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ASAE-S-13

ECONOMICS OF NUCLEAR AND CONVENTIONAL TANKERS

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Prepared by:
Jack J. Gordon
and
Keith E. Buck

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Approved by:

Charles M. Rice, Manager
Reactor Engineering Department

AMERICAN - STANDARD
Atomic Energy Division • Mountain View, California

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TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	1
DISCUSSION	2
RESULTS	14
Graphical Results	14
Tabular Results	29
Cost per Ton and Revenue Index	29
Return on Investment and Annual Profit	45

FIGURES

		<u>Page</u>
1	Speed-Distance Combinations Wherein Cost per Ton is Equal for Nuclear and Conventional Ships, Tankers (1965).....	15
2	Speed-Distance Combinations Wherein Cost per Ton is Equal for Nuclear and Conventional Ships, Tankers (1970).....	16
3	Cost per Ton vs Speed, Tankers (1957)	17
4	Cost per Ton vs Speed, Tankers (1965)	18
5	Cost per Ton vs Speed, Tankers (1970)	19
6	Revenue Index vs Speed for Fixed Return on Investment, Tankers, 4,000-Mile Trade Route (1957)	20
7	Revenue Index vs Speed for Fixed Return on Investment, Tankers, 12,000-Mile Trade Route (1957)	21
8	Revenue Index vs Speed for Fixed Return on Investment, Tankers, 20,000-Mile Trade Route (1957)	22
9	Revenue Index vs Speed for Fixed Return on Investment, Tankers, 4,000-Mile Trade Route (1965)	23
10	Revenue Index vs Speed for Fixed Return on Investment, Tankers, 12,000-Mile Trade Route (1965)	24
11	Revenue Index vs Speed for Fixed Return on Investment, Tankers, 20,000-Mile Trade Route (1965)	25
12	Revenue Index vs Speed for Fixed Return on Investment, Tankers, 4,000-Mile Trade Route (1970)	26
13	Revenue Index vs Speed for Fixed Return on Investment, Tankers, 12,000-Mile Trade Route (1970)	27
14	Revenue Index vs Speed for Fixed Return on Investment, Tankers, 20,000-Mile Trade Route (1970)	28

TABLES

		<u>Page</u>
I	Tanker Family Extension	3
II	Weights and Construction Costs of Conventionally Powered Tankers (1957, 1965, and 1970)	4
III	Weights and Construction Costs of PWR Powered Tankers (1957, 1965, and 1970)	5
IV	Weights and Construction Costs of BWR Powered Tankers (1957 1965 and 1970)	6
V	Weights and Construction Costs of OMR Powered Tankers (1957 1965, and 1970)	7
VI	Weights and Construction Costs of GCR Powered Tankers (1957 1965, and 1970)	8
VII	Fixed Costs per Day for Conventionally Powered Tankers (1957 1965, and 1970)	9
VIII	Fixed Costs per Day for PWR Powered Tankers (1957, 1965, and 1970)	10
IX	Fixed Costs per Day for BWR Powered Tankers (1957, 1965, and 1970)	11
X	Fixed Costs per Day for OMR Powered Tankers (1957, 1965, and 1970) ..	12
XI	Fixed Costs per Day for GCR Powered Tankers (1957, 1965 and 1970)	13
XII	Reactor Type Comparisons. Tankers 4,000-Mile Trade Route (1957) . . .	30
XIII	Reactor Type Comparisons. Tankers, 8,000-Mile Trade Route (1957)	31
XIV	Reactor Type Comparisons Tankers 12,000-Mile Trade Route (1957)	32
XV	Reactor Type Comparisons. Tankers, 16,000-Mile Trade Route (1957)	33

TABLES (Continued)

	<u>Page</u>
XVI Reactor Type Comparisons Tankers 20 000-Mile Trade Route (1957)	34
XVII Reactor Type Comparisons Tankers, 4,000-Mile Trade Route (1965)	35
XVIII Reactor Type Comparisons, Tankers 8,000-Mile Trade Route (1965)	36
XIX Reactor Type Comparisons Tankers, 12 000-Mile Trade Route (1965) ..	37
XX Reactor Type Comparisons Tankers, 16,000-Mile Trade Route (1965)	38
XXI Reactor Type Comparisons Tankers, 20 000-Mile Trade Route (1965)	39
XXII Reactor Type Comparisons Tankers, 4 000-Mile Trade Route (1970)	40
XXIII Reactor Type Comparisons Tankers, 8,000-Mile Trade Route (1970)	41
XXIV Reactor Type Comparisons, Tankers, 12,000-Mile Trade Route (1970)	42
XXV Reactor Type Comparisons Tankers, 16,000-Mile Trade Route(1970)	43
XXVI Reactor Type Comparisons Tankers, 20 000-Mile Trade Route (1970)	44
XXVII Reactor Type Comparisons Tankers Aruba to New York (1957).....	48
XXVIII Reactor Type Comparisons, Tankers, Borneo to San Francisco 1957).....	50
XXIX Reactor Type Comparisons Tankers Kuwait to New York (1957)	52
XXX Reactor Type Comparisons Tankers Aruba to New York (1965)	54
XXXI Reactor Type Comparisons Tankers Borneo to San Francisco (1965).....	56

TABLES (Continued)

	<u>Page</u>
XXXII Reactor Type Comparisons, Tankers, Kuwait to New York (1965)	58
XXXIII Reactor Type Comparisons, Tankers, Aruba to New York (1970)	60
XXXIV Reactor Type Comparisons, Tankers, Borneo to San Francisco (1970)	62
XXXV Reactor Type Comparisons, Tankers, Kuwait to New York (1970)	64

INTRODUCTION

This report presents the results of a project conducted by American-Standard Atomic Energy Division to supplement the information presented in Report No. ASAE-S-5, "Economics of Nuclear and Conventional Merchant Ships", issued by American-Standard on June 30, 1958.

This project was conducted under Atomic Energy Commission Contract No. AT(04-3)-109, Directive 1. The cognizant office is the Division of Reactor Development, Maritime Reactors Branch.

Specifically, the work performed augments that portion of the previous report devoted to a study of the economics of nuclear tankers by presenting economic data on three additional tanker sizes, each driven at three different speeds. The data presented here are of the same nature and are organized in the same format as the corresponding information given in Report No. ASAE-S-5. In certain instances the data from that report are repeated here to facilitate direct comparison of the different ship sizes. In addition, operating costs and return on investment are tabulated for all six ship sizes on three specific trade routes.

DISCUSSION

Three tanker sizes, herein designated as E, F, and G, were specified by the Maritime Reactors Branch. Powering calculations for these ships were made by MRB using the same block coefficients and speed/length ratios as those used in the previous study. With these specifications as a starting point, American-Standard proceeded to estimate weights and costs along with other pertinent data for these ships. Each ship was evaluated with five different power plants, a conventional geared-turbine plant, and each of the four reactor types used previously, namely, pressurized-water, boiling-water, organic-moderated, and gas-cooled. Economic comparisons were then made by the calculational methods described in Report No. ASAE-S-5.

Ship dimensions and power data are shown in Table I. This table also shows the number of crew members and the thermal rating of various nuclear reactors used to power the ships. Table II presents the calculated pertinent weights of conventional geared turbine tankers along with their estimated construction costs for the years 1957, 1965, and 1970. The same information for nuclear-powered tankers using pressurized-water, boiling-water, organic-moderated, and gas-cooled reactor systems is contained in Tables III, IV, V, and VI, respectively. Detailed descriptions of the methods by which these data were obtained are given in Report No. ASAE-S-5.

Fixed costs are shown on a daily basis for 1957, 1965, and 1970 in Tables VII through XI. Again, reference should be made to the previous report for detailed descriptions of the estimating methods.

TABLE I
TANKER FAMILY EXTENSION

	E			F			G		
	1	2	3	1	2	3	1	2	3
Length Overall, Feet	650.0	650.0	650.0	775.0	775.0	775.0	875.0	875.0	875.0
Length B.P., Feet	622.4	622.4	622.4	742.0	742.0	742.0	838.0	838.0	838.0
Beam, Feet	85.8	85.8	85.8	101.0	101.0	101.0	113.0	113.0	113.0
Depth, Feet	44.7	44.7	44.7	53.5	53.5	53.5	60.0	60.0	60.0
Draft, Feet	33.7	33.7	33.7	40.3	40.3	40.3	45.3	45.3	45.3
Block Coefficient	0.800	0.755	0.700	0.800	0.755	0.700	0.800	0.755	0.700
λ	1.08772			1.09601			1.23781		
Normal Shaft Horsepower	10.334	15.033	25.033	17.267	27.262	41.034	28.380	41.949	62.247
Sustained Sea Speed, Knots	15.30	17.26	19.92	16.75	18.90	21.82	17.76	20.08	23.18
Speed Length Ratio	0.613	0.693	0.800	0.613	0.693	0.800	0.613	0.693	0.800
Fuel Consumption (Conv.), Tons/Mile	0.1568	0.2022	0.2917	0.2393	0.3348	0.4365	0.3709	0.4850	0.6234
Fuel Consumption Reduction per 1,000 Tons less DWT, Tons/Mile	0.0021	0.0029	0.0047	0.0021	0.0029	0.0047	0.0021	0.0029	0.0047
Crew	44	45	46	50	51	53	55	56	58
Reactor Rating (TMW)									
PWR	36.2	52.5	86.0	59.6	93.8	140.5	97.5	144.0	212.5
BWR	32.9	47.9	78.9	54.5	85.9	128.9	89.2	132.0	195.1
OMR	34.0	49.1	80.8	55.9	87.7	131.4	91.0	134.7	199.0
GCR	29.3	43.0	70.8	48.8	77.0	116.0	80.0	118.6	175.6

TABLE II
WEIGHTS AND CONSTRUCTION COSTS OF CONVENTIONALLY POWERED TANKERS
(1957, 1965, and 1970)

Ship Size Ship Speed	E			F			G		
	1	2	3	1	2	3	1	2	3
Steel Weight, Tons	6,750	6,657	6,527	11,200	11,033	10,830	15,950	15,611	15,320
Outfit and Hull Eng., Tons	1,210	1,210	1,210	1,600	1,600	1,600	1,910	1,910	1,910
Machinery Weight, Tons	725	880	1,130	940	1,155	1,455	1,200	1,470	1,780
Light Ship Weight, Tons	8,685	8,747	8,867	13,740	13,788	13,885	19,060	18,991	19,010
Crew and Stores, Tons	87	77	66	80	70	61	79	69	60
Fresh Water, Tons	168	240	390	274	430	647	445	660	972
Fuel and Cargo Oil, Tons	31,949	29,525	26,454	55,183	51,092	46,024	80,211	74,461	67,278
TOTAL DEADWEIGHT, TONS	32,204	29,842	26,910	55,537	51,592	46,732	80,735	75,190	68,310
Displacement, Tons	40,889	38,589	35,777	69,277	65,380	60,617	99,795	94,181	87,320
Steel Hull Cost (1957)	4,104	4,047	3,968	6,810	5,708	6,585	9,698	9,491	9,315
Outfit and Hull Eng. Cost	3,700	3,700	3,700	4,892	4,892	4,892	5,840	5,840	5,840
Machinery Cost	2,796	3,394	4,358	3,625	4,454	5,611	4,628	5,669	6,865
TOTAL CONSTRUCTION COST	10,600	11,141	12,026	15,327	16,054	17,088	20,166	21,000	22,020
Inspection and Owner's Outfit	848	891	962	1,226	1,284	1,367	1,613	1,680	1,762
TOTAL COST (Excl. Design 1957)	11,448	12,032	12,988	16,553	17,338	18,455	21,779	22,680	23,782
Steel Hull Cost (1965)	5,083	5,013	4,915	8,434	8,308	8,155	12,010	11,755	11,536
Outfit and Hull Eng. Cost	4,513	4,513	4,513	5,967	5,967	5,967	7,123	7,123	7,123
Machinery Cost	3,383	4,107	5,273	4,386	5,389	6,789	5,600	6,859	8,307
TOTAL CONSTRUCTION COST	12,979	13,633	14,701	18,787	19,664	20,911	24,733	25,737	26,966
Inspection and Owner's Outfit	1,038	1,091	1,177	1,501	1,572	1,673	1,974	2,056	2,157
TOTAL COST (Excl. Design 1965)	14,017	14,724	15,878	20,288	21,236	22,584	26,707	27,793	29,123
Steel Hull Cost (1970)	5,812	5,732	5,620	9,643	9,499	9,325	13,733	13,441	13,191
Outfit and Hull Eng. Cost	5,111	5,111	5,111	6,758	6,758	6,758	8,068	8,068	8,068
Machinery Cost	3,814	4,629	5,944	4,944	6,075	7,653	6,313	7,732	9,364
TOTAL CONSTRUCTION COST	14,737	15,472	16,675	21,345	22,332	23,736	28,114	29,241	30,623
Inspection and Owner's Outfit	1,179	1,238	1,337	1,704	1,785	1,900	2,242	2,335	2,449
TOTAL COST (Excl. Design 1970)	15,916	16,710	18,012	23,049	24,117	25,636	30,356	31,576	33,072

Note: All costs in thousands of dollars.

