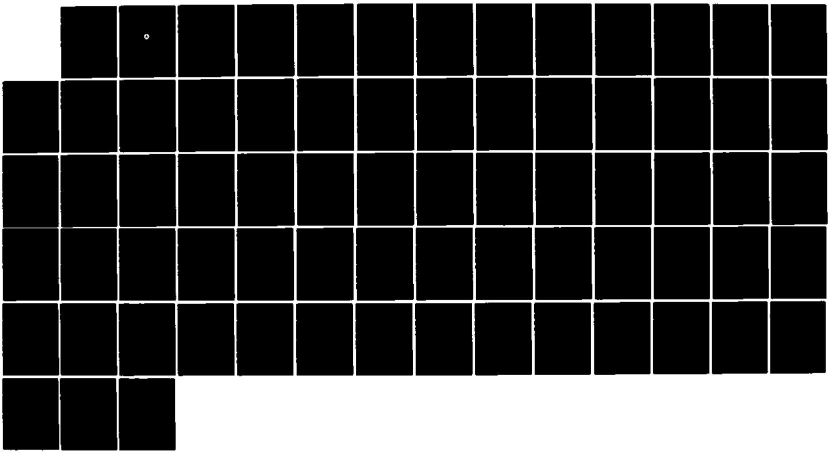
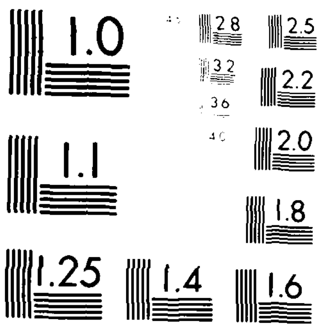
AD-A156 578 US COAST GUARD PATROL BOAT (WPB) PLANNING HULL 1/1
FEASIBILITY STUDY..(U) NAVAL SEA COMBAT SYSTEMS
ENGINEERING STATION NORFOLK VA L T CODEGA ET AL.
UNCLASSIFIED DEC 84 NAVSEACOMBATSYSENGSTA-60-134 F/G 13/10 NL





MICROCOPY RESOLUTION TEST CHART

Report No. CG-D-9-85

AD-A156 578

U. S. COAST GUARD PATROL BOAT (WPB) PLANING HULL FEASIBILITY STUDY

DECEMBER 1984

FINAL REPORT

This document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

Prepared for:

U.S. Department of Transportation
United States Coast Guard
Office of Research and Development
Washington, D.C. 20593

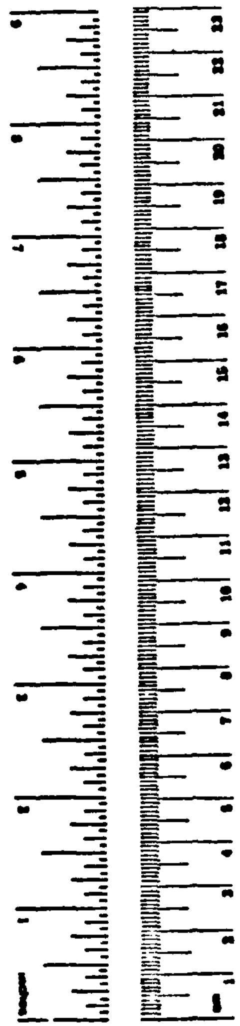
NOTICE

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

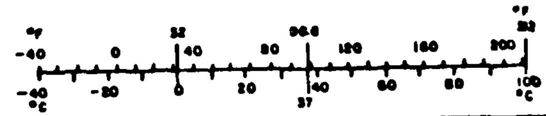
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



Technical Report Documentation Page

Field	Entry
1. Report No.	CG-D-9-85
2. Government Accession No.	
3. Recipient's Catalog No.	
4. Title and Subtitle	U. S. COAST GUARD PATROL BOAT (WPB) PLANING HULL FEASIBILITY STUDY
5. Report Date	DECEMBER 1984
6. Performing Organization Code	
7. Author(s)	LOUIS T. CODEGA, E. GORDON HATCHELL
8. Performing Organization Report No.	NAVSEACOMBATSYSENGSTA REPORT NO. 60-134
9. Performing Organization Name and Address	NAVAL SEA COMBAT SYSTEMS ENGINEERING STATION NAVAL STATION NORFOLK, VIRGINIA 23511
10. Work Unit No. (TRAIS)	
11. Contract or Grant No.	DTCG23-84-F-20050
12. Sponsoring Agency Name and Address	UNITED STATES COAST GUARD OFFICE OF RESEARCH AND DEVELOPMENT (G-DMT) WASHINGTON, D. C. 20593
13. Type of Report and Period Covered	FINAL AUGUST-DECEMBER 1984
14. Sponsoring Agency Code	

15. Supplementary Notes

THIS REPORT REPRESENTS A REFINEMENT OF A PREVIOUS FEASIBILITY STUDY PUBLISHED IN REPORT NO. CG-D-33-83 (NAVSEACOMBATSYSENGSTA REPORT NO. 60-111).

16. Abstract

THIS REPORT DESCRIBES THE FEASIBILITY STUDY OF A HIGH SPEED PLANING CRAFT DESIGNED AS A POSSIBLE REPLACEMENT FOR THE CURRENT FLEET OF U. S. COAST GUARD 82' AND 95' PATROL BOATS. THIS CRAFT WAS DESIGNED BY THE COMBATANT CRAFT ENGINEERING DEPARTMENT, NAVAL SEA COMBAT SYSTEMS ENGINEERING STATION, NORFOLK FOR CLOSE TO SHORE, SEA STATE 3-5, HIGH SPEED OPERATION, WITH THE CAPABILITY FOR A FIVE-DAY MISSION. THE CRAFT DEVELOPED IS A 120 FOOT, 139 LONG TON, HARD CHINE VESSEL, AND IS CAPABLE OF A SUSTAINED SPEED OF 33 KNOTS IN CALM WATER.

THE HULL FORM FOR THIS CRAFT WAS DERIVED FROM INFORMATION OBTAINED FORM AN EXTENSIVE FULL AND MODEL SCALE TEST PROGRAM CONDUCTED ON THE CPIC-X PROTOTYPE CRAFT, AND FROM EVALUATION OF OTHER SMALL PLANING COMBATNAT CRAFT TESTED AND OPERATED BY THE U. S. NAVY. CALCULATIONS AND ESTIMATES WERE PERFORMED USING THE TECHNIQUES AND INFORMATION ROUTINELY EMPLOYED FOR SIMILAR CRAFT FOR THE U. S. NAVY, INCLUDING PHFMOPT, A PLANING HULL FEASIBILITY DESIGN PROGRAM.

17. Key Words		18. Distribution Statement
PLANING CRAFT	ACCELERATION	DOCUMENT IS AVAILABLE TO THE U. S. PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161
[illegible] CHINE	USCG	
[illegible]	PLANING HULL	
[illegible]	DESIGN	
[illegible]		

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
[illegible]	UNCLASSIFIED	[illegible]	

Form DOT F 1700.7

Reproduction of completed page authorized

The authors wish to thank the following persons who contributed to this report:

Mr. David Fox
Mr. Michael Jones
Mr. Lester Williams

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

LIST OF TABLES

ADMINISTRATIVE INFORMATION

This study was initiated by the United States Coast Guard, Office of Research and Development, Marine Technology Division (G-DMT-2/54) as part of the Advanced Marine Vehicle Program. Work was carried out under MIPR Number DTCG23-84-F-20050.

INTRODUCTION

This report describes the feasibility study of a high speed planing craft designed to replace the current fleet of United States Coast Guard 82' and 95' Patrol Boats. This craft was designed by the Combatant Craft Engineering Department, Naval Sea Combat Systems Engineering Station, Norfolk for close to shore, sea state 3-5, high speed operation, with the capability for a five-day mission. The craft developed is a 120 foot, 139 long ton, hard chine vessel, and is capable of a sustained speed of 33 knots in calm water.

The hull form for this craft was derived from information obtained from an extensive full and model scale test program conducted on the CPIC-X prototype craft, and from evaluation of other small, planing, combatant craft tested and operated by the U. S. Navy. Calculations and estimates were performed using the techniques and information routinely employed for similiar craft for the U. S. Navy, including the feasibility study program described in Reference (1).

MISSION REQUIREMENTS AND DESIGN GUIDELINES

The following mission requirements and guidelines were provided by the Coast Guard for the proposed craft:

A. <u>Mission Requirements:</u>

1. Primary Missions

   a. Enforcement of Laws and Treaties
   b. Search and Rescue
   c. Military Preparedness
   d. Port and Environmental Safety

2. Secondary Missions

   a. Short Range Aids to Navigation
   b. Marine Environmental Response

B. Design Guidelines

1. Arrangement and Equipment

   a. 5.4 Meter Rigid Inflatable Boat (RIB) w/70 hp Outboard
   b. Powered Davit w/Two Sided Launch
   c. Towing Bitt and Line for 500 Long Ton Vessel
   d. One 25 mm Gun w/2000 Rounds
   e. Two .50 Caliber MG w/4000 Rounds

2. Speed/Sea State

   a. Hot Pursuit combined with fuel economy
   b. 10 Knot patrol speed minimum
   c. 20 Knots continuous/Sea State 3 minimum
   d. 26 Knots continuous/Sea State 3 preferred

3. Endurance

   a. 5 day mission
      (1) 24 Hrs. 20 Knots minimum
      (2) 96 Hrs. at 10 knots minimum
      (3) 10% Reserve fuel

4. Operating Environment

   a. 90% of operation south of 38°N (No ice capability)
   b. Within 300 miles of land

5. Complement

a. 2 Officers
b. 2 CPOs
c. 12 Enlisted
d. 2 Spares

6. Desired Design Features

a. USN Criteria for Intact and Damaged Stability
b. Anchoring Capability
c. Refueling at Sea Capability
d. Proven System for Reducing Motion

7. Given Weights

a.	Group 4	2.0 LT
b.	Group 7	2.5 LT
c.	Potable Water	4.5 LT
d.	Crew and Effects	3.0 LT
e.	Stores	2.5 LT

VEHICLE DESCRIPTION AND CHARACTERISTICS

The craft developed to meet the Coast Guard requirements is a derivative of the two patrol boats described in Reference (2): one was 110 feet LOA with a 26.3 foot beam, and the other was 125 feet LOA, with a 23 foot beam. It was decided to choose a length of 120 feet to combine the better powering and seakeeping characteristics of the longer boat with a 24 foot beam to improve its arrangements and stability. In many ways, the chosen hull size combines the best characteristics of both hull forms. Table 1 gives the craft's principal characteristics.

The craft's deep-vee, double-chine hull form is the most suitable for high speed operation in a seaway and is similar to those developed in Reference (2). The hull form is a derivative of the proven CPIC-X, and is depicted in Figures 1 and 2, the Body Plan and Lines Plan respectively. The hull is longitudinally framed and constructed entirely of aluminum alloy. Armament consists of 50 cal. machine guns, which can be mounted on the several stations provided, a 25 mm gun, and small arms as required.

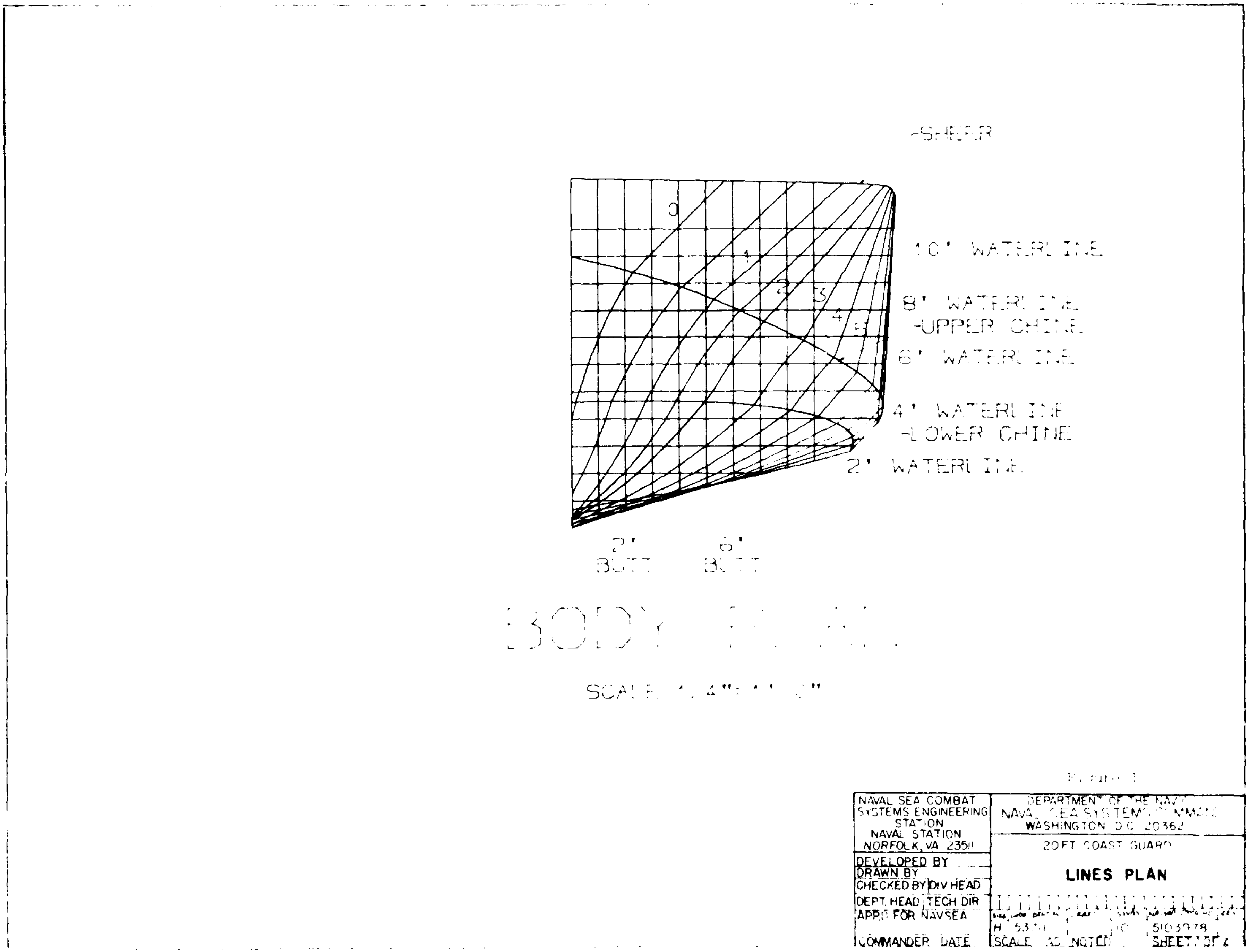
Propulsion is provided by twin MTU 16V538TB92 engines, which are noted for their reliability and high power-to-weight ratio. Each engine is capable of up to 4080 horsepower intermittently, and 3410 horsepower continuously. The craft is driven through a reversing reduction gear by a fixed pitch propeller.

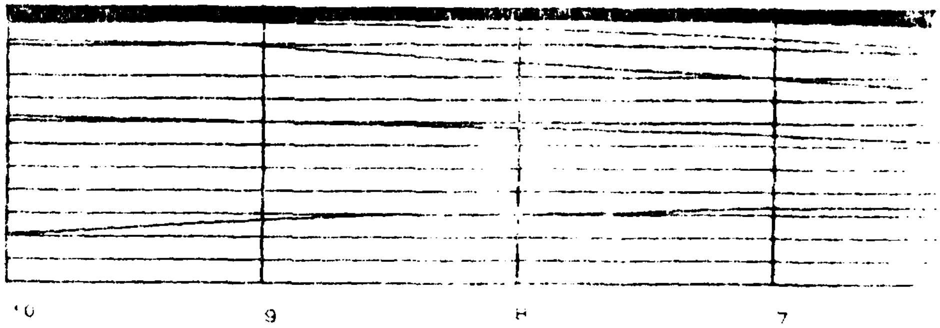
Engine exhaust is through the transom instead of stacks. This will be acceptable because of the relatively short length of exhaust pipe, and removes the undesirable main deck arrangements necessitated by the stacks on the previous designs. Figure 3 is the Outboard Profile and Main Deck Arrangement.

The craft is capable of pilot house control of all systems. Bridge wing controllers are provided for rudder and throttle functions. There is an Engineer's Operating Station (EOS) located in the forward end of the engine room which is used for monitoring all mechanical systems in an air conditioned, soundproof environment. Habitability is enhanced with four crew berthing compartments, all located as far aft in the hull as possible. Officer berthing, and the galley and mess deck are located in the deck house to minimize unnecessary traffic through berthing areas.

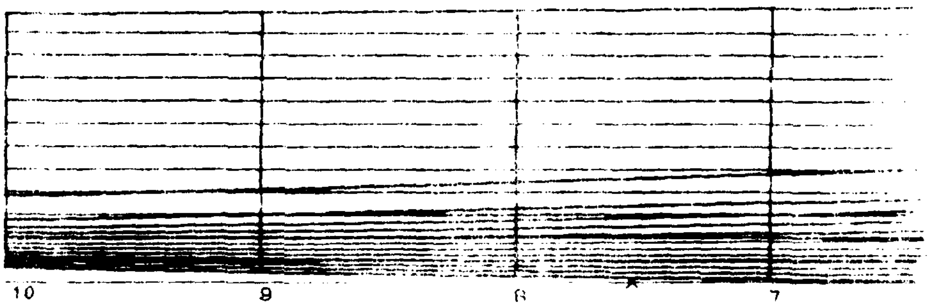
Table 1. 120' WPBX Principal Characteristics

Length Overall	120.0 feet
Length Waterline	112.0 feet
Beam Maximum	24.0 feet
Beam Waterline	23.0 feet
Draft, full load	4.7 feet
Draft, navigational	7.0 feet
Displacement, - full load	139.0 LT
- light ship	[illegible] LT
Maximum Speed (full load, calm water)	36.3 kts
Range (full load) - 10 Knots	2700 NM
- 33.3 Knots	634 NM
Endurance	270 Hours
Fuel Capacity	8826 Gal.
Potable Water Capacity	1500 Gal.
Crew - Officers	2
- CPOs	2
- Enlisted	12
Propulsion Machinery	- Twin MTU 16V538TB92 Marine Diesels - KSS60 Reverse/Reduction Gear - Twin Fixed Pitch Propellers
Generators	two DDAD 4V71, 100 kW each
Armament:	6-50 Caliber Pintle Mounts 1-25 mm Gun
Electronics:	UHF, VHF and HF Radios and Direction Finders Navigation Receivers Navigation Radars

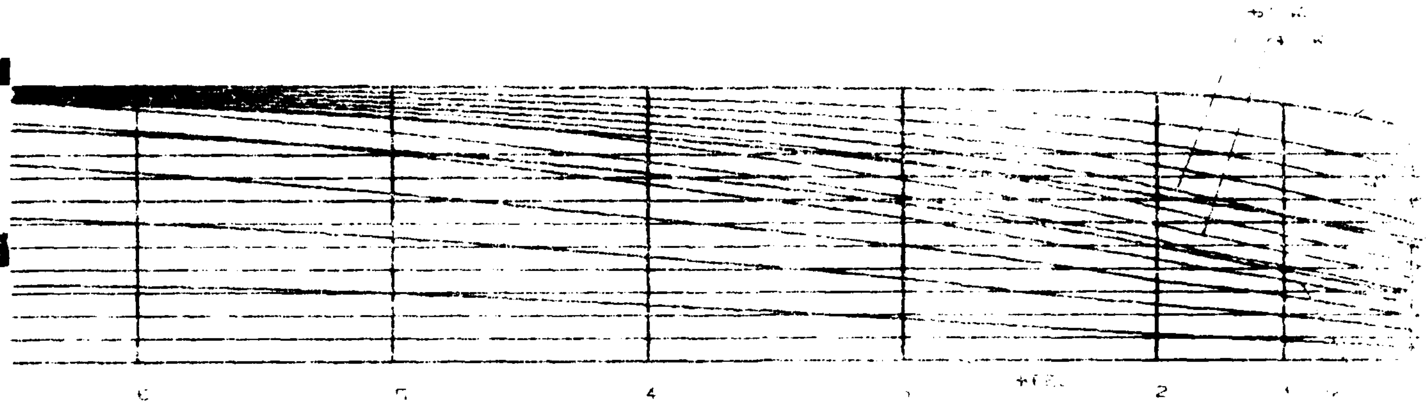

SHEER
10' WATERLINE
8' WATERLINE
UPPER CHINE
6' WATERLINE
4' WATERLINE
LOWER CHINE
2' WATERLINE
2' BUTT
6' BUTT
NAVAL SEA COMBAT SYSTEMS ENGINEERING STATION
NAVAL STATION
NORFOLK, VA 23511
DEVELOPED BY
DRAWN BY
CHECKED BY
DIV HEAD
DEPT. HEAD
TECH DIR
APPR FOR NAVSEA
COMMANDER
DATE
DEPARTMENT OF THE NAVY
WASHINGTON D.C. 20362
20FT COAST GUARD
LINES PLAN
5103978
SCALE
SHEET



