NAVY DEPARTMENT

THE DAVID W. TAYLOR MODEL BASIN

WASHINGTON 7, D.C.

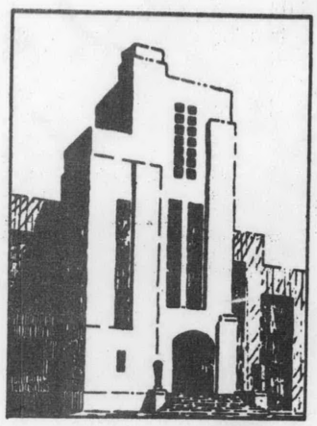
AGB 1 and 2
TMB MODEL 3705

PREDICTIONS OF PERFORMANCES
WITH AND WITHOUT ICE GUARDS

Part 1: Propulsion

By
R. E. Fisher

Prepared for the
Bureau of Ships (Code 420)



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PREDICTIONS OF PERFORMANCES
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Part 1: Propulsion

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Agency Requesting Model Tests: Bureau of Ships (Code 420)
Vessels: Twin Screw Coast Guard Cutters (Ice Breakers).
Propeller Design Speed (without Guards): 16 knots.
Plans: Propellers: U.S.C.G. Plan 96-99CR44001A
Original Lines: U.S.C.G. Plan 96-98CR0101-2
Ice Guards: BuShips Plan P.D. 1593.
Authorization: BuShips ltr S12-5(420) of 3 Jan 50 to TMB.

INDEX OF PLATES

CALCULATIONS

In order to compare with existing tests, Geber's Frictional Coefficients with a G-factor of 0.108 were used in all calculations for EHP and for the frictional differences required for the propulsion tests. Similarly a density ratio SW/FW = 1.024 and a salt-water temperature of 50° F were assumed for the predictions. The calculations followed the method described in C. and R. Bulletin No. 7.

COMMENTS

The ice guards increase the total EHP for the full speed range as is evidenced in the following tabulation for several ship speeds:

COMPARISON OF EHP WITH AND WITHOUT ICE GUARDS			
Ship Speed Knots	EHP		
	With Guards	Without Guards	Percent Increase With Ice Guards
8	650	490	33
10	1380	970	42
12	2520	1800	40
14	4260	3210	33
16	9030	6460	40

A similar comparison of SHP and RPM compiled from data in Plates 4 and 5 follows:

COMPARISON OF RPM AND SHP WITH AND WITHOUT ICE GUARDS					
Ship Speed Knots	RPM		SHP		
	With Guards	Without Guards	With Guards	Without Guards	Percent Increase With Ice Guards
8	61.2	57.1	1030	680	51
10	76.7	71.3	2180	1575	38
12	92.2	86.1	4000	2870	39
14	108.1	102.3	6710	5090	32
16	133.8	126.1	14200	10600	34

The above increases in power with ice guards are a considerable part of the totals. If such increases warrant a redesign of the guards then the following analysis of the increases of EHP appears to be of importance:

ANALYSIS OF INCREASE IN EHP WITH ICE GUARDS				
Ship Speed in Knots	Increases in EHP			
	Total	Frictional	Residuary	Residuary / Total
8	160	30	130	0.81
10	410	50	360	0.88
12	720	75	645	0.90
14	1050	115	935	0.89
16	2570	180	2390	0.93

Since the last column above indicates that more than 80 percent of the increase in power with ice guards is required to overcome residuary rather than frictional resistance, it is suggested that a study be made of the streamline flow prior to a possible revision of design. Also, if the guards were extended farther aft than that shown in Plate 9 to better protect the propellers, the increase in wetted surface would be relatively insignificant.

Thrust oscillations with amplitudes up to 20 percent of the thrust readings were observed during the propulsion tests. These oscillations suggest that the shape of the ice guards as shown in Plate 8 may cause variation in the pressure and velocity of the water entering the propellers as the ship pitches. If the guards were made of faired struts, the apertures between them should tend to relieve pressure variations and thus partially eliminate such oscillations.

The results with ice guards in Plates 5 and 6 were also analyzed at 15 and 16 knots ship speeds to determine whether or not propeller cavitation would cause an increase in power requirements. The analysis indicates that no such increase is anticipated at 15 knots; but that such an increase may be required at 16 knots. Consequently if the ship has enough power to make 16 knots with only the stern screws turning, then cavitation may cause the SHP prediction in Plate 5 to be low.

While the possible inception of power absorbing cavitation near 16 knots may not be particularly detrimental when the ice breaker is operating under the conditions of Test 15, nevertheless there will be other operating conditions during which the stern propellers will turn at higher slip ratios. Such an increase in slip ratio could readily make cavitation a vital factor in speed or erosion and require a revision of the design of the stern propellers for optimum operation with the subject ice guards.

All data concerning maneuvering will be covered in Part 2 of this report.