TABLE III
WEIGHTS AND CONSTRUCTION COSTS OF PWR-POWERED TANKERS
(1957, 1965, and 1970)

Ship Size Ship Speed	E			F			G		
	1	2	3	1	2	3	1	2	3
Steel Weight, Tons	6,750	6,657	6,527	11,200	11,033	10,830	15,950	15,611	15,320
Outfit and Hull Eng., Tons	1,210	1,210	1,210	1,600	1,600	1,600	1,910	1,910	1,910
Machinery Weight, Tons	605	725	936	780	975	1,199	995	1,201	1,460
Reactor Weight, Tons	800	900	1,060	940	1,101	1,302	1,102	1,303	1,645
Light Ship Weight	9,365	9,492	9,733	14,520	14,709	14,931	19,957	20,025	20,335
Crew and Stores, Tons	87	77	66	80	70	61	79	69	60
Fresh Water, Tons	168	240	390	274	430	647	445	660	972
Take Home Fuel, Tons	117	117	117	210	210	210	330	330	330
Cargo, Tons	31,152	28,663	25,471	54,193	49,961	44,768	78,984	73,097	65,623
TOTAL DEADWEIGHT, TONS	31,524	29,097	26,044	54,757	50,671	45,686	79,838	74,156	66,985
Displacement, Tons	40,889	38,589	35,777	69,277	65,380	60,617	99,795	94,181	87,320
Steel Hull Cost (1957)	4,104	4,047	3,968	6,810	6,708	6,585	9,698	9,491	9,315
Outfit and Hull Eng. Cost	3,700	3,700	3,700	4,892	4,892	4,892	5,840	5,840	5,840
Machinery Cost	2,752	3,310	4,280	3,575	4,480	5,450	4,530	5,500	6,720
Reactor Cost	4,550	5,175	6,300	5,440	6,520	7,620	6,625	7,700	9,000
TOTAL CONSTRUCTION COST	15,106	16,232	18,248	20,717	22,600	24,547	26,693	28,531	30,875
Inspection and Owner's Outfit	848	891	962	1,226	1,284	1,367	1,613	1,680	1,762
TOTAL COST (Excl. Design 1957)	15,954	17,123	19,210	21,943	23,884	25,914	28,306	30,211	32,637
Steel Hull Cost (1965)	5,083	5,013	4,915	8,434	8,308	8,155	12,010	11,755	11,536
Outfit and Hull Eng. Cost	4,513	4,513	4,513	5,967	5,967	5,967	7,123	7,123	7,123
Machinery Cost	3,321	3,994	5,166	4,315	5,407	6,578	5,467	6,638	8,110
Reactor Cost	4,450	5,176	6,175	5,330	6,395	7,470	6,495	7,540	8,800
TOTAL CONSTRUCTION COST	17,367	18,696	20,769	24,046	26,077	28,170	31,095	33,056	35,569
Inspection and Owner's Outfit	1,038	1,091	1,177	1,501	1,572	1,673	1,974	2,056	2,157
TOTAL COST (Excl. Design 1965)	18,405	19,787	21,946	25,547	27,649	29,843	33,069	35,112	37,725
Steel Hull Cost (1970)	5,812	5,732	5,620	9,643	9,499	9,325	13,733	13,441	13,191
Outfit and Hull Eng. Cost	5,111	5,111	5,111	6,758	6,758	6,758	8,068	8,068	8,068
Machinery Cost	3,740	4,498	5,817	4,858	6,088	7,407	6,156	7,474	9,132
Reactor Cost	4,375	5,000	6,076	5,245	6,300	7,380	6,400	7,455	8,720
TOTAL CONSTRUCTION COST	19,038	20,341	22,624	26,504	28,645	30,870	34,357	36,438	39,111
Inspection and Owner's Outfit	1,179	1,238	1,337	1,704	1,785	1,900	2,242	2,335	2,449
TOTAL COST (Excl. Design 1970)	20,217	21,579	23,961	28,208	30,430	32,770	36,599	38,773	41,560

Note: All Costs in thousands of dollars.

TABLE IV
WEIGHTS AND CONSTRUCTION COSTS OF BWR-POWERED TANKERS
(1957, 1965, and 1970)

Ship Size Ship Speed	E			F			G		
	1	2	3	1	2	3	1	2	3
Steel Weight, Tons	6,750	6,657	6,527	11,200	11,033	10,830	15,950	15,611	15,320
Outfit and Hull Eng., Tons	1,210	1,210	1,210	1,600	1,600	1,600	1,910	1,910	1,910
Machinery Weight, Tons	605	725	936	780	975	1,199	995	1,201	1,460
Reactor Weight, Tons	803	911	1,064	946	1,098	1,305	1,115	1,321	1,625
Light Ship Weight, Tons	9,368	9,503	9,737	14,526	14,706	14,934	19,970	20,043	20,315
Crew and Stores, Tons	87	77	66	80	70	61	79	69	60
Fresh Water, Tons	168	240	390	274	430	647	445	660	972
Take Home Fuel, Tons	117	117	117	210	210	210	330	330	330
Cargo, Tons	31,149	28,652	25,467	54,187	49,964	44,765	78,971	73,079	65,643
TOTAL DEADWEIGHT, TONS	31,521	29,086	26,040	54,751	50,674	45,683	79,825	74,138	67,005
Displacement, Tons	40,889	38,589	35,777	69,277	65,380	60,617	99,795	94,181	87,320
Steel Hull Cost (1957)	4,104	4,047	3,968	6,810	6,708	6,585	9,698	9,491	9,315
Outfit and Hull Eng. Cost	3,700	3,700	3,700	4,892	4,892	4,892	5,840	5,840	5,840
Machinery Cost	2,945	3,542	4,580	3,825	4,794	5,832	4,847	5,885	7,190
Reactor Cost	4,155	4,625	5,395	4,800	5,551	6,499	5,645	6,552	7,770
TOTAL CONSTRUCTION COST	14,904	15,914	17,661	20,327	21,945	23,808	26,030	27,768	30,115
Inspection and Owner's Outfit	848	891	962	1,226	1,284	1,367	1,613	1,680	1,762
TOTAL COST (Excl. Design 1957)	15,752	16,805	18,623	21,553	23,229	25,175	27,643	29,448	31,877
Steel Hull Cost (1965)	5,083	5,013	4,915	8,434	8,308	8,155	12,010	11,755	11,536
Outfit and Hull Eng. Cost	4,513	4,513	4,513	5,967	5,967	5,967	7,123	7,123	7,123
Machinery Cost	3,554	4,275	5,528	4,616	5,786	7,039	5,850	7,103	8,678
Reactor Cost	4,065	4,550	5,300	4,720	5,474	6,385	5,535	6,450	7,645
TOTAL CONSTRUCTION COST	17,215	18,351	20,256	23,737	25,535	27,546	30,518	32,431	34,982
Inspection and Owner's Outfit	1,038	1,091	1,177	1,501	1,572	1,673	1,974	2,056	2,157
TOTAL COST (Excl. Design 1965)	18,253	19,442	21,433	25,238	27,107	29,219	32,492	34,487	37,139
Steel Hull Cost (1970)	5,812	5,732	5,620	9,643	9,499	9,325	13,733	13,441	13,191
Outfit and Hull Eng. Cost	5,111	5,111	5,111	6,758	6,758	6,758	8,068	8,068	8,068
Machinery Cost	4,002	4,814	6,224	5,198	6,515	7,926	6,587	7,998	9,771
Reactor Cost	3,748	4,135	4,840	4,280	4,998	5,775	5,055	5,830	6,705
TOTAL CONSTRUCTION COST	18,673	19,792	21,795	25,879	27,770	29,784	33,443	35,337	37,735
Inspection and Owner's Outfit	1,179	1,238	1,337	1,704	1,785	1,900	2,242	2,335	2,449
TOTAL COST (Excl. Design 1970)	19,852	21,030	23,132	27,583	29,555	31,684	35,685	37,672	40,184

Note: All costs in thousands of dollars.

TABLE V
WEIGHTS AND CONSTRUCTION COSTS OF OMR-POWERED TANKERS
(1957, 1965, and 1970)

Ship Size Ship Speed	E			F			G		
	1	2	3	1	2	3	1	2	3
Steel Weight, Tons	6,750	6,657	6,527	11,200	11,033	10,830	15,950	15,611	15,320
Outfit and Hull Eng., Tons	1,210	1,210	1,210	1,600	1,600	1,600	1,910	1,910	1,910
Machinery Weight, Tons	605	725	936	780	975	1,199	995	1,201	1,460
Reactor Weight, Tons	756	866	1,089	912	1,139	1,637	1,366	1,658	2,009
Light Ship Weight, Tons	9,321	9,458	9,762	14,492	14,747	15,266	20,221	20,380	20,699
Crew and Stores, Tons	87	77	66	80	70	61	79	69	60
Fresh Water, Tons	168	240	390	274	430	647	445	660	972
Take Home Fuel, Tons	117	117	117	210	210	210	330	330	330
Cargo, Tons	31,196	28,697	25,442	54,221	49,923	44,433	78,720	72,742	65,259
TOTAL DEADWEIGHT, TONS	31,568	29,131	26,015	54,785	50,633	45,351	79,574	73,801	66,621
Displacement, Tons	40,889	38,589	35,777	69,277	65,380	60,617	99,795	94,181	87,320
Steel Hull Cost (1957)	4,104	4,047	3,968	6,810	6,708	6,585	9,698	9,491	9,315
Outfit and Hull Eng. Cost	3,700	3,700	3,700	4,892	4,892	4,892	5,840	5,840	5,840
Machinery Cost	2,752	3,310	4,280	3,575	4,480	5,450	4,530	5,500	6,720
Reactor Cost	3,540	3,855	4,505	4,000	4,650	5,995	5,150	6,050	7,040
TOTAL CONSTRUCTION COST	14,096	14,912	16,453	19,277	20,730	22,922	25,218	26,881	28,915
Inspection and Owner's Outfit	848	891	962	1,226	1,284	1,367	1,613	1,680	1,762
TOTAL COST (Excl. Design 1957)	14,944	15,803	17,415	20,503	22,014	24,289	26,831	28,561	30,677
Steel Hull Cost (1965)	5,083	5,013	4,915	8,434	8,308	8,155	12,010	11,755	11,536
Outfit and Hull Eng. Cost	4,513	4,513	4,513	5,967	5,967	5,967	7,123	7,123	7,123
Machinery Cost	3,321	3,994	5,166	4,315	5,407	6,578	5,467	6,638	8,110
Reactor Cost	3,579	3,950	4,680	4,101	4,835	5,750	4,900	5,805	6,840
TOTAL CONSTRUCTION COST	16,496	17,470	19,274	22,817	24,517	26,450	29,500	31,321	33,609
Inspection and Owner's Outfit	1,038	1,091	1,177	1,501	1,572	1,673	1,974	2,056	2,157
TOTAL COST (Excl. Design 1965)	17,534	18,561	20,451	24,318	26,089	28,123	31,474	33,377	35,766
Steel Hull Cost (1970)	5,812	5,732	5,620	9,643	9,499	9,325	13,733	13,441	13,191
Outfit and Hull Eng. Cost	5,111	5,111	5,111	6,758	6,758	6,758	8,068	8,068	8,068
Machinery Cost	3,740	4,498	5,817	4,858	6,088	7,407	6,156	7,474	9,132
Reactor Cost	3,575	3,950	4,705	4,101	4,865	5,800	4,950	5,860	6,915
TOTAL CONSTRUCTION COST	18,238	19,291	21,253	25,360	27,210	29,290	32,907	34,843	37,306
Inspection and Owner's Outfit	1,179	1,238	1,337	1,704	1,785	1,900	2,242	2,335	2,446
TOTAL COST (Excl. Design 1970)	19,417	20,529	22,590	27,064	28,995	31,190	35,149	37,178	39,755

Note: All costs in thousands of dollars.

TABLE VI
WEIGHTS AND CONSTRUCTION COSTS OF GCR-POWERED TANKERS
(1957, 1965, and 1970)

Ship Size Ship Speed	E			F			G		
	1	2	3	1	2	3	1	2	3
Steel Weight, Tons	6,750	6,657	6,527	11,200	11,033	10,830	15,950	15,611	15,320
Outfit and Hull Eng., Tons	1,210	1,210	1,210	1,600	1,600	1,600	1,910	1,910	1,910
Machinery Weight, Tons	550	665	850	705	886	1,080	905	1,100	1,340
Reactor Weight, Tons	<u>1,017</u>	<u>1,124</u>	<u>1,373</u>	<u>1,185</u>	<u>1,429</u>	<u>1,748</u>	<u>1,454</u>	<u>1,768</u>	<u>2,130</u>
Light Ship Weight, Tons	9,527	9,656	9,960	14,690	14,948	15,258	20,219	20,389	20,700
Crew and Stores, Tons	87	77	66	80	70	61	79	69	60
Fresh Water, Tons	168	240	390	274	430	647	445	660	972
Take Home Fuel, Tons	117	117	117	210	210	210	330	330	330
Cargo, Tons	<u>30,990</u>	<u>28,499</u>	<u>25,244</u>	<u>54,023</u>	<u>49,722</u>	<u>44,441</u>	<u>78,722</u>	<u>72,733</u>	<u>65,258</u>
TOTAL DEADWEIGHT, TONS	31,362	28,933	25,817	54,587	50,432	45,359	79,576	73,792	66,620
Displacement, Tons	40,889	38,589	35,777	69,277	65,380	60,617	99,795	94,181	87,320
Steel Hull Cost (1957)	4,104	4,047	3,968	6,810	6,708	6,585	9,698	9,491	9,315
Outfit and Hull Eng. Cost	3,700	3,700	3,700	4,892	4,892	4,892	5,840	5,840	5,840
Machinery Cost	6,223	7,525	9,618	7,977	10,026	12,221	10,240	12,447	15,163
Reactor Cost	<u>5,595</u>	<u>6,085</u>	<u>7,085</u>	<u>6,290</u>	<u>7,303</u>	<u>8,672</u>	<u>7,410</u>	<u>8,755</u>	<u>10,345</u>
TOTAL CONSTRUCTION COST	19,622	21,357	24,371	25,969	28,929	32,370	33,188	36,533	40,663
Inspection and Owner's Outfit	<u>848</u>	<u>891</u>	<u>962</u>	<u>1,226</u>	<u>1,284</u>	<u>1,367</u>	<u>1,613</u>	<u>1,680</u>	<u>1,762</u>
TOTAL COST (Excl. Design 1957)	20,470	22,248	25,333	27,195	30,213	33,737	34,801	38,213	42,425
Steel Hull Cost (1965)	5,083	5,013	4,915	8,434	8,308	8,155	12,010	11,755	11,536
Outfit and Hull Eng. Cost	4,513	4,513	4,513	5,967	5,967	5,967	7,123	7,123	7,123
Machinery Cost	6,011	7,269	9,291	7,706	9,685	11,805	9,892	12,024	14,647
Reactor Cost	<u>5,640</u>	<u>6,085</u>	<u>7,055</u>	<u>6,300</u>	<u>7,275</u>	<u>8,625</u>	<u>7,375</u>	<u>8,705</u>	<u>10,320</u>
TOTAL CONSTRUCTION COST	21,247	22,880	25,774	28,407	31,235	34,552	36,400	39,607	43,626
Inspection and Owner's Outfit	<u>1,038</u>	<u>1,091</u>	<u>1,177</u>	<u>1,501</u>	<u>1,572</u>	<u>1,673</u>	<u>1,974</u>	<u>2,056</u>	<u>2,157</u>
TOTAL COST (Excl. Design 1965)	22,285	23,971	26,951	29,908	32,807	36,225	38,374	41,663	45,783
Steel Hull Cost (1970)	5,812	5,732	5,620	9,643	9,499	9,325	13,733	13,441	13,191
Outfit and Hull Eng. Cost	5,111	5,111	5,111	6,758	6,758	6,758	8,068	8,068	8,068
Machinery Cost	6,341	7,668	9,801	8,128	10,216	12,453	10,434	12,683	15,451
Reactor Cost	<u>5,485</u>	<u>5,945</u>	<u>6,920</u>	<u>6,155</u>	<u>7,010</u>	<u>8,480</u>	<u>7,235</u>	<u>8,560</u>	<u>10,177</u>
TOTAL CONSTRUCTION COST	22,749	24,456	27,452	30,684	33,483	37,016	39,470	42,752	46,887
Inspection and Owner's Outfit	<u>1,179</u>	<u>1,238</u>	<u>1,337</u>	<u>1,704</u>	<u>1,785</u>	<u>1,900</u>	<u>2,242</u>	<u>2,335</u>	<u>2,449</u>
TOTAL COST (Excl. Design 1970)	23,928	25,694	28,789	32,388	35,268	38,916	41,712	45,087	49,336

Note: All costs in thousands of dollars.