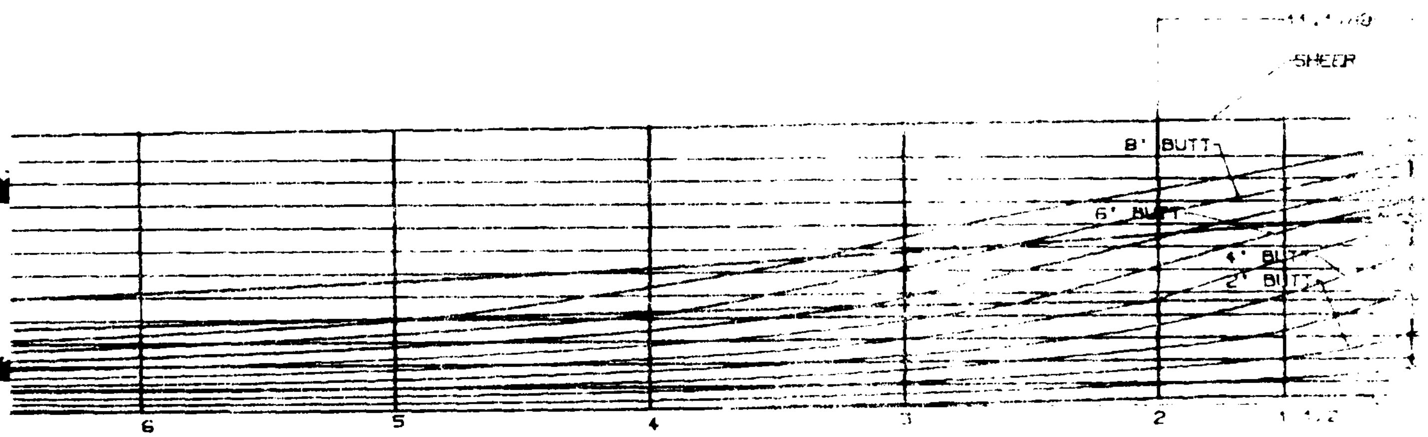
9
7



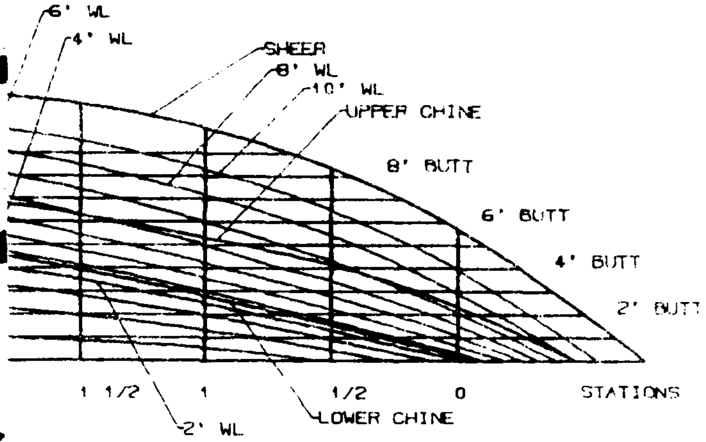
10
9
7



HA

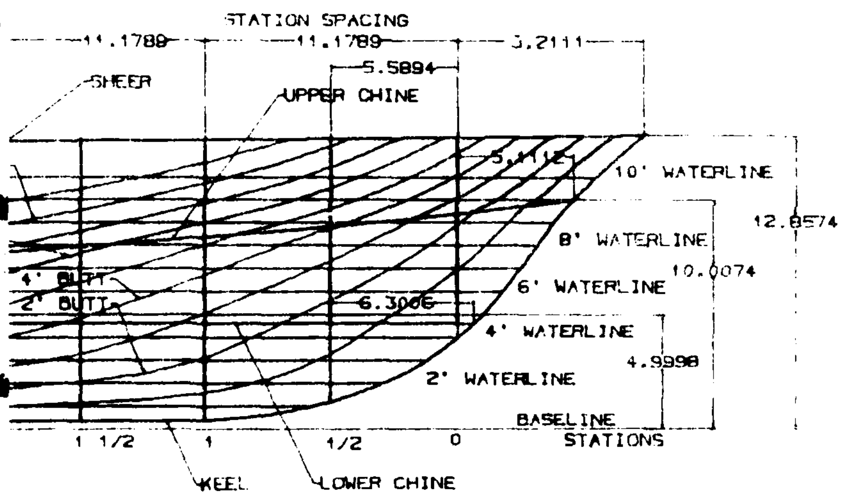


PRO



HALFBREADTH PLAN

SCALE 1/8"=1'-0"



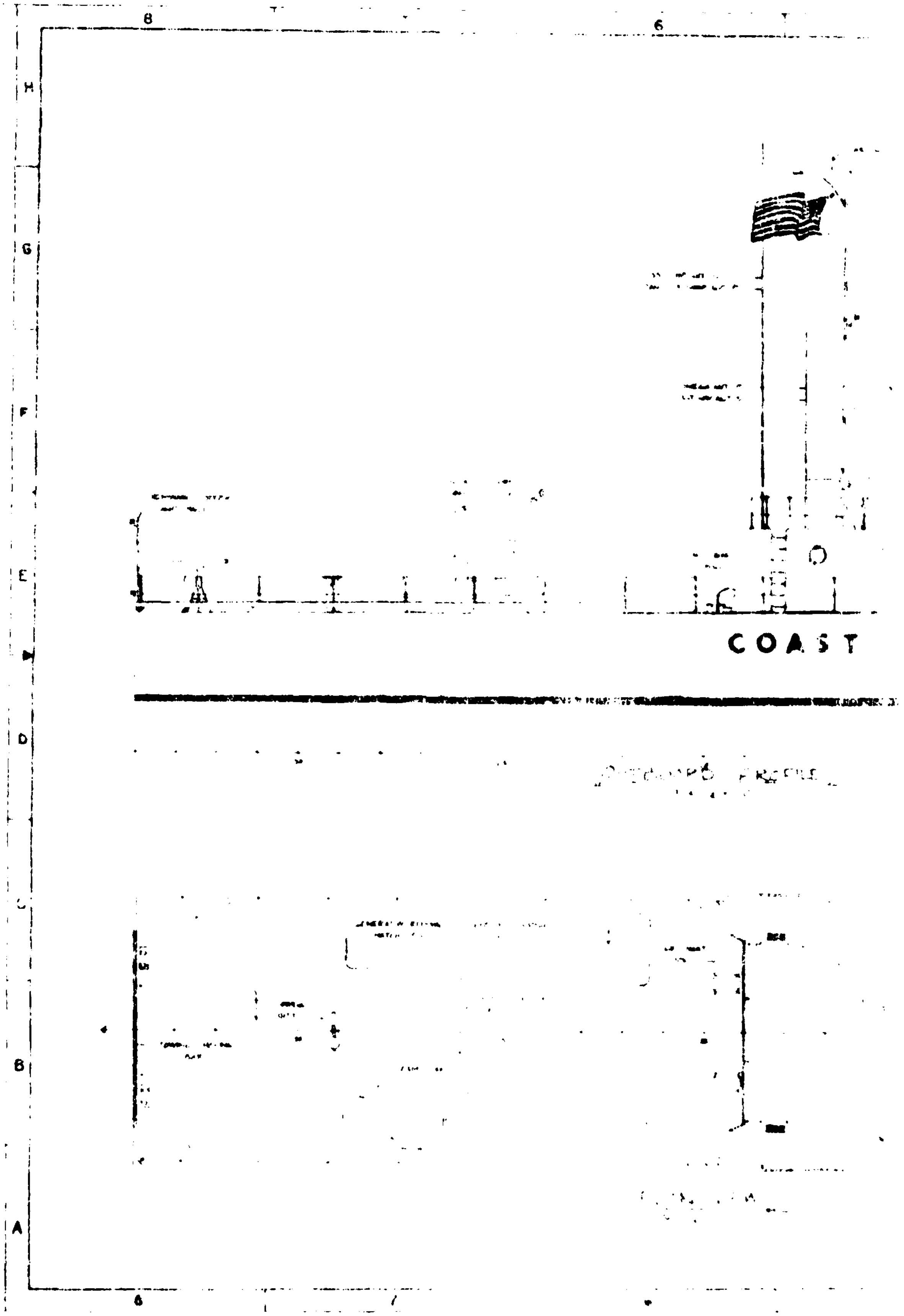
PROFILE

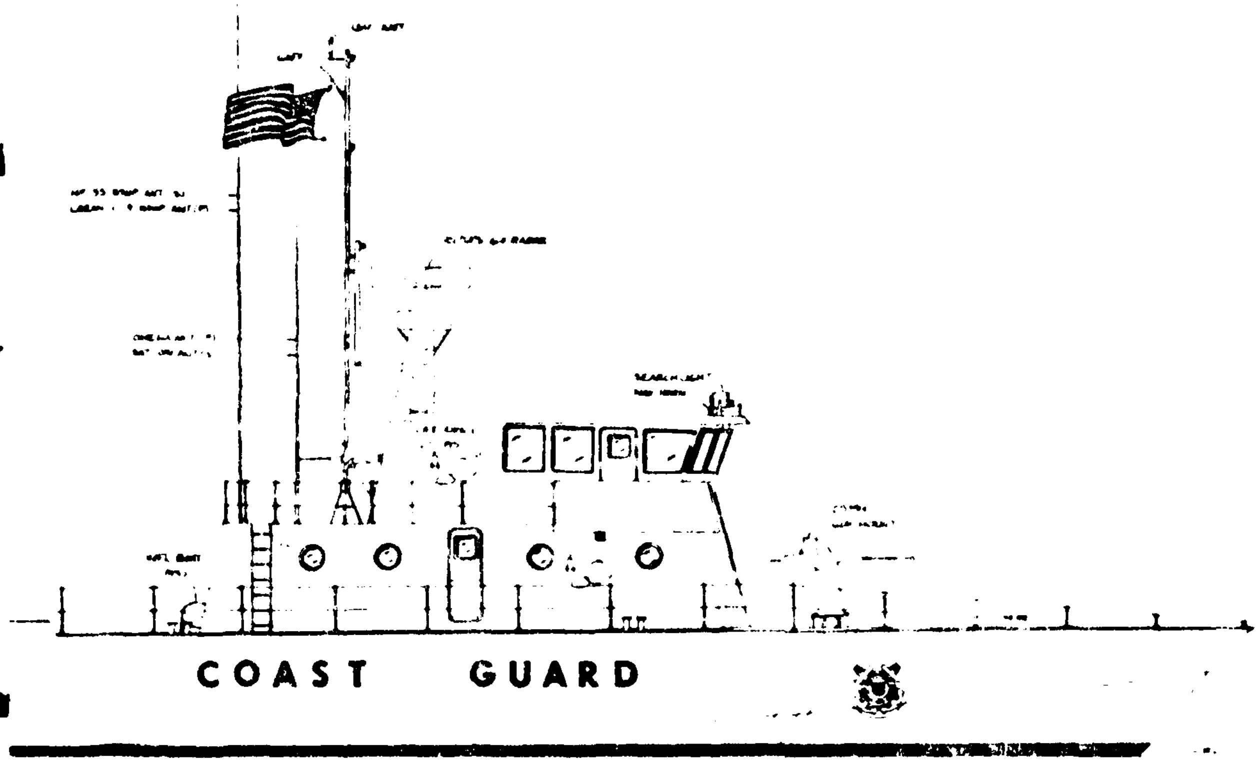
SCALE 1/8"=1'-0"

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
WASHINGTON D.C.

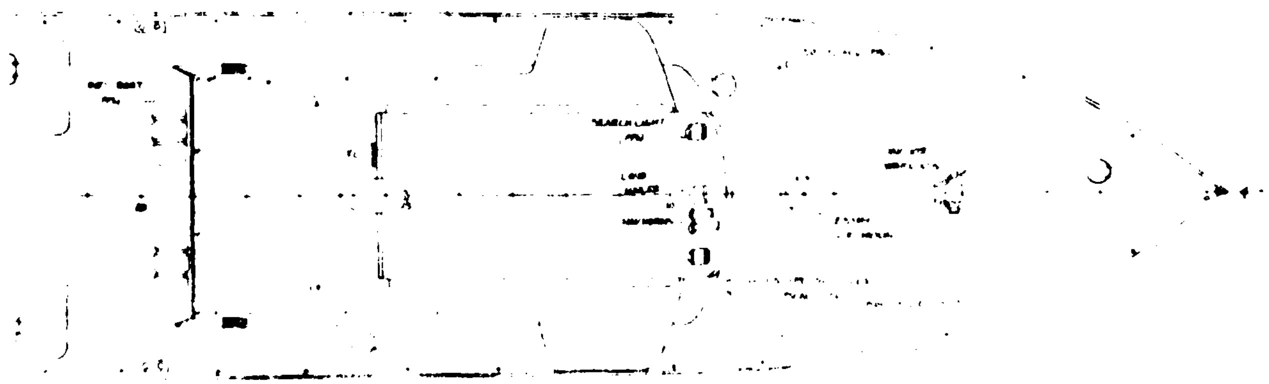
DEVELOPED BY
DRAWN BY

LINES PLAN


COAST

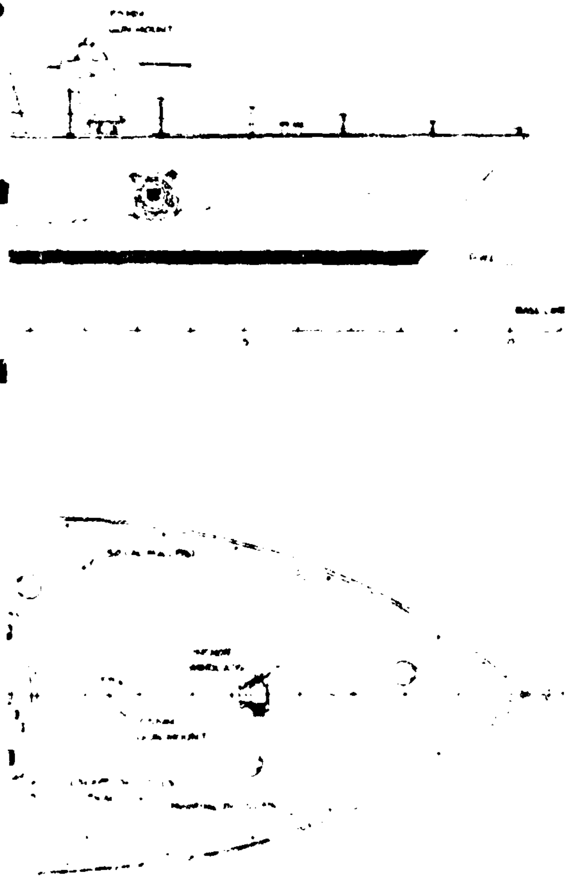


OUTBOARD PROFILE



PLAN VIEW

REVISIONS



DATA LIST

FEASIBILITY DRAWING

NAVAL ... COMMAND

... PATROL BOAT

OUT... AND

JET ... ARRANGEMENT

WEIGHT BREAKDOWN

Weights for the craft, in most cases, have been estimated from actual weights of similiar ships previously constructed and then adjusted to reflect differences between this boat and the prior ones. Some major weights, for example those of the main engines, aluminum structure and military payload, were either known values or calculated directly. The weight breakdown for the patrol boat is given in Table 2 for both full load and minimum operating conditions.

Although the total weight of the craft is similiar to that reported for the boats in Reference (2), some weight groups are considerably different and must be explained. The small differences in engine and electrical weights, groups 2 and 3, are due to more refined estimates based on the actual equipment that will be installed. The weight of groups 5 and 6, however, is greater than that previously reported based on some further research into the present 95' and 82' Coast Guard Patrol Boats. The group 7 weight is considerably less in this design because of the deletion of the EMERLEC 25 mm gun. The fuel weight is also less because of more refined estimates of fuel consumption. Finally, the margin has been increased to 10% of the light ship weight.

Table 2. 120' WPBX Ship Weight Breakdown

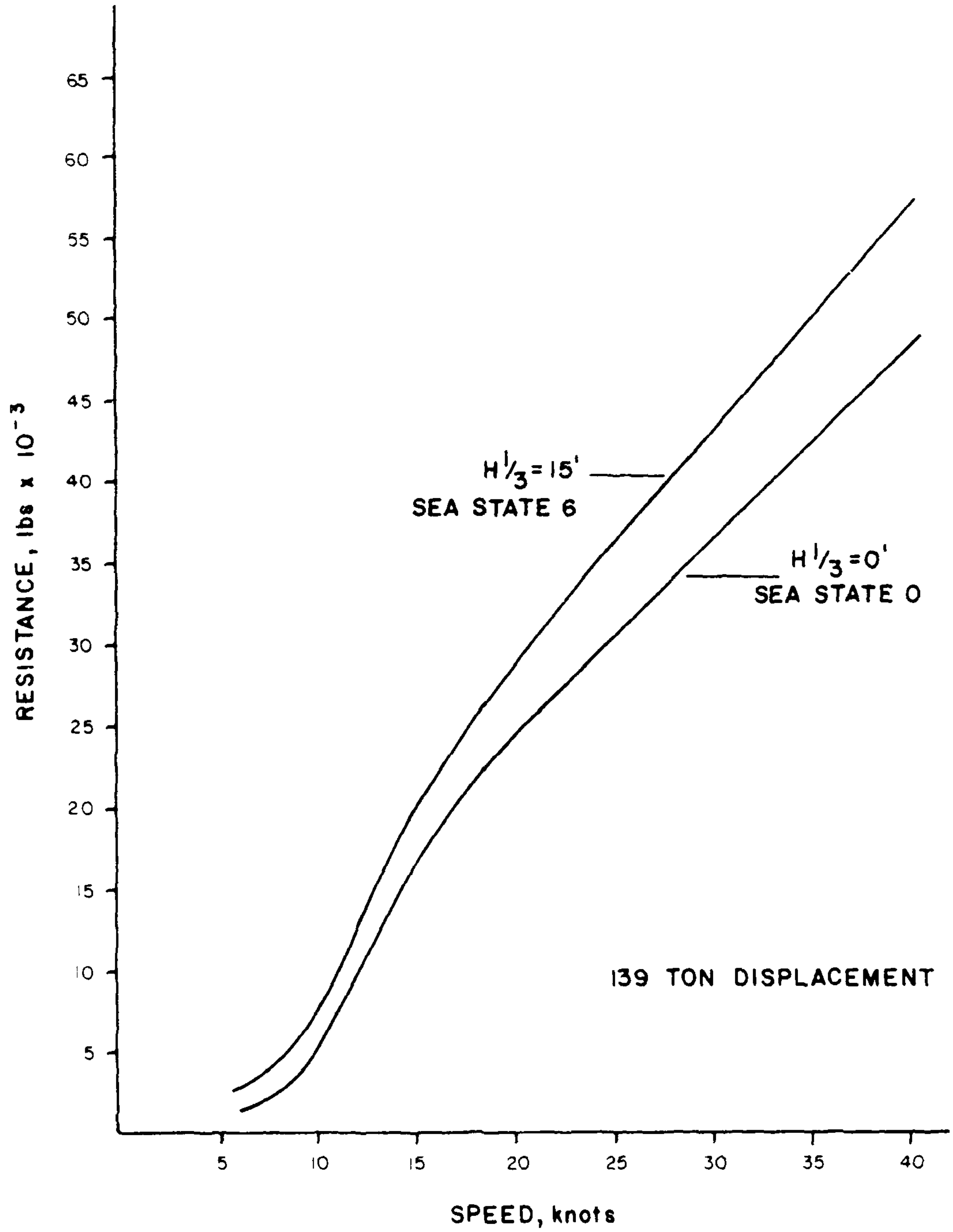
SWBS GROUP NO.	DESCRIPTION	WEIGHT POUNDS
1	Structure	61,344
2	Propulsion Systems	57,242
3	Electrical Systems	14,660
4	Command and Surveillance	4,430
5	Auxiliary Systems	[illegible]
6	Outfit and Furnishings	30,354
7	Combat Systems	5,600
	Light Ship w/o Margin	216,1[illegible]
	Margin, 10	21,62[illegible]
	Light Ship w/Margin	237,[illegible]13

LOAD ITEM	WEIGHT, FULL LOAD POUNDS	WEIGHT, MIN OP Pounds
Crew and Effects	6,720.0	6,720.0
Fuel	51,137.0	17,029.0
Potable Water	10,080.0	6,720.0
Stores	5,600.0	1,866.5
Total, Loads	73,537.0	32,335.5
TOTAL, Light Ship and Loads	311,350	270,149

SPEED/POWER ESTIMATE

The techniques used to predict the resistance and powering requirements for this craft have been used by the Combatant Craft Engineering Department for a number of years, and have produced acceptable predictions for craft of this type. Bare hull resistance was estimated from David Taylor Naval Ship Research and Development Center (DTSNRDC) Series [illegible] hard chine planing hull data published in Reference (3). The appendage drag was estimated using the methods described by Blount and Fox in Reference (4). The calculation of added resistance in waves was based on Hoggard's work, Reference (5). The propeller selection was based on the Gawn-Burrill series, Reference (6), using the thrust deduction factors from Reference (7). A maximum of [illegible] back cavitation was considered acceptable.