PLATE I

Ice Guard Body Plan

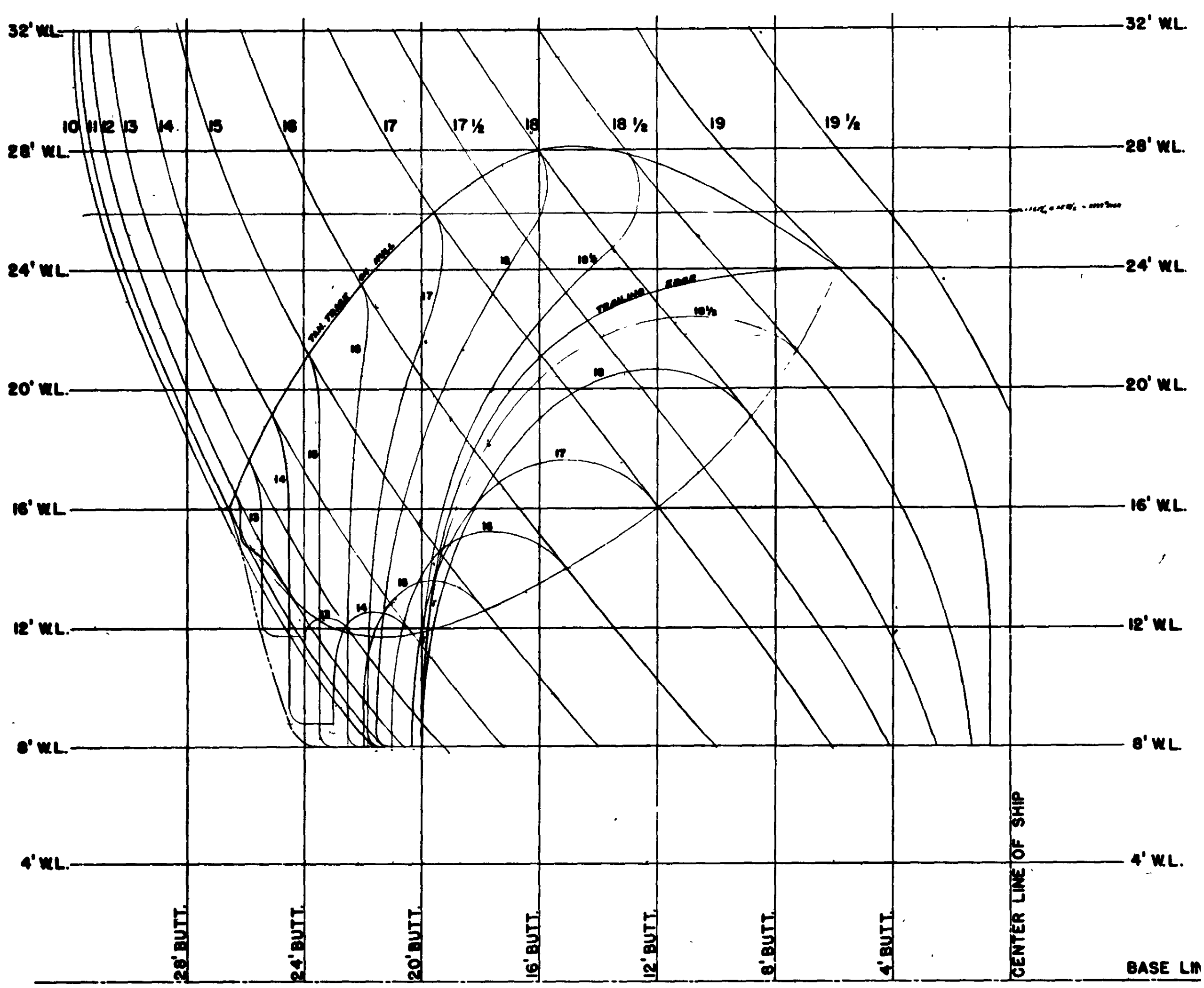
