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COMPARATIVE PERFORMANCE OF HIGH
EFFICIENCY SHIP PROPULSION SYSTEMS
FOR DESTROYER HULL TYPES. VOLUME II.
APPENDICES

Alan J. Stewart

Bradford Computer and Systems, Incorporated

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Advanced Research Projects Agency

6 December 1974

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VOLUME II
APPENDICES

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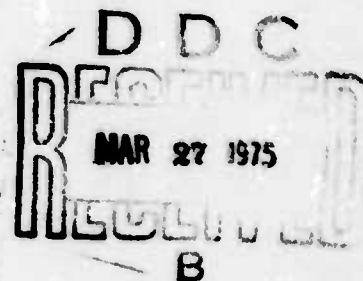
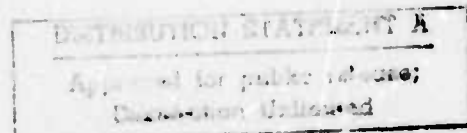
VOLUME II
APPENDICES

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Final Report
6 December 1974



VOLUME II

APPENDICES

<u>Appendices</u>	<u>Page</u>
A. MATH MODELS	A-1
A.1 TURBINE MATH MODELS	A-1
A.1.1 Main (LM-2500) Turbine	A-5
A.1.2 Cruise (Garrett GTPF990) Turbine	A-8
A.1.3 Adjusted FOM	A-8
A.2 PROPELLER MATH MODEL	A-12
A.3 SHIP DRAG MODEL	A-18
A.4 TURBINE-PROPELLER- DRAG PERFORMANCE RELATIONSHIPS	A-20
A.4.1 Propeller/ Drag Performance	A-20
A.4.2 Propeller/Turbine Performance	A-25
A.4.2.1 Optimum Pitch	A-25
A.4.2.2 Selection of Gear Ratios and Electric Machinery voltages	A-29
A.4.2.3 Selection of Operating Pitches	A-30
A.5 ENDURANCE CALCULATIONS	A-34
A.6 ELECTRIC DRIVE MATH MODELS	A-41
A.7 ALTERNATOR MATH MODEL	A-41
B. SYSTEM COMPONENTS	B-1
B.1 MOTORS	B-1
B.2 MAIN GENERATORS	B-1
B.3 CRUISE GENERATORS	B-1
B.4 AC-DC GENERATOR	B-4
B.5 ALTERNATOR	B-4
B.6 TRANSMISSION LINES	B-9
B.7 HELIUM COMPRESSORS	B-15
B.8 HELIUM CRYOSECTIONS	B-15

VOLUME II
APPENDICES (Cont'd)

<u>Appendices</u>	<u>Page</u>
B.9 HELIUM CRYOLINES	B-16
B.10 SWITCHGEAR	B-17
B.11 ESTIMATE OF SHIPS SERVICE POWER	B-19
C. COMPUTER STUDIES	C-1
C.1 GENERAL	C-1
C.2 COMPUTER PROGRAM	C-3
C.3 COMPUTER RESULTS	C-11
D. DESCRIPTION OF ENGINE ROOM MODIFICATIONS	D-1
Reprint of report prepared for Bradford Computer & Systems, Inc. by M. Rosenblatt & Sons, Inc.	

VOLUME II LIST OF ILLUSTRATIONS

<u>Number</u>		<u>Page</u>
A-1	Power Versus Speed for Fixed Fuel Rate	A-4
A-2	LM-1500 Turbine Model - Optimum Operating Conditions	A-6
A-3	LM-2500 Turbine Model - Power and SFC Versus Speed	A-7
A-4	Garret 930 Turbine Model - Optimum Operating Conditions	A-9
A-5	Garret 930 Turbine Model - Power and FCS Versus Speed	A-10
A-6	Propeller Relationships	A-15
A-7	Propeller Operation With $PD = 1.5$	A-21
A-8	Propeller Efficiency Versus P/D Ratio	A-23
A-9	Operating Point With Fixed Gear Ratio	A-28
A-10	Optimum P/D Ratio Versus Speed - Geared Drive	A-31
A-11	Optimum P/D Ratio Versus Speed - Electric Drive	A-33
A-12	Motor Math Model	A-42
A-13	Generator Math Model	A-43
A-14	Transmission Line Math Model	A-44
A-15	Alternator Math Model	A-45
B-1	40,000 HP Superconducting Motor	B-2
B-2	20,000 HP Superconducting Main Generator	B-3
B-3	5,000 HP Superconducting Cruise Generator	B-5
B-4	5,000 HP AC-DC Generator	B-6
B-5	10,000 AC Alternator	B-8
B-6	Line and Fuel Rates Versus Resistances	B-11
B-7	Transmission Line Configuration	B-13

VOLUME II
LIST OF TABLES

<u>Number</u>		<u>Page</u>
A-1	Propeller Characteristics Versus P/D	A-17
A-2	Ship Drag Characteristics	A-19
A-3	Propeller Operating Efficiency Versus P/D Ratio	A-22
A-4	Endurance Fuel Load	A-35

APPENDIX A - MATH MODELS

This appendix contains the math models used in computer simulation of the systems.

A.1 TURBINE MATH MODELS

The gas turbines were modeled using the following expression for fuel rate: (1)

$$W_F = \frac{Q_T + W_1 + W_2 S_T}{W_3 + W_4 S_T} \quad (A1)$$

Where: W_F = Fuel Rate (lb/hr)

Q_T = Turbine Torque (lb - ft)

S_T = Turbine Speed (rpm)

W_1 , W_2 , W_3 and W_4 are constants characterizing the turbine.

The following constraints were imposed:

$Q_T \leq Q_{MAX}$ Where Q_{MAX} = Max. allowable steady-state torque

$S_T \leq S_{MAX}$ Where S_{MAX} = Max. allowable steady-state rpm

$W_{MIN} \leq W_F \leq W_{MAX}$ Where W_{MIN} = Min. allowable (idle)/fuel rate

W_{MAX} = Max. allowable fuel rate

The turbine power is:

$$P_T = 1.904 \times 10^{-4} S_T Q_T \quad (A2)$$

Where: P_T = Turbine shaft horsepower

(1) Expressions developed by NSRDC, Annapolis.

Specific Fuel Consumption is:

$$SFC = W_F / P_T \text{ (lb/hp - hr)} \quad (A3)$$

The maximum available turbine power occurs at $W_F = W_{MAX}$ and a turbine speed, S_0 ; at this point:

$$Q_0 = \frac{W_3 W_{MAX} - W_1}{2}$$

$$S_0 = \frac{W_3 W_{MAX} - W_1}{2 (W_4 W_F + W_2)} = \frac{Q_0}{W_4 W_F + W_2}$$

$$P_{MAX} = 1.904 \times 10^{-4} S_0 Q_0$$

$$SFC_{MIN} = W_{MAX} / P_{MAX}$$

In order to compare turbine performance at various operating points, a turbine figure-of-merit was defined as:

$$FOM = SFC_{MIN} / SFC \quad (A4)$$

For any given power, P_T , there will be an optimum Speed, S_{T0} , which minimizes the fuel rate (and SFC), given by:

$$S_{T0} = \sqrt{(\beta W_4 P_T)^2 + \beta W_3 P_T} - \beta W_4 P_T \quad (A5)$$

$$\text{Where } \beta = \frac{5252}{W_1 W_4 + W_2 W_3}$$

For a given fuel rate, W_F , the maximum power and associated speed and torque may be expressed by:

$$S_{T0} = \rho / 2\sigma$$

$$Q_{T0} = \rho / 2$$

$$P_{T0} = 1.904 \times 10^{-4} \rho^2 / 4\sigma$$

$$\text{Where: } \rho = W_3 W_F - W_1$$

$$\sigma = W_4 W_F + W_2$$

With the fuel rate fixed, power may then be expressed as a function of the speed:

$$\frac{P_T}{P_{T0}} = \left(2 - \frac{S_T}{S_{T0}} \right) \left(\frac{S_T}{S_{T0}} \right); W_F \text{ constant.} \quad (A6)$$

This behavior is shown in figure A1.

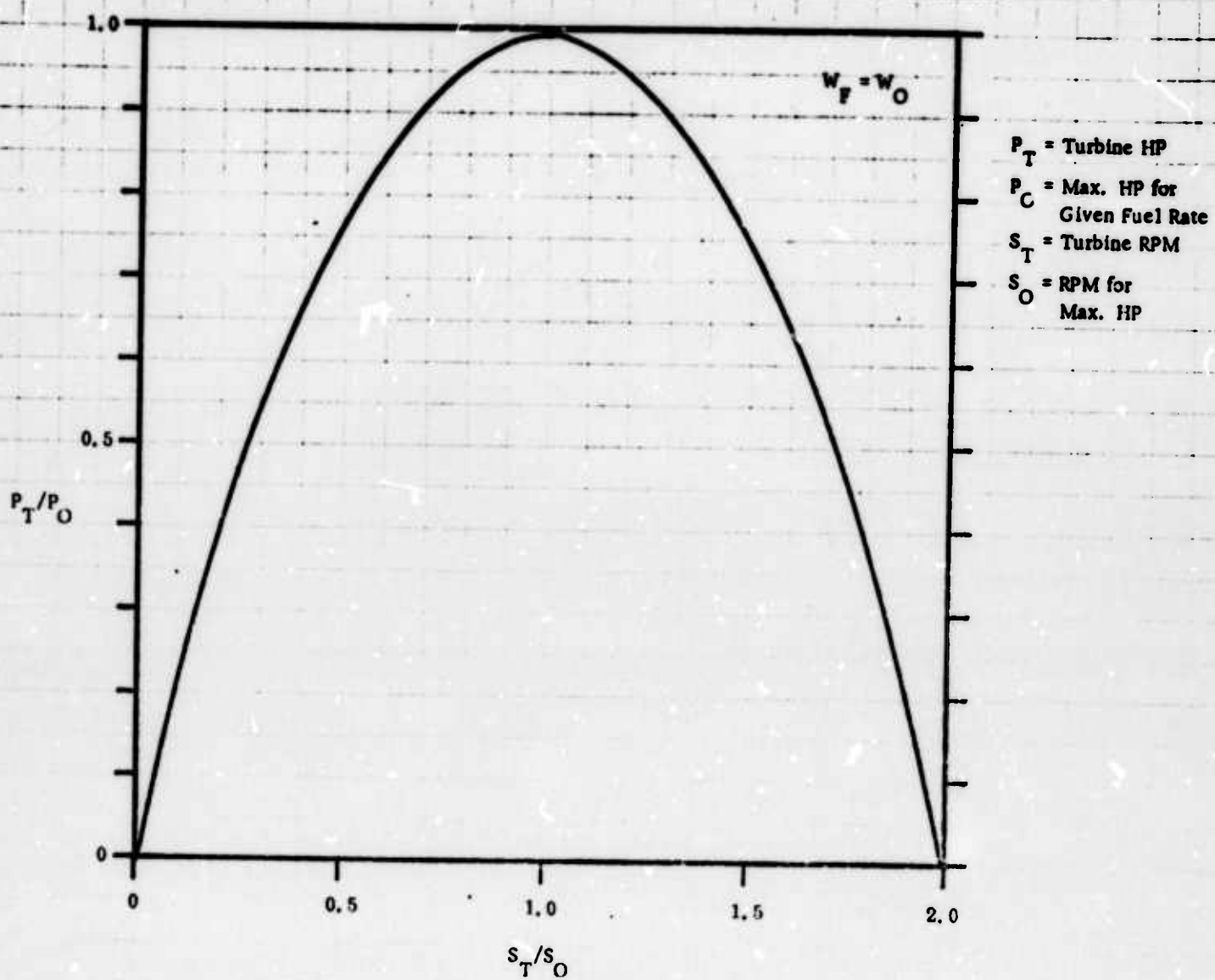


Figure A-1. Power vs. Speed for Fixed Fuel Rate

A.1.1.1 Main (LM - 2500) Turbine

Constants used for the LM - 2500 turbine were as follows⁽¹⁾:

$$W_1 = 6600$$

$$W_3 = 9.143$$

$$W_2 = 1.05$$

$$W_4 = 1.143 \times 10^{-3}$$

$$W_{\text{MIN}} = 1100 \text{ lb/hr}$$

$$W_{\text{MAX}} = 8400 \text{ lb/hr}$$

$$Q_{\text{MAX}} = 60,000 \text{ lb-ft}$$

$$S_{\text{MAX}} = 3600 \text{ rpm}$$

These values result in optimum operating speeds vs. power and corresponding FOM and fuel rate values, as shown in figure A2. Maximum power is 22,024 hp at 3295 rpm, with an SFC of 0.3814 lb/hp-hr (FOM = 1.0).

A performance map showing power and SFC vs. shaft speed is shown in figure A3. The effect on fuel consumption of operating the turbine at other than the optimum speed, S_{T0} (shown by a dash-dotted line) may be seen on the figure. For example, at 10,000 hp:

<u>Speed</u>	<u>Fuel Rate</u>	<u>SFC</u>	<u>% Increase in Fuel</u>
2000 rpm	5099 lb/hr	0.510	7.1
2840 rpm ⁽²⁾	4760 lb/hr	0.476	0
3600 rpm	4966 lb/hr	0.497	4.3

(1) Based on NSRDC, Annapolis values developed for superconductive drive system studies; the values used (with the possible exception of W_{MIN}) should not vary significantly for 20,000 hp turbines other than the LM-2500; while the study results for each configuration depend on the specific constants, comparative results between configurations are not highly sensitive to the choice of constants.

(2) Optimum speed.

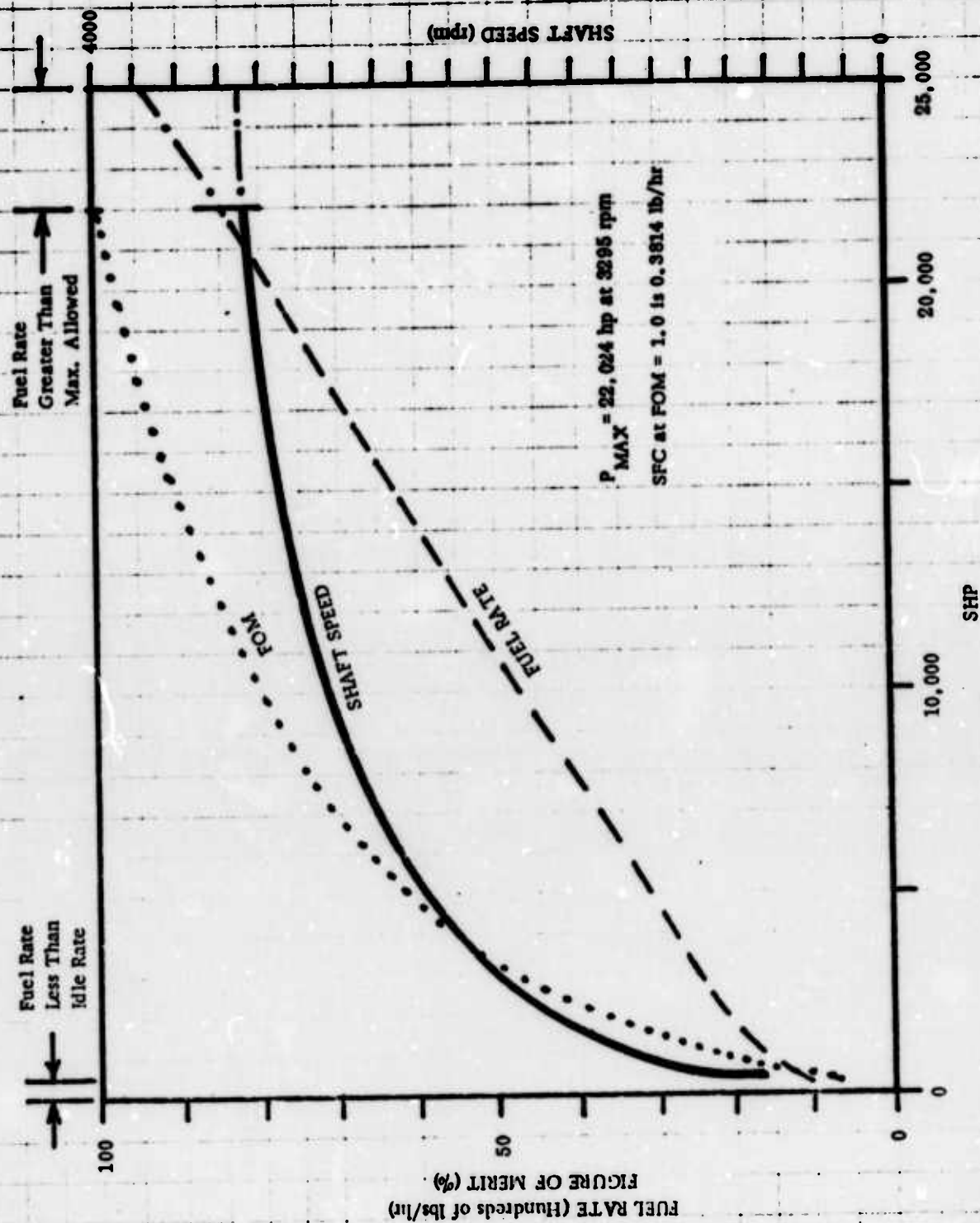


Figure A-2. LM-2500 Turbine Model - Optimum Operating Conditions

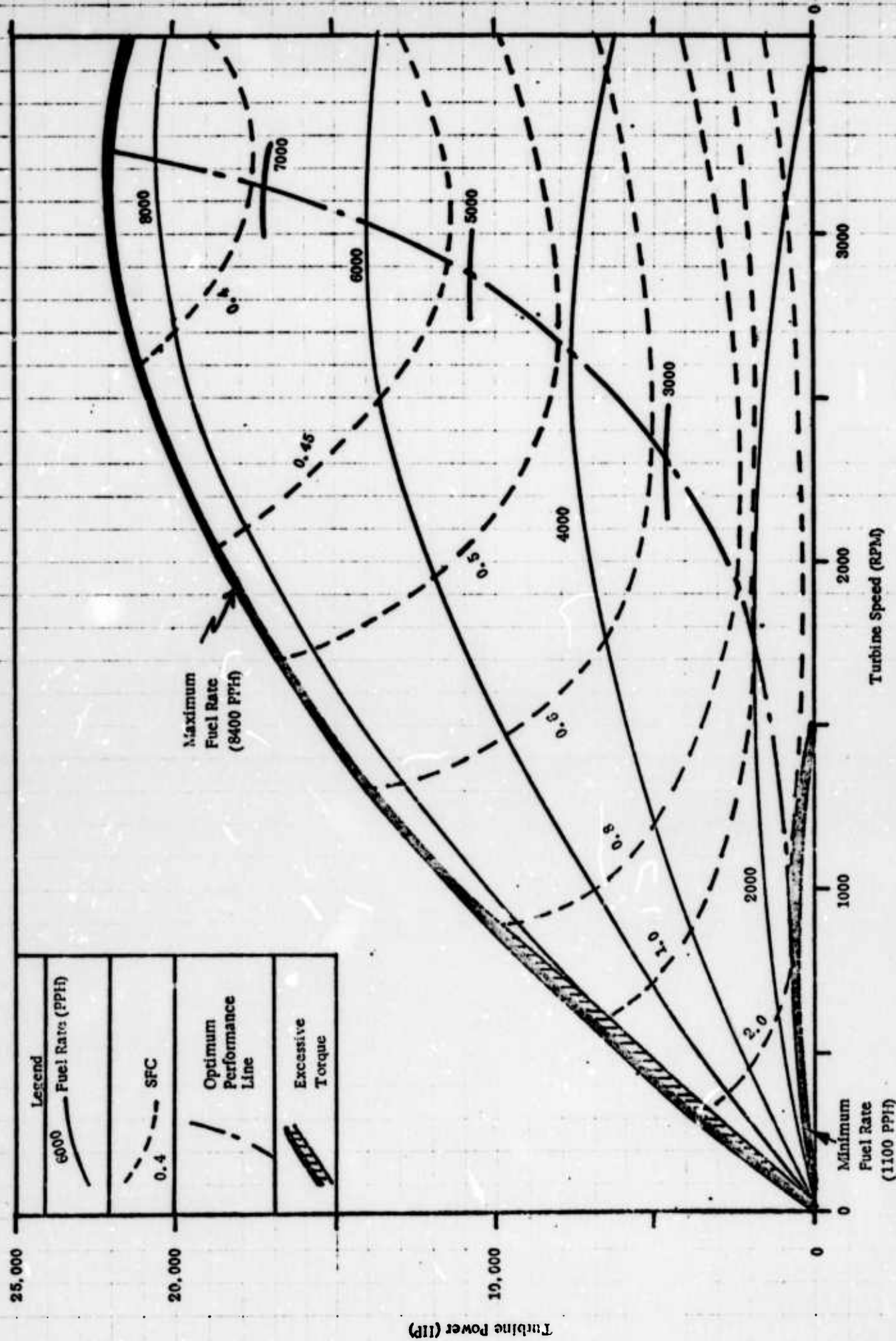


Figure A-3. LM-2500 Turbine Model - Power and SFC Vs. Speed

A.1.2 Cruise (Garrett GTPF990) Turbine

The following constants were used⁽¹⁾:

$$W_1 = 750$$

$$W_3 = 3.35$$

$$W_2 = 0.06$$

$$W_4 = 19 \times 10^{-5}$$

$$W_{\text{MIN}} = 360 \text{ lb/hr}$$

$$W_{\text{MAX}} = 2700 \text{ lb/hr}$$

$$Q_{\text{MAX}} = 7500 \text{ lb - ft}$$

$$S_{\text{MAX}} = 7200 \text{ rpm}^{(2)}$$

Resulting optimum performance points are shown in figure A4, and performance as a function of power and speed are shown in figure A5.

Maximum power is 5716 hp at 7200 rpm⁽³⁾ with an SFC of 0.4724 (FOM = 1.0).

A.1.3 Adjusted FOM

The figure-of-merit expresses the turbine efficiency as a percent of its optimum SFC. The SFC, in turn, may be related to the thermal efficiency of the turbine.

- (1) Based on NSRDC-Annapolis superconducting propulsion study values (characteristic of 5,000 hp turbines; see footnote⁽¹⁾ on page A-5).
- (2) 7200 rpm is the power assembly speed; the standard Navy version has a built-in 2-1 gear reduction to 3600 rpm. Ref: Gas Turbine World, September 1974, p. 12.
- (3) Performance is limited by the 7200 rpm shaft speed limit; if there were no speed limitation, optimum speed would be 7238 rpm with no change in the SFC (SFC = 0.4724).

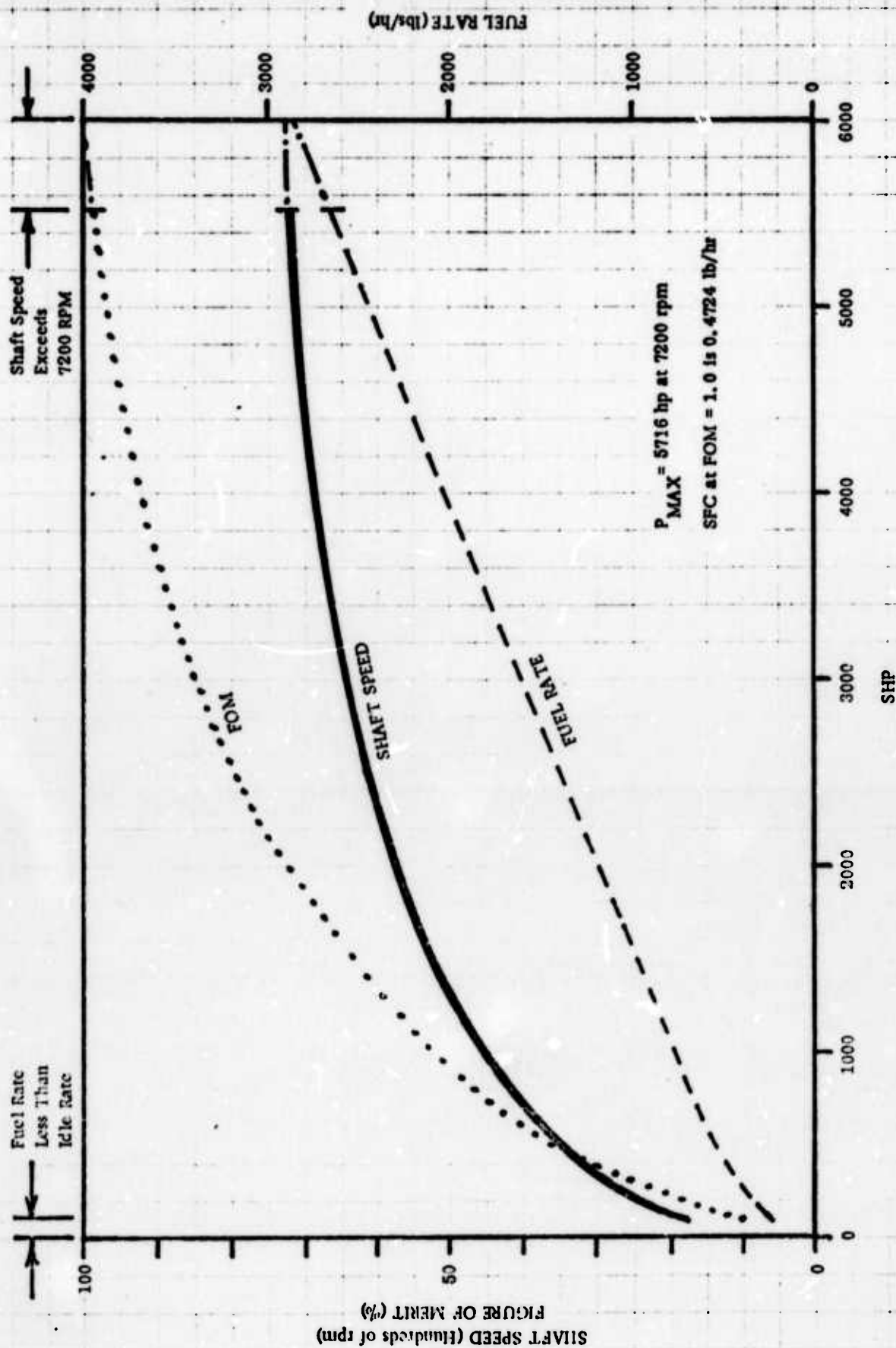


Figure A-4. Garrett 990 Turbine Model - Optimum Operating Conditions

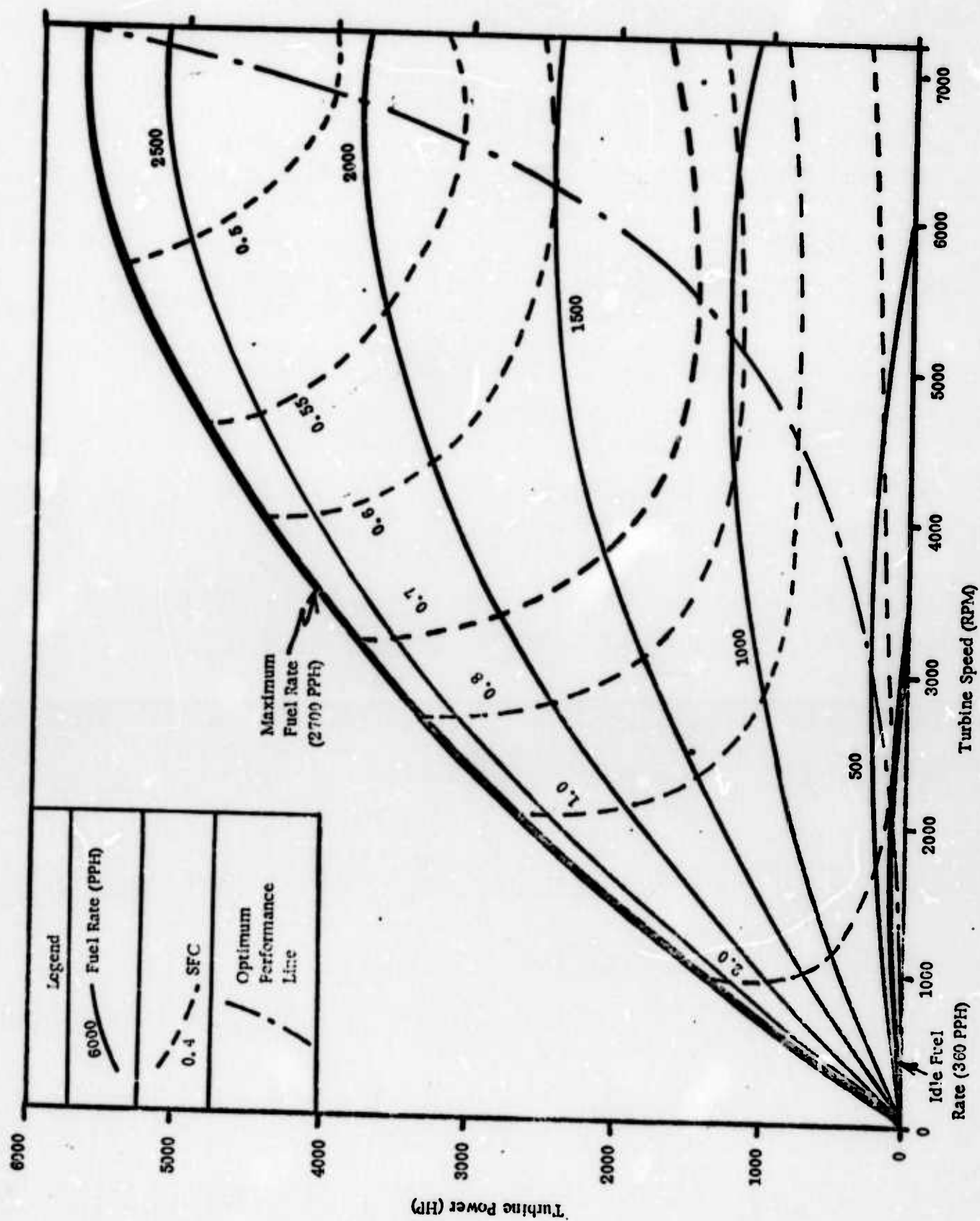


Figure A-5. Garrett 930 Turbine Model - Power and SFC Vs. Speed

Taking the gross heat of combustion of Navy distillate fuel as 19,300 btu/lb⁽¹⁾ and using 2545 btu/hp-hr gives a value of 0.1319 lbs of fuel/hp-hr for 100% conversion efficiency. For the two turbines:

	<u>Min. SFC</u>	<u>Max. Thermal Eff.</u>
Main	0.3814	0.3457
Cruise	0.4724	0.2791

and:

$$\text{Thermal Eff.} = \text{FOM} \times (\text{Max. thermal eff.})$$

The use of FOM, frees the analysis from fuel type and is used in the system analysis. In order to compare the two turbines on a common basis, the cruise turbine FOM is adjusted to account for its reduced thermal efficiency whenever comparisons are made between turbines. The adjusted cruise FOM is:

$$\text{Adjusted Cruise FOM} = \frac{\text{Main SFC}_{\text{Min}}}{\text{Cruise SFC}_{\text{Min}}} \times \text{FOM} = 0.8074 \times \text{FOM.} \quad (\text{A7})$$

For the adjusted cruise FOM:

$$\text{Thermal Eff} = (\text{Adj. FOM}) \times (\text{Max. thermal eff. for main turbine})$$

(1) R.J. Gauthey and J.P. DeTolla, "The Energy Crises and Naval Ship Research and Development," Naval Engineers Journal, 86, June 1974, p. 101.

A.2 PROPELLER MATH MODEL

In order to obtain a reasonable estimate of propeller performance, the behavior of thrust and torque coefficients for a standard propeller series⁽¹⁾ were linearized and modeled as follows:

$$C_T = T_M \left(1 - \frac{J}{T_0} \right) \quad (A8)$$

$$C_Q = Q_M \left(1 - \frac{J}{Q_0} \right) \quad (A9)$$

$$\left. \begin{aligned} T_M &= T_{M1} + T_{M2} R + T_{M3} R^2 \\ T_0 &= T_{01} + T_{02} R + T_{03} R^2 \\ Q_M &= Q_{M1} + Q_{M2} \text{ Sine } [Q_{M3} (R - R_x)] \\ Q_0 &= Q_{01} + Q_{02} R + Q_{03} R^2 \end{aligned} \right\} \quad (A11)$$

Where: C_T = Thrust coefficient

C_Q = Torque coefficient

J = Advance coefficient

T_M = Value of C_T at $J = 0$

T_0 = Value of J at $C_T = 0$

Q_M = Value of C_Q at $J = 0$

(1) T.P. O'Brien, The Design of Marine Screw Propellers, Hutchison Scientific and Technical Publishers, London. Gawn standard screw series (pps. 88-92) was used to obtain the model form.

(Cont'd)

Q_0 = Value of J at $C_Q = 0$

R = Pitch to Diameter (P/D) ratio

$T_{M1}, T_{M2}, T_{M3}, T_{01}, T_{02}, T_{03}, Q_{M1}, Q_{M2},$

$Q_{M3}, Q_{01}, Q_{02}, Q_{03}$ and RX are constants characterizing the propeller.

The following standard relationships are used:

$$J = \frac{v}{nD} = 101.3 \frac{V}{SD}$$

$$T = en^2 D^4 C_T$$

$$Q = en^2 D^5 C_Q$$

$$\eta_p = \frac{J}{2\pi} \cdot \frac{C_T}{C_Q}$$

(A12)

Where: v = Ship speed in fps

V = Ship speed in knots

n = Propeller speed in rev/sec

S = Propeller speed in rpm

D = Propeller diameter in feet

e = Water density in slugs/ft³

T = Thrust in lbs

Q = Torque in lb - ft

η_p = Propeller efficiency

Maximum propeller efficiency occurs at:

$$J = Q_0 \left[1 - \sqrt{1 - \frac{T_0}{Q_0}} \right] \quad (J \text{ for max } \eta_p). \quad (A13)$$

The relationships between J , C_T , C_Q , T_0 , T_M , Q_0 , Q_M , and N are shown in figure A6.

For the propeller model used in the study the following values were used:

$T_{01} = 0.0500$	$Q_{01} = 0.4550$
$T_{02} = 1.0130$	$Q_{02} = 0.5470$
$T_{03} = 0.0060$	$Q_{03} = 0.1577$
$T_{M1} = -0.2600$	$Q_{M1} = 0.1830$
$T_{M2} = 1.0000$	$Q_{M2} = 0.1633$
$T_{M3} = -0.1800$	$Q_{M3} = 1.5160$
$D = 17 \text{ ft}$	$RX = 1.4250$
$\rho = 1.9905 \text{ slugs/ft}^3$	

These values were selected to:

- Match the general characteristics of the Gawn standard screw series in terms of relative efficiencies at various pitches.
- Provide approximately 72 to 73% efficiency under actual operation (selected arbitrarily as a reasonable efficiency).

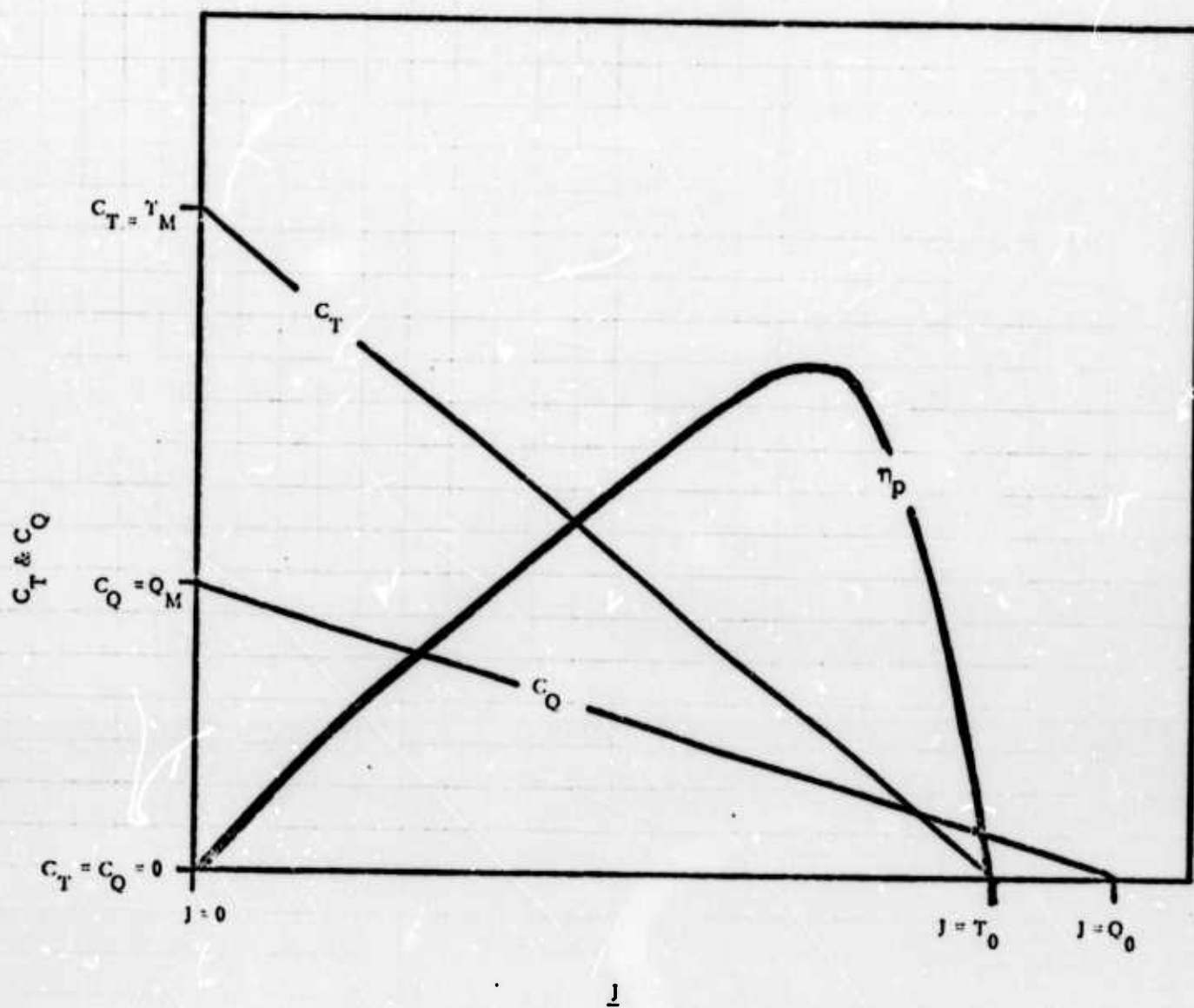


Figure A-6. Propeller Relationships

The values given for c and D provide the following characteristics:

$$J = 5.961 \frac{V}{S} \quad (A14)$$

$$T = 46.18 C_T \cdot S^2 \quad (A15)$$

$$Q = 785.1 C_Q \cdot S^2 \quad (A16)$$

The values given for T_{M1} , T_{M2} , etc. give the values shown in table A1.

Table A- 1
Propeller Characteristics vs P/D

<u>P/D</u>	<u>T_M</u>	<u>T₀</u>	<u>Q_M</u>	<u>Q₀</u>	<u>Maximum Efficiency</u>	
					<u>J</u>	<u>η_p</u>
0.2735	0.0000	0.3275	0.02219	0.6164	0.1944	0.0000
0.3000	0.0238	0.3544	0.02118	0.6333	0.2131	0.0229
0.4000	0.1112	0.4562	0.01972	0.6990	0.2870	0.1620
0.5000	0.1950	0.5580	0.02201	0.7679	0.3664	0.3392
0.6000	0.2752	0.6600	0.02799	0.8400	0.4511	0.4825
0.7000	0.3518	0.7620	0.03753	0.9152	0.5408	0.5720
0.8000	0.4248	0.8642	0.05041	0.9935	0.6351	0.6260
0.9000	0.4942	0.9666	0.06632	1.0750	0.7335	0.6602
1.0000	0.5600	1.0690	0.08492	1.1597	0.8354	0.6852
1.1000	0.6222	1.1716	0.10576	1.2475	0.9397	0.7057
1.2000	0.6808	1.2742	0.12837	1.3385	1.0452	0.7237
1.3000	0.7358	1.3770	0.15224	1.4326	1.1504	0.7393
1.4000	0.7872	1.4800	0.17681	1.5299	1.2535	0.7523
1.5000	0.8350	1.5830	0.20153	1.6303	1.3525	0.7621
1.6000	0.8792	1.6862	0.22582	1.7339	1.4462	0.7686
1.7000	0.9198	1.7894	0.24912	1.8407	1.5336	0.7724
1.8000	0.9568	1.8929	0.27092	1.9505	1.6150	0.7746
1.9000	0.9902	1.9964	0.29069	2.0636	1.6911	0.7766
2.000	1.0200	2.1000	0.30799	2.1798	1.7627	0.7799

A.3 SHIP DRAG MODEL

The ship's drag characteristics were modeled as follows:

$$\text{EHP} = C_D \cdot V^3 \quad (\text{A17})$$

$$C_D = C_{D0} \text{ for } V \leq 27 \text{ knots} \quad (\text{A18})$$

$$C_D = C_{D0} \frac{V - C_2}{V_x - C_2} \text{ for } V \geq 27 \text{ knots}$$

$$\begin{aligned} D_S &= \left(\frac{3600 \text{ sec/hr}}{6080 \text{ ft/mile}} \right) \cdot (550 \text{ lb - ft/sec/hp}) \cdot \frac{\text{EHP}}{V} \\ &= 325.7 C_D V^2 \end{aligned} \quad (\text{A19})$$

Where: EHP = Effective horsepower

V = Speed in knots

C_{D0} , C_2 and V_x are drag constants.

This form was chosen to approximate a V^2 dependence on drag at lower speeds with drag increasing faster in the 30-knot region. Values were chosen for the three constants of:

$$C_{D0} = 1.4 \text{ hp/(kt)}^3$$

$$C_2 = 5 \text{ knots}$$

$$V_x = 27 \text{ knots}$$

The resultant drag/power profile is given in table A2.

Table A-3
Ship Drag Characteristics

<u>Speed (kts)</u>	<u>Drag (lbs)</u>	<u>Effective Hp</u>	<u>Speed (kts)</u>	<u>Drag (lbs)</u>	<u>Effective Hp</u>
1.0	456.	1.40	19.0	164587.	9602.59
2.0	1824.	11.20	20.0	182368.	11199.99
3.0	4103.	37.80	21.0	201061.	12965.39
4.0	7295.	89.60	22.0	220666.	14907.19
5.0	11398.	175.00	23.0	241182.	17033.79
6.0	16413.	302.40	24.0	262610.	19353.59
7.0	22340.	480.20	25.0	284951.	21874.98
8.0	29179.	716.80	26.0	308202.	24606.38
9.0	36930.	1020.60	27.0	332368.	27556.19
10.0	45592.	1400.00	28.0	373689.	32129.70
11.0	55166.	1863.40	29.0	418286.	37248.61
12.0	65653.	2419.20	30.0	466282.	42954.48
13.0	77051.	3075.80	31.0	517801.	49290.50
14.0	89360.	3841.60	32.0	572968.	56301.31
15.0	102582.	4725.00	33.0	631906.	64033.13
16.0	116716.	5734.40	34.0	694740.	72533.63
17.0	131761.	6878.19	35.0	761594.	81852.19
18.0	147718.	8164.79	36.0	832594.	92039.44

A.4 TURBINE-PROPELLER-DRAG PERFORMANCE RELATIONSHIPS

A.4.1 Propeller/Drag Performance

The maximum propeller efficiencies given in table A1 cannot be attained unless the advance coefficient J is at the proper value. However, under steady-state operating conditions, the value of J is fixed by the relationship between propeller thrust coefficient and ship's drag, since the total propeller thrust must equal the drag at steady-state.