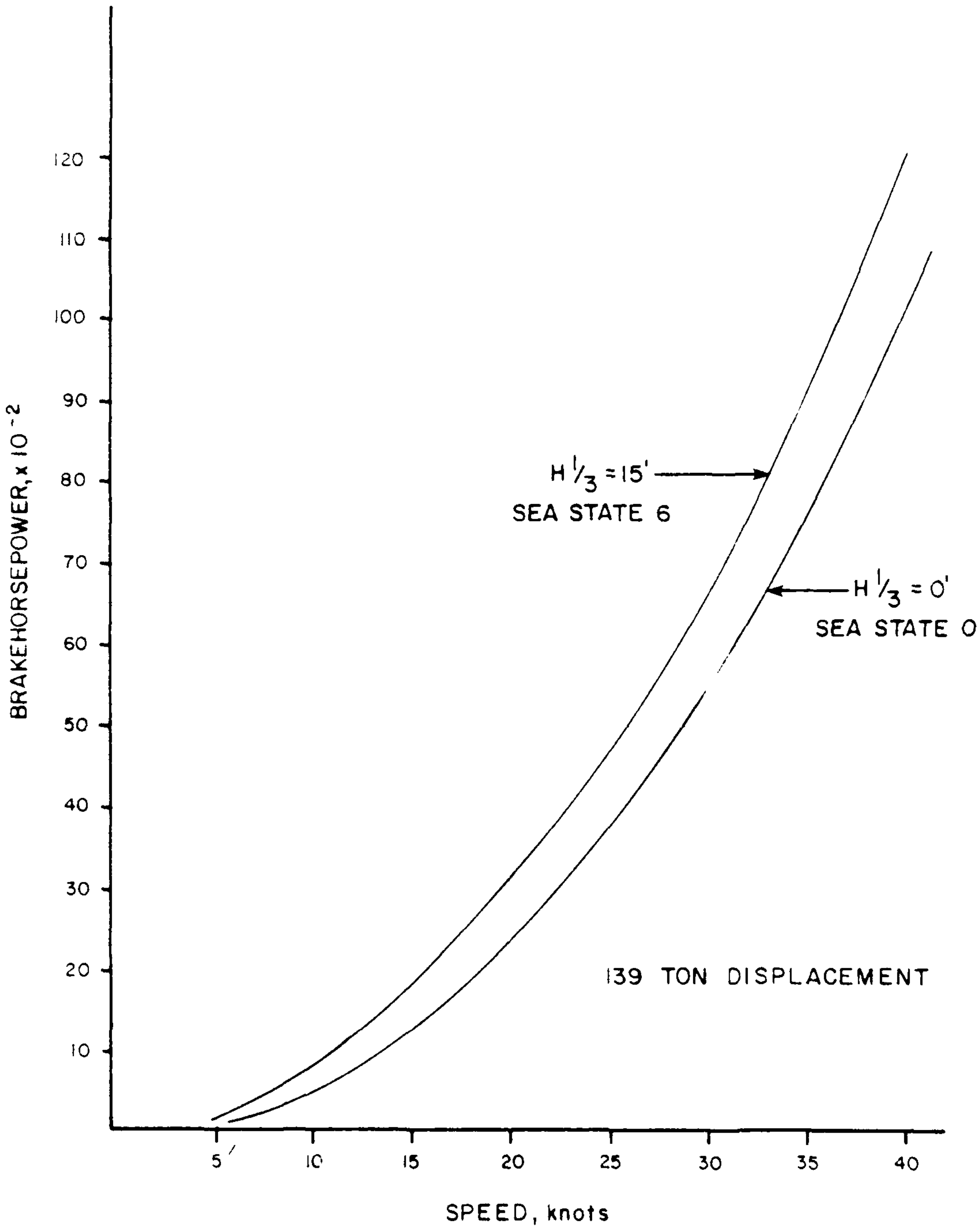
Figure 4 shows the predicted full load resistance in both calm water and sea state 6. There is little increase in resistance in waves. Figure 5 is a graph of brake horsepower (BHP) vs. speed, also for calm water and sea state 6. Figure 6 shows the speed degradation in waves, assuming constant power is available throughout the range. The speeds attainable with the installed engines are discussed below.



RESISTANCE vs. SPEED

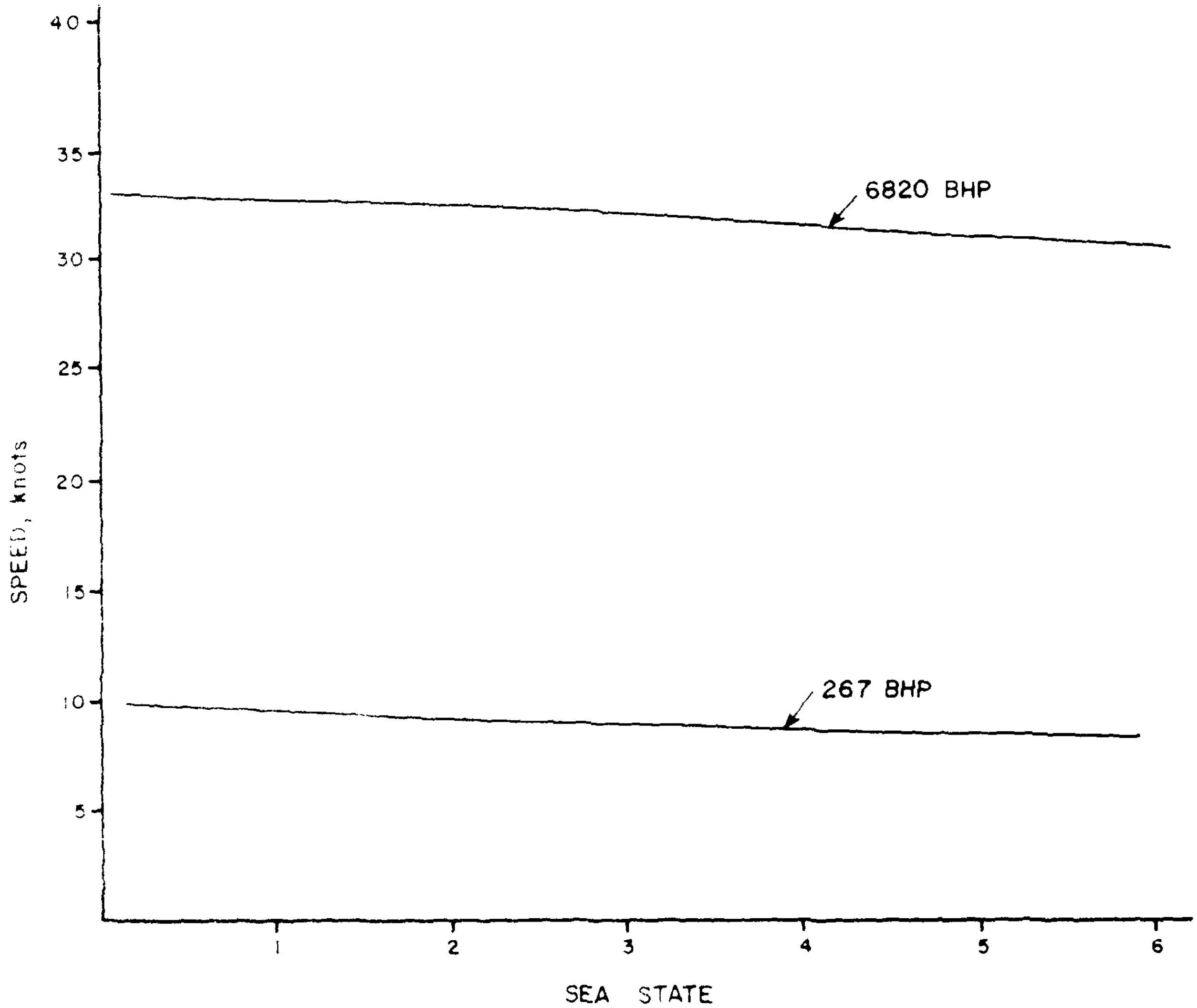
120' WPBX

Figure 3



BRAKEHORSEPOWER vs. SPEED
120' WPBX

Figure 6



SPEED DEGRADATION DUE TO SEA STATE

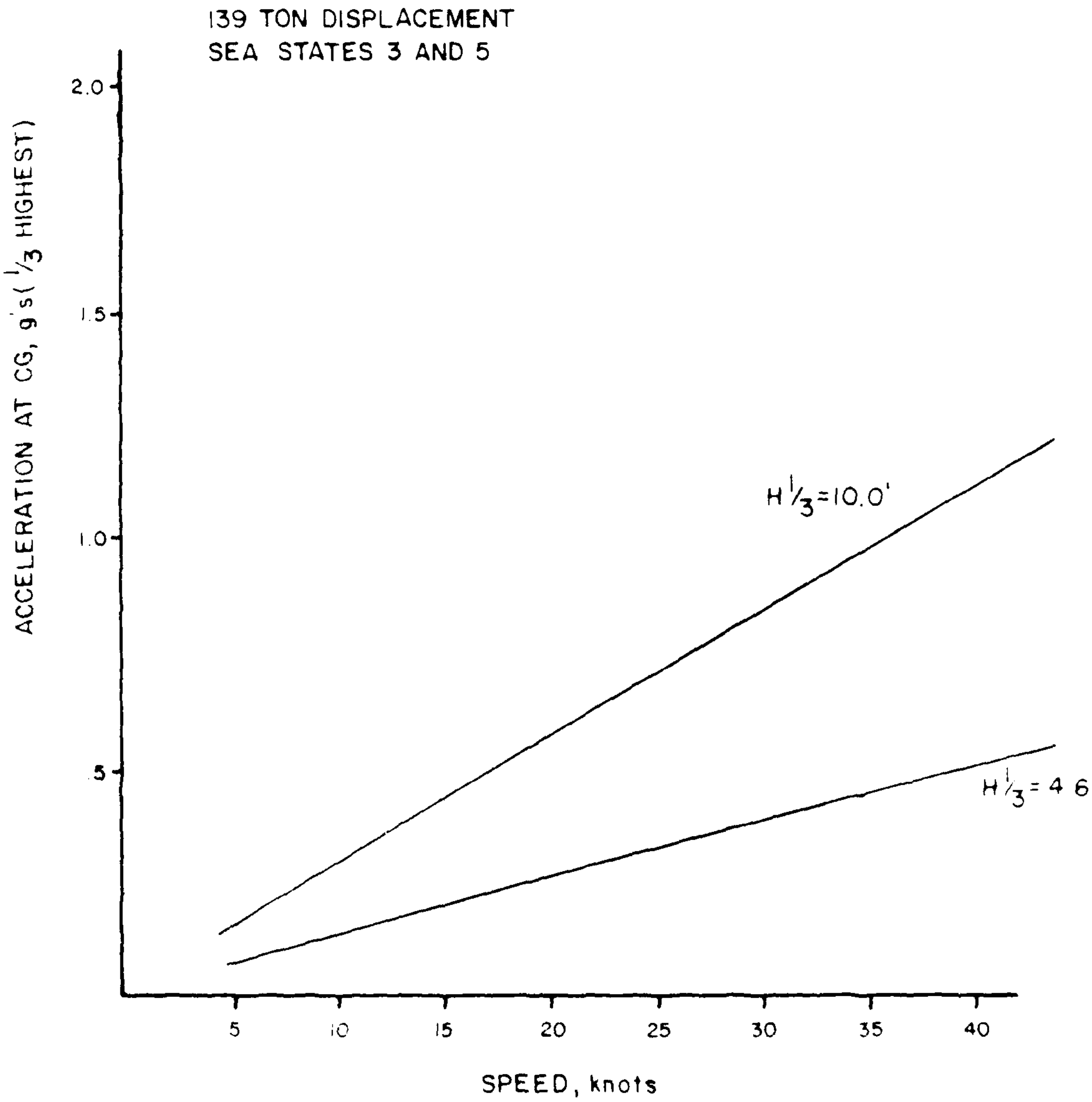
120' WPBX

ACCELERATION AND RIDE QUALITY

Accelerations for both craft were calculated using equations presented in Reference (8). These accelerations are plotted in Figures 7 and 8. Both graphs indicate that the craft would experience relatively low accelerations for a planing hull at high speeds, but the accelerations are still higher than those that would be experienced by a displacement craft going at a lower speed, Reference (9). During periods of pursuit in rough seas the crew may not be able to function fully. With a smoother riding hull, the longer transit times will lead to motion sickness, even though the motions are less.

There are presently two criteria for predicting ride quality. The first of these is a rule of thumb approach that can be used as a comparison between different craft. Here, the speed required to produce a 0.4 g significant acceleration is predicted for increasing sea states, Figure 9. The second criterion requires the calculation of the maximum value of the 1/3 RMS center of gravity accelerations from those previously calculated. These are plotted against their center frequency, and the likelihood of motion sickness, Figure 10.

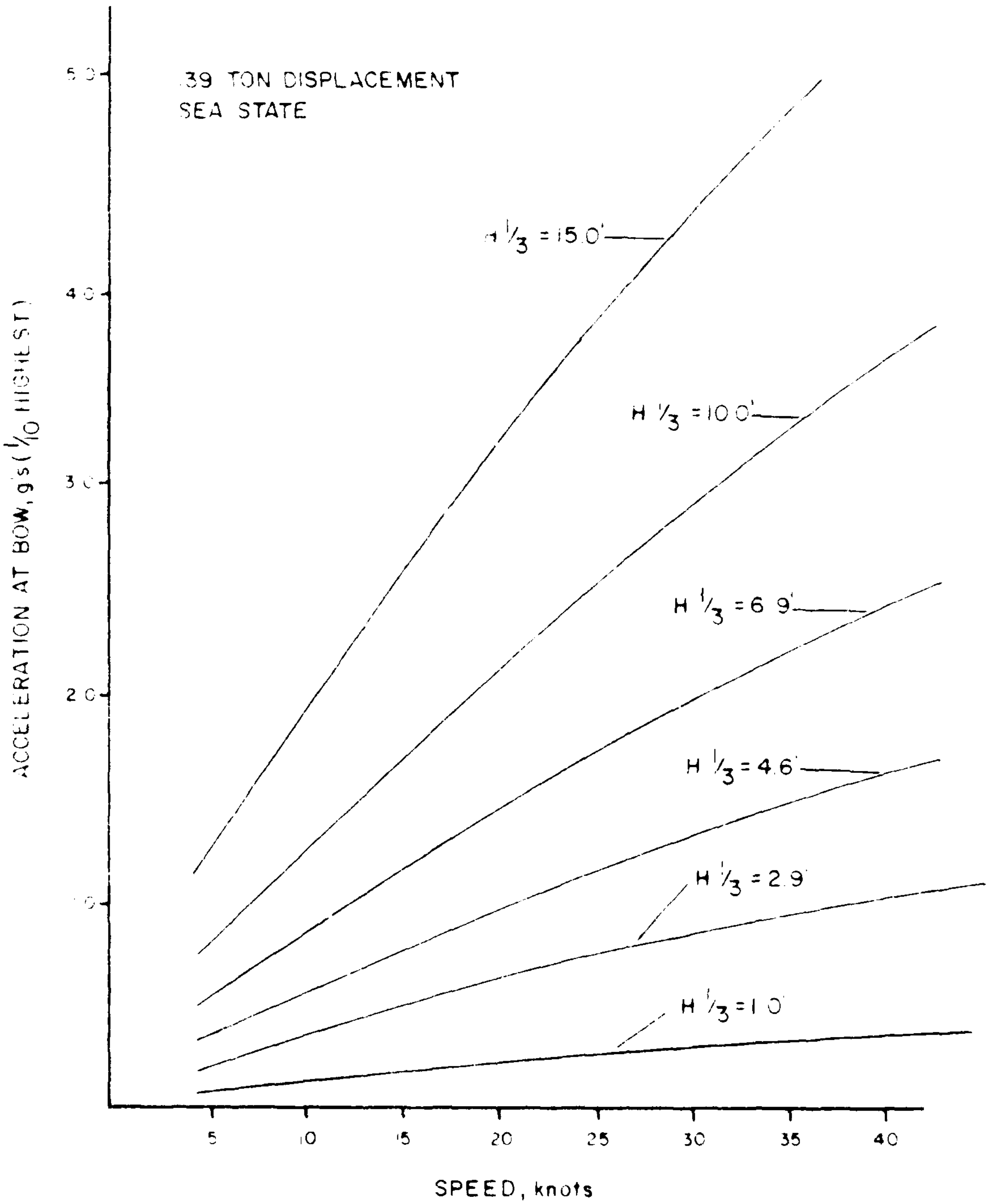
Figures 11 and 12 are indications of the maximum roll and pitch that can be expected from the craft. These figures were taken from actual CPIC full scale trial data, and it is expected that this craft would experience lower motions than shown here due to its larger weight and added mass.



