MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THESIS

TRAWLER DESIGN

By

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Course XIII

Cambridge, Massachusettts

June, 1946

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Professor G. W. Swett
Secretary of the Faculty
Massachusetts Institute of Technology
Cambridge, Massachusetts

Dear Sir:

In partial fulfillment of the requirements for the Degree of Bachelor of Science, I herewith submit the following thesis on "Trawler Design".

Respectfully,

Viggo E. Maack

ACKNOWLEDGEMENTS

I am deeply grateful for Professor Daniell's help and suggestions in writing this thesis. I also wish to acknowledge the assistance given by Professor Burtiner and Professor Chapman in preparation of this thesis.

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TRAWLER DESIGN

PARENT SHIPS:

JEANNE D'ARC AND VILLANOVA

LWL	123.05'
B	24.00'
H	9.58'
Displacement	406.2 tn.
A	175.8 ft^2
Wetted Surface	3771 ft^2
$\sqrt{LWL}$	11
B/H	2.64
$\frac{\Delta}{(\frac{L}{100})^3}$	218
l	.6572

Data used for powering the ship..

LOA	136'--4¼"
LBP	122'
LDWL	124'--8½"
Beam	24'

Designed Mean Draft 10'--8¾"

Designed Mean Draft to Bottom of Keel 11'--2¾"

Δ = 515.7 tn.

Designed Drag of Keel 2'--6½"

V = 11kt

WEIGHT STATEMENT OF PARENT SHIP:

weight of hull, and hull eng. and hull fitt., outfit, crew	273.6
propelling machinery	71.3
weight of fuel	31.97
weight of water and stores	9.67
paying deadweight, permanent ballast	187.82
	571.4 tn.

hull and hull fittings	270.1	47.2%
propelling mach.	71.3	12.6%
fuel and water	40.5	7.0%
complements and effects	1.00	.2%
paying deadweight	173.00	30.3%
ballast	14.0	2.5%
margin	3.0	.5%
	571.9	100.00 %

THE NEW DESIGN:

TRAWLER TO FISH IN THE SEA AROUND ICELAND

CREW: 34 men

CARGO (FISH AND ICE): 270 tons (or there about)

CRUISING RADIUS: 1500 miles

SPEED: about 12kt (cruising)

The parent ship is made for 11kt but the new design should make 12kt, what would save about 10 hours for the distance between Reykjavik and Grimsby (1100 nautical miles)..

The first thing I do it to find the effect by changing the speed to 12kt.

$w_a = 273.6$	$K_a \Delta$
$w_b = 71.3$	$\frac{\Delta^{2/3} V^3}{K_b C}$
$w_c = 31.97$	$\frac{\Delta^{2/3} \gamma R V_c^2}{2240 K_c}$
$w_d = 9.67$	$\frac{K_d N d}{2240}$
$w_e = 187.82$	I
$\Delta = 574.5$	

$$w = kx^a y^b z^c \Delta^n$$

$$w = wAr$$

$$A = \left(\frac{K_1}{K}\right)\left(\frac{x'}{x}\right)^a \left(\frac{y_1}{y}\right)^b \left(\frac{z}{z}\right)^c = 1 \times \left(\frac{12}{11}\right)^3 = 1.298$$

w	A	r	w
273.6	1.00	r	273.6
71.3	1.298	$r^{2/3}$	92.55

Cont.

w	A	r	w
31.97	1.00	$r^{2/3}$	91.97
9.67	1.00	1	9.67
187.82	1.00	1	187.82

$$\Delta' = r\Delta = 273.8r + 124.52\, r^{2/3} + 197.49$$

$$r - .414 r^{2/3} - .6568 = 0$$

$$r = 1.078$$

w'_a	=	1.074 x 273.6	292.5
w'_b	=	1.049 x 71.3	74.5
w'_c	=	1.049 x 31.97	33.42
w'_d	=	1.00 x 9.67	9.07
w'_e	=	1.00 x 187.82	187.82
			Δ' = 597.91

That means that I must add 23.4 tons to my displacement.

If this speed change were the only change, I would be satisfied by this and start my design, but as more paying deadweight (fish) and more men are needed, I must make other changes but many changes make the value of the weight equation doubtful.

CHANGE CRUISING SPEED TO 12kt

	A		
w_a' :	273.6 x 1.00	r	$273.6\,r$
w_b' :	71.3 x 1.00	$r^{2/3}$	$71.3\,r^{2/3}$
w_c' :	31.97 x 1.190	$r^{2/3}$	$38.1\,r^{2/3}$
w_d' :	9.67 x 1.000	1	9.67
w_e' :	187.82 x 1.000	1	187.82

$r = 1.033 \qquad r^{2/3} = 1.0219$

w_a' :	273.6 x 1.033	=	283.0
w_b' :	71.3 x 1.0219	=	72.9
w_c' :	38.10 x 1.0219	=	38.9
w_d' :	9.67 x 1.00	=	9.67
w_e' :	187.82 x 1.00	=	187.82
		$\Delta' =$	592.27

$$\frac{\Delta'}{\Delta} = \frac{592.27}{574.5} = 1.032 \text{ (checks)}$$

By just changing the cruising speed, I must add 18 tons to my displacement. If I mow would take the new weight statement and increase the cruising radius by 25%.(The weight equation is only appliable when there is a change in one weight group.)

CRUSING RADIUS INCREASED BY 25%

	A		
w_a':	283 x 1	r	283 r
w_b':	72.9 x 1	$r^{2/3}$	72.9 $r^{2/3}$
w_c':	38.9 x 1.25	$r^{2/3}$	48.6 $r^{2/3}$
w_d':	9.67 x 1	1	9.67
w_e':	187.82 x 1	1	187.82

$$\Delta' = r\Delta = 283r + 121.5r^{2/3} + 197.49$$

$$r - .393\, r^{2/3} - .639 = 0$$

	$r = 1.035$	$r = 1.023$
$w_a' =$	1.035 x 283	293
$w_b'' =$	1.023 x 72.9	74.6
$w_c'' =$	1.023 x 46.8	49.8
$w_d'' =$	1.00 x 9.67	9.67
$w_e'' =$	1.00 x 187.82	187.82
	$\Delta'' =$	614.89

$$\frac{\Delta''}{\Delta} = \frac{614.89}{592.27} = 1.035 \text{ (checks)}$$

I will still go further and see how doubling the number of crew and increasing the fish and ice weights to 270 tons.

CREW 34 AND PAYING WEIGHT INCREASED TO 270 TONS

A 2

A $\frac{270}{187.82}$ 1.443

$W_{a}'' =$ 293 x 1 x r 293

$W_{b}'' =$ 74.6 x 1 x r 74.6

$W_{c}'' =$ 49.8 x 1 x r 49.8

$W_{d}'' =$ 9.67 x 2 x 1 19.24

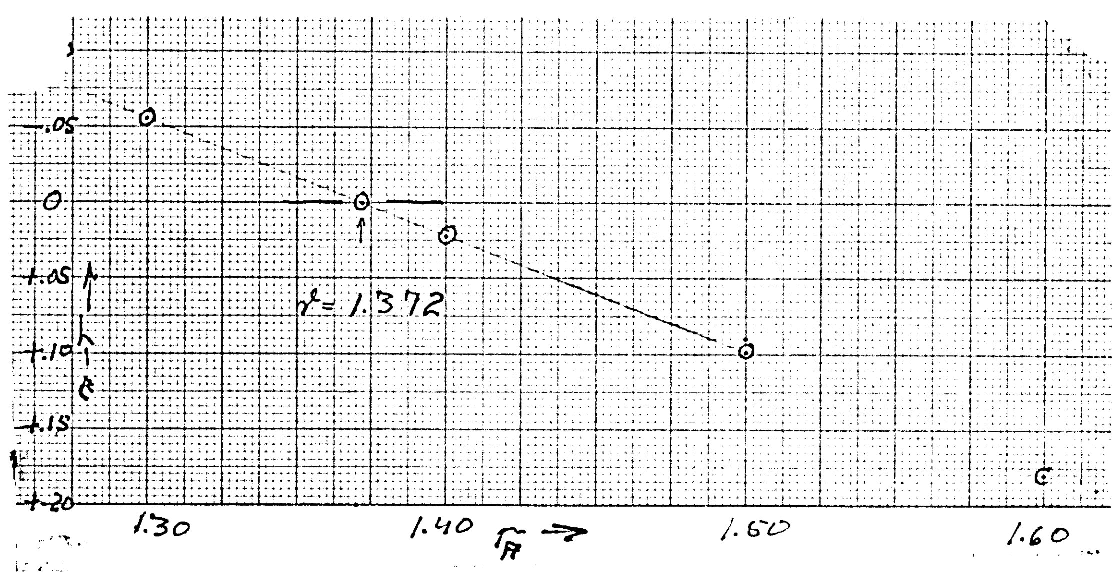
$W_{e}'' =$ 187.82 x 1.443 x 1 270.

$$\Delta r = 293r + 124.4r^{2/3} + 289.24$$

$$r - .387r^{2/3} - .898 = 0$$

Solution:

Assumed r_A	$(.387r^{2/3} + .898) = T$	$r_A - T$
1.30	1.355	-.055
1.40	1.378	.022
1.50	1.401	.099
1.60	1.419	.181



$r = 1.372 \qquad r^{2/3} = 1.234$

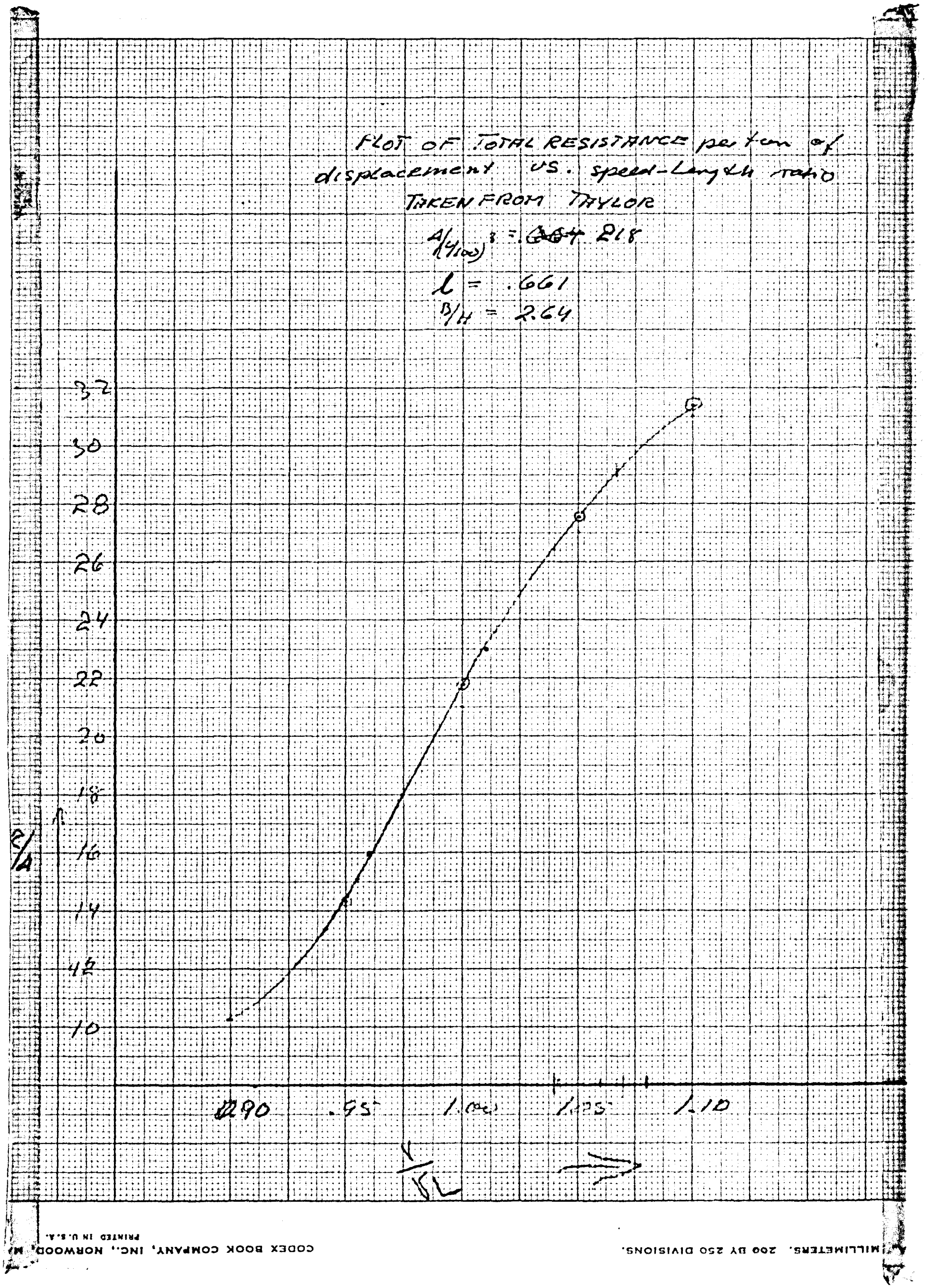
$w_a'' =$	293 x 1.372	402.0
$w_b'' =$	64.6 x 1.234	92.1
$w_c'' =$	49.8 x 1.234	61.5
$w_d'' =$	19.24 x 1	19.2
$w_e'' =$	270 x 1	270.0
	$\Delta'' =$	867.2

$$\frac{\Delta''}{\Delta} = \frac{867.2}{614.9} = 1.380$$

PARENT SHIP: $\frac{B}{H} = 2.64 \quad \frac{\Delta}{(\frac{L}{100})^3} = 218 \quad A_x = 175.8\ ft^2$