TABLE VII
FIXED COSTS PER DAY FOR CONVENTIONALLY POWERED TANKERS - 1957, 1965, 1970

Ship Size Ship Speed	E			F			G		
	1	2	3	1	2	3	1	2	3
1957 Operating Costs									
Wages	1,150	1,176	1,202	1,306	1,332	1,385	1,437	1,463	1,515
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	394	413	445	568	595	633	747	778	816
Insurance	491	503	514	705	720	738	910	927	952
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	<u>2,666</u>	<u>2,802</u>	<u>3,025</u>	<u>3,855</u>	<u>4,038</u>	<u>4,298</u>	<u>5,072</u>	<u>5,282</u>	<u>5,539</u>
TOTAL DAILY FIXED COSTS ^a	5,021	5,216	5,510	6,814	7,067	7,440	8,581	8,867	9,243
1965 Operating Costs									
Wages	1,571	1,606	1,642	1,785	1,820	1,892	1,963	1,999	2,070
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	482	505	544	695	728	774	914	952	998
Insurance	600	615	629	862	881	903	1,113	1,134	1,164
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	<u>3,265</u>	<u>3,429</u>	<u>3,698</u>	<u>4,725</u>	<u>4,946</u>	<u>5,260</u>	<u>6,220</u>	<u>6,473</u>	<u>6,783</u>
TOTAL DAILY FIXED COSTS ^a	6,238	6,477	6,837	8,447	8,757	9,215	10,625	10,975	11,436
1970 Operating Costs									
Wages	1,910	1,953	1,997	2,170	2,214	2,300	2,387	2,431	2,518
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	547	573	618	788	826	879	1,037	1,080	1,133
Insurance	681	698	713	978	999	1,024	1,263	1,287	1,321
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	<u>3,707</u>	<u>3,892</u>	<u>4,195</u>	<u>5,368</u>	<u>5,617</u>	<u>5,971</u>	<u>7,070</u>	<u>7,354</u>	<u>7,702</u>
TOTAL DAILY FIXED COSTS ^a	7,165	7,438	7,847	9,684	10,038	10,560	12,172	12,569	13,095

^aExcluding fuel costs.

TABLE VIII
FIXED COSTS PER DAY FOR PWR-POWERED TANKERS - 1957, 1965, 1970

Ship Size Ship Speed	E			F			G		
	1	2	3	1	2	3	1	2	3
1957 Operating Costs									
Wages	1,242	1,270	1,298	1,411	1,439	1,495	1,552	1,581	1,637
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	394	413	445	568	595	633	747	778	816
Insurance	974	1,061	1,160	1,315	1,389	1,547	1,616	1,705	1,942
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	3,740	4,014	4,503	5,143	5,598	6,074	6,633	7,081	7,650
Fuel Inventory Costs	293	375	560	411	610	914	634	937	1,385
TOTAL DAILY FIXED COSTS ^a	6,963	7,455	8,290	9,228	10,013	11,049	11,597	12,499	13,851
1965 Operating Costs									
Wages	1,700	1,739	1,777	1,932	1,970	2,047	2,125	2,164	2,241
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	482	505	544	695	728	774	914	952	998
Insurance	1,059	1,142	1,247	1,426	1,499	1,664	1,775	1,873	2,106
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	4,314	4,638	5,144	5,988	6,481	6,995	7,751	8,230	8,843
Fuel Inventory Costs	293	375	560	411	610	914	634	937	1,385
TOTAL DAILY FIXED COSTS ^a	8,168	8,721	9,596	10,832	11,670	12,780	13,614	14,573	15,994
1970 Operating Costs									
Wages	2,068	2,114	2,161	2,349	2,396	2,489	2,584	2,632	2,725
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	547	573	618	788	826	879	1,037	1,080	1,133
Insurance	1,120	1,206	1,304	1,515	1,580	1,751	1,896	1,998	2,231
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	4,739	5,058	5,616	6,612	7,133	7,681	8,579	9,088	9,742
Fuel Inventory Costs	293	375	560	411	610	914	634	937	1,385
TOTAL DAILY FIXED COSTS ^a	9,087	9,648	10,583	12,093	12,927	14,100	15,145	16,152	17,637

^a-Excluding variable fuel costs.

TABLE IX
FIXED COSTS PER DAY FOR BWR-POWERED TANKERS - 1957, 1965, 1970

Ship Size Ship Speed	E			F			G		
	1	2	3	1	2	3	1	2	3
1957 Operating Costs									
Wages	1,242	1,270	1,298	1,411	1,439	1,495	1,552	1,581	1,637
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	394	413	445	568	595	633	747	778	816
Insurance	956	1,030	1,124	1,283	1,362	1,518	1,574	1,676	1,905
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	3,692	3,939	4,365	5,052	5,445	5,901	6,479	6,903	7,472
Fuel Inventory Costs	287	375	558	415	600	880	619	902	1,390
TOTAL DAILY FIXED COSTS ^a	6,891	7,349	8,114	9,109	9,823	10,813	11,386	12,257	13,641
1965 Operating Costs									
Wages	1,700	1,739	1,777	1,932	1,970	2,047	2,125	2,164	2,241
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	482	505	544	695	728	774	914	952	998
Insurance	1,042	1,112	1,208	1,395	1,474	1,636	1,731	1,844	2,076
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	4,278	4,557	5,024	5,916	6,354	6,849	7,616	8,084	8,705
Fuel Inventory Costs	287	375	558	415	600	880	619	902	1,390
TOTAL DAILY FIXED COSTS ^a	8,109	8,610	9,435	10,733	11,508	12,572	13,420	14,363	15,831
1970 Operating Costs									
Wages	2,068	2,114	2,161	2,349	2,396	2,489	2,584	2,632	2,725
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	547	573	618	788	826	879	1,037	1,080	1,133
Insurance	1,099	1,169	1,263	1,475	1,553	1,715	1,842	1,961	2,191
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	4,653	4,929	5,422	6,465	6,928	7,427	8,364	8,830	9,419
Fuel Inventory Costs	245	315	460	347	495	702	512	718	1,036
TOTAL DAILY FIXED COSTS ^a	8,932	9,442	10,248	11,842	12,580	13,598	14,754	15,638	16,925

^a-Excluding variable fuel costs.

TABLE X
FIXED COSTS PER DAY FOR OMR-POWERED TANKERS - 1957, 1965, 1970

Ship Size Ship Speed	E			F			G		
	1	2	3	1	2	3	1	2	3
1957 Operating Costs									
Wages	1,242	1,270	1,298	1,411	1,439	1,495	1,552	1,581	1,637
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	394	413	445	568	595	633	747	778	816
Insurance	927	1,000	1,107	1,252	1,328	1,467	1,550	1,640	1,807
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	3,503	3,704	4,082	4,806	5,160	5,693	6,289	6,695	7,191
Fuel Inventory Costs	204	260	370	285	394	677	500	691	978
DAILY FIXED COSTS ^a	6,590	6,969	7,626	8,702	9,298	10,351	11,053	11,802	12,850
1965 Operating Costs									
Wages	1,700	1,739	1,777	1,932	1,970	2,047	2,125	2,164	2,241
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	482	505	544	695	728	774	914	952	998
Insurance	1,010	1,080	1,190	1,361	1,437	1,581	1,705	1,804	1,970
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	4,110	4,351	4,794	5,700	6,115	6,592	7,377	7,824	8,383
Fuel Inventory Costs	204	260	370	285	394	677	500	691	978
TOTAL DAILY FIXED COSTS ^a	7,826	8,257	8,999	10,353	11,026	12,057	13,036	13,852	14,991
1970 Operating Costs									
Wages	2,068	2,114	2,161	2,349	2,396	2,489	2,584	2,632	2,725
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	547	573	618	788	826	879	1,037	1,080	1,133
Insurance	1,066	1,135	1,244	1,440	1,514	1,658	1,813	1,919	2,078
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	4,551	4,812	5,295	6,344	6,796	7,311	8,239	8,714	9,319
Fuel Inventory Costs	204	260	370	285	394	677	500	691	978
TOTAL DAILY FIXED COSTS ^a	8,756	9,216	10,012	11,624	12,308	13,400	14,588	15,453	16,654

^a-Excluding variable fuel costs.

TABLE XI
FIXED COSTS PER DAY FOR GCR-POWERED TANKERS - 1957, 1965, 1970

Ship Size Ship Speed	E			F			G		
	1	2	3	1	2	3	1	2	3
1957 Operating Costs									
Wages	1,242	1,270	1,298	1,411	1,439	1,495	1,552	1,581	1,637
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	394	413	445	568	595	633	747	778	816
Insurance	1,092	1,175	1,314	1,457	1,556	1,785	1,795	1,932	2,257
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	4,798	5,215	5,938	6,374	7,082	7,908	8,157	8,957	9,944
Fuel Inventory Costs	252	314	440	340	467	645	481	656	913
TOTAL DAILY FIXED COSTS ^a	8,098	8,709	9,759	10,530	11,521	12,852	13,147	14,321	15,988
1965 Operating Costs									
Wages	1,700	1,739	1,777	1,932	1,970	2,047	2,125	2,164	2,241
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	482	505	544	695	728	774	914	952	998
Insurance	1,146	1,234	1,380	1,530	1,634	1,874	1,885	2,029	2,370
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	5,224	5,619	6,317	7,010	7,690	8,491	8,995	9,766	10,731
Fuel Inventory Costs	252	314	440	340	467	645	481	656	913
TOTAL DAILY FIXED COSTS ^a	9,124	9,733	10,782	11,887	12,871	14,217	14,815	15,984	16,761
1970 Operating Costs									
Wages	2,068	2,114	2,161	2,349	2,396	2,489	2,584	2,632	2,725
Subsistence	88	90	92	100	102	106	110	112	116
Stores, Supplies, & Equip.	160	160	160	200	200	200	220	220	220
Maintenance & Repairs	547	573	618	788	826	879	1,037	1,080	1,133
Insurance	1,201	1,292	1,445	1,603	1,712	1,963	1,974	2,125	2,483
Other Misc. Vessel Expense	72	72	72	80	80	80	85	85	85
Amortization Charges	5,609	6,023	6,748	7,592	8,267	9,122	9,777	10,568	11,564
Fuel Inventory Costs	252	314	440	340	467	645	481	656	913
TOTAL DAILY FIXED COSTS ^a	9,997	10,638	11,736	13,090	14,050	15,484	16,268	17,478	19,239

^a-Excluding variable fuel cost.

RESULTS

GRAPHICAL RESULTS

SPEED DISTANCE COMBINATIONS WHEREIN COST PER TON IS EQUAL FOR NUCLEAR AND CONVENTIONAL SHIPS

Areas wherein the cost of moving cargo is equal for nuclear and conventional tankers are shown for 1965 and 1970, as a function of speed and distance in Figures 1 and 2. No plot is shown for 1957 because only two "break-even" points are indicated for that year and they are both on the 20,000-mile round trip trade route.

These data are in good agreement with the results presented in the previous report, indicating that nuclear ships become competitive with conventional ships at shorter trade route distances as the speed of the ship is increased. They also indicate increasing competitiveness in the future.

COST PER TON vs SPEED

Cost per ton of cargo is shown as a function of speed for 1957, 1965, and 1970 in Figures 3, 4, and 5, respectively. These plots represent a 20,000-mile round trip trade route, and the nuclear ship represented in each case is the one with the lowest cost per ton in its size and speed class. Results of the previous study for ship sizes A, B, and C are included to facilitate direct comparisons.

REVENUE INDEX vs SPEED

"Revenue Index" curves are shown for 4,000, 12,000, and 20,000-mile round trip trade routes for the years 1957, 1965, and 1970 in Figures 6 through 14. Revenue Index, as described in the previous report, is the ratio of unit cargo revenue that must be earned by a nuclear vessel to that earned by a conventional counterpart so that both vessels will have the same return on investment. These index curves are shown as a function of speed for all tankers of each size and speed class with each reactor type. The trends shown are similar to and in good agreement with those previously indicated for tanker sizes A, B and C.

Tankers - 1965

FIGURE 1 -- SPEED-DISTANCE COMBINATIONS WHEREIN COST PER TON IS EQUAL FOR NUCLEAR AND CONVENTIONAL SHIPS

Tankers - 1970

FIGURE 2 -- SPEED-DISTANCE COMBINATIONS WHEREIN COST PER TON IS EQUAL FOR NUCLEAR AND CONVENTIONAL SHIPS

Tankers - 1957

FIGURE 3 -- COST PER TON vs SPEED

Tankers - 1965

FIGURE 4 -- COST PER TON vs SPEED

Tankers - 1970

FIGURE 5 -- COST PER TON vs SPEED

Revenue Index

FIGURE 6--REVENUE INDEX VS. SPEED FOR FIXED RETURN ON INVESTMENT

FIGURE 7--REVENUE INDEX VS. SPEED FOR FIXED RETURN ON INVESTMENT

FIGURE 8--REVENUE INDEX VS. SPEED FOR FIXED RETURN ON INVESTMENT

FIGURE 9--REVENUE INDEX VS. SPEED FOR FIXED RETURN ON INVESTMENT

FIGURE 10--REVENUE INDEX VS. SPEED FOR FIXED RETURN ON INVESTMENT

Tankers

20,000 Mile Trade Route

- 1965 -

FIGURE 11 -- REVENUE INDEX VS. SPEED FOR FIXED RETURN ON INVESTMENT

FIGURE 12 -- REVENUE INDEX VS. SPEED FOR FIXED RETURN ON INVESTMENT

FIGURE 13 -- REVENUE INDEX VS. SPEED FOR FIXED RETURN ON INVESTMENT

Revenue Index

FIGURE 14--REVENUE INDEX VS. SPEED FOR FIXED RETURN ON INVESTMENT

TABULAR RESULTS

COST PER TON AND REVENUE INDEX

The relative economic position of the various power plants is given as a function of cost per ton of cargo for 1957, 1965, and 1970 in Tables XII through XXVI. These tables also show annual operating costs and revenue index at 0% return on investment for each vessel on each of the trade routes investigated. In most cases vessels powered by the OMR reactors operate at a lower cost per ton of cargo than the other nuclear ships. The BWR-powered tankers, however, usually operate at a cost within a few cents above, and in many cases a few cents below, that of the OMR-powered tankers. In a few cases, the PWR-powered ships can operate at the lowest unit cost.