From A.2 and A.3:

$$T = 46.18 C_T S^2 \quad (A15)$$

$$D_S = 325.7 C_D V^2 \quad (A19)$$

$$J = 5.961 V/S \quad (A14)$$

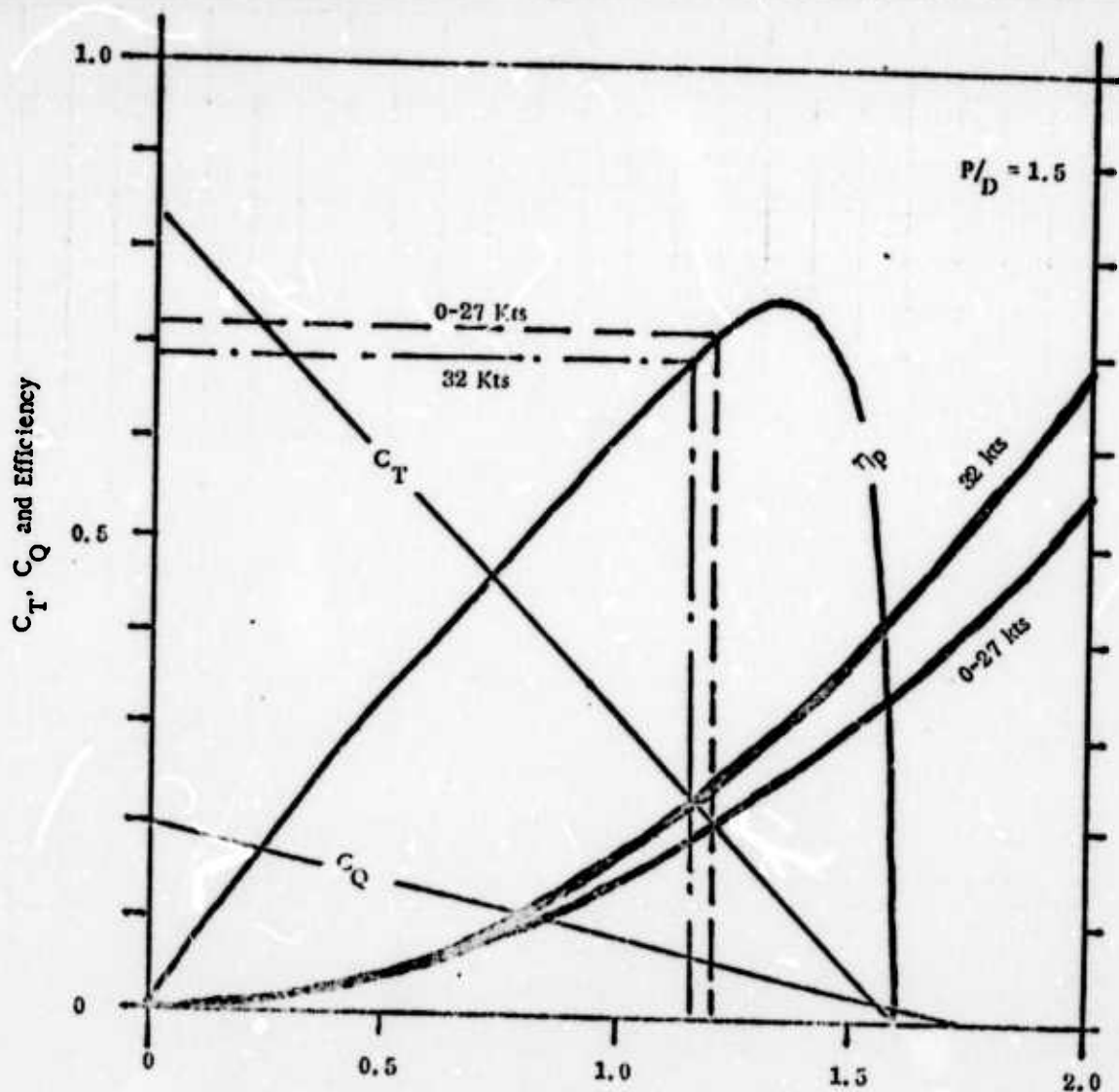
Combining ($D_S = 2T$):

$$C_T = 9.921 \times 10^{-2} C_D J^2$$

while, from A2:

$$C_T = T_M \left(1 - \frac{J}{T_0}\right) \quad (A8)$$

Figure A7 shows the resulting operating points for a P/D ratio of 1.5. Operating efficiencies and advance coefficient, J , are given versus P/D ratio in table A3 and figure A8. For speeds up to 27 knots, maximum possible operating efficiency is 72.8% at a P/D ratio of 1.38; at 32 knots maximum efficiency is 71.3% at a 1.29 P/D ratio.



$$R = 1.5$$

J (Advance Coefficient)

$$T_M = 0.8350 \quad Q_M = 0.2015$$

$$T_0 = 1.5830 \quad Q_0 = 1.6303$$

For Maximum η_p :

$$J = 1.353$$

$$\eta_p = 76.2\%$$

Operating Point for 0-27 kts:

$$J = 1.202$$

$$\eta = 72.6\%$$

$$C_T = 0.2010$$

$$C_Q = 0.05294$$

Operating Point for 32 kts:

$$J = 1.153$$

$$\eta = 70.6\%$$

$$C_T = 0.2268$$

$$C_Q = 0.05899$$

Figure A-7. Propeller Operation With PD = 1.5

<u>P/D Ratio</u>	<u>Maximum Propeller Efficiency</u>	<u>Operating⁽¹⁾ Propeller Efficiency</u>	<u>Advance⁽¹⁾ Coefficient (j)</u>
0.2735	0	0	0
0.3	0.023	0.022 - 0.023	0.238 - 0.225
0.4	0.162	0.129 - 0.138	0.375 - 0.364
0.5	0.339	0.269 - 0.289	0.469 - 0.456
0.6	0.483	0.404 - 0.430	0.557 - 0.541
0.7	0.573	0.510 - 0.534	0.637 - 0.620
0.8	0.626	0.587 - 0.607	0.718 - 0.696
0.9	0.660	0.643 - 0.655	0.795 - 0.769
1.0	0.685	0.681 - 0.685	0.869 - 0.841
1.1	0.706	0.706 - 0.703	0.940 - 0.909
1.2	0.724	0.720 - 0.711	1.009 - 0.972
1.3	0.739	0.727 - 0.713	1.076 - 1.037
1.4	0.752	0.726 - 0.710	1.140 - 1.095
1.5	0.762	0.726 - 0.706	1.202 - 1.149
1.6	0.769	0.723 - 0.700	1.262 - 1.209
1.7	0.772	0.719 - 0.695	1.319 - 1.263
1.8	0.775	0.716 - 0.691	1.374 - 1.312
1.9	0.777	0.715 - 0.689	1.426 - 1.361
2.0	0.780	0.716 - 0.690	1.476 - 1.406

(1) First value is for 0 to 27 kts; second is for 32 kts.

Table A-3. Propeller Operating Efficiency Versus P/D Ratio

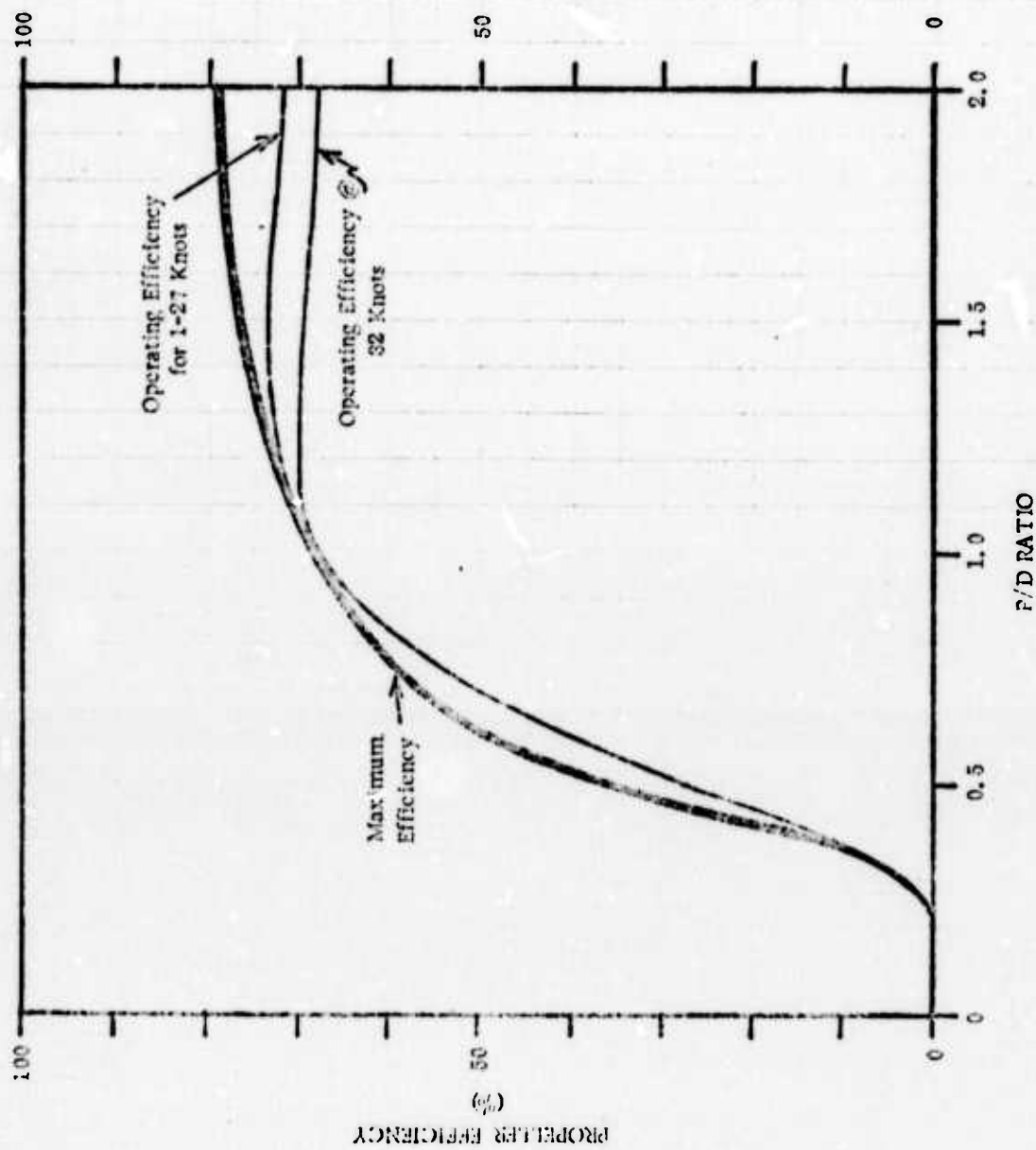


Figure A-8. Propeller Efficiency vs. P/D Ratio

From Section A.2,

$$J = 5.961 \frac{V}{S} \quad (A14)$$

This results in a limitation on P/D ratio if propeller shaft speed is limited;
for example, 32 knots:

<u>Maximum Allowed Shaft rpm</u>	<u>Minimum Allowable P/D Ratio</u>
160	1.57
165	1.51
170	1.45
175	1.39
180	1.34

A.4.2 Propeller/Turbine Performance

A.4.2.1 Optimum Pitch

As discussed in A.4.1 and A.1, propeller efficiency and turbine efficiency are both affected by shaft rpm. If there is a fixed mechanical gear ratio between the propeller shaft and turbine, the optimum P/D ratio for minimum fuel rate will occur at some value other than that for the turbine or propeller alone. For example, with two main turbines operating at 23 kts and 96% drive efficiency:

Maximum Propeller Efficiency = 0.728 at 120 rpm
With a P/D ratio of 1.4

Maximum Turbine FOM = 0.862 at 3392 rpm
With an output of 26,050 hp

If the gear ratio were 28.3 to 1 (3392 rpm/120 rpm), the turbine would deliver 25,010 shaft hp and effective power would be 18,210 hp with an (ideal) efficiency of:

$$0.728 \times 0.862 \times 0.960 = 0.602.$$

However, with a fixed gear ratio of 21.5 to 1, optimum performance occurs as shown in figure A9:

P/D Ratio	= 1.27
Shaft Speed	= 130 rpm
Turbine Speed	= 2783 rpm
Effective Power	= 17,030 ⁽¹⁾

⁽¹⁾ Fixed at 17,030 hp by drag at 23 knots.

Shaft Power	= 23,470 hp
Turbine Power	= 24,450 hp ⁽¹⁾
Fuel Rate	= 10,930 lbs/hr
Propeller Efficiency	= 0.726
Turbine FOM	= 0.853
Drive Efficiency	= 0.960
Overall Propulsion Efficiency	= 0.594

For the same conditions (23 knots with two main turbines) the electrical drive system is optimized by adjusting the "gear ratio" through reduction of the generator magnetic field and optimizes as follows:

P/D Ratio	= 1.35
Shaft Speed	= 124 rpm
Turbine Speed	= 2960 rpm (76.6% magnet field)
Effective Gear Ratio	= 23.9 to 1
Effective Power	= 17,030 hp
Shaft Power	= 23,040 hp
Turbine Power	= 24,100 hp
Fuel Rate	= 10,800 lbs/hr
Propeller Efficiency	= 0.728
Turbine FOM	= 0.852 ⁽²⁾
Drive Efficiency	= 0.971
Overall Propulsion Efficiency	= 0.602

(1) Turbine Power = (Effective hp)/(propulsion efficiency x drive efficiency)

(2) The slight decrease over the geared case in turbine FOM reflects the drop in turbine power required; 0.852 is the maximum FOM for 24,100 hp from two turbines.

The electric drive is thus 1.3% more efficient at 23 knots; at lower speeds the difference is more pronounced, leading to an overall 6-7% advantage for the electric drive when averaged over the mission profile.

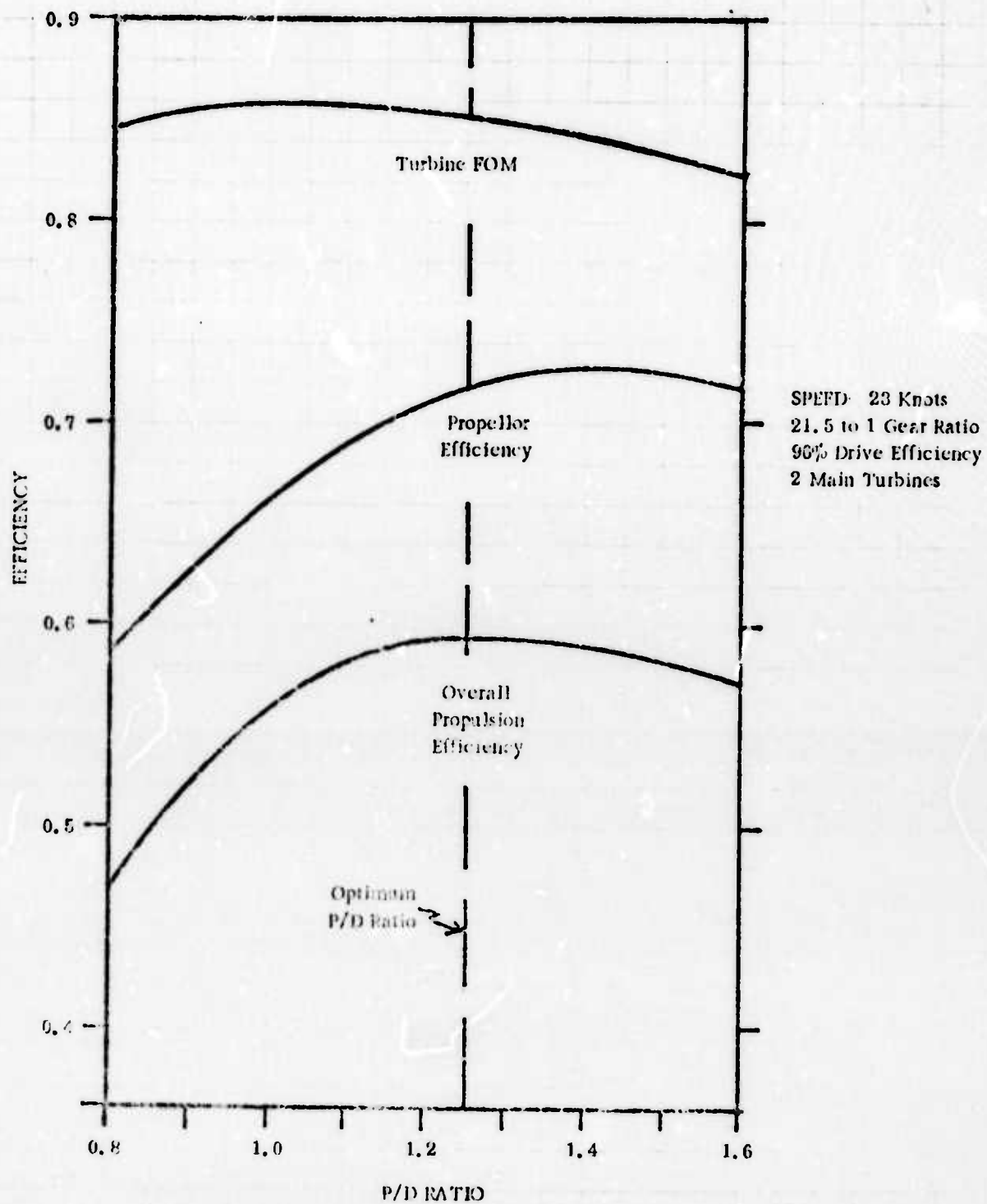


Figure A-9. Operating Point With Fixed Gear Ratio

A.4.2.2 Selection of Gear Ratios and Electric Machinery Voltages

The propeller pitch determines the propeller rpm at each speed; turbine rpm and efficiency then depend on the gear ratio, in the geared drive case, and on the motor/generator emf (volts/rpm), in the electric drive case. The combination is limited by:

- . Propeller cavitation
- . Turbine upper speed limit.

In order to determine the optimum gear ratios for the turbines and the optimum electric machine voltages, the system math model was exercised subject to the following constraints:

- . Propeller limited to 168 rpm⁽¹⁾
- . Main turbine limited to 3600 rpm
- . Cruise turbine limited to 7200 rpm

The results gave, for minimum fuel consumption:

- . Main Gear Ratio 21.5 to 1
- . Cruise Gear Ratio: 74.0 to 1
- . Electric Motor emf: 1.6328 v/rpm⁽²⁾
- . Main Generator: 0.0911 v/rpm⁽²⁾
- . Cruise Generator: 0.0209 v/rpm⁽²⁾

(1) Based on cavitation; see, D.A. Rains and R.J. d'Arcy, "Considerations in the DD 963 Propulsion System Design," Naval Engineers Journal, August 1972, p. 68.

(2) The electric drive system has a variable "gear ratio" with minimum values of 17.9 to 1 for the main turbines and 78 to 1 for the cruise turbines.

A.4.2.3 Selection of Operating Pitches

With the gear ratios and electrical constants established, the optimum propeller pitch for each speed was determined. The result for the geared drive with main turbines is shown in figure A10. Below 5 knots with one turbine, and below 7 knots with two turbines, pitch must be used to regulate speed because the turbine fuel rate is at its minimum value of 1100 lbs/hr per turbine. At 5 knots, the optimum pitch for 1 turbine is 1.15; it drops to 1.06 at 11 knots and then rises to 1.16 at 21 knots. Similar effects occur for each combination of turbines. A continuously variable pitch is undesirable for cruise conditions, since the minimum fuel rate can be closely approached by using a fixed pitch for each combination of turbines in use.

Based on the results shown in figure A9 and similar results for the cruise turbines, fixed pitch ratios were selected for each combination of turbines. These values were verified as giving optimum performance by inserting them in the math model and running them over the mission profile. The values selected were:

<u>Number of Turbines</u>	<u>Baseline System</u>	<u>Baseline +Alternators</u>	<u>Baseline +Cruise Turbines</u>	<u>Alternators +Cruise Turbines</u>
1 Cruise	-	-	-	1.10
2 Cruise	-	-	1.25	1.30
1 Main	-	1.10	-	1.10
2 Main	1.20	1.30	1.30	1.30
3 Main	-	1.40	-	1.40
4 Main	1.50	1.50	1.50	1.50

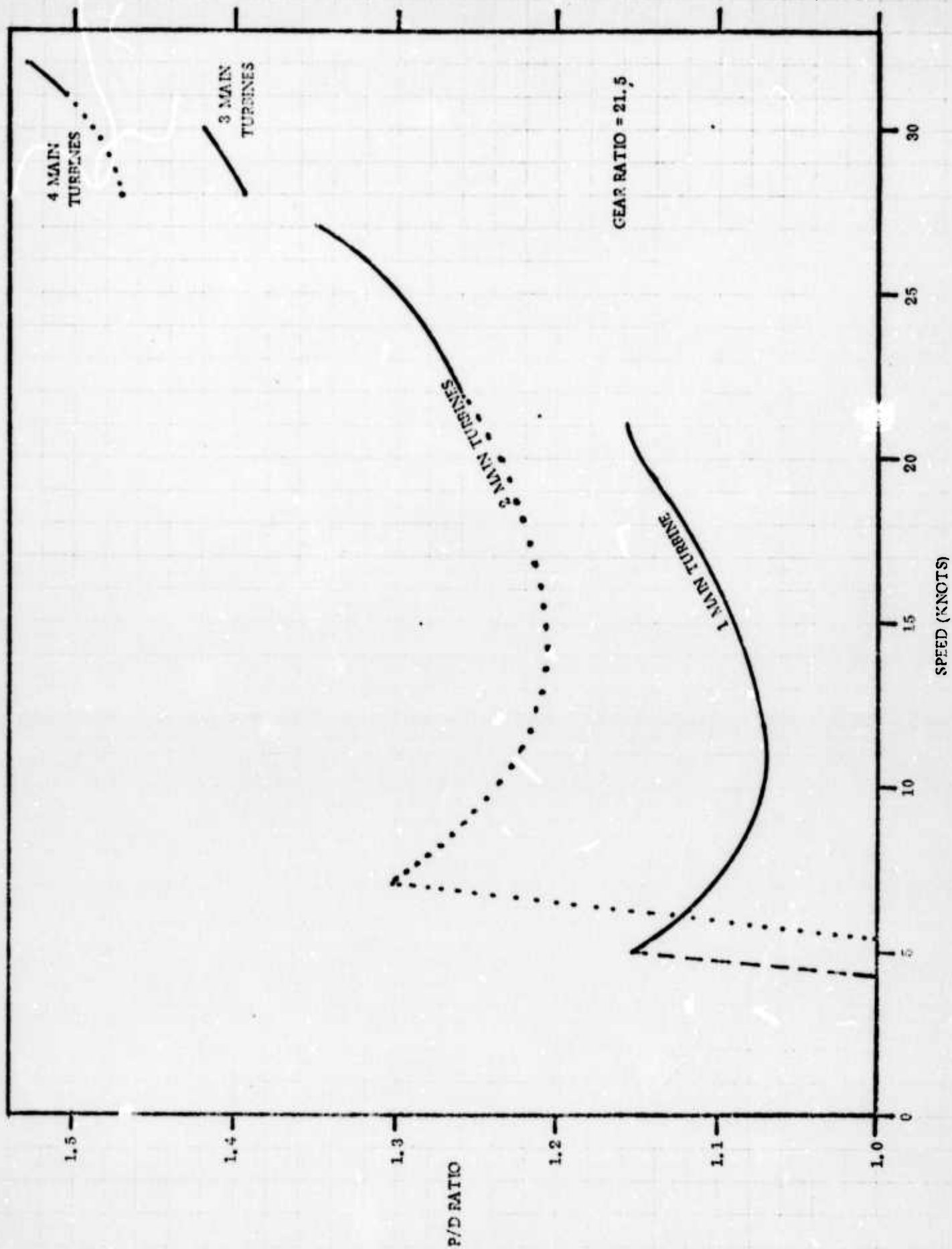


Figure A-10. Optimum P/D Ratio vs. Speed - Geared Drive

For the electric system, the optimum pitch is much closer to the pitch (1.38) where maximum propeller efficiency occurs, as shown in figure A11⁽¹⁾. Because of the small variation in optimum pitch in the electric drive case, it is advantageous to use a fixed pitch propeller and a single pitch was therefore selected for the electric drive. The minimum fuel consumption over the mission profile occurs for a P/D ratio of 1.35; however, this requires a propeller speed of 179 rpm at 32 knots. In order to keep propeller speed close to 168 knots, a fixed P/D ratio of 1.45 was selected resulting in 169.6 rpm at 32 knots (a P/D of 1.50 would give 165.4 knots and the nearest 0.05 variation in P/D was selected).

(1) Pitch is set to 1.5 when the turbine fuel rate is at idle and speed is controlled by varying the magnet field.

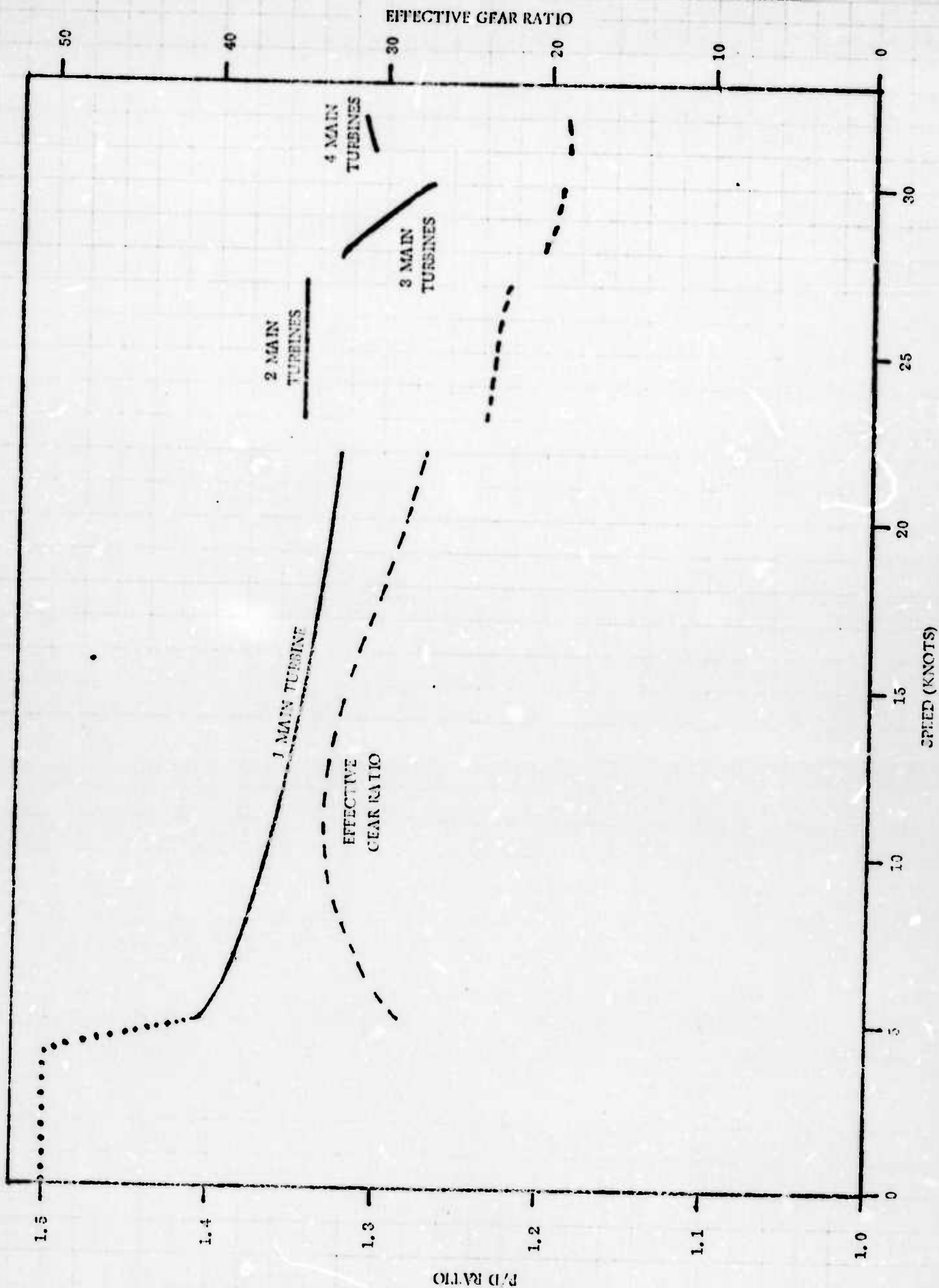


Figure A-11. Optimum P/D Ratio vs. Speed - Electric Drive

A.5 ENDURANCE CALCULATIONS

Endurance calculations are based on BUSHIPS Design Data Sheet DDS 9400-1⁽¹⁾. Values of endurance and endurance speed used to calculate endurance fuel load were selected to match those of the DD-931 and DL-2: 4500 miles at 20 knots⁽²⁾.

Endurance power and fuel rate were taken from the baseline math model analysis. Ships service electric load was estimated at 4,000 kw at a fuel rate of 0.8 lb/kw-hr (see Appendix B) and "fuel consumption for other services" was estimated at 10% of the ships service electric load. A "tailpipe allowance factor" of 0.95 was selected (i.e. 5% of the fuel is unavailable). The endurance fuel load calculations, based on DDS 9400-1, are shown in Table A4. The result of the calculation is 1428 long tons of fuel; 1430 tons was selected as the endurance fuel load.

(1) Design Data Sheet DDS 9400-1, "Calculation of Surface Ship Endurance Fuel Requirements," 1 Nov. 1963.

(2) R.T. Miller, C.L. Long and S. Reitz, "ASW Surface Ship of the '80's" Study," Naval Engineers Journal, Dec. 1972, p. 15.

Table A-4

ENDURANCE FUEL LOAD ⁽¹⁾		
①	Endurance	4,500 n. miles ⁽²⁾
②	Endurance Speed	20 knots ⁽²⁾
③	Full Load Displacement	7,600 l. tons
④	Full Rated Power	80,000 SHP
⑤	Endurance Power at ② and ③	15,500 SHP ⁽³⁾
⑥	Avg. Endurance Power	
	= 1.1 x 5	17,100 SHP
⑦	Ratio: ⑥ / ④	0.21
⑧	Cruising Electric Load	4,000 kw ⁽⁴⁾
⑨	Fuel Rate at ⑥	0.517 lb/SHP-hr ⁽³⁾
⑩	Prop. Fuel Consumption	
	= ⑥ x ⑨	8,850 lbs/hr
⑪	Aux. Gen. Fuel Rate at ⑧	0.8 lb/kw-hr ⁽⁴⁾
⑫	Aux. Gen. Fuel Consumption	
	= ⑧ x ⑪	3,200 lb/hr
⑬	Fuel Consumption for Other Services	320 lb/hr ⁽⁵⁾
⑭	All-Purpose Fuel Consumption	
	= ⑩ + ⑫ + ⑬	12,370 lb/hr
⑮	All-Purpose Fuel Rate	
	= ⑭ / ⑥	0.723 lb/SHP-hr

(1) Ref: BUSHIPS Design Data Sheet DDS 9400-1, "Calculation of Surface Ship Endurance Fuel Requirements," 1 Nov. 1963.

(2) Values selected to equal DD-931 and DL-2.

(3) Values from baseline model.

(4) Estimated values for ships service.

(5) Estimated at 10% of auxiliary generator fuel consumption.

Table A-4 (Cont'd)

(16)	Fuel Rate Correction Factor based on (7)	1.04 ⁽¹⁾
(17)	Specific Fuel Rate = (15) x (16)	0.752 lb/SHP-hr
(18)	Endurance Fuel Rate = (17) x 1.05 ⁽²⁾	0.790 lb/SHP-hr
(19)	Burnable Fuel = (1) x (6) x (18) / ((2) x 2240)	1,357 l.tons
(20)	Tailpipe Allowance Factor	0.95 ⁽³⁾
(21)	Endurance Fuel Load = (19) / (20)	1,428 l.tons

(1) Value from ref. (1) above; 1.04 applies for (7) ≤ 1/3.

(2) Value from ref. (1) above; represents arbitrary 5% increase in fuel rate to allow for deterioration over two-year period.

(3) Value from ref. (1) above; 0.95 factor selected for broad, shallow tanks.

The endurance fuel load computation reduces to:

$$4.935 \times 10^{-4} K \left(\frac{\text{Endurance}}{\text{End. Speed}} \right) (\text{All-Purpose Fuel Consumption})$$

Where:

K = Fuel Rate Correction Factor

$$= 1.04 \text{ for } \left(\frac{\text{SHP}}{\text{Full Rated Power}} \right) \leq 0.33$$

$$= 1.03 \text{ for } 0.34 \leq \left(\frac{\text{SHP}}{\text{FRP}} \right) \leq 0.66$$

$$= 1.02 \text{ for } \left(\frac{\text{SHP}}{\text{FRP}} \right) > 0.67$$

All-Purpose Fuel Consumption = (Propulsion Fuel Consumption⁽¹⁾)
+ (Auxiliary Generator Fuel Consumption) + (Fuel Consumption
for other Services).

Conversely:

$$\text{Range (Endurance)} = \frac{2027 (\text{Speed}) (\text{Endurance Fuel Load})}{K (\text{All-Purpose Fuel Consumption})} \quad (\text{A20})$$

(1) Taker of power required at endurance speed in endurance fuel load calculations (allows for adverse sea conditions and bottom fouling over a two year period).

In order to provide a comparison between various configurations, range was calculated according to the above expression. The total of auxiliary generator and other services was held fixed at 3520 lb/hr in all calculations. Fuel rate was taken from the computer results at each speed⁽¹⁾ and an allowance was made for additional ships service load as follows:

$$\begin{aligned} \text{Added Ship Service Load (kw)} &= (\text{Cooling Load}) \\ &+ (\text{Refrigeration Load}) + (\text{Lubrication Load}) \end{aligned}$$

Where:

$$\text{Cooling Load (kw)} = 0.02 (\text{Turbine HP} - \text{Shaft HP})$$

(Estimated ship service load required for pumping coolant and seawater to remove heat generated by losses).

$$\text{Refrigeration Load} = \text{Power required for helium compressors}$$

$$\text{Lubrication Load} = \text{Power required for lubrication of electrical generators}^{(2)}.$$

$$\text{Added Fuel Load (lb/hr)} = 0.8 \times (\text{Added Ships Service Load})$$

(1) No 110% adjustment factor used on power.

(2) Motor lubrication considered even tradeoff against mechanical gear system.

Example:

Electric drive system with cruise turbines at 25 knots; two main turbines operating:

$$\left. \begin{array}{l} \text{Turbine IHP} = 30980 \\ \text{Shaft HP} = 30040 \end{array} \right\} 19 \text{ kw cooling load}$$

$$\text{Refrigeration Load} = 130 \text{ kw}$$

$$\text{Lubrication Load} = \underline{2 \text{ kw}} \text{ (Two Generators)}$$

$$\text{Total added ships service load: } 151 \text{ kw}$$

$$\times 0.8 = 121 \text{ lb/hr added fuel load}$$

Fuel rates:

$$\text{Turbines: } 12,890 \text{ lb/hr}$$

$$\text{Added Load: } 121 \text{ lb/hr}$$

$$\text{Ships Service: } \underline{3520 \text{ lb/hr}}$$

$$\text{Total: } 16,531 \text{ lb/hr (All-purpose fuel rate)}$$

$$\text{SHP} \div \text{Rated Power (80,000 HP)} = 0.38; K = 1.03$$

$$\text{Range} = \frac{2027 (25) (1430)}{1.03 (16531)} = 4256 \text{ miles}$$

Average results over the mission profile are based on the average mission speed of 15.8 knots and the average power loss and lubrication load. The endurance fuel load is reduced by the weight of any added propulsion equipment.

i.e., over the mission profile:

$$\text{Range} = \frac{2027 (15.8) (1430 - \text{Added Equipment Weight})}{1.04 (\text{Average All-Purpose Fuel Consumption})}$$

$$= \frac{30795 (1430 - \text{Added Weights})}{(\text{Average All-Purpose Fuel Consumption})}$$

(A21)

Example:

For the geared-drive baseline:

$$\begin{array}{ll} \text{Average Turbine HP} & = 10770 \\ \text{Average Shaft HP} & = 10340 \end{array} \left. \vphantom{\begin{array}{l} 10770 \\ 10340 \end{array}} \right\} 9 \text{ kw cooling load}$$
$$\text{Refrigeration Load} = 0$$
$$\text{Lubrication Load} = \frac{0}{9 \text{ kw total load (7 lb/hr)}}$$

Fuel Rates:

$$\begin{array}{ll} \text{Average Turbine Fuel Rate} & = 6392 \text{ lb/hr} \\ \text{Average Added Load} & = 7 \text{ lb/hr} \\ \text{Ships Service Load} & = \underline{3520 \text{ lb/hr}} \\ & 9919 \text{ lb/hr total} \end{array}$$

$$\text{Added Weight} = 0$$

$$\text{Range} = \frac{30795 (1430)}{9919} = 4440 \text{ miles}$$

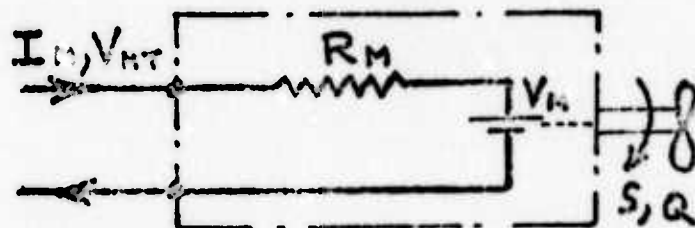
A.6 ELECTRIC DRIVE MATH MODELS

Math models for the electric motors, generators, transmission lines, and buss lines are shown in figures A-12 through A-14.

A.7 ALTERNATOR MATH MODEL

Analysis of the crossover efficiency, as shown in figure A-15 gives an expression for drive system efficiency in the crossover mode equal to 0.921 for a drive efficiency of 0.96 and alternator efficiencies of 0.98 each. The same result is obtained by using $0.96 \times (0.98)^2$; i.e., by multiplying the drive efficiency by the alternator pair efficiency of 0.96. The latter method is used in the computer program whenever crossover is used.

MOTOR MATH MODEL



I_M = Input Current (Amps)

V_{MT} = Terminal Voltage

V_M = Back emf (volts)

R_M = Internal resistance (ohms)

S = Shaft rpm

Q = Shaft torque (lb-ft)

K_M = Back emf (volts/rpm)

K_F = Friction loss (Kw/rpm²)

K_E = Eddy current loss (Kw/rpm²)

K_V = Viscous loss (Kw/rpm³)

Given S and Q (from propeller characteristics)

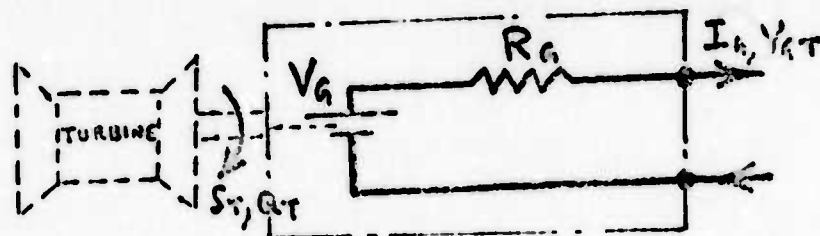
$$I_M = \frac{0.1428 S \cdot Q + 1000 (K_F S^2 + K_E S^2 + K_V S^3)}{K_M S}$$

$$V_M = K_M S$$

$$V_{MT} = V_M + I_M R_M$$

Figure A-12

GENERATOR MATH MODEL



- I_G = Generator Current (amps)
- V_{GT} = Terminal Voltage
- V_G = Back emf (volts)
- R_G = Internal Resistance (ohms)
- S_T = Shaft (turbine) rpm
- P_T = Turbine hp
- K_G = Back emf (volts/ipm)
- K_T = Friction loss (Kw/rpm²)
- K_E = Eddy current loss (Kw/rpm² at full field)
- K_V = Viscous loss (Kw/rpm³)
- P_f = Percent magnet field

Given I_G and V_{GT} (from Buss Line):

$$V_G = V_{GT} - I_G R_G$$

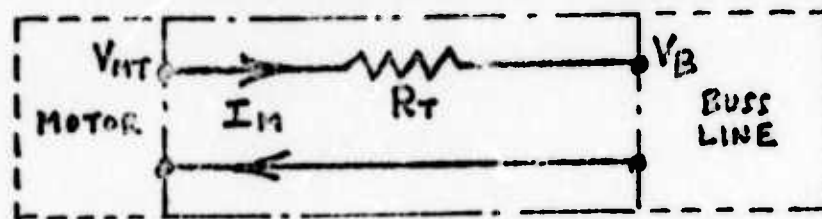
$$S_T^* = \frac{V_G}{P_f K_G}$$

$$P_T^* = \frac{I_G V_G + 1000 \left[K_T S_T^{*2} + K_E (P_f S_T^*)^2 + K_V S_T^{*3} \right]}{745.7}$$

* S_T and P_T are a function of the percent magnet field.

Figure A-13

TRANSMISSION LINE MATH MODEL



V_{MT} = Motor terminal voltage

V_B = Buss voltage

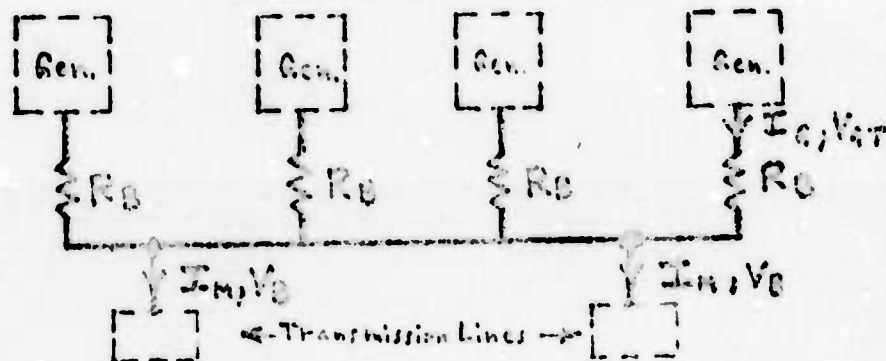
I_M = Motor current (amps)

R_T = Transmission line resistance (ohms)

Given I_M and V_{MT} (from motor):

$$V_B = V_{MT} + I_M R_T$$

BUSS LINE MATH MODEL



I_M = Motor current (amps)

I_G = Generator current (amps)

V_B = Buss voltage

V_{GT} = Generator terminal voltage

R_B = Buss resistance

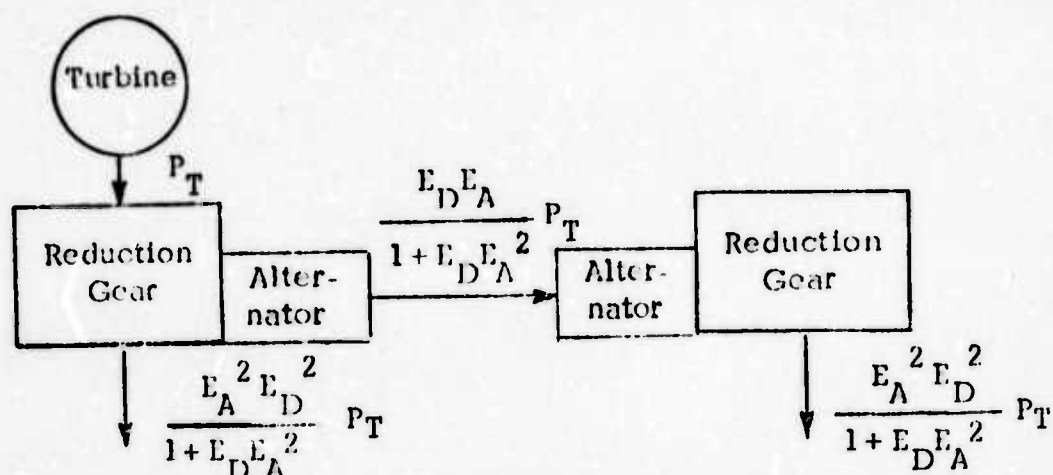
N_T = No. of turbines operating

Given I_M and V_B (from transmission line):

$$I_G = \frac{2 I_M}{N_T}$$

$$V_{GT} = V_B + I_G R_B$$

Figure A-14



$$\text{Overall efficiency} = 2 \left(\frac{E_A^2 E_D^2}{1 + E_D E_A^2} \right)$$

Where:

P_T = Turbine Shaft Power

E_A = Alternator Efficiency

E_D = Drive Efficiency

For $E_A = 0.98$ and $E_D = 0.96$:

Power transferred = $0.489 P_T$

Efficiency = 0.921

Figure A-15. Alternator Math Model

APPENDIX B - SYSTEM COMPONENTS

This appendix contains details of the superconductive motors, generators and ancillary equipment used as a basis for electric drive performance in the study, as well as the alternator design used for the geared systems.

B.1 MOTORS

The motor design used is based on a design developed at NSRDC, Annapolis, Maryland⁽¹⁾; essential details are shown in figure B-1.

B.2 MAIN GENERATORS

The 20,000 hp main generator design is also based on an NSRDC design⁽²⁾ and is shown in figure B-2.

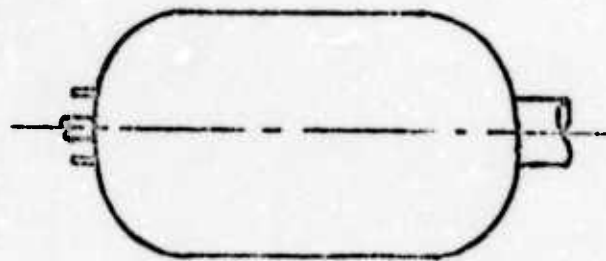
B.3 CRUISE GENERATORS

The 5,000 hp cruise generator is similar to a 5,000 hp, 15,000 rpm generator design developed at NSRDC. The generator was redesigned to operate at 7,200 rpm for use with the Garrett 990 gas turbine and machine losses and helium requirements were estimated using techniques

(1) T. J. Doyle, "Superconductive Propulsion Motor Development at NSRDC," Naval Ship Research and Development Center, Annapolis, Maryland, August, 1974.

(2) H.O. Stevens, "Superconductive Generation Development for Ship Electric Drive Systems," Naval Ship Research and Development Center, Annapolis, Maryland, August, 1974.