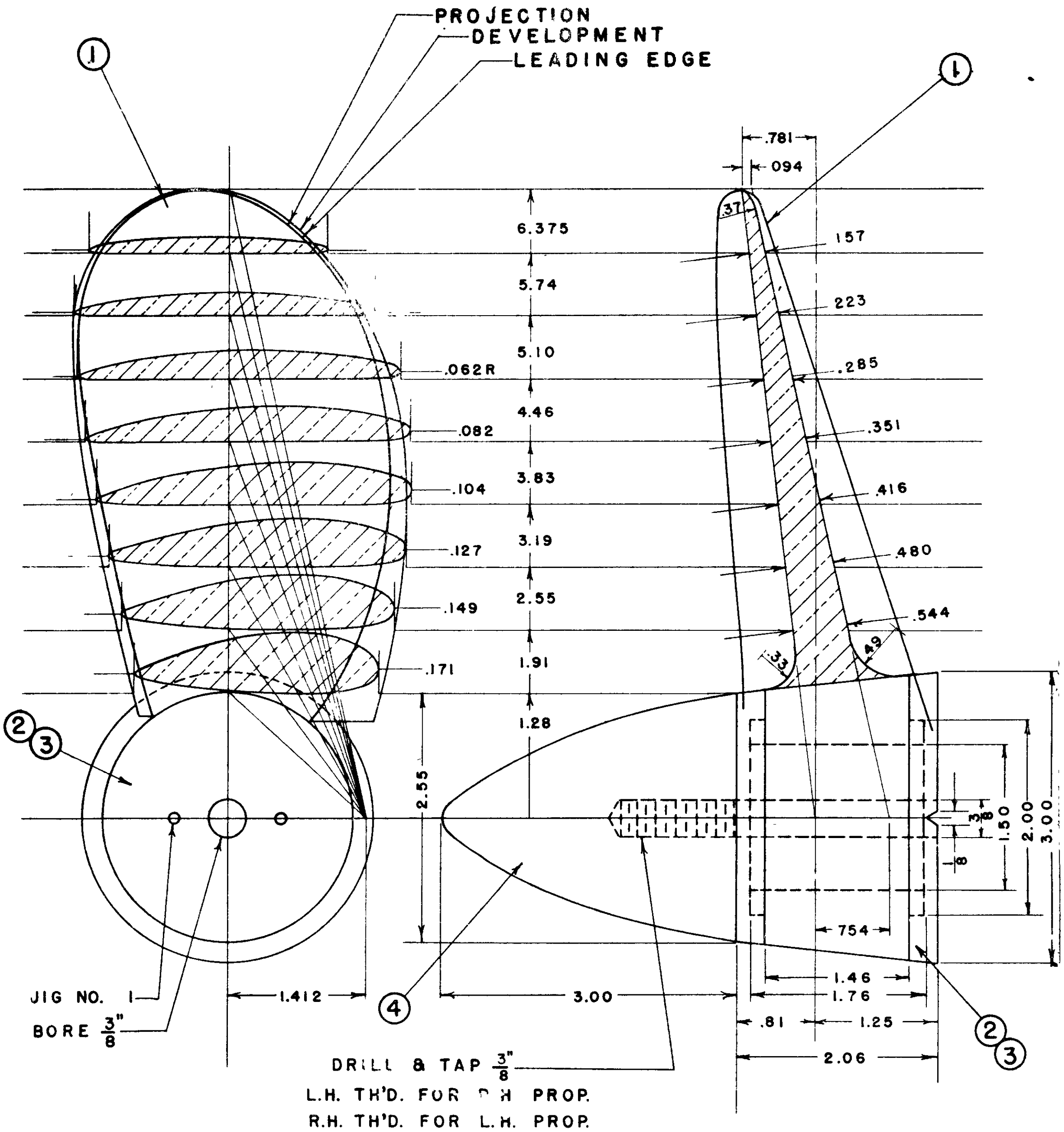