The influence of fuel cost is observed in a comparison of the annual operating costs given in these tables. Increasing speed has a decided effect on annual operating costs because of the greater fuel consumption at high speeds. Increasing trade route length has practically no effect at the lower speeds, but operating costs increase considerably with trade route length at the higher speeds. This is because of the higher ratio of sea time on the longer routes. Daily costs in port are not affected by speed, whereas daily costs at sea increase rapidly with speed, as mentioned above.

The Revenue Index number (I_0) is useful in making several comparisons, e.g., return on investment, as explained in the previous report.

TABLE XII

REACTOR TYPE COMPARISONS

Tankers, 4,000 Mile Trade Route - 1957

<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Operating Cost \$10³</u>	<u>Revenue Index (I₀)</u>
E	15.30	Conv.	2.95	2127	
		OMR	3.79	2736	1.284
		BWR	3.84	2770	1.302
		PWR	3.85	2780	1.306
		GCR	4.47	3211	1.516
	17.26	Conv.	3.20	2293	
		OMR	4.09	2955	1.279
		BWR	4.14	2984	1.294
		PWR	4.17	3009	1.304
		GCR	4.89	3504	1.527
	19.92	Conv.	3.75	2587	
		OMR	4.74	3335	1.264
		BWR	4.78	3663	1.274
		PWR	4.83	3401	1.288
		GCR	5.76	4018	1.535
F	16.75	Conv.	2.20	2934	
		OMR	2.72	3635	1.233
		BWR	2.74	3668	1.245
		PWR	2.76	3692	1.253
		GCR	3.16	4214	1.434
	18.90	Conv.	2.44	3224	
		OMR	3.00	3998	1.226
		BWR	3.02	4030	1.235
		PWR	3.05	4071	1.247
		GCR	3.55	4715	1.452
	21.82	Conv.	2.79	3576	
		OMR	3.41	4433	1.222
		BWR	3.42	4483	1.226
		PWR	3.47	4547	1.244
		GCR	4.10	5339	1.471
G	17.76	Conv.	1.90	3827	
		BWR	2.29	4636	1.201
		PWR	2.31	4685	1.213
		OMR	2.32	4681	1.216
		GCR	2.65	5347	1.390
	20.08	Conv.	2.09	4181	
		OMR	2.48	5027	1.190
		BWR	2.49	5065	1.193
		PWR	2.52	5130	1.208
		GCR	2.94	5941	1.406
	23.18	Conv.	2.37	4614	
		OMR	2.82	5590	1.189
		BWR	2.86	5707	1.207
		PWR	2.90	5786	1.224
		GCR	3.39	6735	1.433

TABLE XIII

REACTOR TYPE COMPARISONS

Tankers, 8,000 Mile Trade Route - 1957

<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Operating Cost \$10³</u>	<u>Revenue Index (I₀)</u>
E	15.30	Conv.	5.12	2129	
		OMR	6.45	2740	1.259
		BWR	6.53	2768	1.274
		PWR	6.55	2777	1.278
		GCR	7.60	3208	1.484
	17.26	Conv.	5.56	2312	
		OMR	6.90	2976	1.241
		BWR	6.95	2993	1.250
		PWR	7.00	3015	1.259
		GCR	8.21	3515	1.476
	19.92	Conv.	6.61	2647	
		BWR	7.92	3394	1.198
		OMR	7.92	3389	1.197
		PWR	8.00	3428	1.210
		GCR	9.55	4058	1.445
F	16.75	Conv.	3.79	2947	
		OMR	4.59	3650	1.210
		BWR	4.62	3670	1.217
		PWR	4.64	3692	1.224
		GCR	5.32	4219	1.404
	18.90	Conv.	4.22	3279	
		BWR	5.02	4054	1.188
		OMR	5.02	4046	1.187
		PWR	5.07	4091	1.199
		GCR	5.91	4748	1.399
	21.82	Conv.	4.85	3685	
		BWR	5.60	4532	1.155
		OMR	5.61	4504	1.156
		PWR	5.68	4592	1.170
		GCR	6.74	5408	1.388
G	17.76	Conv.	3.28	3871	
		BWR	3.83	4651	1.168
		PWR	3.87	4695	1.179
		OMR	3.90	4718	1.189
		GCR	4.44	5371	1.354
	20.08	Conv.	3.61	4281	
		BWR	4.12	5106	1.143
		OMR	4.13	5089	1.144
		PWR	4.17	5167	1.156
		GCR	4.87	6002	1.350
	23.18	Conv.	4.11	4797	
		OMR	4.62	5702	1.122
		BWR	4.66	5785	1.131
		PWR	4.72	5865	1.147
		GCR	5.55	6847	1.347

TABLE XIV

REACTOR TYPE COMPARISONS

Tankers, 12,000 Mile Trade Route - 1957

<u>Ship Size</u>	<u>Speed (Knts)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Operating Cost \$10³</u>	<u>Revenue Index (I₀)</u>
E	15.30	Conv.	7.39	2129	
		OMR	9.11	2742	1.233
		BWR	9.21	2767	1.247
		PWR	9.24	2775	1.250
		GCR	10.73	3208	1.452
	17.26	Conv.	8.06	2320	
		OMR	9.72	2985	1.204
		BWR	9.77	2996	1.211
		PWR	9.83	3018	1.219
		GCR	11.54	3520	1.430
	19.92	Conv.	9.76	2674	
		BWR	11.06	3408	1.132
		OMR	11.09	3413	1.135
		PWR	11.17	3440	1.143
		GCR	13.35	4075	1.366
F	16.75	Conv.	5.44	2954	
		OMR	6.46	3656	1.138
		BWR	6.49	3671	1.193
		PWR	6.53	3691	1.200
		GCR	7.49	4221	1.376
	18.90	Conv.	6.11	3303	
		BWR	7.03	4064	1.150
		OMR	7.04	4067	1.151
		PWR	7.09	4099	1.160
		GCR	8.28	4763	1.354
	21.82	Conv.	7.09	3735	
		BWR	7.79	4554	1.097
		OMR	7.82	4535	1.101
		PWR	7.89	4613	1.111
		GCR	9.37	5439	1.320
G	17.76	Conv.	4.70	3891	
		BWR	5.37	4657	1.141
		PWR	5.42	4700	1.152
		OMR	5.48	4734	1.164
		GCR	6.23	5381	1.323
	20.08	Conv.	5.21	4326	
		BWR	5.75	5124	1.103
		OMR	5.77	5116	1.107
		PWR	5.82	5183	1.116
		GCR	6.80	6029	1.304
	23.18	Conv.	6.01	4881	
		OMR	6.42	5753	1.067
		BWR	6.46	5820	1.073
		PWR	6.55	5901	1.088
		GCR	7.70	6898	1.280

TABLE XV

REACTOR TYPE COMPARISONS

Tankers, 16,000 Mile Trade Route - 1957

<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Operating Cost \$10³</u>	<u>Revenue Index (I_o)</u>
E	15.30	Conv.	9.75	2130	
		OMR	11.78	2743	1.208
		BWR	11.90	2767	1.220
		PWR	11.93	2774	1.223
		GCR	13.86	3207	1.421
	17.26	Conv.	10.72	2325	
		OMR	12.53	2990	1.167
		BWR	12.58	2998	1.172
		PWR	12.67	3020	1.180
		GCR	14.86	3523	1.385
	19.92	Conv.	13.27	2689	
		BWR	14.20	3415	1.070
		OMR	14.26	3427	1.075
		PWR	14.33	3447	1.080
		GCR	17.14	4085	1.291
F	16.75	Conv.	7.15	2957	
		OMR	8.33	3660	1.166
		BWR	8.36	3671	1.170
		PWR	8.41	3691	1.176
		GCR	9.65	4222	1.350
	18.90	Conv.	8.11	3317	
		BWR	9.03	4070	1.114
		OMR	9.06	4078	1.117
		PWR	9.11	4104	1.123
		GCR	10.64	4771	1.312
	21.82	Conv.	9.55	3764	
		BWR	9.98	4567	1.045
		OMR	10.02	4553	1.049
		PWR	10.10	4624	1.058
		GCR	12.01	5456	1.257
G	17.76	Conv.	6.19	3902	
		BWR	6.91	4660	1.117
		PWR	6.98	4703	1.127
		OMR	7.06	4743	1.140
		GCR	8.02	5387	1.295
	20.08	Conv.	6.91	4352	
		BWR	7.39	5134	1.068
		OMR	7.42	5132	1.072
		PWR	7.47	5192	1.079
		GCR	8.74	6044	1.263
	23.18	Conv.	8.08	4931	
		OMR	8.22	5782	1.017
		BWR	8.26	5841	1.021
		PWR	8.37	5921	1.035
		GCR	9.85	6927	1.218

TABLE XVI

REACTOR TYPE COMPARISONS

Tankers, 20,000 Mile Trade Route - 1957

<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Operating Cost \$10³</u>	<u>Revenue Index (I₀)</u>
E	15.30	Conv.	12.22	2130	
		OMR	14.44	2743	1.182
		BWR	14.59	2767	1.193
		PWR	14.62	2774	1.197
		GCR	16.99	3207	1.390
	17.26	Conv.	13.56	2329	
		OMR	15.34	2993	1.131
		BWR	15.39	2999	1.135
		PWR	15.50	3021	1.143
		GCR	18.19	3524	1.341
	19.92	Conv.	17.18	2700	
		BWR	17.35	3420	1.009
		OMR	17.44	3435	1.015
		PWR	17.50	3451	1.018
		GCR	20.93	4092	1.218
F	16.75	Conv.	8.92	2960	
		OMR	10.21	3662	1.143
		BWR	10.24	3671	1.147
		PWR	10.29	3691	1.153
		GCR	11.81	4223	1.323
	18.90	Conv.	10.23	3326	
		BWR	11.04	4074	1.079
		OMR	11.08	4085	1.083
		PWR	11.13	4107	1.088
		GCR	13.01	4776	1.271
	21.82	BWR	12.16	4575	0.994
		OMR	12.23	4564	0.999
		Conv.	12.23	3783	
		PWR	12.31	4631	1.006
		GCR	14.64	5467	1.197
G	17.76	Conv.	7.74	3910	
		BWR	8.46	4663	1.093
		PWR	8.53	4704	1.102
		OMR	8.64	4749	1.116
		GCR	9.81	5391	1.267
	20.08	Conv.	8.72	4369	
		BWR	9.02	5141	1.033
		OMR	9.06	5142	1.038
		PWR	9.11	5198	1.045
		GCR	10.67	6053	1.223
	23.18	OMR	10.02	5800	0.969
		BWR	10.06	5854	0.972
		PWR	10.20	5934	0.985
		Conv.	10.34	4964	
		GCR	12.00	6946	1.160

TABLE XVII
REACTOR TYPE COMPARISONS
Tankers, 4000 Mile Trade Route - 1965

<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Operating Cost \$10³</u>	<u>Revenue Index (I₀)</u>
E	15.30	Conv.	3.58	2581	
		OMR	4.34	3132	1.211
		BWR	4.42	3183	1.233
		PWR	4.42	3186	1.234
		GCR	4.96	3555	1.384
	17.26	Conv.	3.86	2766	
		OMR	4.65	3352	1.203
		BWR	4.72	3397	1.221
		PWR	4.75	3423	1.230
		GCR	5.35	3835	1.386
	19.92	Conv.	4.48	3091	
		OMR	5.31	3733	1.184
		BWR	5.37	3776	1.197
		PWR	5.43	3817	1.210
		GCR	6.21	4330	1.385
F	16.75	Conv.	2.67	3544	
		OMR	3.11	4158	1.167
		BWR	3.14	4195	1.178
		PWR	3.17	4226	1.187
		GCR	3.50	4663	1.314
	18.90	Conv.	2.93	3863	
		OMR	3.39	4517	1.156
		BWR	3.43	4572	1.169
		PWR	3.46	4611	1.179
		GCR	3.87	5140	1.321
	21.82	Conv.	3.32	4253	
		OMR	3.85	5001	1.159
		BWR	3.85	5043	1.160
		PWR	3.89	5100	1.173
		GCR	4.42	5751	1.332
G	17.76	Conv.	2.29	4596	
		BWR	2.62	5302	1.144
		OMR	2.62	5290	1.145
		PWR	2.64	5351	1.154
		GCR	2.92	5887	1.274
	20.08	Conv.	2.49	4982	
		OMR	2.83	5716	1.135
		BWR	2.83	5744	1.135
		PWR	2.86	5801	1.146
		GCR	3.20	6454	1.282
	23.18	Conv.	2.80	5457	
		OMR	3.17	6283	1.130
		BWR	3.21	6394	1.144
		PWR	3.23	6443	1.153
		GCR	3.48	6903	1.242

TABLE XVIII
REACTOR TYPE COMPARISONS
Tankers, 8000 Mile Trade Route - 1965

<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Operating Cost \$10³</u>	<u>Revenue Index (I₀)</u>
E	15.30	Conv.	6.22	2583	
		OMR	7.38	3131	1.185
		BWR	7.50	3178	1.205
		PWR	7.50	3179	1.205
		GCR	8.42	3551	1.353
	17.26	Conv.	6.71	2787	
		OMR	7.81	3364	1.164
		BWR	7.90	3399	1.178
		PWR	7.96	3424	1.186
		GCR	8.98	3841	1.338
	19.92	Conv.	7.88	3154	
		OMR	8.81	3771	1.118
		BWR	8.86	3797	1.124
		PWR	8.95	3834	1.135
		GCR	10.27	4360	1.303
F	16.75	Conv.	4.58	3559	
		OMR	5.24	4164	1.143
		BWR	5.28	4189	1.151
		PWR	5.31	4220	1.159
		GCR	5.89	4662	1.285
	18.90	Conv.	5.06	3920	
		OMR	5.64	4549	1.116
		BWR	5.69	4585	1.124
		PWR	5.73	4621	1.133
		GCR	6.43	5164	1.272
	21.82	Conv.	5.75	4367	
		BWR	6.28	5077	1.092
		OMR	6.31	5062	1.096
		PWR	6.35	5131	1.103
		GCR	7.24	5804	1.257
G	17.76	Conv.	3.93	4643	
		BWR	4.37	5306	1.111
		OMR	4.39	5311	1.116
		PWR	4.41	5353	1.121
		GCR	4.88	5901	1.240
	20.08	Conv.	4.29	5088	
		BWR	4.66	5770	1.087
		OMR	4.68	5768	1.091
		PWR	4.71	5824	1.096
		GCR	5.28	6500	1.230
	23.18	Conv.	4.85	5648	
		OMR	5.17	6378	1.066
		BWR	5.20	6450	1.071
		PWR	5.24	6497	1.079
		GCR	5.67	6992	1.168

