRINT 340,QMR,PSX,TSX,HPSX
340 FORMAT('0',T10,'DRAIN FLOW, LB/HR',T33,F10.0/
   1' ',T10,'DRAIN PRESSURE, PSIA',T33,F11.1/
   2' ',T10,'DRAIN TEMPERATURE, F',T33,F11.1/
   3' ',T10,'DRAIN ENTHALPY, BTU/LB',T33,F11.1)
350 CONTINUE
    IF(NRH.GT.0) GOTO 370
    IF(NRH.EQ.0) GOTO 359
    PRINT 358
358 FORMAT('0',T10,'TABLE V  EXTERNAL REHEATER, SEE TABLE II')
    GOTO400
359 PRINT 360
360 FORMAT('0',T10,'TABLE V  THERE IS NO REHEATER')
    GOTO400
370 PRINT 380,NDRH1,QRH1,HRH1,PCRH1,TCRH1,HCRH1
380 FORMAT('0',T10,'TABLE V  LIVE STEAM REHEATER'/
   1'0',T10,'1ST STAGE DRAINS TO FW HEATER NO.',I2/
   2' ',T10,'1ST STAGE STEAM FLOW, LB/HR',T43,F10.0/
   3' ',T10,'1ST STAGE STEAM ENTHALPY, BTU/LB',T43,F11.1/
   4' ',T10,'1ST STAGE PRESSURE, PSIA',T43,F11.1/
   5' ',T10,'1ST STAGE DRAIN TEMPERATURE, F',T43,F11.1/
   5' ',T10,'1ST STAGE DRAIN ENTHALPY, BTU/LB',T43,F11.1)
    IF(NRH.EQ.1) GOTO400
    PRINT 390,NDRH2,QRH2,HRH2,PCRH2,TCRH2,HCRH2
390 FORMAT('0',T10,'2ND STAGE DRAINS TO FW HEATER NO.',I2/
   1' ',T10,'2ND STAGE STEAM FLOW, LB/HR',T43,F10.0/
   2' ',T10,'2ND STAGE STEAM ENTHALPY, BTU/LB',T43,F11.1/
   3' ',T10,'2ND STAGE PRESSURE, PSIA',T43,F11.1/
   4' ',T10,'2ND STAGE DRAIN TEMPERATURE, F',T43,F11.1/
   5' ',T10,'2ND STAGE DRAIN ENTHALPY, BTU/LB',T43,F11.1)
400 CONTINUE
    IF(MR.GT.0)GOTO420
    PRINT 410
410 FORMAT('0',T10,'TABLE VI  THERE ARE NO MOISTURE REMOVAL STAGES')
    GOTO440
420 PRINT 428
428 FORMAT('0',T10,'TABLE VI  MOISTURE REMOVAL STAGES')
    PRINT 429,(L,L=1,MR)
429 FORMAT('0',T10,'MOISTURE REMOVAL STAGE NO.',T36,5(10X,I2,2X))
    PRINT 430,(IMR(L),L=1,MR)
430 FORMAT(' ',T10,'DRAINS TO FW HEATER NO.',T36,5(10X,I2,2X))
    PRINT 431,(PMR(L),L=1,MR)
431 FORMAT(' ',T10,'STAGE PRESSURE, PSIA',T36,5(8X,F6.1))
    PRINT 432,(TMR(L),L=1,MR)
432 FORMAT(' ',T10,'TEMPERATURE, F',T36,5(8X,F6.1))
    PRINT 433,(QMF(L),L=1,MR)
433 FORMAT(' ',T10,'WATER REMOVED, LB/HR',T36,5(5X,F8.0,1X))
    PRINT 434,(HMF(L),L=1,MR)
434 FORMAT(' ',T10,'WATER ENTHALPY, BTU/LB',T36,5(8X,F6.1))
    PRINT 435,(QMG(L),L=1,MR)
435 FORMAT(' ',T10,'STEAM REMOVED, LB/HR',T36,5(5X,F8.0,1X))
    PRINT 436,(HMG(L),L=1,MR)
436 FORMAT(' ',T10,'STEAM ENTHALPY, BTU/LB',T36,5(7X,F7.1))