$m = .761 \quad b = .505 \quad l = .661$

	$\frac{V}{\sqrt{L}}$	.90	.95	1.00	1.05	1.10
R_r/Δ	$B/H = 3.75$	5.5	8.5	14	18.5	22
	$B/H = 2.25$	4.6	8.3	15.5	20.8	24.0
	$B/H = 2.64$	4.8	8.3	15.1	20.2	23.5
		4.6	5.1	5.6	6.2	6.7
		5.45	6.04	6.64	7.35	7.94
R_t/Δ		10.25	14.34	21.74	27.55	31.44


PLOT OF TOTAL RESISTANCE per ton of displacement vs. speed-Length ratio
TAKEN FROM TAYLOR
Δ/(L/100)³ = ~~.264~~ .218
l = .661
B/H = 2.64
32
30
28
26
24
22
20
18
16
14
12
10
R/Δ
.90
.95
1.00
1.05
1.10
V/√L

At 11 kt $\quad \frac{V}{\sqrt{L}} = \frac{11}{\sqrt{123}}$ 1.01

$$\frac{R_t}{\Delta} = 23^{\#}$$

$$R_t = 23 \times 406 = 9230^{\#}$$

EHP = .003071 x 9230 x 11 = 312

According to this calculation (which is far from being exact), I get my new Δ 867.2

$$\frac{\Delta'}{\Delta} = \frac{867.2}{406} = 2.134 = \lambda^3 \quad \text{(length ratio)}$$

λ = 1286 $\qquad \lambda^2 = 1.656$

New Dimensions:

LWL = 123 x 1.286 = 156'

B = 24 x 1.286 = 30.8'

H = 9.58 x 1.286 = 12.3'

For $\frac{V}{\sqrt{L}}$ = 1.01 $\qquad V = V_o \sqrt{\frac{L}{L_o}} = 11\sqrt{\frac{156}{123}} = 12.4 kt$

Then I would have EHP:

R_t = 23 x 867.2 = 19920 #

EHP = .003071 x 19920 x 12.4 = 760

But by keeping the speed down to 12, I get:

$$\frac{V}{\sqrt{L}} = \frac{12}{12.5} = .96$$

$\frac{R_t}{\Delta} = 16^{\#}/\text{tn.} \qquad R_t = 16 \times 867.2 = 13880^{\#}$

EHP = 512

Summary:

As my ship is going to be operated under quite a different condition than the parent ship and I have no Icelandic parent ship because I think there is no convenient parent ship as all the Icelandic trawlers have been bought second-hand and not for Icelandic conditions, I take my ship nearest to the final calculations on page 8.

$w_a = 402$ (hull, hull eng., hull fitt., crew)

$w_b = 92.1$ (weight of propelling mach.)

$w_c = 61.5$ (weight of fuel)

$w_d = 19.2$ (weight of water and stores)

$w_e = 270.0$ (paying deadweight, ballast, margin)

$\Delta = 867.2$

LWL $= 156.'$

B $= 30.8'$

H $= 12.3'$

V $= 12$kt

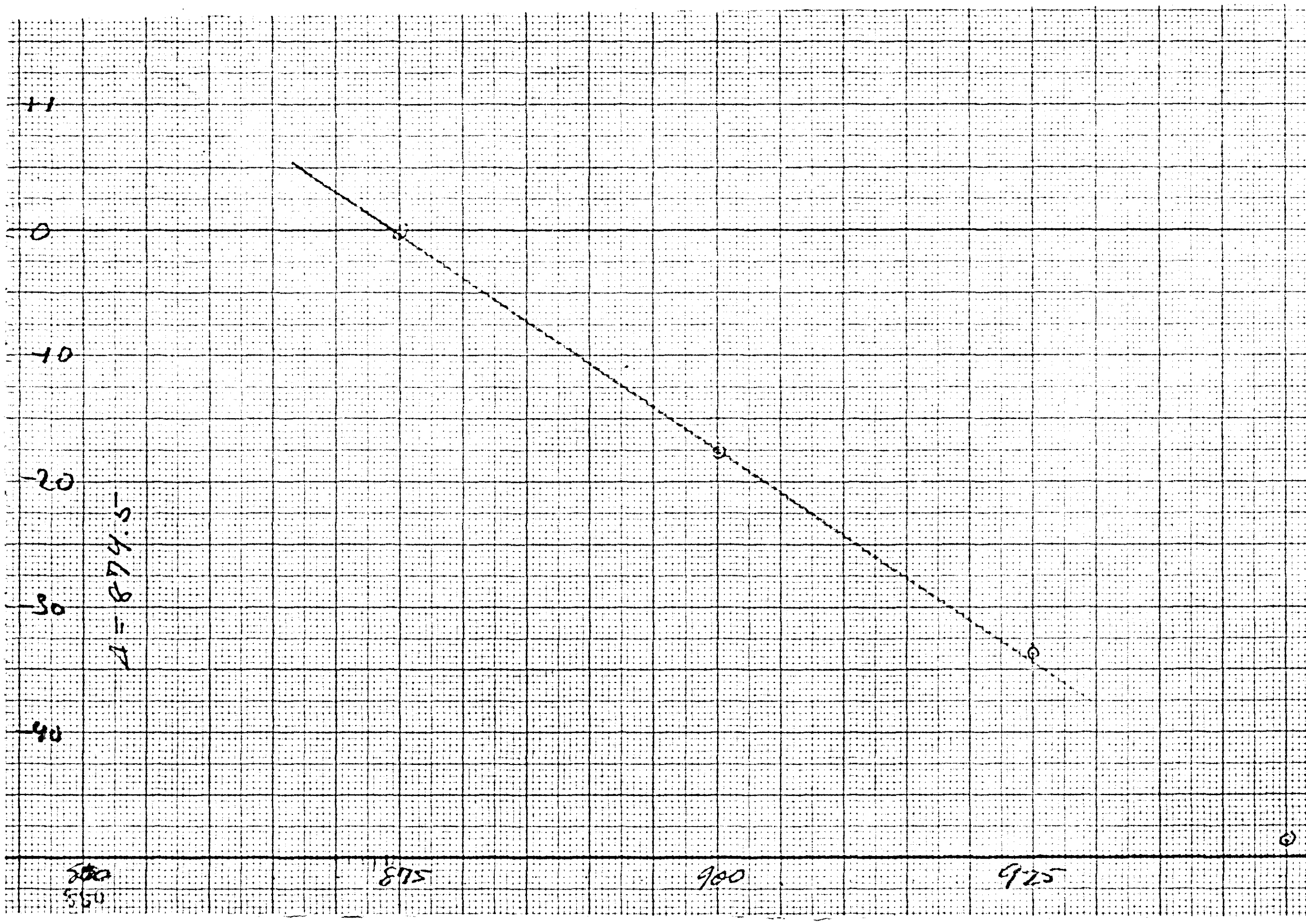
$A_{xx} = 291\ ft^2$

Now I would like to group the weights into the following groups:

	wt. in tons	%
w_1 = hull and hull fittings	39.1	45
w_2 = propelling mach.	92.1	10.6
w_3 = fuel and water	80.7	9.1
w_4 = complements and effects	1.8	.2
w_5 = paying deadweight	287	.33
w_6 = ballast	17	2
w_7 = margin	1	
	870.6	100.00 %

$$\frac{w_2}{EHP} = \frac{92.1}{512} = .1799$$

Δ_a	875	900	925	950	975
$\frac{\Delta_a}{\Delta}$	1.005	1.033	1.062	1.091	1.120
$\left(\frac{\Delta_a}{\Delta}\right)^{1/3}$	1.001	1.012	1.020	1.029	1.038
$\left(\frac{\Delta_a}{\Delta}\right)^{2/3}$	1.003	1.022	1.041	1.060	1.078
$L_a = L\left(\frac{\Delta_a}{\Delta}\right)^{1/3}$	156.1	159.2	1.622	165.2	168.0
$\sqrt{L_a}$	12.5	12.63	12.73	12.85	12.97
$\frac{V=12}{\sqrt{L}}$	.960	.950	.942	.933	.926
R_t/Δ_a	15.9	14.5	13.4	12.6	11.9
R_{ta}	13920	13040	12400	11970	11650
.0030 71x2	.03687				
EHP	514	482	458	442	431
W_{2a}	92.6	86.8	82.7	79.5	77.6
W_{1a}	393.5	405.0	416.0	427.0	438.0
$W_{3a} \cdot 80.7\left(\frac{\Delta_a}{\Delta}\right)^{2/3}$	80.9	82.5	84.0	85.6	87.1
W_{4a}	1.8	1.8	1.9	1.9	2.0
W_{5a}	287	287	287	287	287
W_{6a}	18	18.2	18.5	19	19.5
W_{7a}	1.0	1.0	1.1	1.1	1.2
Δ_a'	874.8	882.3	891.2	901.2	912.4
$\Delta_a' - \Delta_a$	-0.2	-17.7	-33.8	-48.8-	-62.6



+1
0
-10
-20
-30
-40
875
900
925
A = 874.5

Principal Dimensions:

$$\frac{\Delta'}{\Delta} = \frac{874.5}{870.6} = 1.005 = \lambda^3$$

$$\lambda = 1.001$$

$$\lambda^{2/3} = 1.003$$

LWL = 156.1'

B = 30.8'

H = 12.3'

V = 12kt*

$A_{\text{⊗}}$ = 300

w_1 = 392.2

w_2 = 92.2

w_3 = 80.8

w_4 = - 1.8

w_5 = 288.2

w_6 = 17.1

w_7 = 2.2

Δ = 874.5 tons

When I have done this, I take the Vincent Curves of sectional areas and plot my curve for sectional areas vs. length B.P. Having my curve plotted, I get 882 tons which is about 1.1% off. I consider that satisfactory.

I also took my moment readings and found that by this curve my C.B. is at my ⊗ section.

RUDDER CALCULATIONS

I use balanced rudder--streamlined.