40,000 HP SUPERCONDUCTING MOTOR



Design Point:

40,000 hp at 180 rpm
(30,510 kw at 300 v)

Size:

OD: 6.47 ft
Length: 11.67 ft
Volume: 384 ft³

Weight:

Machine weight: 130,000 lbs
Mount weight: 6,500 lbs
Total weight: 136,500 lbs

Performance at Design Point:

Power Input:	30,510 (40,915 hp)	
Losses:	Ohmic	620.6 kw
	Brush Eddy Current	59.2 kw
	Brush Viscous Drag	0.4 kw
	Bearing, Seals and Windage	2.1 kw
		682 kw total (915 hp)
Power Output:	40,000 hp (29,828 kw)	
Current:	101,700 amps	
Voltage:	300 volts	Efficiency: 97.76%

Helium Required:

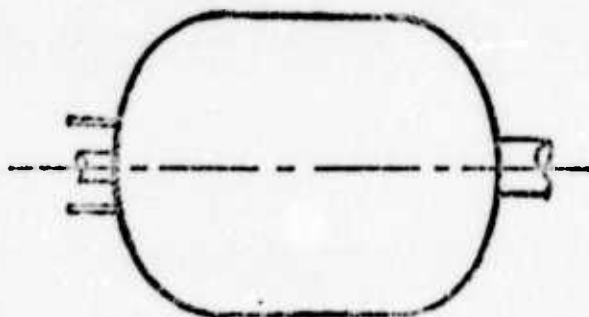
0.097 gm/sec at 4.5 K, 1.1 atmosphere

Design Constants:

K_M (Back emf):	1.6328 v/rpm
R_M (Internal Resistance):	60 micro-ohm
K_F (Friction Loss):	6.481×10^{-5} kw/(rpm) ²
K_E (Eddy Current Loss):	1.827×10^{-3} kw/(rpm) ² (at full field)
K_V (Viscous Loss):	6.859×10^{-8} kw/(rpm) ³

Figure B-1

20,000 HP SUPERCONDUCTING MAIN GENERATOR



Design Point: 20,000 hp @ 3300 rpm
(14,800 kn @ 300v)

<u>Size</u>		<u>Weight</u>	
OD:	3.17 ft	Machine Weight:	10,000 lbs
Length:	4.17 ft	Mount Weight:	500 lbs
Volume:	32.8 ft	Total Weight:	10,500 lbs

Performance at design point:

Power Input:	20,000 hp (14,914 kw)		
Losses:	Ohmic:	27.3 kw	
	Brush Eddy Current:	27.8 kw	
	Brush Viscous Drag:	31.2 kw	
	Bearings, Seals & Windage:	20.0 kw	
		106	kw Total

Power Output:	14,208 kw		
Current:	49,360 amps		
Voltage:	300 volts	Efficiency:	99.29%

Helium Required: 0.045 gm/sec at 4.5 K, 1.1 atmosphere

Design Constants:

K_a (Back emf): 0.09111 volts/rpm

R_a (Internal Resistance): 11.2 micro-ohms

(Friction Loss): $1.8365 \times 10^{-6} \text{ kw}/(\text{rpm})^2$

K_e (Eddy Current Loss): $2.553 \times 10^{-6} \text{ kw}/(\text{rpm})^2$ (At full Field)

K_v (Viscous Loss): $8.682 \times 10^{-10} \text{ kw}/(\text{rpm})^3$

Figure B-2

similar to those used at NSRDC⁽¹⁾. The final design is shown in figure B-3.

B.4 AC-DC GENERATOR

Garrett Aeresearch Manufacturing Company has proposed a non-superconducting 5,000 hp ac-dc generator for use with the Garrett 990 turbine⁽²⁾. This generator develops the dc power required by the superconducting motors by generating ac power which is then rectified to dc by a bank of 120 diodes. The machine is less efficient than the superconducting cruise generator (96.5% against 99.2%) and weighs about 1-1/2 times as much. It has the advantages of not requiring liquid helium cooling and an ability for rapid changes in field excitation (very rapid field changes are not possible in the superconducting machine because of magnet and inductance limitations). The use of the ac-dc generator as a substitute for the superconducting generator is discussed in the text. Figure B-4 gives the essential design details.

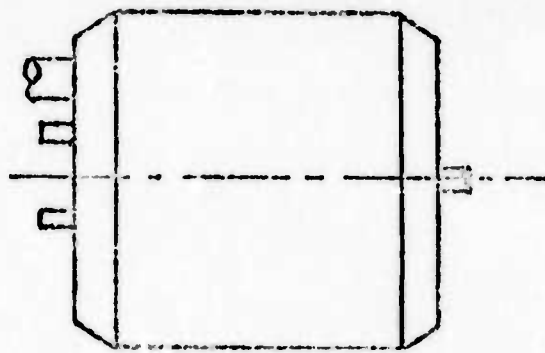
B.5 ALTERNATOR

The alternator used as a basis for the geared drive crossover systems is also based on Aeresearch designs developed for NAVSHEPS. It is, essentially, the ac-dc generator design without

(1) T.J. Doyle and M.J. Cannell, "Development of the Shaped Field Superconductive Motor," Naval Ship Research and Development Center, Bethesda, Maryland, Report No. 4178, January 1974.

(2) Work performed under the auspices of the U.S. Navy Naval Ships System Command under Contract No. N0024-73-C-5487.

5,000 HP SUPERCONDUCTING CRUISE GENERATOR



Design Point:

5,000 hp @ 7,200 rpm
(3,700 kw @ 150 v)

Size:

OD: 2.33 ft
Length: 2.33 ft
Volume: 10.0 ft³

Weight

Machine weight: 3,500 lbs
Mount weight: 350 lbs
Total weight: 3,850 lbs

Performance at Design Point:

Power Input: 5,000 hp (3,728 kw)
Losses: Ohmic 14.6 kw
Brush Eddy Current 3.0 kw
Brush Viscous Drag 1.8 kw
Bearings, Seals and Windage 9.0 kw
28 kw total
Power Output: 3,700 kw
Current: 24,640 amps
Voltage: 150 volts Efficiency: 99.24%

Helium Required:

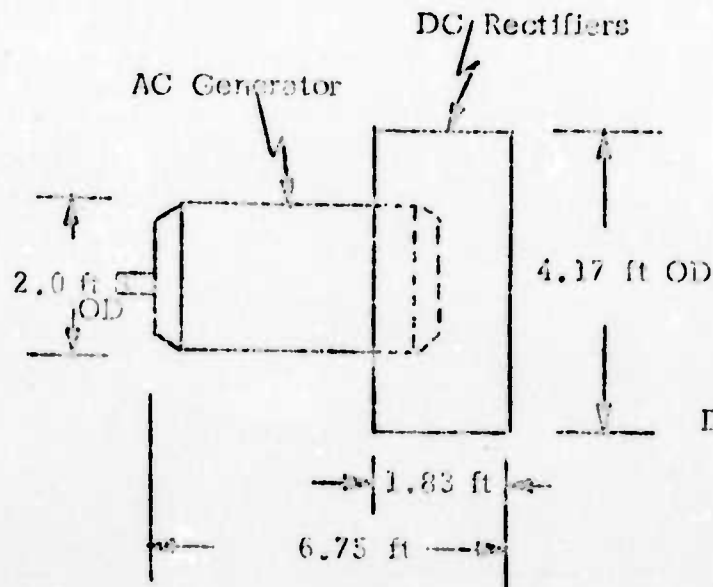
0.051 gm/sec at 4.5° K, 1.1 atmosphere

Design Constants:

K_b (Back emf): 0.0209 volts/rpm
 R_G (Internal Resistance): 24 micro-ohms
 K_f (Friction Loss): 0.1736×10^{-6} kw/(rpm)²
 K_e (Eddy Current Loss): 0.0579×10^{-6} kw/(rpm)² (at full fill)
 K_v (Viscous Loss): 4.8225×10^{-12} kw/(rpm)³

Figure B-3

5,000 HP AC-DC GENERATOR



Size

See sketch
Volume: 28 ft³ (41 ft³ envelope)

Weight

Machine weight: 5,570 lbs
Mount weight: 500 lbs
Total weight: 6,070 lbs

Performance at Design Point:

Power Input: 5,000 hp (3,728 kw)
Losses: Ohmic (ac) 80.2 kw
Friction and windage 7.1 kw
Ohmic (rectifiers) 41.3 kw
122 kw

Power Output: 3,599 kw
Current: 23,650 amps-dc
Voltage: 152 volts-dc Efficiency: 96.5%

Note: ac efficiency (without rectifiers) = 97.6%

Figure B-4

rectifiers. Under the contract previously cited, three designs were developed with the following characteristics for the ac portion of the machines:

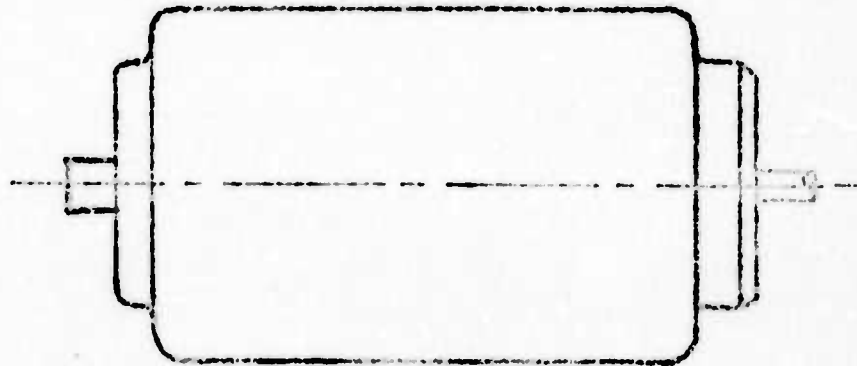
<u>Power</u>	<u>OD</u>	<u>Length</u>	<u>Weight</u>	<u>Speed</u>	<u>ac Efficiency</u>
3,000 hp	18"	43"	1,900 lbs	10,000 rpm	97.2%
5,000 hp	24"	61"	4,950 lbs	7,200 rpm	97.6%
20,000 hp	50"	84"	19,600 lbs	3,600 rpm	98.4%

The crossover alternator for this application must be capable of handling 10,000 hp when either one or three main turbines are used to power the two propeller shafts. The design data for the three machines above was extrapolated to arrive at the following specifications for the required alternator:

<u>Power</u>	<u>OD</u>	<u>Length</u>	<u>Weight</u>	<u>Speed</u>	<u>ac Efficiency</u>
10,000 hp	36"	72"	10,000 lbs	5,000 rpm	98.0%

The 98% efficiency is considered a conservative estimate in view of the fact that the original designs were constrained by the necessity of limiting voltages because of the rectifier bank in the ac-dc versions; with these limitations removed, efficiency greater than 98% should be possible. The 98% value was used in the study and a value of 96% efficiency was used for a pair of alternators for crossover. Essential details of the alternator are shown in figure B-5.

10,000 HP AC ALTERNATOR



Design Point:

10,000 hp at 5,000 rpm
(7,450 kw @ 4,160 vac)

Size

OD: 3.0 ft
Length: 6.0 ft
Volume: 42.4 ft³

Weight:

Machine weight: 10,000 lbs
Mount weight: 1,000 lbs
Total weight: 11,000 lbs

Performance at Design Point:

Power input:	10,000 hp (7457 kw)	
Losses:	149 kw (est.)	
Power output:	7,308 kw (9,416 kva)	
Current:	2,029 amps	
Voltage:	4,160 volts	Efficiency: 98.9%

Figure B-5

B.6 TRANSMISSION LINES

Varying the transmission line resistances vs. performance over the mission profile provided the following relationship for the baseline configuration:

Fuel consumed due to line resistances (in lbs/hr),

$$W_F = 0.76 R_T + 0.98 R_{MG} + 0.22 R_C \text{ (Main Turbines only)}$$

$$= 0.69 R_T + 0.80 R_{MG} + 0.20 R_C + 0.14 R_{CC} \text{ (Main + Cruise Turbines)}$$

Where:

R_T = Motor transmission line resistance

R_{MG} = Main generator buss line resistance

R_{CG} = Cruise generator buss line resistance

R_C = Crossover line resistance

(All in micro-ohms)

Taking the transmission lines as coaxial aluminum tubes with integral fluid cooling tubes, the cross-sectional area required for the aluminum and the cooling tubes is:

$$\text{Aluminum: } 53.76 \frac{L}{R} \text{ (in}^2\text{)}$$

$$\text{Coolant: } 2.653 \times 10^{-11} I^2 R \text{ (in}^2\text{)}$$

Where:

L = Length (ft)

R = Resistance (micro-ohms)

I = Maximum design current (amps)

An additional 20% is allowed for coolant pipe and insulation thickness.

The total weight of the transmission line is:

$$W_L = \frac{48.56}{R} \cdot L^2 + 1.385 \times 10^{-11} I^2 R \cdot L \text{ (lbs)}$$

A trade-off thus occurs between the transmission line weights and the weight of fuel consumed, as shown in figure B-6.

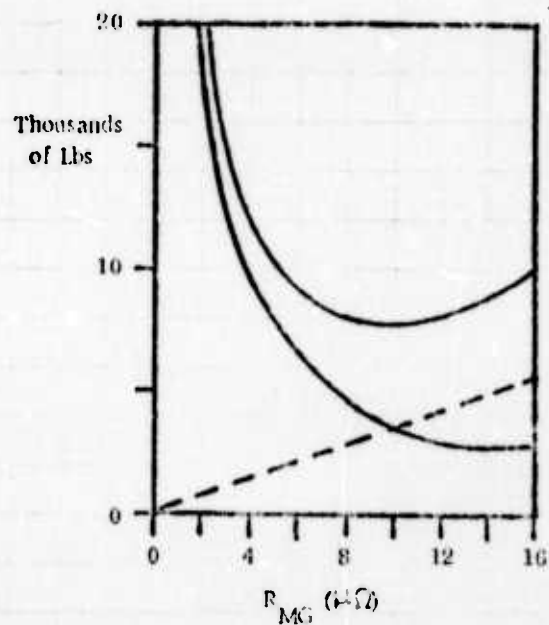
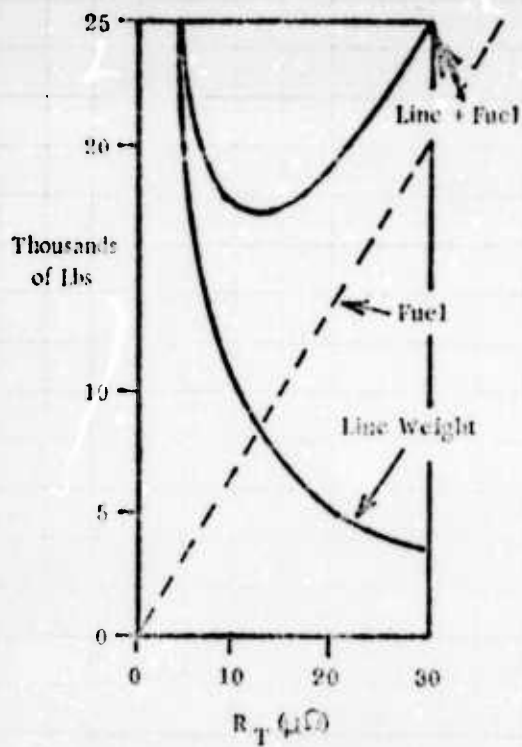
The transmission line weights were optimized against the amount of fuel burned in 500 hours with the following results:

- . Baseline configuration

- .. Motor transmission lines(2): 17 $\mu\Omega$, 32' long, 3000 lbs each.
- .. Main generator buss lines: 9 $\mu\Omega$ each, 55' total, 4190 lbs total.
- .. Fwd cruise generator line: 95 $\mu\Omega$, 82', 4000 lbs.
- .. Aft cruise generator line: 72 $\mu\Omega$, 52', 1910 lbs.
- .. Crossover line: 110 $\mu\Omega$, 157', 11260 lbs.

- . Reconfigured Engine Room Version

- .. Motor transmission lines(2): 62 $\mu\Omega$ each; fwd. line 132', 16100 lbs; aft line 44'; 1890 lbs.
- .. Main generator buss lines: 10 $\mu\Omega$, 72' total, 5600 lbs total.
- .. Fwd cruise generator line: 97 $\mu\Omega$, 98', 5000 lbs.
- .. Aft cruise generator line: 100 $\mu\Omega$, 71', 2630 lbs.
- .. Crossover line: 27 $\mu\Omega$, 41', 3030 lbs.



NOTE: All Fuel Weights are for 500 Hrs of Operation

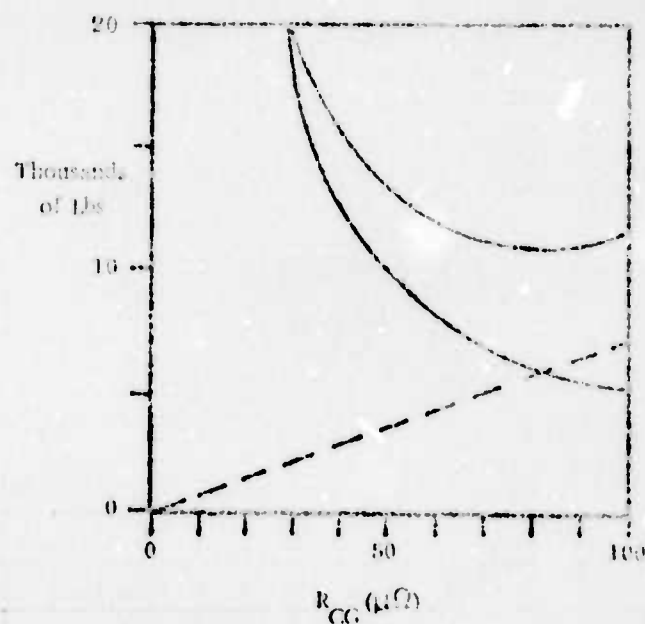
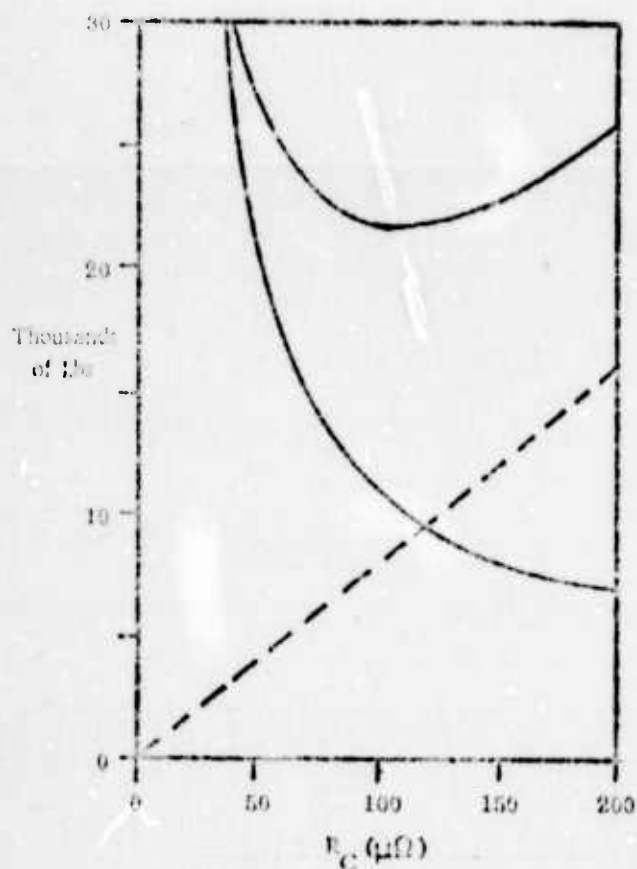


Figure B-6. Line and Fuel Rates vs. Resistances

The actual configurations are shown in figure B-7. As may be seen, the total resistance between motors and generators differs for each combination selected. In order to simplify analysis, a set of equivalent resistances were computed which would give the same ohmic (I^2R) loss as the actual physical configuration, but which would permit a single motor transmission line resistance to be used between the motors and a common buss point. Each generator is then considered to be connected to this common point with a resistance which is the same as that for each of the other generators. The resultant values are ⁽¹⁾:

<u>Baseline Configuration</u>	<u>Reconfigured Engine Room</u>
$R_T = 17$	55
$R_1 = 94.3$	98.7
$R_2 = 77.0$	107
$R_3 = 33.6$	8.72
$R_4 = 9.0$	17.0
$R_5 = 18.0$	3.59
$R_6 = 9.0$	17.0

where:

R_T is resistance between motor and buss point

R_1 is for 1 engine turbine

R_2 is for 2 engine turbines

R_3 is for 1 main turbine

R_4 is for 2 main turbines

R_5 is for 3 main turbines

R_6 is for 4 main turbines

(1) All values in micro-ohms.

For cruise turbines located in the engine rooms, instead of topside, the transmission lines were assumed to be 20 ft/ long with a resistance of 27 micro-ohms each and a weight of 1500 lbs. for the pair. The values for R_T and R_3 through R_6 remain the same as for the reconfigured engine room case; R_1 and R_2 become:

$$R_1 = 18.72 \mu\Omega$$

$$R_2 = 27.00 \mu\Omega$$

B.7 HELIUM COMPRESSORS

Based on the estimated motor and generator helium losses, the amount of compressor power required for each was estimated as follows:

<u>Machine</u>	<u>Helium Loss</u>	<u>Carnot Power Required to Reliquify</u>	<u>Compressor Power Required</u>
Motor	0.097 gm/sec	0.694 Kw	22.8 Kw
Main Generator	0.045 gm/sec	0.322 Kw	12.8 Kw
Cruise Generator	0.046 gm/sec	0.329 Kw	13.0 Kw

Assuming one compressor per engine room, the total compressor power required is:

Main Turbines Only:	48.4 Kw
Main + Cruise Turbines:	61.4 Kw

The compressor sizes required for these outputs were estimated at:

	<u>Main Turbines Only</u>	<u>Main + Cruise Turbines</u>
Maximum Power	50 Kw	65 Kw
Volume	33 ft ³	43 ft ³
Weight	2500 lbs	3250 lbs
Length	7 ft	7 ft
Diameter	2.5 ft	2.8 ft

B.8 HELIUM CRYOSECTIONS

Helium cryosections are mounted adjacent to each superconducting machine and form the final refrigeration (expansion) stage. All cryosections were kept the same size for commonality, being sized to handle a maximum

load of 0.10 gm/sec of helium. Two cryosections are used per motor to facilitate rapid cooldown and to provide redundancy in case of failure. The generators have one cryosection each which normally operate at half capacity except during initial cooldown. Each cryosection is 2.0 ft. in diameter by 5.0 ft. long and weights 933 lbs.

B.9 HELIUM CRYOLINES

The cryogenic transfer lines between the compressors and cryosection were designed to handle the maximum load, based on the number of cryosections used. Line sizes and weights required are as follows:

<u>Number of Cryosections</u>	<u>Line OD</u>	<u>Weight (lbs/ft)</u>
1	2.0"	2.28
2	2.9"	4.56
3	3.5"	6.84
4	4.1"	9.12
5	4.6"	11.40

The total length of lines and total weight for each configuration is:

	<u>Baseline Configuration</u>	<u>Reconfigured Engine Room</u>
Fwd. Engine Room	46 ft; 232 lbs	140 ft; 752 lbs
Fwd. Cruise Turbine	80 ft; 184 lbs	70 ft; 175 lbs
Aft Engine Room	56 ft; 243 lbs	54 ft; 322 lbs
Aft Cruise Turbine	60 ft; 138 lbs	60 ft; 150 lbs

B.10 SWITCHGEAR

Based on designs developed at NSRDC, Annapolis, the sizes and weights for electrical switches required were estimated as follows:

<u>For Use With</u>	<u>Size</u>	<u>Weight</u>
Cruise Generator	15" x 21" x 5"	85 lbs each
Main Generator	21" x 30" x 7"	275 lbs each
Crossover Line	17" x 26" x 5"	135 lbs each

The switches have been designed to handle the maximum currents + transients which occur in each application and serve to connect and disconnect the generators from the buss line, reverse generator polarities and to open and close the crossover line. In addition to the switches, rheostats are required so that voltages can be matched when bringing generators on and off line, when switching in crossover and when reversing the motors. The rheostats required were estimated as follows:

<u>For Use With</u>	<u>Size</u>	<u>Weight</u>
Cruise Generator	29" x 20" x 24"	740 lbs
Main Generator	40" x 40" x 48"	4000 lbs
Crossover Line	29" x 20" x 24"	770 lbs

For each application, four switches and one rheostat are required in order to provide forward/reverse polarities and disconnect. The total switchgear units resulting are packaged as follows:

For Use With	<u>Size</u>	<u>Weight</u>
Cruise Generator	24" x 30" x 41"	1100 lbs each
Main Generator	40" x 48" x 70"	5100 lbs each
Crossover Line	24" x 32" x 46"	1300 lbs each

B.11 ESTIMATE OF SHIPS SERVICE POWER

Based on trends in electric power capacity aboard DD class vessels as follows: ⁽¹⁾

<u>Year</u>	<u>Kw Power</u>
1945	1,000
1955	2,000
1975	6,000

an installed capacity of 6,000 Kw was assumed. A steady load of 4,000 Kw was then assumed for assessing impact on ship's range (parametric variations in the study allow adjustment for changes in this power level).

A level of 4,900 Kw can be provided by one nominally 5000 hp turbine operating at near full load; fuel load would be 2700 lbs/hr. If a second, standby, turbine is assumed to be operating at all times at an idel fuel load of 360 lbs/hr, the total fuel load is 3060 lbs/hr for 4000 kw output, or 0.77 lb/Kw-hr. Based on this, the ships auxiliary generator fuel rate was assumed to be 0.8 lb/Kw-hr.

(1) C. Graham, "Factors Affecting Naval Ship Design", Naval Engineers Journal, February, 1972, p.85.

APPENDIX C - COMPUTER STUDIES

C.1 GENERAL

This appendix contains a general discussion of the computer program utilized for analysis of the various propulsion configurations over the mission profile and output data sheets for the most important cases.

Math models for the turbines, propellers, drag, electric motors and generators and electrical transmission lines which were incorporated into the computer program are detailed in Appendix A.

Electric drive system losses were analyzed based on the motor, generator and transmission line models. Geared drives were analyzed by assuming a fixed gear efficiency for the main reduction gears and shafting losses⁽¹⁾ and a fixed efficiency for the crossover alternators⁽²⁾ and turbine horsepower required at each speed was obtained by dividing shaft horsepower by the efficiency.

Cooling loads were computed based on an estimated 9.02 kw of ship service load per hp lost in the transmission system and 0.8 lbs/kwh was used as the ship service auxiliary generator fuel rate. For the electrical

(1) 0.960 efficiency was used in the study.

(2) 0.960 efficiency per alternator, or 0.960 for the pair was used.

systems, 1 kw of power was added for each generator in use for lubrication pump power (motor lubrication was assumed to be an equal trade-off for the main reduction gear lube load). Constant helium compressor powers were used through the electrical drive missions⁽¹⁾.

(1) 100 kw for main turbines only; 130 kw for main and cruise turbine configurations.

C.2 COMPUTER PROGRAM

The math model computer program consists of a main program and four subprograms:

- . PITCH
- . GENM
- . MISSN
- . ROUND

The function of each is as follows:

MAIN Program

- . Reads calculation limits and performance (speed and configuration) requirements.
- . Obtains fuel rate from PITCH for given pitch ratio.
- . Optimizes pitch, if pitch is not fixed, by a search procedure; fuel rate is obtained from PITCH for each pitch ratio until minimum fuel is obtained. Four different search procedures are utilized:
 - .. Fibonacci search for minimum fuel (used for electric drive).
 - .. Interval search for minimum fuel (used for geared drive.)
 - .. Interval search for fuel rate equal to turbine idle rate (used for geared drive under low power condition).
 - .. Pitch is fixed for electric drives when fuel rate drops below the idle rate.

- . Increases number of turbines when the fuel rate exceeds the maximum allowed with the existing configuration.
- . When cruise turbines are used, compares results for main turbines and uses the most efficient.
- . Calculates and prints final results for each speed.
- . Passes final result for each speed to MISSN and calls for summary when last speed is reached (last speed for which turbine configuration specified can attain results within allowed fuel and turbine speed limitations).
- . Reads new performance requirements when summary is complete.
- . Reads in new or changed specification data (gear ratios, electric constants, etc.) when called for.

PITCH Subprogram

- . Reads propeller and drag constants.
- . For geared drive, reads gear ratios, efficiencies and turbine constants.
- . For electric drive, reads motor constants and transmission line resistances.
- . Computes drag, propeller and turbine characteristics.
- . Computes turbine fuel when supplied with propeller pitch from MAIN (calculated directly for geared drive; for electric drive,

motor/propeller speed and torque are computed, voltages and currents are computed and required generator voltage and current are passed to GENM, which returns fuel rate).

GENM Subprogram (used for electric drive only)

- . Reads generator and turbine constants.
- . Computes turbine idle characteristics.
- . Computes fuel rate when supplied with generator voltage and current.
 - .. If magnet field is not fixed, the optimum turbine speed is computed and the field is adjusted to match this field.
 - .. If the field is fixed, the corresponding speed and fuel rate are computed.
 - .. If fuel drops below the minimum turbine (idle) fuel rate, the magnet field is reduced until fuel rate equals idle unless no field change is allowed.
- . "Flags" the result if maximum turbine speed is exceeded or fuel rate is above or below the allowable fuel rate.

MISSN Subprogram

- . Reads mission profile (percent time at each speed).
- . Receives ship speed, turbine configuration, propeller speed, horsepower (turbine, shaft and effective), pitch ratio, effective

gear ratio, turbine fuel rate, turbine figure of merit, refrigeration load and lubrication load from PITCH.

- . Selects values corresponding to smallest fuel rate when more than two sets of data are received at the same speed.
- . Computes miles/ton of turbine fuel, and, per thousand hours: miles, tons of fuel and total propulsion system (turbines plus electric system load) tons/mile. Prints results for each speed.
- . Computes and prints average results over mission profile.
- . Calls ROUND to round results to specified accuracy before printing.

ROUND Subprogram

- . Rounds data to accuracy called for in input. For example, if 4-place accuracy is specified, 35693.1 becomes 35690.0; 21.2195 becomes 21.2200, etc.

Program Variables

The program has the following variables as inputs, independent of the specific configuration being investigated:

Overall Limits

- . Required accuracy in fuel rate.
- . Required accuracy in P/D ratio.
- . Number of iterations allowed in search for minimum fuel.
- . Maximum allowable P/D ratio.

Drag Calculations

- . 3 Drag coefficients (C_{D0} , V_X and C_{D2})

Propellers

- . Propeller diameter
- . Water density
- . 6 thrust coefficients (T_{01} , T_{02} , etc.)
- . 7 torque coefficients (Q_{01} , Q_{02} , etc.)

Turbines (Main and Cruise)

- . 4 Turbine fuel constants (W_1 , W_2 , W_3 and W_4).
- . Minimum fuel rates.
- . Maximum fuel rates.
- . Maximum rpms.

Geared Drive

- . Main gear ratio
- . Cruise gear ratio
- . Gear efficiency
- . Alternator efficiency

Electric Drive

- . Refrigeration power requirements
- . Lubrication power requirements
- . Magnet field (fixed or variable)

- . 5 Motor constants (K_{TM} , K_{EM} , K_{VM} , K_M and R_M)
- . 5 Generator constants (K_{FG} , K_{IG} , K_{VG} , K_G and R_G)
(both cruise and main)
- . 7 Resistances (R_T and $R_{B1} - R_{B6}$)

Mission Profile

- . Percent time at each speed

For each configuration run, the following variables are input:

Speed

- . Minimum speed.
- . Maximum speed.
- . Increments in speed (between minimum and maximum speeds specified).
- . Minimum number of turbines and type.
- . Maximum number of turbines and type.
- . Odd number of turbines allowed or not allowed (i.e., crossover or no crossover).
- . P/D ratio (fixed or variable).
- . Percent magnet field (fixed or variable) (electric drive only).
- . Number of digits accuracy desired in final printout.
- . Magnet field adjustment allowed or not allowed (electric drive only).

In addition:

- . A punch card record of results for each speed may be called for. ⁽¹⁾
- . Step-by-step details of each search procedure may be called for.
- . The search calculation made may be changed (between Fibonacci and interval search).

(1) Cards may be used as input to an existing mission analysis program which gives details of performance of each system component at each speed and may be run over different mission profiles.

C.3 COMPUTER RESULTS

This section contains results of the computer runs for various configurations and variations.

Included are:

- . Program constants used for the geared drive systems (Ref. No. 10).
- . Program constants used for the electric drive systems (baseline configuration, ref. no. 1; reconfigured engine room, ref. no. 2 and optimum configuration⁽¹⁾, ref. no. 3).
- . Propeller performance, ship drag and mission profile.
- . Mission profile summaries⁽²⁾ for the baseline, baseline + alternators, baseline + cruise turbines and baseline + alternators and cruise turbines configurations.
- . Mission profile summaries for the electric drive systems (baseline configuration, reconfigured engine room for the systems with and without cruise turbines and optimum configuration for the system with cruise turbines.

(1) Cruise turbines moved to engine room.

(2) "RANCE" is the range based on turbine fuel rate only; "TONS OF FUEL AND TONS PER MILE" include the impact of cooling, lube system and helium compressor loads. "SPEED RATIO" is the ratio of turbine speed to propeller rpms. "REL. NO." refers to the program constants.

- Mission Profile Summaries for the geared and electric configurations with variable (fully optimized) pitches.
- Mission Profile Summaries for the electric drive baseline configurations with the generator fields fixed (at 90%), fixed to the nearest 10% and fixed at "optimum" settings. ⁽¹⁾
- Mission Profile Summaries for each turbine (1 cruise, 2 cruise, 1 main, etc.) for the baseline configuration electric drive; included for these summaries is a second page for each giving details of propeller, turbine and drive efficiencies, percent magnet field, voltages and currents.

(1) 90% for cruise turbines
 60% for one main turbine
 75% for two main turbines
 90% for three and four main turbines

REF. NO. 101

ADVANCED DESTROYER FUEL OPTIMIZATION...

UNDER LOW POWER CONDITIONS, A FUEL RATE WITHIN 0.010 LBS/HR OF MIN IS SOUGHT
.....A MAXIMUM OF 50 ITERATIONS ARE ALLOWED

FOR HIGHER POWER CONDITIONS A SEARCH ROUTINE IS USED TO FIND THE MINIMUM FUEL RATE TO WITHIN 0.0030 CHANGE IN THE P/D RATIO
OR UNTIL THE FUEL RATE CHANGES BY LESS THAN 0.010 LBS/HR

THE MAX. ALLOWABLE P/D RATIO IS 0.0000

THE PROGRAM RUN IS TERMINATED IF MORE THAN 700 VALUES OF SHIPS SPEED ARE ENCOUNTERED

PROGRAM CONSTANTS

MAIN GEAR RATIO= 21.50 CRUISE GEAR RATIO= 74.00
GEAR EFFICIENCY= 0.960
ALTERNATOR EFFICIENCY= 0.9500
FRIC COEFFICIENTS...C1=1.4000 VX=27.00 C2=5.0000

WATER DENSITY=1.0025

PROPELLER DIAMETER=17.00

THRUST COEFFICIENTS...

T01= 0.0500 T02= 1.0130 T03= 0.0960
T04= 0.2500 T05= 1.0000 T06= 0.1700

TORQUE COEFFICIENTS...

C01= 0.4550 C02= 0.3470 C03= 0.1577
C04= 0.1850 C05= 0.1633 C06= 1.5140 CX=1.4750

CRUISE TURBINE CONSTANTS...W1= 750.00 W2= 0.040
W3= 0.3500 W4= 1.5000-03

WMIN= 360.0 RPM
WMAX= 2700.0 RPM
SWIN= 7200.0 RPM

MAX. POWER = 5715.00 HP AT 7232.21 RPM (2.117 HP/LB/HR)

MAIN TURBINE CONSTANTS...W1= 5600.00 W2= 1.050
W3= 0.1420 W4= 1.1420-02

WMIN= 1100.0 RPM
WMAX= 8400.0 RPM
SWIN= 3600.0 RPM

MAX. POWER = 22074.05 HP AT 3295.46 RPM (2.622 HP/LB/HR)

MOTOR CONSTANTS...

KPM= 0.60810E-04
 KPM= 0.18270E-02
 KVM= 0.68590E-07
 K4= 0.16328E 01
 K5= 0.60000E-04

TRANSMISSION CONSTANTS

RT= 0.17000E-04
 RH(1)= 0.94280E-04
 RH(3)= 0.34500E-04
 RH(5)= 0.17950E-04

0.77030E-04
 0.90000E-05
 0.90000E-05

VALUES GIVEN BELOW ARE FOR 100 PERCENT GENERATOR FIELD

MAIN GENERATOR CONSTANTS...
 KE=0.16360E-09
 KF=0.25530E-05
 KV=0.28820E-09
 KG=0.61100E-01
 RG=0.11200E-04

TURBINE CONSTANTS...

W1= 0.60000E-000
 W2= 1.050
 W3= 9.143
 W4= 0.1143E-02
 WMIN= 1100.0 PPM
 WMAX= 6400.0 PPM
 SWAX= 3600.0

IDLE POWER= 16.45 HP AT 1472-91 RPM
 IDLE FUEL= 1100.00 PPM FUEL... 134.18 VOLTS AT TERMINALS
 MAX POWER= 22024.06 HP AT 3295.40 RPM (2.622 HP/LB/HR)

VALUES GIVEN BELOW ARE FOR 100 PERCENT GENERATOR FIELD

CRUISE GENERATOR CONSTANTS...
 KE=0.17360E-09
 KF=0.57930E-07
 KV=0.43220E-11
 KG=0.23600E-01
 RG=0.24000E-04

TURBINE CONSTANTS...

W1= 750.000
 W2= 0.060
 W3= 3.350
 W4= 0.1400E-03
 WMIN= 300.0 PPM
 WMAX= 2700.0 PPM
 SWAX= 7200.0

IDLE POWER= 4.09 HP AT 1502.45 RPM
 IDLE FUEL= 960.00 PPM FUEL... 73.20 VOLTS AT TERMINALS
 MAX POWER= 5715.60 HP AT 7255.21 RPM (2.117 HP/LB/HR)

REFRIGERATION POWER= 100.00 KW FOR MAIN GENERATORS ONLY AND 130.00 KW FOR MAIN + CRUISE GENERATORS

TURB POWER= 1.00 KW PER GENERATOR

DRAW COEFFICIENTS...
 C1=1.4000 VX=27.00 C2=5.0000

WATER DENSITY=1.9905

PROPELLOR DIAMETER=17.00

THRUST COEFFICIENTS...

T01= 0.0500 T02= 1.0130 T03= 0.0060
 T01=0.2600 T02= 1.0000 T03=0.1600

TORQUE COEFFICIENTS...

C01= 0.4550 C02= 0.5470 C03= 0.1977
 C01= 0.1870 C02= 0.1473 C03= 1.5100
 KX=1.4250

MAIN CONSTANTS... TRANSMISSION CONSTANTS

KF1= 0.04810E-04	RT= 0.00000E-04
KF4= 0.10770E-02	RE(1)= 0.00720E-04
KV1= 0.00590E-07	RE(3)= 0.07000E-03
KV= 0.10320E-01	RE(5)= 0.00000E-05
KM= 0.00000E-04	

RM(2)= 0.10700E-03
RM(4)= 0.17000E-04
RM(6)= 0.17000E-04

VALUES GIVEN BELOW ARE FOR 100 PERCENT GENERATOR FIELD

MAIN GENERATOR CONSTANTS... TURBINE CONSTANTS...
KF=0.00000E-00
KV=0.00000E-00
KG=0.00000E-01
RG=0.00000E-04

W1= 1.000
W2= 1.000
W3= 1.000

W4= 0.1143E-02
WMIN= 1100.0 PPM
WMAX= 8400.0 PPM
SWAX= 3000.0

IDLE POWER= 16.49 HP AT 1472.91 RPM

IDLE FUEL= 1100.00 PPH FUEL... 134.18 VOLTS AT TERMINALS
MAX POWER= 22024.00 HP AT 3745.45 RPM (2.622 HP/LB/MIN)

VALUES GIVEN BELOW ARE FOR 100 PERCENT GENERATOR FIELD

CRUISE GENERATOR CONSTANTS... TURBINE CONSTANTS...
KF=0.00000E-00
KV=0.00000E-00
KG=0.00000E-01
RG=0.00000E-04

W1= 750.000
W2= 0.000
W3= 0.000

W4= 0.1900E-03
WMIN= 100.0 PPM
WMAX= 2700.0 PPM
SWAX= 7200.0

IDLE POWER= 4.00 HP AT 1502.45 RPM

IDLE FUEL= 360.00 PPH FUEL... 73.20 VOLTS AT TERMINALS
MAX POWER= 5715.50 HP AT 7235.21 RPM (2.117 HP/LB/MIN)

REFERRATION POWER= 100.00 KW FOR MAIN GENERATORS ONLY AND 130.00 KW FOR MAIN + CRUISE GENERATORS

IDLE POWER= 1.00 KW PER GENERATOR

CRAG COEFFICIENTS... C00=1.4000 VY=27.00 C2=5.0000

WATER DENSITY=1.9905

PROPELLER DIAMETER=17.00

THRUST COEFFICIENTS...

T01= 0.0000 T02= 1.0130 T03= 0.0000
T41= 0.0000 T42= 1.0000 T43= 0.1800

TURBINE COEFFICIENTS...