TABLE XIX
REACTOR TYPE COMPARISONS
Tankers, 12,000 Mile Trade Route - 1965

<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Operating Cost \$10³</u>	<u>Revenue Index (I₀)</u>
E	15.30	Conv.	8.97	2585	
		OMR	10.41	3131	1.161
		BWR	10.58	3176	1.179
		PWR	10.58	3177	1.179
		GCR	11.88	3549	1.325
	17.26	Conv.	9.72	2796	
		OMR	10.97	3370	1.129
		BWR	11.09	3401	1.141
		PWR	11.16	3425	1.148
		GCR	12.60	3844	1.296
	19.92	Conv.	11.63	3183	
		OMR	12.31	3788	1.059
		BWR	12.36	3806	1.063
		PWR	12.47	3842	1.073
		GCR	14.33	4374	1.232
F	16.75	Conv.	6.57	3567	
		OMR	7.37	4166	1.121
		BWR	7.41	4188	1.128
		PWR	7.46	4218	1.136
		GCR	8.28	4663	1.259
	18.90	Conv.	7.30	3946	
		OMR	7.90	4563	1.082
		BWR	7.94	4592	1.088
		PWR	8.00	4626	1.096
		GCR	8.99	5175	1.232
	21.82	Conv.	8.40	4420	
		BWR	8.72	5093	1.037
		OMR	8.77	5089	1.044
		PWR	8.81	5146	1.048
		GCR	10.05	5829	1.196
G	17.76	Conv.	5.64	4665	
		BWR	6.13	5308	1.086
		OMR	6.16	5321	1.092
		PWR	6.18	5354	1.095
		GCR	6.84	5908	1.212
	20.08	Conv.	6.19	5136	
		BWR	6.50	5782	1.049
		OMR	6.54	5791	1.056
		PWR	6.56	5834	1.058
		GCR	7.36	6520	1.189
	23.18	Conv.	7.07	5737	
		OMR	7.17	6421	1.014
		BWR	7.19	6476	1.016
		PWR	7.24	6522	1.024
		GCR	7.85	7033	1.110

TABLE XX
REACTOR TYPE COMPARISONS
Tankers, 16,000 Mile Trade Route - 1965

<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Operating Cost \$10³</u>	<u>Revenue Index (I₀)</u>
E	15.30	Conv.	11.84	2585	
		OMR	13.45	3131	1.136
		PWR	13.66	3175	1.154
		BWR	13.66	3175	1.154
		GCR	15.34	3548	1.296
	17.26	Conv.	12.92	2801	
		OMR	14.13	3373	1.094
		BWR	14.28	3402	1.105
		PWR	14.37	3425	1.112
		GCR	16.23	3845	1.255
	19.92	Conv.	15.79	3199	
		OMR	15.81	3798	1.002
		BWR	15.85	3811	1.004
		PWR	16.00	3847	1.013
		GCR	18.38	4381	1.165
F	16.75	Conv.	8.63	3571	
		OMR	9.49	4168	1.100
		BWR	9.54	4186	1.105
		PWR	9.61	4216	1.113
		GCR	10.66	4663	1.235
	18.90	Conv.	9.69	3961	
		OMR	10.16	4570	1.048
		BWR	10.20	4595	1.053
		PWR	10.28	4629	1.061
		GCR	11.56	5180	1.193
	21.82	BWR	11.15	5101	0.987
		OMR	11.24	5105	0.995
		PWR	11.26	5153	0.997
		Conv.	11.29	4451	
		GCR	12.86	5842	1.129
G	17.75	Conv.	7.42	4677	
		BWR	7.88	5309	1.062
		OMR	7.93	5326	1.069
		PWR	7.95	5354	1.071
		GCR	8.80	5911	1.186
	20.08	Conv.	8.21	5163	
		BWR	8.33	5789	1.015
		OMR	8.39	5804	1.023
		PWR	8.40	5840	1.024
		GCR	9.45	6531	1.151
	23.18	OMR	9.17	6446	0.966
		BWR	9.18	6491	0.967
		PWR	9.25	6536	0.974
		Conv.	9.49	5789	
		GCR	10.04	7056	1.057

TABLE XXI

REACTOR TYPE COMPARISONS

Tankers, 20,000 Mile Trade Route - 1965

<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Operating Cost \$10³</u>	<u>Revenue Index (I₀)</u>
E	15.30	Conv.	14.83	2586	
		OMR	16.48	3131	1.112
		PWR	16.74	3175	1.129
		BWR	16.74	3175	1.129
		GCR	18.80	3547	1.268
	17.26	Conv.	16.33	2805	
		OMR	17.30	3375	1.059
		BWR	17.46	3402	1.069
		PWR	17.57	3425	1.076
		GCR	19.85	3846	1.215
	19.92	OMR	19.31	3804	0.946
		BWR	19.35	3814	0.947
		PWR	19.52	3849	0.956
		Conv.	20.42	3210	
		GCR	22.44	4386	1.099
F	16.75	Conv.	10.77	3573	
		OMR	11.62	4169	1.079
		BWR	11.68	4186	1.084
		PWR	11.76	4215	1.091
		GCR	13.05	4663	1.211
	18.90	Conv.	12.21	3971	
		OMR	12.41	4575	1.016
		BWR	12.46	4597	1.020
		PWR	12.55	4631	1.028
		GCR	14.12	5184	1.156
	21.82	BWR	13.58	5107	0.939
		OMR	13.70	5114	0.948
		PWR	13.72	5158	0.949
		Conv.	14.46	4471	
		GCR	15.67	5851	1.084
G	17.76	Conv.	9.27	4684	
		BWR	9.63	5310	1.039
		OMR	9.70	5329	1.046
		PWR	9.71	5354	1.047
		GCR	10.76	5913	1.161
	20.08	BWR	10.17	5793	0.983
		OMR	10.25	5812	0.991
		PWR	10.25	5844	0.991
		Conv.	10.34	5181	
		GCR	11.53	6539	1.114
	23.18	OMR	11.17	6462	0.920
		BWR	11.17	6500	0.920
		PWR	11.25	6545	0.927
		Conv.	12.14	5824	
		GCR	12.23	7071	1.007

TABLE XXII
REACTOR TYPE COMPARISONS

Tankers, 4,000 Mile Trade Route - 1970					
Ship Size	Speed (Knots)	Power Plant Type	Cost per Ton of Cargo (\$)	Annual Operating Cost \$10 ³	Revenue Index (I ₀)
E	15.30	Conv.	4.05	2920	
		OMR	4.73	3414	1.168
		BWR	4.83	3484	1.193
		PWR	4.84	3489	1.195
		GCR	5.37	3848	1.325
	17.26	Conv.	4.35	3117	
		OMR	5.03	3627	1.155
		BWR	5.15	3706	1.182
		PWR	5.17	3724	1.188
		GCR	5.77	4133	1.326
	19.92	Conv.	5.02	3460	
		OMR	5.68	3995	1.133
		BWR	5.78	4068	1.153
		PWR	5.86	4121	1.167
		GCR	6.64	4628	1.323
F	16.75	Conv.	3.01	3996	
		OMR	3.40	4540	1.131
		BWR	3.46	4620	1.151
		PWR	3.48	4644	1.157
		GCR	3.81	5065	1.266
	18.90	Conv.	3.28	4331	
		OMR	3.65	4871	1.113
		BWR	3.72	4960	1.132
		PWR	3.76	5010	1.143
		GCR	4.15	5516	1.265
	21.82	Conv.	3.70	4744	
		OMR	4.12	5355	1.113
		BWR	4.13	5408	1.115
		PWR	4.17	5465	1.127
		GCR	4.72	6144	1.276
G	17.76	Conv.	2.57	5161	
		OMR	2.84	5736	1.106
		BWR	2.85	5777	1.110
		PWR	2.89	5848	1.124
		GCR	3.15	6359	1.226
	20.08	Conv.	2.78	5564	
		OMR	3.05	6151	1.094
		BWR	3.06	6200	1.098
		PWR	3.10	6290	1.113
		GCR	3.43	6922	1.231
	23.18	Conv.	3.12	6063	
		OMR	3.39	6715	1.088
		BWR	3.41	6805	1.096
		PWR	3.48	6928	1.116
		GCR	3.89	7714	1.250

TABLE XXIII

REACTOR TYPE COMPARISONS

Tankers, 8,000 Mile Trade Route - 1970

<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Operating Cost \$10³</u>	<u>Revenue Index (I₀)</u>
E	15.30	Conv.	7.03	2922	
		OMR	8.03	3409	1.141
		PWR	8.21	3480	1.167
		BWR	8.21	3480	1.167
		GCR	9.11	3841	1.295
	17.26	Conv.	7.55	3138	
		OMR	8.43	3631	1.116
		BWR	8.62	3710	1.142
		PWR	8.65	3721	1.145
		GCR	9.66	4135	1.280
	19.92	Conv.	8.80	3523	
		OMR	9.38	4016	1.066
		BWR	9.54	4088	1.084
		PWR	9.64	4130	1.095
		GCR	10.95	4651	1.244
F	16.75	Conv.	5.16	4011	
		OMR	5.71	4537	1.105
		BWR	5.81	4616	1.126
		PWR	5.83	4634	1.130
		GCR	6.39	5060	1.238
	18.90	Conv.	5.66	4388	
		OMR	6.06	4886	1.071
		BWR	6.17	4973	1.090
		PWR	6.21	5011	1.098
		GCR	6.89	5531	1.218
	21.82	Conv.	6.40	4858	
		OMR	6.72	5391	1.050
		BWR	6.73	5441	1.052
		PWR	6.78	5481	1.060
		GCR	7.71	6185	1.204
G	17.76	Conv.	4.41	5208	
		OMR	4.75	5741	1.076
		BWR	4.76	5779	1.079
		PWR	4.81	5841	1.091
		GCR	5.26	6366	1.193
	20.08	Conv.	4.78	5670	
		OMR	5.02	6179	1.049
		BWR	5.03	6225	1.052
		PWR	5.09	6299	1.064
		GCR	5.65	6955	1.181
	23.18	Conv.	5.37	6254	
		OMR	5.49	6775	1.023
		BWR	5.53	6863	1.030
		PWR	5.61	6960	1.045
		GCR	6.31	7785	1.175

TABLE XXIV

REACTOR TYPE COMPARISONS

Tankers, 12,000 Mile Trade Route - 1970

<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Operating Cost \$10³</u>	<u>Revenue Index (I₀)</u>
E	15.20	Conv.	10.14	2923	
		OMR	11.33	3407	1.117
		PWR	11.57	3476	1.141
		BWR	11.58	3477	1.142
		GCR	12.85	3838	1.266
	17.26	Conv.	10.94	3147	
		OMR	11.83	3632	1.081
		BWR	12.10	3711	1.106
		PWR	12.12	3719	1.108
		GCR	13.56	4136	1.239
	19.92	Conv.	12.97	3551	
		OMR	13.08	4026	1.002
		BWR	13.30	4097	1.025
		PWR	13.42	4133	1.034
		GCR	15.26	4660	1.176
F	16.75	Conv.	7.40	4018	
		OMR	8.02	4535	1.083
		BWR	8.17	4615	1.103
		PWR	8.19	4629	1.106
		GCR	8.98	5058	1.213
	18.90	Conv.	8.17	4414	
		OMR	8.47	4892	1.037
		BWR	8.61	4978	1.054
		PWR	8.67	5012	1.061
		GCR	9.63	5538	1.178
	21.82	OMR	9.32	5408	0.999
		Conv.	9.33	4911	
		BWR	9.33	5456	1.000
		PWR	9.39	5489	1.006
		GCR	10.69	6203	1.145
G	17.76	Conv.	6.33	5229	
		OMR	6.65	5743	1.051
		BWR	6.67	5780	1.055
		PWR	6.74	5838	1.065
		GCR	7.37	6368	1.166
	20.08	Conv.	6.89	5717	
		OMR	6.99	6191	1.014
		BWR	7.01	6235	1.016
		PWR	7.08	6302	1.027
		GCR	7.87	6969	1.141
	23.18	OMR	7.60	6802	0.971
		BWR	7.65	6889	0.978
		PWR	7.75	6975	0.990
		Conv.	7.82	6343	
		GCR	8.73	7818	1.116

TABLE XXV

REACTOR TYPE COMPARISONS

Tankers, 16,000 Mile Trade Route - 1970

<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Operating Cost \$10³</u>	<u>Revenue Index (I₀)</u>
E	15.30	Conv.	13.38	2924	
		OMR	14.63	3405	1.093
		PWR	14.94	3474	1.116
		BWR	14.95	3476	1.117
		GCR	16.59	3836	1.239
	17.26	Conv.	14.54	3152	
		OMR	15.22	3633	1.047
		BWR	15.58	3712	1.071
		PWR	15.60	3718	1.073
		GCR	17.45	4136	1.200
	19.92	OMR	16.78	4031	0.953
		BWR	17.06	4102	0.969
		PWR	17.20	4136	0.977
		Conv.	17.60	3568	
		GCR	19.58	4666	1.112
F	16.75	Conv.	9.72	4022	
		OMR	10.33	4535	1.062
		BWR	10.52	4614	1.082
		PWR	10.55	4627	1.084
		GCR	11.56	5057	1.189
	18.90	Conv.	10.83	4429	
		OMR	10.88	4895	1.004
		BWR	11.06	4981	1.021
		PWR	11.13	5012	1.028
		GCR	12.36	5542	1.142
	21.82	OMR	11.93	5417	0.951
		BWR	11.94	5464	0.952
		PWR	12.00	5493	0.957
		Conv.	12.54	4942	
		GCR	13.68	6213	1.091
G	17.76	Conv.	8.32	5241	
		OMR	8.55	5745	1.028
		BWR	8.58	5780	1.032
		PWR	8.66	5836	1.041
		GCR	9.49	6370	1.140
	20.08	OMR	8.96	6197	0.981
		BWR	8.98	6241	0.984
		PWR	9.07	6304	0.993
		Conv.	9.13	5745	
		GCR	10.09	6977	1.105
	23.18	OMR	9.70	6817	0.925
		BWR	9.77	6904	0.931
		PWR	9.88	6983	0.942
		Conv.	10.49	6395	
		GCR	11.15	7836	1.063