PLATE 2

Drawing of Model Propellers 2260 & 2261



PROP. NO.	DIA. INS.	PITCH INS.	PITCH RATIO	MEAN WIDTH RATIO	NO. OF BLADES	TOTAL PROJ. AREA	P.A. / D.A.	B. T. F.	DIRECTION OF ROTATION
2260	12.75	8.875	.696	.228	3	40.50	.317	.059	R
2261	12.75	8.875	.696	.228	3	40.50	.317	.059	L

PLATE 3

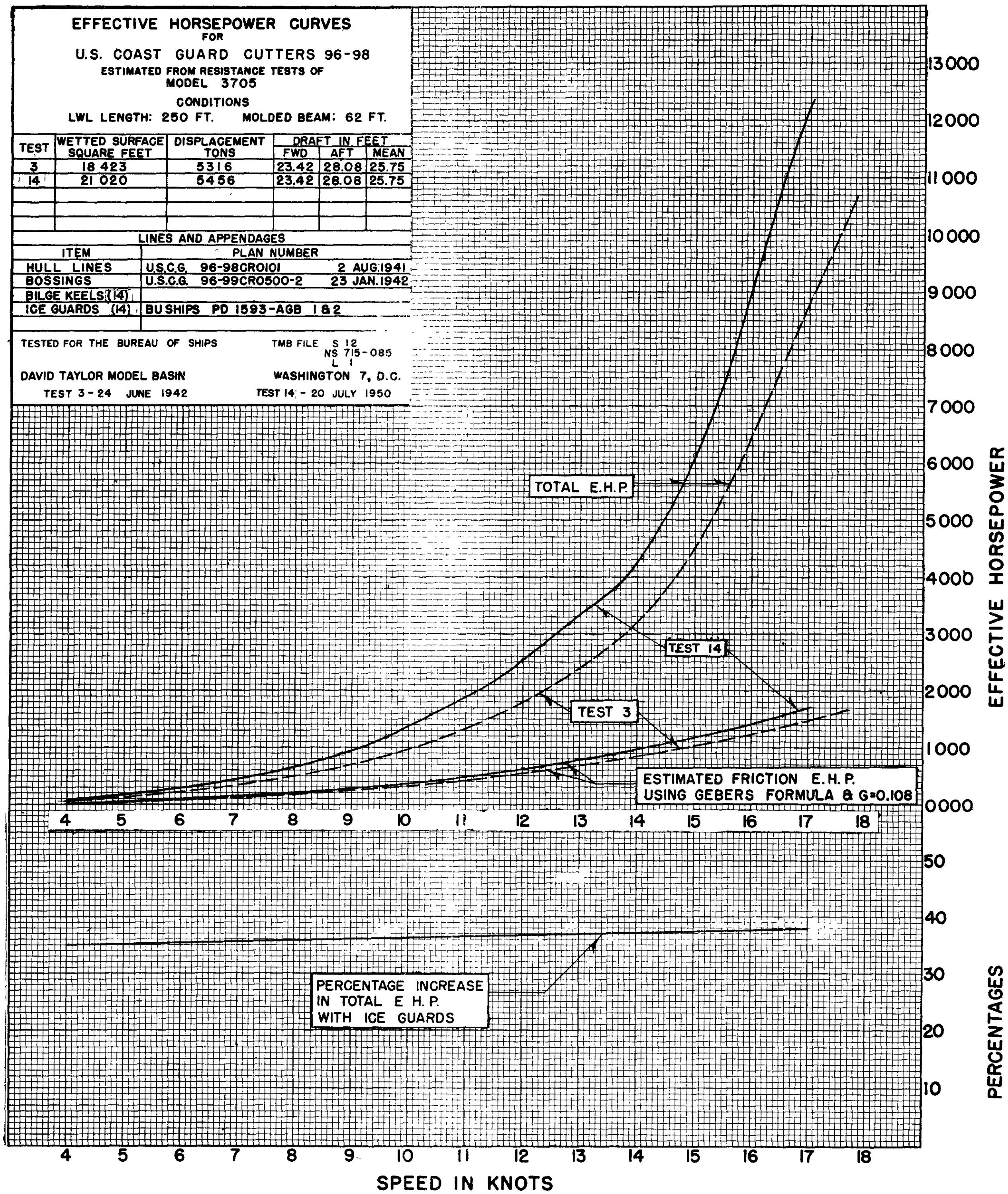

EFFECTIVE HORSEPOWER CURVES
FOR
U.S. COAST GUARD CUTTERS 96-98
ESTIMATED FROM RESISTANCE TESTS OF
MODEL 3705
CONDITIONS
LWL LENGTH: 250 FT. MOLDED BEAM: 62 FT.
TEST | WETTED SURFACE SQUARE FEET | DISPLACEMENT TONS | DRAFT IN FEET FWD | AFT | MEAN
3 | 18 423 | 5316 | 23.42 | 28.08 | 25.75
14 | 21 020 | 5456 | 23.42 | 28.08 | 25.75
LINES AND APPENDAGES
ITEM | PLAN NUMBER
HULL LINES | U.S.C.G. 96-98CR0101 2 AUG.1941
BOSSINGS | U.S.C.G. 96-99CR0500-2 23 JAN.1942
BILGE KEELS (14)
ICE GUARDS (14) | BUSHIPS PD 1593-AGB 1 & 2
TESTED FOR THE BUREAU OF SHIPS
TMB FILE S 12 NS 715-085 L 1
DAVID TAYLOR MODEL BASIN
WASHINGTON 7, D.C.
TEST 3 - 24 JUNE 1942
TEST 14 - 20 JULY 1950
TOTAL E.H.P.
TEST 14
TEST 3
ESTIMATED FRICTION E.H.P.
USING GEBERS FORMULA & G=0.108
PERCENTAGE INCREASE
IN TOTAL E H.P.
WITH ICE GUARDS
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0000
50
40
30
20
10
EFFECTIVE HORSEPOWER
PERCENTAGES
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
SPEED IN KNOTS