440 NPAGE=NPAGE+1
    PRINT 100,(CMTS(K),K=1,18),VERS,NPAGE
    IF(NF.GT.0)GOTO460
    PRINT 450
450 FORMAT('0',T10,'TABLE VII  THERE ARE NO FW HEATERS')
    GOTO500
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450 PRINT 470
470 FORMAT('0',T10,'TABLE VII  FW HEATERS')
    N1=1
    N2=NP
    IF(NP.LE.6)GOTO480
    N2=6
480 PRINT 481,(I,I=N1,N2)
481 FORMAT('0',T10,'FW HEATER NO.',T44,6I14)
    PRINT 482,(QF(I),I=N1,N2)
482 FORMAT(' ',T10,'FW FLOW, LB/HR ',T45,6F14.0)
    PRINT 483,(TO(I),I=N1,N2)
483 FORMAT(' ',T10,'FW TEMPERATURE OUT, F',T46,6F14.1)
    PRINT 484,(HO(I),I=N1,N2)
484 FORMAT(' ',T10,'FW ENTHALPY OUT, BTU/LB ',T46,6F14.1)
    PRINT 485,(TI(I),I=N1,N2)
485 FORMAT(' ',T10,'FW TEMPERATURE IN, F',T46,6F14.1)
    PRINT 486,(HI(I),I=N1,N2)
486 FORMAT(' ',T10,'FW ENTHALPY IN, BTU/LB ',T46,6F14.1)
    PRINT 487,(PE(I),I=N1,N2)
487 FORMAT(' ',T10,'EXTRACTION STAGE PRESSURE, PSIA',T46,6F14.1)
    PRINT 488,(QE(I),I=N1,N2)
488 FORMAT(' ',T10,'EXTRACTION STEAM FLOW, LB/HR ',T45,6F14.0)
    PRINT 489,(HE(I),I=N1,N2)
489 FORMAT(' ',T10,'EXTRACTION STEAM ENTHALPY, BTU/LB ',T46,6F14.1)
    PRINT 490,(PSH(I),I=N1,N2)
490 FORMAT(' ',T10,'SHELL PRESSURE, PSIA',T46,6F14.1)
    PRINT 491,(TSH(I),I=N1,N2)
491 FORMAT(' ',T10,'SHELL TEMPERATURE, F',T46,6F14.1)
    PRINT 492,(QD(I),I=N1,N2)
492 FORMAT(' ',T10,'SHELL DRAIN FLOW, LB/HR ',T45,6F14.0)
    PRINT 493,(TD(I),I=N1,N2)
493 FORMAT(' ',T10,'SHELL DRAIN TEMPERATURE, F',T46,6F14.1)
    PRINT 494,(HD(I),I=N1,N2)
494 FORMAT(' ',T10,'SHELL DRAIN ENTHALPY, BTU/LB ',T46,6F14.1)
    IF(N2.EQ.NP)GOTO500
    N1=7
    N2=NP
    GOTO480
500 CONTINUE
    PCI=PC*CPSI
    PRINT 510,PC,PCI,QC,TC,HC
510 FORMAT('0',T10,'TABLE VIII  CONDENSER'/
   1'0',T10,'CONDENSER PRESSURE, PSIA',T41,9X,F10.5,
   2T65,'=',T70,F10.2,T85,'IN. HGA'/
   3' ',T10,'CONDENSATE FLOW, LB/HR',T41,F14.0/
   4' ',T10,'CONDENSATE TEMPERATURE, F',T41,9X,F6.1/
   5' ',T10,'CONDENSATE ENTHALPY, BTU/LB',T41,9X,F6.1)
    NPAGE=NPAGE+1
    PRINT 100,(CMTS(K),K=1,18),VERS,NPAGE
    PRINT 511
511 FORMAT('0',T10,'TABLE IX  CONDENSATE AND FEEDWATER')
    IF(QCR.LT.1.)GOTO519
    PRINT 512,QCR,HCR
512 FORMAT(
   1'0',T10,'CONDENSATE FLOW BY-PASSED TO STEAM GENERATOR, LB/HR',