C01= 0.4550 C02= 0.5470 C03= 0.1577
C41= 0.1630 C42= 0.1633 C43= 1.5160 KA=1.4250

ELECTRIC DRIVE ID NUMBER 2

MOTOR CONSTANTS...
 RPM= 0.64810E-04
 RPM= 0.18270E-02
 KVM= 0.68590E-07
 KVM= 0.18378E-01
 RV= 0.50000E-04

TRANSMISSION CONSTANTS
 RT= 0.00000E-04
 RT(1)= 0.18720E-06
 RT(3)= 0.87200E-05
 RT(5)= 0.45500E-05

RT(2)= 0.27000E-04
 RT(4)= 0.17000E-04
 RT(6)= 0.17000E-04

VALUES GIVEN BELOW ARE FOR 100 PERCENT GENERATOR FIELD

MAIN GENERATOR CONSTANTS...
 KE=0.1030E-05
 KE=0.75510E-05
 KV=0.88970E-09
 KG=0.91100E-01
 KM=0.11200E-04

TURBINE CONSTANTS...
 W1=6000.000
 W2= 1.050
 W3= 9.143
 W4= 0.1143E-02
 WMIN= 1450.0 RPM
 WMAX= 8450.0 RPM
 SVAN= 3602.0

100% POWER= 16.49 HP AT 1472.91 RPM
 100% FIELD= 1100.00 RPM FIELD... 134.18 VOLTS AT TERMINALS
 MAX POWER= 22074.06 HP AT 3255.48 RPM (2.672 HP/LB/HR)

VALUES GIVEN BELOW ARE FOR 100 PERCENT GENERATION FIELD

CRUISE GENERATOR CONSTANTS...
 KE=0.1730E-06
 KE=0.57500E-07
 KV=0.48220E-11
 KG=0.70000E-01
 KM=0.24000E-04

TURBINE CONSTANTS...
 W1= 750.000
 W2= 0.360
 W3= 0.350
 W4= 0.1400E-03
 WMIN= 300.0 RPM
 WMAX= 2700.0 RPM
 SVAN= 7200.0

100% POWER= 4.30 HP AT 3502.45 RPM
 100% FIELD= 360.00 RPM FIELD... 73.20 VOLTS AT TERMINALS
 MAX POWER= 5715.00 HP AT 7258.21 RPM (2.117 HP/LB/HR)

APPROXIMATION POWER= 100.00 KW FOR MAIN GENERATORS ONLY AND 130.00 KW FOR MAIN + CRUISE GENERATORS

TURBINE POWER= 1.00 KW PER GENERATOR

CRUISE COEFFICIENTS...
 CGC=1.4000 KA=27.00 C2=5.0000

WATER DENSITY=1.9905

PROPELLER DIAMETER=17.00

THRUST COEFFICIENTS...
 T01= 0.0500 T02= 1.0130 T03= 0.0000
 T01=0.2600 T02= 1.0000 T03=0.1000

TORQUE COEFFICIENTS...
 Q01= 0.4550 Q02= 0.5470 Q03= 0.1977
 Q01= 0.1810 Q02= 0.1633 Q03= 1.5100 KA=1.4250

GEARED DRIVE SYSTEM

REF. NO. 101

MISSION PROFILE SUMMARY - BASELINE CONFIGURATION

KTS	PCT. TIME	P/C RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NV/TCN)	NAUT. MILES	TONS FUEL	TONS PER MILE	N. OF TURBINES
1	1.10	0.278	44.09	21.50	1.40	440.20	459.60	2200.	1.018	11.	10.81	0.982	2 MAIN
2	1.20	0.305	47.58	21.50	1.100	410.20	427.30	2200.	2.036	24.	11.06	0.461	2 MAIN
3	1.30	0.330	50.73	21.50	37.70	374.30	390.10	2200.	3.054	36.	11.78	0.327	2 MAIN
4	1.40	0.357	52.03	21.50	30.40	358.40	374.30	2200.	4.073	48.	11.50	0.246	2 MAIN
5	1.50	0.386	50.07	21.50	175.00	322.10	339.00	2200.	5.091	60.	11.70	0.176	2 MAIN
6	1.20	0.967	42.35	21.50	302.40	351.50	470.30	2200.	6.108	72.	11.70	0.164	2 MAIN
7	1.20	1.200	41.34	21.50	420.20	666.60	691.50	2350.	6.647	84.	12.64	0.150	2 MAIN
8	1.20	1.200	47.23	21.50	714.00	595.30	1017.00	2350.	6.912	96.	13.80	0.145	2 MAIN
9	1.20	1.200	53.15	21.50	1031.00	1417.00	1624.00	2350.	7.059	108.	15.21	0.142	2 MAIN
10	1.20	1.200	59.06	21.50	1470.00	1744.00	2035.00	2150.	7.107	120.	14.08	0.141	2 MAIN
11	6.50	1.200	64.04	21.50	1763.00	2007.00	2405.00	2150.	7.075	132.	0.00	0.141	2 MAIN
12	6.10	1.200	70.03	21.50	3410.00	3350.00	3455.00	2150.	6.000	144.	115.10	0.143	2 MAIN
13	7.10	1.200	76.07	21.50	3076.00	3374.00	4049.00	4265.	6.556	156.	132.50	0.156	2 MAIN
14	7.10	1.200	82.58	21.50	3943.00	5314.00	5555.00	4690.	6.687	168.	143.50	0.150	2 MAIN
15	6.10	1.200	68.59	21.50	4725.00	5561.00	6934.00	5174.	6.454	180.	157.20	0.154	2 MAIN
16	6.10	1.200	64.40	21.50	5743.00	7662.00	8204.00	5704.	6.284	192.	175.50	0.152	2 MAIN
17	6.50	1.200	100.40	21.50	6073.00	8560.00	9430.00	6097.	5.042	204.	195.30	0.153	2 MAIN
18	7.20	1.200	106.30	21.50	8165.00	11340.00	11810.00	6012.	5.044	216.	222.40	0.172	2 MAIN
19	7.20	1.200	113.20	21.50	8003.00	13340.00	13933.00	7004.	5.603	228.	241.60	0.170	2 MAIN
20	8.00	1.200	119.10	21.50	11700.00	15550.00	16700.00	8336.	5.373	240.	331.70	0.180	2 MAIN
21	7.35	1.200	124.00	21.50	12973.00	18000.00	18750.00	9144.	5.144	252.	308.60	0.173	2 MAIN
22	4.30	1.200	125.60	21.50	14010.00	20000.00	21540.00	10020.	4.919	264.	172.60	0.204	2 MAIN
23	1.30	1.200	135.60	21.50	17030.00	23050.00	24640.00	10560.	4.692	276.	75.52	0.213	2 MAIN
24	1.30	1.200	141.70	21.50	17970.00	24070.00	25090.00	11070.	4.465	288.	60.47	0.209	2 MAIN
25	0.30	1.200	147.40	21.50	18170.00	24370.00	25090.00	11090.	4.237	300.	40.09	0.234	2 MAIN
26	0.30	1.200	150.30	21.50	24710.00	34170.00	34930.00	13090.	4.014	312.	31.04	0.246	2 MAIN
27	0.30	1.200	152.40	21.50	27530.00	34560.00	37860.00	15590.	3.870	324.	27.50	0.268	2 MAIN
28	0.30	1.200	144.30	21.50	37230.00	44500.00	44350.00	21030.	2.983	336.	20.50	0.326	4 MAIN
29	0.30	1.500	144.30	21.50	37230.00	51890.00	53050.00	23410.	2.775	348.	31.39	0.361	4 MAIN
30	0.30	1.500	152.40	21.50	42080.00	60190.00	62400.00	26040.	2.579	360.	34.05	0.388	4 MAIN
31	0.30	1.500	159.00	21.50	49700.00	69460.00	72340.00	29070.	2.393	372.	39.02	0.419	4 MAIN
32	0.30	1.500	155.40	21.50	54350.00	79000.00	83130.00	30320.	2.218	384.	43.35	0.452	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	13.76	KNOTS
EFFECTIVE POWER.....	7920.	HP
SHAFT POWER.....	10340.	HP
TURBINE POWER.....	10770.	HP
TURBINE FUEL.....	6772.	105/HR
PROPELLSION FUEL.....	6999.	105/HR

AVERAGE ELECTRICAL LOAD

PROPELLSION COOLING....	0. KW
GENERATOR LUBE SYSTEM....	0. KW
HELIUM COMPRESSORS....	0. KW

TOTAL LOAD.. 0. KW (6.0 LBS/HR)

GEARED DRIVE SYSTEM

REF. NO. 101

MISSION PROFILE SUMMARY - BASELINE 4 ALTERNATORS

KTS	PCT. TIME	P/O RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (N/TON)	PER THOUSAND HOURS			NO. OF TURBINES
										HAUT. MILES	TONS FUEL	TONS PER MILE	
1	1.00	0.252	36.16	21.50	1.40	226.00	266.20	1100	2.036	11	5.40	0.401	1
2	1.00	0.251	40.46	21.50	11.20	271.00	240.30	1100	4.073	24	5.37	0.246	1
3	1.00	0.406	43.48	21.50	37.60	218.00	271.50	1100	6.109	36	5.39	0.166	1
4	1.00	0.403	42.36	21.50	50.50	216.00	215.20	1100	8.135	43	5.02	0.123	1
5	1.00	1.100	31.70	21.50	170.00	245.00	267.10	1127	2.877	60	6.00	0.100	1
6	1.00	1.100	30.04	21.50	302.60	425.50	464.60	1772	10.522	72	5.82	0.095	1
7	1.00	1.100	45.39	21.50	461.20	473.40	733.30	1460	10.890	84	7.07	0.087	1
8	1.00	1.100	50.72	21.50	715.60	1018.00	1102.00	1651	10.590	86	7.06	0.087	1
9	1.00	1.100	57.03	21.50	1071.00	1443.00	1568.00	1772	10.500	104	10.12	0.079	1
10	1.00	1.100	60.76	21.50	1300.00	1604.00	2158.00	2137	10.510	100	11.54	0.086	1
11	1.00	1.100	60.76	21.50	1558.00	2042.00	2069.00	2431	10.080	693	69.04	0.100	1
12	6.70	1.100	76.07	21.50	2410.00	3421.00	2700.00	2766	0.540	674	67.36	0.104	1
13	7.00	1.100	82.91	21.50	3073.00	4450.00	4730.00	7151	0.221	610	28.27	0.100	1
14	7.00	1.100	84.73	21.50	3422.00	5000.00	5607.00	3911	0.797	601	113.40	0.114	1
15	6.00	1.100	95.00	21.50	4723.00	6300.00	7263.00	4021	0.000	1000	102.00	0.100	1
16	5.00	1.100	101.40	21.50	5734.00	8174.00	8817.00	4692	7.912	676	127.70	0.107	1
17	5.00	1.100	107.60	21.50	6678.00	9746.00	10590.00	5032	7.603	1122	150.10	0.134	1
18	7.20	1.100	119.10	21.50	8165.00	11570.00	12550.00	5637	7.030	1266	193.00	0.161	1
19	7.70	1.100	120.40	21.50	9603.00	13610.00	14760.00	6370	6.702	1463	210.00	0.150	1
20	8.50	1.100	126.00	21.50	11700.00	15710.00	17220.00	7375	6.132	1760	240.00	0.169	1
21	7.50	1.100	137.10	21.50	12670.00	18700.00	19930.00	7666	5.000	1578	244.20	0.164	1
22	4.00	1.100	131.50	21.50	14510.00	20510.00	21360.00	10710	4.005	646	107.40	0.200	2
23	1.50	1.100	137.20	21.50	17030.00	24300.00	24740.00	10040	4.713	749	73.34	0.213	2
24	1.00	1.300	132.00	21.50	18450.00	26820.00	27730.00	11060	4.300	812	60.40	0.202	2
25	0.70	1.300	129.50	21.50	18970.00	30000.00	31750.00	13070	4.300	175	40.74	0.234	2
26	0.50	1.300	144.00	21.50	24010.00	33550.00	35260.00	14190	4.105	130	31.72	0.256	2
27	0.40	1.300	146.60	21.50	27590.00	37510.00	39490.00	15450	3.916	108	27.63	0.266	2
28	0.30	1.400	157.60	21.50	32170.00	44420.00	48110.00	16740	3.142	84	26.65	0.317	3
29	0.30	1.400	154.10	21.50	37000.00	51620.00	54050.00	22740	2.921	87	28.67	0.347	3
30	0.30	1.400	160.70	21.50	42930.00	59820.00	63970.00	24020	2.506	60	30.42	0.372	3
31	0.30	1.500	159.00	21.50	40000.00	45400.00	72760.00	28320	2.397	63	25.02	0.410	4
32	0.20	1.500	165.40	21.50	56300.00	70000.00	81700.00	22720	2.219	67	42.35	0.452	4

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER.....	7420	HP
SHAFT POWER.....	10660	HP
TURBINE POWER.....	11240	HP
TURBINE FUEL.....	5144	LBS/HR
PROPULSION FUEL.....	5357	LBS/HR

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING.....	16	KW
GENERATOR LOAD SYSTEM.....	0	KW
CELLUM COMPRESSORS.....	0	KW

TOTAL LOAD.. 16 KW (12.5 LBS/HR)

MISSION PROFILE SUMMARY - BASELINE + CRUISE TURBINES

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED KNOTS	EFFECTIVE HP	SHAFT HP	TURBINE 1	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS		NO. OF TURBINES
										NAUT. MILES	TONS FUEL	TONS PER MILE
1	1-10	0.286	31.10	74.00	1.40	135.00	140.70	720.	3.111	11.	3.54	0.321
2	1-20	0.371	34.52	74.00	11.20	119.50	124.50	720.	6.222	24.	3.86	0.161
3	1-20	0.542	35.29	74.00	37.80	115.20	120.00	720.	9.333	26.	3.86	0.107
4	1-20	0.804	26.39	74.00	86.80	135.10	144.90	720.	12.444	48.	4.32	0.090
5	1-20	1.250	26.55	74.00	175.00	241.50	251.70	807.	13.890	60.	5.05	0.072
6	1-20	1.250	38.29	74.00	302.40	417.50	434.90	943.	14.290	72.	5.92	0.070
7	1-20	1.250	40.81	74.00	480.20	652.40	690.60	1105.	14.190	84.	6.94	0.071
8	1-20	1.250	45.72	74.00	716.80	952.50	1031.00	1295.	13.840	96.	8.13	0.072
9	1-20	1.250	51.44	74.00	1021.00	1402.00	1458.00	1516.	13.300	108.	9.49	0.075
10	1-20	1.250	57.15	74.00	1400.00	1933.00	2013.00	1770.	12.850	120.	10.82	0.079
11	5-30	1.250	60.87	74.00	1883.00	2672.00	2800.00	2041.	11.950	132.	11.85	0.084
12	5-30	1.250	68.58	74.00	2619.00	3342.00	3474.00	2393.	11.230	144.	13.02	0.088
13	7-00	1.250	74.30	74.00	3076.00	4248.00	4421.00	2770.	10.310	156.	14.04	0.093
14	7-10	1.250	80.01	74.00	3542.00	4933.00	5224.00	3199.	9.813	168.	15.15	0.102
15	5-80	1.250	85.73	74.00	4725.00	6573.00	6795.00	3577.	9.137	180.	16.26	0.113
16	5-10	1.250	91.44	74.00	5734.00	7917.00	8246.00	4271.	8.492	192.	17.37	0.127
17	5-60	1.250	97.16	74.00	6743.00	9456.00	9811.00	4833.	7.879	204.	18.48	0.132
18	7-20	1.300	99.72	21.50	8195.00	11330.00	11780.00	5433.	7.347	216.	19.59	0.137
19	7-70	1.300	105.30	21.50	9837.00	13210.00	13760.00	6039.	6.820	228.	20.70	0.142
20	8-00	1.300	113.10	21.50	11250.00	15150.00	15700.00	6747.	6.293	240.	21.81	0.147
21	7-50	1.300	116.30	21.50	12870.00	17640.00	18380.00	7455.	5.766	252.	22.92	0.152
22	4-30	1.300	121.90	21.50	14610.00	20510.00	21350.00	8145.	5.239	264.	24.03	0.157
23	1-50	1.300	127.40	21.50	16350.00	23430.00	24410.00	8853.	4.711	276.	25.14	0.162
24	1-30	1.300	133.00	21.50	18300.00	26330.00	27710.00	9561.	4.184	288.	26.25	0.167
25	0-70	1.300	138.50	21.50	21870.00	30900.00	31980.00	10269.	3.657	300.	27.36	0.172
26	0-50	1.300	145.00	21.50	26810.00	38590.00	39250.00	11077.	3.130	312.	28.47	0.177
27	0-40	1.300	149.60	21.50	32540.00	47910.00	49490.00	11885.	2.603	324.	29.58	0.182
28	0-30	1.500	148.50	21.50	32130.00	45000.00	46550.00	12693.	2.076	336.	30.69	0.187
29	0-20	1.500	146.20	21.50	37250.00	51630.00	53050.00	13501.	1.549	348.	31.80	0.192
30	0-10	1.500	152.60	21.50	42950.00	60140.00	62590.00	14309.	1.022	360.	32.91	0.197
31	0-50	1.500	159.00	21.50	49290.00	69600.00	72100.00	15117.	0.495	372.	34.02	0.202
32	0-30	1.500	165.40	21.50	55330.00	79800.00	83130.00	15925.	0.000	384.	35.13	0.207

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS	AVERAGE ELECTRICAL LOAD	9. KW
EFFECTIVE POWER.....	7425.	HP	PROPULSION COOLING...	0. KW
SHAFT POWER.....	10260.	HP	GENERATOR LUBE SYSTEM	0. KW
TURBINE POWER.....	10460.	HP	HELIUM COMPRESSORS...	0. KW
TURBINE FUEL.....	5543.	LBS/HR		
PROPULSION FUEL	5560.	LBS/HR		
		TOTAL LOAD..	9. KW (	6.9 LBS/HR)

MISSION PROFILE SUMMARY - BASELINE & ALTERNATORS AND CRUISE TURBINES

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (N/MTON)	PER THOUSAND HOURS			NO. OF TURBINES
										NAUT. MILES	TONS FUEL	TONS PER MILE	
1	1-10	0.297	25.94	74.00	1.40	70.57	76.56	360.	5.222	11.	1.77	0.161	1 CRUISE
2	1-20	0.428	26.52	74.00	11.20	67.28	73.01	360.	12.440	24.	1.93	0.080	1 CRUISE
3	1-20	0.735	26.82	74.00	17.80	70.05	76.02	360.	13.670	36.	1.93	0.054	1 CRUISE
4	1-20	1.100	25.36	74.00	89.60	127.00	137.60	417.	21.470	48.	2.23	0.047	1 CRUISE
5	1-20	1.100	31.70	74.00	176.00	244.00	254.10	514.	21.730	60.	2.76	0.046	1 CRUISE
6	1-20	1.100	38.04	74.00	302.40	428.50	454.90	635.	21.140	72.	3.40	0.047	1 CRUISE
7	1-20	1.100	44.58	74.00	480.20	580.40	716.30	781.	20.090	84.	4.19	0.050	1 CRUISE
8	1-20	1.100	50.72	74.00	716.80	1016.00	1102.00	956.	18.770	86.	5.12	0.053	1 CRUISE
9	1-20	1.100	57.05	74.00	1021.00	1466.00	1559.00	1150.	17.330	108.	6.22	0.058	1 CRUISE
10	1-20	1.100	63.39	74.00	1408.00	1984.00	2153.00	1400.	16.030	120.	7.51	0.053	1 CRUISE
11	6-30	1.100	56.73	74.00	1863.00	2640.00	2855.00	1578.	14.690	663.	47.29	0.058	1 CRUISE
12	6-30	1.100	76.07	74.00	2414.00	3428.00	3729.00	1699.	13.450	806.	59.92	0.075	1 CRUISE
13	7-20	1.100	82.41	74.00	3076.00	4358.00	4729.00	2343.	12.330	910.	74.18	0.082	1 CRUISE
14	7-10	1.300	77.56	74.00	3642.00	5255.00	5605.00	3198.	9.805	564.	101.50	0.102	2 CRUISE
15	6-20	1.300	83.10	74.00	4725.00	6500.00	6771.00	3677.	9.139	1070.	111.70	0.110	2 CRUISE
16	6-10	1.300	88.64	74.00	5734.00	7839.00	8218.00	4215.	8.503	576.	114.90	0.116	2 CRUISE
17	6-40	1.300	94.18	74.00	6878.00	9462.00	9857.00	4820.	7.901	1122.	142.20	0.127	2 CRUISE
18	7-20	1.100	114.10	21.50	8165.00	11570.00	12590.00	5687.	7.070	1296.	183.30	0.141	1 MAIN
19	7-70	1.100	120.40	21.50	9502.00	13610.00	14780.00	6350.	6.702	1463.	218.00	0.150	1 MAIN
20	8-00	1.100	126.80	21.50	11200.00	15670.00	17220.00	7075.	6.337	1780.	281.00	0.156	1 MAIN
21	7-50	1.100	133.10	21.50	12930.00	18370.00	19930.00	7866.	5.930	1575.	264.20	0.158	1 MAIN
22	4-30	1.300	121.50	21.50	14910.00	20510.00	21350.00	10310.	4.925	946.	192.40	0.203	2 MAIN
23	1-50	1.300	127.40	21.50	17040.00	23430.00	24410.00	10940.	4.711	345.	73.34	0.213	2 MAIN
24	1-30	1.300	133.00	21.50	19250.00	26530.00	27730.00	11940.	4.502	312.	69.40	0.222	2 MAIN
25	0-50	1.300	144.00	21.50	21870.00	30000.00	31350.00	11020.	4.300	175.	40.76	0.213	2 MAIN
26	0-50	1.300	144.00	21.50	24610.00	33550.00	35260.00	14190.	4.106	130.	31.72	0.244	2 MAIN
27	0-40	1.300	143.60	21.50	27580.00	37610.00	39430.00	15450.	3.916	108.	27.63	0.250	2 MAIN
28	0-30	1.400	147.00	21.50	32130.00	44360.00	46110.00	19240.	3.262	84.	26.65	0.317	3 MAIN
29	0-30	1.400	154.10	21.50	37250.00	51580.00	56030.00	27240.	2.521	57.	29.67	0.343	3 MAIN
30	0-30	1.400	160.70	21.50	42950.00	59670.00	64270.00	24920.	2.096	90.	33.49	0.372	3 MAIN
31	0-30	1.500	159.00	21.50	49740.00	64660.00	72160.00	29020.	2.393	93.	36.92	0.419	4 MAIN
32	0-30	1.500	165.40	21.50	56300.00	76830.00	83130.00	32320.	2.218	96.	43.35	0.452	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER.....	7428.	HP
SHAFT POWER.....	10400.	HP
TURBINE POWER.....	11000.	HP
TURBINE FUEL.....	5017.	LBS/HR
PROPULSION FUEL.....	5028.	LBS/HR

AVERAGE ELECTRICAL LOAD	
PROPULSION COOLING....	14. KW
GENERATOR LUBE SYSTEM	0. KW
HELIX COMPRESSORS....	0. KW

TOTAL LOAD... 14. KW (11.0 LBS/HR)

ELECTRIC DRIVE SYSTEM

REF. NO. 01

MISSION PROFILE SUMMARY - MAIN ONLY - BASELINE

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS			NO. OF TURBINES
										NAUT. MILES	TONS FUEL	TONS PER MILE	
1	1-10	1-450	5-09	291-10	1-40	1-92	11-27	1100	2-036	11	5-80	0-527	1 MAIN
2	1-20	1-450	10-18	143-40	11-20	15-34	24-96	1100	4-073	24	6-33	0-264	1 MAIN
3	1-20	1-450	13-26	91-59	47-80	51-96	61-70	1100	6-109	36	6-33	0-176	1 MAIN
4	1-20	1-450	20-35	61-81	84-60	123-20	132-90	1100	8-145	48	6-33	0-132	1 MAIN
5	1-20	1-450	25-44	29-50	175-00	240-50	249-40	1102	10-170	60	6-34	0-105	1 MAIN
6	1-20	1-450	30-53	31-25	302-40	415-70	429-40	1235	10-360	72	7-06	0-098	1 MAIN
7	1-20	1-450	35-61	32-80	403-20	500-10	681-40	1355	11-240	84	7-41	0-084	1 MAIN
8	1-20	1-450	40-70	33-57	710-80	905-30	1018-00	1576	11-370	96	8-88	0-092	1 MAIN
9	1-20	1-450	45-76	34-23	1021-00	1403-00	1450-00	1743	11-310	108	9-99	0-094	1 MAIN
10	1-20	1-450	50-88	34-62	1400-00	1924-00	1991-00	2018	11-100	120	11-25	0-096	1 MAIN
11	6-30	1-450	55-57	34-79	1803-00	2561-00	2552-00	2234	10-790	804	66-54	0-099	1 MAIN
12	6-70	1-450	61-05	34-77	2415-00	3325-00	3440-00	2584	10-400	910	93-89	0-103	1 MAIN
13	7-00	1-450	66-14	34-56	3070-00	4223-00	4345-00	2921	9-759	954	107-20	0-108	1 MAIN
14	7-10	1-450	71-23	34-27	3842-00	5290-00	5482-00	3299	9-529	1020	115-50	0-113	1 MAIN
15	6-30	1-450	76-32	33-84	4720-00	6492-00	6750-00	3721	9-351	976	116-50	0-119	1 MAIN
16	6-10	1-450	81-40	33-33	5738-00	7882-00	8201-00	4191	8-079	1122	141-40	0-126	1 MAIN
17	6-50	1-450	86-49	32-75	6878-00	9492-00	9848-00	4713	7-621	1296	172-50	0-133	1 MAIN
18	7-20	1-450	91-58	32-11	8165-00	11220-00	11700-00	5291	6-753	1760	206-90	0-141	1 MAIN
19	7-70	1-450	96-67	31-44	9603-00	13200-00	13760-00	5928	6-359	1575	250-80	0-159	1 MAIN
20	8-50	1-450	101-60	30-75	11200-00	15390-00	16100-00	6029	5-582	946	160-00	0-169	1 MAIN
21	7-50	1-450	106-80	30-04	12970-00	17820-00	18660-00	7398	4-753	345	73-05	0-212	2 MAIN
22	6-50	1-450	111-40	29-32	14910-00	20490-00	21400-00	8230	4-545	312	69-20	0-222	2 MAIN
23	1-50	1-450	117-00	25-30	17030-00	23410-00	24170-00	10620	4-334	175	40-68	0-232	2 MAIN
24	1-30	1-450	122-10	24-86	19390-00	26000-00	27470-00	11320	4-132	130	31-68	0-244	2 MAIN
25	0-70	1-450	127-20	24-44	21870-00	30070-00	31070-00	12920	3-939	103	27-80	0-256	2 MAIN
26	0-50	1-450	132-30	24-00	24610-00	33620-00	34470-00	14050	3-205	81	25-88	0-308	3 MAIN
27	0-40	1-450	137-40	23-53	27550-00	37330-00	39140-00	15350	3-017	37	28-99	0-333	3 MAIN
28	0-30	1-450	142-70	21-62	32130-00	44000-00	46050-00	16210	2-737	40	32-46	0-351	3 MAIN
29	0-30	1-450	149-10	21-25	37250-00	51750-00	53790-00	21330	2-412	93	38-73	0-416	4 MAIN
30	0-30	1-450	156-50	20-87	42990-00	60010-00	62410-00	24110	2-239	56	43-06	0-449	4 MAIN
31	0-30	1-450	163-00	19-57	48790-00	69240-00	71950-00	28750					
32	0-30	1-450	169-60	19-24	56300-00	79520-00	82750-00	32020					

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15-76	KNOTS
EFFECTIVE POWER.....	7423	HP
SHAFT POWER.....	10230	HP
TURBINE POWER.....	10650	HP
TURBINE FUEL.....	4988	LBS/HR
PRODUCTION FUEL.....	5076	LBS/HR

AVERAGE ELECTRICAL LOAD
 PRODUCTION COOLING... 5- KW
 GENERATOR LUBE SYSTEM... 1- KW
 HELIUM COMPRESSORS... 100- KW

TOTAL LOAD... 110- KW (57.7 LBS/HR)

ELECTRIC DRIVE SYSTEM

REF. NO. 02

MISSION PROFILE SUMMARY - MAIN ONLY - RECONFIGURED ENGINE ROOM

KTS	PCT	P/D	RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	PER THOUSAND HOURS				NO. OF TURBINES
									FUEL RATE (PPH)	RANGE (NM/TON)	NAUT. MILES	TONS FUEL	TONS PER MILE
1	1.10	1.450	5.04	291.10	1.40	1.40	1.40	31.27	1100.	2.036	11.	5.80	0.527
2	1.20	1.450	10.18	143.40	11.20	11.20	15.34	74.95	1100.	4.073	24.	6.33	0.264
3	1.20	1.450	15.26	91.59	37.60	37.60	51.48	61.68	1100.	6.109	36.	6.33	0.179
4	1.20	1.450	20.35	61.83	89.60	89.60	123.20	132.80	1100.	8.145	48.	6.33	0.132
5	1.20	1.450	25.44	46.48	175.00	175.00	248.50	248.40	1100.	10.170	60.	6.33	0.106
6	1.20	1.450	30.53	31.24	302.40	302.40	415.70	426.80	1237.	10.860	72.	7.06	0.093
7	1.20	1.450	35.61	22.58	480.00	480.00	608.10	608.00	1794.	11.250	84.	7.90	0.090
8	1.20	1.450	40.70	17.54	719.00	719.00	895.40	1316.00	1775.	11.380	96.	8.87	0.092
9	1.20	1.450	45.79	14.20	1021.00	1021.00	1406.00	1447.00	1761.	11.320	108.	9.93	0.092
10	1.20	1.450	50.88	10.54	1400.00	1400.00	1924.00	1946.00	2016.	11.110	120.	11.24	0.094
11	6.12	1.450	55.97	74.76	1045.00	1045.00	2501.00	2642.00	2261.	10.800	653.	66.46	0.090
12	6.70	1.450	61.40	64.74	2414.00	2414.00	3323.00	3436.00	2980.	10.420	504.	79.64	0.099
13	7.00	1.450	66.14	54.55	3049.00	3049.00	4228.00	4471.00	4419.	9.980	510.	93.73	0.103
14	7.10	1.450	71.23	44.23	3842.00	3842.00	5269.00	5470.00	3293.	9.544	594.	107.00	0.108
15	6.60	1.450	76.32	33.81	4725.00	4725.00	6455.00	6726.00	3713.	9.049	1020.	115.30	0.113
16	6.10	1.450	81.40	23.73	5739.00	5739.00	7932.00	8170.00	4161.	8.571	976.	116.20	0.119
17	6.60	1.450	86.44	17.72	6876.00	6876.00	9454.00	9683.00	4701.	8.101	1122.	141.10	0.120
18	7.20	1.450	91.58	12.08	8103.00	8103.00	11223.00	11550.00	5275.	7.643	1296.	172.40	0.133
19	7.70	1.450	96.67	8.42	9603.00	9603.00	13200.00	13720.00	5909.	7.202	1463.	206.20	0.141
20	8.90	1.450	101.80	33.72	11200.00	11200.00	15390.00	15020.00	6609.	6.732	1760.	266.10	0.149
21	7.50	1.450	106.80	30.01	12970.00	12970.00	17820.00	18360.00	7370.	6.383	1575.	249.90	0.159
22	4.30	1.450	111.90	29.70	14910.00	14910.00	20470.00	21370.00	8200.	6.028	946.	159.30	0.168
23	1.50	1.450	117.00	25.36	17530.00	17530.00	23310.00	24430.00	10900.	5.709	345.	73.62	0.213
24	1.30	1.450	122.10	24.53	19390.00	19390.00	25000.00	27780.00	11920.	4.509	312.	69.75	0.224
25	0.70	1.450	127.20	24.50	21810.00	21810.00	33070.00	31430.00	13030.	4.299	175.	41.04	0.235
26	0.50	1.450	132.30	24.05	24610.00	24610.00	35870.00	35340.00	14220.	4.005	130.	31.98	0.246
27	0.40	1.450	137.40	23.60	27500.00	27500.00	37880.00	39580.00	15500.	3.701	108.	27.88	0.258
28	0.30	1.450	143.70	21.63	32130.00	32130.00	44200.00	46430.00	19330.	3.245	84.	26.04	0.310
29	0.30	1.450	150.10	21.24	37290.00	37290.00	51750.00	54220.00	21670.	2.917	67.	29.19	0.335
30	0.30	1.450	156.50	20.90	42990.00	42990.00	60010.00	63000.00	24290.	2.767	90.	32.70	0.353
31	0.30	1.450	163.00	19.67	49240.00	49240.00	69240.00	73030.00	29110.	2.325	93.	39.15	0.421
32	0.30	1.450	169.60	19.29	56300.00	56300.00	76520.00	84060.00	32400.	2.212	96.	43.60	0.454

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER.....	7428.	HP
SHAFT POWER.....	10230.	HP
TURBINE POWER.....	10640.	HP
TURBINE FUEL.....	4985.	LBS/HR (0.141 TONS/MILE)
PROPUSSION FUEL.....	5072.	LBS/HR (0.144 TONS/MILE)
TOTAL LOAD... 109. KW (87.5 LBS/HR)		

AVERAGE ELECTRICAL LOAD

PROPUSSION COOLING...	8. KW
GENERATOR LUBE SYSTEM	1. KW
HELIUM COMPRESSORS...	100. KW

ELECTRIC DRIVE SYSTEM

REF.NO. 01

MISSION PROFILE SUMMARY - MAIN CASE - BASELINE

PER THOUSAND HOURS

KTS	PCT.	P/D	SHAFT	SPEED	EFFECTIVE	SHAFT	TURBINE	FUEL RATE	RANGE	NAUT.	TONS	TONS	PER MILE	NO. OF
	TIME	RATIO	RPM	RATIO	HP	HP	4P	(PPH)	(NM/TON)	MILES	FUEL	FUEL		TURBINES
1	1-10	1.450	5.09	686.10	1.40	1.92	5.19	360.	5.222	11.	2.23	0.208	0.208	1 CRUISE
2	1-20	1.450	10.18	323.20	11.20	15.34	18.08	360.	12.470	24.	2.49	0.104	0.104	1 CRUISE
3	1-20	1.450	15.28	177.70	37.60	51.96	55.03	360.	13.870	36.	2.47	0.069	0.069	1 CRUISE
4	1-20	1.450	20.35	106.60	89.00	123.20	126.30	405.	22.110	48.	2.72	0.057	0.057	1 CRUISE
5	1-20	1.450	25.44	114.80	175.00	240.50	250.30	492.	22.710	60.	3.20	0.053	0.053	1 CRUISE
6	1-20	1.450	30.53	118.70	302.40	417.70	432.50	599.	22.440	72.	3.77	0.052	0.052	1 CRUISE
7	1-20	1.450	35.61	115.60	480.70	680.10	687.20	729.	21.500	84.	4.47	0.053	0.053	1 CRUISE
8	1-20	1.450	40.70	119.20	716.00	987.10	1027.00	887.	20.210	96.	5.31	0.055	0.055	1 CRUISE
9	1-20	1.450	45.78	117.70	1021.00	1403.00	1434.00	1075.	13.720	108.	6.32	0.059	0.059	1 CRUISE
10	1-20	1.450	50.88	115.70	1460.00	1924.00	2012.00	1299.	17.250	120.	7.53	0.063	0.063	1 CRUISE
11	6-30	1.450	55.97	112.70	1863.00	2501.00	2683.00	1523.	15.770	132.	8.65	0.069	0.069	1 CRUISE
12	6-70	1.450	61.05	108.70	2419.00	3325.00	3490.00	1872.	14.360	144.	9.20	0.074	0.074	1 CRUISE
13	7-00	1.450	66.14	105.70	3076.00	4223.00	4447.00	2231.	13.350	156.	10.10	0.080	0.080	1 CRUISE
14	7-10	1.450	71.23	88.58	3842.00	5263.00	5471.00	3166.	9.904	168.	102.80	0.104	0.104	1 CRUISE
15	6-80	1.450	76.32	85.39	4725.00	6455.00	6736.00	3651.	9.203	180.	114.20	0.112	0.112	2 CRUISE
16	6-10	1.450	81.40	73.33	5734.00	7867.00	8201.00	4191.	8.551	192.	117.10	0.120	0.120	1 MAIN
17	6-00	1.450	86.48	62.75	6876.00	9424.00	9856.00	4713.	3.379	204.	132.20	0.127	0.127	1 MAIN
18	7-20	1.450	91.58	32.11	8193.00	11220.00	11700.00	5291.	7.321	216.	173.70	0.134	0.134	1 MAIN
19	7-70	1.450	96.67	31.44	9603.00	13200.00	13760.00	5928.	7.179	228.	207.70	0.142	0.142	1 MAIN
20	8-00	1.450	101.80	30.75	11200.00	15350.00	15900.00	6679.	6.758	240.	263.00	0.151	0.151	1 MAIN
21	7-50	1.450	106.80	30.04	12970.00	17420.00	18000.00	7368.	6.359	252.	251.60	0.160	0.160	1 MAIN
22	4-30	1.450	111.90	26.32	14910.00	20490.00	21400.00	8238.	5.982	264.	160.50	0.170	0.170	1 MAIN
23	1-30	1.450	117.00	25.30	17010.00	23410.00	24170.00	10820.	4.783	276.	73.21	0.212	0.212	2 MAIN
24	1-30	1.450	122.10	24.88	19350.00	26000.00	27700.00	11830.	4.559	288.	49.34	0.222	0.222	2 MAIN
25	0-70	1.450	127.20	24.44	21870.00	30070.00	31070.00	12420.	4.334	300.	40.75	0.232	0.232	2 MAIN
26	0-50	1.450	132.30	24.00	24810.00	33520.00	34970.00	14000.	4.132	312.	31.74	0.244	0.244	2 MAIN
27	0-40	1.450	137.40	23.55	27580.00	37500.00	39190.00	15350.	3.939	324.	27.65	0.256	0.256	2 MAIN
28	0-30	1.450	142.70	23.00	32130.00	44400.00	46950.00	19210.	3.265	336.	25.91	0.308	0.308	3 MAIN
29	0-30	1.450	153.10	21.25	37200.00	51750.00	53750.00	21930.	3.017	348.	29.02	0.334	0.334	3 MAIN
30	0-30	1.450	156.50	20.87	42950.00	60010.00	62410.00	24110.	2.757	360.	32.49	0.354	0.354	3 MAIN
31	0-30	1.450	167.00	19.57	49290.00	69740.00	71450.00	28790.	2.412	372.	38.76	0.417	0.417	4 MAIN
32	0-30	1.450	168.60	19.24	55300.00	79520.00	82780.00	32020.	2.239	384.	43.09	0.449	0.449	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.70	KNOTS	AVERAGE ELECTRICAL LOAD
EFFECTIVE POWER.....	7479.	HP	PROPULSION COOLING....
SHAFT POWER.....	10250.	HP	GENERATOR LUBE SYSTEM..
TURBINE POWER.....	10460.	HP	HELIUM COMPRESSORS....
TURBINE FUEL....	4750.	LBS/HR (0.135 TONS/MILE)	
PROPULSION FUEL.....	4862.	LBS/HR (0.138 TONS/MILE)	
		TOTAL LOAD..	140. KW (111.9 LBS/HR)

9. KW
1. KW
130. KW

ELECTRIC DRIVE SYSTEM

REF.NO. 02

MISSION PROFILE SUMMARY - MAIN + CRUISE - RECONFIGURED ENGINE ROOM

KTS	PCT.	DYN	SHAFT	SPEED	EFFECTIVE	SHAFT	TURNING	FUEL RATE	RANGE	PER THOUSAND HOURS			NO. OF
										NAUT.	TONS	TONS	
			RPM	RATIO	HP	HP	HP	(PPH)	(NM/TON)	MILES	FUEL	PER MILE	TURBINES
1	1.10	1.450	5.00	66.10	1.40	1.42	5.19	300.	5.222	11.	2.28	0.209	1 CRUISE
2	1.20	1.450	10.16	326.10	11.20	15.34	18.89	300.	12.440	24.	2.49	0.104	1 CRUISE
3	1.20	1.450	15.26	177.60	17.80	21.96	50.70	300.	13.670	36.	2.49	0.059	1 CRUISE
4	1.20	1.450	20.35	102.60	89.40	123.20	128.60	405.	22.100	43.	2.73	0.057	1 CRUISE
5	1.20	1.450	25.44	114.40	175.00	240.50	250.90	492.	22.740	60.	3.20	0.053	1 CRUISE
6	1.20	1.450	30.53	116.40	302.40	415.70	431.60	600.	22.410	72.	3.78	0.052	1 CRUISE
7	1.20	1.450	35.61	116.40	450.20	560.10	649.50	730.	21.470	84.	4.48	0.053	1 CRUISE
8	1.20	1.450	40.70	116.40	716.80	865.30	1031.00	888.	20.170	96.	5.32	0.055	1 CRUISE
9	1.20	1.450	45.75	117.60	1021.00	1403.00	1470.00	1078.	19.710	108.	6.34	0.059	1 CRUISE
10	1.20	1.450	50.88	115.40	1420.00	1924.00	2021.00	1303.	17.200	120.	7.55	0.063	1 CRUISE
11	6.30	1.450	55.97	117.30	1833.00	2591.00	2597.00	1568.	15.710	693.	47.11	0.069	1 CRUISE
12	6.70	1.450	61.05	108.90	2419.00	3325.00	3910.00	1879.	14.300	804.	59.43	0.074	1 CRUISE
13	7.00	1.450	66.14	105.10	3076.00	4223.00	4474.00	2241.	12.950	910.	73.43	0.081	1 CRUISE
14	7.10	1.450	71.23	88.77	3842.00	5240.00	5524.00	3167.	9.840	994.	104.50	0.105	2 CRUISE
15	6.80	1.450	76.32	86.57	4725.00	6450.00	6105.00	5077.	9.137	1020.	115.00	0.113	2 CRUISE
16	6.10	1.450	81.40	83.30	5734.00	7882.00	8170.00	4181.	8.571	976.	116.80	0.120	1 MAIN
17	5.80	1.450	86.49	82.72	6876.00	9354.00	9806.00	4701.	8.101	1122.	141.80	0.126	1 MAIN
18	7.20	1.450	91.58	82.03	8165.00	11270.00	11550.00	5275.	7.643	1296.	173.20	0.134	1 MAIN
19	7.70	1.450	96.67	81.42	9603.00	13200.00	13720.00	5909.	7.202	1403.	207.00	0.142	1 MAIN
20	2.90	1.450	101.80	80.72	11240.00	15390.00	15920.00	6006.	6.752	1780.	267.00	0.150	1 MAIN
21	7.50	1.450	106.80	80.00	12970.00	17820.00	18500.00	7370.	6.383	1575.	250.70	0.159	1 MAIN
22	4.30	1.450	111.90	79.30	14910.00	20490.00	21370.00	8205.	6.305	946.	159.80	0.169	1 MAIN
23	1.30	1.450	117.00	78.36	17030.00	23410.00	24430.00	10900.	4.723	345.	73.78	0.214	2 MAIN
24	1.30	1.450	122.10	74.83	19330.00	26030.00	27760.00	11920.	4.535	312.	67.92	0.224	2 MAIN
25	0.70	1.450	127.20	74.50	21870.00	30070.00	31430.00	13030.	4.298	175.	41.12	0.235	2 MAIN
26	0.50	1.450	132.30	74.05	24810.00	33820.00	35390.00	14220.	4.095	130.	32.04	0.246	2 MAIN
27	0.40	1.450	143.70	73.60	27500.00	37660.00	39460.00	15200.	3.901	108.	27.52	0.255	2 MAIN
28	0.30	1.450	150.10	71.23	32130.00	44400.00	46470.00	16330.	3.245	84.	26.07	0.310	3 MAIN
29	0.30	1.450	156.50	70.60	37250.00	51750.00	54220.00	21670.	2.997	87.	29.22	0.336	3 MAIN
30	0.30	1.450	163.00	70.60	42890.00	60010.00	63060.00	24290.	2.767	90.	32.74	0.364	3 MAIN
31	0.30	1.450	169.00	70.62	49290.00	69240.00	73030.00	29110.	2.535	93.	39.21	0.422	4 MAIN
32	0.30	1.450	175.60	70.29	56300.00	79520.00	84050.00	32400.	2.212	96.	43.64	0.455	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER.....	7428.	HP
SHAFT POWER.....	10230.	HP
TURBINE POWER.....	10670.	HP
TURBINE FUEL.....	4753.	LBS/HR
PROPELLER FUEL.....	4865.	LBS/HR

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING....	9.	KW
GENERATOR LUBE SYSTEM	1.	KW
HELIUM COMPRESSORS....	130.	KW

TOTAL LOAD... 140. KW (112.1 LBS/HR)

MISSION PROFILE SUMMARY - MAIN + CRUISE - OPTIMUM CONFIGURATION

PER THOUSAND HOURS														
KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	NAUT. MILES	TONS		NO. OF TURBINES	
											FUEL	PER MILE		
1	1-10	1-450	5.09	656.10	1-40	1-92	5-18	300.	6-222	11.	2-28	0-208	1	CRUISE
2	1-20	1-450	10.18	326.20	11-20	15-34	18-84	300.	12-440	24.	2-49	0-104	1	CRUISE
3	1-20	1-450	15.26	178.00	37-80	51-96	55-74	360.	18-670	36.	2-49	0-069	1	CRUISE
4	1-20	1-450	20.35	108.00	69-80	123-20	177-70	405.	22-130	48.	2-73	0-057	1	CRUISE
5	1-20	1-450	25.44	114.80	175-00	240-50	244-90	491.	22-800	60.	3-19	0-053	1	CRUISE
6	1-20	1-450	30.53	117.90	302-60	415-70	479-90	597.	22-500	72.	3-76	0-052	1	CRUISE
7	1-20	1-450	35.61	119.20	480-20	633-10	881-80	727.	21-580	84.	4-46	0-053	1	CRUISE
8	1-20	1-450	40.70	118.60	719-80	935-30	1017-00	882.	20-310	96.	5-29	0-055	1	CRUISE
9	1-20	1-450	45.79	117.40	1021-00	1403-00	1449-00	1069.	18-870	108.	6-29	0-056	1	CRUISE
10	1-20	1-450	50.88	114.90	1400-00	1924-00	1984-00	1269.	17-370	120.	7-47	0-062	1	CRUISE
11	6-30	1-450	55.97	111.50	1693-00	2561-00	2544-00	1550.	15-930	693.	4-57	0-067	1	CRUISE
12	6-70	1-450	61.05	108.40	2419-00	3725-00	3442-00	1854.	14-500	804.	58-63	0-073	1	CRUISE
13	7-00	1-450	66.14	104.70	3076-00	4228-00	4181-00	2209.	13-230	910.	72-30	0-079	1	CRUISE
14	7-10	1-450	71.23	100.90	3842-00	5280-00	5479-00	2613.	12-000	994.	86-24	0-087	1	CRUISE
15	6-00	1-450	76.32	86.30	4725-00	6495-00	6774-00	3045.	9-215	1020.	114-00	0-112	2	CRUISE
16	6-10	1-450	81.40	83.30	5754-00	7852-00	8170-00	4181.	8-571	976.	116-60	0-120	1	MAIN
17	6-00	1-450	86.48	82.72	6978-00	9494-00	9808-00	4701.	8-101	1122.	141-80	0-126	1	MAIN
18	7-20	1-450	91.58	82.08	8405-00	11220-00	11550-00	5275.	7-643	1296.	173-20	0-134	1	MAIN
19	7-30	1-450	96.07	81.42	9504-00	13200-00	13720-00	5909.	7-202	1463.	207-00	0-142	1	MAIN
20	6-50	1-450	101.80	80.72	11200-00	15340-00	15920-00	6506.	6-732	1780.	267-00	0-150	1	MAIN
21	7-50	1-450	106.80	80.01	12670-00	17420-00	18590-00	7370.	6-333	1575.	250-70	0-159	1	MAIN
22	4-30	1-450	111.90	79.30	14910-00	20490-00	21370-00	8255.	6-006	546.	159-80	0-169	1	MAIN
23	1-50	1-450	117.00	78.36	17030-00	23410-00	24430-00	10900.	4-723	345.	73-73	0-214	2	MAIN
24	1-70	1-450	122.10	74.93	19350-00	26930-00	27780-00	11920.	4-505	312.	69-92	0-224	2	MAIN
25	0-70	1-450	127.20	74.50	21670-00	30070-00	31430-00	13030.	4-258	175.	41-12	0-235	2	MAIN
26	0-50	1-450	132.30	74.05	24610-00	33820-00	35490-00	14220.	4-093	130.	32-04	0-246	2	MAIN
27	0-40	1-450	137.40	73.60	27550-00	37830-00	39560-00	15500.	3-901	108.	27-52	0-259	2	MAIN
28	0-30	1-450	142.70	71.63	32130-00	44400-00	46430-00	16330.	3-245	87.	26-07	0-310	3	MAIN
29	0-30	1-450	153.10	71.28	37230-00	51750-00	54720-00	21670.	2-997	87.	39-22	0-339	3	MAIN
30	0-30	1-450	158.50	70.90	42950-00	60010-00	63000-00	24290.	2-757	90.	32-74	0-364	3	MAIN
31	0-20	1-450	163.00	19.62	49240-00	69240-00	73010-00	29110.	2-385	93.	39-21	0-422	4	MAIN
32	0-30	1-450	168.60	19.24	56330-00	79520-00	84360-00	32400.	2-212	96.	43-24	0-455	4	MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER.....	7428.	HP
SHAFT POWER.....	10230.	HP
TURBINE POWER.....	10650.	HP
TURBINE FUEL.....	4705.	LBS/HR
PROPELLION FUEL.....	4815.	LBS/HR

AVERAGE ELECTRICAL LOAD
 PROPELLION COOLING... 8. KW
 GENERATOR LUBE SYSTEM... 1. KW
 HELIUM COMPRESSORS... 130. KW

TOTAL LOAD... 140. KW (111.6 LBS/HR)