ACCELERATION AT CG vs. SPEED

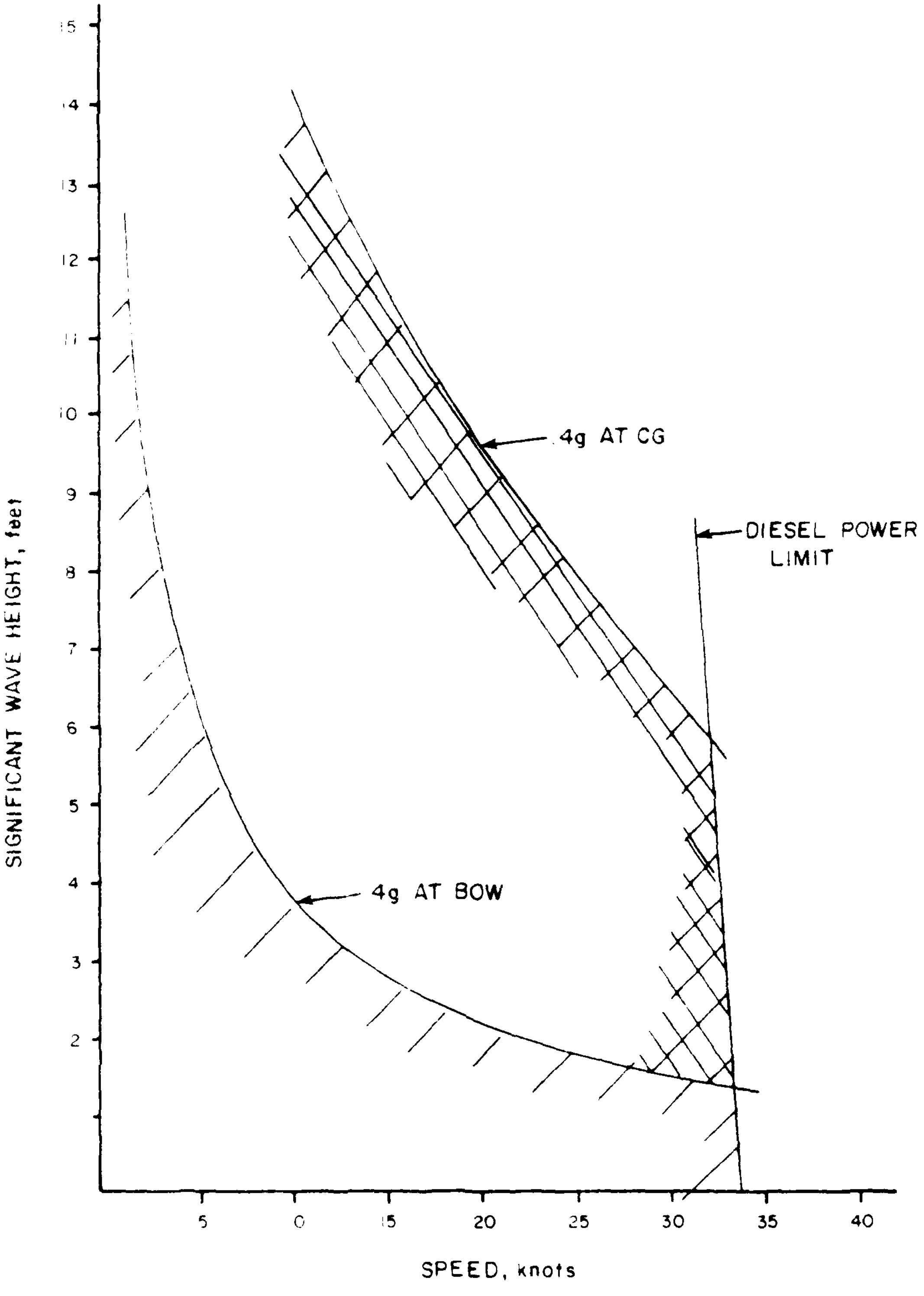
120' WPBX

Figure 7



ACCELERATION AT BOW vs. SPEED

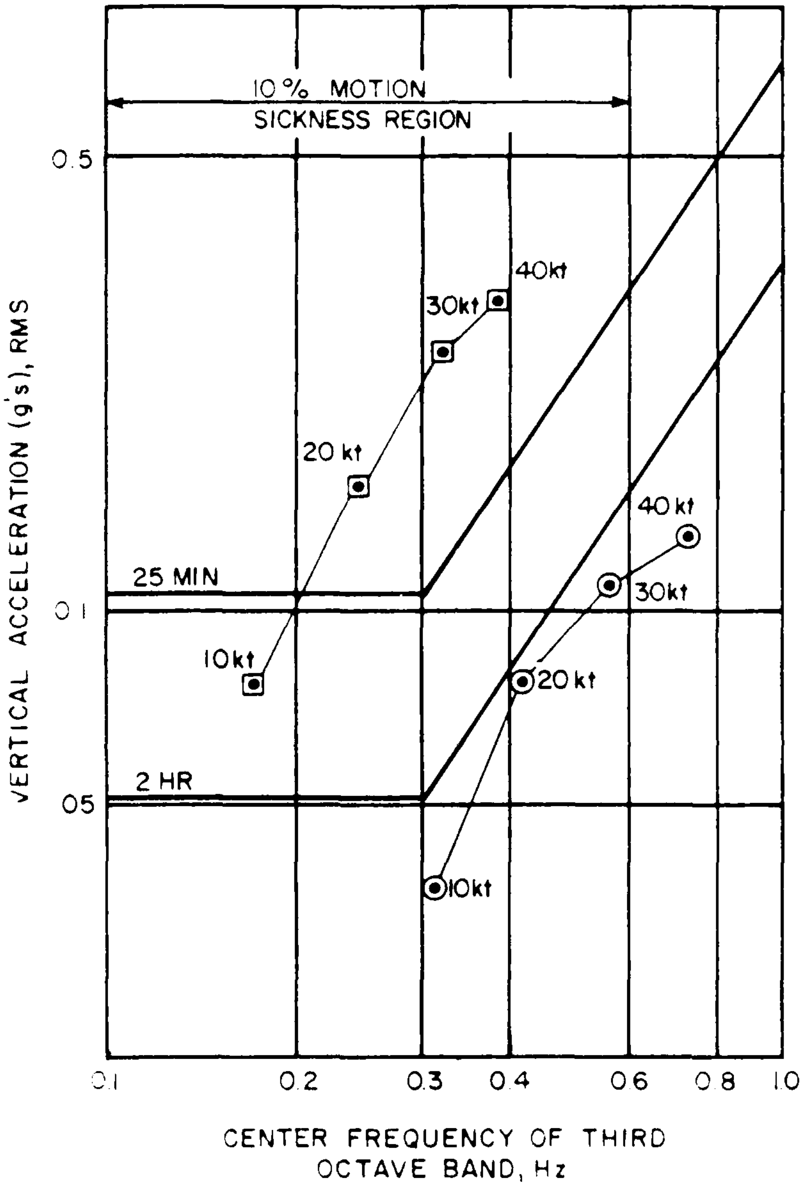
120' WPBX



OPERATIONAL LIMITS

120' WPBX

Figure 4



139 TON DISPLACEMENT

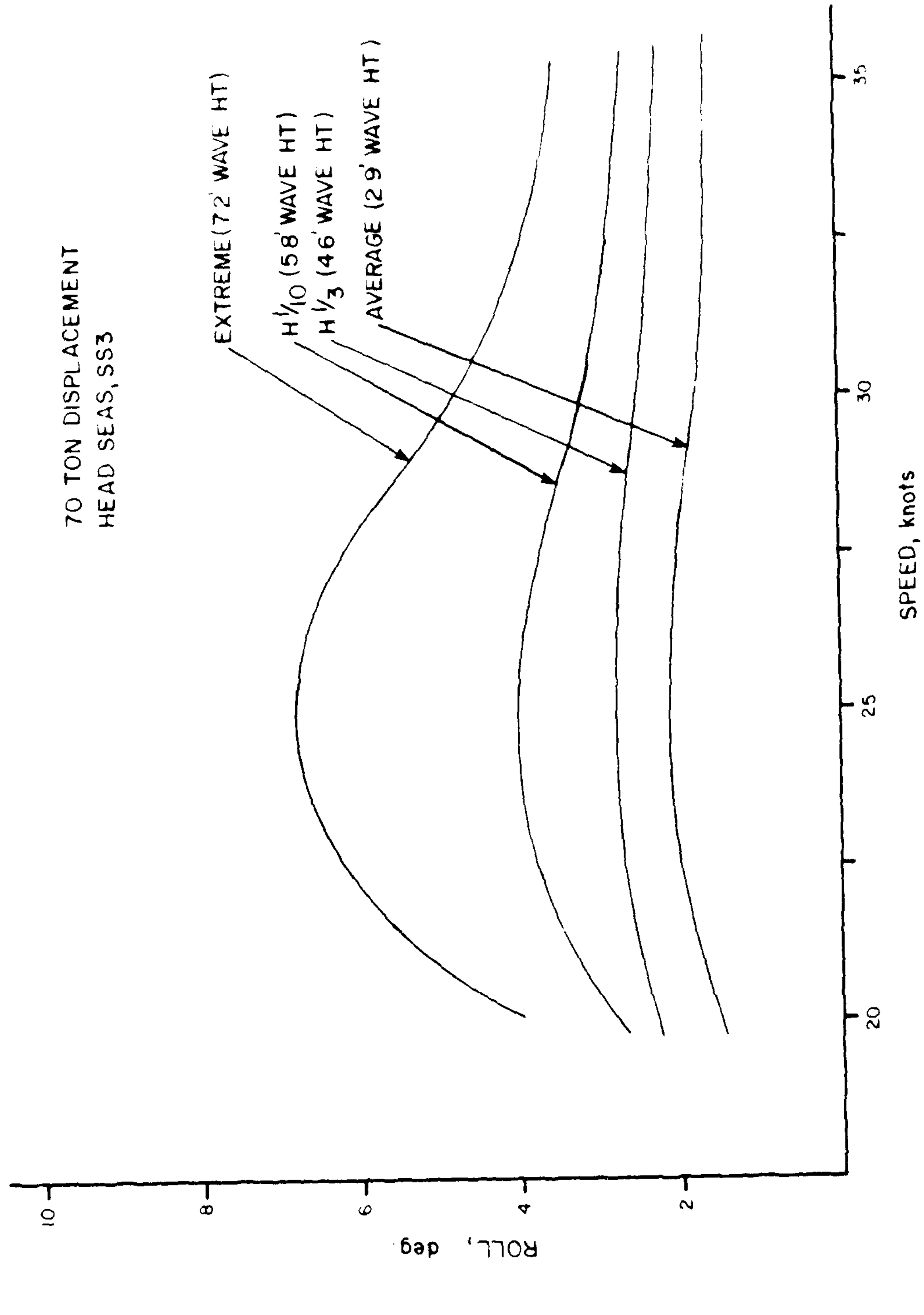
Sea State 3, H 1/3 = 4.6'

Sea State 5, H 1/3 = 12.0'

kt = Knots

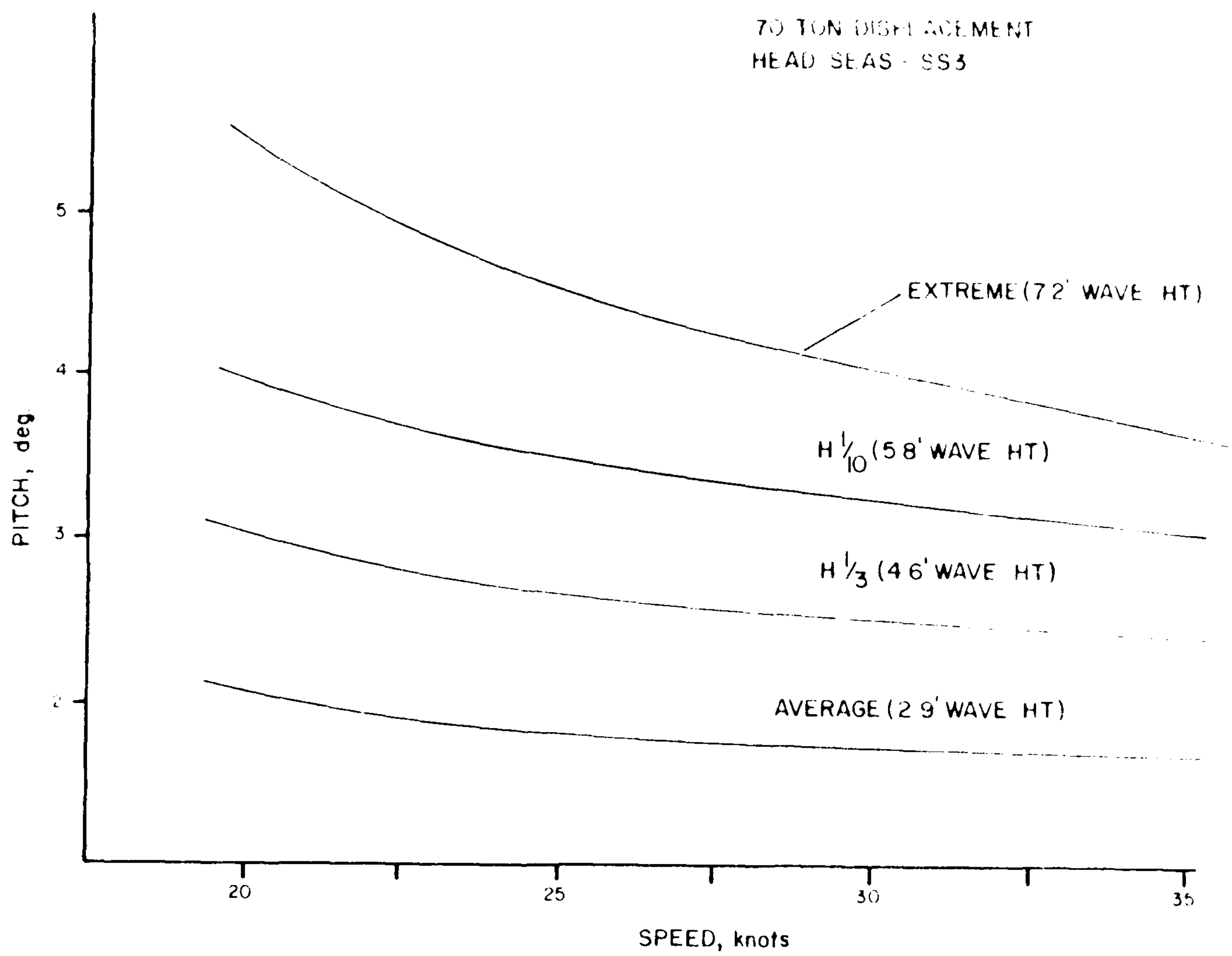
MOTION SICKNESS PREDICTION

120' WPBX



ROLL vs. SPEED
95' CPIC

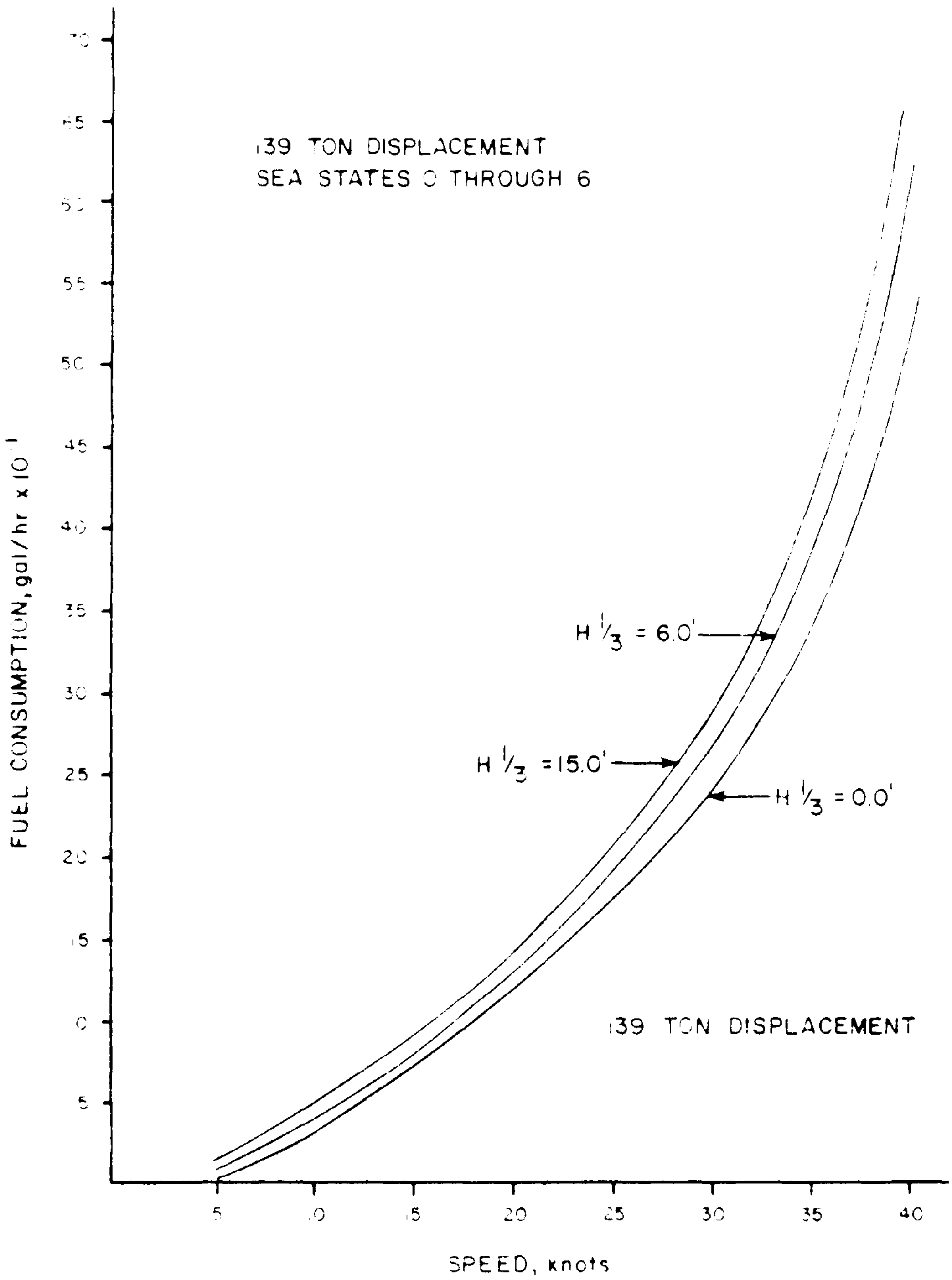
Figure 11



PITCH vs. SPEED
95' CPIC

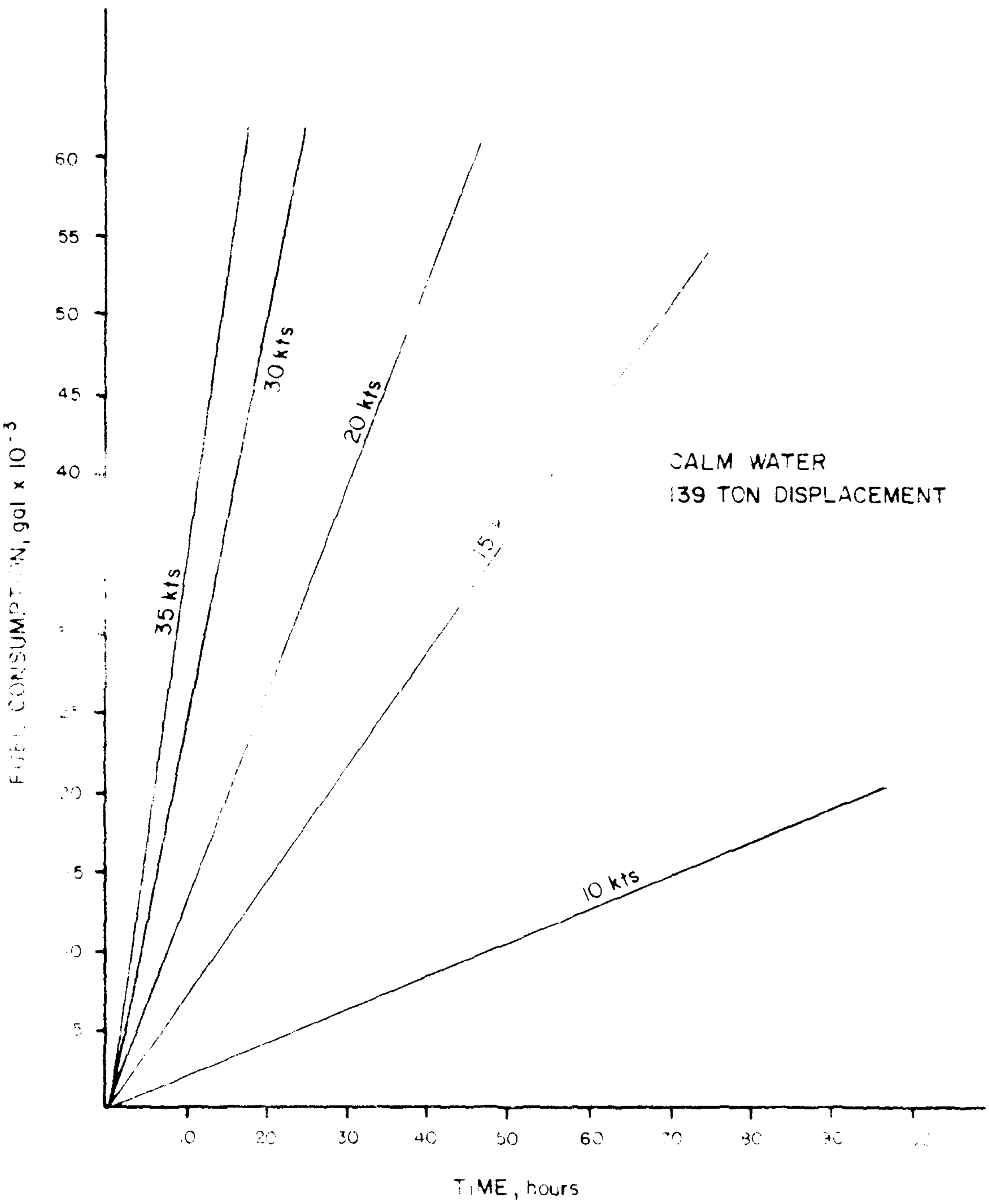
RANGE, ENDURANCE, AND FUEL CONSUMPTION

Range, endurance, and fuel consumption characteristics are shown in figures 1[illegible] through 16. Additionally, the fuel consumption curve for the engine chosen is shown in figure 17, reference (17). Range and endurance calculations were based on the Breguet formula, which accounts for fuel burnoff throughout the range. Fuel consumption calculations are based on the [illegible] ton full load displacement. The craft will meet the minimum range requirements of 5 days, with 96 hours at 10 knots, and 24 hours at 30 knots, with 10% reserves. This necessitates the stowage of 5466 gallons of fuel. Actual stowage is provided for 8826 gallons, including the day and settling tanks, which enables the craft to perform a mission of 24 hours at 35 knots, and 11[illegible] hours at 10 knots, with no reserves. There will be some degradation of the maximum speed attainable with this fuel load, however, until the weight of the extra fuel has been burned off.