   2T70,F10.0/
   3' ',T10,'CONDENSATE ENTHALPY BY-PASSED TO STEAM GENERATOR, BTU/LB'
   4,T70,5X,F6.1)
519 PRINT 520,QFP,TFP,HFP,DHP,DP,QR,TR,HR,QMU
520 FORMAT(
   1'0',T10,'FW FLOW TO FW PUMP, LB/HR',T70,F10.0/
   2' ',T10,'FW TEMPERATURE TO FW PUMP, F',T70,5X,F6.1/
   3' ',T10,'FW ENTHALPY TO FW PUMP, BTU/LB',T70,5X,F6.1/
   4' ',T10,'FW ENTHALPY RISE ACROSS FW PUMP, BTU/LB',T70,5X,F6.1/
   5' ',T10,'FW PRESSURE INCREASE ACROSS FW PUMP, PSI',T70,4X,F6.0/
   6'0',T10,'FW FLOW TO STEAM GENERATOR, LB/HR',T70,F10.0/
   7' ',T10,'FW TEMPERATURE TO STEAM GENERATOR, F',T70,5X,F6.1/
   8' ',T10,'FW ENTHALPY TO STEAM GENERATOR, BTU/LB',T70,5X,F6.1/
   9'0',T10,'MAKE-UP TO CONDENSER HOTWELL, LB/HR',T70,F10.0)
    PRINT 521,QRO,HT
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521 FORMAT('0',T10,'STEAM FLOW FROM STEAM GENERATOR, LB/HR',T70,F10.0/
   1' ',T10,'STEAM ENTHALPY FROM STEAM GENERATOR, BTU/LB',T70,4X,F7.1)
    IF(IFPT.LT.1)GOTO528
    PRINT 525,QFPT
525 FORMAT('0',T10,'THROTTLE STEAM FLOW FW PUMP TURBINE, LB/HR',T70,
   1F10.0)
    PXFPTI=PXFPT*CPSI
    PRINT 527,PRFPT,HBFPT,PXFPT,PXFPTI,HXFPT
527 FORMAT(' ',T10,'THROTTLE PRESSURE FW PUMP TURBINE, PSIA',T70,
   1F11.1/
   2' ',T10,'THROTTLE ENTHALPY FW PUMP TURBINE, BTU/LB',T70,F11.1/
   3' ',T10,'EXHAUST PRESSURE FW PUMP TURBINE, PSIA',T70,F15.5,
   4T90,'=',F10.2,T105,'IN. HGA'/
   5' ',T10,'EXHAUST ENTHALPY FW PUMP TURBINE, BTU/LB',T70,F11.1)
528 NPAGE=NPAGE+1
    PRINT 100,(CRPS(K),K=1,18),VERS,NPAGE
    IF(LK.GT.0)GOTO550
    PRINT 540
540 FORMAT('0',T10,'TABLE X   VALVE STEM AND SHAFT LEAKAGES WERE NOT C
   1ALCULATED')
    GOTO600
550 PRINT 560,QSSR,HSSR,QMC,QSPE
560 FORMAT('0',T10,'TABLE X   VALVE STEM AND SHAFT LEAKAGES'/
   1'0',T10,'STEAM SEAL REGULATOR'/
   2' ',T12,'FLOW TO SSR, LB/HR',T65,F8.0/
   3' ',T12,'ENTHALPY AT SSR, BTU/LB',T67,F7.1/
   4' ',T12,'FLOW FROM SSR TO MAIN CONDENSER, LB/HR',T65,F8.0/
   5' ',T12,'FLOW FROM SSR TO STEAM PACKING EXHAUSTER, LB/HR',T65,
   5F8.0)
    IF(NF.EQ.0)GOTO562
    PRINT 561,NF,QFWH
561 FORMAT(' ',T12,'FLOW FROM SSR TO FW HEATER NO.',I3,', LB/HR',T65,
   1F8.0)
552 PRINT 563,QSSRMU,HSSRMU
563 FORMAT(' ',T12,'MAKE-UP FROM THROTTLE STEAM, LB/HR',T65,F8.0/