GEARED DRIVE SYSTEM

REF. NO. 101

MISSION PROFILE SUMMARY - BASELINE - VARIABLE PITCH

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS			NO. OF TURBINES
										NAUT. MILES	TONS FUEL	TONS PER MILE	
1	1.10	0.278	44.00	21.50	1.40	440.20	458.60	2200.	1.018	11.	10.81	0.382	2
2	1.20	0.305	47.58	21.50	11.20	410.20	421.30	2200.	2.036	24.	11.79	0.491	2
3	1.20	0.378	50.70	21.50	37.80	374.50	390.10	2200.	3.055	26.	11.79	0.327	2
4	1.20	0.487	52.03	21.50	86.60	358.40	373.30	2200.	4.073	48.	11.79	0.246	2
5	1.20	0.646	50.07	21.50	175.00	383.10	398.00	2200.	5.091	60.	11.79	0.186	2
6	1.20	0.967	42.35	21.50	392.40	451.50	470.10	2200.	6.109	72.	11.79	0.164	2
7	1.20	1.301	38.78	21.50	480.20	660.60	689.20	2200.	6.109	84.	12.62	0.150	2
8	1.20	1.270	45.26	21.50	716.60	883.20	1028.00	2590.	6.919	96.	12.62	0.145	2
9	1.20	1.247	51.57	21.50	1081.00	1409.00	1468.00	2850.	7.062	108.	15.20	0.142	2
10	1.20	1.232	57.17	21.50	1400.00	1936.00	2017.00	3151.	7.109	120.	16.89	0.141	2
11	6.20	1.220	64.13	21.50	1863.00	2591.00	2683.00	3480.	7.080	693.	97.93	0.141	2
12	6.70	1.212	70.13	21.50	2419.00	3352.00	3482.00	3845.	6.991	804.	115.10	0.143	2
13	7.00	1.207	76.49	21.50	3076.00	4267.00	4445.00	4247.	6.956	910.	132.80	0.145	2
14	7.10	1.208	82.28	21.50	3847.00	5322.00	5551.00	4690.	6.687	994.	148.80	0.150	2
15	6.80	1.208	89.16	21.50	4723.00	6554.00	6927.00	5174.	6.494	1022.	157.20	0.154	2
16	6.10	1.211	93.38	21.50	5734.00	7952.00	8283.00	5704.	6.283	976.	155.50	0.159	2
17	6.60	1.216	99.30	21.50	6979.00	9590.00	9927.00	6281.	6.062	1122.	193.30	0.168	2
18	7.20	1.232	104.90	21.50	8165.00	11310.00	11780.00	6510.	5.895	1296.	222.40	0.172	2
19	7.70	1.231	110.10	21.50	9603.00	13280.00	13740.00	7593.	5.605	1463.	261.20	0.179	2
20	8.00	1.238	115.20	21.50	11209.00	15480.00	16170.00	8332.	5.377	1780.	331.50	0.195	2
21	7.50	1.247	120.30	21.50	12970.00	17910.00	18550.00	9133.	5.150	1575.	306.20	0.194	2
22	4.30	1.259	125.10	21.50	14910.00	20570.00	21420.00	9099.	4.929	846.	192.20	0.203	2
23	1.50	1.273	129.50	21.50	17930.00	23470.00	24450.00	10930.	4.712	345.	73.32	0.213	2
24	1.30	1.283	134.40	21.50	19390.00	26650.00	27760.00	11040.	4.507	313.	69.39	0.222	2
25	0.70	1.299	138.70	21.50	21670.00	30100.00	31330.00	13020.	4.300	173.	40.76	0.233	2
26	0.50	1.313	143.00	21.50	24610.00	33890.00	35240.00	14190.	4.105	130.	31.72	0.244	2
27	0.40	1.328	147.10	21.50	27560.00	37870.00	39450.00	15440.	3.917	108.	27.61	0.256	2
28	0.30	1.472	147.10	21.50	32130.00	44440.00	46290.00	21020.	2.983	84.	23.20	0.336	4
29	0.30	1.479	147.10	21.50	27250.00	51820.00	53980.00	23400.	2.776	87.	31.39	0.361	4
30	0.30	1.489	153.50	21.50	42350.00	60140.00	62640.00	26040.	2.579	90.	34.65	0.389	4
31	0.30	1.500	158.40	21.50	49290.00	69500.00	72390.00	29020.	2.393	93.	38.92	0.419	4
32	0.30	1.527	163.20	21.50	56300.00	79970.00	82310.00	32310.	2.218	96.	43.54	0.452	4

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	18.76	KNOTS	
EFFECTIVE POWER.....	7426.	HP	
SHAFT POWER.....	10300.	HP	
TURBINE POWER.....	10730.	HP	
TURBINE FUEL.....	6366.	LBS/HR	(0.181 TONS/MILE)
PROPELLSION FUEL.....	6393.	LBS/HR	(0.181 TONS/MILE)
TOTAL LOAD..			9. KW (6.9 LBS/HR)

AVERAGE ELECTRICAL LOAD

PROPELLSION COOLING....	9. KW
GENERATOR LUBE SYSTEM	0. KW
HELIUM COMPRESSORS....	0. KW

MISSION PROFILE SUMMARY - BASELINE + ALTERNATORS + CRUISE TURBINES - VARIABLE PITCH

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NAVTON)	PER THOUSAND HOURS			NO. OF TURBINES
										NAUT. MILES	TONS FUEL	TONS PER MILE	
1	1-10	0.287	25.94	74.00	1.40	70.57	76.58	390.	5.222	11.	1.77	0.161	1 CRUISE
2	1-20	0.428	26.52	74.00	11.20	57.26	73.01	360.	12.460	24.	1.93	0.080	1 CRUISE
3	1-20	0.735	26.82	74.00	37.80	70.05	76.02	360.	18.670	36.	1.93	0.054	1 CRUISE
4	1-20	1.115	25.15	74.00	89.60	128.80	137.40	417.	21.490	48.	2.23	0.047	1 CRUISE
5	1-20	1.094	31.91	74.00	175.00	243.60	259.70	514.	21.780	60.	2.76	0.046	1 CRUISE
6	1-20	1.076	35.59	74.00	302.40	431.30	468.00	634.	21.180	72.	3.40	0.047	1 CRUISE
7	1-20	1.074	45.37	74.00	480.20	688.30	744.70	785.	20.090	84.	4.18	0.050	1 CRUISE
8	1-20	1.089	51.58	74.00	718.80	1022.00	1105.00	954.	18.770	96.	5.12	0.053	1 CRUISE
9	1-20	1.100	57.58	74.00	1021.00	1451.00	1575.00	1150.	17.380	108.	6.22	0.058	1 CRUISE
10	1-20	1.113	63.42	74.00	1400.00	1984.00	2153.00	1400.	16.000	120.	7.51	0.063	1 CRUISE
11	6-30	1.113	69.15	74.00	1863.00	2633.00	2856.00	1678.	14.690	693.	47.28	0.055	1 CRUISE
12	6-70	1.131	74.42	74.00	2419.00	3402.00	3692.00	1697.	13.490	804.	59.88	0.074	1 CRUISE
13	7-00	1.151	78.47	74.00	3079.00	4307.00	4674.00	2364.	12.520	910.	74.04	0.081	1 CRUISE
14	7-10	1.259	79.30	74.00	3842.00	5296.00	5517.00	3195.	9.813	994.	101.40	0.102	1 CRUISE
15	8-30	1.279	84.25	74.00	4725.00	6508.00	6760.00	3876.	9.141	1020.	111.70	0.110	2 CRUISE
16	5-10	1.294	88.74	74.00	5734.00	7890.00	8218.00	4215.	8.503	978.	114.90	0.115	2 CRUISE
17	5-50	1.322	93.05	74.00	6578.00	9434.00	9848.00	4619.	7.903	1122.	142.20	0.127	2 CRUISE
18	7-20	1.122	112.30	21.50	8165.00	11510.00	12480.00	5685.	7.092	1296.	183.20	0.141	1 MAIN
19	7-70	1.133	117.50	21.50	9608.00	12490.00	13540.00	6345.	6.707	1463.	218.70	0.153	1 MAIN
20	8-40	1.146	123.20	21.50	11200.00	15700.00	17040.00	7064.	6.312	1780.	281.50	0.167	1 MAIN
21	7-50	1.153	128.20	21.50	12970.00	18150.00	19590.00	7845.	5.935	1575.	263.50	0.203	2 MAIN
22	4-30	1.239	129.10	21.50	14910.00	20570.00	21420.00	9999.	4.929	946.	192.20	0.213	2 MAIN
23	1-50	1.273	125.53	21.50	17030.00	23470.00	24450.00	10930.	4.712	345.	73.32	0.222	2 MAIN
24	1-30	1.283	124.40	21.50	19350.00	26850.00	27750.00	11940.	4.503	312.	69.39	0.233	2 MAIN
25	0-50	1.313	138.70	21.50	21870.00	29850.00	31350.00	13020.	4.370	175.	40.76	0.244	2 MAIN
26	0-50	1.313	149.00	21.50	24610.00	33830.00	35240.00	14190.	4.105	130.	31.72	0.255	2 MAIN
27	0-40	1.328	147.10	21.50	27560.00	37870.00	39450.00	15440.	3.917	108.	27.51	0.266	2 MAIN
28	0-30	1.397	168.10	21.50	32130.00	43350.00	45100.00	19845.	3.162	84.	26.65	0.317	3 MAIN
29	0-30	1.408	183.40	21.50	37250.00	51570.00	53070.00	22230.	2.922	87.	29.97	0.343	3 MAIN
30	0-30	1.428	199.10	21.50	42950.00	59920.00	61020.00	24920.	2.577	90.	33.45	0.372	3 MAIN
31	0-30	1.503	158.40	21.50	49290.00	69500.00	72390.00	29020.	2.393	93.	38.02	0.419	4 MAIN
32	0-50	1.527	163.20	21.50	56200.00	79970.00	8310.00	32310.	2.218	96.	43.34	0.452	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER.....	7428.	HP
SHAFT POWER.....	10350.	HP
TURBINE POWER.....	11090.	HP
TURBINE FUEL.....	5013.	LBS/HR
PROPULSION FUEL.....	5024.	LBS/HR

AVERAGE ELECTRICAL LOAD		
PROPULSION COOLING....	14.	KW
GENERATOR LUBE SYSTEM	0.	KW
HELIUM COMPRESSORS....	0.	KW
TOTAL LOAD... 14. KW (11.0 LBS/HR)		

ELECTRIC DRIVE SYSTEM

REF. NO. 01

MISSION PROFILE SUMMARY - MAIN ONLY - VARIABLE P/D

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS				NO. OF TURBINES
										NAUT. MILES	TONS FUEL	TONS PER MILE		
1	1.10	1.500	4.96	298.70	1.40	1.93	11.27	1100.	2.035	11.	5.60	0.527		1 MAIN
2	1.20	1.500	9.92	147.20	11.20	15.42	24.95	1100.	4.073	24.	6.33	0.264		1 MAIN
3	1.20	1.500	14.67	93.99	37.80	52.05	61.73	1100.	6.109	35.	6.33	0.176		1 MAIN
4	1.20	1.500	19.33	63.42	84.60	123.40	133.00	1100.	8.145	48.	6.33	0.132		1 MAIN
5	1.20	1.466	26.08	28.77	175.00	240.30	243.50	1102.	10.170	60.	6.34	0.106		1 MAIN
6	1.20	1.390	31.51	30.33	302.40	415.20	424.15	1237.	13.380	72.	7.06	0.098		1 MAIN
7	1.20	1.386	36.63	31.43	480.20	659.40	561.10	1359.	11.240	84.	7.91	0.094		1 MAIN
8	1.20	1.380	42.34	32.25	718.60	934.20	1017.00	1575.	11.380	96.	8.37	0.092		1 MAIN
9	1.20	1.364	47.96	32.86	1021.00	1401.00	1448.00	1782.	11.320	108.	9.55	0.092		1 MAIN
10	1.20	1.364	53.42	32.96	1400.00	1923.00	1967.00	2016.	11.110	120.	11.24	0.094		1 MAIN
11	6.30	1.364	58.76	33.12	1863.00	2599.00	2640.00	2232.	13.800	693.	66.48	0.096		1 MAIN
12	6.70	1.360	64.25	33.02	2419.00	3322.00	3438.00	2581.	13.420	804.	79.67	0.099		1 MAIN
13	7.00	1.354	69.84	32.73	3078.00	4224.00	4374.00	2917.	9.982	910.	93.76	0.103		1 MAIN
14	7.10	1.346	75.57	32.28	3842.00	5277.00	5467.00	3294.	9.520	994.	107.10	0.108		1 MAIN
15	6.60	1.346	80.97	31.87	4725.00	6500.00	6750.00	3715.	9.345	1020.	115.30	0.113		1 MAIN
16	6.10	1.346	86.36	31.35	5734.00	7877.00	8175.00	4183.	3.538	976.	116.20	0.119		1 MAIN
17	6.60	1.335	92.30	30.66	6878.00	9430.00	9814.00	4703.	8.298	1122.	141.10	0.126		1 MAIN
18	7.20	1.332	97.73	30.07	8165.00	11220.00	11660.00	5278.	7.540	1256.	172.50	0.133		1 MAIN
19	7.70	1.327	103.70	29.30	9603.00	13200.00	13730.00	5911.	7.200	1463.	206.30	0.141		1 MAIN
20	8.90	1.327	109.10	28.65	11200.00	15390.00	16030.00	6609.	6.779	1780.	266.20	0.150		1 MAIN
21	7.50	1.327	114.60	27.99	12970.00	17620.00	18570.00	7373.	6.480	1575.	250.00	0.159		1 MAIN
22	4.30	1.325	120.20	27.29	14910.00	20490.00	21380.00	8208.	6.004	946.	159.40	0.163		1 MAIN
23	1.50	1.346	123.90	23.89	17030.00	23400.00	24100.00	10600.	4.772	345.	72.91	0.211		2 MAIN
24	1.30	1.346	129.50	23.44	19350.00	26980.00	27400.00	11600.	4.554	312.	68.35	0.221		2 MAIN
25	0.70	1.340	134.90	23.03	21870.00	30050.00	30480.00	12690.	4.344	175.	40.59	0.212		2 MAIN
26	0.50	1.346	140.30	22.61	24610.00	33500.00	34800.00	14060.	4.142	130.	31.61	0.243		2 MAIN
27	0.40	1.346	145.70	22.19	27500.00	37800.00	39300.00	15320.	3.948	108.	27.53	0.255		2 MAIN
28	0.30	1.321	154.60	20.66	32130.00	44300.00	45600.00	19150.	3.276	84.	25.79	0.307		3 MAIN
29	0.30	1.301	163.30	19.51	37230.00	51550.00	53400.00	21430.	3.032	67.	26.84	0.332		3 MAIN
30	0.30	1.275	173.00	18.66	42890.00	59200.00	61690.00	23960.	2.805	90.	32.24	0.358		3 MAIN
31	0.30	1.305	176.20	18.41	49290.00	68500.00	71310.00	28610.	2.427	93.	36.48	0.414		4 MAIN
32	0.30	1.311	183.20	18.44	56300.00	79020.00	81920.00	31600.	2.294	95.	42.76	0.445		4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS	AVERAGE ELECTRICAL LOAD	
EFFECTIVE POWER.....	7420.	HP	PROPULSION COOLING....	8. KW
SHAFT POWER.....	10220.	HP	GENERATOR LUBE SYSTEM	1. KW
TURBINE POWER.....	10610.	HP	HELIUM COMPRESSORS...	100. KW
TURBINE FUEL.....	4975.	LBS/HR		
PROPULSION FUEL.....	5663.	LBS/HR		
				TOTAL LOAD... 109. KW (87.1 LBS/HR)

ELECTRIC DRIVE SYSTEM

REF. NO. 01

MISSION PROFILE SUMMARY - MAIN + CRUISE - VARIABLE P/D

PER THOUSAND HOURS

KTS	PCT.	P/D	SHAFT	SPEED	EFFECTIVE	SHAFT	TURBINE	FUEL RATE	RANGE	NAUT.	TONS	TONS	NO. OF
TIME	RATIO	RPM	RPM	RATIO	HP	HP	HP	(PPH)	(NM/TON)	MILES	FUEL	PER MILE	TURBINES
1	1.10	1.500	4.96	704.10	1.40	1.94	5.18	360.	6.222	11.	2.23	0.208	1 CRUISE
2	1.20	1.500	9.92	594.70	11.20	15.42	12.48	300.	12.440	24.	2.49	0.194	1 CRUISE
3	1.20	1.500	14.87	102.30	37.60	52.05	52.63	300.	13.670	36.	2.49	0.089	1 CRUISE
4	1.20	1.400	20.84	109.70	64.80	123.30	126.30	405.	22.110	43.	2.73	0.057	1 CRUISE
5	1.20	1.366	26.35	110.80	175.00	240.30	250.10	482.	22.770	60.	3.20	0.053	1 CRUISE
6	1.20	1.372	31.90	113.10	302.40	415.20	431.90	595.	22.450	72.	3.77	0.052	1 CRUISE
7	1.20	1.364	37.39	113.60	480.20	654.40	685.90	726.	21.520	84.	4.47	0.053	1 CRUISE
8	1.20	1.354	42.98	112.90	716.60	984.20	1024.30	892.	20.240	96.	5.31	0.055	1 CRUISE
9	1.20	1.348	48.58	110.90	1021.00	1432.50	1468.00	1073.	18.770	108.	6.31	0.058	1 CRUISE
10	1.20	1.340	54.08	108.20	1450.00	1923.00	2005.00	1293.	17.230	120.	7.51	0.063	1 CRUISE
11	6.30	1.334	59.60	104.30	1869.00	2500.00	2673.00	1598.	15.810	693.	46.84	0.068	1 CRUISE
12	6.70	1.327	65.47	101.30	2419.00	3225.00	3475.00	1808.	14.400	604.	59.03	0.073	1 CRUISE
13	7.00	1.325	71.01	97.75	3073.00	4227.00	4428.00	2223.	13.100	910.	72.85	0.080	1 CRUISE
14	7.10	1.346	75.57	82.45	3462.00	5277.00	5456.00	3161.	9.222	994.	103.60	0.104	2 CRUISE
15	6.80	1.346	80.97	81.39	4775.00	6490.00	6716.00	3642.	9.223	1020.	113.90	0.112	2 CRUISE
16	6.10	1.345	86.36	81.36	5374.00	7877.00	8175.00	4183.	8.568	976.	116.90	0.120	1 MAIN
17	5.60	1.336	92.30	80.06	6274.00	9490.00	9414.00	4703.	8.095	1122.	141.80	0.126	1 MAIN
18	7.20	1.332	97.75	80.87	8182.00	11224.00	11500.00	5218.	7.940	1256.	173.20	0.134	1 MAIN
19	7.70	1.327	103.70	79.40	8803.00	13230.00	13730.00	5911.	7.200	1483.	207.10	0.142	1 MAIN
20	8.90	1.327	109.10	28.65	11203.00	15390.00	16030.00	6509.	6.779	1780.	267.10	0.150	1 MAIN
21	7.50	1.327	114.60	27.94	12970.00	17620.00	18370.00	7373.	6.380	1575.	250.80	0.159	1 MAIN
22	4.30	1.325	120.20	27.29	16910.00	20490.00	21340.00	8208.	6.004	946.	159.90	0.159	1 MAIN
23	1.50	1.346	123.90	23.69	17030.00	23400.00	24100.00	10300.	4.772	345.	73.08	0.212	2 MAIN
24	1.30	1.340	129.50	23.44	19350.00	26500.00	27400.00	11800.	4.554	512.	69.20	0.222	2 MAIN
25	0.70	1.345	134.80	23.03	21570.00	30300.00	30950.00	12890.	4.344	175.	40.67	0.232	2 MAIN
26	0.50	1.346	140.30	22.61	24610.00	33800.00	34800.00	14060.	4.142	130.	31.86	0.244	2 MAIN
27	0.40	1.346	145.70	22.19	27580.00	37650.00	38060.00	15320.	3.946	108.	27.58	0.255	2 MAIN
28	0.30	1.321	154.60	20.06	32130.00	44340.00	45840.00	19150.	3.276	84.	25.82	0.307	3 MAIN
29	0.30	1.301	163.50	19.51	37250.00	51630.00	53410.00	21430.	3.032	87.	28.83	0.332	3 MAIN
30	0.30	1.275	173.00	18.86	42950.00	59620.00	61640.00	23960.	2.805	90.	32.28	0.359	3 MAIN
31	0.20	1.305	176.80	18.41	46240.00	66850.00	71310.00	26610.	2.627	93.	38.51	0.414	4 MAIN
32	0.30	1.311	183.20	18.44	56360.00	79020.00	81920.00	31800.	2.254	96.	42.79	0.446	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS	AVERAGE ELECTRICAL LOAD
EFFECTIVE POWER.....	7428.	HP	PROPULSION COOLING....
SHAFT POWER.....	10220.	HP	GENERATOR LUBE SYSTEM
TURBINE POWER.....	10620.	HP	HELIUM COMPRESSORS....
TURBINE FUEL.....	4735.	LBS/HR	(0.134 TONS/MILE)
PROPULSION FUEL.....	4848.	LBS/HR	(0.137 TONS/MILE)
TOTAL LOAD... 139. KW (111.3 LBS/HR)			

ELECTRIC DRIVE SYSTEM

REF. NO. 01

MISSION PROFILE SUMMARY - FIELDS FIXED AT 90 PERCENT - MAIN TURBINES ONLY

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (GPH)	RANGE (NM/TON)	PER THOUSAND HOURS			NO. OF TURBINES
										NAUT. MILES	TONS FUEL	PER MILE	
1	1.10	1.450	5.09	291.10	1.40	1.92	11.27	1100.	2.026	11.	5.80	0.527	1 MAIN
2	1.20	1.450	10.18	143.40	11.20	15.59	24.96	1100.	4.073	24.	6.33	0.264	1 MAIN
3	1.20	1.450	15.26	91.58	37.30	51.96	61.69	1100.	6.109	36.	6.33	0.176	1 MAIN
4	1.20	1.450	20.35	61.80	89.60	123.20	132.90	1100.	8.145	48.	6.33	0.132	1 MAIN
5	1.20	1.450	25.44	20.10	175.00	240.50	247.60	1131.	9.902	60.	6.49	0.108	1 MAIN
6	1.20	1.450	30.53	20.14	302.40	415.70	427.40	1291.	10.410	72.	7.35	0.102	1 MAIN
7	1.20	1.450	35.61	20.16	480.20	660.10	676.40	1430.	10.600	84.	8.36	0.100	1 MAIN
8	1.20	1.450	40.70	20.21	719.00	995.30	1013.00	1688.	10.550	96.	9.53	0.099	1 MAIN
9	1.20	1.450	45.79	20.25	1021.00	1403.00	1443.00	1948.	10.390	108.	10.87	0.101	1 MAIN
10	1.20	1.450	50.88	20.29	1400.00	1924.00	1991.00	2230.	10.040	120.	12.39	0.103	1 MAIN
11	6.30	1.450	55.97	20.32	1863.00	2561.00	2639.00	2547.	9.673	603.	73.95	0.107	1 MAIN
12	6.70	1.450	61.05	20.36	2419.00	3325.00	3429.00	2900.	9.269	804.	87.21	0.111	1 MAIN
13	7.00	1.450	66.14	20.40	3078.00	4228.00	4306.00	3291.	8.950	910.	105.40	0.116	1 MAIN
14	7.10	1.450	71.23	20.41	3842.00	5280.00	5459.00	3721.	8.429	994.	123.60	0.121	1 MAIN
15	6.50	1.450	76.32	20.47	4775.00	6495.00	6725.00	4192.	8.014	1020.	129.80	0.127	1 MAIN
16	6.10	1.450	81.40	20.51	5734.00	7662.00	8172.00	4708.	7.613	976.	170.50	0.134	1 MAIN
17	6.60	1.450	86.49	20.55	6875.00	9454.00	9816.00	5270.	7.226	1122.	157.80	0.141	1 MAIN
18	7.20	1.450	91.58	20.59	8165.00	11220.00	11670.00	5980.	6.857	1295.	191.80	0.148	1 MAIN
19	7.70	1.450	96.67	20.62	9603.00	13200.00	13750.00	6542.	6.505	1463.	228.00	0.156	1 MAIN
20	8.90	1.450	101.80	20.66	11200.00	15390.00	16050.00	7259.	6.172	1780.	282.00	0.164	1 MAIN
21	7.50	1.450	106.50	20.69	12970.00	17820.00	18620.00	8033.	5.856	1575.	272.10	0.173	1 MAIN
22	4.30	1.450	111.90	20.36	14910.00	20450.00	21080.00	10190.	4.838	946.	197.30	0.209	2 MAIN
23	1.50	1.450	117.00	20.38	17030.00	23410.00	24120.00	11120.	4.635	345.	75.06	0.218	2 MAIN
24	1.30	1.450	122.10	20.40	19350.00	26600.00	27430.00	12110.	4.439	312.	70.85	0.227	2 MAIN
25	0.70	1.450	127.20	20.42	21870.00	30070.00	31030.00	13180.	4.248	175.	41.50	0.237	2 MAIN
26	0.50	1.450	132.30	20.44	24610.00	33820.00	34830.00	14330.	4.065	130.	32.21	0.249	2 MAIN
27	0.40	1.450	137.40	20.46	27560.00	37880.00	39150.00	15560.	3.888	108.	27.96	0.259	2 MAIN
28	0.30	1.450	142.70	20.45	32130.00	44400.00	45030.00	19240.	3.260	84.	25.92	0.309	3 MAIN
29	0.30	1.450	150.10	20.53	37250.00	51750.00	53730.00	21540.	3.015	87.	29.00	0.333	3 MAIN
30	0.30	1.450	156.50	20.57	42550.00	60010.00	62400.00	24120.	2.787	90.	32.46	0.361	3 MAIN
31	0.30	1.450	163.00	20.55	49290.00	69240.00	71990.00	28860.	2.406	93.	38.81	0.417	4 MAIN
32	0.30	1.450	169.50	20.59	56300.00	79520.00	82810.00	32150.	2.230	96.	43.24	0.450	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER.....	7429.	HP
SHAFT POWER.....	10230.	HP
TURBINE POWER.....	10610.	HP
TURBINE FUEL.....	5420.	LBS/HR.
PROPELLSION FUEL.....	5567.	LBS/HR.

AVERAGE ELECTRICAL LOAD	8. KW
PROPELLSION COOLING...	1. KW
GENERATOR LUBE SYSTEM	100. KW
HELIUM COMPRESSORS...	100. KW

TOTAL LOAD... 109. KW (87.1 LBS/HR)

MISSION PROFILE SUMMARY - FIELDS FIXED AT 90 PERCENT - MAIN + CRUISE TURBINES

KTS	PCT. TIME	R/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS			NC. OF TURBINES
										NAUT. MILES	TONS FUEL	TONS PER MILE	
1	1-10	1.450	5.09	686.10	1.40	1.92	5.19	360.	6.222	11.	2.28	0.208	1 CRUISE
2	1-20	1.450	10.18	326.10	11.20	15.39	18.88	260.	12.440	24.	2.49	0.104	1 CRUISE
3	1-20	1.450	19.26	177.70	37.80	51.96	55.63	360.	18.670	36.	2.49	0.059	1 CRUISE
4	1-20	1.450	29.35	97.90	69.60	123.20	127.90	409.	21.880	49.	2.76	0.057	1 CRUISE
5	1-20	1.450	25.44	86.24	175.00	240.50	249.40	502.	22.300	60.	3.25	0.054	1 CRUISE
6	1-20	1.450	30.53	86.52	302.40	415.70	431.00	617.	21.790	72.	3.87	0.054	1 CRUISE
7	1-20	1.450	35.61	88.31	480.20	650.10	685.00	756.	20.750	84.	4.61	0.055	1 CRUISE
8	1-20	1.450	40.70	99.09	716.80	985.30	1024.00	921.	19.460	96.	5.50	0.057	1 CRUISE
9	1-20	1.450	45.79	99.37	1021.00	1403.00	1461.00	1116.	18.070	108.	6.54	0.061	1 CRUISE
10	1-20	1.450	50.88	89.65	1400.00	1924.00	2008.00	1343.	16.680	120.	7.76	0.065	1 CRUISE
11	6-30	1.450	55.97	85.94	1863.00	2561.00	2679.00	1607.	15.330	693.	48.20	0.070	1 CRUISE
12	5-70	1.450	61.05	90.22	2418.00	3325.00	3486.00	1912.	14.060	904.	60.40	0.075	1 CRUISE
13	7-00	1.450	66.14	90.50	3075.00	4228.00	4443.00	2263.	12.870	910.	74.11	0.081	1 CRUISE
14	7-10	1.450	71.23	90.79	3542.00	5280.00	5564.00	2657.	11.760	994.	87.99	0.089	1 CRUISE
15	6-80	1.450	76.32	89.23	4725.00	6495.00	6738.00	3654.	9.155	1020.	114.30	0.112	1 MAIN
16	6-10	1.450	81.40	20.51	5734.00	7832.00	8172.00	4708.	7.613	976.	131.20	0.134	1 MAIN
17	8-60	1.450	86.48	20.55	6873.00	9454.00	9816.00	5270.	7.224	1122.	159.50	0.149	1 MAIN
18	7-20	1.450	91.58	20.58	8165.00	11220.00	11670.00	5830.	6.857	1296.	192.60	0.159	1 MAIN
19	7-70	1.450	96.67	20.62	9503.00	13200.00	13750.00	6542.	6.505	1463.	226.00	0.165	1 MAIN
20	8-90	1.450	101.80	20.66	11200.00	15350.00	16060.00	7259.	6.172	1760.	293.00	0.173	1 MAIN
21	7-50	1.450	105.80	20.69	12870.00	17620.00	18620.00	8033.	5.855	1575.	272.00	0.209	2 MAIN
22	4-30	1.450	111.90	20.36	14910.00	20490.00	21090.00	10180.	4.635	946.	197.80	0.209	2 MAIN
23	1-30	1.450	117.00	20.38	17080.00	23410.00	24120.00	11120.	4.635	345.	75.22	0.218	2 MAIN
24	1-30	1.450	122.10	20.40	19350.00	26600.00	27430.00	12110.	4.438	312.	70.99	0.228	2 MAIN
25	0-50	1.450	127.20	20.42	21870.00	30070.00	31030.00	13180.	4.248	175.	41.57	0.238	2 MAIN
26	0-40	1.450	132.30	20.44	24410.00	33200.00	34930.00	14330.	4.065	130.	32.25	0.248	2 MAIN
27	0-30	1.450	137.40	20.46	27550.00	37630.00	39150.00	15560.	3.968	108.	26.00	0.259	2 MAIN
28	0-30	1.450	142.70	20.48	32130.00	44400.00	46030.00	16240.	3.260	84.	25.95	0.269	3 MAIN
29	0-30	1.450	150.10	20.51	37250.00	51750.00	53730.00	21540.	3.015	87.	29.04	0.334	3 MAIN
30	0-30	1.450	156.50	20.53	42950.00	60010.00	62400.00	24120.	2.787	90.	32.49	0.361	3 MAIN
31	0-30	1.450	163.00	20.55	49200.00	69240.00	71990.00	28560.	2.406	93.	36.95	0.418	4 MAIN
32	0-30	1.450	169.60	20.59	56300.00	79580.00	82810.00	32150.	2.230	96.	43.27	0.451	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.75	KNOTS	AVERAGE ELECTRICAL LOAD	8. KW
EFFECTIVE POWER	7428.	HP	PROPULSION COOLING...	1. KW
SHAFT POWER....	10230.	HP	GENERATOR LUBE SYSTEM	130. KW
TURBINE POWER..	10630.	HP	HELIUM COMPRESSORS...	
TURBINE FUEL...	5063.	LBS/HR		
PROPULSION FUEL	5194.	LBS/HR		
			TOTAL LOAD..	139. KW (111.5 LBS/HR)

ELECTRIC DRIVE SYSTEM

REF.NO. 1

MISSION PROFILE SUMMARY - MAIN ONLY - NEAREST 10 PERCENT MAGNET FIELD

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS			NO. OF TURBINES
										NAUT. MILES	TONS FUEL	TONS PER MILE	
1	1.10	1.450	5.09	291.10	1.40	1.92	11.27	1100.	2.035	11.	5.50	0.527	1 MAIN
2	1.20	1.450	10.18	143.40	11.20	15.39	24.96	1100.	4.073	24.	6.33	0.264	1 MAIN
3	1.20	1.450	15.26	91.54	37.80	51.96	61.69	1100.	6.109	36.	6.33	0.176	1 MAIN
4	1.20	1.450	20.35	61.72	89.60	123.20	132.90	1100.	8.145	48.	6.33	0.132	1 MAIN
5	1.20	1.450	25.44	50.15	175.00	240.50	249.80	1102.	10.160	60.	6.34	0.106	1 MAIN
6	1.20	1.450	30.53	38.21	300.40	415.70	429.20	1238.	10.880	72.	7.06	0.098	1 MAIN
7	1.20	1.450	35.61	30.26	480.20	660.10	661.00	1397.	11.230	84.	7.92	0.094	1 MAIN
8	1.20	1.450	40.70	30.32	716.80	935.30	1016.00	1581.	11.340	96.	8.90	0.093	1 MAIN
9	1.20	1.450	45.79	30.37	1021.30	1403.00	1448.00	1791.	11.260	108.	10.03	0.093	1 MAIN
10	1.20	1.450	50.88	30.43	1400.30	1924.00	1987.00	2030.	11.040	120.	11.31	0.094	1 MAIN
11	5.30	1.450	55.97	30.49	1863.00	2551.00	2647.00	2299.	10.720	693.	66.98	0.097	1 MAIN
12	5.70	1.450	61.05	30.55	2419.00	3325.00	3440.00	2502.	10.330	804.	80.31	0.100	1 MAIN
13	7.00	1.450	65.14	30.60	3076.00	4328.00	4373.00	2941.	9.901	994.	94.51	0.104	1 MAIN
14	7.10	1.450	71.23	30.65	3842.00	5200.00	5473.00	3319.	9.449	994.	107.60	0.109	1 MAIN
15	6.30	1.450	76.32	30.71	4725.00	6495.00	6742.00	4206.	8.522	1020.	116.10	0.114	1 MAIN
16	5.10	1.450	81.40	30.76	5734.00	7880.00	8193.00	4723.	8.063	976.	113.90	0.120	1 MAIN
17	6.60	1.450	87.49	30.82	6878.00	9454.00	9841.00	5295.	7.615	1123.	141.70	0.125	1 MAIN
18	7.20	1.450	91.58	30.87	8165.00	11220.00	11700.00	5929.	7.179	1295.	173.00	0.134	1 MAIN
19	7.70	1.450	95.67	30.93	9603.00	13200.00	13780.00	6630.	6.757	1463.	206.90	0.141	1 MAIN
20	5.90	1.450	101.80	30.98	11200.00	15393.00	16100.00	6630.	6.352	1780.	267.10	0.150	1 MAIN
21	7.50	1.450	106.80	31.04	12970.00	17920.00	18680.00	7405.	5.953	1575.	251.10	0.159	1 MAIN
22	4.30	1.450	111.90	31.10	14910.00	20493.00	21460.00	8264.	5.758	946.	150.50	0.170	1 MAIN
23	1.50	1.450	117.00	26.20	17030.00	23410.00	24180.00	10830.	4.758	345.	73.13	0.212	2 MAIN
24	1.30	1.450	122.10	26.23	19350.00	26600.00	27490.00	11860.	4.534	312.	69.37	0.222	2 MAIN
25	0.70	1.450	127.20	22.97	21070.00	30070.00	31050.00	12950.	4.324	175.	40.77	0.233	2 MAIN
26	0.50	1.450	132.30	22.99	24610.00	33820.00	34960.00	14110.	4.126	130.	31.72	0.244	2 MAIN
27	0.30	1.450	137.40	23.02	27960.00	37830.00	39180.00	15360.	3.938	108.	27.61	0.256	2 MAIN
28	0.30	1.450	143.70	20.40	32130.00	44300.00	46030.00	19340.	3.260	84.	25.92	0.309	3 MAIN
29	0.30	1.450	150.10	20.53	37250.00	51750.00	53730.00	21540.	3.015	67.	29.00	0.333	3 MAIN
30	0.30	1.450	156.50	20.57	42950.00	60010.00	62400.00	24120.	2.787	90.	32.49	0.361	3 MAIN
31	0.30	1.450	163.00	18.49	49290.00	69240.00	71920.00	28650.	2.407	93.	38.81	0.417	4 MAIN
32	0.30	1.450	169.60	18.53	56300.00	79520.00	82730.00	32040.	2.237	96.	43.09	0.449	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER.....	7428.	HP
SHAFT POWER.....	10230.	HP
TURBINE POWER.....	10650.	HP
TURBINE FUEL.....	4999.	LBS/HR
PROPULSION FUEL.....	5027.	LBS/HR

AVERAGE ELECTRICAL LOAD
PROPULSION COOLING... 9. KW
GENERATOR LUBE SYSTEM 1. KW
HELIUM COMPRESSORS... 100. KW

TOTAL LOAD... 110. KW (87.7 LBS/HR)

MISSION PROFILE SUMMARY - MAIN + CRUISE - NEAREST 10 PERCENT MAGNET FIELD

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NAV/TCN)	PER THOUSAND HOURS			NO. OF TURBINES
										NAUT. MILES	TONS FUEL	TONS PER MILE	
1	1.10	1.450	5.09	566.00	1.40	1.92	5.19	360.	6.222	11.	2.28	0.208	1 CRUISE
2	1.20	1.450	10.18	325.00	11.20	15.39	19.88	350.	12.440	24.	2.49	0.104	1 CRUISE
3	1.20	1.450	15.26	177.40	37.80	51.96	55.62	360.	18.670	36.	2.49	0.069	1 CRUISE
4	1.20	1.450	20.35	113.10	89.60	121.20	128.40	405.	22.090	48.	2.73	0.057	1 CRUISE
5	1.20	1.450	25.44	113.50	175.00	249.50	250.30	492.	22.760	60.	3.20	0.053	1 CRUISE
6	1.20	1.450	30.53	113.80	302.40	415.70	432.30	599.	22.430	72.	3.77	0.052	1 CRUISE
7	1.20	1.450	35.61	114.20	450.20	660.10	686.60	736.	21.480	84.	4.47	0.053	1 CRUISE
8	1.20	1.450	40.70	114.50	716.80	985.50	1026.00	887.	20.260	96.	5.32	0.055	1 CRUISE
9	1.20	1.450	45.79	114.90	1021.00	1403.00	1464.00	1075.	19.750	108.	6.33	0.059	1 CRUISE
10	1.20	1.450	50.88	115.30	1403.00	1924.00	2012.00	1299.	17.250	120.	7.53	0.063	1 CRUISE
11	6.30	1.450	55.97	115.60	1863.00	2561.00	2693.00	1564.	15.760	693.	46.99	0.068	1 CRUISE
12	6.70	1.450	61.05	101.50	2419.00	3325.00	3488.00	1877.	14.320	804.	59.36	0.074	1 CRUISE
13	7.00	1.450	66.14	101.80	3076.00	4228.00	4446.00	2232.	13.050	910.	73.14	0.080	1 CRUISE
14	7.10	1.450	71.23	80.79	3842.00	5200.00	5564.00	2567.	11.760	984.	87.99	0.089	1 CRUISE
15	6.80	1.450	76.32	66.23	4725.00	6495.00	6782.00	3554.	9.195	1070.	114.30	0.112	2 CRUISE
16	6.10	1.450	81.40	80.45	5734.00	7882.00	8182.00	4202.	8.530	976.	117.40	0.120	2 CRUISE
17	5.50	1.450	85.49	80.82	6878.00	9454.00	9841.00	4723.	8.063	1122.	142.40	0.127	1 MAIN
18	7.20	1.450	91.58	30.87	8155.00	11220.00	11700.00	5295.	7.615	1296.	173.80	0.134	1 MAIN
19	7.70	1.450	96.67	30.93	9503.00	13200.00	13700.00	5929.	7.179	1463.	207.70	0.142	1 MAIN
20	5.90	1.450	101.80	30.98	11200.00	15390.00	16100.00	6657.	6.757	1730.	266.00	0.151	1 MAIN
21	4.30	1.450	106.80	31.04	12970.00	17820.00	18630.00	7405.	6.352	1575.	251.90	0.160	1 MAIN
22	4.30	1.450	111.80	31.10	14910.00	20490.00	21400.00	8284.	5.963	946.	161.00	0.170	1 MAIN
23	1.30	1.450	117.00	26.20	17030.00	23410.00	24190.00	10930.	4.758	345.	73.30	0.212	2 MAIN
24	1.30	1.450	122.10	26.23	19350.00	26600.00	27490.00	11950.	4.594	312.	69.51	0.223	2 MAIN
25	0.70	1.450	127.20	22.97	21870.00	30070.00	31050.00	12950.	4.324	175.	40.85	0.233	2 MAIN
26	0.50	1.450	132.30	22.99	24810.00	33920.00	34860.00	14110.	4.128	130.	31.77	0.244	2 MAIN
27	0.50	1.450	137.40	23.02	27580.00	37590.00	39180.00	15360.	3.938	108.	27.65	0.256	2 MAIN
28	0.30	1.450	143.10	20.49	32130.00	44400.00	46070.00	19240.	3.260	84.	25.95	0.309	3 MAIN
29	0.30	1.450	150.10	20.53	37350.00	51750.00	53790.00	21540.	3.015	67.	26.04	0.334	3 MAIN
30	0.30	1.450	158.50	20.57	42950.00	60010.00	62400.00	24120.	2.787	60.	32.49	0.361	3 MAIN
31	0.30	1.450	163.00	18.49	48290.00	69240.00	71920.00	28950.	2.407	93.	38.84	0.418	4 MAIN
32	0.30	1.450	169.60	18.53	56390.00	79520.00	82730.00	32040.	2.237	96.	43.13	0.449	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED..... 15.79 KNOTS
EFFECTIVE POWER..... 7429. HP
SHAFT POWER..... 10230. HP
TURBINE POWER..... 10570. HP
TURBINE FUEL..... 4720. LBS/HR
PROPULSION FUEL..... 4632. LBS/HR

AVERAGE ELECTRICAL LOAD
PROPULSION COOLING... 9. KW
GENERATOR LUBE SYSTEM 1. KW
HELIUM COMPRESSORS... 130. KW

TOTAL LOAD.. 140. KW (112.0 LBS/HR)

ELECTRIC DRIVE SYSTEM

REF. NO. 1

MISSION PROFILE SUMMARY - MAIN ONLY - FIXED FIELDS

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS			NO. OF TURBINES
										NAUT. MILES	TONS FUEL	TONS PER MILE	
1	1-10	1-450	5.09	291.10	1-40	1-92	11-27	1100.	2-036	11.	5.90	0.527	1 MAIN
2	1-20	1-450	10.18	143.50	11-20	15-39	24-96	1100.	4-073	24.	6.23	0.264	1 MAIN
3	1-20	1-450	15.26	91.54	37-80	51-96	61-69	1100.	6-109	36.	6.35	0.176	1 MAIN
4	1-20	1-450	20.35	61.72	59-60	123-20	132-90	1100.	9-145	48.	6.23	0.132	1 MAIN
5	1-20	1-450	25.44	50.15	175-00	240-50	243-60	1102.	10-160	60.	6.34	0.106	1 MAIN
6	1-20	1-450	30.54	30.21	302-40	415-70	429-20	1236.	10-260	72.	7.06	0.093	1 MAIN
7	1-20	1-450	35.61	30.26	480-20	660-10	681-00	1397.	11-230	84.	7.92	0.094	1 MAIN
8	1-20	1-450	40.70	30.37	716-80	935-30	1016-00	1581.	11-340	96.	8.90	0.093	1 MAIN
9	1-20	1-450	45.79	30.47	1021-00	1423-00	1447-00	1791.	11-260	108.	10-03	0.093	1 MAIN
10	1-20	1-450	50.88	30.47	1400-00	1924-00	1937-00	2030.	11-040	120.	11-51	0.094	1 MAIN
11	6-30	1-450	55.97	30.49	1833-00	2561-00	2647-00	2799.	10-720	692.	66-96	0.097	1 MAIN
12	6-70	1-450	61.05	30.54	2419-00	3325-00	3440-00	2602.	10-320	804.	80-31	0.100	1 MAIN
13	7-00	1-450	66.14	30.60	3076-00	4228-00	4378-00	2941.	9-901	910.	94-51	0.104	1 MAIN
14	7-10	1-450	71.23	30.65	3842-00	5220-00	5475-00	3319.	9-449	994.	107-90	0.109	1 MAIN
15	6-00	1-450	76.32	30.71	4723-00	6475-00	6742-00	3739.	9-966	1020.	116-10	0.114	1 MAIN
16	6-10	1-450	81.40	30.76	5734-00	7832-00	8193-00	4206.	8-522	976.	116-90	0.120	1 MAIN
17	5-50	1-450	86.49	30.82	6573-00	9654-00	9341-00	4723.	9-063	1122.	141-70	0.126	1 MAIN
18	7-20	1-450	91.58	30.87	8163-00	11220-00	11700-00	5295.	7-615	1296.	173-00	0.134	1 MAIN
19	7-70	1-450	96.67	30.93	9403-00	13200-00	13700-00	5929.	7-179	1463.	206-60	0.141	1 MAIN
20	8-90	1-450	101.80	30.92	11200-00	15590-00	16100-00	6630.	6-757	1780.	267-10	0.150	1 MAIN
21	7-50	1-450	106.80	31.04	12970-00	17320-00	18660-00	7405.	6-352	1575.	251-10	0.159	1 MAIN
22	4-30	1-450	111.90	31.10	14910-00	20490-00	21493-00	8264.	5-963	946.	160-50	0.170	1 MAIN
23	1-50	1-450	117.00	24.45	17030-00	23410-00	24160-00	10620.	4-761	345.	73-09	0.212	2 MAIN
24	1-30	1-450	122.10	24.58	19350-00	26600-00	27470-00	11830.	4-545	312.	69-21	0.222	2 MAIN
25	0-70	1-450	127.20	24.50	21670-00	30070-00	31070-00	12920.	4-334	175.	40-68	0.232	2 MAIN
26	0-50	1-450	132.30	24.52	24610-00	33820-00	34580-00	14100.	4-130	130.	31-70	0.244	2 MAIN
27	0-40	1-450	137.40	24.55	27690-00	37630-00	39200-00	15330.	3-932	108.	27-65	0.256	2 MAIN
28	0-30	1-450	143.70	20.49	32130-00	44400-00	46030-00	19240.	3-260	84.	25-92	0.309	3 MAIN
29	0-30	1-450	150.10	20.53	37430-00	51730-00	53730-00	21540.	3-015	87.	20-00	0.333	3 MAIN
30	0-30	1-450	156.50	20.54	42950-00	59010-00	62400-00	24123.	2-797	90.	32-46	0.361	3 MAIN
31	0-30	1-450	163.00	20.56	49230-00	69240-00	71990-00	28650.	2-406	93.	36-82	0.417	4 MAIN
32	0-30	1-450	169.60	20.59	56360-00	79520-00	82910-00	32150.	2-230	96.	43-24	0.450	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED..... 15.75 KNOTS
 EFFECTIVE POWER..... 74230. HP
 SHAFT POWER..... 10230. HP
 TURBINE POWER..... 10690. HP
 TURBINE FUEL..... 4999. LBS/HR
 PROPULSION FUEL..... 5087. LBS/HR