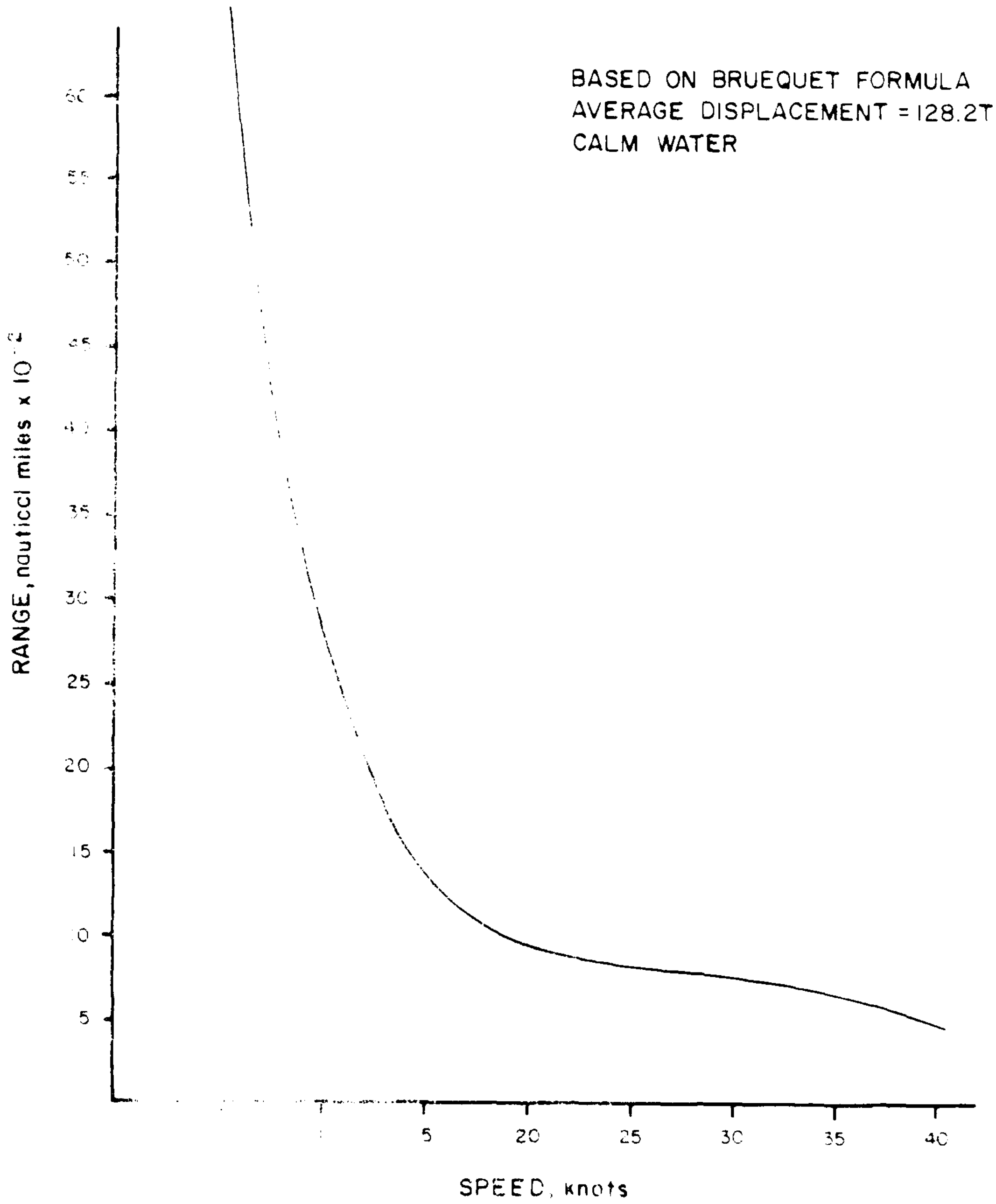
FUEL CONSUMPTION vs. SPEED

120' WPBX



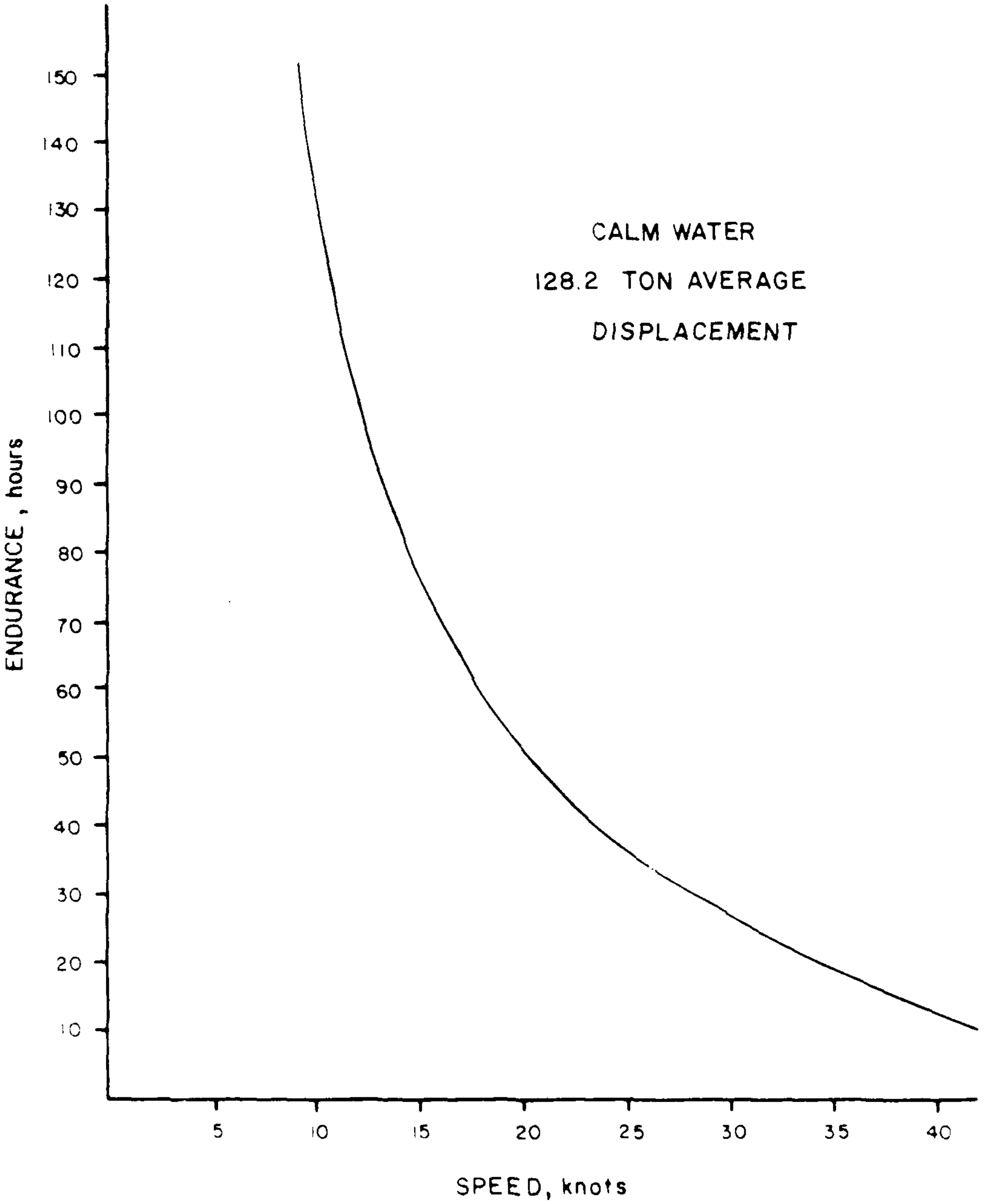
FUEL CONSUMPTION vs. TIME

120' WPBX

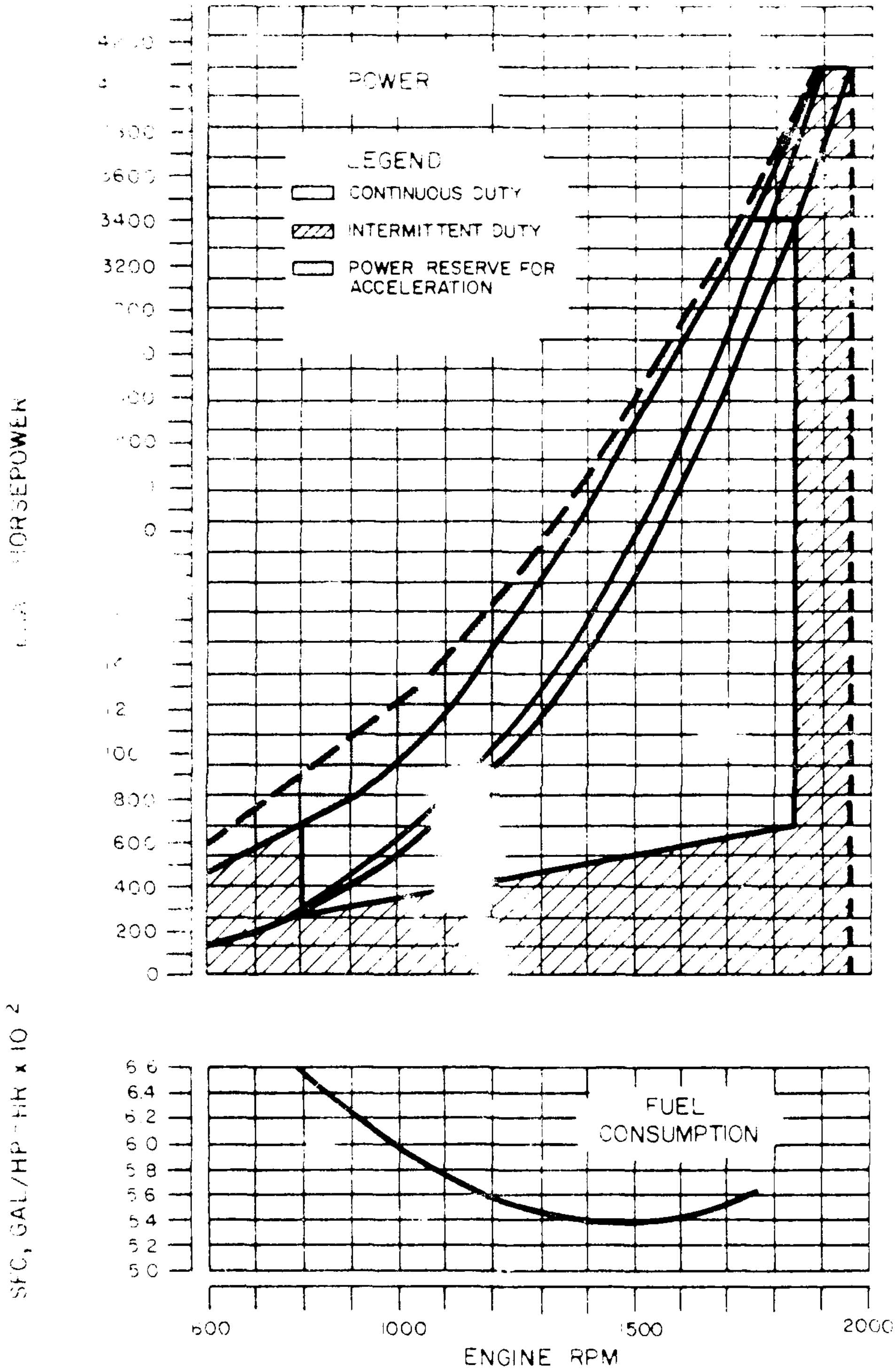


RANGE vs. SPEED

120' WPBX



ENDURANCE vs. SPEED
120' WPBX



POWER/FUEL CONSUMPTION CURVES

16V538TB92

HULL STRUCTURE

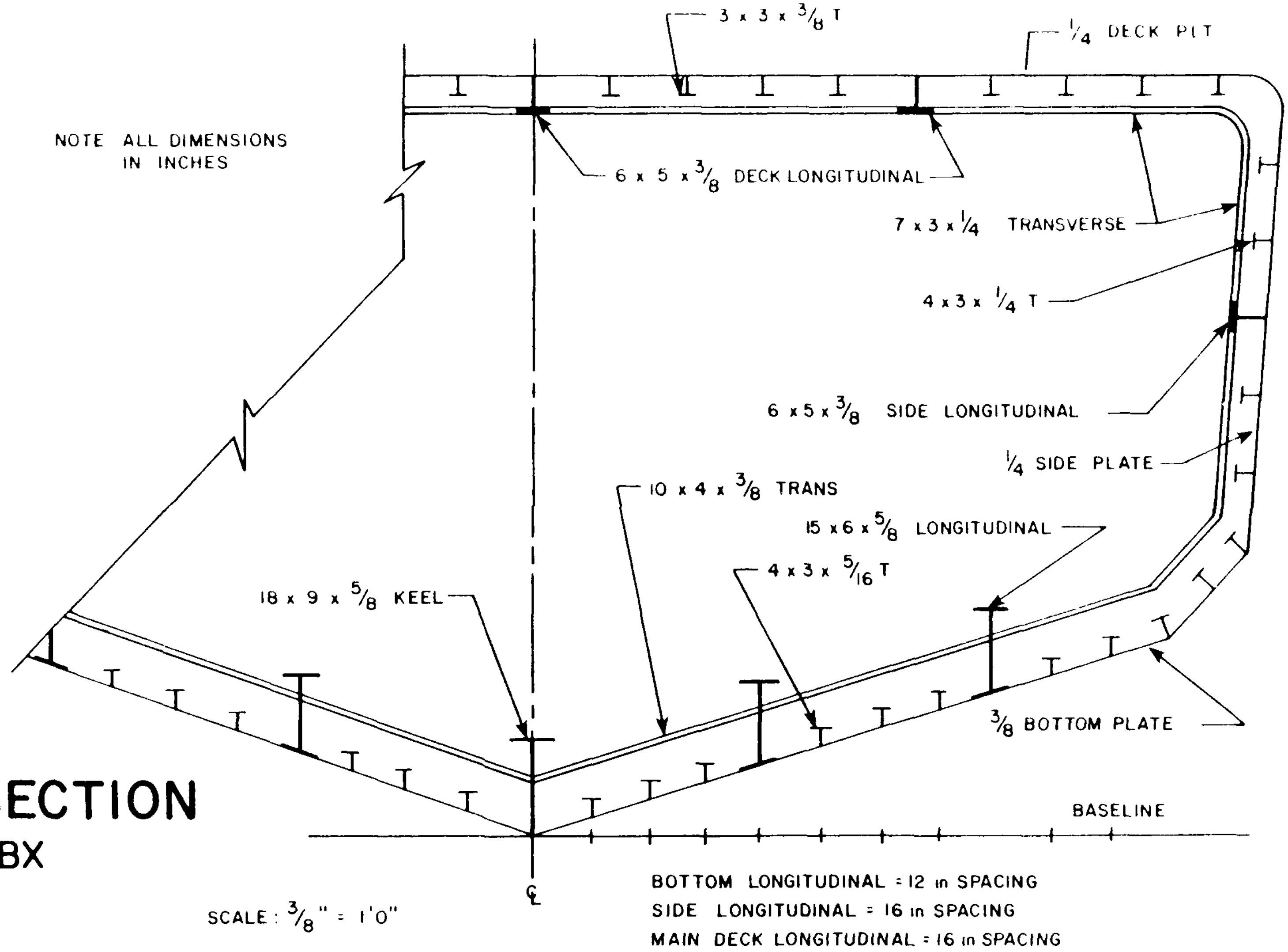
The hull material chosen is aluminum alloy. This was preferred over steel construction because of the required high performance of the craft. The high structural weight of steel was traded for heavier engines of a higher horsepower and for the ability to carry more fuel.

The particular alloy, 5086, was chosen for its ease of fabrication, maintainability, availability and corrosion resistance. The alloy is readily available, and is the one usually specified for marine applications.

Watertight bulkheads are also of aluminum. They are specifically located so as to allow the craft to meet the U. S. Navy criteria to permit the flooding of two adjacent compartments, with no specified length of damage, without immersing the margin line located 3 inches below the main deck at side.

Major girders are provided in both the bottom and main deck for longitudinal bending strength. A typical midship section for a craft of this size and type is shown in Figure 18. Some scantlings are expected to change slightly as the design is developed.

This midships section was designed to a bending moment of 16,000 foot-tons, using the method of Heller and Jasper, Reference (11), with a 60% midship moment reduction as recommended by Allen and Jones, Reference (12). The maximum accelerations assumed were 1.5 g's at the center of gravity, and 6 g's at the bow. These are both considered the maximum accelerations that might be anticipated in the life of the craft.



MIDSHIP SECTION
120' WPBX

PROPULSION SYSTEM

Propulsion power for this craft is provided by twin MTU 16V538TB-92 diesel engines driving twin propellers through KSS reduction gears. The ratings of this engine, and the speeds provided in calm water are shown in Table 3.

The drive train uses fixed pitch propellers, but if it is found as the design progresses that controllable pitch propellers will be more effective for the craft's expected mission scenarios, they will be recommended for inclusion.

Table 3. Speed At Various Engine Ratings

Total BHP	Rating	Speed, knots
6820	Continuous	33.3
7540	2 hours every 12	35.1
8160	1/2 hour every 24	36.1

STABILITY

A stability investigation was conducted for the patrol boat using usual U. S. Navy standards and calculation methods, Reference (15). The craft was found to meet all of the applicable standards in both the full load and minimum operating conditions. The results of these calculations are summarized below.

Floodable Length

A floodable length calculation was performed for the craft in the full load condition, which is always the governing case. The margin line was taken to be parallel to the sheer line, and three inches below it. The governing criteria for this length craft is that the cutter survive the flooding of any two adjacent compartments, with the specified length of damage. The resulting floodable length curve in Figure 19 shows that the vessel meets the applicable standard.

Intact Dynamic Stability

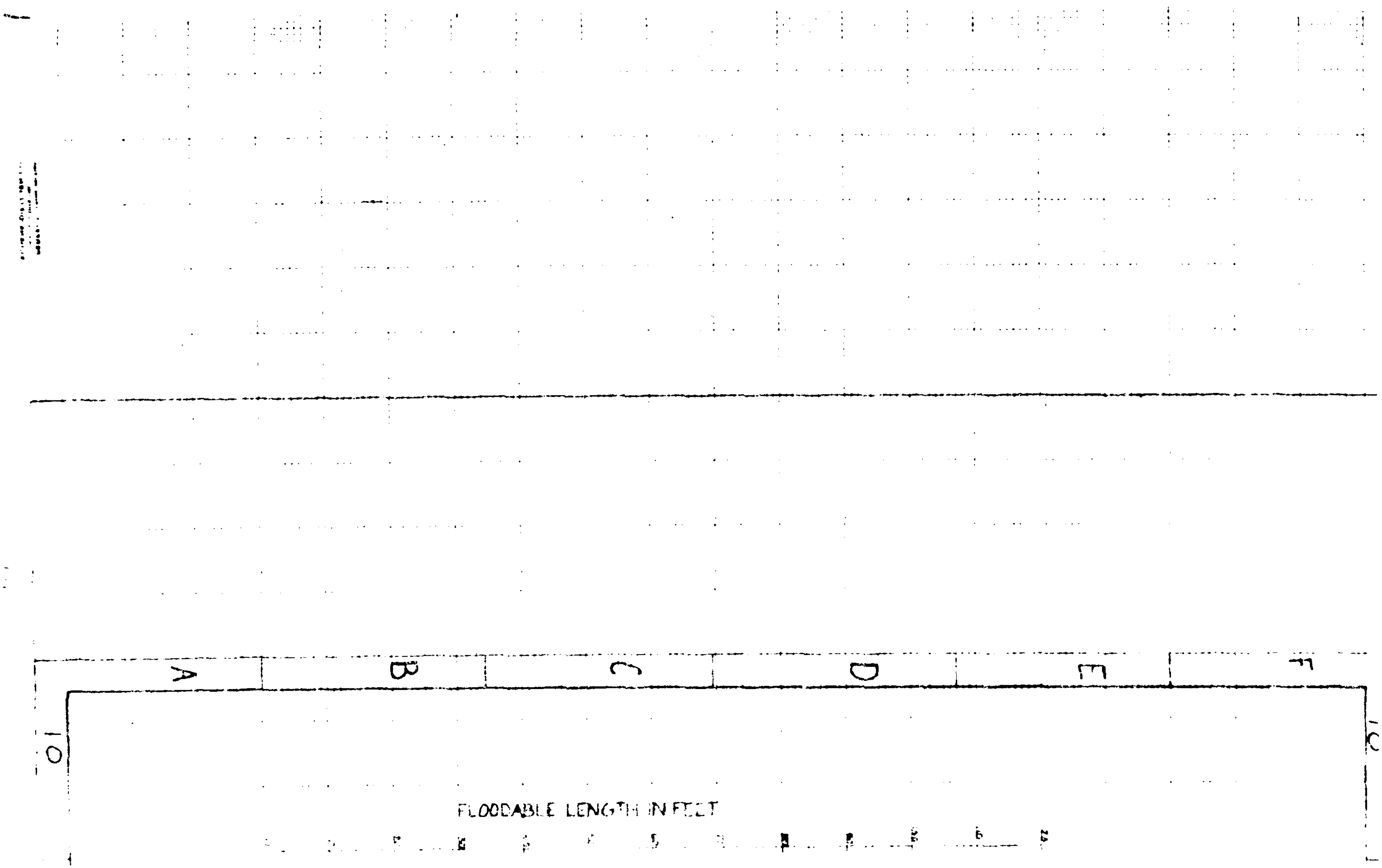
A study of intact dynamic stability was conducted for the craft in both the full load and minimum operating conditions. These calculations measure the ability of the craft to resist heeling caused by an external source, in this particular case a beam wind of 70 knots. Additionally, as a measure of the craft's ability to resist rolling due to wave action, the energy available to resist a roll to windward must exceed the energy stored in a 25 degrees roll to leeward by 40 percent. As a margin for gusts and inaccuracies in assumptions and as an indication of the ultimate stability of the vessel, the righting arm at the angle of heel assumed by the craft must be no more than 60 percent of the maximum available.

The result, shown in Figures 20 and 21, is that the cutter satisfies all of the applicable criteria. For this type of craft, the minimum operating condition is the most critial, but there is sufficient margin even in this condition to allow for reasonable KG growth.

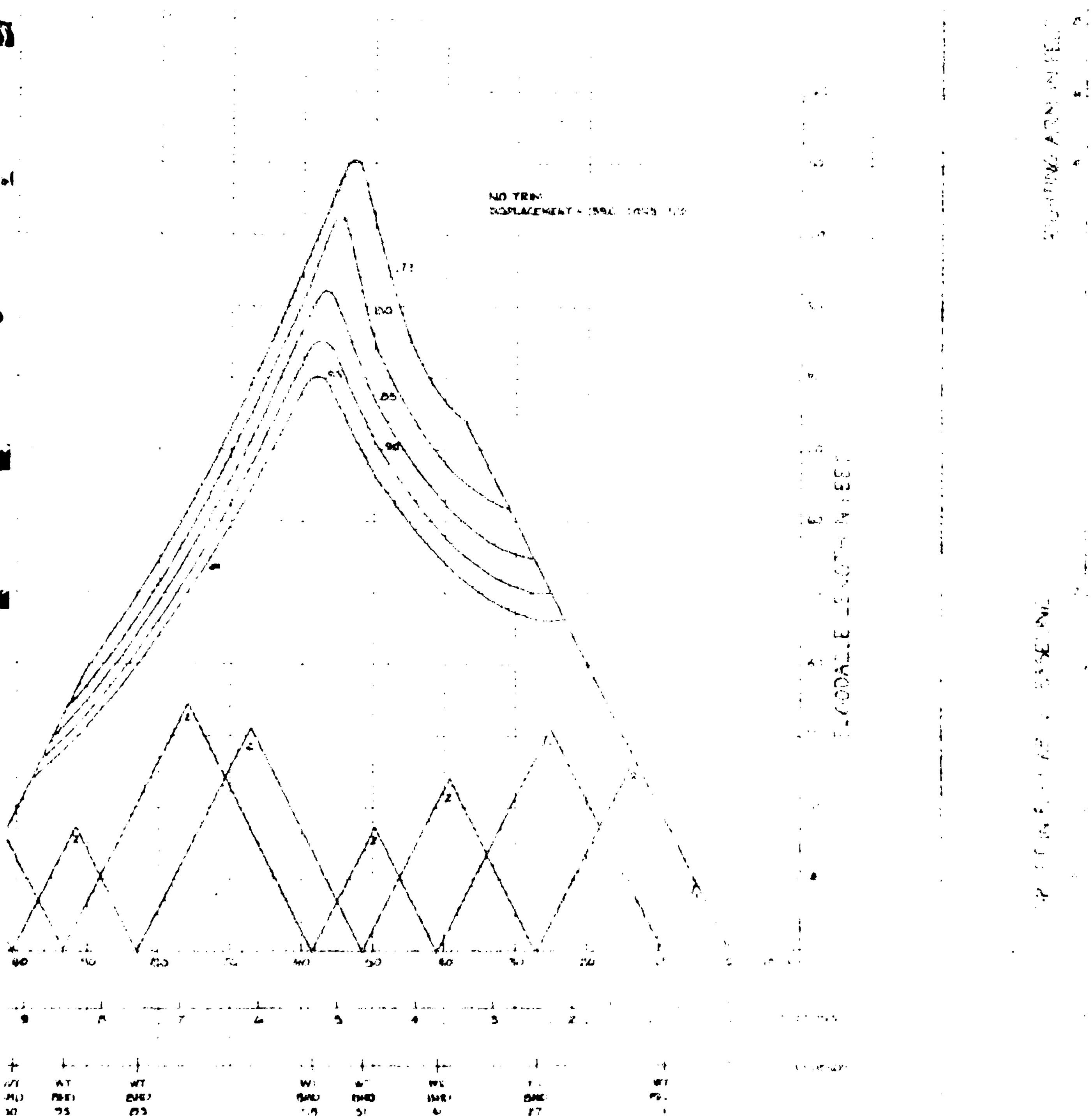
Damaged Stability

An investigation of the craft's damaged stability was conducted for both the full load and minimum operating conditions. These calculations are a measure of the craft's ability to survive after receiving damage from an external source. The applicable standard for this craft is that it be able to survive any combination of flooding involving the loss of one main transverse bulkhead. Additionally, a wind heeling moment must be imposed on the craft. (The wind velocity varies with the size of the vessel, in this case 20 knots was used.) The angle of heel assumed by the craft must not exceed 15 degrees, and the available righting energy must exceed a value that varies with the size of the craft. In this case, the required energy was 14 foot-tons.