TABLE XXVI
REACTOR TYPE COMPARISONS

Tankers, 20,000 Mile Trade Route - 1970					
<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Operating Cost \$10³</u>	<u>Revenue Index (I₀)</u>
E	15.30	Conv.	16.77	2924	
		OMR	17.93	3405	1.069
		PWR	18.31	3472	1.092
		BWR	18.33	3476	1.093
		GCR	20.33	3835	1.212
	17.26	Conv.	18.37	3156	
		OMR	18.62	3634	1.013
		BWR	19.06	3713	1.037
		PWR	19.08	3718	1.038
		GCR	21.35	4137	1.162
	19.92	OMR	20.48	4035	0.899
		BWR	20.82	4105	0.914
		PWR	20.98	4137	0.921
		Conv.	22.77	3578	
		GCR	23.89	4669	1.049
F	16.75	Conv.	12.14	4025	
		OMR	12.64	4534	1.042
		BWR	12.87	4614	1.061
		PWR	12.90	4625	1.063
		GCR	14.15	5057	1.166
	18.90	OMR	13.29	4898	0.973
		BWR	13.51	4983	0.989
		PWR	13.59	5013	0.995
		Conv.	13.65	4438	
		GCR	15.10	5544	1.106
	21.82	OMR	14.53	5423	0.905
		BWR	14.54	5469	0.906
		PWR	14.61	5496	0.911
		Conv.	16.05	4962	
		GCR	16.66	6220	1.038
G	17.76	Conv.	10.39	5249	
		OMR	10.46	5745	1.006
		BWR	10.49	5781	1.009
		PWR	10.59	5835	1.019
		GCR	11.60	6371	1.116
	20.08	OMR	10.93	6202	0.950
		BWR	10.96	6245	0.952
		PWR	11.06	6306	0.961
		Conv.	11.51	5763	
		GCR	12.31	6983	1.070
	23.18	OMR	11.80	6827	0.881
		BWR	11.88	6914	0.887
		PWR	12.01	6988	0.896
		Conv.	13.40	6429	
		GCR	13.57	7848	1.012

RETURN ON INVESTMENT AND ANNUAL PROFIT

Three actual trade routes were simulated to obtain a comparison of earning power of the various tankers. Tariff rates were taken as the nine-year average of monthly, single-voyage dirty-tanker, charter rates paid during the period January 1948 through December 1956.*

Table XXVII gives cost per ton of cargo, annual profit, and return on investment for United States built and operated tankers on the Aruba to New York run for 1957. This is a round trip route of 3,500 miles and the average tariff rate used is \$3.04/ton. This table shows the inability of nuclear vessels to compete with conventional vessels on short trade routes at the present time.

Performance of the various tankers carrying oil from Borneo to San Francisco, a distance of 14,000 miles round trip is shown in Table XXVIII. The tariff rate on this run is taken at \$11.20 per ton. Here the competition offered by the nuclear vessels analyzed in this project is somewhat better than on the shorter route, but the conventional vessels are still much better money earners except in the largest and highest speed classes.

The third actual trade route simulated was from Kuwait to New York. On this run it is assumed that the smaller tankers, sizes A and E, can pass through the Suez Canal both loaded and in ballast, giving them a round trip distance of 16,500 miles. Sizes B and F are assumed to traverse the canal in ballast but not in the loaded condition. Therefore, they must travel 20,000 miles to make the round trip. The larger vessels cannot use the canal in either case and must, therefore, make the entire trip around the Cape of Good Hope. In this case the round trip distance is 23,500 miles.

*Analysis of World Tanker Fleet December 1956 Sun Oil Company, Statistical Research Department

The USMC flat rate is \$12.70 per ton via Suez and \$14.95 per ton via the Cape of Good Hope. However, it does not seem logical to pay more for oil carried one way than the other as long as both routes are open. For the present comparison, the previously mentioned average was used. Coincidentally this average is exactly the same as the USMC flat rate via Suez (\$12.70 per ton).

Canal fees were estimated by an approximation developed by Harry Benford,* on the basis of deadweight tonnage. For tankers passing both ways through the canal, this amounts to \$500 plus \$0.75 per deadweight ton for the round trip, and for those using the canal only in ballast, the fee was estimated as \$250 plus \$0.25 per deadweight ton. Table XXIX shows tanker performance in this application. All the nuclear tankers in the highest speed class, except those powered by GCR reactors, can compete successfully with their conventional counterparts, and the larger ones that ply around the Cape have considerably greater earning power than the conventional tankers in the same class.

Tables XXX through XXXV give the same data for these three trade routes for the years 1965 and 1970. Since costs are assumed to increase, but tariff rates are held constant (for this calculation), the earning power shown for all ships is lower than it is in 1957. This may be an indication of necessary tariff increases or subsidy requirements in the future which are beyond the scope of this project.

Nuclear ships are still at a disadvantage on the short Aruba to New York run in 1970.

On the Borneo to San Francisco route, the fast nuclear ships investigated here offer keen competition in 1965 and have a decided advantage over their conventional counterparts in 1970.

*Harry Benford, "Engineering Economy in Tanker Design", University of Michigan.

In 1965 the small and medium-sized nuclear ships in the second speed group compete on even terms on the Kuwait to New York run. Those in the highest speed group are superior to the conventional ships in earning power. The larger nuclear ships are competitive at all speeds, having a decided advantage at the higher speeds. In 1970, even the small, slow, nuclear ships compete on a nearly equal earning basis, while the larger nuclear tankers have better earning power at all speeds investigated.

TABLE XXVII

REACTOR TYPE COMPARISONS

Tankers, 3,500 Mile Trade Route - 1957

Trade Route	Ship Size	Speed (Knots)	Power Plant Type	Cost per Ton of Cargo (\$)	Annual Profit (Loss) \$10 ³	Return on Investment (%)
Aruba to New York 3,500 miles round trip Tariff \$3.04	A	14.29	Conv.	3.43	(195)	(2.24)
			PWR	4.66	(795)	(6.29)
			BWR	4.66	(792)	(6.30)
			OMR	4.54	(738)	(6.17)
			GCR	5.43	(1166)	(7.04)
		16.16	Conv.	3.69	(316)	(3.45)
			PWR	5.04	(974)	(7.18)
			BWR	5.03	(967)	(7.19)
			OMR	4.92	(917)	(7.28)
			GCR	5.91	(1392)	(7.76)
		18.65	Conv.	4.20	(546)	(5.53)
			PWR	5.73	(1275)	(8.50)
			BWR	5.69	(1248)	(8.48)
			OMR	5.58	(1204)	(8.79)
			GCR	6.78	(1770)	(8.84)
	E	15.30	Conv.	2.69	279	2.44
			PWR	3.52	(380)	(2.38)
			BWR	3.51	(370)	(2.35)
			OMR	3.46	(330)	(2.21)
			GCR	4.09	(823)	(4.02)
		17.26	Conv.	2.92	96	0.80
			PWR	3.82	(616)	(3.59)
			BWR	3.79	(592)	(3.52)
			OMR	3.75	(556)	(3.52)
			GCR	4.48	(1124)	(5.05)
		19.92	Conv.	3.41	(281)	(2.17)
			PWR	4.44	(1070)	(5.57)
			BWR	4.39	(1031)	(5.54)
			OMR	4.35	(1000)	(5.74)
			GCR	5.29	(1705)	(6.73)
	B	15.95	Conv.	2.36	724	5.34
			PWR	3.02	24	0.13
			BWR	3.00	42	0.23
			OMR	2.97	76	0.44
			GCR	3.47	(459)	(1.96)
		18.03	Conv.	2.55	517	3.64
			PWR	3.27	(249)	(1.25)
			BWR	3.24	(207)	(1.06)
			OMR	3.19	(164)	(0.89)
			GCR	3.77	(775)	(3.06)
		20.82	Conv.	2.94	99	0.65
			PWR	3.71	(702)	(3.19)
			BWR	3.70	(686)	(3.21)
			OMR	3.72	(696)	(3.38)
			GCR	4.41	(1423)	(4.91)

TABLE XXVII (Cont.)

REACTOR TYPE COMPARISONS

Tankers, 3,500 Mile Trade Route - 1957

Trade Route	Ship Size	Speed (Knots)	Power Plant Type	Cost per Ton of Cargo (\$)	Annual Profit (Loss) \$10 ³	Return on Investment (%)
Aruba to New York 3,500 miles round trip Tariff \$3.04	F	16.75	Conv.	2.01	1495	9.03
			PWR	2.53	743	3.38
			BWR	2.51	766	3.56
			OMR	2.49	805	3.92
			GCR	2.90	208	0.76
		18.90	Conv.	2.23	1167	6.73
			PWR	2.80	349	1.46
			BWR	2.77	391	1.68
			OMR	2.75	424	1.93
			GCR	3.26	(313)	(1.04)
		21.82	Conv.	2.54	692	3.75
			PWR	3.20	(221)	(0.85)
			BWR	3.15	(157)	(0.62)
			OMR	3.14	(134)	(0.55)
			GCR	3.78	(1039)	(3.08)
	G	17.76	Conv.	1.74	2854	13.10
			PWR	2.12	2029	7.17
			BWR	2.10	2078	7.52
			OMR	2.12	2017	7.52
			GCR	2.43	1347	3.87
		20.08	Conv.	1.91	2468	10.88
			PWR	2.32	1584	5.24
			BWR	2.29	1648	5.59
			OMR	2.28	1660	5.81
			GCR	2.70	745	1.95
		23.18	Conv.	2.16	1857	7.81
			PWR	2.68	784	2.40
			BWR	2.64	866	2.72
			OMR	2.60	951	3.10
			GCR	3.13	(194)	(0.46)
	C	18.58	Conv.	1.54	4491	10.83
			PWR	1.85	3610	10.62
			BWR	1.81	3713	11.28
			OMR	1.81	3703	11.49
			GCR	2.09	2871	6.88
		21.00	Conv.	1.70	3999	14.42
			PWR	2.05	2976	8.22
			BWR	2.01	3099	8.72
			OMR	1.99	3164	9.22
			GCR	2.32	2179	4.78
		24.25	Conv.	1.99	3025	10.31
			PWR	2.44	1742	4.41
			BWR	2.41	1825	4.73
			OMR	2.38	1896	5.18
			GCR	2.82	643	1.25

TABLE XXVIII
REACTOR TYPE COMPARISONS

Trade Route	Ship Size	Tankers (1957)			Annual Profit (Loss) \$10 ³	Return on Investment (%)
		Speed (Knots)	Power Plant Type	Cost per Ton of Cargo (\$)		
Borneo to San Francisco 14,000 miles round trip Tariff \$11.20	A	14.29	Conv.	11.06	22	0.25
			PWR	14.20	(481)	(3.80)
			BWR	14.21	(481)	(3.82)
			OMR	13.88	(430)	(3.59)
			GCR	16.57	(852)	(5.15)
		16.16	Conv.	11.97	(117)	(1.28)
			PWR	15.01	(624)	(4.60)
			BWR	15.01	(622)	(4.63)
			OMR	14.76	(582)	(4.62)
			GCR	17.61	(1046)	(5.84)
		18.65	Conv.	14.11	(418)	(4.23)
			PWR	16.67	(899)	(5.99)
			BWR	16.55	(876)	(5.95)
			OMR	16.42	(857)	(6.26)
			GCR	19.74	(1403)	(7.00)
	E	15.30	Conv.	8.56	656	5.74
			PWR	10.59	160	1.00
			BWR	10.56	167	1.06
			OMR	10.45	196	1.31
			GCR	12.30	(288)	(1.41)
		17.26	Conv.	9.38	451	3.75
			PWR	11.25	(15)	(0.09)
			BWR	11.18	6	0.03
			OMR	11.13	20	0.13
			GCR	13.20	(534)	(2.40)
		19.92	Conv.	11.48	(64)	(0.49)
			PWR	12.75	(420)	(2.18)
			BWR	12.64	(388)	(2.08)
			OMR	12.68	(400)	(2.30)
			GCR	15.25	(1083)	(4.28)
	B	15.95	Conv.	7.46	1260	9.30
			PWR	9.00	784	4.24
			BWR	8.95	799	4.37
			OMR	8.91	816	4.73
			GCR	10.37	295	1.26
		18.03	Conv.	8.15	1025	7.21
			PWR	9.56	598	3.00
			BWR	9.46	636	3.27
			OMR	9.43	648	3.53
			GCR	11.03	61	0.24
		20.82	Conv.	9.77	460	3.02
			PWR	10.56	242	1.10
			BWR	10.57	232	1.08
			OMR	10.70	183	0.89
			GCR	12.60	(522)	(1.80)

TABLE XXVIII (Cont.)
REACTOR TYPE COMPARISONS

<u>Trade Route</u>	<u>Ship Size</u>	Tankers (1957)			<u>Annual Profit (Loss) \$10³</u>	<u>Return on Invest- ment (%)</u>
		<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>		
Borneo to San Francisco	F	16.75	Conv.	6.29	2309	13.95
			PWR	7.47	1841	8.39
			BWR	7.43	1861	8.63
			OMR	7.40	1877	9.15
			GCR	8.57	1294	4.76
	G	18.90	Conv.	7.10	1913	11.03
			PWR	8.10	1567	6.56
			BWR	8.04	1602	6.90
			OMR	8.05	1592	7.23
			GCR	9.46	874	2.89
14,000 miles round trip		21.82	Conv.	8.30	1312	7.11
			PWR	9.00	1129	4.36
			BWR	8.89	1186	4.71
			OMR	8.92	1160	4.77
			GCR	10.69	257	0.76
		17.76	Conv.	5.44	4122	18.93
			PWR	6.20	3788	13.38
			BWR	6.75	3829	13.85
			OMR	6.27	3722	13.87
			GCR	7.13	3076	8.84
Tariff \$11.20		20.08	Conv.	6.06	3687	16.26
			PWR	6.64	3553	11.76
			BWR	6.57	3609	12.25
			OMR	6.60	3573	12.51
			GCR	7.77	2660	6.96
		23.18	Conv.	7.03	2911	12.24
			PWR	7.47	2957	9.06
			BWR	7.36	3040	9.54
			OMR	7.33	3051	9.94
			GCR	8.78	1905	4.49
	C	18.58	Conv.	4.81	6333	23.74
			PWR	5.35	6138	18.05
			BWR	5.26	6236	18.93
			OMR	5.29	6184	19.19
			GCR	6.10	5371	12.88
		21.00	Conv.	5.37	5786	20.86
			PWR	5.84	5785	15.98
			BWR	5.72	5912	16.64
			OMR	5.70	5915	17.24
			GCR	6.63	4955	10.86
		24.25	Conv.	6.56	4442	15.15
			PWR	6.80	4770	12.09
			BWR	6.74	4838	12.53
			OMR	6.75	4793	13.09
			GCR	7.91	3597	7.01