AVERAGE ELECTRICAL LOAD
 PROPULSION COOLING... 9. KW
 GENERATOR LUBE SYSTEM 1. KW
 HELIUM COMPRESSORS... 100. KW

TOTAL LOAD... 110. KW (87.7 LBS/HR)

C-34

MISSION PROFILE SUMMARY - MAIN + CRUISE - FIXED FIFLOS

KTS	PCT-TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NAM/TON)	PER THOUSAND HOURS			NO. OF TURBINES
										NAUT. MILES	TONS FUEL	TONS PER MILE	
1	1-10	1-450	5-09	685-10	1-40	1-92	5-19	360-	9-222	11-	2-28	0-208	1 CRUISE
2	1-20	1-450	10-18	325-10	11-20	15-39	16-88	360-	12-440	24-	2-49	0-104	1 CRUISE
3	1-20	1-450	15-26	177-70	37-80	51-96	55-63	360-	13-670	36-	2-49	0-069	1 CRUISE
4	1-20	1-450	20-35	87-96	89-00	123-20	127-90	409-	21-380	48-	2-76	0-057	1 CRUISE
5	1-20	1-450	25-44	88-24	175-00	240-50	249-40	502-	22-380	60-	3-25	0-054	1 CRUISE
6	1-20	1-450	30-53	88-52	202-40	415-70	431-00	617-	21-790	72-	3-87	0-054	1 CRUISE
7	1-20	1-450	35-61	88-81	460-20	680-10	685-00	756-	20-750	84-	4-61	0-055	1 CRUISE
8	1-20	1-450	40-70	89-29	716-80	985-30	1024-00	921-	19-480	96-	5-50	0-057	1 CRUISE
9	1-20	1-450	45-79	89-37	1021-00	1403-00	1461-00	1119-	18-070	108-	6-54	0-061	1 CRUISE
10	1-20	1-450	50-88	89-65	1400-00	1924-00	2008-00	1343-	15-680	120-	7-76	0-065	1 CRUISE
11	6-30	1-450	55-97	89-84	1862-00	2561-00	2679-00	1607-	15-320	693-	48-20	0-070	1 CRUISE
12	6-70	1-450	61-05	90-22	2419-00	3329-00	3486-00	1912-	14-060	804-	60-40	0-075	1 CRUISE
13	7-00	1-450	66-14	90-50	3076-00	4220-00	4443-00	2263-	12-870	910-	74-11	0-081	1 CRUISE
14	7-10	1-450	71-23	90-79	3842-00	5280-00	5304-00	2667-	11-750	994-	87-59	0-089	1 CRUISE
15	6-80	1-450	76-31	89-23	4325-00	6495-00	6736-00	3654-	9-195	1020-	114-30	0-112	2 CRUISE
16	6-10	1-450	81-40	80-76	5754-00	7882-00	8193-00	4206-	8-522	975-	117-50	0-120	1 MAIN
17	6-60	1-450	86-49	80-82	6878-00	9454-00	9841-00	4723-	8-083	1122-	142-40	0-127	1 MAIN
18	7-20	1-450	91-58	80-87	8163-00	11220-00	11700-00	5295-	7-615	1296-	173-80	0-134	1 MAIN
19	7-70	1-450	96-67	80-93	9503-00	13200-00	13780-00	5929-	7-179	1463-	207-70	0-142	1 MAIN
20	3-90	1-450	101-80	80-55	11200-00	15390-00	16100-00	6930-	5-757	1780-	265-00	0-151	1 MAIN
21	7-30	1-450	106-80	81-04	12970-00	17130-00	18680-00	7405-	6-352	1575-	251-90	0-160	1 MAIN
22	4-30	1-450	111-90	81-10	14610-00	20490-00	21490-00	8284-	5-963	946-	161-00	0-170	1 MAIN
23	1-50	1-450	117-00	84-45	17030-00	23410-00	24160-00	10820-	4-751	345-	73-25	0-212	2 MAIN
24	1-30	1-450	122-10	84-48	19350-00	26800-00	27470-00	11820-	4-545	312-	69-35	0-222	2 MAIN
25	0-70	1-450	127-20	84-53	21870-00	30370-00	31070-00	12920-	4-334	175-	40-76	0-233	2 MAIN
26	0-50	1-450	132-30	84-53	23610-00	33820-00	34580-00	14100-	4-130	130-	31-75	0-244	2 MAIN
27	0-40	1-450	137-40	84-53	27580-00	37380-00	39200-00	15380-	3-932	108-	27-59	0-259	2 MAIN
28	0-30	1-450	142-70	84-53	32130-00	44000-00	45030-00	19240-	3-200	94-	25-65	0-309	3 MAIN
29	0-30	1-450	150-10	84-53	37250-00	51750-00	53730-00	21540-	3-015	87-	29-04	0-334	3 MAIN
30	0-30	1-450	154-50	84-57	42550-00	60010-00	62400-00	24130-	2-737	90-	32-49	0-361	3 MAIN
31	0-20	1-450	163-00	84-55	48290-00	68240-00	71990-00	28860-	2-406	93-	36-85	0-418	4 MAIN
32	0-30	1-450	169-60	84-59	56300-00	79520-00	82810-00	32150-	2-230	95-	43-27	0-451	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.70	KNOTS
EFFECTIVE POWER.....	7426	HP
SHAFT POWER.....	10230	HP
TURBINE POWER.....	10670	HP
TURBINE FUEL.....	4779	LBS/HR
PROPELLER FUEL.....	4641	LBS/HR

AVERAGE ELECTRICAL LOAD	9- KW
PROPULSION COOLING...	1- KW
GENERATOR LUBE SYSTEM	130- KW
HELIUM COMPRESSORS...	130- KW

TOTAL LOAD.. 140. KW (112.0 LBS/HR)

***** RUN TERMINATED AFTER 145 SPEED CALCULATIONS

ELECTRIC DRIVE SYSTEM

REF. NO. 501- I

MISSION PROFILE SUMMARY - SINGLE CRUISE TURBINE

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	NAUT. MILES	PER THOUSAND HOURS		NO. OF TURBINES
											TONS FUEL	TONS PER MILE	
1	1.10	1.450	5.00	686.10	1.40	1.92	5.19	360.	6.222	11.	2.28	0.208	1 CRUISE
2	1.20	1.450	10.10	373.20	11.20	15.39	18.86	360.	13.440	24.	2.49	0.104	1 CRUISE
3	1.20	1.450	15.20	177.70	37.80	51.96	55.63	360.	18.670	36.	2.49	0.060	1 CRUISE
4	1.20	1.450	20.30	103.00	69.60	123.20	128.30	405.	22.110	48.	2.75	0.057	1 CRUISE
5	1.20	1.450	25.44	114.70	175.00	240.50	250.30	492.	22.760	60.	3.20	0.053	1 CRUISE
6	1.20	1.450	30.53	110.20	362.40	415.70	412.50	590.	22.440	72.	3.77	0.052	1 CRUISE
7	1.20	1.450	35.61	119.60	480.20	650.10	637.20	729.	21.500	94.	4.47	0.053	1 CRUISE
8	1.20	1.450	40.70	119.20	716.50	983.30	1027.00	897.	20.210	96.	5.31	0.055	1 CRUISE
9	1.20	1.450	45.79	117.70	1021.00	1403.00	1464.00	1075.	18.760	106.	6.32	0.059	1 CRUISE
10	1.20	1.450	50.80	115.30	1400.00	1924.00	2012.00	1299.	17.250	120.	7.53	0.063	1 CRUISE
11	6.70	1.450	54.97	112.20	1883.00	2561.00	2681.00	1563.	15.770	693.	45.05	0.268	1 CRUISE
12	6.70	1.450	61.05	104.70	2419.00	3325.00	3400.00	1872.	14.360	804.	59.20	0.074	1 CRUISE
13	7.00	1.450	65.14	105.00	3076.00	4228.00	4447.00	2231.	13.050	910.	73.10	0.080	1 CRUISE

* * INSUFFICIENT DATA FOR FULL MISSION PROFILE * * *

PERFORMANCE AVERAGES OVER MISSION PROFILE (319 HOURS)

SPEED.....	5.41	KNOTS	AVERAGE ELECTRICAL LOAD	1.	KW
EFFECTIVE POWER	1710.	HP	PROPULSION COOLING...	0.	KW
SHAFT POWER....	2351.	HP	GENERATOR LUBE SYSTEM	130.	KW
TURBINE POWER..	2467.	HP	HELIUM COMPRESSORS...		
TURBINE FUEL...	1437.	LBS/HR			
PROPULSION FUEL	1543.	LBS/HR	TOTAL LOAD..	131.	KW (104.8 LBS/HR)

REF.NO. 501-1

SINGLE CRUISE TURBINE

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHAFT (THALIA-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	LF
1 CRUISE	1.00	5.09	0.90	398.80	244.87	1.4500	72.75	0.41	91.07	0.27	78.40	100.00	8.31	92.27	LF
1 CRUISE	2.00	10.18	3.97	805.84	282.71	1.4500	72.75	2.72	94.73	1.87	85.09	92.43	16.64	357.27	LF
1 CRUISE	3.00	15.26	5.04	1515.32	330.13	1.4500	72.75	7.64	95.51	5.31	89.28	79.48	24.92	795.02	LF
1 CRUISE	4.00	20.35	15.70	2213.73	409.31	1.4500	72.75	14.96	95.57	10.44	103.78	72.77	33.34	1403.51	LF
1 CRUISE	5.00	25.44	24.23	2921.24	492.08	1.4500	72.75	24.03	95.02	16.80	114.84	69.16	41.71	2188.74	LF
1 CRUISE	6.00	30.53	35.76	3609.31	594.82	1.4500	72.75	34.11	95.11	23.85	118.23	67.38	50.09	3144.71	LF
1 CRUISE	7.00	35.61	48.87	4297.73	729.30	1.4500	72.75	44.51	95.35	31.10	119.53	66.85	58.48	4273.42	LF
1 CRUISE	8.00	40.70	63.57	4953.68	885.56	1.4500	72.75	54.71	95.32	38.19	117.72	68.33	65.89	5574.88	LF
1 CRUISE	9.00	45.79	80.45	5590.26	1074.88	1.4500	72.75	64.34	95.38	44.85	115.73	69.99	75.31	7049.07	LF
1 CRUISE	10.00	50.86	99.33	6202.31	1293.60	1.4500	72.75	73.17	95.43	50.92	112.72	72.13	83.74	8496.01	LF
1 CRUISE	11.00	55.97	120.18	6780.21	1532.65	1.4500	72.75	81.09	95.48	56.33	108.74	74.97	92.19	10315.69	LF
1 CRUISE	12.00	61.05	143.83	7338.72	1871.58	1.4500	72.75	88.03	95.28	61.05	105.02	77.55	100.65	12593.11	LF
1 CRUISE	13.00	66.14	167.50	7969.02	2230.81	1.4500	72.75	94.16	95.30	65.13	105.02	77.55	109.12	14673.25	LF
1 CRUISE	14.00	71.23	194.58	8597.92	2645.13	1.4500	72.75	99.41	94.35	68.60	101.19	80.74	117.61	17011.17	HS

LF = FUEL BELOW MINIMUM REQUIRED RATE

HS = FUEL ABOVE MAXIMUM FUEL RATE

HES = TURBINE SPEED EXCESSIVE

HES = TURBINE FUEL AND SPEED EXCESSIVE

REF.NO. 501- 1

SINGLE CRUISE TURBINE

TURBINE CONFIG.	SPEED (KNOTS)	SHFT RPM	SHFT (TH. LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	CRUISE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS
1 CRUISE	1.00	5.09	0.59	3490.66	360.00	1.4500	72.75	0.58	37.10	0.18	686.09	11.43	8.31	92.27
1 CRUISE	2.00	10.18	3.97	3318.76	360.00	1.4500	72.75	2.48	81.55	1.47	326.15	24.11	16.64	357.27
1 CRUISE	3.00	15.26	8.94	2712.58	360.00	1.4500	72.75	7.30	93.40	4.96	177.72	44.40	24.93	795.02
1 CRUISE	4.00	20.35	15.89	2213.73	403.21	1.4500	72.75	14.56	95.97	10.44	108.73	72.77	33.34	1405.51
1 CRUISE	5.00	25.44	24.93	2021.26	492.03	1.4500	72.75	24.03	96.09	16.80	114.84	69.16	41.71	2188.74
1 CRUISE	6.00	30.53	35.76	3609.31	573.02	1.4500	72.75	34.11	96.11	23.85	118.23	67.33	50.09	3144.71
1 CRUISE	7.00	35.61	48.67	4257.73	729.30	1.4500	72.75	44.51	95.05	31.10	119.55	66.85	59.48	4273.42
1 CRUISE	8.00	40.70	63.57	4853.68	836.56	1.4500	72.75	54.71	95.95	38.19	117.25	67.24	66.89	5574.85
1 CRUISE	9.00	45.79	80.45	5390.26	1074.88	1.4500	72.75	61.34	95.92	44.85	117.72	68.33	75.31	7049.07
1 CRUISE	10.00	50.88	99.73	5865.31	1299.66	1.4500	72.75	73.17	95.66	50.92	115.28	69.99	83.74	8696.01
1 CRUISE	11.00	55.97	120.18	6230.21	1552.55	1.4500	72.75	81.09	95.48	56.33	112.22	72.13	92.19	10515.69
1 CRUISE	12.00	61.05	143.03	6568.72	1871.68	1.4500	72.75	88.08	95.28	61.05	108.74	74.67	100.65	12503.11
1 CRUISE	13.00	66.14	167.86	6946.02	2230.81	1.4500	72.75	94.16	95.08	65.13	105.02	77.56	109.12	14673.26
1 CRUISE	14.00	71.23	194.63	7207.52	2645.16	1.4500	72.75	99.41	94.86	69.50	101.19	80.74	117.51	17011.17

LF = FUEL BELOW MINIMUM REQUIRED RATE

HF = FUEL ABOVE MAXIMUM FUEL RATE

HS = TURBINE SPEED EXCESSIVE

HFS = TURBINE FUEL AND SPEED EXCESSIVE

MISSION PROFILE SUMMARY - TWO CRUISE TURBINES

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS			NO. OF TURBINES
										NAUT. MILES	TONS FUEL	TONS PER MILE	
1	1-10	1-450	5-09	683-40	1-40	1-92	2-35	720-	3-111	11-	4-05	0-369	2 CRUISE
2	1-20	1-450	10-18	336-10	11-20	15-39	22-04	720-	6-222	24-	4-42	0-124	2 CRUISE
3	1-20	1-450	15-26	207-90	37-80	51-96	58-76	720-	9-333	36-	4-42	0-123	2 CRUISE
4	1-20	1-450	20-35	122-00	89-60	123-20	129-70	720-	12-440	48-	4-42	0-092	2 CRUISE
5	1-20	1-450	25-44	86-00	175-00	240-50	249-10	804-	13-920	60-	4-88	0-091	2 CRUISE
6	1-20	1-450	30-53	90-06	302-40	415-70	429-80	937-	14-340	72-	5-59	0-078	2 CRUISE
7	1-20	1-450	35-61	92-70	480-20	640-10	662-00	1095-	14-320	84-	6-43	0-077	2 CRUISE
8	1-20	1-450	40-70	94-19	715-80	935-30	1018-00	1279-	14-010	96-	7-42	0-077	2 CRUISE
9	1-20	1-450	45-79	94-72	1021-00	1403-00	1449-00	1495-	13-490	108-	8-58	0-079	2 CRUISE
10	1-20	1-450	50-83	94-49	1400-00	1924-00	1983-00	1744-	12-840	120-	9-91	0-083	2 CRUISE
11	6-30	1-450	55-57	93-62	1863-00	2561-00	2645-00	2031-	12-130	693-	50-14	0-087	2 CRUISE
12	6-70	1-450	61-05	92-73	2419-00	3325-00	3440-00	2361-	11-380	804-	73-84	0-092	2 CRUISE
13	7-00	1-450	65-14	90-57	3076-00	4230-00	4377-00	2738-	10-640	910-	88-94	0-093	2 CRUISE
14	7-10	1-450	71-23	88-58	3847-00	5280-00	5471-00	3186-	9-904	994-	103-80	0-104	2 CRUISE
15	6-80	1-450	75-32	86-39	4725-00	6495-00	6735-00	3651-	9-203	1020-	114-20	0-112	2 CRUISE
16	6-10	1-450	81-40	84-05	5734-00	7882-00	8184-00	4197-	8-540	976-	117-30	0-120	2 CRUISE
17	6-50	1-450	86-49	81-70	6976-00	9454-00	9828-00	4808-	7-919	1122-	145-00	0-129	2 CRUISE

* * INSUFFICIENT DATA FOR FULL MISSION PROFILE * * *

PERFORMANCE AVERAGES OVER MISSION PROFILE (595 HOURS)

SPEED.....	12.27	KNOTS	AVERAGE ELECTRICAL LOAD	
EFFECTIVE POWER.....	3322-	HP	PROPULSION COOLING...	2. KW
SHAFT POWER.....	4066-	HP	GENERATOR LUBE SYSTEM	1. KW
TURBINE POWER...	4766-	HP	HELIUM COMPRESSORS...	130. KW
TURBINE FUEL...	2814-	LBS/HR	TOTAL LOAD.. 133. KW (106.5 LBS/HR)	
PROPULSION FUEL	2921-	LBS/HR		

TWO CRUISE TURBINES

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.IR-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FO4	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
2 CRUISE	1.00	5.09	0.99	398.26	481.40	1.4500	72.75	0.21	89.13	0.14	78.28	100.00	8.31	92.27	LF
2 CRUISE	2.00	10.18	3.97	798.00	532.64	1.4500	72.75	1.45	93.37	0.89	78.42	100.00	16.64	357.27	LF
2 CRUISE	3.00	15.26	8.94	1199.21	602.78	1.4500	72.75	4.23	95.59	2.96	78.57	100.00	24.93	755.02	LF
2 CRUISE	4.00	20.35	15.89	1637.31	693.28	1.4500	72.75	8.71	95.29	6.11	80.26	98.08	33.34	1405.51	LF
2 CRUISE	5.00	25.44	24.83	2188.32	804.45	1.4500	72.75	14.63	99.59	10.26	86.02	91.37	41.71	2188.74	LF
2 CRUISE	6.00	30.53	35.75	2758.35	937.53	1.4500	72.75	21.65	98.71	15.24	90.06	87.72	50.09	3144.71	LF
2 CRUISE	7.00	35.61	48.67	3391.55	1094.90	1.4500	72.75	29.42	96.73	20.72	92.70	85.38	58.48	4273.42	LF
2 CRUISE	8.00	40.70	63.57	3831.65	1279.42	1.4500	72.75	37.57	95.31	26.46	94.19	84.18	66.89	5574.83	LF
2 CRUISE	9.00	45.79	80.55	4337.44	1494.60	1.4500	72.75	45.80	90.31	32.25	94.72	83.66	75.31	7049.07	LF
2 CRUISE	10.00	50.88	99.33	4807.38	1747.90	1.4500	72.75	53.86	86.73	37.92	94.49	84.22	83.74	8996.01	LF
2 CRUISE	11.00	55.97	120.18	5240.19	2031.34	1.4500	72.75	61.57	86.73	43.33	93.63	85.15	92.19	10515.69	LF
2 CRUISE	12.00	61.05	143.03	5635.52	2351.29	1.4500	72.75	69.81	86.37	48.40	92.23	86.54	100.65	12508.11	LF
2 CRUISE	13.00	66.14	167.85	5990.48	2738.08	1.4500	72.75	79.51	85.50	53.06	90.57	88.34	109.12	14673.26	LF
2 CRUISE	14.00	71.23	194.68	6308.26	3188.38	1.4500	72.75	91.62	85.51	57.31	88.53	90.49	117.61	17011.17	LF
2 CRUISE	15.00	75.32	223.48	6593.23	3550.95	1.4500	72.75	87.15	85.42	61.13	86.39	92.95	126.11	19521.63	LF
2 CRUISE	16.00	81.40	254.27	6844.68	4198.57	1.4500	72.75	92.12	85.31	64.54	84.08	95.58	134.63	22205.21	LF
2 CRUISE	17.00	86.48	287.05	7095.57	4808.85	1.4500	72.75	98.54	85.20	67.57	81.70	98.64	143.15	25061.31	LF
2 CRUISE	18.00	91.56	321.62	7393.66	5493.09	1.4500	72.75	100.45	85.07	70.21	80.74	100.00	151.69	28090.15	HS

LF = FUEL BELOW MINIMUM REQUIRED RATE

HF = FUEL ABOVE MAXIMUM FUEL RATE

HS = TURBINE SPEED EXCESSIVE

HFS = TURBINE FUEL AND SPEED EXCESSIVE

TWO CRUISE TURBINES

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT FRO (IN. LB.-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	VOLTAGE	MOTOR AMPS
2 CRUISE	1.00	5.09	0.99	3502.53	720.00	1.4500	72.75	C.55	23.04	0.09	688.44	11.37	8.31	92.27
2 CRUISE	2.00	10.18	3.97	3419.57	720.00	1.4500	72.75	1.45	65.84	0.73	336.06	23.34	16.64	357.27
2 CRUISE	3.00	15.26	8.94	3172.57	720.00	1.4500	72.75	3.86	88.42	2.46	207.86	37.80	24.98	795.02
2 CRUISE	4.00	20.35	15.89	2483.51	720.00	1.4500	72.75	8.51	94.98	5.88	122.03	64.50	33.34	1405.51
2 CRUISE	5.00	25.44	24.85	2183.32	804.46	1.4500	72.75	14.63	96.56	10.28	86.02	51.67	41.71	2188.74
2 CRUISE	6.00	30.53	35.76	2749.35	937.53	1.4500	72.75	21.66	96.71	15.24	90.06	87.72	50.09	3144.71
2 CRUISE	7.00	35.61	48.67	3301.55	1094.90	1.4500	72.75	29.42	96.78	20.72	92.70	85.38	58.48	4273.42
2 CRUISE	8.00	40.70	63.57	3833.55	1279.49	1.4500	72.75	37.57	96.81	26.46	94.19	84.18	66.80	5574.88
2 CRUISE	9.00	45.79	80.45	4337.44	1494.60	1.4500	72.75	45.80	96.81	32.26	94.72	83.86	75.31	7049.07
2 CRUISE	10.00	50.88	99.33	4807.38	1743.90	1.4500	72.75	53.86	96.78	37.92	94.49	84.22	83.74	8696.01
2 CRUISE	11.00	55.97	120.18	5240.19	2031.39	1.4500	72.75	61.57	96.73	43.33	93.63	85.15	92.19	10315.69
2 CRUISE	12.00	61.05	143.03	5634.52	2361.29	1.4500	72.75	68.81	96.67	48.40	92.29	86.54	100.65	12308.11
2 CRUISE	13.00	66.14	167.86	5990.48	2738.08	1.4500	72.75	75.51	96.60	53.06	90.57	88.34	109.12	14573.26
2 CRUISE	14.00	71.23	194.69	6309.36	3156.38	1.4500	72.75	81.62	96.51	57.31	88.56	90.49	117.61	17011.17
2 CRUISE	15.00	76.22	223.48	6591.23	3650.56	1.4500	72.75	87.15	96.42	61.13	86.36	92.95	126.11	19521.83
2 CRUISE	16.00	81.40	254.27	6844.66	4195.67	1.4500	72.75	92.12	96.31	64.54	84.06	95.68	134.63	22205.21
2 CRUISE	17.00	86.49	287.05	7055.57	4808.45	1.4500	72.75	96.54	96.20	67.57	91.70	98.64	143.15	25061.31
2 CRUISE	18.00	91.58	321.92	7393.88	5493.09	1.4500	72.75	100.45	96.07	70.21	80.74	100.00	151.69	28390.15

HS

LF = FUEL BELOW MINIMUM REQUIRED RATE

HF = FUEL ABOVE MAXIMUM FUEL RATE

HS = TURBINE SPEED EXCESSIVE

HFS = TURBINE FUEL AND SPEED EXCESSIVE

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TCN)	NAUT. MILES	TCN FUEL	TONS PER MILE	NO. OF TURBINES
1	1-10	1-450	5-09	291-10	1-40	1-92	11-27	1100.	2-036	11.	5-80	0-527	1 MAIN
2	1-20	1-450	10-18	143-40	11-20	15-39	24-96	1100.	4-073	24.	6-33	0-264	1 MAIN
3	1-20	1-450	15-26	91-59	37-80	51-55	61-70	1100.	6-109	26.	6-33	0-176	1 MAIN
4	1-20	1-450	20-35	61-81	88-60	123-20	132-90	1100.	8-145	48.	6-33	0-132	1 MAIN
5	1-20	1-450	25-44	29-50	175-90	240-50	248-70	1102.	10-170	60.	6-34	0-106	1 MAIN
6	1-20	1-450	30-53	31-26	302-40	415-70	429-40	1238.	10-860	72.	7-06	0-098	1 MAIN
7	1-20	1-450	35-61	32-60	480-20	660-10	681-80	1395.	11-240	84.	7-91	0-094	1 MAIN
8	1-20	1-450	40-70	33-57	716-80	985-30	1018-00	1576.	11-370	96.	8-88	0-092	1 MAIN
9	1-20	1-450	45-79	34-33	1021-00	1400-00	1450-00	1763.	11-310	108.	9-99	0-092	1 MAIN
10	1-20	1-450	50-88	34-52	1400-00	1924-00	1931-80	2018.	11-100	120.	11-25	0-094	1 MAIN
11	6-30	1-450	55-97	34-79	1563-00	2561-00	2652-00	2284.	10-790	693.	66-54	0-096	1 MAIN
12	6-30	1-450	61-05	34-77	2419-00	3325-00	3446-00	2584.	10-400	804.	79-76	0-099	1 MAIN
13	7-00	1-450	66-14	34-52	3075-00	4228-00	4335-00	2921.	9-969	910.	93-84	0-103	1 MAIN
14	7-10	1-450	71-23	34-27	3842-00	5283-00	5482-00	3299.	9-506	994.	107-30	0-108	1 MAIN
15	6-80	1-450	76-32	33-84	4725-00	6405-00	6750-00	3721.	9-029	1020.	115-50	0-113	1 MAIN
16	6-10	1-450	81-40	32-33	5734-00	7992-00	8201-00	4191.	8-551	976.	116-50	0-119	1 MAIN
17	6-60	1-450	86-49	32-75	6876-00	9454-00	9743-00	4713.	8-079	1122.	141-40	0-126	1 MAIN
18	7-20	1-450	91-56	32-11	8105-00	11220-00	11700-00	5291.	7-521	1296.	172-90	0-133	1 MAIN
19	7-70	1-450	96-57	31-44	9005-00	13300-00	13760-00	5928.	7-179	1463.	206-90	0-141	1 MAIN
20	8-30	1-450	101-80	30-75	11200-00	15390-00	15100-00	6628.	6-758	1790.	267-00	0-150	1 MAIN
21	7-50	1-450	106-80	30-64	12970-00	17520-00	18660-00	7398.	6-359	1575.	250-80	0-159	1 MAIN
22	4-30	1-450	111-90	29-32	14910-00	20490-00	21480-00	9238.	5-982	946.	160-00	0-169	1 MAIN

INTELLIGENCE DATA FOR FULL MISSION PROFILE

PERFORMANCE AVERAGES OVER MISSION PROFILE (941 HOURS)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	7. KW
GENERATOR LUBE SYSTEM	1. KW
HELIUM COMPRESSORS...	100. KW
TOTAL LOAD...	108. KW (26.4 LBS/HR)

SPEED.....	15.13	KNOTS
EFFECTIVE POWER.....	4250.	HP
SHAFT POWER.....	8590.	HP
TURBINE POWER.....	9500*	HP
TURBINE FUEL.....	4329.	135/H3
TURBINE FUEL.....	4415.	135/H3
PROPELLER FUEL.....		135/H3
		(0.128 TONS/MILE)
		(0.130 TONS/MILE)

ONE MAIN TURBINE

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FO4	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
1 MAIN	1.00	5.09	0.99	91.37	754.24	1.4500	72.75	0.11	91.21	0.07	17.96	100.00	8.31	92.27	LF
1 MAIN	2.00	10.18	3.97	207.33	811.63	1.4500	72.75	0.75	94.76	0.53	20.38	88.30	16.64	357.27	LF
1 MAIN	3.00	15.26	8.94	370.18	869.44	1.4500	72.75	0.32	95.04	1.42	24.25	74.32	24.93	795.02	LF
1 MAIN	4.00	20.35	15.89	553.73	986.11	1.4500	72.75	4.94	96.50	3.47	27.21	66.37	33.34	1403.51	LF
1 MAIN	5.00	25.44	24.83	750.43	1101.81	1.4500	72.75	3.61	96.71	6.06	29.50	61.33	41.71	2123.74	
1 MAIN	6.00	30.53	35.76	954.41	1237.60	1.4500	72.75	13.23	96.79	9.32	31.26	57.97	50.09	3144.71	
1 MAIN	7.00	35.61	48.67	1160.97	1395.02	1.4500	72.75	18.64	96.31	13.13	32.60	55.70	58.48	4275.42	
1 MAIN	8.00	40.70	63.57	1366.30	1575.97	1.4500	72.75	24.64	96.78	17.35	33.57	54.19	66.89	5974.88	
1 MAIN	9.00	45.79	80.45	1567.29	1762.57	1.4500	72.75	31.03	96.73	21.64	34.23	53.25	75.31	7049.07	
1 MAIN	10.00	50.88	98.33	1761.52	2017.64	1.4500	72.75	37.63	96.37	26.46	34.62	52.73	83.74	8696.01	
1 MAIN	11.00	55.97	120.18	1947.11	2283.65	1.4500	72.75	44.29	96.59	31.12	34.77	52.57	92.19	10515.69	
1 MAIN	12.00	61.05	143.03	2122.72	2583.73	1.4500	72.75	50.85	96.31	35.71	34.77	52.70	100.55	12503.11	
1 MAIN	13.00	66.14	167.86	2287.45	2921.07	1.4500	72.75	57.25	96.42	40.16	34.58	53.08	109.12	14673.25	
1 MAIN	14.00	71.23	194.68	2440.81	3299.08	1.4500	72.75	63.38	96.32	44.41	34.27	53.67	117.61	17011.17	
1 MAIN	15.00	76.32	223.48	2582.63	3721.32	1.4500	72.75	69.13	96.22	46.43	33.84	54.44	126.11	19521.83	
1 MAIN	16.00	81.40	254.27	2713.02	4141.49	1.4500	72.75	74.63	96.11	52.18	33.33	55.38	134.63	22705.21	
1 MAIN	17.00	86.49	287.03	2842.28	4713.41	1.4500	72.75	79.69	96.00	55.66	32.75	56.47	143.15	25061.31	
1 MAIN	18.00	91.58	321.82	2940.92	5290.48	1.4500	72.75	84.37	95.89	58.86	32.11	57.58	151.69	28090.15	
1 MAIN	19.00	96.67	358.57	3039.53	5928.71	1.4500	72.75	89.67	95.77	61.78	31.44	59.02	160.25	31291.80	
1 MAIN	20.00	101.76	397.30	3128.70	6629.11	1.4500	72.75	92.60	95.55	64.44	30.75	60.46	168.82	34666.17	
1 MAIN	21.00	106.84	438.03	3209.33	7397.77	1.4500	72.75	96.13	95.53	66.84	30.04	62.00	177.40	38213.25	
1 MAIN	22.00	111.93	480.74	3281.95	8238.31	1.4500	72.75	99.44	95.40	69.01	29.32	63.63	185.99	41923.10	
1 MAIN	23.00	117.02	525.43	3347.31	9154.85	1.4500	72.75	102.39	95.27	70.56	28.60	65.34	194.60	45825.68	HF

LF = FUEL BELOW MINIMUM REQUIRED RATE

HF = FUEL ABOVE MAXIMUM FUEL RATE

HS = TURBINE SPEED EXCESSIVE

HFS = TURBINE FUEL AND SPEED EXCESSIVE

ONE MAIN TURBINE

REF.NO. 501-3

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS
1 MAIN	1.00	5.09	0.99	1481.14	1100.00	1.4500	72.75	0.39	17.07	0.05	291.12	6.17	8.31	92.27
1 MAIN	2.00	10.18	3.97	1459.49	1100.00	1.4500	72.75	C.87	61.57	C.39	143.43	12.54	16.64	357.27
1 MAIN	3.00	15.26	8.94	1397.97	1100.00	1.4500	72.75	2.14	84.22	1.31	91.59	19.68	24.98	795.02
1 MAIN	4.00	20.35	15.89	1257.96	1100.00	1.4500	72.75	4.61	92.68	3.11	61.81	29.21	33.34	1405.51
1 MAIN	5.00	25.44	24.83	750.43	1101.81	1.4500	72.75	8.61	96.71	6.06	29.50	61.33	41.71	2188.74
1 MAIN	6.00	30.53	35.76	954.41	1237.60	1.4500	72.75	13.23	96.79	9.32	31.26	57.97	50.09	3144.71
1 MAIN	7.00	35.61	48.67	1160.97	1395.02	1.4500	72.75	18.64	96.81	13.12	32.60	55.70	58.48	4273.42
1 MAIN	8.00	40.70	63.57	1356.30	1575.97	1.4500	72.75	24.64	96.78	17.35	33.57	54.19	66.89	5574.88
1 MAIN	9.00	45.79	80.45	1567.29	1732.67	1.4500	72.75	31.03	96.73	21.84	34.23	53.25	75.31	7049.07
1 MAIN	10.00	50.88	99.33	1761.52	2017.64	1.4500	72.75	37.63	96.67	26.46	34.62	52.73	83.74	8696.01
1 MAIN	11.00	55.97	120.18	1947.11	2283.66	1.4500	72.75	44.29	96.59	31.12	34.79	52.57	92.19	10515.63
1 MAIN	12.00	61.05	143.03	2122.72	2593.73	1.4500	72.75	50.86	96.51	35.71	34.77	52.70	100.65	12508.11
1 MAIN	13.00	66.14	167.35	2287.45	2921.07	1.4500	72.75	57.25	96.42	40.16	34.58	53.05	109.12	14673.25
1 MAIN	14.00	71.23	194.68	2440.81	3299.08	1.4500	72.75	63.38	96.32	44.41	34.27	53.67	117.61	17011.17
1 MAIN	15.00	76.32	223.48	2582.63	3721.32	1.4500	72.75	69.18	96.22	48.43	33.84	54.44	126.11	19521.83
1 MAIN	16.00	81.40	254.27	2713.02	4191.49	1.4500	72.75	74.63	96.11	52.18	33.23	55.38	134.63	22205.21
1 MAIN	17.00	86.49	287.05	2832.28	4713.41	1.4500	72.75	79.69	96.00	55.66	32.75	56.47	143.15	25051.31
1 MAIN	18.00	91.58	321.82	2940.92	5290.93	1.4500	72.75	84.37	95.89	58.86	32.11	57.68	151.69	28080.16
1 MAIN	19.00	96.67	358.57	3030.53	5928.21	1.4500	72.75	89.67	95.77	61.78	31.44	59.02	160.25	31291.80
1 MAIN	20.00	101.76	397.30	3128.76	6629.11	1.4500	72.75	92.60	95.65	64.44	30.75	60.46	168.82	34666.17
1 MAIN	21.00	106.84	438.03	3209.33	7397.77	1.4500	72.75	96.18	95.53	66.84	30.04	62.00	177.40	38213.25
1 MAIN	22.00	111.93	480.74	3281.95	8238.31	1.4500	72.75	99.44	95.40	69.01	29.32	62.63	185.99	41933.10
1 MAIN	23.00	117.02	525.43	3347.31	9154.85	1.4500	72.75	102.39	95.27	70.96	28.60	63.34	194.80	45825.68

LF = FUEL BELOW MINIMUM REQUIRED RATE

HF = FUEL ABOVE MAXIMUM FUEL RATE

HS = TURBINE SPEED EXCESSIVE

HFS = TURBINE FUEL AND SPEED EXCESSIVE

ELECTRIC DRIVE SYSTEM

REF.NO. 501-4

MISSION PROFILE SUMMARY - TWO MAIN TURBINES

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS			TONS PER MILE	NO. OF TURBINES
										NAUT. MILES	TONS FUEL			
1	1.10	1.450	5.09	291.40	1.40	1.92	20.53	2200.	1.018	11.	11.21		1.019	2 MAIN
2	1.20	1.450	10.18	144.70	11.20	15.39	34.28	2400.	2.036	24.	12.22		0.509	2 MAIN
3	1.20	1.450	15.26	94.50	37.80	51.96	71.05	2200.	3.055	36.	12.22		0.340	2 MAIN
4	1.20	1.450	20.35	67.87	89.60	123.20	142.20	2200.	4.073	48.	12.22		0.255	2 MAIN
5	1.20	1.450	25.44	49.74	175.80	240.50	259.10	2200.	5.091	60.	12.22		0.204	2 MAIN
6	1.20	1.450	30.53	33.15	302.40	415.70	432.50	2200.	6.109	72.	12.22		0.170	2 MAIN
7	1.20	1.450	35.61	24.21	480.20	650.10	675.20	2347.	6.680	84.	13.01		0.155	2 MAIN
8	1.20	1.450	40.70	25.19	716.80	985.30	1013.00	2577.	6.953	96.	14.25		0.143	2 MAIN
9	1.20	1.450	45.79	25.96	1021.00	1403.00	1442.00	2835.	7.111	108.	15.63		0.145	2 MAIN
10	1.20	1.450	50.88	25.56	1400.00	1924.00	1978.00	3122.	7.174	120.	17.17		0.143	2 MAIN
11	6.30	1.450	55.97	27.00	1863.00	2561.00	2632.00	3442.	7.159	693.	99.12		0.143	2 MAIN
12	6.70	1.450	61.05	27.31	2419.00	3325.00	3418.00	3795.	7.082	894.	116.00		0.144	2 MAIN
13	7.00	1.450	66.14	27.49	3076.00	4223.00	4346.00	4186.	6.957	910.	133.40		0.147	2 MAIN
14	7.10	1.450	71.23	27.55	3842.00	5280.00	5430.00	4616.	6.753	994.	149.00		0.150	2 MAIN
15	6.80	1.450	76.32	27.55	4725.00	6495.00	6680.00	5090.	6.602	1020.	157.10		0.154	2 MAIN
16	6.10	1.450	81.40	27.45	5734.00	7892.00	8110.00	5609.	6.390	976.	155.10		0.159	2 MAIN
17	6.50	1.450	86.49	27.23	6378.00	9454.00	9731.00	6177.	6.165	1122.	184.50		0.164	2 MAIN
18	7.20	1.450	91.55	27.05	8165.00	11220.00	11560.00	6798.	5.932	1296.	221.30		0.171	2 MAIN
19	7.70	1.450	96.67	26.77	9603.00	13200.00	13600.00	7474.	5.694	1463.	260.00		0.178	2 MAIN
20	8.90	1.450	101.80	26.45	11200.00	15390.00	15870.00	8211.	5.456	1780.	323.80		0.185	2 MAIN
21	7.50	1.450	106.80	26.09	12970.00	17820.00	18380.00	9011.	5.220	1575.	304.70		0.193	2 MAIN
22	4.30	1.450	111.90	25.71	14910.00	20490.00	21140.00	9878.	4.989	946.	191.40		0.202	2 MAIN
23	1.50	1.450	117.00	25.30	17030.00	23410.00	24170.00	10820.	4.763	345.	73.05		0.212	2 MAIN
24	1.30	1.450	122.10	24.88	19350.00	26600.00	27470.00	11830.	4.545	312.	69.20		0.222	2 MAIN
25	0.70	1.450	127.20	24.44	21870.00	30070.00	31070.00	12920.	4.334	175.	40.68		0.232	2 MAIN
26	0.50	1.450	132.30	24.00	24610.00	33820.00	34970.00	14090.	4.132	130.	31.68		0.244	2 MAIN
27	0.40	1.450	137.40	23.55	27560.00	37880.00	39190.00	15350.	3.939	108.	27.60		0.256	2 MAIN

* * INSUFFICIENT DATA FOR FULL MISSION PROFILE * * *

PERFORMANCE AVERAGES OVER MISSION PROFILE (985 HOURS)

SPEED.....	15.54	KNOTS	AVERAGE ELECTRICAL LOAD
EFFECTIVE POWER.....	6878.	HP	PROPULSION COOLING....
SHAFT POWER.....	9453.	HP	GENERATOR LUBE SYSTEM
TURBINE POWER.....	9741.	HP	HELIUM COMPRESSORS....
TURBINE FUEL....	5999.	LBS/HR	
PROPULSION FUEL	6085.	LBS/HR	
			TOTAL LOAD... 108. KW (106.1 LBS/HR)

TWO MAIN TURBINES

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHAFT TFTI	TURBINE KPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FO4	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
2 MAIN	1.00	5.09	0.99	91.29	1495.34	1.4500	72.75	0.06	83.13	0.04	17.94	100.00	8.31	92.27	LF
2 MAIN	2.00	10.18	3.97	182.76	1573.07	1.4500	72.75	0.43	94.39	0.27	17.96	100.00	16.64	92.27	LF
2 MAIN	3.00	15.26	8.94	274.41	1577.85	1.4500	72.75	1.23	95.79	0.86	17.98	100.00	24.73	795.02	LF
2 MAIN	4.00	20.35	15.89	400.79	1809.38	1.4500	72.75	2.69	98.47	1.69	19.69	91.58	33.34	1405.51	LF
2 MAIN	5.00	25.44	24.83	547.29	1904.54	1.4500	72.75	4.82	99.35	3.40	21.51	83.74	41.71	2129.74	LF
2 MAIN	6.00	30.53	35.74	702.10	2143.54	1.4500	72.75	7.62	97.35	5.38	23.00	76.41	50.09	3144.71	LF
2 MAIN	7.00	35.61	48.67	862.24	2347.31	1.4500	72.75	11.04	97.13	7.80	24.21	74.55	58.48	4273.42	LF
2 MAIN	8.00	40.70	63.57	1025.17	2577.21	1.4500	72.75	14.99	97.25	10.61	25.19	71.74	66.87	5574.63	LF
2 MAIN	9.00	45.79	80.45	1188.79	2834.89	1.4500	72.75	19.43	97.33	13.73	25.95	69.57	75.31	7049.07	LF
2 MAIN	10.00	50.88	99.33	1351.28	3122.31	1.4500	72.75	24.15	97.30	17.10	26.56	68.17	83.74	8695.01	LF
2 MAIN	11.00	55.97	120.18	1511.12	3441.56	1.4500	72.75	29.17	97.27	20.65	27.00	67.12	92.19	10515.69	LF
2 MAIN	12.00	61.05	143.03	1671.07	3795.35	1.4500	72.75	34.35	97.27	24.31	27.31	66.44	100.55	12503.11	LF
2 MAIN	13.00	66.14	167.86	1818.08	4185.99	1.4500	72.75	39.63	97.25	28.02	27.49	65.55	109.12	14673.26	LF
2 MAIN	14.00	71.23	194.68	1963.37	4516.40	1.4500	72.75	44.86	97.22	31.74	27.56	65.55	117.61	17011.17	LF
2 MAIN	15.00	76.32	223.48	2102.30	5089.55	1.4500	72.75	50.05	97.19	35.41	27.55	66.05	126.11	19521.83	LF
2 MAIN	16.00	81.40	254.27	2234.45	5608.59	1.4500	72.75	55.15	97.15	39.20	27.45	66.36	134.63	22205.21	LF
2 MAIN	17.00	86.49	287.05	2359.53	6176.77	1.4500	72.75	60.09	97.12	42.47	27.28	66.83	143.13	25051.31	LF
2 MAIN	18.00	91.58	321.82	2477.40	6797.51	1.4500	72.75	64.84	97.08	45.81	27.05	67.46	151.69	28090.15	LF
2 MAIN	19.00	96.67	358.57	2588.05	7474.32	1.4500	72.75	69.33	97.03	49.00	26.77	68.24	160.25	31291.80	LF
2 MAIN	20.00	101.76	397.30	2691.53	8210.82	1.4500	72.75	73.70	96.98	52.03	26.45	69.13	168.82	34666.17	LF
2 MAIN	21.00	106.84	438.03	2788.03	9010.53	1.4500	72.75	77.73	96.99	54.88	26.09	70.15	177.40	38213.25	LF
2 MAIN	22.00	111.93	480.74	2877.75	9877.73	1.4500	72.75	81.62	96.94	57.56	25.71	71.27	185.99	41933.10	LF
2 MAIN	23.00	117.02	525.43	2960.48	10815.57	1.4500	72.75	85.22	96.89	60.07	25.30	72.48	194.60	45825.65	LF
2 MAIN	24.00	122.11	572.17	3038.03	11828.47	1.4500	72.75	88.53	96.83	62.40	24.88	73.79	203.22	49890.99	LF
2 MAIN	25.00	127.19	620.79	3109.98	12919.98	1.4500	72.75	91.72	96.78	64.58	24.44	75.15	211.95	54129.05	LF
2 MAIN	26.00	132.28	671.44	3174.92	14094.15	1.4500	72.75	94.63	96.72	66.59	24.00	76.11	220.50	58539.85	LF
2 MAIN	27.00	137.37	724.09	3235.45	15354.91	1.4500	72.75	97.34	96.56	68.45	23.55	78.11	229.16	63123.40	LF
2 MAIN	28.00	143.62	811.51	3315.97	17377.27	1.4500	72.36	100.95	96.53	70.52	23.08	79.94	240.05	70732.75	HF