   1' ',T12,'ENTHALPY OF MAKE-UP STEAM, BTU/LB',T67,F7.1)
    PRINT 570,LK1,QLK1,HLK1,QLK2,HLK2,LK3,QLK3,HLK3,QLK4,HLK4
570 FORMAT('0',T10,'THROTTLE VALVE STEM'/
   1' ',T12,'LEAK NO. 1 (DRAINS TO FW HEATER NO.',I3,'), LB/HR',T65,
   2F8.0/
   3' ',T12,'ENTHALPY LEAK NO. 1, BTU/LB',T67,F7.1/
   4' ',T12,'LEAK NO. 2 (DRAINS TO SSR), LB/HR',T65,F8.0/
   5' ',T12,'ENTHALPY LEAK NO. 2, BTU/LB',T67,F7.1/
   6'0',T10,'GOVERNING STAGE SECTION'/
   7' ',T12,'LEAK NO. 3 (DRAINS TO FW HEATER NO.',I3,'), LB/HR',T65,
   8F8.0/
   9' ',T12,'ENTHALPY LEAK NO. 3, BTU/LB',T67,F7.1/
   A' ',T12,'LEAK NO. 4 (DRAINS TO SSR), LB/HR',T65,F8.0/
   B' ',T12,'ENTHALPY LEAK NO. 4, BTU/LB',T67,F7.1)
    PRINT 580,LK5,QLK5,HLK5,QLK6,HLK6
580 FORMAT('0',T10,'HP TURBINE SECTION'/
   1' ',T12,'TOTAL LEAK NO. 5 (DRAINS TO FW HEATER NO.',I3,'), LB/HR',
   2T65,F8.0/
   3' ',T12,'ENTHALPY LEAK NO. 5, BTU/LB',T67,F7.1/
   4' ',T12,'TOTAL LEAK NO. 6 (DRAINS TO SSR), LB/HR',T65,F8.0/
   5' ',T12,'ENTHALPY LEAK NO. 6, BTU/LB',T67,F7.1)
600 CONTINUE
    RETURN
    END
```

```
C
      SUBROUTINE SGROUP(PB,TB,HB,SB,VB,AMB,MB,QB,NE,    PX,TX,HX,SX,VX,
     1AMX,MX,PXI,TXI,HXI,SXI,VXI,AMXI,MXI,PXLP)
      IMPLICIT REAL*8(A-H,O-Z)
C SUBPROGRAM  FOR STAGE GROUP STEAM CONDITIONS
      COMMON /CONV/HCON,UERCON,AMCON,RHCON,WCON,PCON,SSRCON,XSPCON
C  INITIALIZE
      TX= TSL(PX)
      SG=SPTD(PX,TX)
      SF= SPT(TX)
      HG=HPS(PX,SPTD(PX,TX))
      HF= HPT(TX)
C  CORRECTION FOR NONCONDENSING TURBINE SUPERSATURATION LOSS EFFECTS
C  AND MECH. DES. CONSIDERATIONS(GET-6020 PAGE 5)
      IF(PXLP.LT.3.D0)GOTO10
      CT=0.99D0
      GOTO100
   10 CT=1.D0
C  TEST BOWL STEAM
  100 IF(MB.GT.2)GOTO200
C  BOWL STEAM IS WET, OR DRY AND SATURATED
C  SHELL STEAM IS WET
      AMXS=(SG-SB)/(SG-SF)
      HXS=(1.D0-AMXS)*HG+AMXS*HF
      PR=PB/PX
      VF=(1.0D+6)*VPTD(PB,TB)
      QVN=QB*VB/NE
      BE=   F4(PR,PB,VF)
      CIVF=FIG5(QVN,PR,VF,PB)
      CM=1.D0-AMB*FIG7(PR,PB)
      AE=HB-HXS
      UE=AE*BE*CIVF*    CM*CT
      HX=HB-UE
      GOTO510
C  BOWL STEAM IS SUPERHEATED
C  TEST SHELL STEAM
  200 IF(SG.GT.SB)GOTO300
C  SHELL STEAM IS SUPERHEATED
      TXS=TSUPS(PX,SB)