$L \times H = 156 \times 12.3 = 1918.8$

My parent ship has a rudder area of 50 square feet and $L \times H$ is $123 \times 12 = 1476$

My rudder area should be:

$$50 \times \frac{1918}{1976} = 65 \text{ sq. ft.}; \frac{A}{LH} = .0340$$

In PNA

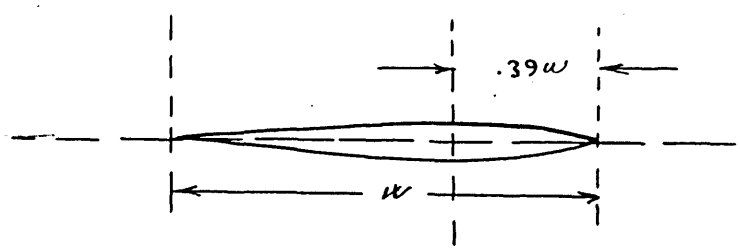
P/LH for a single screw seagoing tugboat = .254

HL = 2190 ft^2

By this I would have 55.4 sq. ft.

I would use 64 ft^2.

For using an almost rectangular rudder, I find that the center of pressure is 39% from the leading edge.



FUEL OIL CONSUMPTION:

M. E. Vol. 1, page 3 gives a fuel consumption for Geared Diesel as .49 #/SHP/HR all purposes at 1000 SHP

In this ship I have two 250 H.P. Auxilary Diesels to drive the generators for windlass, lighting, radio, grinder (bones and heads grinder) and main engine.

EHP Calculations:

From my displacement curve I have Δ = 850 tons

at H = 12.3'

L = 156'

B = 30.6'

b = .506

$m = \frac{297.6}{12.3 \times 30.6} = .789$

$\ell = \frac{b}{m} = \frac{.506}{.789} = .641$

$B/H = 2.49$

$V = 12kt$

$\frac{V}{\sqrt{L}} = .961$

$\frac{\Delta}{\left(\frac{L}{100}\right)^3} = 222$

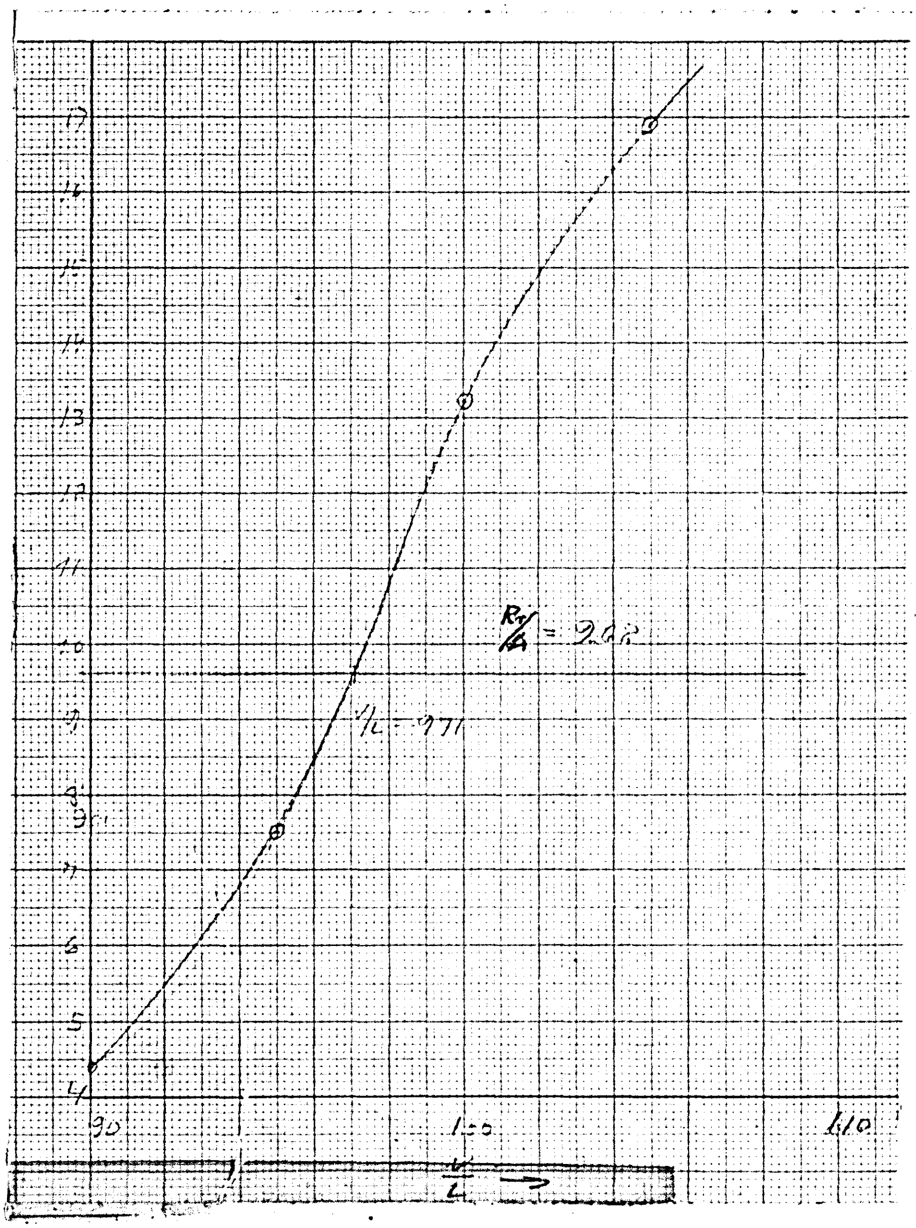
$R_T = R_f + R_r$

$R_f = f S V^{1.825} = .009065 \times 5690 \times 93 = 4790\#$

$S = 15.65\sqrt{156 \times 850} = 5690 \text{ ft}^2$

	$V/\sqrt{L}$ .90	.95	1.00	1.05	
B/H = 2.25	4.3	7.4	13.4	17.1	
B/H = 3.75	5.1	7.8	12.1	15.8	R_r/Δ
B/H = 2.49	4.4	7.5	13.2	16.9	

Fom interpolation between beam length ratio and from the curves, I get R_r/Δ = 9.62#/ton



PROPELLER AND FUEL CONSUMPTION

$R_t = 4790 \quad 9.62 \times 850 - 12970\#$

$EHP = .003071 \times 12970 \times 12 = 478$

$PHP = \dfrac{EHP}{e_p \times e_r \times e_h} \quad . \quad e_h = \dfrac{1-t}{1-w}$

w = .23 (PNA VII p. 149)

$t = kw = .70 \times .23 = .16$

$e_h = \dfrac{.84}{.77} = 1.08 \qquad e_r = 1$

I find e from Schoernherr's curves.

d = 7.5'	4 blades
RPM = 240	MWR = .25
V = 12 kt	BL. Th. Fr. = .05
EHP = 478	n = 3.33 r/sec.

$K_t = \dfrac{326 \times EHP}{Vn^2d^4(1-t)} = .221$

$J = \dfrac{1.689\ V(1-w)}{nd} = .62$

From the chart I get $e_p = 63.1\%$ p/d - .96

If I now assume several n values and make d = 7.5

EHP = 478

V = 12kt

and find the maximum efficiency.

$K_t = \dfrac{326 \times 478}{1.99 \times 12 \times .84 \times 3150} \dfrac{1}{n^2} = 2.46 \dfrac{1}{n^2}$

$J = \dfrac{1.689 \times 12 \times .771}{7.5} \dfrac{1}{n} = \dfrac{2.08}{n}$

RPM = 165
n = 2.75 kt = .325 ep = .52

J = .775 p/d = 1.33

RPM = 180
n = 3 kt = .273 ep = .605

J = .694 p/d = 1.17

RPM = 195
n = 3.25 kt = .233 ep = .629

J = .64 p/d = 1.00

RPM = 210
n = 3.50 kt = .20 ep = .636

J = .594 p/d = .85

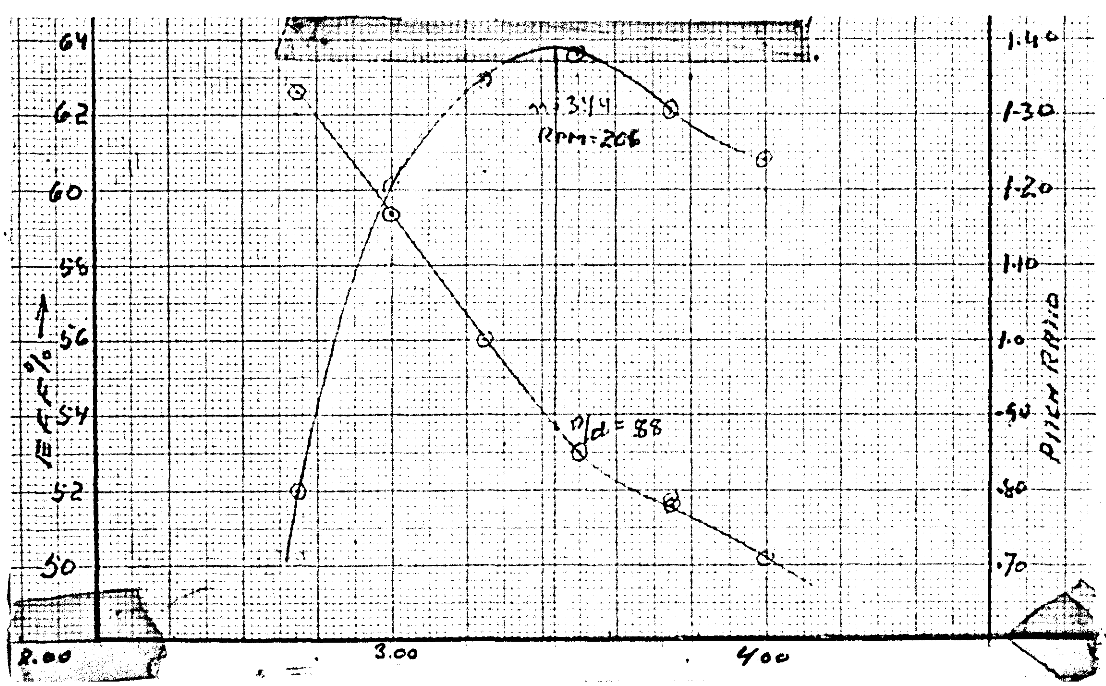
RPM = 225
n = 3.75 kt = 17.5 ep = 62.1

J = .555 p/d = .78

RPM = 240

n = 4.00 kt = .154 ep = .608

J = .52 p/d = .41



By this calculation I get maximum effeciency for

RPM = 208 Pitch = 6.6 p/d = .88

e_p max. = 63.8%

$$PHP = \frac{EHP}{e_p \times e_h \times e_r} = \frac{478}{.638 \times 1.08 \times 1} = 694$$

$$BHP = \frac{PHP}{e_t} = \frac{694}{.95} = 732 \qquad e_t = \text{Eff. of transmission}$$

Labbertan p. 237 long shafting

$$IHP = \frac{BHP}{e_m} = \frac{732}{.80} = 915 \text{ HP}$$

I use 1100 for rough weather and hauling.

Total HP of the ship is then:

Main engine	1100
2 Aux. engines	500
	1600 HP

My fuel consumption would be:

1600 x .48 #/hr. = 1600 x .48 x 24 = #/day =

$$18400 \text{ \#/day} = \frac{1600 \times .48 \times 24}{.95 \times 62.4} = 310 \text{ ft}^3/\text{day}$$

or 4.72 tons a day

If the cruising radius takes 14 days, I need space for fuel oil of 4350 ft^3.

P. N. A. VI.. gives $2\frac{1}{2}$ - $2\frac{3}{4}$ deduction for the framing in double bottom so I need really 4350 x 1.025 = 4460 ft^3 of the displacement volume.