LF = FUEL BELOW MINIMUM REQUIRED RATE

HF = FUEL ABOVE MAXIMUM FUEL RATE

HS = TURBINE SPEED EXCESSIVE

HFS = TURBINE FUEL AND SPEED EXCESSIVE

TWO MAIN TURBINES

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHAFT (THL-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FCM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS
2 MAIN	1.00	5.09	0.99	1482.72	2200.00	1.4500	72.75	0.36	9.37	0.02	291.43	6.16	8.31	92.27
2 MAIN	2.00	10.18	3.97	1471.91	2200.00	1.4500	72.75	0.59	44.91	0.19	144.65	12.42	16.64	357.27
2 MAIN	3.00	15.26	8.94	1442.35	2200.00	1.4500	72.75	1.23	73.12	0.66	94.50	19.02	24.98	795.02
2 MAIN	4.00	20.35	15.89	1381.24	2200.00	1.4500	72.75	2.47	85.59	1.55	67.87	26.52	33.34	1405.51
2 MAIN	5.00	25.44	24.83	1265.34	2200.00	1.4500	72.75	4.49	92.83	3.03	49.74	36.22	41.71	2188.74
2 MAIN	6.00	30.53	35.76	1011.99	2200.00	1.4500	72.75	7.50	96.11	5.24	33.15	54.40	50.09	3144.71
2 MAIN	7.00	35.61	48.67	862.24	2347.31	1.4500	72.75	11.04	97.18	7.90	24.21	74.56	58.48	4273.42
2 MAIN	8.00	40.70	63.57	1025.17	2577.21	1.4500	72.75	14.99	97.25	10.61	25.19	71.74	66.89	5574.88
2 MAIN	9.00	45.79	80.45	1188.79	2834.89	1.4500	72.75	19.40	97.28	13.73	25.96	69.67	75.31	7049.07
2 MAIN	10.00	50.88	99.33	1351.28	3122.31	1.4500	72.75	24.16	97.30	17.10	26.56	63.17	83.74	8696.01
2 MAIN	11.00	55.97	120.18	1511.12	3441.66	1.4500	72.75	29.17	97.30	20.65	27.00	67.12	92.19	10515.69
2 MAIN	12.00	61.05	143.03	1667.07	3795.35	1.4500	72.75	34.35	97.29	24.31	27.31	66.44	100.65	12508.11
2 MAIN	13.00	66.14	167.86	1818.08	4185.99	1.4500	72.75	39.60	97.27	28.02	27.49	66.06	109.12	14673.26
2 MAIN	14.00	71.23	194.68	1963.37	4616.40	1.4500	72.75	44.86	97.25	31.74	27.56	65.95	117.61	17011.17
2 MAIN	15.00	76.32	223.48	2102.30	5089.56	1.4500	72.75	50.06	97.22	35.41	27.55	66.05	126.11	19521.83
2 MAIN	16.00	81.40	254.27	2234.45	5608.59	1.4500	72.75	55.15	97.19	39.00	27.45	66.36	134.63	22205.21
2 MAIN	17.00	86.49	287.05	2359.53	6176.77	1.4500	72.75	60.05	97.16	42.47	27.28	66.83	143.15	25061.31
2 MAIN	18.00	91.58	321.82	2477.40	6797.51	1.4500	72.75	64.84	97.12	45.81	27.05	67.46	151.69	28090.16
2 MAIN	19.00	96.67	358.57	2598.05	7474.32	1.4500	72.75	69.38	97.08	49.00	26.77	68.24	160.25	31261.80
2 MAIN	20.00	101.76	397.30	2691.53	8210.82	1.4500	72.75	73.70	97.03	52.02	26.45	69.13	168.92	34666.17
2 MAIN	21.00	106.84	438.03	2788.03	9010.68	1.4500	72.75	77.78	96.99	54.88	26.09	70.15	177.40	38213.25
2 MAIN	22.00	111.93	480.74	2877.75	9877.70	1.4500	72.75	81.62	96.94	57.56	25.71	71.27	185.09	41933.10
2 MAIN	23.00	117.02	525.43	2960.93	10815.67	1.4500	72.75	85.22	96.89	60.07	25.30	72.43	194.60	45825.68
2 MAIN	24.00	122.11	572.12	3038.03	11828.47	1.4500	72.75	88.58	96.83	62.40	24.88	73.79	203.22	49890.99
2 MAIN	25.00	127.19	620.79	3109.22	12919.98	1.4500	72.75	91.72	96.78	64.58	24.44	75.18	211.85	54129.05
2 MAIN	26.00	132.28	671.44	3174.52	14094.15	1.4500	72.75	94.63	96.72	66.59	24.00	76.64	220.50	58539.85
2 MAIN	27.00	137.37	724.09	3235.46	15354.91	1.4500	72.75	97.34	96.66	68.45	23.55	78.18	229.16	63123.40
2 MAIN	28.00	142.68	811.51	3315.97	17377.27	1.4500	72.36	100.96	96.53	70.52	23.09	79.94	240.05	70732.75

LF = FUEL BELOW MINIMUM REQUIRED RATE

HF = FUEL ABOVE MAXIMUM FUEL RATE

HS = TURBINE SPEED EXCESSIVE

HFS = TURBINE FUEL AND SPEED EXCESSIVE

ELECTRIC DRIVE SYSTEM

REF. NO. 501-5

MISSION PROFILE SUMMARY - THREE MAIN TURBINES

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TCN)	PER THOUSAND HOURS			NO. OF TURBINES
										NAUT. MILES	TCNS FUEL	TONS PER MILE	
1	1.10	1.450	5.09	291.50	1.40	1.92	29.80	3300.	0.679	11.	16.61	1.510	3 MAIN
2	1.20	1.450	10.18	145.10	11.20	15.39	43.62	3300.	1.358	24.	18.12	0.755	3 MAIN
3	1.20	1.450	15.26	95.42	37.80	51.96	80.54	3300.	2.036	36.	18.12	0.503	3 MAIN
4	1.20	1.450	20.35	69.63	89.60	123.20	151.90	3300.	2.715	48.	18.12	0.378	3 MAIN
5	1.20	1.450	25.44	52.95	175.00	240.50	269.20	3300.	3.394	60.	18.12	0.302	3 MAIN
6	1.20	1.450	30.53	40.07	302.40	415.70	441.50	3300.	4.073	72.	18.12	0.252	3 MAIN
7	1.20	1.450	35.61	26.75	450.20	650.10	695.20	3300.	4.752	84.	18.12	0.216	3 MAIN
8	1.20	1.450	40.70	21.16	716.80	995.30	1015.00	3518.	5.054	96.	19.29	0.201	3 MAIN
9	1.20	1.450	45.79	21.92	1021.00	1403.00	1444.00	3517.	5.282	108.	20.89	0.193	3 MAIN
10	1.20	1.450	50.88	22.54	1400.00	1924.00	1981.00	4147.	5.401	120.	22.66	0.189	3 MAIN
11	6.30	1.450	55.97	23.04	1863.00	2561.00	2636.00	4511.	5.462	683.	129.20	0.186	3 MAIN
12	6.70	1.450	61.05	23.43	2419.00	3325.00	3423.00	4511.	5.473	804.	149.40	0.185	3 MAIN
13	7.00	1.450	66.14	23.72	3076.00	4228.00	4352.00	5349.	5.444	910.	169.80	0.197	3 MAIN
14	7.10	1.450	71.23	23.52	3642.00	5230.00	5437.00	5827.	5.382	994.	187.40	0.189	3 MAIN
15	6.80	1.450	76.32	24.05	4725.00	6495.00	6689.00	6348.	5.293	1020.	195.30	0.191	3 MAIN
16	6.10	1.450	81.40	24.10	5734.00	7662.00	8121.00	6515.	5.183	976.	190.70	0.195	3 MAIN
17	6.60	1.450	85.49	24.09	6878.00	9454.00	9744.00	7532.	5.056	1122.	224.50	0.200	3 MAIN
18	7.20	1.450	91.58	24.03	8165.00	11220.00	11570.00	8200.	4.917	1296.	266.40	0.206	3 MAIN
19	7.70	1.450	96.67	23.92	9603.00	13200.00	13610.00	8924.	4.769	1463.	309.80	0.212	3 MAIN
20	8.00	1.450	101.80	23.77	11200.00	15390.00	15890.00	9707.	4.615	1780.	389.30	0.219	3 MAIN
21	7.30	1.450	106.80	23.57	12970.00	17820.00	18400.00	10550.	4.458	1575.	356.40	0.226	3 MAIN
22	4.30	1.450	111.90	23.35	14910.00	20490.00	21170.00	11450.	4.299	946.	221.80	0.235	3 MAIN
23	1.50	1.450	117.00	23.10	17030.00	23410.00	24200.00	12440.	4.140	345.	83.97	0.243	3 MAIN
24	1.30	1.450	122.10	22.83	19350.00	26600.00	27510.00	13500.	3.983	312.	78.90	0.253	3 MAIN
25	0.70	1.450	127.20	22.53	21870.00	30070.00	31110.00	14630.	3.828	175.	46.03	0.263	3 MAIN
25	0.50	1.450	132.30	22.22	24610.00	33820.00	35010.00	15840.	3.676	130.	35.59	0.274	3 MAIN
27	0.40	1.450	137.40	21.91	27560.00	37860.00	39230.00	17140.	3.529	108.	30.79	0.285	3 MAIN
28	0.30	1.450	143.70	21.60	32130.00	44400.00	46050.00	19210.	3.265	140.	43.13	0.308	3 MAIN
29	0.50	1.450	150.10	21.25	37250.00	51750.00	53750.00	21530.	3.017	145.	48.31	0.333	3 MAIN
30	0.50	1.450	156.50	20.87	42950.00	60010.00	62410.00	24110.	2.787	150.	54.09	0.361	3 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.74	KNOTS	AVERAGE ELECTRICAL LOAD	7. KW
EFFECTIVE POWER	7336.	HP	PROPULSION COOLING...	3. KW
SHAFT POWER....	10090.	HP	GENERATOR LUPE SYSTEM	100. KW
TURBINE POWER...	10420.	HP	HELIUM COMPRESSORS...	
TURBINE FUEL...	7526.	LBS/HR		
PROPULSION FUEL	7614.	LBS/HR		
		(0.213 TONS/MILE)	TOTAL LOAD..	110. KW (87.6 LBS/HR)
		(0.216 TONS/MILE)		

THREE MAIN TURBINES

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH. I.A.-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FO4	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	RUSS VOLTAGE	MOTOR AMPS	
3 MAIN	1.00	5.09	0.99	91.29	2236.46	1.4500	72.75	0.04	87.16	0.02	17.94	100.00	8.31	92.27	LF
3 MAIN	2.00	10.18	3.97	182.76	2333.94	1.4500	72.75	0.27	92.34	0.13	17.96	100.00	16.64	357.27	LF
3 MAIN	3.00	15.26	8.94	274.41	2459.00	1.4500	72.75	0.85	94.93	0.59	17.98	100.00	24.98	795.02	LF
3 MAIN	4.00	20.35	15.89	366.24	2512.64	1.4500	72.75	1.87	95.93	1.31	18.00	100.00	33.34	1405.51	LF
3 MAIN	5.00	25.44	24.83	458.26	2795.92	1.4500	72.75	3.40	96.33	2.29	18.01	100.00	41.71	2168.74	LF
3 MAIN	6.00	30.53	35.76	548.72	3004.71	1.4500	72.75	5.44	96.58	3.83	19.15	89.15	50.09	3144.71	LF
3 MAIN	7.00	35.61	48.67	721.11	3249.12	1.4500	72.75	7.99	96.58	5.64	20.25	89.15	58.42	4273.42	LF
3 MAIN	8.00	40.70	63.57	861.32	3518.04	1.4500	72.75	11.00	97.37	7.77	21.16	85.38	66.39	5574.83	LF
3 MAIN	9.00	45.79	80.45	1001.69	3816.98	1.4500	72.75	14.43	97.15	10.20	21.92	82.51	75.31	7049.07	LF
3 MAIN	10.00	50.88	99.33	1140.79	4147.48	1.4500	72.75	18.22	97.15	17.87	22.54	80.32	83.74	8696.01	LF
3 MAIN	11.00	55.97	120.18	1289.35	4511.44	1.4500	72.75	22.29	97.16	15.75	23.04	78.56	92.19	10515.69	LF
3 MAIN	12.00	61.05	143.03	1430.34	4911.11	1.4500	72.75	26.53	97.16	18.79	23.43	77.43	100.65	12309.11	LF
3 MAIN	13.00	66.14	167.66	1568.80	5348.71	1.4500	72.75	31.03	97.14	21.93	23.72	76.55	109.12	14573.26	LF
3 MAIN	14.00	71.23	194.68	1703.98	5826.80	1.4500	72.75	35.53	97.12	25.15	23.92	75.93	117.61	17011.17	LF
3 MAIN	15.00	76.32	223.48	1835.24	6348.67	1.4500	72.75	40.19	97.09	28.39	24.05	75.66	126.11	19521.83	LF
3 MAIN	16.00	81.40	254.27	1962.05	6915.36	1.4500	72.75	44.79	97.08	31.63	24.10	75.56	134.63	22205.21	LF
3 MAIN	17.00	86.49	287.05	2084.01	7531.70	1.4500	72.75	49.34	97.03	34.83	24.09	75.56	143.15	25001.31	LF
3 MAIN	18.00	91.58	321.82	2203.82	8200.23	1.4500	72.75	53.82	96.93	37.98	24.03	75.93	151.69	28090.15	LF
3 MAIN	19.00	96.67	358.57	2312.28	8924.23	1.4500	72.75	58.19	96.95	41.04	23.92	76.36	160.25	31281.82	LF
3 MAIN	20.00	101.76	397.30	2418.26	9707.07	1.4500	72.75	62.42	96.91	44.01	23.77	76.93	168.82	34666.17	LF
3 MAIN	21.00	106.84	433.03	2518.70	10552.27	1.4500	72.75	66.50	96.86	46.86	23.57	77.64	177.40	38213.25	LF
3 MAIN	22.00	111.93	469.74	2613.81	11493.42	1.4500	72.75	70.42	96.81	49.60	23.35	78.46	185.99	41933.10	LF
3 MAIN	23.00	117.02	505.43	2703.09	12444.13	1.4500	72.75	74.15	96.76	52.21	23.10	79.39	194.60	45925.68	LF
3 MAIN	24.00	122.11	542.12	2787.22	13458.28	1.4500	72.75	77.72	96.71	54.68	22.83	80.41	203.22	49890.99	LF
3 MAIN	25.00	127.19	579.79	2866.18	14529.54	1.4500	72.75	81.10	96.66	57.03	22.53	81.54	211.85	54129.05	LF
3 MAIN	26.00	132.28	617.44	2940.13	15841.82	1.4500	72.75	84.29	96.53	59.24	22.23	82.75	220.50	58533.83	LF
3 MAIN	27.00	137.37	654.09	3009.28	17138.99	1.4500	72.75	87.30	96.42	61.32	21.91	84.04	229.16	63113.40	LF
3 MAIN	28.00	143.68	691.51	3102.80	18211.71	1.4500	72.75	91.42	96.32	63.79	21.60	85.41	240.05	67732.75	LF
3 MAIN	29.00	150.06	728.64	3188.44	19211.71	1.4500	71.97	95.22	95.29	65.99	21.25	86.97	251.10	72929.25	LF
3 MAIN	30.00	156.51	765.86	3260.55	21528.77	1.4500	71.58	93.72	95.15	67.54	20.87	88.72	262.31	78734.25	LF
3 MAIN	31.00	163.03	803.11	3337.52	24113.38	1.4500	71.19	101.92	96.00	69.65	20.47	90.63	273.68	84169.25	HF

LF = FUEL BELOW MINIMUM REQUIRED RATE
 HF = FUEL ABOVE MAXIMUM FUEL RATE
 HS = TURBINE SPEED EXCESSIVE
 HFS = TURBINE FUEL AND SPEED EXCESSIVE

THREE MAIN TURBINES

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRO (TH. LB.-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FCM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS
3 MAIN	1.00	5.09	0.99	1483.25	3300.00	1.4500	72.75	0.34	6.46	0.02	291.53	6.15	8.31	92.27
3 MAIN	2.00	10.18	3.97	1476.00	3300.00	1.4500	72.75	0.50	35.29	0.13	145.05	12.38	16.44	357.27
3 MAIN	3.00	15.26	8.94	1456.46	3300.00	1.4500	72.75	0.93	64.51	0.44	95.42	18.84	24.93	793.02
3 MAIN	4.00	20.35	15.89	1417.07	3300.00	1.4500	72.75	1.76	81.07	1.04	65.53	25.85	33.34	1405.51
3 MAIN	5.00	25.44	24.83	1346.87	3300.00	1.4500	72.75	3.11	99.37	2.02	52.95	34.02	41.71	2183.74
3 MAIN	6.00	30.53	35.75	1223.33	3300.00	1.4500	72.75	5.13	93.72	3.50	40.07	45.00	50.09	3144.71
3 MAIN	7.00	35.61	48.67	952.73	3300.00	1.4500	72.75	7.92	96.32	5.55	26.75	67.47	58.48	4273.42
3 MAIN	8.00	40.70	63.57	861.32	3516.08	1.4500	72.75	11.00	97.07	7.77	21.16	85.23	66.89	5574.83
3 MAIN	9.00	45.79	80.45	1003.69	3816.98	1.4500	72.75	14.43	97.13	10.20	21.92	82.51	75.31	7049.07
3 MAIN	10.00	50.88	99.33	1146.79	4147.46	1.4500	72.75	18.22	97.19	12.87	22.54	80.32	83.74	8666.01
3 MAIN	11.00	55.97	120.18	1289.36	4511.48	1.4500	72.75	22.29	97.16	15.75	23.04	78.66	92.19	10515.69
3 MAIN	12.00	61.05	143.03	1430.34	4911.11	1.4500	72.75	26.58	97.16	18.79	23.43	77.43	100.65	12558.11
3 MAIN	13.00	66.14	167.86	1588.80	5348.71	1.4500	72.75	31.03	97.14	21.93	23.72	76.55	109.12	14673.26
3 MAIN	14.00	71.23	194.68	1703.98	5826.80	1.4500	72.75	35.59	97.12	25.15	23.92	75.98	117.61	17011.17
3 MAIN	15.00	76.32	223.48	1835.24	6348.07	1.4500	72.75	40.19	97.09	28.39	24.05	75.65	126.11	19521.83
3 MAIN	16.00	81.40	254.27	1962.05	6915.36	1.4500	72.75	44.79	97.09	31.63	24.10	75.56	134.63	22205.21
3 MAIN	17.00	86.49	287.05	2084.01	7531.70	1.4500	72.75	49.34	97.03	34.83	24.09	75.66	142.15	25061.31
3 MAIN	18.00	91.58	321.82	2200.82	8200.23	1.4500	72.75	53.02	96.99	37.98	24.03	75.93	151.69	28390.16
3 MAIN	19.00	96.67	358.57	2312.28	8924.23	1.4500	72.75	58.19	96.95	41.04	23.92	76.35	160.25	31291.80
3 MAIN	20.00	101.76	397.30	2418.26	9707.07	1.4500	72.75	62.42	96.91	44.01	23.77	76.92	169.82	34868.17
3 MAIN	21.00	106.84	438.03	2518.70	10552.27	1.4500	72.75	66.50	96.89	46.86	23.57	77.04	177.40	38213.25
3 MAIN	22.00	111.93	480.74	2613.61	11463.42	1.4500	72.75	70.42	96.81	49.60	23.35	78.46	185.59	41593.10
3 MAIN	23.00	117.02	525.43	2703.09	12444.16	1.4500	72.75	74.16	96.76	52.21	23.10	79.35	194.60	45825.68
3 MAIN	24.00	122.11	572.12	2787.22	13498.28	1.4500	72.75	77.72	96.71	54.68	22.83	80.41	203.22	49890.99
3 MAIN	25.00	127.19	620.79	2866.18	14629.54	1.4500	72.75	81.10	96.66	57.03	22.53	81.54	211.85	54129.05
3 MAIN	26.00	132.28	671.44	2940.13	15841.82	1.4500	72.75	84.29	96.60	59.24	22.23	82.75	220.50	58539.95
3 MAIN	27.00	137.37	724.09	3009.28	17138.99	1.4500	72.75	87.30	96.55	61.32	21.91	84.04	229.16	63123.40
3 MAIN	28.00	143.68	811.51	3102.80	19211.71	1.4500	72.36	91.42	96.42	63.79	21.60	85.41	240.05	70732.75
3 MAIN	29.00	150.06	905.68	3188.44	21528.77	1.4500	71.97	95.22	96.25	65.99	21.25	86.97	251.10	78929.25
3 MAIN	30.00	155.51	1006.86	3266.55	24113.38	1.4500	71.58	98.72	96.15	67.94	20.87	88.72	262.31	87734.25
3 MAIN	31.00	163.03	1115.27	3337.52	26990.12	1.4500	71.19	101.92	96.00	69.65	20.47	90.63	273.68	97169.25

LF = FUEL BELOW MINIMUM REQUIRED RATE
 HF = FUEL ABOVE MAXIMUM FUEL RATE
 HS = TURBINE SPEED EXCESSIVE
 HFS = TURBINE FUEL AND SPEED EXCESSIVE

ELECTRIC DRIVE SYSTEM

REF. NO. 501-6

MISSION PROFILE SUMMARY - FOUR MAIN TURBINES

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS			NO. OF TURBINES
										NAUT. MILES	TONS FUEL	TONS PER MILE	
1	1.10	1.450	5.09	291.60	1.40	1.92	39.06	4400.	0.509	11.	22.02	2.002	4 MAIN
2	1.20	1.450	10.18	145.30	11.20	15.39	52.97	4400.	1.018	24.	24.02	1.001	4 MAIN
3	1.20	1.450	15.26	95.88	37.80	51.96	90.01	4400.	1.527	36.	24.02	3.667	4 MAIN
4	1.20	1.450	20.35	70.43	89.60	123.20	161.60	4400.	2.036	48.	24.02	5.500	4 MAIN
5	1.20	1.450	25.44	54.39	175.00	240.50	279.00	4400.	2.545	60.	24.02	8.400	4 MAIN
6	1.20	1.450	30.53	42.58	302.40	415.70	453.70	4400.	3.055	72.	24.02	10.334	4 MAIN
7	1.20	1.450	35.61	32.44	480.20	660.10	656.70	4400.	3.564	84.	24.02	12.256	4 MAIN
8	1.20	1.450	40.70	18.65	715.80	985.30	1016.00	4425.	4.050	96.	24.15	14.252	4 MAIN
9	1.20	1.450	45.79	19.37	1021.00	1403.00	1445.00	4759.	4.236	108.	25.94	16.240	4 MAIN
10	1.20	1.450	50.88	19.58	1400.00	1924.00	1982.00	5176.	4.370	120.	27.91	18.233	4 MAIN
11	6.30	1.450	55.97	20.49	1863.00	2561.00	2637.00	5328.	4.458	132.	157.80	20.228	4 MAIN
12	5.70	1.450	61.05	20.90	2419.00	3225.00	3423.00	5966.	4.505	144.	181.00	22.225	4 MAIN
13	7.00	1.450	66.14	21.24	3076.00	4228.00	4352.00	6444.	4.519	156.	204.30	24.224	4 MAIN
14	7.10	1.450	71.23	21.45	3842.00	5280.00	5437.00	6963.	4.504	168.	223.40	26.225	4 MAIN
15	6.80	1.450	76.32	21.68	4725.00	6495.00	6689.00	7526.	4.464	180.	231.10	28.227	4 MAIN
16	6.10	1.450	81.40	21.81	5734.00	7892.00	8118.00	8135.	4.405	192.	223.90	30.229	4 MAIN
17	6.60	1.450	86.49	21.89	6878.00	9454.00	9740.00	8794.	4.330	204.	261.70	32.233	4 MAIN
18	7.20	1.450	91.58	21.91	8165.00	11220.00	11570.00	9504.	4.242	216.	308.30	34.238	4 MAIN
19	7.70	1.450	96.67	21.89	9603.00	13200.00	13610.00	10270.	4.144	228.	356.10	36.243	4 MAIN
20	8.90	1.450	101.80	21.83	11200.00	15390.00	15980.00	11090.	4.038	240.	444.40	38.250	4 MAIN
21	7.50	1.450	106.80	21.73	12970.00	17820.00	18380.00	11580.	3.927	252.	464.20	40.257	4 MAIN
22	4.30	1.450	111.90	21.60	14910.00	20490.00	21150.00	12930.	3.811	264.	250.00	42.264	4 MAIN
23	1.50	1.450	117.00	21.44	17030.00	23410.00	24170.00	13950.	3.693	276.	94.05	44.273	4 MAIN
24	1.30	1.450	122.10	21.26	19350.00	26600.00	27480.00	15040.	3.574	288.	87.86	46.282	4 MAIN
25	0.70	1.450	127.20	21.08	21870.00	30070.00	31070.00	16210.	3.455	300.	50.96	48.291	4 MAIN
26	0.50	1.450	122.30	20.84	24510.00	33820.00	34970.00	17460.	3.336	312.	39.19	50.301	4 MAIN
27	0.40	1.450	137.40	20.60	27560.00	37880.00	39180.00	18790.	3.219	324.	23.73	52.312	4 MAIN
28	0.30	1.450	143.70	20.40	32130.00	44400.00	45970.00	20500.	3.001	336.	23.14	54.335	4 MAIN
29	0.30	1.450	150.10	20.16	37250.00	51750.00	53650.00	23260.	2.753	348.	31.31	56.360	4 MAIN
30	0.30	1.450	156.50	19.88	42550.00	60010.00	62280.00	25380.	2.556	360.	34.83	58.387	4 MAIN
31	0.30	1.450	163.00	19.57	49290.00	69240.00	71560.00	28790.	2.412	372.	38.73	60.416	4 MAIN
32	0.30	1.450	169.60	19.24	56300.00	79520.00	82760.00	32020.	2.235	384.	43.06	62.449	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER.....	7429.	HP
SHAFT POWER.....	10230.	HP
TURBINE POWER.....	10550.	HP
TURBINE FUEL.....	8809.	LBS/HR
PROPELLSION FUEL.....	8997.	LBS/HR

AVERAGE ELECTRICAL LOAD	7. KW
PROPELLSION COOLING....	4. KW
GENERATOR LUBE SYSTEM	100. KW
HELIUM COMPRESSORS....	100. KW

TOTAL LOAD.. 111. KW (88.4 LBS/HR)

FOUR MAIN TURBINES

REF. NO. 501-6

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FO4	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS
4 MAIN	1.00	5.09	0.99	91.28	2977.57	1.4500	72.75	0.03	85.25	0.02	17.94	100.00	8.31	92.27 LF
4 MAIN	2.00	10.18	3.97	182.72	3094.79	1.4500	72.75	0.21	91.33	0.14	17.96	100.00	16.64	357.27 LF
4 MAIN	3.00	15.26	8.94	274.33	3240.08	1.4500	72.75	0.55	94.20	0.44	17.97	100.00	24.98	795.02 LF
4 MAIN	4.00	20.35	15.89	366.10	3414.48	1.4500	72.75	1.44	95.39	1.00	17.99	100.00	33.34	1405.51 LF
4 MAIN	5.00	25.44	24.33	458.04	3519.05	1.4500	72.75	2.64	96.09	1.84	18.01	100.00	41.71	2188.74 LF
4 MAIN	6.00	30.53	35.76	550.14	3844.92	1.4500	72.75	4.26	96.53	2.99	18.02	100.00	50.00	3143.71 LF
4 MAIN	7.00	35.61	48.67	642.41	4123.28	1.4500	72.75	5.31	96.32	4.44	18.04	100.00	58.49	4273.42 LF
4 MAIN	8.00	40.70	63.57	739.05	4424.97	1.4500	72.75	8.75	96.97	6.13	18.05	96.81	66.89	5574.88 LF
4 MAIN	9.00	45.79	80.45	847.03	4758.72	1.4500	72.75	11.59	97.05	8.18	19.37	93.26	75.31	7049.07 LF
4 MAIN	10.00	50.88	99.33	1016.58	5125.73	1.4500	72.75	14.75	97.10	10.42	19.38	90.52	83.74	8596.01 LF
4 MAIN	11.00	55.97	120.18	1143.61	5527.58	1.4500	72.75	18.20	97.13	12.86	20.49	88.26	92.19	10515.69 LF
4 MAIN	12.00	61.05	143.03	1278.22	5968.48	1.4500	72.75	21.83	97.14	14.46	20.60	86.98	100.55	12508.11 LF
4 MAIN	13.00	66.14	167.86	1404.58	6444.25	1.4500	72.75	25.76	97.14	18.20	21.24	85.70	109.12	14573.26 LF
4 MAIN	14.00	71.23	194.68	1530.99	6963.32	1.4500	72.75	29.73	97.13	21.04	21.68	84.45	117.61	17011.17 LF
4 MAIN	15.00	76.32	223.48	1654.86	7526.13	1.4500	72.75	33.89	97.11	23.94	21.68	83.76	126.11	19521.83 LF
4 MAIN	16.00	81.40	254.27	1775.68	8135.34	1.4500	72.75	38.06	97.09	26.88	21.81	83.36	134.63	22205.21 LF
4 MAIN	17.00	86.49	287.05	1892.98	8793.72	1.4500	72.75	42.24	97.07	29.83	21.89	83.16	143.15	25061.31 LF
4 MAIN	18.00	91.58	321.82	2008.46	9504.23	1.4500	72.75	46.41	97.04	32.76	21.91	83.14	151.69	28090.16 LF
4 MAIN	19.00	96.67	358.57	2115.84	10259.91	1.4500	72.75	50.53	97.01	35.66	21.89	83.30	160.25	31291.80 LF
4 MAIN	20.00	101.76	397.30	2220.92	11093.96	1.4500	72.75	54.58	96.97	38.50	21.83	83.51	168.82	34688.17 LF
4 MAIN	21.00	106.84	438.03	2321.54	11979.65	1.4500	72.75	58.53	96.94	41.28	21.73	84.05	177.40	38213.25 LF
4 MAIN	22.00	111.93	480.74	2417.63	12930.45	1.4500	72.75	62.37	96.90	43.97	21.60	84.64	185.99	41933.10 LF
4 MAIN	23.00	117.02	525.43	2506.16	13949.79	1.4500	72.75	66.09	96.85	46.57	21.44	85.33	194.60	45825.68 LF
4 MAIN	24.00	122.11	572.12	2598.12	15041.30	1.4500	72.75	69.67	96.82	49.07	21.26	86.14	203.22	49890.99 LF
4 MAIN	25.00	127.19	620.76	2678.57	16208.59	1.4500	72.75	73.11	96.73	51.47	21.05	87.04	211.85	54139.05 LF
4 MAIN	26.00	132.28	671.44	2759.59	17455.42	1.4500	72.75	76.40	96.73	53.76	20.84	88.04	220.30	58530.85 LF
4 MAIN	27.00	137.37	724.09	2830.27	18785.59	1.4500	72.75	79.54	96.69	55.95	20.60	89.12	229.16	63123.40 LF
4 MAIN	28.00	142.46	779.51	2931.08	20903.02	1.4500	72.75	83.83	96.56	58.62	20.40	90.17	240.05	67732.75 LF
4 MAIN	29.00	150.06	835.68	3024.71	23261.31	1.4500	71.97	87.96	96.47	61.07	20.16	91.42	251.10	73929.25 LF
4 MAIN	30.00	158.51	1006.86	3111.26	25883.15	1.4500	71.58	91.78	96.35	63.30	19.88	92.80	262.31	87734.25 LF
4 MAIN	31.00	163.03	1115.27	3190.95	28792.72	1.4500	71.19	95.32	95.22	65.29	19.57	94.48	273.68	97189.25 LF
4 MAIN	32.00	169.62	1231.19	3264.05	32015.66	1.4500	70.80	98.59	95.09	67.07	19.24	96.28	285.21	107256.44 LF
4 MAIN	33.00	176.27	1354.85	3330.89	35578.89	1.4500	70.41	101.61	95.95	68.64	18.90	98.24	295.90	118017.31 HF

LF = FUEL BELOW MINIMUM REQUIRED RATE

HF = FUEL ABOVE MAXIMUM FUEL RATE

HS = TURBINE SPEED EXCESSIVE

HFS = TURBINE FUEL AND SPEED EXCESSIVE

C-52

FOUR MAIN TURBINES

REF.NO. 501- 6

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FCM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS
4 MAIN	1.00	5.09	0.99	1433.51	4400.00	1.4500	72.75	0.34	4.93	0.01	291.58	6.15	8.31	92.27
4 MAIN	2.00	10.18	3.97	1478.04	4400.00	1.4500	72.75	0.46	29.07	0.10	145.25	12.36	16.64	357.27
4 MAIN	3.00	15.26	8.94	1463.48	4400.00	1.4500	72.75	0.78	57.72	0.33	95.88	18.74	24.98	795.02
4 MAIN	4.00	20.35	15.89	1434.32	4400.00	1.4500	72.75	1.40	76.23	0.78	70.48	25.32	33.34	1405.51
4 MAIN	5.00	25.44	24.83	1383.69	4400.00	1.4500	72.75	2.42	86.21	1.52	54.39	33.10	41.71	2188.74
4 MAIN	6.00	30.53	35.76	1299.77	4400.00	1.4500	72.75	3.93	91.61	2.62	42.58	42.23	50.09	3144.71
4 MAIN	7.00	35.61	48.67	1155.21	4400.00	1.4500	72.75	6.04	94.73	4.16	32.44	55.61	58.43	4273.42
4 MAIN	8.00	40.70	63.57	759.05	4424.97	1.4500	72.75	8.76	96.97	6.18	10.65	56.81	66.69	5574.88
4 MAIN	9.00	45.79	80.45	887.03	4758.72	1.4500	72.75	11.59	97.05	8.18	19.37	93.28	75.31	7049.07
4 MAIN	10.00	50.88	99.33	1015.56	5125.73	1.4500	72.75	14.75	97.10	10.42	15.98	55.52	82.74	8686.01
4 MAIN	11.00	55.97	120.18	1146.61	5527.68	1.4500	72.75	18.20	97.13	12.86	20.49	89.36	92.19	10315.69
4 MAIN	12.00	61.05	143.03	1276.22	5966.48	1.4500	72.75	21.88	97.14	15.46	20.90	86.68	100.65	12508.11
4 MAIN	13.00	66.14	167.86	1404.58	6444.26	1.4500	72.75	25.76	97.14	18.20	21.24	85.40	109.12	14673.29
4 MAIN	14.00	71.23	194.68	1530.99	6963.32	1.4500	72.75	29.78	97.13	21.04	21.49	84.45	117.61	17011.17
4 MAIN	15.00	76.32	223.49	1654.36	7526.13	1.4500	72.75	33.99	97.11	23.94	21.68	83.78	126.11	19521.83
4 MAIN	16.00	81.40	254.27	1775.66	8135.34	1.4500	72.75	38.06	97.09	26.88	21.51	83.36	134.63	22205.21
4 MAIN	17.00	86.49	287.05	1892.98	8793.72	1.4500	72.75	42.24	97.07	29.83	21.89	83.16	143.15	25061.31
4 MAIN	18.00	91.58	321.82	2036.46	9504.23	1.4500	72.75	46.41	97.04	32.76	21.91	83.14	151.69	28000.16
4 MAIN	19.00	96.67	358.57	2115.84	10269.91	1.4500	72.75	50.53	97.01	35.66	21.89	83.30	160.25	31251.80
4 MAIN	20.00	101.76	397.30	2220.52	11093.96	1.4500	72.75	54.58	96.97	38.50	21.83	83.61	168.92	34666.17
4 MAIN	21.00	106.84	438.03	2321.54	11979.66	1.4500	72.75	58.53	96.94	41.28	21.73	84.05	177.40	38213.25
4 MAIN	22.00	111.93	480.74	2417.63	12930.45	1.4500	72.75	62.37	96.90	43.97	21.60	84.64	185.99	41933.10
4 MAIN	23.00	117.02	525.43	2509.16	13949.79	1.4500	72.75	66.09	96.86	46.57	21.44	85.33	194.60	45825.68
4 MAIN	24.00	122.11	572.12	2596.12	15041.30	1.4500	72.75	69.67	96.82	49.07	21.26	86.14	203.22	49890.99
4 MAIN	25.00	127.19	620.79	2679.57	16208.59	1.4500	72.75	73.11	96.78	51.47	21.06	87.04	211.85	54129.05
4 MAIN	26.00	132.28	671.44	2756.59	17455.42	1.4500	72.75	76.40	96.73	53.76	20.84	88.04	220.50	58539.85
4 MAIN	27.00	137.37	724.09	2830.27	18785.59	1.4500	72.75	79.54	96.69	55.95	20.60	89.12	229.16	63123.40
4 MAIN	28.00	142.68	777.51	2931.08	20903.02	1.4500	72.36	83.88	96.58	58.62	20.40	90.17	240.05	67732.73
4 MAIN	29.00	150.06	905.68	3024.71	23261.31	1.4500	71.97	87.96	96.47	61.07	20.16	91.42	251.10	73929.25
4 MAIN	30.00	156.51	1005.86	3111.26	25883.16	1.4500	71.58	91.78	96.35	63.30	19.88	92.66	262.31	80734.25
4 MAIN	31.00	163.03	1115.27	3190.95	28792.72	1.4500	71.19	95.32	96.22	65.29	19.57	94.48	273.68	87169.25
4 MAIN	32.00	169.62	1231.19	3264.05	32015.66	1.4500	70.80	98.59	96.09	67.07	19.24	96.23	285.21	94256.44
4 MAIN	33.00	176.27	1354.35	3330.29	35578.89	1.4500	70.41	101.61	95.95	68.64	18.90	96.24	296.90	118017.31

LF = FUEL BELOW MINIMUM REQUIRED RATE

HF = FUEL ABOVE MAXIMUM FUEL RATE

HS = TURBINE SPEED EXCESSIVE

HFS = TURBINE FUEL AND SPEED EXCESSIVE

APPENDIX D

DESCRIPTION OF ENGINE ROOM

MODIFICATIONS

Description of Engine Room Modifications
for Installation of High Efficiency
Propulsion Systems in Destroyer Type Hulls

Prepared for
Bradford Computer & Systems, Inc.
1700 Broadway
New York, New York 10019

Under Contract
N0014-74-C-0398

by
M. Rosenblatt & Sons, Inc.
350 Broadway
New York, New York 10013

BSDD-2870-05

CONTENTS

1. Introduction
2. General
3. Modifications
 - 3.1 Addition of Cruise Turbines
 - 3.2 Addition of Crossover Alternators
 - 3.3 Substitution of Superconducting Electric Propulsion, Existing Engine Room Configuration
 - 3.4 Substitution of Superconducting Electric Propulsion, Reconfigured Engine Room
4. Estimate of Weight Changes

LIST OF ILLUSTRATIONS

- 2.1 Fluid Systems Schematic Diagram
- 3.1 500 HP Cruise Turbine Module
- 3.2 Location of Cruise Turbine Modules
- 3.3 Location of Propulsion Motors

LIST OF TABLES

- 3.1 Summary of Characteristics for a 10,000 HP Superconducting Alternator
- 4.1 Summary of Weight Changes, Addition of Cruise Turbine
- 4.2 Summary of Weight Changes, Addition of Crossover Alternator
- 4.3 Summary of Weight Changes, Superconducting Electric Propulsion, Present Configuration
- 4.4 Summary of Weight Changes, Superconducting Electric Propulsion Reconfigured Engine Room

LIST OF DRAWINGS

The following drawings, which are under separate cover, supplement this report.

<u>MR&S DWG. NO.</u>	<u>TITLE</u>
2870-01	Addition of 5000 HP Cruise Gas Turbine for DD's
2870-02	Addition of Crossover Alternator for DD's
2870-03	Superconducting Electric Propulsion for DD's, Existing Configuration
2870-04	Superconducting Electric Propulsion for DD's, Reconfigured Engine Room

1. Introduction

At the request of Bradford Computer and Systems, Inc. (15 July 1974, C-2870) M. Rosenblatt & Son, Inc. was to conduct a study, at a feasibility level, of modifying the propulsion system of a modern type destroyer in order to obtain a higher fuel efficiency during cruising and low speed operations.

Baseline information as to the system configuration for each modification was based on information furnished by Bradford. In those instances where information was not directly applicable to the propulsion systems under study, new definitions of equipment configuration were engineered or estimated. This work involved ascertaining equipment characteristics of possible candidate systems and investigating the feasibility of integrating each system into the configuration of a modern type destroyer.

In order to demonstrate the feasibility of adding new equipment to typical modern destroyer type ships, in conjunction with the study of the comparative performance of high efficiency ship propulsion systems, four arrangement drawings have been prepared. Each drawing shows the modifications to both forward and after engine rooms to accommodate the required equipment for each proposed propulsion system. The propulsion configuration of an existing destroyer type (DD263) was used as a baseline for the equipment arrangements in order to provide a real life basis for the study. The baseline propulsion system consists of four LM-2500 gas turbines (80,000 HP total), mechanically geared to two independent shafts (40,000 HP each) and is considered representative of modern destroyer type ships. The four possible modifications to this baseline system are summarized as follows:

- 1.1 Drawing No. 2870-01 shows the addition of two 5000 HP gas turbines, one to each engine room, to provide the capability for reduced power

cruising. Each new gas turbine is mechanically coupled to the existing main propulsion gear.

- 1.2 Drawing No.2870-02 shows the addition of a 10,000 HP alternator and its associated equipment to each engine room, to permit a single propulsion turbine to drive both shafts via an electrical crossover between port and starboard propulsion systems. During crossover operation, one alternator will be driven as a synchronous motor by the other alternator.
- 1.3 Drawing No.2870-03 shows the substitution of superconducting electric propulsion equipment for the existing mechanical reduction gearing, while retaining the existing machinery arrangement. This modification provides the main propulsion system with the capability of accepting connections to external 5000 HP cruise turbines and an electrical crossover connection, both of which provide for cruising at reduced power levels.
- 1.4 Drawing No.2870-04 shows the substitution of superconducting electric propulsion equipment for mechanical reduction gearing, as above, except that the existing machinery configuration has been optimized by elevating the propulsion gas turbines to reduce intake and exhaust ducting and by locating the propulsion motors aft to reduce shaft length.

2. General

All four engine room arrangement drawings show equipment currently under development. The arrangements shown are based on preliminary information and are, of course, subject to change as a result of future design developments and as additional information is made available. Engineering

judgement was often required in allowing for service access and interface requirements.

Of the four engine room arrangements outlined in the introduction, those showing the addition of high performance alternators and superconducting machinery have been based on data previously developed through prior propulsion studies primarily for a SWATH type ship, and additional information furnished by Bradford Computer and Systems, Inc.

Although there is a convenient similarity between the SWATH propulsion plant and that of the destroyer chosen as typical of modern destroyer types, (twin screw, 80,000 sub total), some modification of the SWATH propulsion plant was necessary for installation in the destroyer type hull. The SWATH was provided with a large single engine room containing both port and starboard propulsion plants. Many of the services for the superconducting machinery on both plants (i.e. helium, coolanol, etc.) had a common source.

Destroyers, on the other hand, are usually provided with two separate engine rooms, each intended to be as independent as is practical from the other. Thus, in the destroyer arrangement drawings, several of the SWATH systems have been modified to provide independent superconducting machinery support systems, such as helium and coolanol systems for each engine room, as shown in Figure 2-1. In addition, motor and generator bearing lube oil requirements have been provided from the existing main lube oil system, in lieu of providing each new machine with its own individual lube oil system, as was shown for the SWATH study.