      HXS=HPS(PX,SPTD(PX,TXS))
      PR=PB/PX
      QVN=QB*VB/NE
      BE=   F3(QVN,PR)
      AE=HB-HXS
      UE=AE*BE*CT
      HX=HB-UE
      GOTO530
C  BOWL STEAM IS SUPERHEATED
C  SHELL STEAM IS WET
C  FIND UE FROM BOWL TO SATURATION LINE
  300 P1=PB
      P2=PX
      DO320 IT=1,100
      PXI=(P1+P2)/2.D0
      PR=PB/PXI
      QVN=QB*VB/NE
      BE=  F3(QVN,PR)
      TXSI=TSUPS(PXI,SB)
      HXSI=HPS(PXI,SPTD(PXI,TXSI))
      AEI=HB-HXSI
      UEI=AEI*BE*CT
      HXI=HB-UEI
      TXI= TSL(PXI,
      HGI=HPS(PXI,SPTD(PXI,TXI))
C  TEST HXI
      ADH=DABS(HGI-HXI)
      IF(ADH.LE.HCON)GOTO370
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C  RE-SET P1 OR P2
      IF(HGT.LT.HXI)GOTO310
      P2=PXI
      GOTO320
  310 P1=PXI
  320 CONTINUE
      PRINT 321,ADH
  321 FORMAT('0-SUBROUTINE SGROUP-SATURATION LINE ENTHALPY DID NOT CONVE
     1RGE, ADH =',1PD14.6)
  370 IF(PX.LT.(PXI-0.1D0))GOTO380
      UE=UEI
      HX=HXI
      IF(HX.GT.HG) GOTO530
      GOTO520
C  FIND STEAM CONDITIONS AT SATURATION LINE
  380 MXI=2
      AMXI=0.0D0
      SXI=SPTD(PXI,TXI)
      VXI=VPTD(PXI,TXI)
C  FIND UE FROM SATURATION LINE TO SHELL
      PR=PXI/PX
      VP=(3.0D+6)*VXI
      QVN=QB*VXI/NE
      BE=  F4(PR,PXI,VP)
      CIVP=FIG5(QVN,PR,VP,PXI)
      AMXS=(SG-SXI)/(SG-SF)
      HXS=(1.0-AMXS)*HG+AMXS*HF
      AEIX=HXI-HXS
      UEIX=AEIX*BE*CIVP*CT
      HX=HXI-UEIX
      UE=HB-HX
C  FIND SHELL STEAM CONDITIONS
C  WET
  510 MX=1
      AMX=(HG-HX)/(HG-HF)
      SX=(1.D0-AMX)*SG+AMX*SF
      VX=(1.D0-AMX)*VPTD(PX,TX)+AMX* VFT(TX)
      RETURN
C  DRY AND SATURATED
  520 MX=2
      AMX=0.0D0
      SX=SG
      VX=VPTD(PX,TX)
      RETURN
C  SUPERHEATED
  530 MX=3
      AMX=0.0D0
      TX=TSUPH(PX,HX)
      SX=SPTD(PX,TX)
      VX=VPTD(PX,TX)
      RETURN
      END
```

```
C
      SUBROUTINE SLEAK1(NP,PSH,QT,PT,HT,LK1,QLK1,HLK1,QLK2,HLK2,NPGS)
      IMPLICIT REAL*8(A-H,O-Z)
C
C SUBPROGRAM  FOR VALVE STEM PACKING LEAKAGES
C  TABLE II, P. 12, GER-2454A
C
      DIMENSION PSH(12)
      COMMON /Z/ TFR,SLOPE,QTKEEP,PKEEP,QGKEEP,PGKEEP,VGKEEP,GCKEEP,DUME
C
  100 LK1=0
      IF(TFR.GE.1.0D0) QLK12=0.001*QT
      IF(TFR.LT.1.0D0) QLK12=.001*QTKEEP
      IF(PT.GE.300.0)GOTO110
      QLK1=0.