I put double bottom at 3' water line and get by this, space of 2800 ft^3. I also put oil in a 3.5' wide space which I make at aft of the fishholds. (Thermal conductivity of the oil is .109 which is low.) In order to trim the ship I make changes in the 2800 ft. space available in the double bottom and put some of the liver oil tanks aft and the fuel oil more forward. The space I get in this 3.5 ft. oil tank aft of the fish hold is 1870 ft. In order to avoid heat transfer after the oil has been consumed in this tank, I put in cork-plates on the fish hold side of the bulkhead. (thermal conductivity .025)

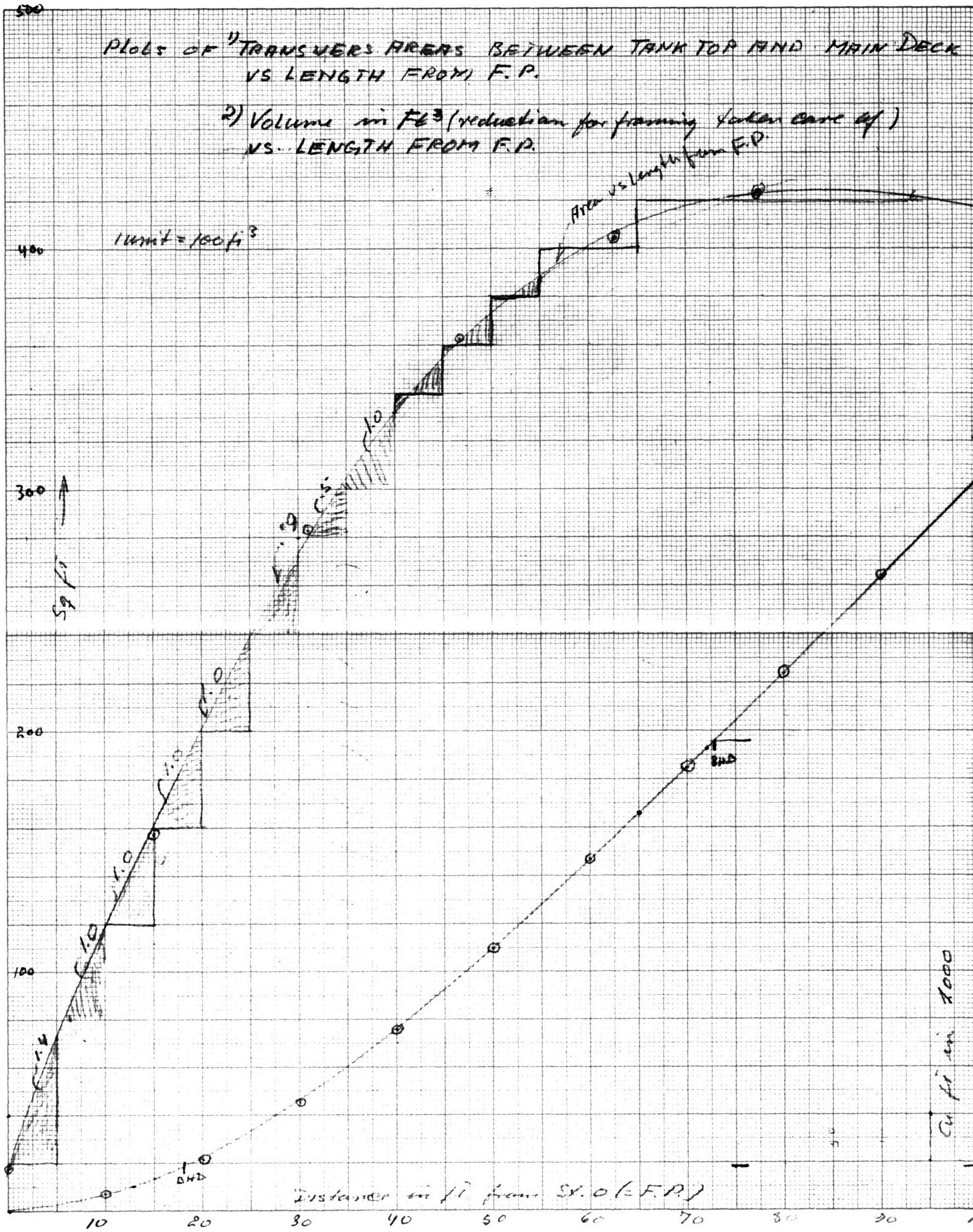
CARGO HOLD SIZE

Area from top of double bottom to main deck:

Station	Area	Ft from St.0
0	18.1	0
$\frac{1}{2}$	102.8	7.8
1	147	15.6
2	293	31.2
3	363	46.8
4	383	62.4
5	422	78.0
6	422	93.6

Now I make a plot of the areafrom station 0 under the main deck. The area under that curve would give me volume up to any point from St. 0.

(Plot on next page)



Plots of 1) TRANSVERS AREAS BETWEEN TANK TOP AND MAIN DECK VS LENGTH FROM F.P.
2) Volume in Ft³ (reduction for framing taken care of) VS. LENGTH FROM F.P.
Area vs length from F.P.
1 unit = 100 ft³
Sq ft
Cu ft in 1000
BHD
Distance in ft from St. 0 (= F.P.)
500
400
300
200
100
10
20
30
40
50
60
70
80
90
100
2
4
6
8
10
12
14
16
18
20
22
24
26
28

24

P. N. A. VI gives for the stowage factor of fish as 50 ft^3 to a ton. Using this figure (although I have refrigerating coils in this trawler, which undoubtedly take less space than the ice) and for 290 tons of fish I need 290 x 50 = 14500 ft^3 or according to the graph, from station 1, 65' aft.

By putting the bulkhead 72.8' aft, I get 17800 ft^2 having subtracted for usual framing. As I have insulation and refrigeration, I use this value which leaves me 13800 ft^3 = 270 - 280 tn.

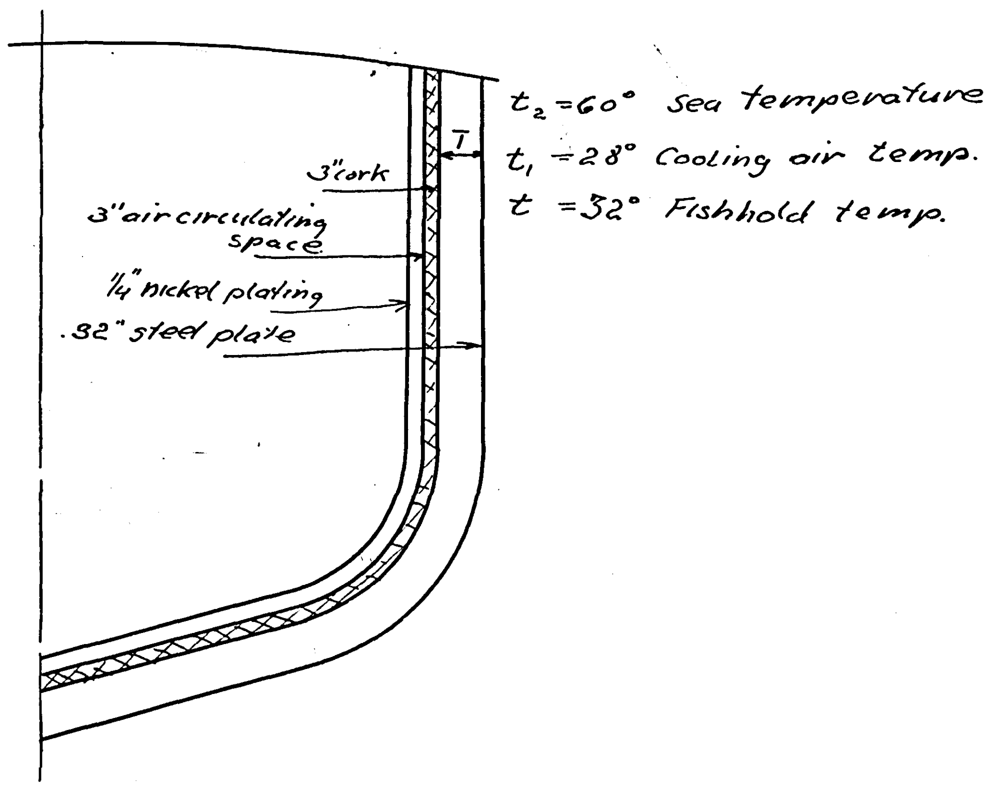
FISH-HOLD AND HEAT TRANSFER

In REFRIGERATING ENGINEERING V. 33, 1937, p. 373 is a description of the fish-hold of the trawler, "Storm". There, they use cold air circulating around the hold. By this, they can spare about 2/3 of the ice consumption. Inside the frame flanges is a 3" thick cork-board. Then there is a 3" air passage for the cooling air and nearest to the fish is a waterproof nickel plating.

Down below, I try to calculate or at least to estimate the ratio between the heat transfer coefficient and heat transfer from the aircooling space to the shell out to the sea and to the fish-hold.

The reference I use is McAdams' "Heat Transmission".

According to Am. Bü. Sh.,, I use 7 x 3.45 x .350 x .500 channel. (I just need the web height) The plate thickness is .32"



Assumed temperature in fish-hold to be 32°F.

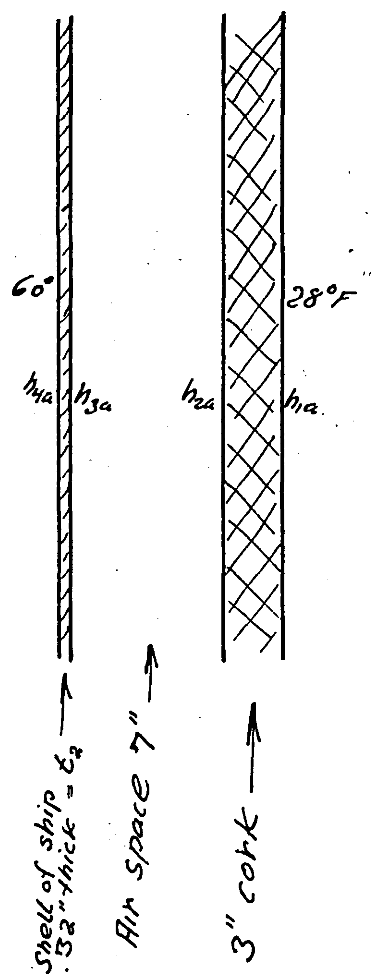
" " " air-cooling space to be 28°F.

" " of sea to be 60°F.

In order to find the film coeficients and the air cooling space, I assume the shape of the air duct rectangular $\frac{1}{4}$' x 15' as the speed is 50'/sec of the air. This gives me Renold's number of 720000, which shows me a turbulant flow.

By using equation 4c, McAdams, p. 168, I get

$h_{1a} = 8.42$



$$\frac{1}{U_{A_1}} = \frac{1}{h_{1a}A_1} + \frac{t_1}{K_{cork}A_1} + \frac{1}{h_{2a}A_1} + \frac{1}{h_{3a}A_1} + \frac{t_2}{K_{steel}A_1} + \frac{1}{h_{4a}A_1}$$

$$\text{or } \frac{1}{U_{A_1}} = \frac{1}{h_{1a}} + \frac{t_1}{K_c} + \frac{1}{h_{2a}} + \frac{1}{h_{3a}} + \frac{t_2}{K_{st}} + \frac{1}{h_{4a}}$$

$h_{1a} = 8.42$

From Eq. 34 p. 207 McAdams

$h_{2a} = 12.58$

$h_{3a} = 11.49$

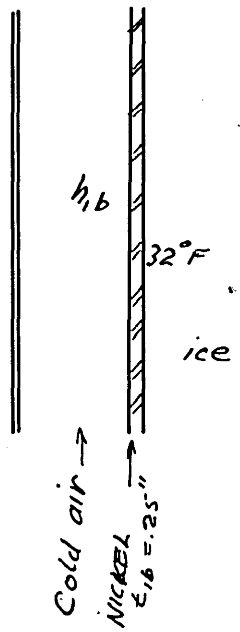
$h_{4a} = 4.6$

$K_c = .025$

$K_{st} = 26$

$$\frac{1}{U_A} = \frac{1}{8.42} + \frac{3}{12\times.025} + \frac{1}{12.58} + \frac{1}{11.49} + \frac{.32}{12\times26} + \frac{1}{4.6}$$

$U_A = .0952$



$h_{1b} = 10.5$ (from p. 207)

$$\frac{1}{U_{A_1}} = \frac{1}{h_{1b}} + \frac{t_{1b}}{K_n} \qquad K_n = 34$$

$$\frac{1}{U_B} = \frac{1}{h_1} + \frac{t}{k_n} = \frac{1}{1.05} + \frac{1}{4 \times 12 \times 34}$$

$$U_B = 9.75$$

Heat transfer from cooling air to the sea:

$$Q_A = U_A A_1 (t_1 - t_2)$$

$$Q_A/A_1 = U_A (t_1 - t_2) = .0952\ (28 - 60)$$

Heat transfer from cooling air to ice in fish-hold:

$$Q_B = U_B A_1 (t_1 - t_3) \qquad t_3 = \text{temp. in fish-hold}$$

$$Q_B/A_1 = U_B (t_1 - t_3) = 9.75 \times (28 - 32)$$

Ratio of heat transfer:

$$\frac{Q_B}{Q_A} = \frac{9.75\ (-4)}{.0952\ (32)} = \left| \frac{12.8}{1} \right|$$

The heat transfer 12.8 times better into the hold than out to the sea.