Subject FLUID SYSTEMS, EACH ENGINE ROOM

Ship or Project STUDY OF HIGH EFFICIENCY PROPULSION SYSTEMS FOR DD'S

Section B-1000 Prepared by J. Rosenblatt Date 10/74 Checked Reviewed

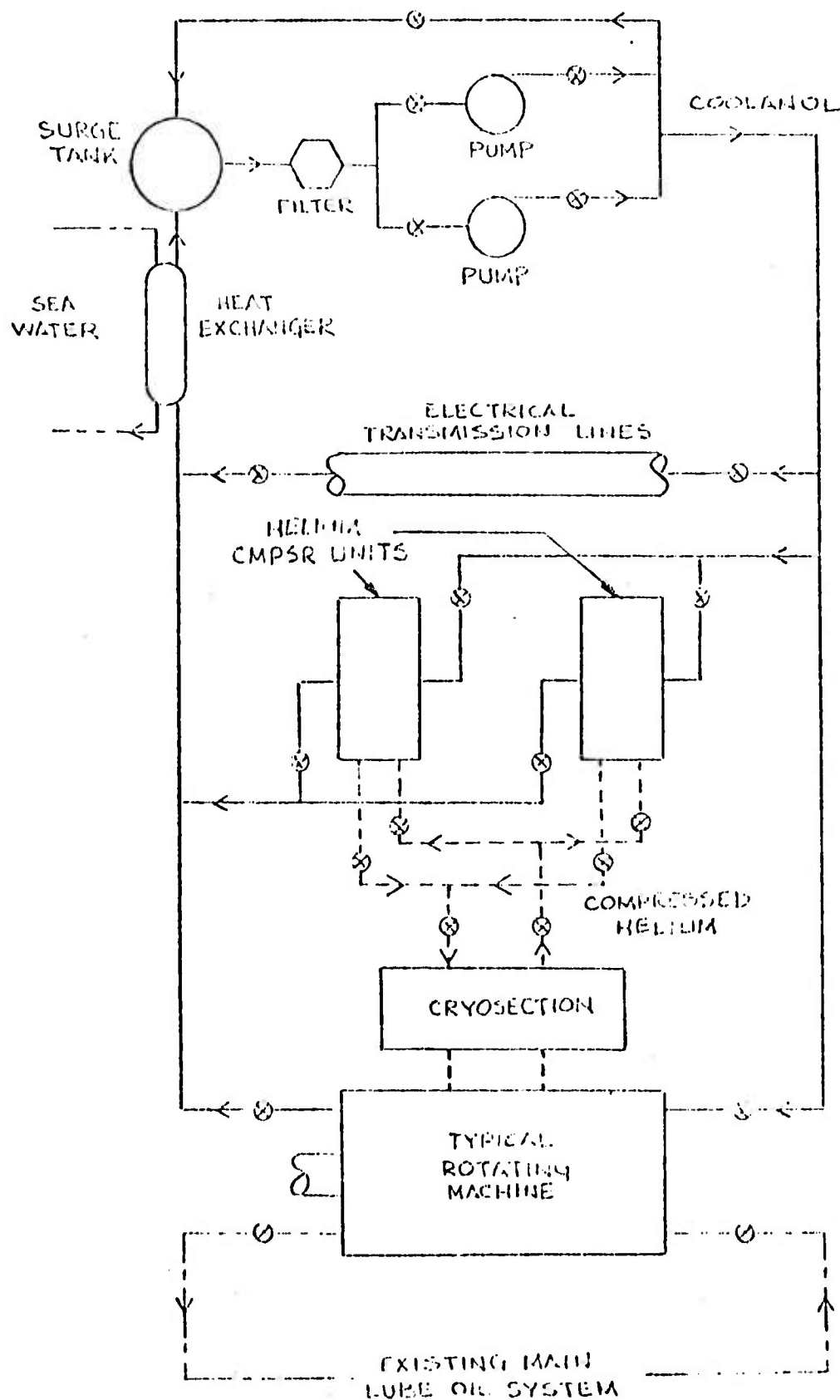


FIGURE 2-1 FLUID SYSTEMS SCHEMATIC
DIAGRAM (EACH ENGINE ROOM)

3. Modifications

3.1 Addition of Cruise Turbines (Drawing No. 2870-01)

The cruise turbine size shown was based on available information for modern marine gas turbines of approximately 5000 HP. The space shown will accommodate the Garrett GTPF990 engine, currently under development for the U.S. Navy. The cruise turbine output is mechanically coupled through angle gearing to the existing main reduction gear which must be modified to accept the cruise turbine input shaft.

Other modifications necessary to accept the cruise turbine, its gearing and its ductwork are as follows:

- a. The shaft turning gear was relocated to the opposite side of the reduction gear.
- b. The main lube oil cooler was relocated to the 7'-6" level, alongside the main reduction gear.
- c. Vertical ladders between the 24'-0" level and the 15'-0" level were relocated. In the forward engine room, this relocation placed the new vertical ladder close to the auxiliary boiler which normally would present a hazard to personnel. However, upgrading the boiler insulation in accordance with the recommendations of current Navy studies should eliminate any hazards due to heat from the boiler.
- d. The machinery platform at the 15'-0" level was extended to provide a turbine and gear service aisle.
- e. The auxiliary boiler exhaust duct was modified by the addition of a transition piece (from a circular to a

rectangular duct cross-section) to permit the new cruise turbine exhaust duct to be run under the existing boiler exhaust duct. In the aft engine room, the existing ship service generator intake duct was also re-routed to clear the new cruise turbine angle gearing.

- f. Several power panels, lighting panels, starting air flasks (forward engine room), and fire-fighting cylinders and hose reels were relocated to suit the new arrangements and ductwork.

3.2 Addition of Crossover Alternators (Drawing No. 2870-02)

The alternator size shown, and the service requirements for this alternator were estimated from existing machine data and from data on other alternator sizes supplied by Bradford Computer and Systems, Inc. The data used in preparing this arrangement is summarized in Table 3-1. Transmission line cooling was not considered necessary as it was assumed that the alternator would be arranged to operate at a higher voltage rating than the acyclic machines used in the SWATH study and that output currents could be transmitted via normally installed Navy 5KVTSQA cable.

The alternator is mounted alongside the existing reduction gear and mechanically coupled via a new transfer gear and a modification to the existing reduction gear. Few other modifications to the existing engine room arrangement are required to accommodate the new equipment. These modifications consist mainly of relocating a few minor items (air starting flasks, fire fighting hose reels and cylinders, etc.) and modifying existing gratings as shown on the drawing.

Subject 10,000 HP CROSSOVER ALTERNATOR

Ship or Project STUDY OF HIGH EFFICIENCY PROPULSION SYSTEMS FOR DD'S

Section BSDS

Prepared by

H. Sprague

Date

10/74

Checked

Reviewed

TABLE 3-1 SUMMARY OF CHARACTERISTICS
FOR 10,000 HP ALTERNATOR

1. ALTERNATOR SIZE AND WEIGHT: (APPROX.)

O. D.	3.0 FT
LENGTH	6.0 FT
VOLUME	40. CU FT
WEIGHT	11,000 LBS
SPEED, AT FULL POWER	5,000 RPM

2. ESTIMATED LOSSES TO COOLANT: 149 KW

WITH COOLANT - SEA WATER TEMPERATURES AND
PRESSURES AS SHOWN IN "SWATH" STUDY:

COOLANT FLOW = 63 GPM

SEA WATER FLOW = 66 GPM

COOLANT PUMP LOAD = 2 HP

HEAT EXCHANGER SIZE (APPROX) =

9" DIA X 100" LENGTH, 350 LBS.

3.3 Substitution of Superconducting Electric Propulsion, Existing Engine Room Configuration (Drawing No: 2870-03)

In this configuration a superconducting electric propulsion system similar to that planned for the SWATH is substituted for the existing main reduction gear in each engine room. One 20,000 HP propulsion generator is direct coupled to each propulsion gas turbine and one 40,000 HP propulsion motor is direct coupled to each propulsion shaft.

The controllable pitch propeller (CRP) is locked into a fixed position and the CRP hydraulic system is removed. Alternately, the CRP could be replaced by a fixed pitch propeller, however the change in efficiency is considered to be small. The difference in weight between the CRP and a fixed pitch propeller was not estimated.

The existing reduction gear lube oil system is retained to provide bearing lube oil to the new equipment. The existing gear driven lube oil pump is replaced by an additional motor driven lube oil pump. The existing main lube oil cooler is retained and relocated to the 7'-6" level to provide space for the new coolanol system. The existing thrust bearing is replaced by a new pedestal type thrust bearing at the after bulkhead in each engine room.

The new helium and coolanol systems are installed mostly on the 15'-0" level which has been extended into the space formerly occupied by the main reduction gear. A new uninterrupted power supply (UPS) power panel and automatic bus transfer switch (ABT) are also installed on the 15'-0" level. Generator disconnect and

crossover switches are located at the 24'-0" level except for the forward engine room, where the crossover switch is located at the 15'-0" level.

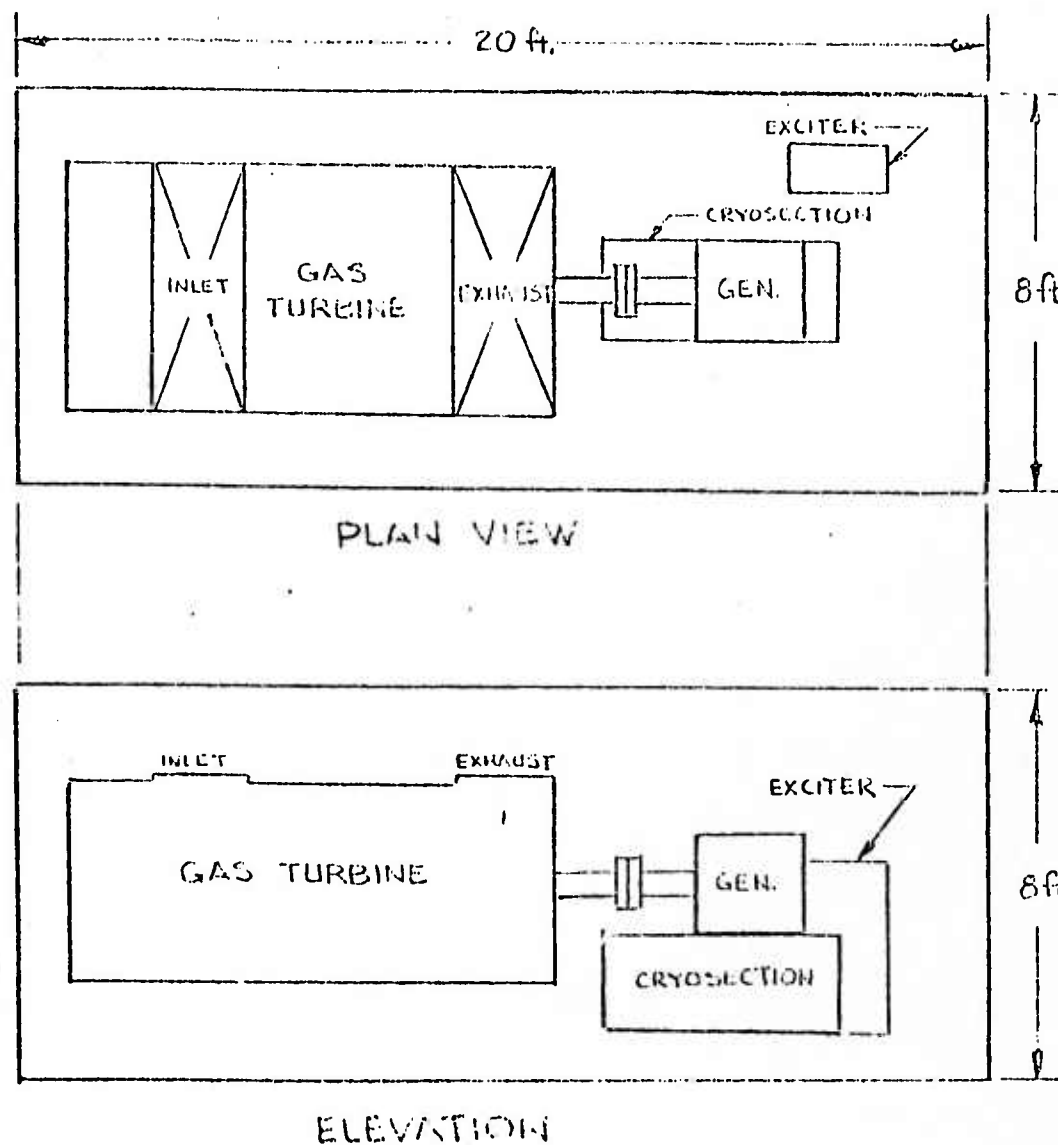
With the exception of the air starting flasks in the forward engine room, almost no other modifications are required to the existing engine room equipment.

The 5000 HP cruise turbine, if used, can be modularized as shown in Figure 3.1 and installed on top of the deck house adjacent to the machinery casing as shown in Figure 3.2. Electrical transmission lines and service piping will be run within the machinery casing between the cruise turbine module and the engine room with disconnect devices in the engine room in the event of damage to the module. Separate disconnect devices are also provided in each engine room to isolate the electrical cross-connect between engine rooms in the event of damage. It should be noted that the cruise turbine module can be easily installed within a standard 8'x8'x20' shipping container.

3.4 Substitution of Superconducting Electric Propulsion, Reconfigured Engine Room (Drawing No. 2870-04)

This modification requires that the existing main reduction gear be replaced by superconducting electric propulsion, as does the previous modification. However, in this case an attempt is made to optimize the engine room arrangement by raising the main propulsion turbines and by relocating the main propulsion motors aft into the shaft alley area.

In this arrangement the propulsion gas turbines and the

Subject .5000 HP CRUISE TURBINE MODULEShip or Project STUDY OF HIGH EFFICIENCY PROPULSION SYSTEMS FOR DD'sSection RSDH Prepared by J. J. [unclear] Date 10/74 Checked _____ Reviewed _____FIGURE 3-1

Subject LOCATION OF CRUISE TURBINE MODULES
 Ship or Project STUDY OF HIGH EFFICIENCY PROPULSION SYSTEMS FOR DD's
 Section BSDIS Prepared By J. H. Higgins Date 10/74 Checked _____ Reviewed _____

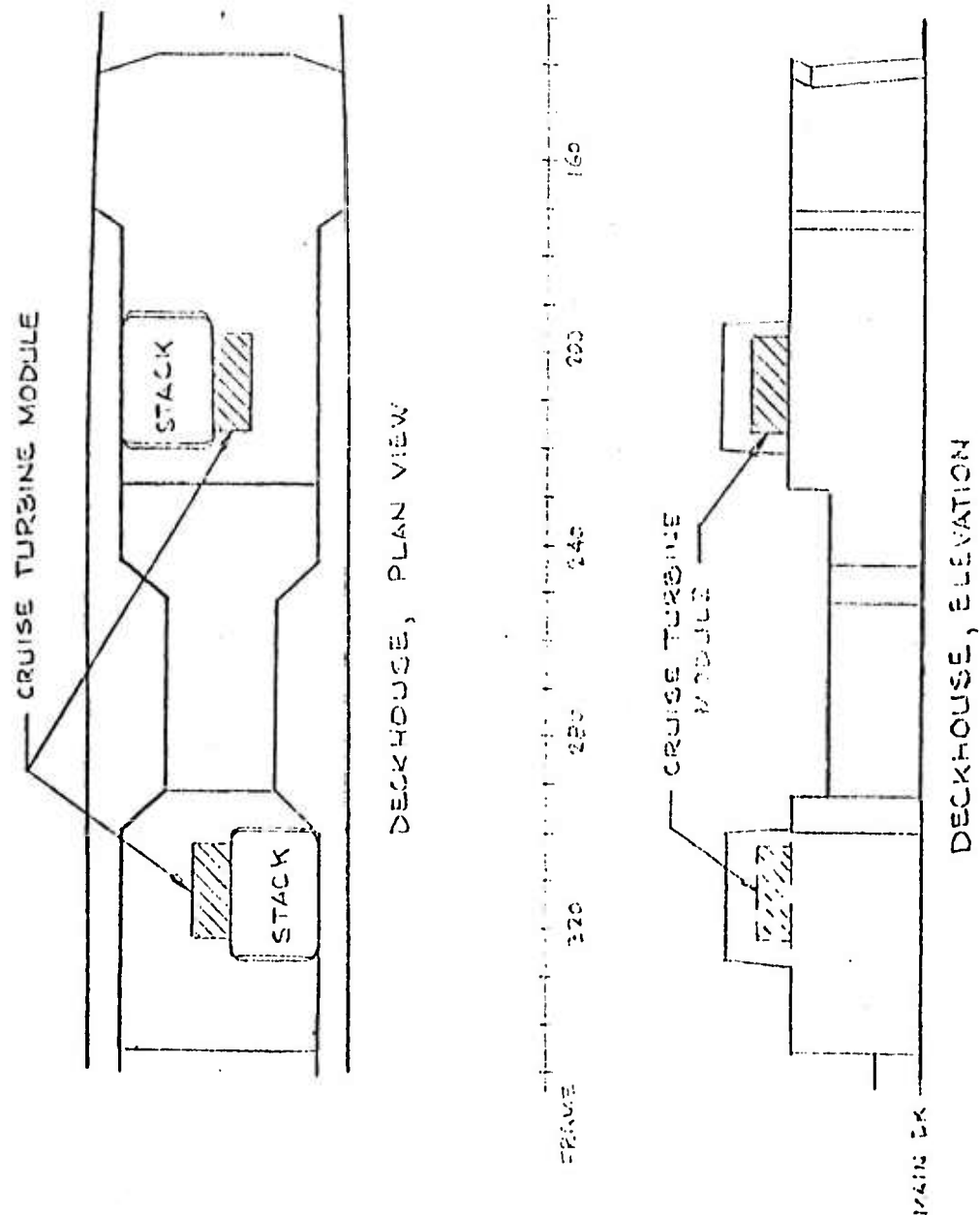


FIGURE 3-2

20,000 HP propulsion generators are moved up onto the 24'-0" level. In addition, the 24'-0" level is extended from the centerline to the shell to fill in the area formerly occupied by the gas turbine ductwork. The generator cryosections are located in the overhead of the 15'-0" level, directly under the propulsion generators.

The 15'-0" level is also extended from the centerline area to the shell. The helium and coolanol systems and the 20,000 HP generator disconnect switches are located on this level. The CRP system is locked in a fixed position as in the last arrangement (Section 3.3) and the existing attached lube oil pump is replaced by a new electrically driven lube oil pump. The main lube oil cooler is relocated to the 7'-6" level.

In this arrangement the existing lube oil storage and settling tanks are relocated from the 24'-0" level to the 15'-0" level while the electronics cabinets on the 15'-0" level are moved to the 24'-0" level. This is to provide the inboard propulsion gas turbine on the 24'-0" level with a service access aisle. Several power panels, the fuel oil service heaters (aft engine room) and an air filter (forward engine room) were also relocated as part of this change.

With the 15'-0" level extended from the centerline area to the shell, there is no longer a need for two vertical access ladders and one of the ladders is eliminated in each engine room. It was necessary to relocate various fire fighting hose reels and cylinders, air starting cylinders (forward engine room) and vertical ladders from the 15'-0" level to the 7'-6" level (forward engine room) and from the 15'-0" level to the 7'-6" level (forward engine room).

The location of the 5000 HP cruise turbines is as shown in Figure 3.2. Only one crossover switch is provided in the aft engine room, since both electric transmission lines must pass through this space.

The location of the propulsion motors is shown in Figure 3.3. The propulsion motors, in this location, appear to displace the shaft alley sewage treatment plant. However, the displaced equipment can be relocated to the space gained under the main propulsion turbines in one of the engine rooms. No attempt has been made at this time to optimize the shaft angles or relocate the shaft tubes. Additional studies are required into the serviceability of the propulsion motors in the location shown and into the possibility of providing a third set of helium-coolant-lube oil service equipment in lieu of piping these services aft from the engine rooms.

4. Estimate of Weight Changes

Tables 4-1, 4-2, 4-3 lists the equipment removed and added as a result of the modifications in Section 3 and the estimated weights for the various equipment. In many cases, weights and sizes shown have been estimated from available information on equipment, that is currently under development. Due to the preliminary nature of much of the available information, no attempt was made to estimate changes in structural weights or changes in various ship systems caused by these modifications.

Subject LOCATION OF PROPULSION MOTORS
Ship or Project STUDY OF HIGH EFFICIENCY PROPULSION SYSTEMS FOR DD's
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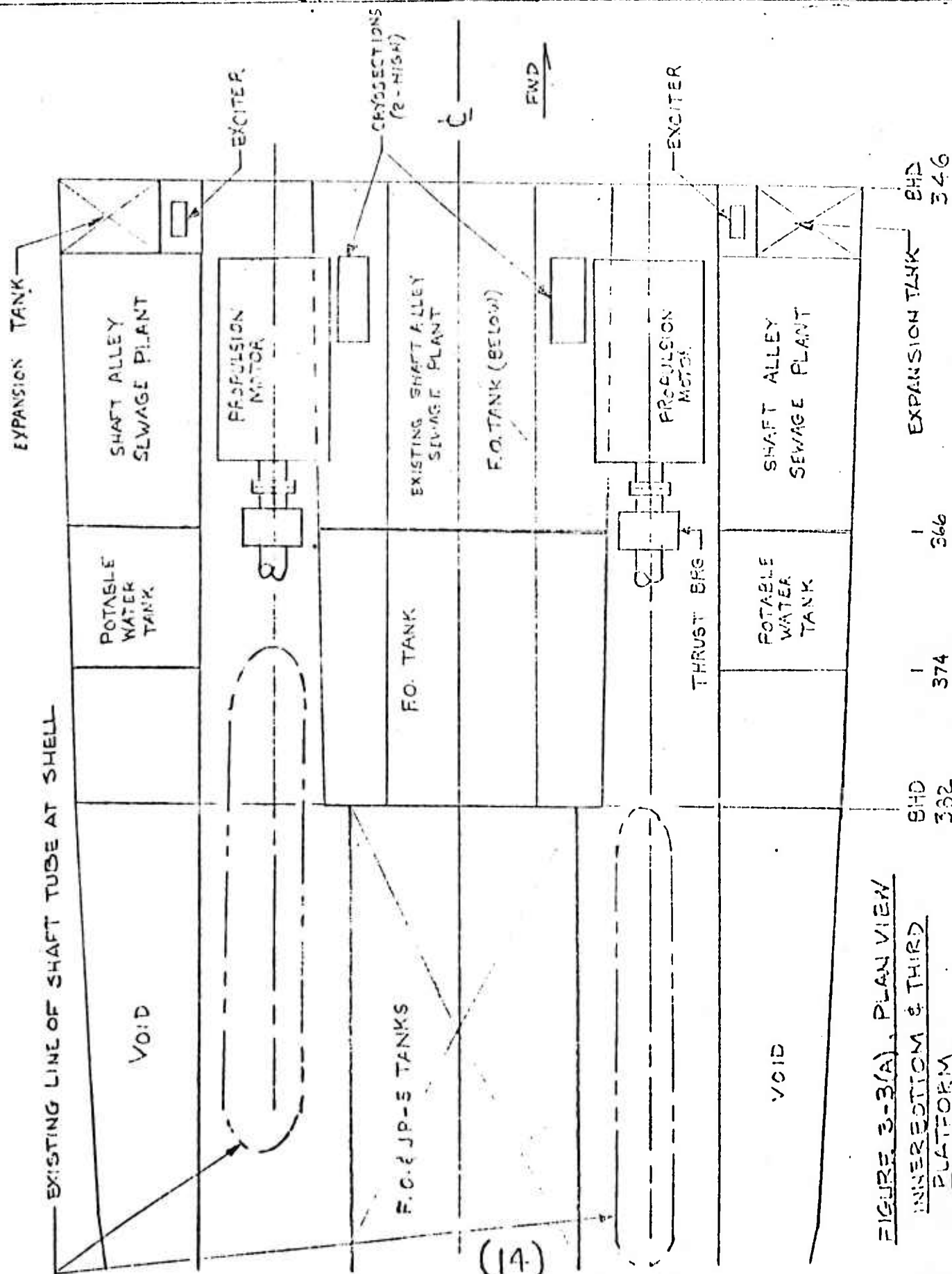


FIGURE 3-3(A), PLAN VIEW
INNER SECTION & THIRD
PLATFORM

Subject

LOCATION OF PROPULSION MOTORS

Ship or Project

STUDY OF HIGH EFFICIENCY PROPULSION SYSTEMS FOR DD's

Section

BSDD

Prepared by J.P.

Date 10/74

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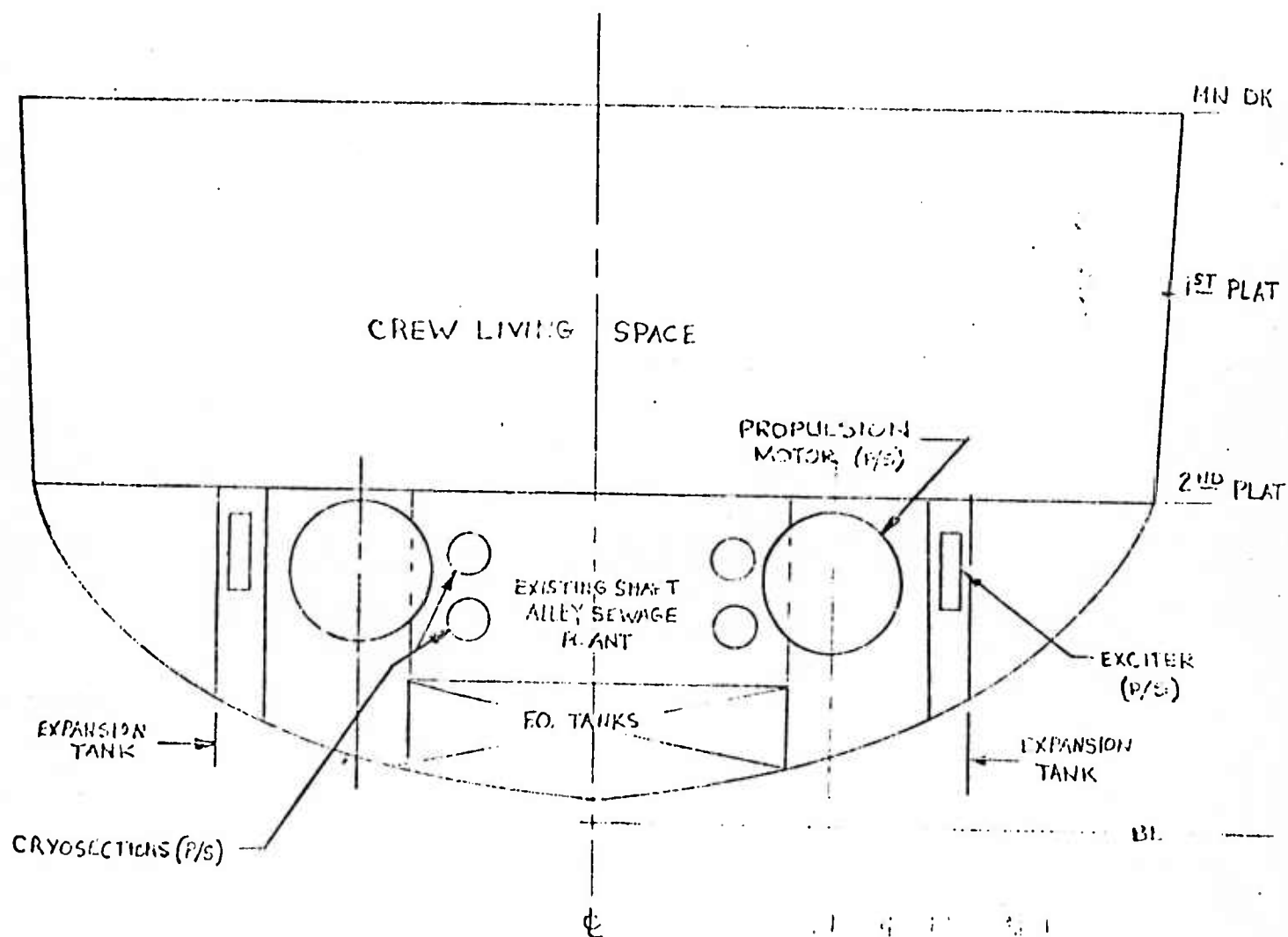


FIGURE 3-3(B)
ELEVATION, FR 346, LOOKING AFT

TABLE 4-1

SUMMARY OF WEIGHT CHANGES

ADDITION OF CRUISE TURBINE

<u>LINE</u>		<u>QTY</u>	<u>UNIT WT (LBS)</u>	<u>UNIT SIZE</u>	<u>TOTAL WEIGHT</u>
1.	5,000 hp Gas Turbine	2	5,000	4'x5'x10'	10,000 lbs
2.	Transfer Gear & Clutch	2	6,000	4'x4'x4' 85'x5'x4.5'	12,000
TOTAL					22,000 lbs

NOTES

1. Above quantities include equipment for both forward and aft engine rooms.
2. There is no equipment removed as a result of this modification.
3. Additional omitted weights:
 - a. Modification to main reduction gear
 - b. Ductwork and new service piping and cables for new cruise turbine

TABLE 4 - 2

SUMMARY OF WEIGHT CHANGES

ADDITION OF CROSSOVER ALTERNATOR

<u>LINE</u>		<u>QTY</u>	<u>UNIT WT (LBS)</u>	<u>UNIT SIZE</u>	<u>TOTAL WEIGHT</u>
1.	10,000 hp Alternator	2	11,000	3' D x 6'	22,000 lbs
2.	Transfer Gear	2	12,000	8'x6'x3'	24,000
3.	Service Module	2	1,500		3,000
TOTAL					49,000 lbs

NOTES

1. Above quantities include equipment for both forward and aft engine rooms.
2. There is no equipment removed as a result of this modification.
3. Weight added as a result of modification to existing main reduction gear is omitted.

TABLE 4 - 3

SUMMARY OF WEIGHT CHANGES

SUPERCONDUCTING ELECTRIC PROPULSION
-EXISTING ENGINE ROOM CONFIGURATION

<u>LINE NOS.</u>	<u>ITEM</u>	<u>WEIGHT CHANGE IN LBS.</u>
1 - 10	Fwd and Aft Engine Rooms - Weights Removed	(390,000)
11 - 37	Aft Engine Room - Weights Added	223,023
38 - 64	Fwd Engine Room - Weights Added	224,664
65	Crossover Between Engine Rooms - Weights Added	9,360
TOTAL CHANGE IN WEIGHT		67,047

NOTES

1. Quantities for equipment removed includes equipment in both forward and aft engine rooms.
2. Weights for CRP hydraulic and Coolanol Systems considered to be even exchange except for new coolanol heat exchanges.
3. Additional study is required to confirm whether or not the high impedance element (25,000 lbs.) is required.

TABLE 4 - 3.1

FWD & AFT ENGINE ROOM WEIGHTS REMOVEDSUPERCONDUCTING ELECTRIC PROPULSION
-EXISTING ENGINE ROOM CONFIGURATION

<u>LINE</u>	<u>ITEM</u>	<u>QTY</u>	<u>UNIT</u> <u>WT (LBS)</u>	<u>UNIT</u> <u>SIZE</u>	<u>TOTAL</u> <u>WEIGHT (LBS)</u>
1.	Main Reduction Gear	2	170,000		340,000
2.	High Impedance Element (See Note 3)	2	35,000		50,000
3.	Attached Mn L.O. Pump	(Included in line 1)			
4.	" CRP Hyd Pump	"	"	"	"
5.	" Oil Dist. Box	"	"	"	"
6.	" Shaft Turn Gear	"	"	"	"
7.	Control -Shaft Turn Gear	(Misc.)			
8.	CRP Head Tank	(See Note 2)			
9.	CRP Sump Tank	"	"	"	
10.	CRP Hydr. Module	"	"	"	
TOTAL REMOVED					<u>(390,000)</u>

TABLE 4 - 3.1

AFT ENGINE ROOM WEIGHTS ADDED

SUPERCONDUCTING ELECTRIC PROPULSION
-EXISTING ENGINE ROOM CONFIGURATION

<u>LINE</u>	<u>ITEM</u>	<u>QTY</u>	<u>UNIT WT (LBS)</u>	<u>UNIT SIZE</u>	<u>TOTAL WEIGHT (LBS)</u>
11.	Coolant Pump (20hp)	2	(See Note 2)		
12.	Cont -Coolant Pump	2	" " "		
13.	Coolant Surge Tank	1	" " "		
14.	Coolant Filter	1	" " "		
15.	Coolant Heat Exchanger	1	4,000	1.5' Dx12'	4,000
16.	Thrust Bearing	1	12,000	3.8' Dx4'	12,000
17.	L.O. SVC Pump (50hp)	1	1,000		1,000
18.	Cont -L.O. SVC Pump (2 spd)	1	90		90
19.	Auto Bus Transfer SW	1	350	0.8'x2'x3'	350
20.	Power Panel	1	380	2'x1'x3.5'	380
21.	Uninterrupted Power Supply	1	1,275	2.7'x2'x3'	1,275
22.	Propulsion Motor (40 K hp)	1	136,500	6.5' Dx11.7'	136,500
23.	Propulsion Generators (70 K hp)	2	10,500	3.2' Dx4.2'	21,000
24.	Exciters	3	375	1'x2'x3.5'	1,125
25.	Gen. Polarity & Discon.	2	5,100	3.7'x4'x5.8'	10,200
26.	Transmission Lines:				
27.	Generator				2,027
28.	Motor				3,008
29.	Helium Compressors	2	3,250	2.6' Dx7.8'	6,500
30.	Cryosections	4	933	2.0' Dx5'	3,732
31.	Cryolines				<u>243</u>
	SUB-TOTAL				203,430
32.	Crossover Switch	1	1,300	2'x2.7'x3.8'	1,300
33.	Transmission Line				<u>1,584</u>
	SUB-TOTAL				2,884

TABLE 4 - 3.1

AFT ENGINE ROOM WEIGHTS ADDEDSUPERCONDUCTING ELECTRIC PROPULSION
-EXISTING ENGINE ROOM CONFIGURATION

<u>LINE</u>	<u>ITEM</u>	<u>QTY</u>	<u>UNIT WT (LBS)</u>	<u>UNIT SIZE</u>	<u>TOTAL WEIGHT (LBS)</u>
34.	Cruise Turbine Module			8'x8'x20'	
a.	5,000 hp Gas Turbine	1	5,000		5,000
b.	5,000 hp Generator		3,850		3,850
c.	Cryosection	1	933		933
d.	Exciter	1	375		375
e.	Container Structure	1	3,500		3,500
35.	Transmission Line				1,813
36.	Cryoline				138
37.	Gen. Polarity & Disconnect Switch	1	1,100	2'x2.5'x3.5'	1,100
SUB-TOTAL					16,709
TOTAL, AFT ENGINE ROOM					223,023

TABLE 4 - 3.2

FWD ENGINE ROOM WEIGHTS ADDEDSUPERCONDUCTING ELECTRIC PROPULSION
-EXISTING ENGINE ROOM CONFIGURATION

<u>LINE</u>	<u>ITEM</u>	<u>QTY</u>	<u>UNIT WT (LBS)</u>	<u>UNIT SIZE</u>	<u>TOTAL WEIGHT (LBS)</u>
38.	Coolant Pump (20hp)	2	(See Note 2)		
39.	Cont -Coolant Pump	2	" " "		
40.	Coolant Surge Tank	1	" " "		
41.	Coolant Filter	1	" " "		
42.	Coolant Heat Exchanger	1	4,000	1.5' Dx12'	4,000
43.	Thrust Bearing	1	12,000	3.8' Dx4'	12,000
44.	L.O. SVC Pump (50 hp)	1	1,000		1,000
45.	Cont -L.O. SVC Pump (2 spd)	1	90		90
46.	Auto Bus Transfer SW	1	350	0.8'x2'x3'	350
47.	Power Panel	1	380	2'x1'x3.5'	380
48.	Uninterrupted Power Supply	1	1,275	2.7'x2'x5'	1,275
49.	Propulsion Motor (40 K hp)	1	136,500	6.5' Dx11.7'	136,500
50.	Propulsion Generators (70 K hp)	2	10,500	3.2' Dx4.2'	21,000
51.	Exciters	3	375	1'x2'x3.5'	1,125
52.	Gen. Polarity & Discon.	2	5,100	3.7'x4'x5.8'	10,200
53.	Transmission Lines;				
54.	Generator				2,152
55.	Motor				3,008
56.	Helium Compressors	2	3,250	2.6' Dx7.8'	6,500
57.	Cryosections	4	933	2.0' Dx5'	3,732
58.	Cryolines				<u>232</u>
	SUB-TOTAL				203,444
59.	Crossover Switch	1	1,300	2'x2.7'x3.8'	1,300
60.	Transmission Line				<u>360</u>
	SUB-TOTAL				1,660

TABLE 4 - 3.2

FWD ENGINE ROOM WEIGHTS ADDEDSUPERCONDUCTING ELECTRIC PROPULSION
-EXISTING ENGINE ROOM CONFIGURATION

<u>LINE</u>	<u>ITEM</u>	<u>QTY</u>	<u>UNIT WT (LBS)</u>	<u>UNIT SIZE</u>	<u>TOTAL WEIGHT (LBS)</u>
61.	Cruise Turbine Module			8'x8'x20'	
a.	5,000 hp Gas Turbine	1	5,000		5,000
b.	5,000 hp Generator	1	3,850		3,850
c.	Cryosection	1	933		933
d.	Exciter	1	375		375
e.	Container Structure	1	3,500		3,500
62.	Transmission Line				4,018
63.	Cryoline				184
64.	Gen. Polarity & Disconnect Switch	1	1,100	2'x2.5'x3.5'	1,100
SUB-TOTAL					18,960
TOTAL, FWD ENGINE ROOM					224,064

TABLE 4 - 3.3

SUPERCONDUCTING ELECTRIC PROPULSION
-EXISTING ENGINE ROOM CONFIGURATION

<u>LINE</u>	<u>ITEM</u>	<u>QTY</u>	<u>UNIT WT (LBS)</u>	<u>UNIT SIZE</u>	<u>TOTAL WEIGHT (LBS)</u>
65.	Transmission Line				9,360
TOTAL					9,360

TABLE 4 - 4

SUMMARY OF WEIGHT CHANGES

SUPERCONDUCTING ELECTRIC PROPULSION
-RECONFIGURED ENGINE ROOM

<u>ITEM NOS.</u>	<u>LOCATION</u>	<u>WEIGHT CHANGE IN LBS.</u>
1 - 11	Fwd and Aft Engine Rooms - Weights Removed	(538,200)
12 - 39	Aft Engine Room - Weights Added	74,620
40 - 58	Fwd Engine Room - Weights Added	86,667
59 - 62	Propulsion Motor Space - Weights Added	301,482
TOTAL CHANGE IN WEIGHT		(75,431)

NOTES

1. Quantities for equipment removed included equipment in both forward and aft engine rooms.
2. Weights for CRP hydraulic and Coolanol Systems considered to be even exchange except for new coolanol heat exchanges.
3. Additional study is required to confirm that high impedance element can be removed.

TABLE 4 - 4.1

FWD & AFT ENGINE ROOM WEIGHTS REMOVEDSUPERCONDUCTING ELECTRIC PROPULSION
-RECONFIGURED ENGINE ROOM

<u>LINE</u>	<u>ITEM</u>	<u>QTY</u>	<u>UNIT WT (LBS)</u>	<u>UNIT SIZE</u>	<u>TOTAL WEIGHT (LBS)</u>
1.	Main Reduction Gear	2	170,000		340,000
2.	High Impedance Element (See Note 3)	2	25,000		50,000
3.	Attached Mn L.O. Pump	(Included in line 1)			
4.	CRP Hyd Pump	"	"	"	"
5.	Oil Dist. Box	"	"	"	"
6.	Shaft Turn Gear	"	"	"	"
7.	Control -Shaft Turn Gear	(Misc.)			
8.	CRP Head Tank	(See Note 2)			
9.	CRP Sump Tank	"	"	"	
10.	CRP Hydr. Module	"	"	"	
11.	Main Propulsion Shafting	650 lb/ft		228'x18"	148,200
					538,200

TABLE 4 - 4.2

AFT ENGINE ROOM WEIGHTS ADDEDSUPERCONDUCTING ELECTRIC PROPULSION
-RECONFIGURED ENGINE ROOM

<u>LINE</u>	<u>ITEM</u>	<u>QTY</u>	<u>UNIT WT (LBS)</u>	<u>UNIT SIZE</u>	<u>TOTAL WEIGHT (LBS)</u>
12.	Coolanol Pump (30 hp)	2	(See Note 2)		
13.	ContCoolanol Pump	2	(See Note 2)		
14.	Coolanol Surge Tank	1	(See Note 2)		
15.	Coolanol Filter	1	(See Note 2)		
16.	Coolanol Heat Exchanger	1	4,000	1.5' Dx12'	4,000
17.	(Not used)				
18.	L.O. SVC Pump (50 hp)	1	1,000		1,000
19.	Cont -L.O. SVC Pump (2SP0)	1	90		90
20.	Auto Bus Transfer SW	1	350	0.8'x2'x3'	350
21.	Power Panel	1	380	2'x1'x3.5'	380
22.	Uninterrupted Power Supply	1	1,275	2.7'x2'x5'	1,275
23.	(Not used)				
24.	Propulsion Generators (70K hp)	2	10,500	3.2' Dx4.2'	21,000
25.	Exciters	2	375	1'x2'x3.5'	375
26.	Gen. Polarity & Discon	2	5,100	3.7'x4'x5.8'	10,200
27.	Transmission Lines:				
28.	Generator				3,126
29.	Motor				1,892
30.	(Not used)				
31.	Helium Compressors	2	3,250	2.8' Cx7'	6,500
32.	Cryosections	2	933	2.0' Dx5'	1,866
33.	Cryolines				322
SUBTOTAL					52,751

TABLE 4 - 4.2

AFT ENGINE ROOM WEIGHTS ADDEDSUPERCONDUCTING ELECTRIC PROPULSION
-RECONFIGURED ENGINE ROOM

<u>LINE</u>	<u>ITEM</u>	<u>QTY</u>	<u>UNIT WT (LBS)</u>	<u>UNIT SIZE</u>	<u>TOTAL WEIGHT (LBS)</u>
34.	Crossover Switch	1	1,300	2'x2.7'x3.8'	1,300
35.	Transmission Line				<u>3,034</u>
	SUBTOTAL				4,334
36.	Cruise Turbine Module			8.x8.x10'	
a.	5,000 hp Gas Turbine	1	5,000		5,000
b.	5,000 hp Generator	1	3,850		3,850
c.	Cryosection	1	933		933
d.	Exciter	1	375		375
e.	Container Structure	1	3,500		3,500
37.	Transmission Line				2,627
38.	Cryoline				150
39.	Gen. Polarity & Disconnect Switch	1	1,100	2'x2.5'x3.5'	1,100
	SUB-TOTAL				<u>17,535</u>
	TOTAL, AFT ENGINE ROOM				74,620

TABLE 4 - 4.2

FWD ENGINE ROOM WEIGHTS ADDEDSUPERCONDUCTING ELECTRIC PROPULSION
-RECONFIGURED ENGINE ROOM

<u>LINE</u>	<u>ITEM</u>	<u>QTY</u>	<u>UNIT WT (LBS)</u>	<u>UNIT SIZE</u>	<u>TOTAL WEIGHT (LBS)</u>
40.	Coolanol Pump (20 hp)	2	(See Note 2)		
41.	Cont - Coolanol Pump	2	" "	"	
42.	Coolanol Surge Tank	1	" "	"	
43.	Coolanol Filter	1	" "	"	
44.	Coolanol Heat Exchanger	1	2,000	1.5' Dx12'	4,000
45.	L.O. SVC Pump (50 hp)	1	1,000		1,000
46.	Cont -L.O. SVC Pump (2 spd)	1	90		90
47.	Auto Bus Transfer SW	1	350	0.8'x2'x3'	350
48.	Power Panel	1	380	2'x1'x3.5'	380
49.	Uninterrupted Power Supply	1	1,275	2.7'x2'x5'	1,275
50.	Propulsion Generators (70 K hp)	2	10,500	3.2' Cx4.2'	21,000
51.	Exciters	2	375	1'x2'x3.5'	750
52.	Gen. Polarity & Discon. SW	2	5,100	3.7'x4'x5.8'	10,200
53.	Transmission Lines:				
54.	Generator				2,469
55.	Motor				16,104
56.	Helium Compressors	2	3,250	2.8' Dx5'	6,500
57.	Cryosections	2	933	2.0' Dx5'	1,866
58.	Cryolines				752
SUB-TOTAL					66,736

TABLE 4 - 4.3

FWD ENGINE ROOM WEIGHTS ADDEDSUPERCONDUCTING ELECTRIC PROPULSION
-RECONFIGURED ENGINE ROOM

<u>LINE</u>	<u>ITEM</u>	<u>QTY</u>	<u>UNIT WT (LBS)</u>	<u>UNIT SIZE</u>	<u>TOTAL WEIGHT (LBS)</u>
59	Cruise Turbine Module			8x8x10'	
a.	5,000 hp Gas Turbine	1	5,000		5,000
b.	5,000 hp Generator	1	3,850		3,850
c.	Cryosection	1	933		933
d.	Exciter	1	375		375
e.	Container Structure	1	3,500		3,500
60.	Transmission Line				4,998
61.	Cryoline				175
62.	Gen. Polarity & Disconnect Switch	1	1,100	2'x2 5'x3.5'	1,100
	SUB-TOTAL				19,931
	TOTAL, FWD ENGINE ROOM				86,667

TABLE 4 - 4.4

PROPULSION MOTOR SPACE WEIGHTS ADDED

<u>LINE</u>	<u>ITEM</u>	<u>QTY</u>	<u>UNIT WT (LBS)</u>	<u>UNIT SIZE</u>	<u>TOTAL WEIGHT (LBS)</u>
63.	Propulsion Motors	2	136,500	6.5' Dx11.7'	273,000
64.	Thrust Bearings	2	12,000	3.8' Dx4'	24,000
65.	Exciters	2	375	1'x2'x3.5'	750
66	Cryosections	4	933	2' Dx5'	3,732
					301,482