TABLE XXIX
REACTOR TYPE COMPARISONS

Tankers (1957)						
<u>Trade Route</u>	<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Profit (Loss) \$10³</u>	<u>Return on investment (%)</u>
Kuwait to New York	A	14.29	Conv.	15.17	(309)	(3.54)
			PWR	18.67	(795)	(6.28)
			BWR	18.68	(793)	(6.31)
			OMR	18.29	(743)	(6.21)
			GCR	21.54	(1165)	(7.04)
		16.16	Conv.	16.49	(466)	(5.07)
			PWR	19.70	(950)	(7.01)
			BWR	19.70	(948)	(7.05)
			OMR	19.39	(907)	(7.20)
			GCR	22.85	(1372)	(7.65)
via Suez 16,500 miles round trip Tariff \$12.70	E	15.30	Conv.	12.06	131	1.14
			PWR	14.27	(341)	(2.14)
			BWR	14.23	(333)	(2.11)
			OMR	14.09	(303)	(2.03)
			GCR	16.34	(787)	(3.85)
		17.26	Conv.	13.20	(100)	(0.83)
			PWR	15.10	(532)	(3.11)
			BWR	15.01	(512)	(3.04)
			OMR	14.93	(495)	(3.13)
			GCR	17.46	(1050)	(4.72)
via Suez in ballast via Cape of Good Hope loaded 20,000 miles round trip Tariff \$12.70	B	15.95	Conv.	11.36	310	2.29
			PWR	13.14	(111)	(0.60)
			BWR	13.08	(95)	(0.52)
			OMR	13.01	(80)	(0.46)
			GCR	15.07	(600)	(2.56)
		18.03	Conv.	12.58	26	0.19
			PWR	13.93	(321)	(1.61)
			BWR	13.79	(283)	(1.45)
			OMR	13.75	(274)	(1.50)
			GCR	16.00	(861)	(3.40)
		20.82	Conv.	15.45	(585)	(3.85)
			PWR	15.29	(694)	(3.15)
			BWR	15.32	(692)	(3.24)
			OMR	15.51	(735)	(3.57)
			GCR	18.16	(1451)	(5.02)

TABLE XXIX (Cont.)
REACTOR TYPE COMPARISONS

Tankers (1957)						
Trade Route	Ship Size	Speed (Knots)	Power Plant Type	Cost per Ton of Cargo (\$)	Annual Profit (Loss) \$10 ³	Return on Investment (%)
Kuwait to New York via Suez in ballast via	F	16.75	Conv.	9.63	1000	6.04
			PWR	10.99	601	2.74
			BWR	10.94	621	2.88
			OMR	10.90	635	3.10
			GCR	12.54	57	0.21
Cape of Good Hope loaded		18.90	Conv.	10.98	548	3.16
			PWR	11.89	307	1.28
			BWR	11.76	341	1.47
			OMR	11.79	329	1.49
			GCR	13.76	(382)	(1.26)
		21.82	Conv.	13.07	(110)	(0.60)
			PWR	13.08	(138)	(0.53)
			BWR	12.92	(81)	(0.32)
			OMR	12.98	(103)	(0.42)
			GCR	15.45	(1005)	(2.98)
via Cape of Good Hope	G	17.76	Conv.	9.15	1516	6.96
			PWR	9.90	1329	4.70
			BWR	9.81	1369	4.95
			OMR	10.03	1262	4.70
			GCR	11.39	621	1.79
23,500 miles round trip		20.08	Conv.	10.41	966	4.26
			PWR	10.57	1049	3.47
			BWR	10.46	1104	3.75
			OMR	10.51	1072	3.75
			GCR	12.37	160	0.42
		23.18	Conv.	12.52	73	0.30
			PWR	11.81	449	1.38
			BWR	11.64	532	1.67
			OMR	11.61	544	1.77
			GCR	13.90	(601)	(1.42)
Tariff \$12.70	C	18.58	Conv.	8.08	2743	10.28
			PWR	8.52	2751	8.09
			BWR	8.39	2845	8.64
			OMR	8.44	2797	8.68
			GCR	9.72	1966	4.71
		21.00	Conv.	9.26	2042	7.36
			PWR	9.27	2340	6.46
			BWR	9.09	2465	6.93
			OMR	9.07	2470	7.20
			GCR	10.54	1480	3.24
		24.25	Conv.	11.76	509	1.73
			PWR	10.75	1348	3.41
			BWR	10.66	1408	3.65
			OMR	10.70	1369	3.74
			GCR	12.52	124	0.24

TABLE XXX
REACTOR TYPE COMPARISONS

Tankers (1965)						
<u>Trade Route</u>	<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Profit or (loss) \$10³</u>	<u>Return on Invest-ment (%)</u>
Aruba to New York 2,500 miles round trip Tariff \$3.04	A	14.29	Conv.	4.20	(571)	(5.36)
			PWR	5.34	(1129)	(7.78)
			BWR	5.37	(1139)	(7.85)
			OMR	5.23	(1075)	(7.71)
			GCR	6.05	(1463)	(8.18)
		16.16	Conv.	4.48	(704)	(6.28)
			PWR	5.73	(1314)	(8.48)
			BWR	5.75	(1317)	(8.53)
			OMR	5.63	(1264)	(8.58)
			GCR	6.49	(1675)	(8.71)
		18.65	Conv.	5.07	(954)	(7.90)
			PWR	6.48	(1626)	(9.49)
			BWR	6.43	(1600)	(9.49)
			OMR	6.33	(1554)	(9.74)
			GCR	7.35	(2037)	(9.59)
	E	15.30	Conv.	3.26	(174)	(1.24)
			PWR	4.04	(786)	(4.27)
			BWR	4.03	(783)	(4.29)
			OMR	3.96	(727)	(4.15)
			GCR	4.53	(1168)	(5.24)
		17.26	Conv.	3.52	(376)	(2.55)
			PWR	4.35	(1031)	(5.21)
			BWR	4.32	(1005)	(5.17)
			OMR	4.25	(954)	(5.14)
			GCR	4.90	(1456)	(6.07)
		19.92	Conv.	4.08	(784)	(4.94)
			PWR	4.99	(1487)	(6.78)
			BWR	4.93	(1447)	(6.75)
			OMR	4.87	(1401)	(6.85)
			GCR	5.70	(2019)	(7.49)
	B	15.95	Conv.	2.86	195	1.18
			PWR	3.45	(437)	(2.04)
			BWR	3.44	(425)	(2.00)
			OMR	3.40	(384)	(1.88)
			GCR	3.84	(850)	(3.33)
		18.03	Conv.	3.07	(31)	(0.18)
			PWR	3.71	(712)	(3.11)
			BWR	3.68	(680)	(3.01)
			OMR	3.64	(638)	(2.96)
			GCR	4.12	(1148)	(4.20)
		20.82	Conv.	3.51	(480)	(2.58)
			PWR	4.24	(1236)	(4.90)
			BWR	4.17	(1167)	(4.73)
			OMR	4.18	(1173)	(4.97)
			GCR	4.75	(1775)	(5.75)

Tankers (1965)

- 55 -

Tankers (1965)

Trade Route	Ship Size	Speed (Knots)	Power Plant Type	Cost per Ton of Cargo (\$)	Annual Profit or (Loss) \$10 ³	Return on Investment (%)
Borneo to San Francisco	A	14.29	Conv.	13.53	(355)	(3.33)
			PWR	16.26	(810)	(5.59)
			BWR	16.36	(824)	(5.68)
			OMR	15.96	(762)	(5.47)
			GCR	18.42	(1147)	(6.41)
	E	16.16	Conv.	14.53	(506)	(4.51)
			PWR	17.05	(958)	(6.18)
			BWR	17.12	(967)	(6.26)
			OMR	16.82	(920)	(6.25)
			GCR	19.31	(1323)	(6.88)
14,000 miles round trip		18.65	Conv.	16.93	(828)	(6.86)
			PWR	18.74	(1238)	(7.22)
			BWR	18.62	(1216)	(7.22)
			OMR	18.44	(1189)	(7.45)
			GCR	21.30	(1659)	(7.81)
		15.30	Conv.	10.39	202	1.44
			PWR	12.12	(241)	(1.31)
			BWR	12.12	(240)	(1.32)
			OMR	11.93	(191)	(1.09)
			GCR	13.61	(628)	(2.82)
Tariff \$11.20		17.26	Conv.	11.30	(24)	(0.16)
			PWR	12.77	(420)	(2.12)
			BWR	12.68	(397)	(2.05)
			OMR	12.55	(363)	(1.96)
			GCR	14.41	(857)	(3.58)
		19.92	Conv.	13.65	(573)	(3.61)
			PWR	14.24	(819)	(3.74)
			BWR	14.11	(784)	(3.66)
			OMR	14.06	(772)	(3.78)
			GCR	16.35	(1380)	(5.12)
	B	15.95	Conv.	9.03	729	4.40
			PWR	10.27	330	1.54
			BWR	10.25	339	1.60
			OMR	10.17	367	1.80
			GCR	11.45	(89)	(0.35)
		18.03	Conv.	9.80	472	2.72
			PWR	10.79	148	0.65
			BWR	10.72	176	0.78
			OMR	10.67	194	0.90
			GCR	12.02	(300)	(1.10)
		20.82	Conv.	11.60	(127)	(0.68)
			PWR	11.99	(290)	(1.15)
			BWR	11.81	(226)	(0.92)
			OMR	11.96	(279)	(1.18)
			GCR	13.49	(852)	(2.76)

TABLE XXXI (Cont.)
REACTOR TYPE COMPARISONS
Tankers (1965)

<u>Trade Route</u>	<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Profit or (Loss) \$10³</u>	<u>Return on Investment (%)</u>
Borneo	F	16.75	Conv.	7.59	1696	8.36
			PWR	8.53	1316	5.15
			BWR	8.48	1345	5.33
			OMR	8.43	1368	5.63
			GCR	9.47	852	2.85
		18.90	Conv.	8.48	1269	5.98
			PWR	9.14	1040	3.77
			BWR	9.07	1076	3.97
			OMR	9.03	1098	4.21
			GCR	10.28	464	1.42
to		21.82	Conv.	9.81	626	2.77
			PWR	10.03	598	2.00
			BWR	9.93	650	2.23
			OMR	10.00	607	2.16
			GCR	11.45	(129)	(0.36)
	San Francisco	17.76	Conv.	6.52	3348	12.54
			PWR	7.06	3135	9.48
			BWR	7.00	3179	9.78
			OMR	7.05	3137	9.97
			GCR	7.82	2551	6.65
14,000 miles round trip		20.08	Conv.	7.18	2877	10.35
			PWR	7.48	2903	8.27
			BWR	7.41	2952	8.56
			OMR	7.46	2900	8.69
			GCR	8.40	2171	5.21
		23.18	Conv.	8.26	2054	7.06
			PWR	8.25	2339	6.20
			BWR	8.19	2387	6.43
			OMR	8.17	2385	6.67
			GCR	8.85	1773	3.87
Tariff \$11.20	C	18.58	Conv.	4.74	5410	16.53
			PWR	6.07	5380	13.51
			BWR	5.97	5495	14.16
			OMR	6.03	5411	14.26
			GCR	6.69	4749	10.28
		21.00	Conv.	6.35	4817	14.17
			PWR	6.50	5066	11.99
			BWR	6.40	5183	12.44
			OMR	6.42	5135	12.74
			GCR	7.17	4376	8.76
		24.25	Conv.	7.64	3403	9.47
			PWR	7.46	4055	8.82
			BWR	7.42	4103	9.07
			OMR	7.67	3804	8.79
			GCR	8.37	3094	5.57

TABLE XXXII
REACTOR TYPE COMPARISONS

Tankers (1965)					Annual Profit (Loss) \$10 ³	Return on Investment (%)
Trade Route	Ship Size	Speed (Knots)	Power Plant Type	Cost per Ton of Cargo (\$)		
Kuwait to New York	A	14.29	Conv.	18.20	(685)	(6.43)
			PWR	21.15	(1124)	(7.75)
			BWR	21.28	(1137)	(7.84)
			OMR	20.80	(1076)	(7.72)
			GCR	23.77	(1460)	(8.16)
via Suez		16.16	Conv.	19.65	(855)	(7.62)
			PWR	22.16	(1284)	(8.29)
			BWR	22.26	(1292)	(8.37)
			OMR	21.89	(1246)	(8.46)
			GCR	24.90	(1649)	(8.58)
		18.65	Conv.	23.10	(1193)	(9.89)
			PWR	24.29	(1572)	(9.17)
			BWR	24.16	(1549)	(9.20)
			OMR	23.92	(1521)	(9.53)
			GCR	27.39	(1992)	(9.38)
16,500 miles round trip	E	15.30	Conv.	14.29	(323)	(2.31)
			PWR	16.11	(742)	(4.03)
			BWR	16.11	(741)	(4.06)
			OMR	15.88	(692)	(3.95)
			GCR	17.91	(1128)	(5.06)
Tariff \$12.70		17.26	Conv.	15.56	(575)	(3.91)
			PWR	16.93	(939)	(4.74)
			BWR	16.83	(916)	(4.71)
			OMR	16.66	(880)	(4.74)
			GCR	18.93	(1374)	(5.73)
		19.92	Conv.	18.85	(1145)	(7.21)
			PWR	18.74	(1345)	(6.13)
			BWR	18.58	(1309)	(6.11)
			OMR	18.52	(1293)	(6.33)
			GCR	21.32	(1901)	(7.06)
via Suez in ballast	B	15.95	Conv.	13.65	(220)	(1.33)
			PWR	14.92	(563)	(2.63)
			BWR	14.89	(554)	(2.61)
			OMR	14.78	(527)	(2.59)
			GCR	16.58	(983)	(3.86)
via Cape of Good Hope loaded		18.03	Conv.	15.00	(526)	(3.03)
			PWR	15.65	(769)	(3.36)
			BWR	15.54	(741)	(3.28)
			OMR	15.48	(725)	(3.36)
			GCR	17.37	(1220)	(4.46)
20,000 miles round trip		20.82	Conv.	18.20	(1172)	(6.31)
			PWR	17.29	(1211)	(4.80)
			BWR	17.05	(1148)	(4.66)
			OMR	17.27	(1197)	(5.08)
			GCR	19.40	(1780)	(5.77)
Tariff \$12.70						