PLATE 4

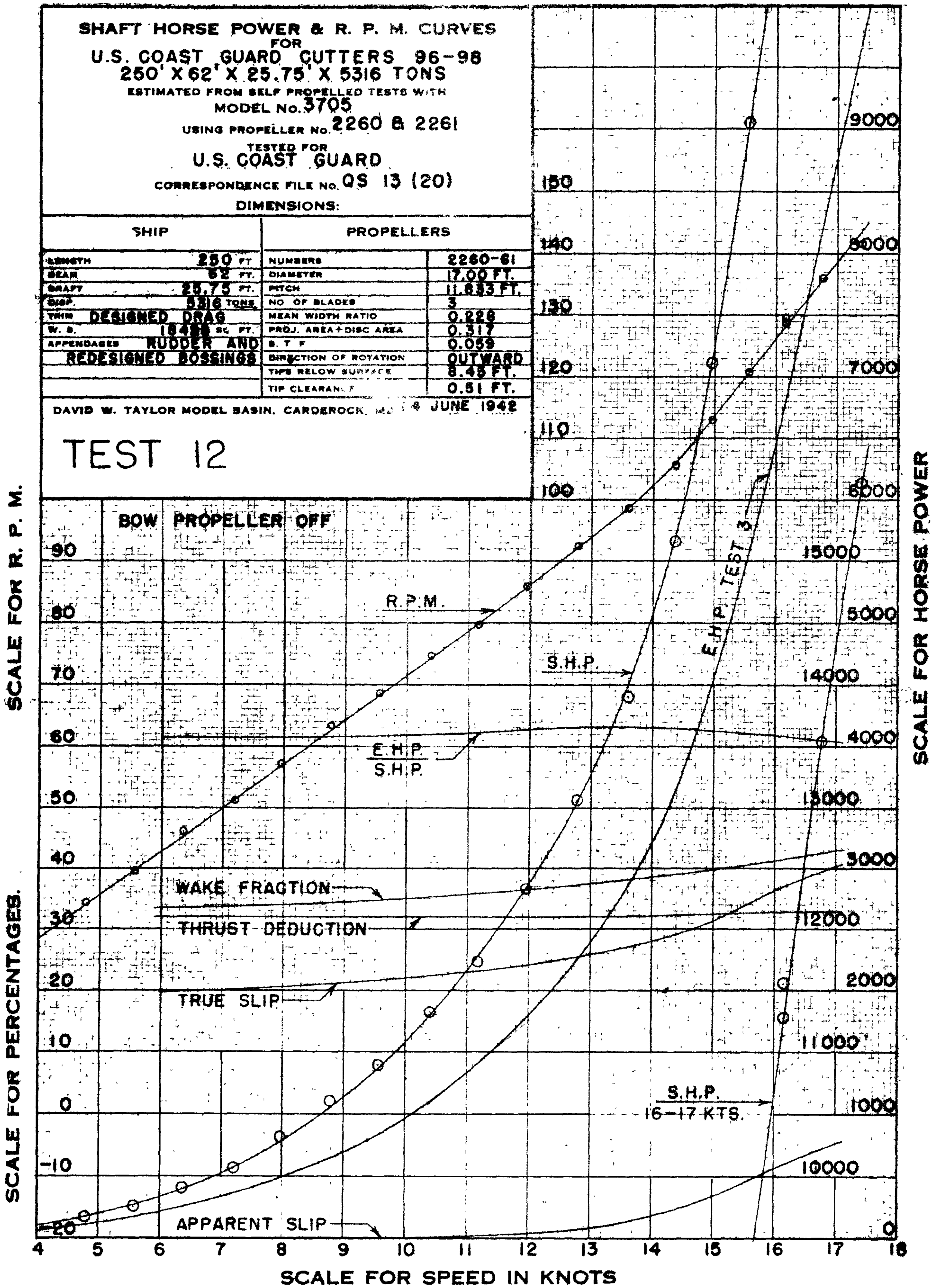

SHAFT HORSE POWER & R. P. M. CURVES
FOR
U.S. COAST GUARD CUTTERS 96-98
250' X 62' X 25.75' X 5316 TONS
ESTIMATED FROM SELF PROPELLED TESTS WITH
MODEL No. 3705
USING PROPELLER No. 2260 & 2261
TESTED FOR
U.S. COAST GUARD
CORRESPONDENCE FILE No. QS 13 (20)
DIMENSIONS:
SHIP
LENGTH 250 FT.
BEAM 62 FT.
DRAFT 25.75 FT.
DISP. 5316 TONS
TRIM DESIGNED DRAG
APPENDAGES RUDDER AND REDESIGNED BOSSINGS
PROPELLERS
NUMBERS 2260-61
DIAMETER 17.00 FT.
PITCH 11.633 FT.
NO. OF BLADES 3
MEAN WIDTH RATIO 0.228
PROJ. AREA ÷ DISC AREA 0.317
B. T. F. 0.059
DIRECTION OF ROTATION OUTWARD
TIP CLEARANCE 0.51 FT.
DAVID W. TAYLOR MODEL BASIN, CARDEROCK
JUNE 1942
TEST 12
BOW PROPELLER OFF
R.P.M.
S.H.P.
E.H.P. TEST 3
E.H.P. / S.H.P.
WAKE FRACTION
THRUST DEDUCTION
TRUE SLIP
S.H.P. 16-17 KTS.
APPARENT SLIP
SCALE FOR R. P. M.
SCALE FOR PERCENTAGES.
SCALE FOR HORSE POWER
SCALE FOR SPEED IN KNOTS