(Of course, the heat flow is really not from the cold air in the duct out to the sea or into the hold, rather the negative heat (or the cold)).

STABILITY CALCULATION

Light Condition

Lever arms and weights are estimated as close as possible.

Item	Wt.	Vert. Above	C.G.from BL Vert. mom	C.G. from FWD	FWD mom.	⌀ Aft.	Aft. mom
Struct. Wt.	351	14.3	5030			5.0	1755
Paint Cement	12.2	4.0	48.8	15.0	183		
Carp. Work	25.6	19.8	507			35	895
Joinerwork	12.0	15.8	190			12	144
Hull, Fitt.	19.0	23.0	436	0			
Hull Eng.	30.5	17.0	519			4	122
Equipment	5.0	25.0	125	2.0	10		
Outfit	30.0	18.0	540	3.0	90		
Prop. Mach.	83	10.0	830			31	2570
Perm. Ballast	10	3.5				3.0	30
	575.6		8260.8		283		5506

$$KG = \frac{8260.8}{575.6} = 14.35'$$

FROM CURVES KM at 575 ton disp. = 17.8'

$$GM = 17.80 - 14.35 = 3.45'$$

TRIM:

$$\begin{array}{r} -5506 \\ +283 \\ \hline 5223 \end{array} = M_L$$

$$\frac{5223}{575.6} = 9.09 \quad \text{C. G. aft of } ⌀$$

.83 C. B — — — at Δ = 576.6

$d = 9.91$ Distance betw. C.G and C.B

$MTI = 57.5$ ft-tn
(FROM CURVES)

$$TRIM = \frac{\Delta \times d}{MTI} = \frac{575 \times 8.66}{57.5 \times 12} = 8.24'$$

TRIM BY STERN

	$GZ_{uncorr.}$	$\sin\theta$	$KG_{calc.} - K_{assum}$	Correction	GZ_c.
15°	3.05	.259	1.35	.35	2.70
30°	5.00	.500	1.35	.67	4.33
45°	3.95	.707	1.35	.95	3.00
60°	1.55	.866	1.35	1.16	.39

$KG_{CALC} = 14.35$
$KG_{ASSUMED} = 13.00$
$1.35'$

READY FOR SEA

ESTIMATION

		Vert. C.G.from BL		Long. from ⊗			
Item	Wt.	Above	Moment	FWD	FWD mom.	Aft.	Aft. mom
Constr. Wt.	575.6	14.35	8260			9.09	5223
Fuel Oil	127	6.0	764			3.3	420
Fresh Water	15.3	9.0	138	68	104		
Lub. Oil	3.4	8.5	29			25	85
Galley Stoves	2.0	18.0	36			50	100
Ice	30.0	10.5	315	54	1620		
Oven	3.3	21.	69			42	139
Free Surfacef-o			29				
Free Surface W			39				
Total	756		9674		1724		5967

$$KG_{CBL} = \frac{9674}{756} = 12.8$$

$$KM = 16.2$$

$$GM = 3.4'$$

TRIM:

$$\begin{array}{r} -5967 \\ +1724 \\ \hline -4243 \end{array} = M_c$$

$$\frac{4243}{556} = 5.61' \text{ CG aft of } ⊗$$

.45 CB — — —

$d = 6.06'$

MT1 = 78.0 ft-tn.

$$\text{TRIM by stern} = \frac{756 \times 6.06}{12 \times 78.0} = .49'$$

θ	$GZ_{unc.}$	$\sin\theta$	$KG_{CALC} - KG_{ASSUM.}$	Correction	$GZ_{corr.}$
15°	2.44	.259	−.2	.05	2.45
30°	3.55	.500	−.2	.1	3.65
45°	2.20	.707	−.2	.14	2.34
60°	−.25	.866	−.2	.17	.08

LOAD CONDITION

ESTIMATION

		Vert. C.G. from BL		Long C.G. from			
Item	Wt.	Above	Moment	FWD	FWD mom.	Aft.	Aft. mom.
Constr. Wt.	576	14.35	8260			9.09	5223
Fuel	65	4.5	392			5.5	357
Water	7.0	6.0	42	68	476		
Lub. Oil	2.0	10.0	20			25	50
Galley	1.0	18.0	18			50	50
Fish & Ice	270	11	2970	36	9750		
Crew	3.3	21	69			42	139
Free Surf. f.o.			29				
Free Surf. f.w.			30				
	923.9		11830		10226.0		5819.0

$$KG \text{ calculated} = \frac{11830}{923.9} = 12.8$$

KM = 15.76

GM = 2.84'

TRIM

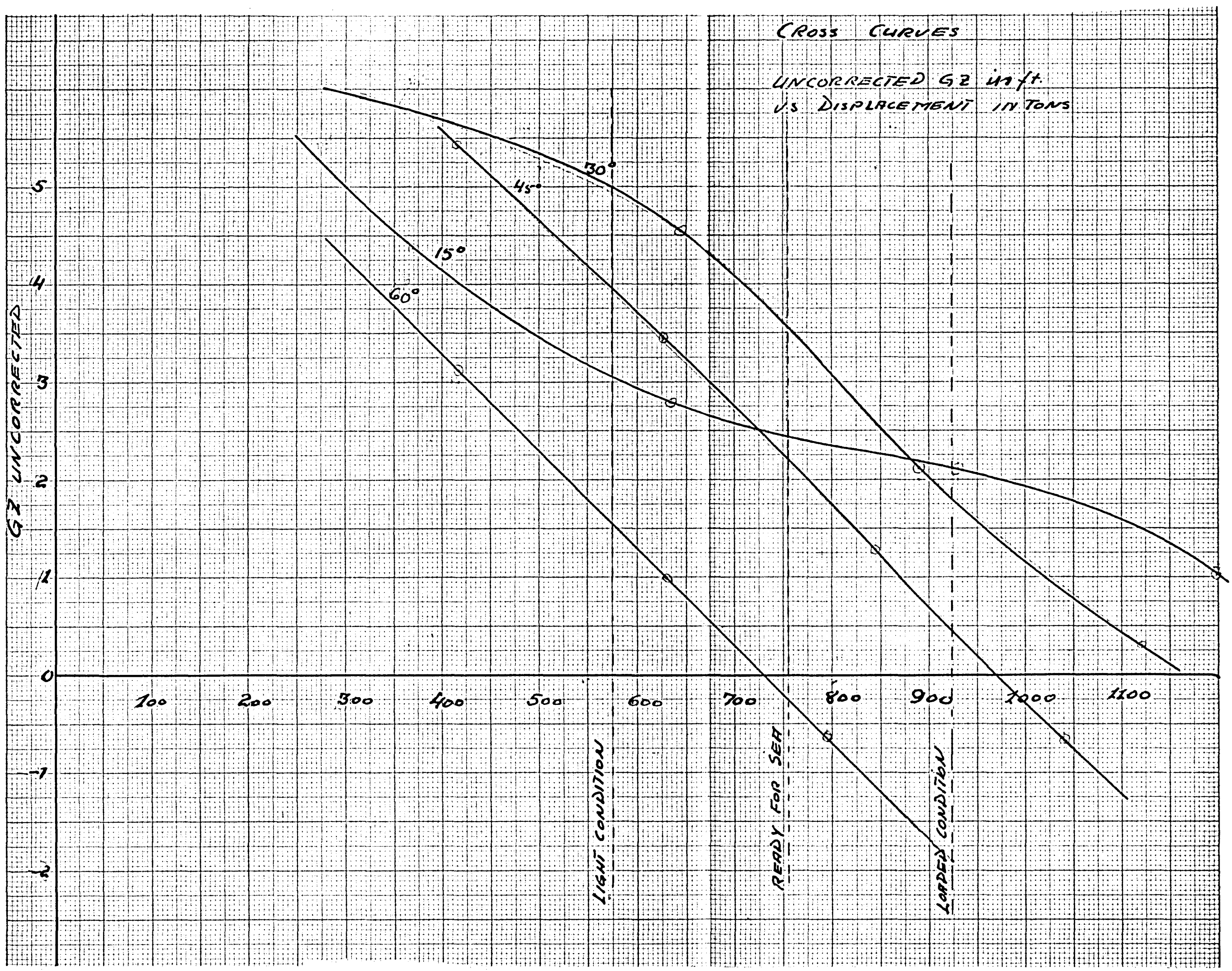
$$\begin{array}{r} -10226 \\ +5819 \\ \hline -4407 \end{array}$$

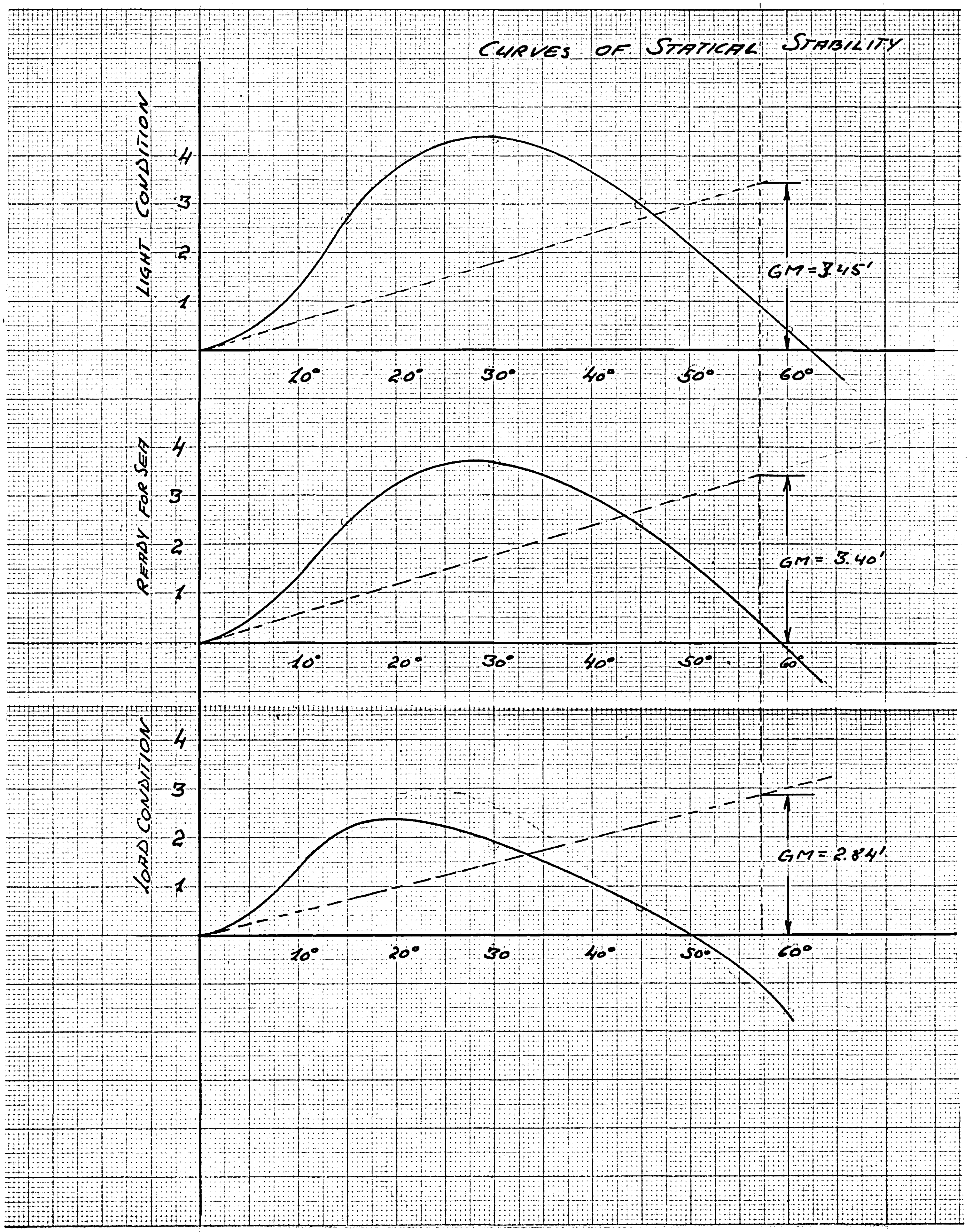
$$\frac{4407}{923.9} = 4.77' \text{ C.G. forw. of } \otimes$$

$$\begin{array}{rl} & \underline{.15} \quad \text{C. B} \quad — \quad — \quad — \\ d & = 4.62' \end{array}$$