      HLK1=0.
      QLK2=QLK12
      HLK2=HT
      RETURN
  110 IF(NP.EQ.NPGS)GOTO130
      I=NPGS+1
      DO120 IL=I,NP
      IF(PSH(IL).GT.250.0)GOTO120
      LK1=IL
      PLK1=PSH(IL)
      GOTO140
  120 CONTINUE
  130 PLK1=200.
  140 QLK2=QLK12*PLK1/PT
      QLK1=QLK12-QLK2
      HLK1=HT
      HLK2=HT
      RETURN
      END
```

```
C
      SUBROUTINE SLEAK2(NP,PSH,NGS,IRGS,PXGS,VXGS,HXGS,LK3,QLK3,HLK3,
     1QLK4,HLK4,PSSR,NPGS)
      IMPLICIT REAL*8(A-H,O-Z)
C
C SUBPROGRAM  FOR TURBINE SHAFT PACKING LEAKAGES (BOWL END)
C  TABLE II, P. 14, GER-6020
C
      DIMENSION PSH(12)
C
  200 LK3=0
      IF(PXGS.GT.PSSR)GOTO211
  210 QLK3=0.
      QLK4=0.
      HLK3=0.
      HLK4=0.
      RETURN
  211 IF(NGS.EQ.2)GO TO 210
      C34=800.
      C4=1200.
  240 IF(PXGS.GE.150.0)GOTO250
      QLK3=0.
      HLK3=0.
      QLK4=C4*DSQRT(PXGS/VXGS)
      HLK4=HXGS
      RETURN
  250 IF(NP.EQ.NPGS)GOTO270
      I=NPGS+1
      DO260 IL=I,NP
      IF(PSH(IL).GT.250.0)GOTO260
      LK3=IL
```

```
      PLK3=PSH(IL)
      GOTO280
  260 CONTINUE
  270 PLK3=100.
  280 HLK3=HXGS
      CALL PROPPH(AM,S,VLK3,T,H,PLK3,HLK3)
      QLK34=C34*DSQRT(PXGS/VXGS)
      QLK4=C4*DSQRT(PLK3/VLK3)
      QLK3=QLK34-QLK4
      HLK4=HXGS
      RETURN
      END
```

```
C
      SUBROUTINE SLEAK3(NP,PSH,NHP,IRHP,PXHP,VXHP,HXHP,LK5,QLK5,HLK5,
     1QLK6,HLK6,PSSR)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /MIS/CNTS(18),      TC,TPP,TR,HR,WRATE,GC,WML,WGL,QMU,QFP,
     *DP,WGEN,WFWP,HTRTM,HTRTG,CEFFM,CEFFG,PC
C
C SUBPROGRAM  FOR TURBINE SHAFT LEAKAGES (EXHAUST END)
C  TABLE II, P. 12, GER-2454A
C
      DIMENSION PSH(12)
C
  300 LK5=0
      IF(PXHP.GT.PSSR) GOTO305
      QLK5=0.
      QLK6=0.
      HLK5=0.
      HLK6=0.
      RETURN
  305 IF(NHP.EQ.2) GO TO 320
  310 NE1=1
      NE2=NHP-1
      GOTO330
  320 NE1=0
      NE2=NHP
  330 IF(WRATE.GE.1300)GO TO 340
      C56=NE1*500. + NE2*750.
      C6=NE1*700. + NE2*1000.
      GO TO 350
  340 C56= NE1*500. + NE2*1150.
      C6=NE1*700. + NE2*1500.