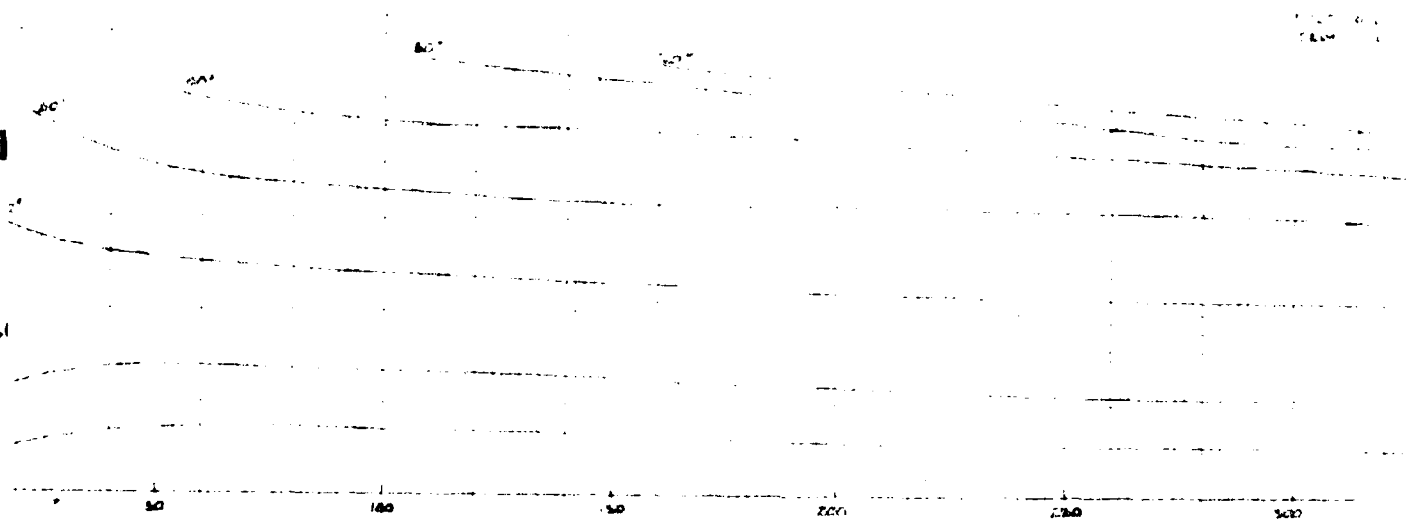
The result of these calculations are shown in Figure 22. These graphs show only the single worst case for both the full load and minimum operating conditions. All combinations of damage were considered, but are omitted for clarity. The graphs show that the cutter will meet the required standards.



A
B
C
D
E
F
10
FLOODABLE LENGTH IN FEET

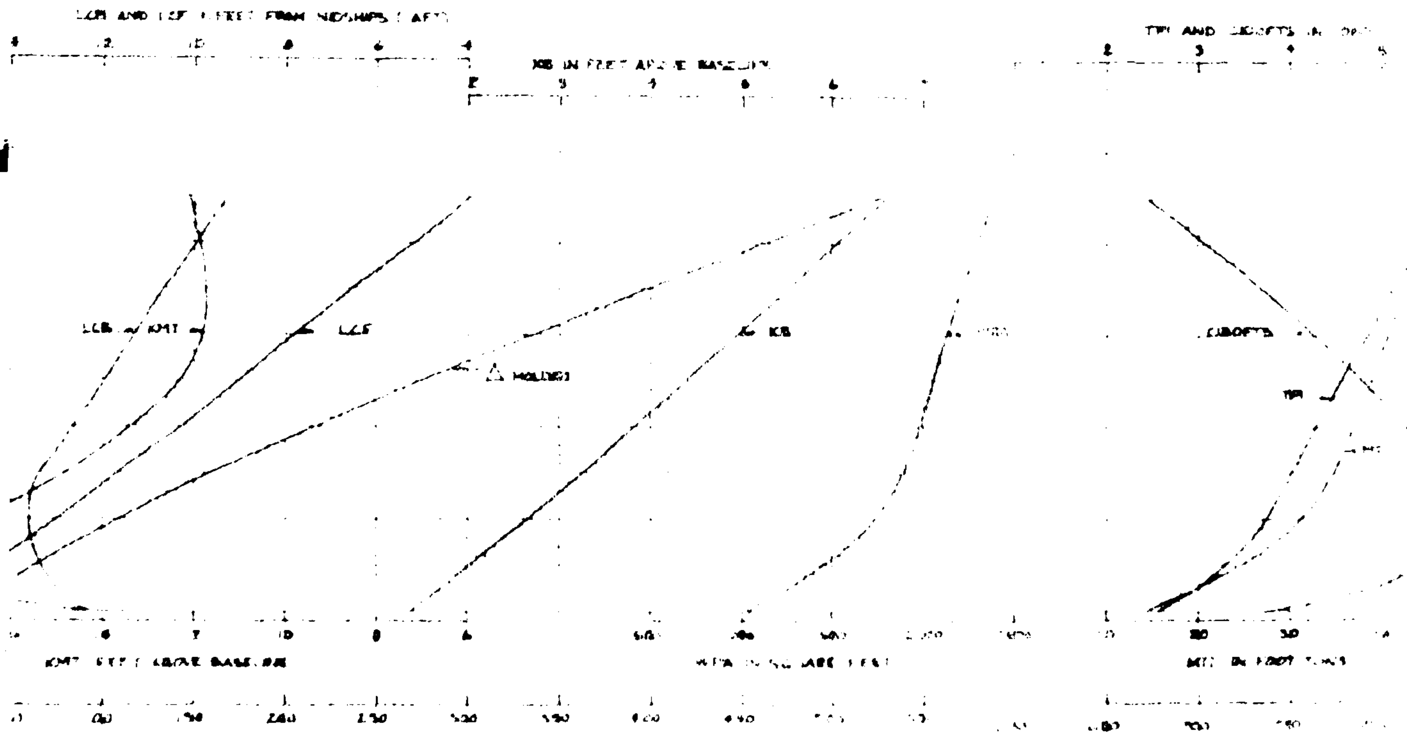


FLOODABLE LENGTH CURVE



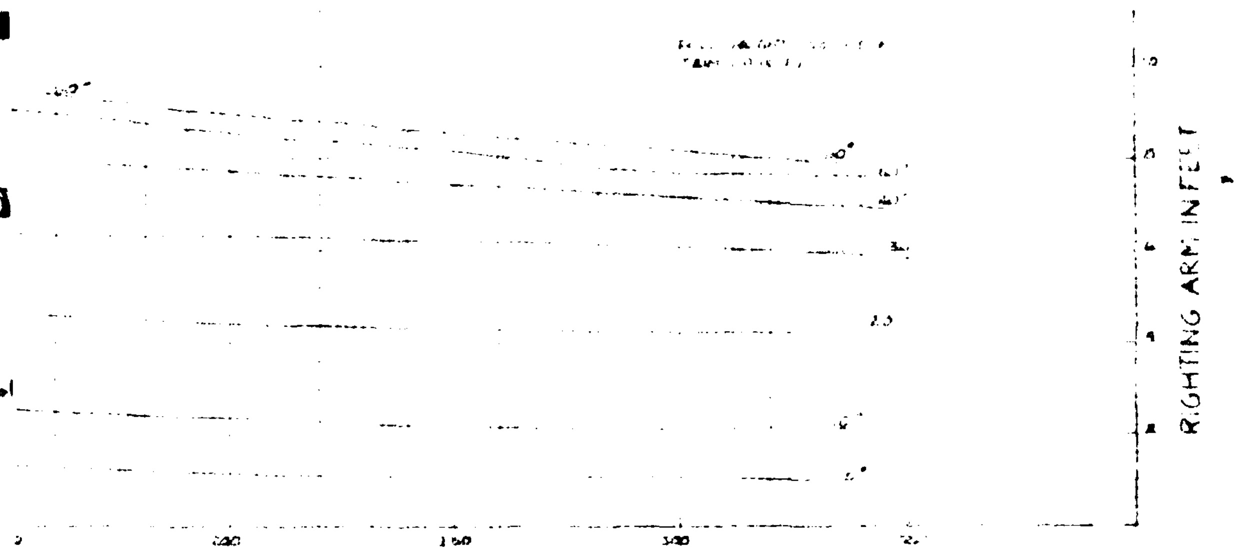
DISPLACEMENT IN TONS

CROSS CURVES OF STABILITY

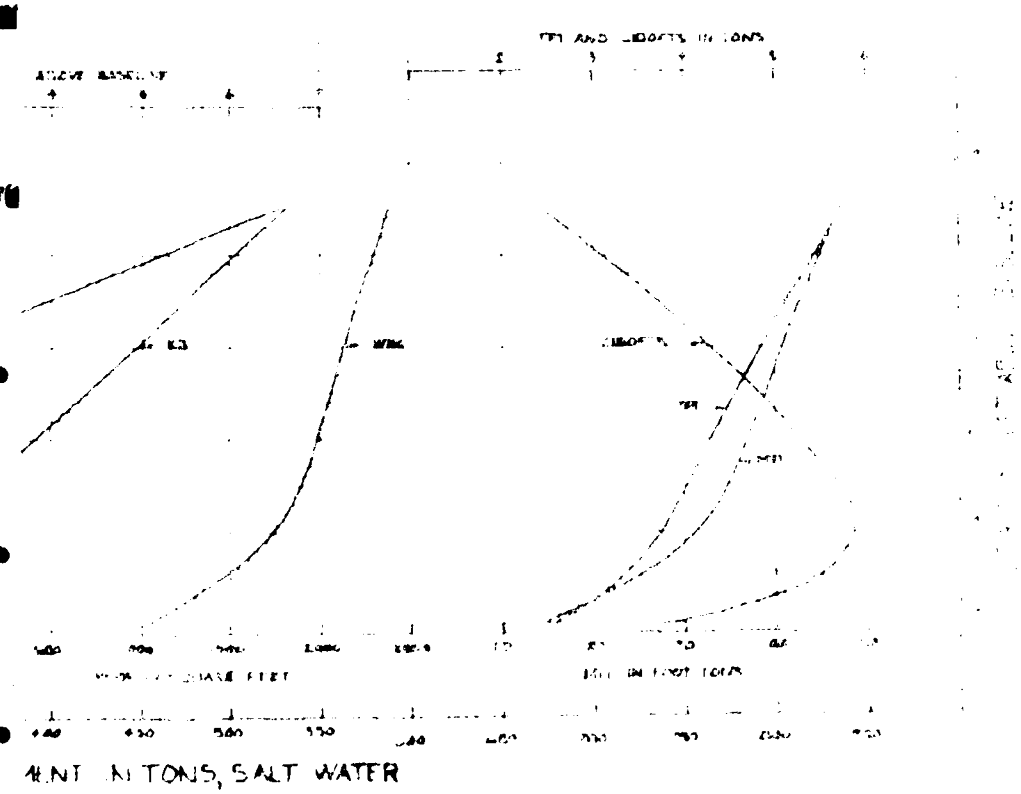


DISPLACEMENT IN TONS SALT WATER

CURVES OF FORM

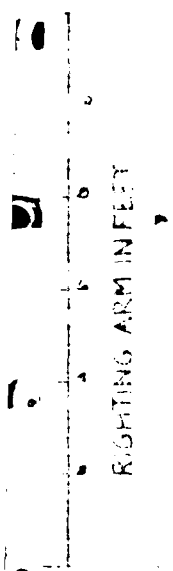


ɔSS CURVES OF STABILITY



CURVES OF FORM

2



LEGEND

Δ - DISPLACEMENT IN LONG TONS
MTI - MOMENT TO ALTER TRIM ONE INCH
TPI - TONS PER INCH IMMERSION
KM - METACENTRIC RADIUS (TRANSVERSE)
KB - CENTER OF BUOYANCY ABOVE BASELINE
LCF - CENTER OF FLOATATION FROM ⊠
WPA - WATER PLANE AREA
LCB - CENTER OF BUOYANCY FROM ⊠
CIDOFTS - CHANGE IN DISPLACEMENT FOR ONE FOOT TRIM BY STERN
GZ - RIGHTING ARMS (ACTUAL)
⊠ - MIDSHIPS @ STATION 5

DOCUMENT TITLE	DOCUMENT

DATA LIST

FEASIBILITY DRAWING

THIS DRAWING DEVELOPED IN CONJUNCTION WITH NAVSEACOMBATSYSENGSTA REPORT NO 90-...

Figure 19

NAVAL SEA COMBAT SYSTEMS ENGINEERING STATION
NAVAL STATION
NORFOLK VA 23511

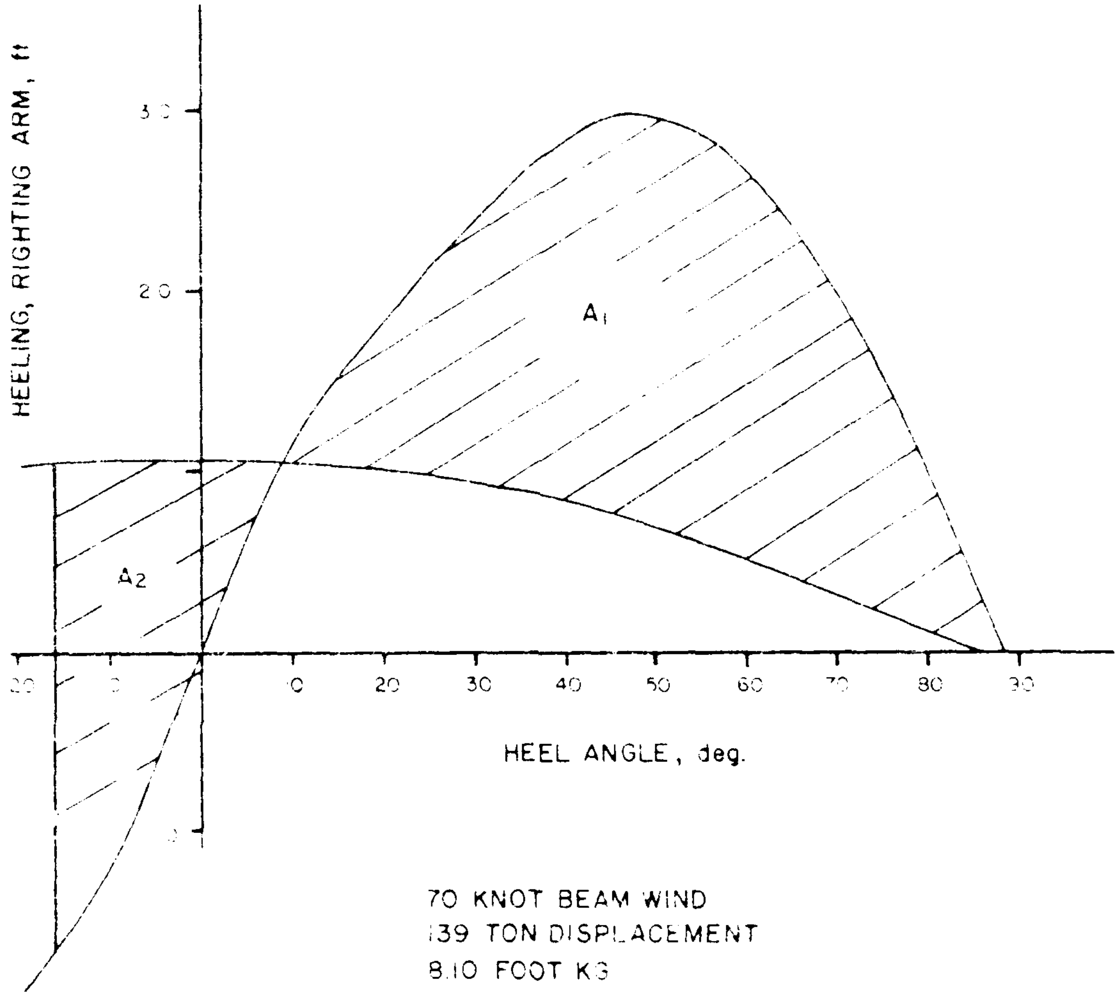
DEVELOPED BY
DRAWN BY LESTER WILLIAMS
CHECK BY
DEPT HEAD
TECH DIR
APPROVED FOR NAVSEA

NAVAL SEA SYSTEMS COMMAND

CURVES OF FORM AND OTHER CURVES

H 53711

2



CRITERIA

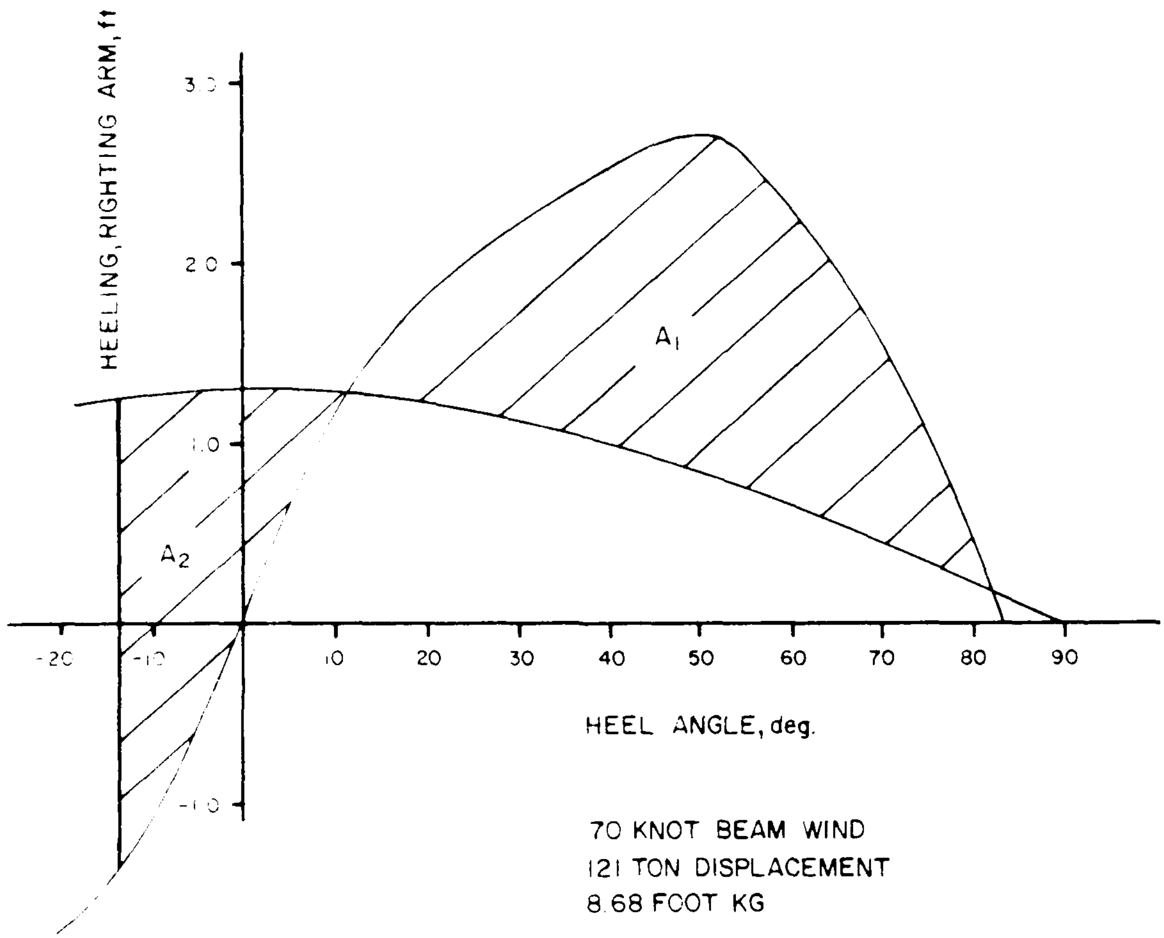
1) ANGLE OF HEEL = 9° < 15° SATISFIED

2) $\frac{\text{RIGHTING ARM AT INTERSECTION}}{\text{MAX RIGHTING ARM}} = \frac{1.07}{3.00} = .36 < .6$ SATISFIED

3) $\frac{\text{AREA A1}}{\text{AREA A2}} > 1.4$ SATISFIED

DYNAMIC STABILITY ANALYSIS
FULL LOAD CONDITION

120' WPBX



CRITERIA

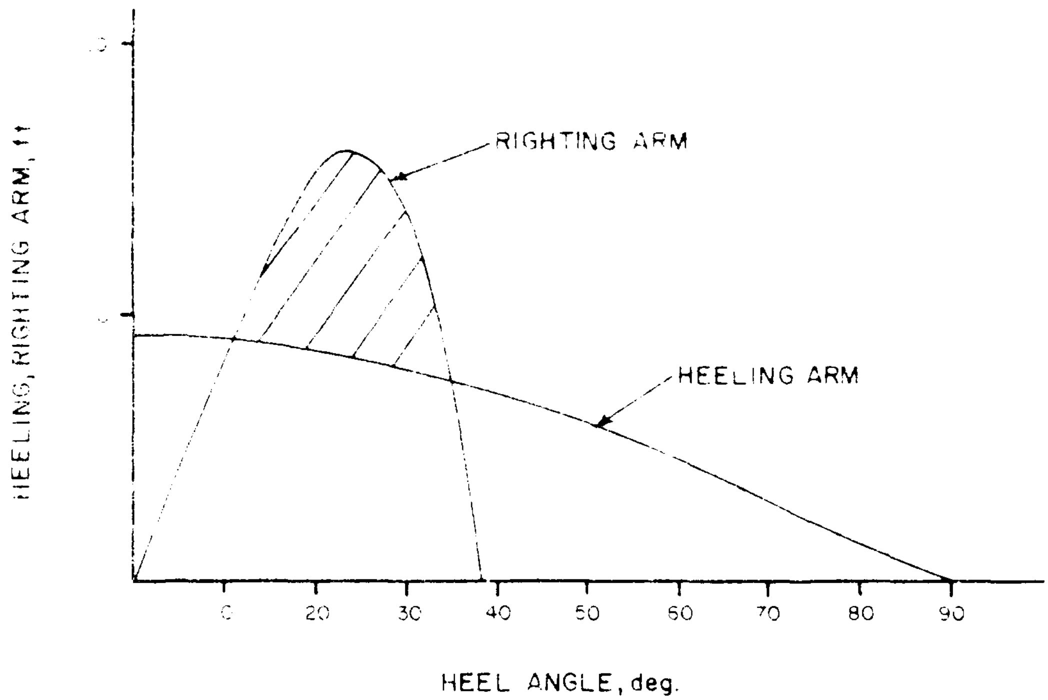
1) ANGLE OF HEEL = 11.5° < 15° SATISFIED

2) $\frac{\text{RIGHTING ARM AT INTERSECTION}}{\text{MAX RIGHTING ARM}} = \frac{1.28}{2.70} = .47 < .6$ SATISFIED

3) $\frac{\text{AREA } A_1}{\text{AREA } A_2} > 1.4$ SATISFIED

DYNAMIC STABILITY ANALYSIS
MIN. OP. CONDITION

120' WPBX



20 KNOT BEAM WIND
139 TON DISPLACEMENT
8.10 FOOT KG
ENGINE ROOM, GENERATOR ROOM, AND
AFT DIESEL OIL TANKS FLOODED

CRITERIA
1) ANGLE OF HEEL = 11° < 15° SATISFIED
2) AVAILABLE ENERGY TO RESIST CAPSIZE = 36 ft. TONS > 14 ft TONS SATISFIED

DAMAGED STABILITY ANALYSIS FULL LOAD CONDITION

120' WPBX

[illegible]

The electric [illegible] two [illegible] with transformers, to provide [illegible] power for [illegible], two battery charging rectifiers to supply [illegible] and two [illegible] inverters to supply power for [illegible] equipment. The estimated [illegible] load is [illegible] for [illegible], [illegible] for battle [illegible], [illegible] at anchor or pierside, and [illegible].