$MTI = 78.5$

$$\text{TRIM FORWARD} = \frac{923 \times 4.62}{12 \times 78.5} = .45''$$


CROSS CURVES
UNCORRECTED GZ in ft.
V.S DISPLACEMENT IN TONS
GZ UNCORRECTED
30°
45°
15°
60°
5
4
3
2
1
0
-1
-2
100
200
300
400
500
600
700
800
900
1000
1100
LIGHT CONDITION
READY FOR SEA
LOADED CONDITION



CURVES OF STATICAL STABILITY
LIGHT CONDITION
GM = 3.45'
READY FOR SEA
GM = 3.40'
LOAD CONDITION
GM = 2.84'
1
2
3
4
10°
20°
30°
40°
50°
60°

36

Assumed KG = 13' ft. STABILITY CURVES - INTEGRATOR 15° Inclination

S.D.		Area Reading	Check Reading	Multiplier	Δ	Moment Readings	Check Readings	Multiplier	Moment	GZ
1	Final	7661	13887			2196	4103			
	Initial	1520	7661			10195	12196			
	Diff.	6141 6180	6226	.0598	370	2000		.808	1616	4.37
2	Final	14485	15010			6798	8966			
	Initial	3865	4485			4549	6798			
	Diff.	10620 10623	10625		635	2200			1775	2.795
3	Final	10525	16096			1860	4330			
	Initial	4968	0525			9410	1860			
	Diff.	15557 15560	15571		931	2460			19.85	2.12
4	Final	6115	6124			6355	7856			
	Initial	6050	6115			4768	6355			
	Diff.	20085 20036	20009		1197				1242	1.04
	Final									
	Initial									
	Diff.									
	Final									
	Initial									
	Diff.									

...med KG = 13 ft.

STABILITY CURVES - INTEGRATOR 30°

° Inclination

		Area Reading	Check Reading	Multiplier	△	Moment Readings	Check Readings	Multiplier	Moment	GZ
1	Final	6882	3402			10455	3225			
	Initial	0317	6082			7676	0455			
	Diff.	6565 6543	6520	.0598	391	2779 2775	2770	.808	2235	5.71
2	Final	14164	14848			7277	10908			
	Initial	3370	04164			3660	7277			
	Diff.	10794 10750	10684		644	3617 3624	3631		2925	4.55
3	Final	19628	24498			3661	6224			
	Initial	4776	9624			1345	3661			
	Diff.	14852 14860	14874		888	2316 2439	2563		1968	2.22
4	Final	23157	21890			6993	7490			
	Initial	4392	3157			6630	6993			
	Diff.	18765 18740	18723		1120	0363 430	0497		347	.309
	Final									
	Initial									
	Diff.									
	Final									
	Initial									
	Diff.									

med KG = 13 ft. STABILITY CURVES - INTEGRATOR 45°

° Inclination

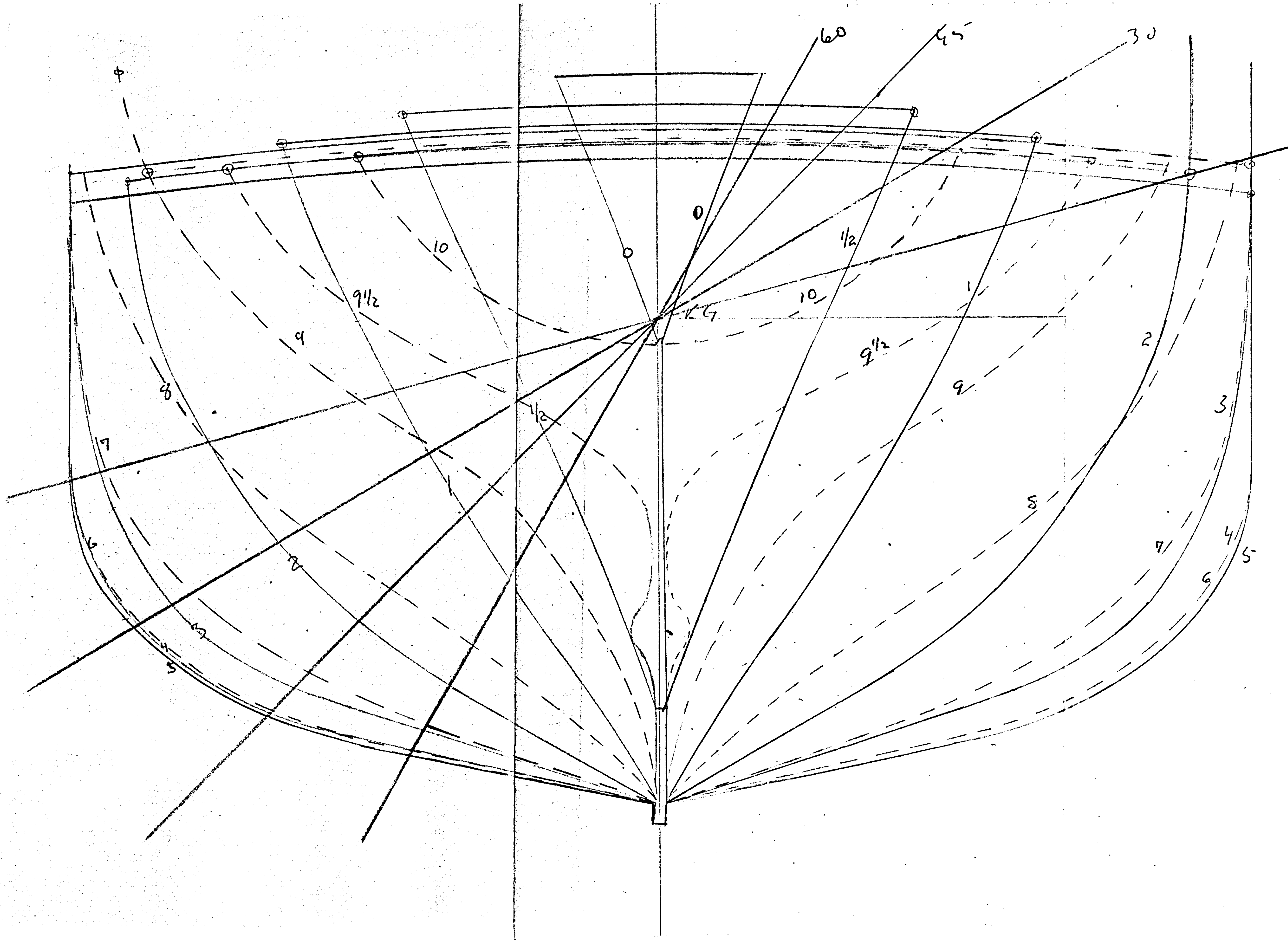
		Area Reading	Check Reading	Multiplier	Δ	Moment Readings	Check Readings	Multiplier	Moment	GZ
	Final	10080	9864			0203	4277			
	Initial	3130	2932			7408	1477			
	Diff.	6950 6941	6932	.0598	415	2795 2797	2800	.808	2255	5.43
2	Final	20278	10757			7357	0067			
	Initial	9828	0278			4707	7357			
	Diff.	10450 10465	10481		626	2650 2680	2710		2163	3.45
3	Final	4742	8850			1862	3174			
	Initial	0634	4742			0494	1862			
	Diff.	14108 14108	14108		844	1368 1338	1312		1080	1.28
4	Final	26123	6330			2622	2023			
	Initial	8675	8941			3551	2839			
	Diff.	17448 17418	17389		1042	-0929 -873	-816		-705	-.676
	Final									
	Initial									
	Diff.									
	Final									
	Initial									
	Diff.									

med KG = 13 ft. STABILITY CURVES - INTEGRATOR 60°

° Inclination

		Area Reading	Check Reading	Multiplier	△	Moment Readings	Check Readings	Multiplier	Moment	GZ
1	Final	13850	10830			5892	75			
	Initial	6880	3850			4300	5892			
	Diff.	6970 6975	6980	.0598	417	1592 1610	1628	.808	130.0	3.12
2	Final	0792	0923			8727	9455			
	Initial	0828	0792		631	7924	8727			
	Diff.	10964 10550	10131			803 766	728		61[illegible]	.978
3	Final	4073				9270				
	Initial	0720	4073			9900	9270			
	Diff.	13353 13353			799	-630 -630			-509	-.642
	Final									
	Initial									
	Diff.									
	Final									
	Initial									
	Diff.									
	Final									
	Initial									
	Diff.									