  350 IF(PXHP.GE.150.0)GOTO360
      QLK5=0.
      HLK5=0.
      QLK6=C6*DSQRT(PXHP/VXHP)
      HLK6=HXHP
      RETURN
  360 IF(NP.EQ.0)GOTO380
      DO370 IL=1,NP
      IF(PSH(IL).GT.150.0) GOTO370
      LK5=IL
      PLK5=PSH(IL)
      GOTO390
  370 CONTINUE
  380 PLK5=100.
  390 HLK5=HXHP
      CALL PROPPH(AM,S,VLK5,T,H,PLK5,HLK5)
      QLK56=C56*DSQRT(PXHP/VXHP)
      QLK6=C6*DSQRT(PLK5/VLK5)
      QLK5=QLK56-QLK6
      HLK6=HXHP
      RETURN
      END
```

```
C
      SUBROUTINE SSRE(PSH,HT,PXLP,        NP)
      IMPLICIT REAL*8(A-H,O-Z)
C
C SUBPROGRAM  FOR STEAM SEAL REGULATOR ENTHALPY
C
      DIMENSION PSH(12)
C
      COMMON /LEAK/QLK1,HLK1,QLK2,HLK2,QLK3,HLK3,QLK4,HLK4,QLK5,HLK5,
     1QLK6,HLK6,QLK7,HLK7,QLK8,HLK8,QLK9,HLK9,QLK10,HLK10,LK,LK1,LK3,
     2LK5,LK7,LK9
      COMMON /SSR/QSPE,QMC,QSSR,HSSR,PSSR,QFWH,QSSRMU,HSSRMU
C
      QSSR=QLK2+QLK4
      HSUM=QLK2*HLK2+QLK4*HLK4
      QSSR=QSSR+QLK6
      HSUM=HSUM+QLK6*HLK6
      HSSR=HSUM/QSSR
      Q=QMC+QSPE
      IF(QSSR.GT.Q)GOTO110
      QFWH=0.
      QSSRMU=Q-QSSR
      QSSR=Q
      HSSRMU=HT
      HSUM=HSUM+QSSRMU*HSSRMU
      HSSR=HSUM/QSSR
      GOTO140
  110 QSSRMU=0.
      HSSRMU=0.
      IF(NP.GT.0)GOTO130
  120 QFWH=0.
      QMC=QSSR-QSPE
      GOTO140
  130 IF(PSSR.LE.PSH(NP))GOTO120
      QFWH=QSSR-Q
  140 IF(PXLP.LE.14.696)GOTO150
      QMC=QSSR
      QFWH=0.
      QSPE=0.
  150 RETURN
      END
```

```
C
      SUBROUTINE STER
      X=1./0.
      RETURN
      END
```

```
C
      SUBROUTINE STRATE(PXGS,H1,S1,H2,S2,HXGS,SXGS)
      IMPLICIT REAL*8(A-H,O-Z)
      NAMELIST/NAME1/HGUESS,HCHECK,I
      I=0
      XMMM=(H1-H2)/(S1-S2)
      BBB=H1-S1*XMMM
      HGUESS=(H1+H2)/2.
   30 SGUESS=(HGUESS-BBB)/XMMM
      CALL PROPPS(A,HCHECK,T,V,X,PXGS,SGUESS)
      IF(DABS(HCHECK-HGUESS).LT.1.0D-3)GO TO 60
      HGUESS=(HGUESS+HCHECK)/2.
      I = I + 1
      IF(I.GT.50) GO TO 70
      GO TO 30
   60 SXGS=SGUESS
      HXGS=HGUESS
      GO TO 80
   70 WRITE(6,NAME1)
   80 RETURN
      END
```

```
C
      SUBROUTINE UNIPOL(A,X,Z,I)
C   A  ARRAY OF POLYNOMIAL COEFS.