The electric plant is configured to [illegible] three modes of operation:

- Single generator operation with one generator in standby.
- [illegible] operation, used primarily for the transfer of load from one generator to the other.
- Split operation, during which both generators run, with each carrying a portion of the load. This mode is used primarily when increased reliability is required, or when the load exceeds the capacity of a single generator.

The control system will be designed for unattended automatic operation, [illegible] the plant can be controlled and monitored from the [illegible] and can be [illegible] from the pilothouse. In automatic operation, upon loss of voltage [illegible] generating unit, a standby unit will automatically start paralleling or [illegible] the unit on the bus. Provisions are made for dropping non-essential [illegible] at any time the load exceeds available generating capacity. Failure of [illegible] automatic and remote control will not prevent the local starting of a generating unit and the process of connecting it to the bus. The electric plant control panel will contain automatic test and fault isolation for all [illegible] plant units.

The distribution system consists of an Electric Plant Control Panel (EPCP) located in the [illegible], Navy type circuit breaker distribution panels fed from the vital and non-vital [illegible] of the EPCP, transformer banks for 120 VAC power, and [illegible] receptacle circuits. All vital auxiliaries for the propulsion plant [illegible] are supplied from the [illegible] system via the emergency supply [illegible].

[illegible] is needed concerning the selection of some of the [illegible]. The [illegible] battery charging rectifiers were selected over [illegible] driven alternators because of reduced maintenance requirements. The static inverter was chosen [illegible] because of its small size, light weight and [illegible].

AUXILIARY SYSTEMS

The following major auxiliary systems are to be provided:

1. Heating, Ventilating, and Air Conditioning.
2. Roll Stabilization
3. Environmental Control and Sanitation
4. Potable Water
5. Fuel
6. Steering
7. Fire Protection
8. Towing
9. Boat Handling

Heating, Ventilating, and Air Conditioning

All of the enclosed areas will be heated and air-conditioned, with the exception of the machinery spaces, which will be heated and supplied with forced air ventilation only. The following criteria governed the design of the heating, air-conditioning, and ventilation system:

Space	Cooling (Maximum Temperature)	Heating (Minimum Temperature)
Auxiliary Machinery Space	80° F db, 68.2° F wb	40° F
Pilot House	80° F db, 68.2° F wb	65° F
Living Areas	80° F db, 68.2° F wb	65° F
Enclosed Working Areas	80° F db, 68.2° F wb	65° F
Galley	105° F	50° F
Main Machinery		40° F

Design Temperature	Cooling	Heating
Sea Water	85° F	28° F
Outside Air	90° F db, 81° F wb	10° F

The heating/cooling system is a reverse cycle system with units designed for mounting in recessed or remote enclosures (e.g., cabinets, voids or beneath bunks) and ducted to provide the entering air at the optimum locations. The quantity of replenishment air for air-conditioned spaces is 5 cfm per person.

The ventilation system has a mechanical air supply and natural exhaust for all machinery spaces and all other spaces requiring removal of any large internal heat gain. The ventilation system for the galley has both mechanical supply and exhaust.

A defroster system is to be provided for the pilot house windows. The system is designed to remove moisture or frost from the windows with heaters, blowers, ducting, controllable louvers and dampers to distribute heated air where it is needed on the windows.

Roll Stabilization

Roll stabilization will be provided by four hydraulically operated trim tabs located just forward of the propellers, approximately 10 feet forward of the transom, with two on the port side and two on the starboard. Hydraulic power will be provided by four self-contained power packs actuating hydraulic cylinders attached to the tabs. In addition to roll stabilization, the tabs will provide a means of controlling the running trim at high speeds, and to remove small lists encountered during unusual loading conditions.

Sanitation System

The sanitation system will consist of a vacuum collection system such as the commercially available Mansfield or EVAK products. These systems both collect wastes during the flush action and force them into a small holding tank with the use of air instead of water. This allows for a smaller tank than that required for water flush systems. Sanitation drainage piping and an additional holding tank would be necessary for the waste water generated during bathing, cooking, etc.

Potable Water System

The potable water system will consist of a fresh water tank, distribution piping, pumps, heaters and a desalinization system. The tank will be supplied with fresh water from shoreside facilities by a main deck connection and fill and vent piping, and by a reverse osmosis desalinator when required. The tank will store 1500 gallons of fresh water. Distribution will be provided by main and branch piping and two pumps located outboard in the diesel generator rooms.

Hot water will be supplied by two 100 gallon quick recovery heaters, while additional or extremely hot water requirements will be met by local boost heaters.

Fuel System

The craft's fuel system will be capable of receiving up to 30 tons of fuel from dockside or another cutter, storing the fuel, transferring the fuel between tanks and supplying the day tanks which in turn will supply the diesel engines.

Fuel receipt will be accomplished by a 5 inch main on each side of the craft feeding each tank through risers. A 2 1/2 inch tank vent will be provided on either side to allow for venting.

A settling tank with a stripping and filter system to remove impurities from the fuel prior to transfer to the day tank will be supplied between the main fuel tanks and the day tanks.

A transfer system consisting of pumps, piping and manifolds will be installed between all tanks to allow ready transfer of fuel as required under all circumstances.

Steering System

The steering system consists of an electric-hydraulic system controlled from the pilot house. The system will also be controllable from an auxiliary steering station on each of the bridge wings using duplicate electric controls, and also by using a manually operated standby hydraulic pump.

Fire Protection

Active fire protection is provided by extinguishing systems installed throughout the craft, using HALON, CO_2, PKP and water as required. See Table 4.

Portable 15 pound CO_2 and 20 pound PKP extinguishers will be located throughout the craft for fighting small, localized fires. CO_2 is used in areas of probable electrical/electronic fires and PKP in areas of probable petroleum based fires.

Two motor driven firemain pumps will be provided for the sprinkler system. In addition, two portable P250 pumps will be located in a space above the main deck.

Passive fire protection will be accomplished by treatment of selected bulkhead/ deck structures with fire resistant insulation material.

Towing

A towing bitt and rail has been provided for use with a braided synthetic towing hawser. There is stowage space allocated for a hawser reel in the lazarette. From this space, the hawser can be easily brought on deck through the hatch in the aft main deck.

The bollard pull of the craft is estimated to be 40,000 pounds, which is sufficient to tow a vessel of 500 tons displacement in moderate sea and wind conditions. Maneuverability should be adequate with the craft's twin rudders and propellers and the forward location of the towing bitt.

Boat Handling

A 5.4 m RHI boat and an Allied knuckle boom crane have been fitted aft on the main deck. The specified crane [illegible] sufficient [illegible] and lower the boat [illegible] side as requested, and [illegible] [illegible]

Table 4. Fire Protection Systems

TYPE OF SPACE	AGENT	TYPE OF SYSTEM
Machinery (main propulsion)	HALON *	Automatic-Optical and Thermal Sensors
Machinery (generator room)	HALON *	Automatic-Optical Sensors
Flammable Liquid Storeroom	HALON *	Automatic-Optical Sensors
Electronic and Electrical	CO2	Manual-Hand Held
Crew Living	CO2 and H_2O	Firemain, Manual-Hand Held
Main Deck	H_2O	Firemain
Galley	PKP/CO2	Hand Held
Ammo Stowage	HALON/H_2O	Automatic-Optical and Thermal Sensors Sprinkler-Firemain
Misc. Stowages	PKP/CO2	Hand Held
Fuel Line Trunks	HALON	Automatic-Optical

* Will also contain hand held extinguishers.

OUTFIT, FURNISHINGS AND ARRANGEMENT

The craft has been designed to accommodate standard Navy and Coast Guard furnishings throughout. The general arrangement is shown in Figure 23, and the major features are discussed below.

Commissary Spaces

The commissary spaces consist of the galley and messroom located on the main deck in the aft portion of the deckhouse and the galley storeroom located just forward of this area to port. The equipment that is to be provided includes:

Range
Oven
Microwave Oven
Refrigerator/Freezer
Coffee Maker
Sink
Rangehood w/Blower and Fire Supression System
Cabinets
Dishwasher
Seats and Mess Tables
Berthing and Washrooms

The berthing spaces and washrooms in the craft are located as follows:

Crew - located on the first platform between frames 8 and 15, in three 4 member compartments. Each compartment has a full height locker, a B-2 locker and a berth with stowage under the mattress for each occupant. Berthing is two high throughout. There are three separate washrooms adjacent to the berthing compartments, each fitted with a water closet, lavatory and shower.

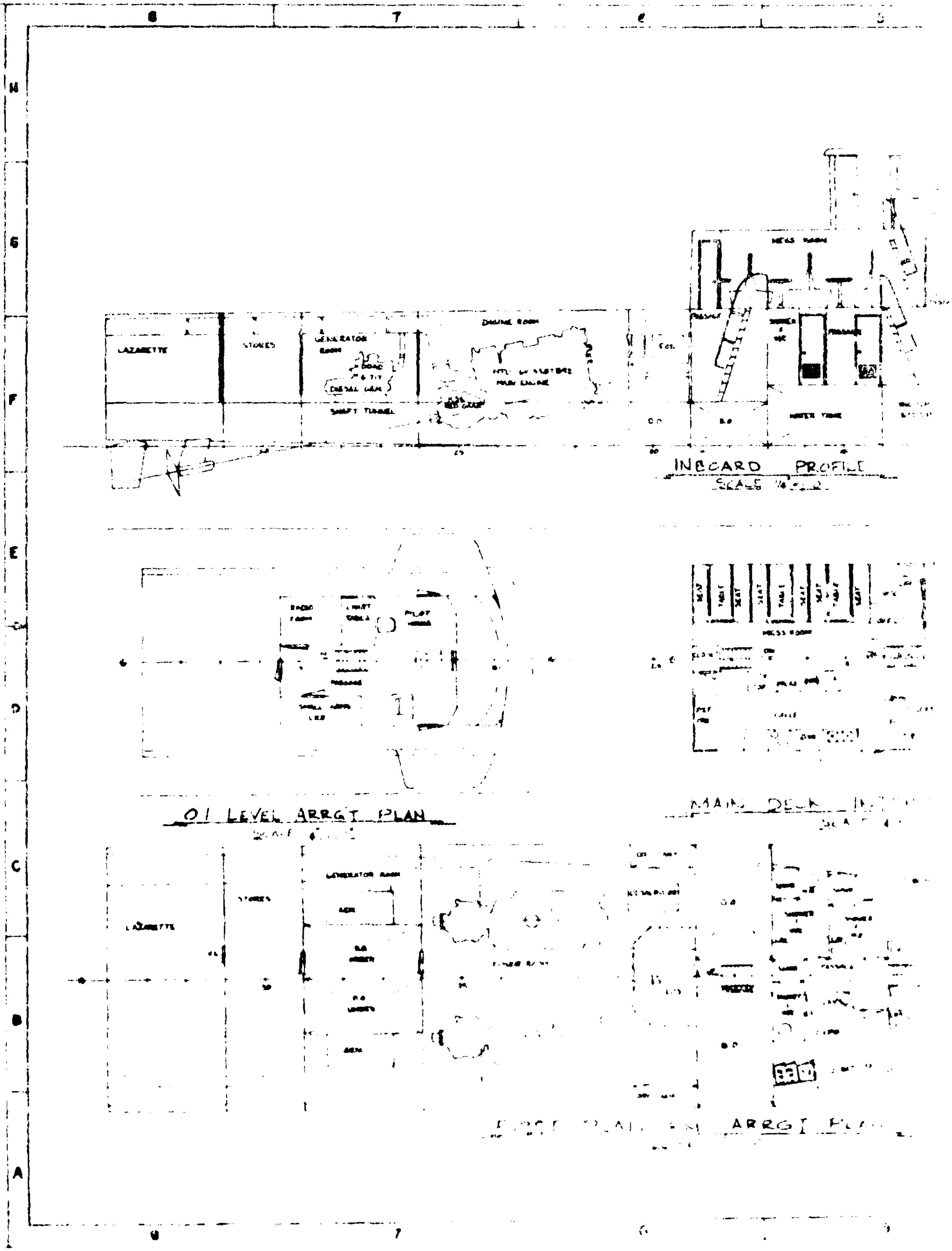
CPO - located on the first platform between frames 15 and 18 on the starboard side, with a head on centerline. The compartment is equipped with a secretary/bureau and a berth with a locker under the mattress for each CPO. The washroom is equipped with a shower, water closet and lavatory.

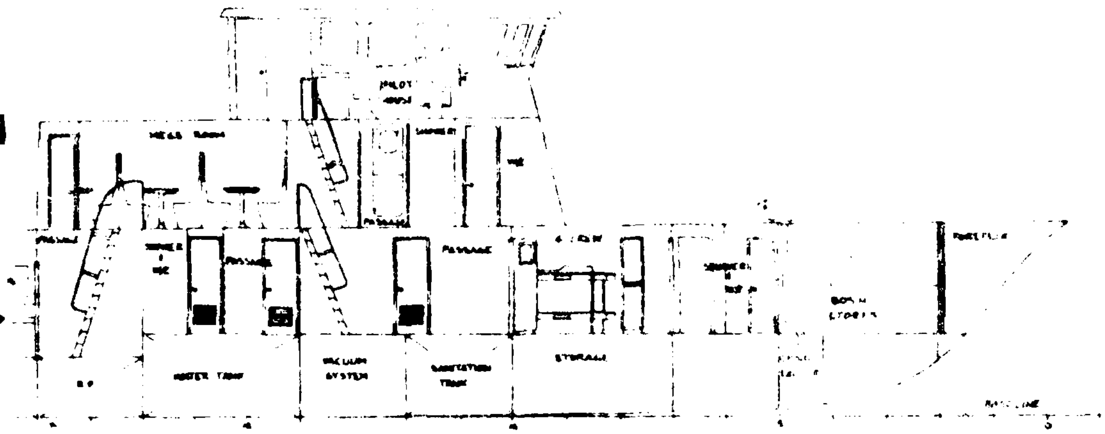
Officer - located on the main deck, in the forward portion of the deck house, in two single person compartments with a shared head. Each compartment has a berth with a locker under the mattress, a secretary/bureau, and a clothes closet. The CO's cabin has a security safe. The washroom is equipped with a water closet and shower and each cabin has its own lavatory.

Spares - located on the main deck to starboard. The cabin is fitted with a berth with a locker under the mattress for each occupant.

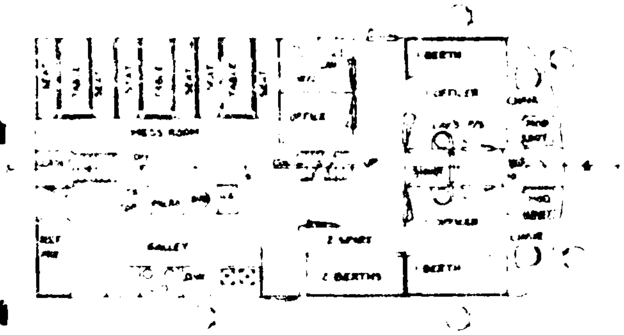
Illumination

Illumination in the living and working areas of the craft will be provided for by overhead mounted watertight flourescent fixtures and overhead mounted watertight incandescent red light fixtures for darkened ship conditions.

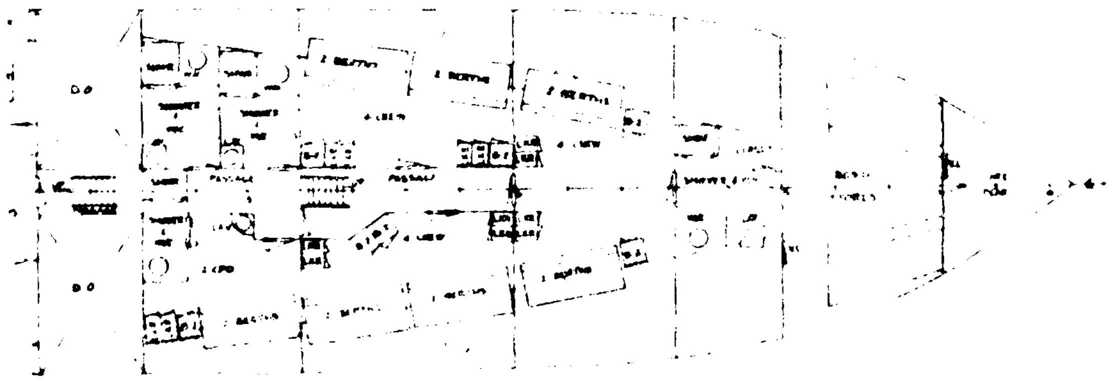
LAZARETTE
STORES
GENERATOR ROOM
DIESEL GEN
SHAFT TUNNEL
ENGINE ROOM
MESS ROOM
PASSAGE
WATER TANK
INBOARD PROFILE
RADIO ROOM
CHART TABLE
PILOT
SMALL ARMS LKR
SEAT
TABLE
01 LEVEL ARRGT PLAN
MAIN DECK
ARRGT PLAN



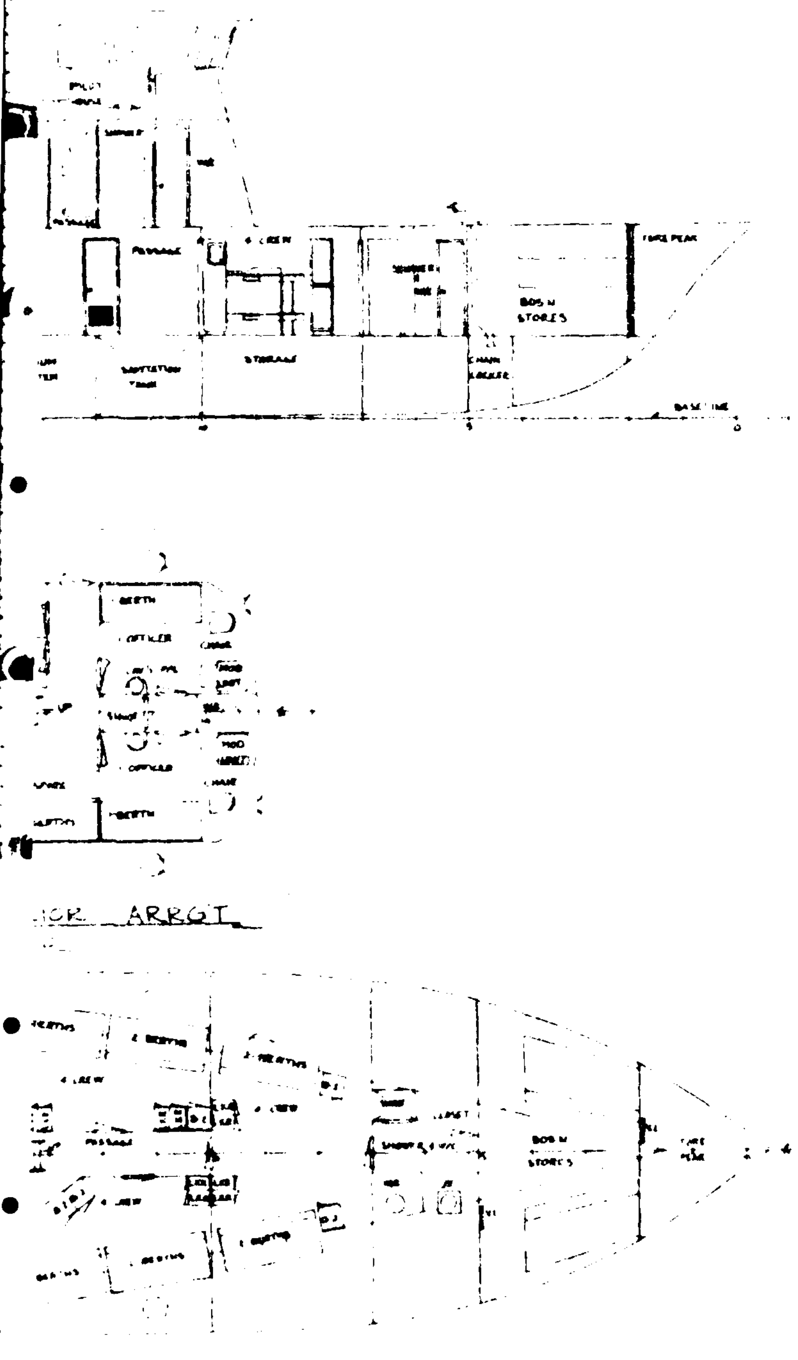
INBOARD PROFILE
SCALE 1/4"=1'-0"



MAIN DECK INTERIOR ARRG'T
SCALE 1/4"=1'-0"



...M ARRG'T PLAN



REVISIONS

DATA LIST

FEASIBILITY DRAWING

Figure

NAVAL SEA SYSTEMS COMMAND

120 FT US COAST GUARD PATROL

INBOARD PROFILE AND DECK ARRANGEMENT

53711

101 51032

INCREASED AND DECREASED SPEED STUDY

Estimates have been made of the principal characteristics of two patrol boats, similiar to the 120' WPBX described, but with design speeds of 40 and 30 knots respectively. All other aspects of the mission requirements remained the same. It should be remembered that a full study has not been done for these craft, so the information provided below should be viewed as a first estimate only. It is anticipated that if these designs were developed, the numbers quoted could change by up to 10%.