PLATE 5

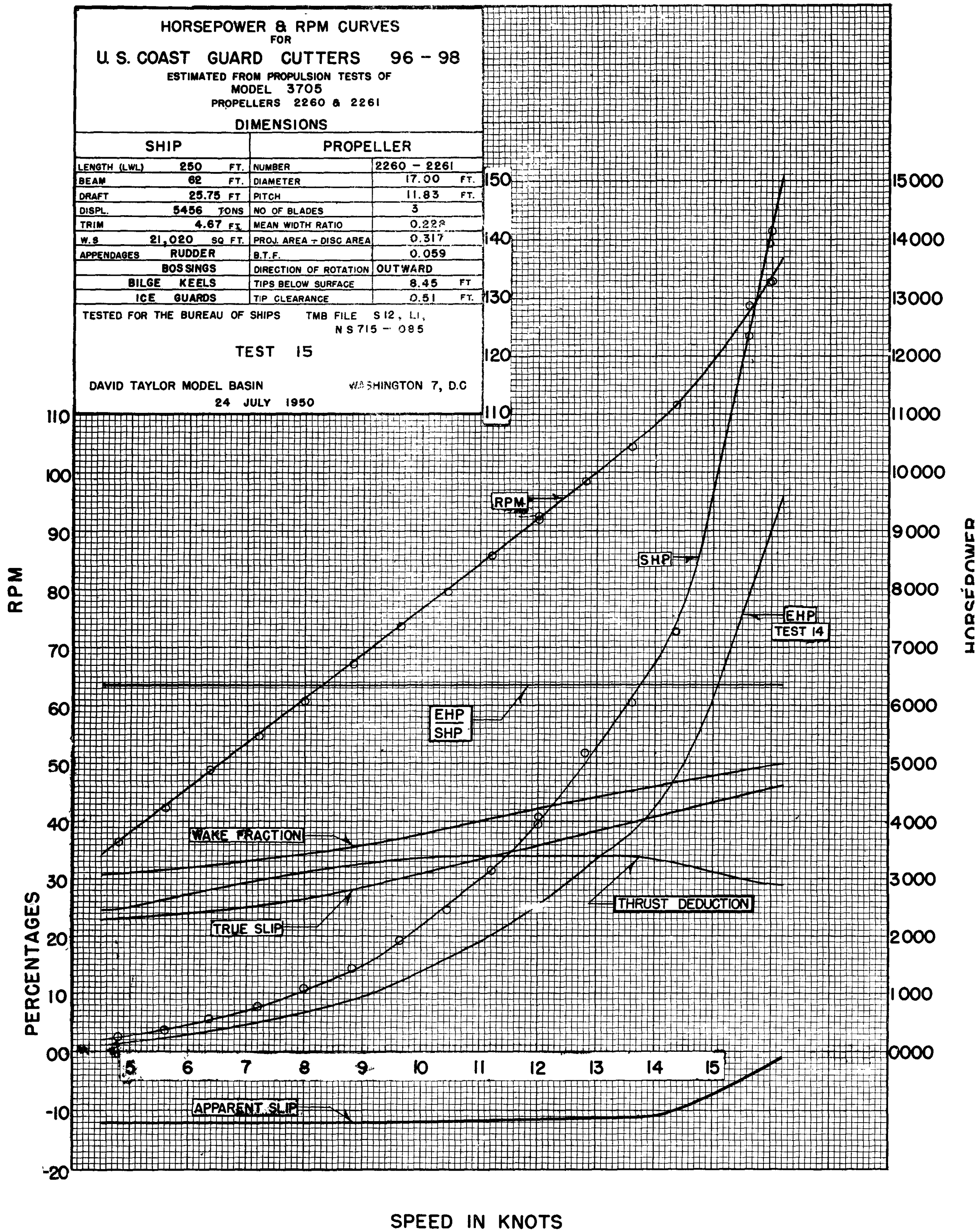
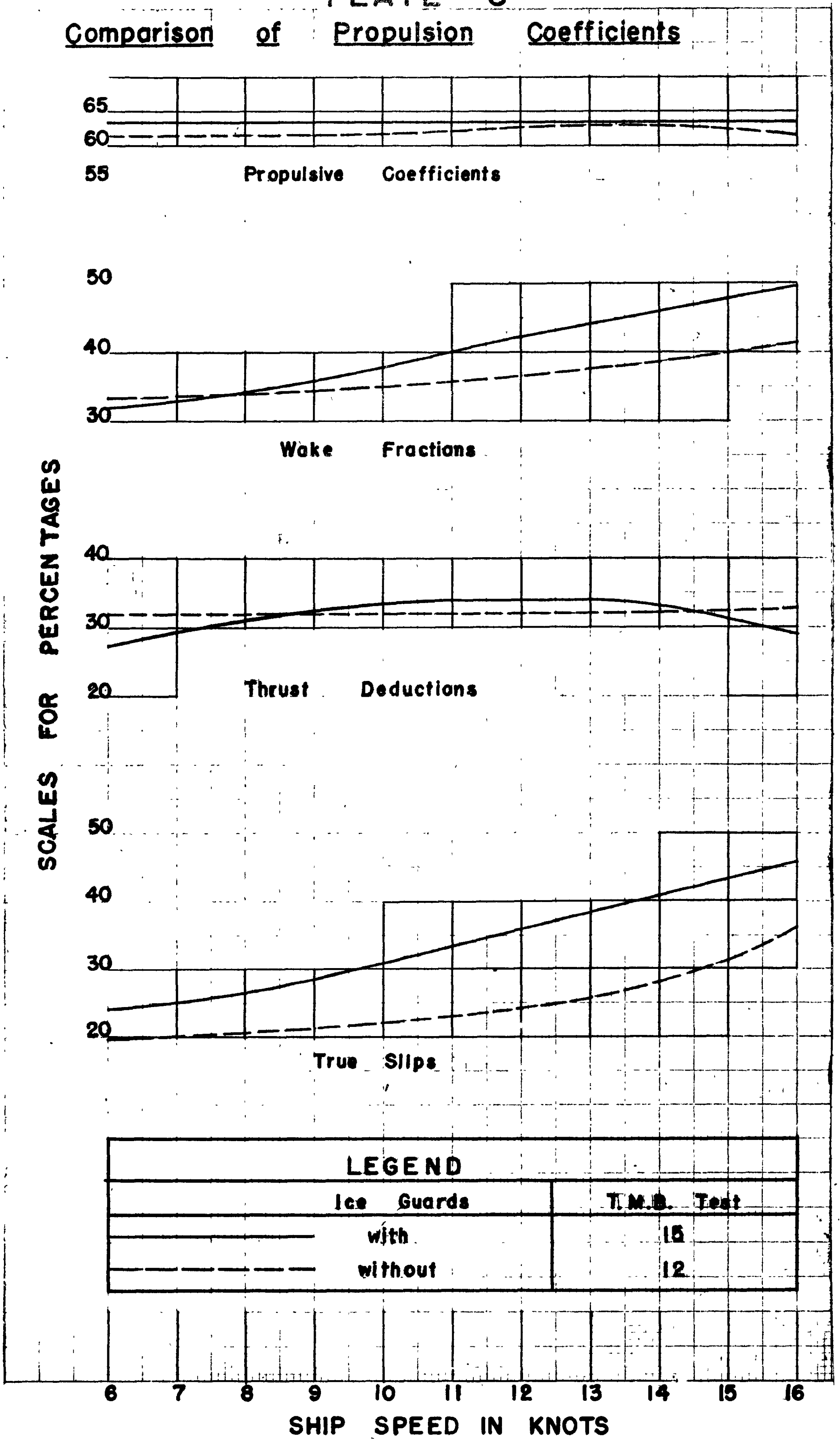