- 58 -

TABLE XXXII (Cont.)
REACTOR TYPE COMPARISONS

Trade Route	Ship Size	Tankers (1965)			Annual Profit (Loss) \$10 ³	Return on Investment (%)
		Speed (Knots)	Power Plant Type	Cost per Ton of Cargo (\$)		
Kuwait to New York via Suez in ballast via Cape of Good Hope loaded	F	16.75	Conv.	11.51	387	1.91
			PWR	12.48	77	0.30
			BWR	12.40	106	0.42
			OMR	12.34	127	0.52
			GCR	13.79	(383)	(1.28)
		18.90	Conv.	13.00	(96)	(0.45)
			PWR	13.30	(217)	(0.79)
			BWR	13.21	(183)	(0.68)
			OMR	13.15	(162)	(0.62)
			GCR	14.90	(790)	(2.41)
via Cape of Good Hope loaded		21.82	Conv.	15.34	(796)	(3.53)
			PWR	14.52	(667)	(2.23)
			BWR	14.37	(615)	(2.11)
			OMR	14.49	(653)	(2.32)
			GCR	16.51	(1390)	(3.84)
	G	17.76	Conv.	10.97	741	2.78
			PWR	11.27	680	2.06
			BWR	11.18	723	2.23
			OMR	11.26	683	2.17
			GCR	12.49	100	0.26
via Cape of Good Hope		20.08	Conv.	12.33	154	0.56
			PWR	11.88	405	1.15
			BWR	11.78	453	1.32
			OMR	11.88	403	1.21
			GCR	13.36	(323)	(0.78)
		23.18	Conv.	14.68	(787)	(2.70)
			PWR	13.02	(158)	(0.42)
			BWR	12.92	(112)	(0.30)
			OMR	12.93	(114)	(0.32)
			GCR	14.65	(723)	(1.58)
23,500 miles round trip	C	18.58	Conv.	9.64	1818	5.56
			PWR	9.67	1997	5.02
			BWR	9.50	2109	5.43
			OMR	9.62	2026	5.34
			GCR	10.66	1349	2.92
		21.00	Conv.	10.87	1070	3.15
			PWR	10.31	1629	3.86
			BWR	10.14	1744	4.19
			OMR	10.20	1696	4.21
			GCR	11.37	909	1.82
Tariff \$12.70		24.25	Conv.	13.68	(535)	(1.49)
			PWR	11.76	646	1.41
			BWR	11.70	688	1.52
			OMR	12.13	391	0.90
			GCR	13.22	(364)	(0.66)

TABLE XXXIII
REACTOR TYPE COMPARISONS
Tankers (1970)

Trade Route	Ship Size	Speed (Knots)	Power Plant Type	Cost per Ton of Cargo (\$)	Annual Profit (Loss) \$10 ³	Return on Investment (%)
Aruba to New York 3,500 miles round trip Tariff \$3.04	A	14.29	Conv.	4.77	(853)	(7.04)
			PWR	5.85	(1377)	(8.68)
			BWR	5.88	(1388)	(8.80)
			OMR	6.01	(1455)	(9.49)
			GCR	6.56	(1708)	(8.93)
	E	16.16	Conv.	5.07	(993)	(7.79)
			PWR	6.26	(1571)	(9.28)
			BWR	6.26	(1564)	(9.39)
			OMR	6.12	(1504)	(9.28)
			GCR	7.00	(1924)	(8.38)
		18.65	Conv.	5.71	(1257)	(9.18)
			PWR	2.02	(1884)	(10.15)
			BWR	6.99	(1861)	(10.29)
			OMR	6.83	(1792)	(10.21)
			GCR	7.87	(2285)	(10.14)
		15.30	Conv.	3.69	(512)	(3.22)
			PWR	4.42	(1090)	(5.39)
			BWR	4.41	(1085)	(5.46)
			OMR	4.32	(1011)	(5.21)
			GCR	4.90	(1460)	(6.10)
		17.26	Conv.	3.97	(727)	(4.35)
			PWR	4.73	(1333)	(6.18)
			BWR	4.71	(1314)	(6.25)
			OMR	4.60	(1232)	(6.00)
			GCR	5.28	(1754)	(6.83)
		19.92	Conv.	4.57	(1154)	(6.40)
			PWR	5.38	(1793)	(7.48)
			BWR	5.31	(1739)	(7.52)
			OMR	5.22	(1667)	(7.38)
			GCR	6.10	(2319)	(8.05)
	B	15.95	Conv.	3.23	(197)	(1.04)
			PWR	3.78	(790)	(3.35)
			BWR	3.79	(799)	(3.45)
			OMR	3.70	(705)	(3.12)
			GCR	4.16	(1190)	(4.32)
		18.03	Conv.	3.45	(435)	(2.18)
			PWR	4.04	(1062)	(4.22)
			BWR	4.01	(1024)	(4.18)
			OMR	3.94	(953)	(3.98)
			GCR	4.44	(1488)	(5.06)
		20.82	Conv.	3.92	(900)	(4.27)
			PWR	4.50	(1530)	(5.54)
			BWR	4.48	(1484)	(5.56)
			OMR	4.49	(1485)	(5.69)
			GCR	5.07	(2110)	(6.39)

TABLE XXXIII (Cont.)
REACTOR TYPE COMPARISONS
Tankers (1970)

Trade Route	Ship Size	Speed (Knots)	Power Plant Type	Cost per Ton of Cargo (\$)	Annual Profit or (Loss) \$10 ³	Return on Investment (%)
Aruba to New York	F	16.75	Conv.	2.74	433	1.88
			PWR	3.19	(212)	(0.75)
			BWR	3.17	(186)	(0.67)
			OMR	3.11	(104)	(0.38)
			GCR	3.48	(645)	(1.99)
		18.90	Conv.	3.00	61	0.25
			PWR	3.45	(594)	(1.95)
			BWR	3.41	(541)	(1.83)
			OMR	3.35	(456)	(1.57)
			GCR	3.81	(1117)	(3.17)
		21.82	Conv.	3.38	(475)	(1.85)
			PWR	3.85	(1145)	(3.49)
			BWR	3.80	(1085)	(3.42)
			OMR	3.79	(1063)	(3.41)
			GCR	4.35	(1849)	(4.75)
3,500 miles round trip	G	17.76	Conv.	2.35	1521	5.01
			PWR	2.65	862	2.36
			BWR	2.62	935	2.62
			OMR	2.61	955	2.72
			GCR	2.89	332	0.80
		20.08	Conv.	2.54	1086	3.44
			PWR	2.85	417	1.08
			BWR	2.81	509	1.35
			OMR	2.80	528	1.42
			GCR	3.15	242	0.54
		23.18	Conv.	2.85	410	1.24
			PWR	3.21	(368)	(0.88)
			BWR	3.15	(236)	(0.59)
			OMR	3.13	(184)	(0.46)
			GCR	3.59	(1181)	(2.39)
Tariff \$3.04	C	18.58	Conv.	2.07	2905	7.80
			PWR	2.29	2255	5.11
			BWR	2.25	2404	5.62
			OMR	2.25	2384	5.62
			GCR	2.49	1665	3.31
		21.00	Conv.	2.25	2355	6.09
			PWR	2.49	1643	3.51
			BWR	2.44	1820	4.00
			OMR	2.43	1832	4.07
			GCR	2.71	1002	1.85
		24.25	Conv.	2.59	1287	3.15
			PWR	2.90	410	0.81
			BWR	2.82	616	1.24
			OMR	2.84	578	1.20
			GCR	3.19	(449)	(0.75)

TABLE XXXIV
REACTOR TYPE COMPARISONS

Tankers (1970)

<u>Trade Route</u>	<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Profit or (Loss) \$10³</u>	<u>Return on Investment (%)</u>
Borneo to San Francisco	A	14.29	Conv.	15.37	(636)	(5.26)
			PWR	17.79	(1055)	(6.65)
			BWR	17.91	(1071)	(6.79)
			OMR	18.31	(1138)	(7.42)
			GCR	19.95	(1390)	(7.27)
	E	16.16	Conv.	16.45	(795)	(6.24)
			PWR	18.58	(1210)	(7.15)
			BWR	18.62	(1213)	(7.28)
			OMR	18.23	(1151)	(7.10)
			GCR	20.81	(1568)	(7.65)
14,000 miles round trip		18.65	Conv.	19.07	(1131)	(8.26)
			PWR	20.25	(1487)	(8.01)
			BWR	20.24	(1481)	(8.19)
			OMR	19.78	(1409)	(8.03)
			GCR	22.76	(1900)	(8.43)
		15.30	Conv.	11.75	(136)	(0.86)
			PWR	13.26	(539)	(2.67)
			BWR	13.27	(542)	(2.73)
			OMR	12.98	(467)	(2.40)
			GCR	14.72	(917)	(3.83)
Tariff \$11.20		17.26	Conv.	12.71	(375)	(2.24)
			PWR	13.86	(714)	(3.31)
			BWR	13.84	(708)	(3.37)
			OMR	13.53	(625)	(3.04)
			GCR	15.51	(1149)	(4.47)
		19.92	Conv.	15.23	(942)	(5.23)
			PWR	15.31	(1110)	(4.63)
			BWR	15.18	(1075)	(4.65)
			OMR	14.93	(1007)	(4.46)
			GCR	17.42	(1665)	(5.78)
	B	15.95	Conv.	10.20	338	1.79
			PWR	11.24	(15)	(0.06)
			BWR	11.31	(37)	(0.16)
			OMR	11.03	59	0.26
			GCR	12.39	(424)	(1.54)
		18.03	Conv.	11.00	69	0.35
			PWR	11.72	(190)	(0.75)
			BWR	11.66	(169)	(0.69)
			OMR	11.47	(98)	(0.41)
			GCR	12.92	(631)	(2.14)
		20.82	Conv.	12.90	(547)	(2.59)
			PWR	12.65	(546)	(1.98)
			BWR	12.65	(537)	(2.01)
			OMR	12.71	(554)	(2.12)
			GCR	14.35	(1171)	(3.54)

Tankers (1970)

- 63 -

TABLE XXXV
REACTOR TYPE COMPARISONS
Tankers, - 1970

<u>Trade Route</u>	<u>Ship Size</u>	<u>Speed (Knots)</u>	<u>Power Plant Type</u>	<u>Cost per Ton of Cargo (\$)</u>	<u>Annual Profit (Loss) \$10³</u>	<u>Return on Investment (%)</u>
Kuwait to New York via Suez	A	14.29	Conv.	20.45	(967)	(7.99)
			PWR	23.00	(1370)	(8.63)
			BWR	23.14	(1385)	(8.78)
			OMR	23.62	(1452)	(9.47)
			GCR	25.61	(1703)	(8.91)
		16.16	Conv.	21.99	(1143)	(8.98)
			PWR	24.02	(1537)	(9.08)
			BWR	24.07	(1538)	(9.23)
			OMR	23.59	(1477)	(9.12)
			GCR	26.71	(1894)	(9.24)
		18.65	Conv.	25.74	(1497)	(10.93)
			PWR	26.13	(1823)	(9.82)
			BWR	26.11	(1814)	(10.03)
			OMR	25.55	(1743)	(9.94)
			GCR	29.17	(2234)	(9.91)
16,500 miles round trip Tariff \$12.70	E	15.30	Conv.	15.95	(662)	(4.16)
			PWR	17.49	(1041)	(5.15)
			BWR	17.50	(1043)	(5.25)
			OMR	17.14	(968)	(4.98)
			GCR	19.25	(1417)	(5.92)
		17.26	Conv.	17.30	(926)	(5.54)
			PWR	18.26	(1234)	(5.72)
			BWR	18.23	(1226)	(5.83)
			OMR	17.84	(1143)	(5.57)
			GCR	20.25	(1666)	(6.48)
		19.92	Conv.	20.82	(1514)	(8.41)
			PWR	20.05	(1637)	(6.83)
			BWR	19.89	(1600)	(6.92)
			OMR	19.59	(1532)	(6.78)
			GCR	22.62	(2188)	(7.60)
via Cape of Good Hope loaded 20,000 miles round trip Tariff \$12.70	B	15.95	Conv.	15.33	(612)	(3.25)
			PWR	16.27	(909)	(3.86)
			BWR	16.38	(931)	(4.02)
			OMR	16.00	(835)	(3.70)
			GCR	17.90	(1318)	(4.79)
		18.03	Conv.	16.76	(930)	(4.66)
			PWR	16.94	(1106)	(4.39)
			BWR	16.87	(1087)	(4.43)
			OMR	16.60	(1016)	(4.25)
			GCR	18.64	(1551)	(5.27)
		20.82	Conv.	20.17	(1592)	(7.55)
			PWR	18.21	(1480)	(5.36)
			BWR	18.22	(1459)	(5.46)
			OMR	18.31	(1470)	(5.63)
			GCR	20.59	(2098)	(6.35)

TABLE XXXV (Cont.)
REACTOR TYPE COMPARISONS

Trade Route	Ship Size	Tankers (1970)			Annual Profit or (Loss) \$10 ³	Return on Investment (%)
		Speed (Knots)	Power Plant Type	Cost per Ton of Cargo (\$)		
Kuwait to New York	F	16.75	Conv.	12.90	(64)	(0.28)
			PWR	13.65	(333)	(1.18)
			BWR	13.61	(321)	(1.16)
			OMR	13.38	(239)	(0.88)
			GCR	14.92	(778)	(2.40)
via Suez in ballast		18.90	Conv.	14.47	(564)	(2.34)
			PWR	14.36	(601)	(1.97)
			BWR	14.27	(569)	(1.93)
			OMR	14.05	(487)	(1.68)
			GCR	15.90	(1152)	(3.27)
via Cape of Good Hope loaded		21.82	Conv.	16.96	(1288)	(5.02)
			PWR	15.43	(1007)	(3.07)
			BWR	15.36	(978)	(3.09)
			OMR	15.35	(965)	(3.09)
			GCR	17.53	(1761)	(4.53)
	G	17.76	Conv.	12.29	177	0.58
			PWR	12.28	201	0.55
			BWR	12.17	253	0.71
			OMR	12.13	269	0.76
			GCR	13.45	(356)	(0.85)
via Cape of Good Hope		20.08	Conv.	13.71	(427)	(1.35)
			PWR	12.81	(56)	(0.14)
			BWR	12.70	2	0.00
			OMR	12.67	16	0.04
			GCR	14.26	(766)	(1.70)
23,500 miles round trip		23.18	Conv.	16.20	(1393)	(4.21)
			PWR	13.89	(599)	(1.44)
			BWR	13.75	(526)	(1.31)
			OMR	13.65	(477)	(1.20)
			GCR	15.69	(1499)	(3.04)
	C	18.58	Conv.	10.77	1147	3.08
			PWR	10.50	1451	3.28
			BWR	10.32	1570	3.67
			OMR	10.35	1544	3.64
			GCR	11.47	811	1.61
Tariff \$12.70		21.00	Conv.	12.05	380	0.98
			PWR	11.08	1103	2.36
			BWR	10.90	1228	2.70
			OMR	10.88	1239	2.75
			GCR	12.14	383	0.71
		24.25	Conv.	15.01	(1258)	(3.08)
			PWR	12.45	171	0.34
			BWR	12.28	290	0.58
			OMR	12.36	236	0.49
			GCR	13.88	(822)	(1.37)