It was found that a craft of 120 foot length, 23 foot beam and 129 ton displacement would be capable of meeting the mission requiremens with a 30 knot cruise speed. For a 40 knot cruise speed, a length of 130 feet, a 24 foot beam, and 170 ton displacement craft was found necessary.

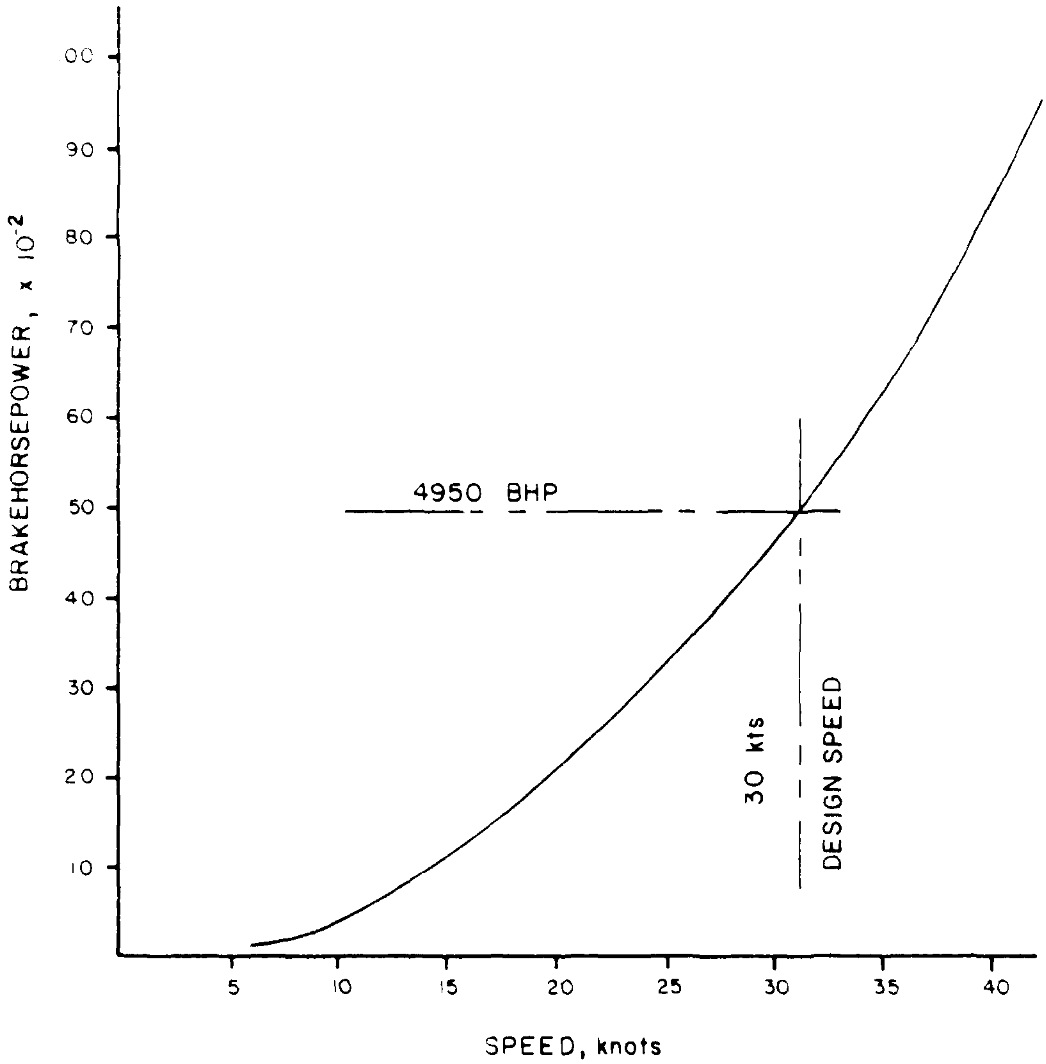
Table 5 gives the estimated weights for groups 1 through 6 for the two craft, along with those for the baseline cutter. Table 6 shows the design and cruise BHP and fuel consumption for the three designs. BHP vs. speed and fuel consumption vs. speed for the 30 knot craft are shown in Figures 24 and 25 respectively. Figures 26 and 27 show the same for the 40 knot craft.

Table 5. Group Weights for Different Speed Craft

Weight Gp	Weight, tons 30 kt craft	40 kt craft	35 kt craft
1	35.8	41.7	36.3
2	20.4	42.2	25.6
3	6.4	7.3	6.5
4	2.0	2.0	2.0
[illegible]	8.4	9.7	8.6
6	13.3	15.2	13.6
[illegible]	2.5	2.5	2.5
[illegible]	88.80	120.6	95.1

Table 6. BHP and Fuel Consumption

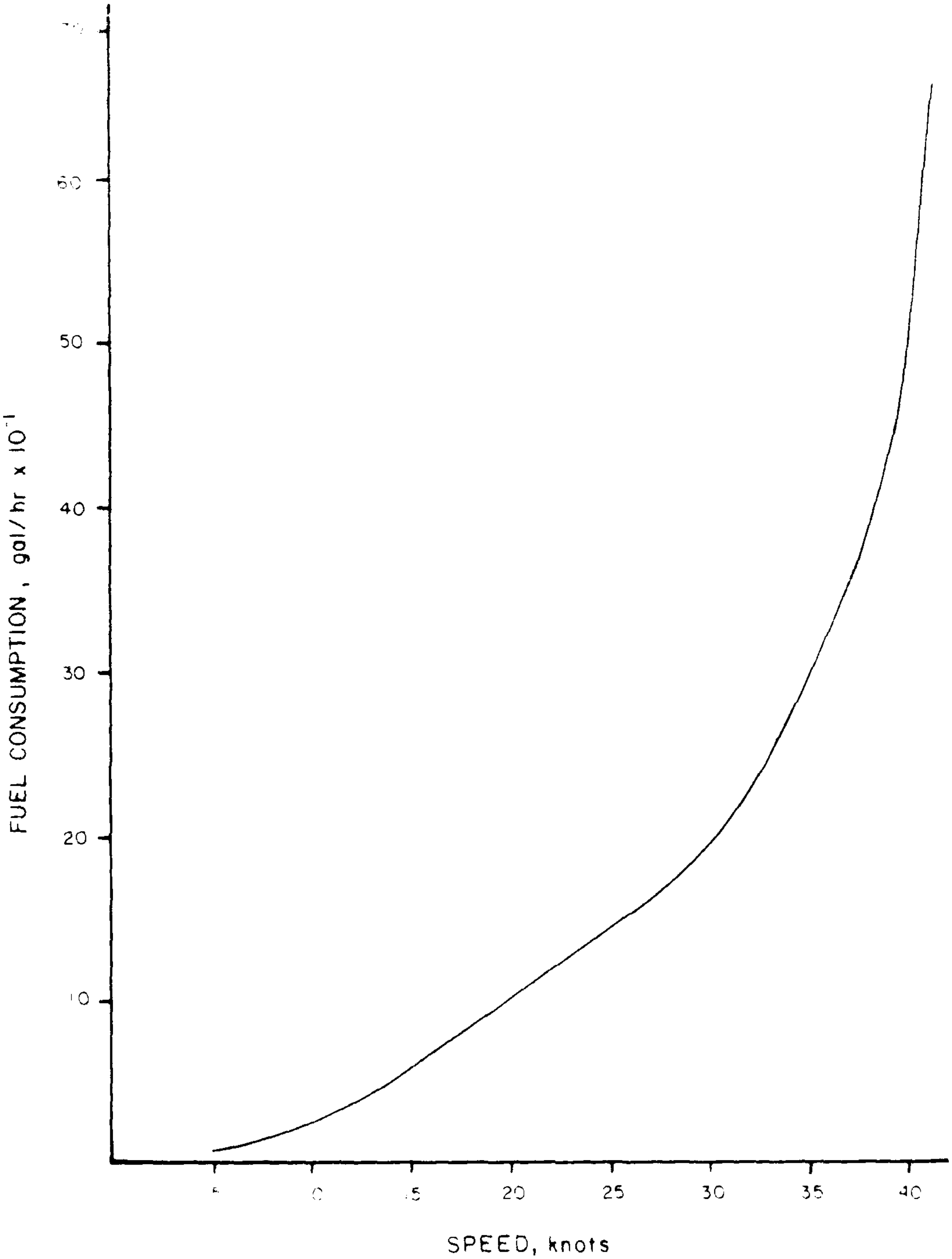
[illegible]	BHP Design	Fuel Consumption Design gal/hr	BHP 10 kts	Fuel Consumption 10 knots gal/hr
[illegible]	4948	214.4	244	17.2
[illegible]	11583	435.9	291	23.2
[illegible]	6981	305.7	247	19.5



BRAKEHORSEPOWER vs. SPEED

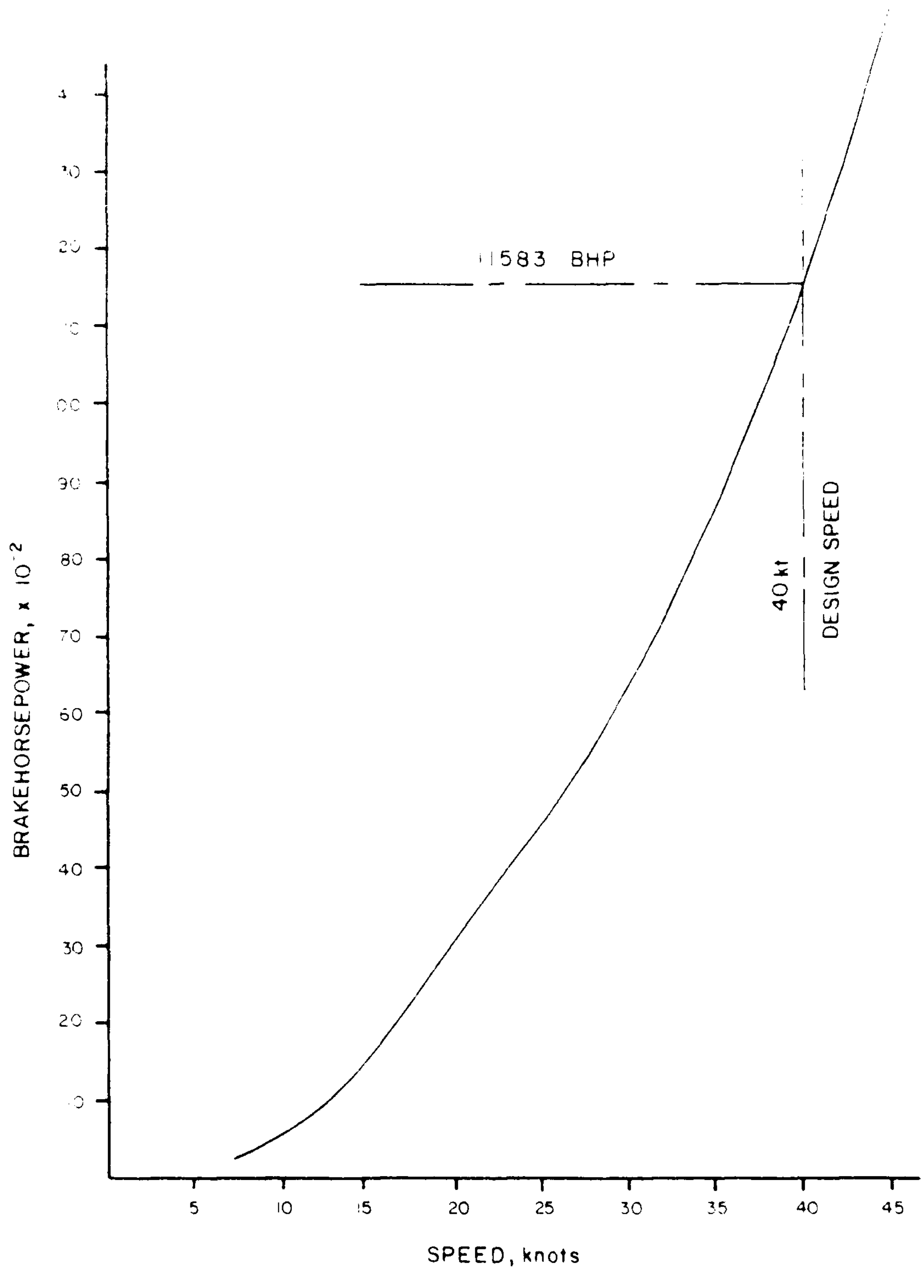
30 kt WPBX

Figure 24



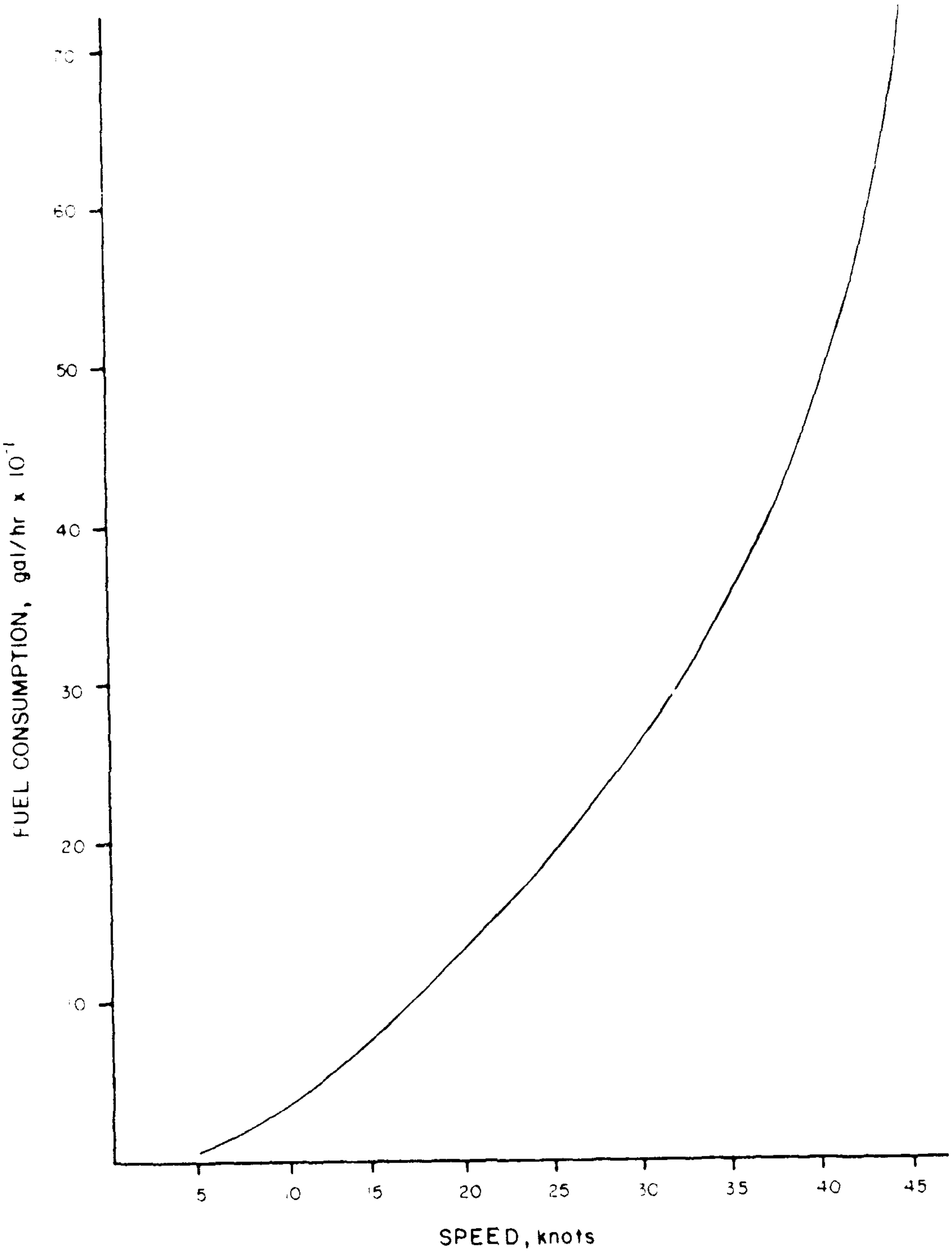
FUEL CONSUMPTION vs. SPEED

30 kt WPBX



BRAKEHORSEPOWER vs. SPEED

40 kt WPBX



FUEL CONSUMPTION vs. SPEED

40 kt WPBX

CONCLUSIONS

The craft presented in this feasibility study is capable of performing both the primary and secondary missions as set forth by the Coast Guard. This craft has the required high speed for interception, good ride quality and low acceleration characteristics in high sea states, can carry, although with some loss in top speed, equipment for aids to navigation work or pollution response.

A comparison between the 120' WPBX and the design guidelines follows:

DESIGN GUIDELINE	120' WPBX
5.4 m RIB w/Crane	Provided
Towing Bitt and Line	Provided
Small Arms Locker	Provided
Clear Area Aft	980 sq. ft. Provided
30 knots, SS2	32.5 knots
25 knots, SS3	32 knots
20 knots, SS4	31.5 knots
35 knot dash	36.1 knots
Survive SS6	Provided
24 hrs at 30 knots	Provided
96 hrs at 10 knots	136 Hours
10% reserves	Provided
2 Officers	Arrangements Provided
2 CPOs	Arrangements Provided
12 Enlisted	Arrangements Provided
Roll Stabilization	Provided
USN Stability Criteria	Provided

REFERENCES

1. Hubble, E. N., "Program PHFMOPT Planing Hull Feasibility Model User's Manual," DTNSRDC/SPD-0840-1, Dec 1978.

2. Jones, M. P. and Hatchell, E. G., "Feasibility Study for the United States Coast Guard Advanced Vehicle Concept (Planing Hull)," [illegible]SEACOMBATSYSENGSTA Report No. 60-111, June 1983.

3. Hubble, E. N., "Resistance of Hard-Chine, Stepless Planing Craft with Systematic Variation of Hull Form, Longitudinal Center of Gravity, and Loading," [illegible] Report 4307, April 1974.

4. Blount, D. L. and Fox, D. L., "Small Craft Power Predictions", Marine Technology, Vol. [illegible], No. 1, January, 1976.

5. Haggard, M. V., "Examining Added Drag of Planing Craft Operating in a Seaway," SNAME, Hampton Roads Section, November 1979.

6. [illegible], R. W. [illegible] Burrill, L. C., "Effect of Cavitation on the Performance of a Series of [illegible] Inch Model Propellers," Trans. [illegible], Vol. [illegible], [illegible].

7. [illegible] Technology, [illegible]

8. [illegible] Operating [illegible]

9. [illegible] J. [illegible] Planing Hulls," [illegible] DIV, May [illegible].

10. [illegible]

11. [illegible]

12. [illegible] R. [illegible] Vehicles," [illegible], NY Metropolitan Section, [illegible]

13. [illegible] St[illegible] No. 06[illegible]

END

FILMED

8-85

DTIC