HORSEPOWER & RPM CURVES
FOR
U. S. COAST GUARD CUTTERS 96 - 98
ESTIMATED FROM PROPULSION TESTS OF
MODEL 3705
PROPELLERS 2260 & 2261
DIMENSIONS
SHIP
PROPELLER
LENGTH (LWL) 250 FT.
BEAM 62 FT.
DRAFT 25.75 FT
DISPL. 5456 TONS
TRIM 4.67 FT.
W.S 21,020 SQ FT.
APPENDAGES RUDDER
BOSSINGS
BILGE KEELS
ICE GUARDS
NUMBER 2260 - 2261
DIAMETER 17.00 FT.
PITCH 11.83 FT.
NO OF BLADES 3
MEAN WIDTH RATIO 0.228
PROJ. AREA ÷ DISC AREA 0.317
B.T.F. 0.059
DIRECTION OF ROTATION OUTWARD
TIPS BELOW SURFACE 8.45 FT
TIP CLEARANCE 0.51 FT.
TESTED FOR THE BUREAU OF SHIPS
TMB FILE S12, L.I, NS715 - 085
TEST 15
DAVID TAYLOR MODEL BASIN
WASHINGTON 7, D.C
24 JULY 1950
RPM
PERCENTAGES
HORSEPOWER
SPEED IN KNOTS
RPM
SHP
EHP
TEST 14
EHP
SHP
WAKE FRACTION
TRUE SLIP
THRUST DEDUCTION
APPARENT SLIP
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
00
-10
-20
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0000
5
6
7
8
9
10
11
12
13
14
15

PLATE 6



Comparison of Propulsion Coefficients
65
60
55
Propulsive Coefficients
50
40
30
Wake Fractions
40
30
20
Thrust Deductions
SCALES FOR PERCENTAGES
50
40
30
20
True Slips
LEGEND
Ice Guards
T.M.B. Test
with
15
without
12
6
7
8
9
10
11
12
13
14
15
16
SHIP SPEED IN KNOTS