Stations for stability Calculation



- DISPLACEMENT AND METACENTRIC SHEET -

Stations	Levers	Half Ord's. Water Lines 1/2	2/4	3/6	Ord's. on W.L.2 ×3	Func. of Areas	Func. of Moments	Metacenter W.L.3 Cubes of Ord's.	Ord's. × Lever	Ord's. × (Lever)²	Half Ord's. Water Lines 3/6	4/8	5/10	Ord's. on W.L.4 ×3	Func. of Areas	Func. of Moments	Metacenter W.L.5 Cubes of Ord's.	Ord's. × Lever	Ord's. × (Lever)²	Half Ord's. Water Lines 5/10	6/12	7/14	Ord's. on W.L.6 ×3	Func. of Areas	Func. of Moments	Metacenter W.L.7 Cubes of Ord's.	Ord's. × Lever	Ord's. × (Lever)²	Half Ord's. Water Lines 7/14	8/16	9/18	Ord's. on W.L.8 ×3	Func. of Areas	Func. of Moments	Metacenter W.L.9 Cubes of Ord's.	Ord's. × Lever	Ord's. × (Lever)²	Appendage ½ Area Stat. ÷ h/3	½ Area ÷ h/3 × Lever
0	+5	0	0	0	0	0	0	0	0	0	0	0	0	—	—	—	—	—	—	0	0	.25	0	.5	2.5	1.12	2.5	12.5	.6	1.25	2.16	3.75	7.66	38.30	10.09	10.80	54.00	0	0
10	-5	0	0	0	0	0	0	—	—	—	0	0	0	—	—	—	—	—	—	0	0	5.00	0	5.80	-25.0	112.50	-25	125.00	5.00	7.09	8.25	21.27	41.61	-208.05	561.49	-41.25	206.25	0	0
Sums		0	0	0				—						—								5.5	0	5.50	-22.5	118.62	-22.50	137.50	5.5	8.34	10.41	25.02	49.27	-169.75	571.58	-30.45	260.25	0	0
Simp. M.		½	½	½		½	½	½	½	½	½	½	½		½	½	½	½	½	½	½	½		½	½	½	½	½	½	½	½		½	½	½	½	½	½	½
Multiple		0	0	0		—	—	—	—	—	—	—	—		—	—	—	—	—	—	—	2.75		2.75	11.25	6.31	-11.25	68.75	2.75	4.17	5.20		24.63	-84.87	285.79	-15.22	130.12	0	0
½	+4½	0	.5	1.25	1.5	3.25	11.62	1.95	5.63	25.33	1.25	2.17	2.92	6.51	12.85	57.82	24.91	13.14	58.98	2.92	3.8	4.7	11.4	22.82	102.69	103.83	21.15	94.94	4.7	5.68	6.5	17.04	33.92	152.64	274.62	29.25	131.36	0	
3	+2	4.86	10.42	12.33	31.26	59.42	118.84	2136.66	25.76	51.52	12.58	14.1	14.75	42.30	84.03	168.06	3209.01	29.50	59.00	14.75	15.23	15.25	45.69	90.92	181.84	3546.54	30.50	61.00	15.25	15.30	15.30	45.90	91.75	183.50	3581.58	30.60	61.20	2.63	+5.26
5	0	7.5	12.33	14.42	36.99	71.24	0	2998.35	0	0	14.42	15.25	15.3	45.75	90.72	0	3581.58	0	0	15.3	15.3	15.3	45.90	91.80	0	3581.58	0	0	15.3	15.3	15.3	45.90	91.80	0	3581.58	0	0	3.84	0
7	-2	4.62	10.33	12.20	30.99	58.14	-116.28	1815.85	-24.40	48.80	12.20	13.84	14.73	44.52	82.29	-164.58	3195.97	-29.46	58.92	14.73	15.05	15.25	45.15	90.18	-180.36	3546.54	-30.50	61.00	15.25	15.3	15.3	45.90	91.75	-273.50	3581.58	-30.60	61.20	2.35	-4.70
9½	-4½	.20	.33	.33	.99	1.85	-8.32	.03	-1.485	6.66	.33	.33	2.17	.99	3.82	-17.90	10.20	-9.77	43.83	2.17	5.75	8.83	17.25	39.00	-153.0	688.48	-39.74	178.37	8.83	10.67	11.70	32.01	63.21	-284.44	1601.61	-52.65	236.94	0	0
Sums		17.18	33.91	44.06	101.73	193.90	+5.86	6952.84	+5.51	132.31	41.08	45.69	49.27	137.07	273.71	-110.6	10021.67	+3.84	220.73	49.87	55.13	59.33	165.36	329.72	-48.83	11466.96	-18.59	395.31	59.33	62.25	63.10	186.75	372.43	-131.80	12680.88	-23.40	490.04	8.82	+.56
Simp. M.		2	2	2		2	2	2	2	2	2	2	2		2	2	2	2	2	2	2	2		2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Multiple		34.36	67.82	88.16		387.80	+11.72	13905.78	+11.02	264.62	82.16	91.38	98.74		547.42	-221.6	20023.34	+7.68	441.46	99.74	110.26	118.66		659.44	-77.66	22933.92	-37.18	790.62	118.66	124.50	128.20		744.86	263.60	25241.78	-46.80	980.08	17.64	1.12
1	+4	.97	2.25	3.75	6.75	13.72	54.88	52.73	15.00	60.00	3.75	5.08	6.25	15.24	30.32	121.28	244.12	25.00	100.00	6.25	7.38	8.38	22.14	44.05	176.20	567.68	33.12	132.48	8.28	10.23	10.57	30.69	60.07	240.28	1284.40	43.44	173.92	.47	1.88
9	-4	.33	1.08	2.22	3.24	6.87	-27.48	10.94	-8.88	35.52	2.22	3.66	6.48	10.98	23.34	-93.36	272.10	-25.92	103.68	6.48	9.27	11.27	27.81	54.83	217.32	1431.40	-45.08	180.32	11.27	12.83	13.75	38.49	76.34	-305.36	2599.58	-55.00	220.00	.19	-.76
Sums		1.30	3.33	5.77	9.99	20.39	+27.40	63.67	6.12	95.52	5.97	8.74	12.73	26.22	53.46	-27.92	516.22	-.92	203.68	12.73	16.65	19.55	49.95	98.88	-41.12	1999.08	-11.96	312.80	19.55	23.06	24.62	69.18	136.41	-65.08	3683.98	-11.52	393.92	.68	+1.12
Simp. M.		1½	1½	1½		1½	1½	1½	1½	1½	1½	1½	1½		1½	1½	1½	1½	1½	1½	1½	1½		1½	1½	1½	1½	1½	1½	1½	1½		1½	1½	1½	1½	1½	1½	1½
Multiple		1.95	5.00	8.66		30.58	+41.10	95.50	+9.18	143.31	8.66	13.11	19.10		80.19	-41.88	774.33	-1.38	305.52	19.10	25.0	29.33		148.32	-61.68	2998.63	-17.94	468.27	29.33	34.52	36.96		204.61	-97.62	5525.97	-17.28	590.88	1.00	1.68
2	+3	2.62	6.17	6.88	18.51	34.18	102.54	325.77	20.64	61.92	6.88	10.5	11.75	31.50	60.63	181.89	1622.20	35.25	105.75	11.75	12.80	13.38	38.40	76.33	228.99	2097.15	40.14	120.42	13.38	13.75	13.84	41.25	82.27	246.66	2650.91	41.52	124.56	.84	2.52
4	+1	6.90	12.17	14.25	36.51	69.83	69.83	2893.66	14.25	14.25	14.25	15.3	15.3	45.60	90.75	90.75	3581.58	15.30	15.30	15.3	15.3	15.3	45.40	91.80	91.80	3581.58	15.30	15.30	15.3	15.3	15.3	45.90	91.80	91.80	3581.58	15.30	15.30	3.18	3.18
6	-1	7.12	12.06	14.17	36.18	69.53	-69.53	2845.19	-14.17	14.17	14.17	15.17	15.3	45.51	90.15	-90.15	3581.58	-15.30	15.30	15.3	15.3	15.3	45.90	91.80	-91.80	3581.58	-15.30	15.30	15.3	15.3	15.3	45.90	91.80	-91.80	3581.58	-15.30	15.30	2.53	-2.53
8	-3	1.50	4.00	7.05	12.00	24.55	-73.65	350.38	-21.15	63.45	7.05	9.80	11.98	29.40	58.17	-174.51	1699.71	-35.76	105.48	11.98	13.17	14.16	39.51	78.76	-235.28	2284.33	-42.48	127.44	14.16	14.75	15.15	44.25	88.31	-264.93	3477.23	-45.45	136.35	.84	-2.52
Sums		18.14	34.40	42.35	103.20	198.09	+29.19	6414.94	-.43	153.76	42.35	50.77	54.27	152.31	299.70	+7.98	10472.07	-.57	241.83	54.27	56.57	58.14	169.71	338.69	-6.29	11544.64	-2.34	278.46	58.14	59.10	59.59	177.30	353.73	-18.27	13291.30	-3.93	291.51	7.39	+.65
Simp. M.		4	4	4		4	4	4	4	4	4	4	4		4	4	4	4	4	4	4	4		4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
Multiple		72.56	137.60	169.40		792.36	+116.76	25659.76	-1.72	615.16	169.40	203.08	217.08		1198.80	+31.92	41916.28	-2.04	967.32	217.08	226.28	232.56		1354.76	-25.16	46178.56	-9.36	1113.84	232.56	236.40	238.36		1416.52	-73.08	53162.20	-15.72	1166.04	29.56	2.60
Sum of Multiples		108.87	210.42	260.22		1210.74	169.60	② 39661.04	+17.48	③ 1023.09	260.22	307.57	335.92		1826.41	-32.12	② 62713.95	① 1.39	③ 1714.30	335.92	361.54	383.30		2165.27	-75.75	② 72117.42	① -75.73	③ 2441.48	383.30	399.59	408.72		2390.62	519.17	② 84515.74	① -95.05	③ 2867.12	48.20	5.40
Simp. Multiplier		1	4	1		48.20	5.40				1	4	1		1258.97	175.00				1	4	1		3085.19	142.88				1	4	1		5250.57	-32.87					
Σ of Volumes		108.87	841.68	260.22		① 1210.77					260.22	1230.28	335.92		① 1826.42					335.92	1446.16	383.30		① 2165.38					383.30	1598.36	408.72		① 2390.38					48.20	
Lever		1	2	3		1258.97	175.00				3	4	5		3085.19	142.88				5	6	7		5250.57	-32.87				7	8	9		7640.95	-552.04				.6	
Σ of Moments		108.87	1683.36	780.66	2572.89	28.92	2601.81				780.66	4921.12	1679.60	9983.19						1679.60	8676.96	2683.10	23022.85						2683.10	12786.88	3678.48	42171.31						28.92	

	W.L.3		W.L.5		W.L.7		W.L.9	
$\Delta_{slice} = m_1 \Sigma V =$	1210.75 × .1981	239.5	1826.41 × .1981	361.4	2165.27 × .1981	429.0	2390.62 × .1981	473.0
$\Delta_{below\ slice} = m_1 \Sigma V =$	48.20 × .1981	-9.55		249.05		610.45		1039.45
$\Delta_{total} =$		249.05		610.45		1039.45		1512.45
$A_{W.L.} = m_2 \times ① =$	260.22 × 10.4	2705	335.92 × 10.4	3495	383.30 × 10.4	3985	408.72 × 10.4	4250
C.G. W.L. from ⊠ $= X = \frac{④ \times S}{①} =$	$\frac{17.48 \times 15.6}{260.22}$	1.04	$\frac{6.39 \times 15.6}{335.92}$	.297	$\frac{-75.73 \times 15.6}{383.30}$	-1.94	$\frac{-95.05 \times 15.6}{408.72}$	-3.64
$I = m_3 \times ② =$	39661.04 × 3.47	120400	62713.95 × 3.47	217500	72117.42 × 3.47	250000	84515.74 × 3.47	293200
$BM = I \div 35\Delta =$	$\frac{120400}{35 \times 249.05}$	13.8	$\frac{217500}{35 \times 610.45}$	10.17	$\frac{250000}{35 \times 1039.45}$	6.88	$\frac{293200}{35 \times 1512.45}$	5.54
$I_⊠ = m_4 \times ③ =$	2530 × 1023.09	2590000	2530 × 1714.30	4340000	2530 × 2441.48	6185000	2530 × 2867.12	7260000
$(A_{W.L.})(X^2) =$		358		308.5		37700		34750
$I_L = I_⊠ - A_{WL} X^2 =$		2590000		4339692		6147900		7225250
$BM_L = I_L \div 35\Delta =$	$\frac{2590000}{35 \times 249.05}$	297	$\frac{4339692}{35 \times 610.45}$	203	$\frac{6147300}{35 \times 1039.45}$	169	$\frac{7225250}{35 \times 1512.45}$	136.5
C.B. from ⊠ $= S \times \frac{f(M_L)}{f(V)} =$	$15.6\ \frac{175}{1258.97}$	2.17	$15.6\ \frac{142.88}{3085.19}$	.722	$15.6\ \frac{(-32.87)}{5250.57}$	-.0976	$15.6\ \frac{(-552.04)}{7640.95}$	-1.128
K.B. $= h \times \frac{f(M_V)}{f(V)} =$	$2\ \frac{2601.81}{1258.97}$	4.13 2.0	8.47 17.63 $2\ \frac{9983.19}{3085.19}$	6.46	16.63 $2\ \frac{23022.85}{5250.57}$	8.77	15.65 $2\ \frac{42171.31}{7640.95}$	11.02
M.T.1 $= \frac{\Delta \times B.M_L}{12 L} =$	$\frac{249.05 \times 297}{12 \times 156}$	39.5	$\frac{610.45 \times 203}{12 \times 156}$	66.2	$\frac{1039.45 \times 169}{12 \times 156}$	93.8	$\frac{1512 \times 136.5}{12 \times 156}$	110.2
Inc. Δ/Ft. Trim by Stern $= \frac{-A \times X}{35 L} =$	$-\frac{2705 \times 1.04}{35 \times 156}$ $\frac{3}{30}$	-.516	$-\frac{3495 \times .107}{35 \times 156}$	-.068	$+\frac{3985 \times 1.94}{35 \times 156}$	+1.42	$\frac{4250 \times 3.64}{35 \times 156}$	2.83
$T = \frac{A_{W.L.}}{420} =$	$\frac{2705}{420}$	6.44	$\frac{3495}{420}$	8.32	$\frac{3985}{420}$	9.49	$\frac{4250}{420}$	10.01
A⊠ Below Layer =		11.52		107.3		227.0		349.2
A⊠ Slice =		95.80		119.7		122.2		122.2
A⊠ Total =		107.3		227.0		349.2		471.4
m =	$\frac{\Sigma A}{HB} = \frac{107.3}{6 \times 30.6}$	.585	$\frac{227}{10 \times 30.6}$	.742	$\frac{349.2}{14 \times 30.6}$	.815	$\frac{471.4}{18 \times 30.6}$	.855
b =	$\frac{35\Delta}{LBH} = \frac{35 \times 249.05}{156 \times 30.6 \times 6}$	.304	$\frac{35 \times 610.45}{156 \times 30.6 \times 10}$	.447	$\frac{35 \times 1039.45}{156 \times 30 \times 14}$	.544	$\frac{35 \times 1512.45}{156 \times 30 \times 18}$	.620
l =	$b/m = .304/.585$	.520	.447/.742	.603	.544/.815	.668	.620/.855	.726
p =	$\frac{A_{WL}}{LB} = 2705/156 \times 30.6 = \frac{2705}{4770}$	.566	3495/4770	.732	3985/4770	.834	4250/4770	.891