C   X  INDEP. VARIABLE
C   Z  DEPENDENT VARIABLE
C   I  DEGREE OF POLYNOMIAL
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION A(10)
      Z = 0.0
      I1 = I + 2
      DO 1 N=1,I
      Z = Z*X
    1 Z = Z + A(I1-N)
      Z = Z*X + A(1)
      RETURN
      END
```

```
C
      SUBROUTINE XLOSS(PA,TX,HEP,HX,QA,AHEP,AMX,NE,BL,PD,IRL,UEEP,XL2)
      IMPLICIT REAL*8(A-H,O-Z)
C SUBPROGRAM  FOR LP CONDENSING TURBINE UEEP
      FIG14(XMOIST)=.87D0*(1.D0-.01D0*XMOIST)*(1.D0-.65D-2*XMOIST)
      DATA CPSI/2.0360234D0/
      DATA PI/3.14159265 4D0/
      PX=PA*CPSI
      AAN = PI * PD * BL / 144.D0
      VP=VPTD(PA,TX)
      VAN = QA * VP * (1.0D0 - AMX) / (3600.D0 * AAN * NE)
      IF(VAN.GT.1400.D0) GO TO 10
      XL=F16(VAN,BL)
      AMF2=FIG14(AMX*100.D0)
      XL2=XL*AMF2
      UEEP=HX*XL2
      RETURN
```

```
 10 PP=PX*VAN/1302.D0
    AMP1=FIG14(AMEP*100.)
    DO 21 IT=1,50
 20 DEP=FIG15(PP)
    HPP=HEP+DEP*AMP1
    P=PP/CPSI
    TPP= TSL(P)
    VPP=VPTD(P,TPP)
    HGPP=HPS(P,SPTD(P,TPP))
    AMPP=(HGPP-HPP)/(HGPP- HFT(TPP))
    VPAN = QA * VPP * (1.D0-AMPP)/(3600.D0 * AAN * NE)
    IF(VPAN.LE.1400.D0) GO TO 30
    PP=PP*VPAN/1302.0
 21 CONTINUE
    WRITE(6,22) VPAN
 22 FORMAT('0-SUBROUTINE XLOSS-VPAN DID NOT CONVERGE, VPAN =',1PD14.6)
 30 XL=F16(VPAN,BL)
    AMPP=FIG14(AMPP*100.D0)
    XL2=XL*AMPP
    UEEP=HPP+XL2
    RETURN
    END
```

```
C
      SUBROUTINE XSEP
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /XS1/PSX,PSI
      COMMON /XS2/HFSX,QMR
      COMMON /XS3/QSI,HSI,TSX,QSX,HSX,AMSX,EMS,HS
C
C SUBPROGRAM  FOR EXTERNAL MOISTURE SEPARATOR CALCULATIONS
C
C  FMR      FRACTION MOISTURE REMOVED
C  EMS      MOISTURE SEPARATION EFFECTIVENESS, PERCENT
C  INLET: QSI, PSI, HSI
C  OUTLET BEFORE MOIST. REM.: HSXB, PSX, QSI, TSX, AMSXB
C  OUTLET AFTER MOIST. REM.: HSX, PSX, QSX, TSX, AMSX
C  SAT. LIQ.: QMR, HFSX
C  SAT. VAP.: HGSX
C  STEAM CONDITIONS AT MOISTURE SEPARATOR OUTLET BEFORE SEPARATION
      HSXB=HSI
      TSX= TSL(PSX)
      HFSX= HFT(TSX)
      HGSX=HPS(PSX,SPTD(PSX,TSX))
      AMSXB=(HGSX-HSXB)/(HGSX-HFSX)
C  MOISTURE REMOVAL
      FMR=EMS*AMSXB*0.01D0
      QMR=FMR*QSI
      QSX=QSI-QMR
C  STEAM CONDITIONS AT MOISTURE SEPARATOR OUTLET AFTER SEPARATION
      AMSX=(AMSXB-FMR)/(1.0D0-FMR)
      HSX=(HSXB-FMR*HFSX)/(1.0D0-FMR)
      RETURN
      END
```

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