$m_1 = \frac{h}{3} \times \frac{S}{3} \times \frac{2}{35}$ $m_3 = \frac{1}{3} \times \frac{S}{3} \times 2$

$m_2 = \frac{2S}{3}$ $m_4 = S^2 \times \frac{S}{3} \times 2$

Principal Dimensions { Length over all = 1 · Length bet. perp's = 156' · Spacing of stat. = s = 15.6' · Spacing of Water Lines = h = 2' · Beam at L.W.L. = 30.6' · Beam moulded = · Depth moulded at side = D = · Depth = · Draft = H = }

ALL SYMBOLS STANDARD

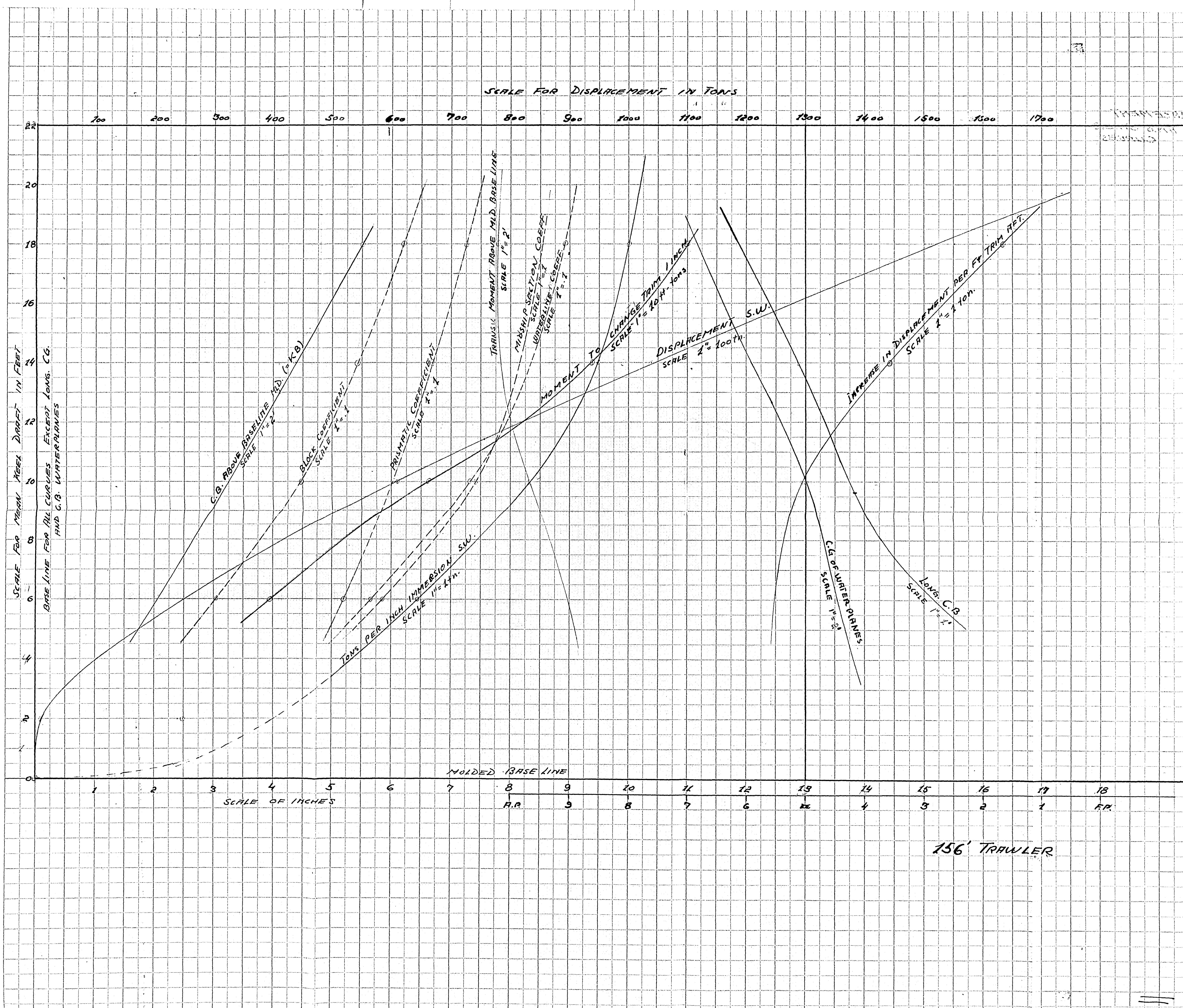
* These Values should check. Data for Appendage Column can be obtained by integrator.

$1 = \frac{2}{3} \times \frac{15.6}{3} \times \frac{2}{35} = 0.1980$ $m_2 = \frac{2}{3} 15.6 = 10.4$ $m_3 = \frac{1}{3} \times \frac{15.6}{3} \times 2 = 3.47$ 4060 143 15.4 30.8

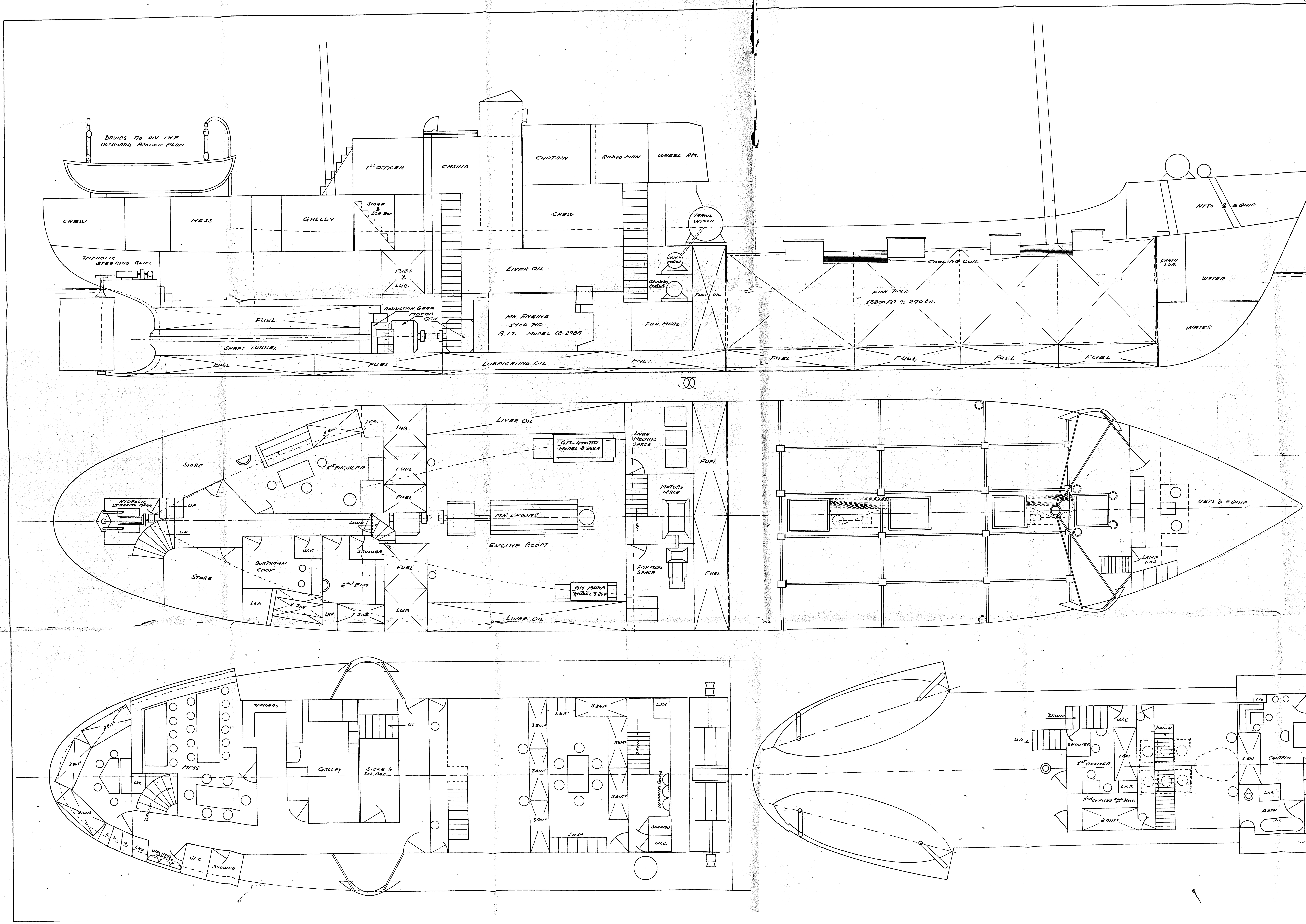
$\frac{\omega}{9} = 7/35 = \frac{1}{5}$ $m_4 = 15.6^2 \times \frac{15.6}{3} \times 2 = 2530$

4775

40


SCALE FOR DISPLACEMENT IN TONS
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700
SCALE FOR MEAN KEEL DRAFT IN FEET
BASE LINE FOR ALL CURVES EXCEPT LONG. C.G. AND C.B. WATERPLANES
C.B. ABOVE BASELINE MLD (=KB) SCALE 1"=2'
BLOCK COEFFICIENT SCALE 1"=.1
PRISMATIC COEFFICIENT SCALE 1"=.1
TRANSV. MOMENT ABOVE MLD. BASE LINE SCALE 1"=2'
MIDSHIP SECTION COEFF. SCALE 1"=.1
WATERLINE COEFF. SCALE 1"=.1
MOMENT TO CHANGE TRIM 1 INCH SCALE 1"=10 ft-tons
DISPLACEMENT S.W. SCALE 1"=100 tn.
INCREASE IN DISPLACEMENT PER FT TRIM AFT. SCALE 1"=1 ton.
TONS PER INCH IMMERSION S.W. SCALE 1"=1 tn.
C.G. OF WATER-PLANES SCALE 1"=2'
LONG. C.B. SCALE 1"=1'
MOLDED BASE LINE
SCALE OF INCHES
A.P. 9 8 7 6 ⊠ 4 3 2 1 F.P.
156' TRAWLER

156' DIESEL-ELECTRIC
TRAWLER
LOA = 170' B = 30.6' H = 12.3'
SCALE 1:50
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
MAY 1946 VIGGO MAACK



GENERAL ARRANGEMENT PLAN OF A
156' LBP DIESEL-ELECTRIC TRAWLER
LOA = 170' B = 30.6'
T = 12.3 D_{MIN} = 16.8'
DISPLACEMENT TO 12.3' = 850 TN
SCALE 1:50
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
MAY 1946 VIGGO MAACK

18' WATERLINE
16' WATERLINE
14' WATERLINE
12' WATERLINE
10' WATERLINE
8' WATERLINE
6' WATERLINE
4' WATERLINE
2' WATERLINE
156' TRAWLER
MAY 1946 V.E. MORCK