PLATE 7

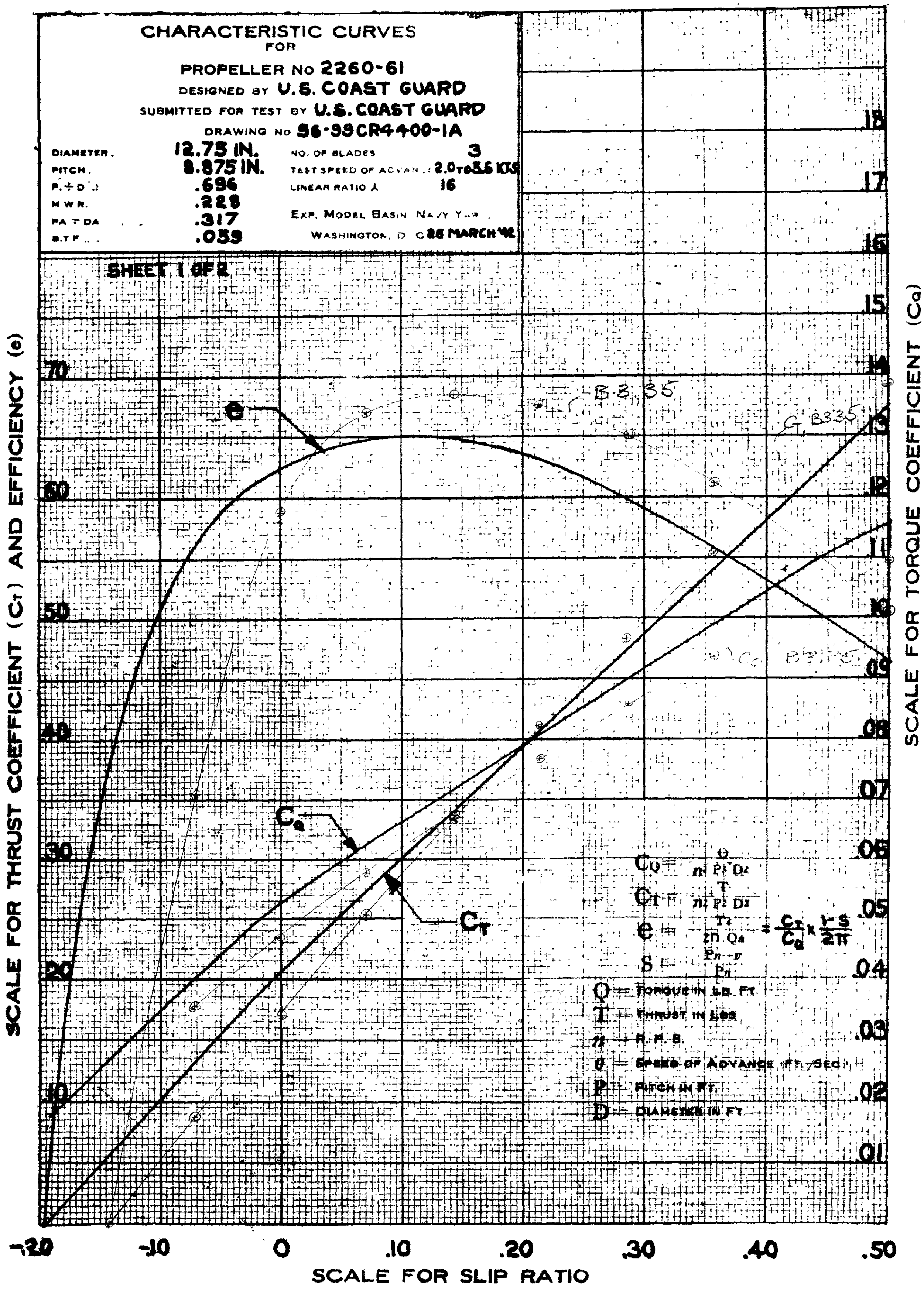

CHARACTERISTIC CURVES
FOR
PROPELLER No 2260-61
DESIGNED BY U.S. COAST GUARD
SUBMITTED FOR TEST BY U.S. COAST GUARD
DRAWING No 36-39CR4400-1A
DIAMETER 12.75 IN.
PITCH 8.875 IN.
P. ÷ D .696
M.W.R. .228
PA ÷ DA .317
B.T.F. .059
NO. OF BLADES 3
TEST SPEED OF ADVANCE 2.0 TO 3.6 KTS
LINEAR RATIO λ 16
EXP. MODEL BASIN NAVY YARD
WASHINGTON, D.C. 28 MARCH '42
SHEET 1 OF 2
e
B335
C_Q
C_T
$C_Q = \frac{Q}{n^2 P^2 D^3}$
$C_T = \frac{T}{n^2 P^2 D^2}$
$e = \frac{Tv}{2\pi n Q_n} = \frac{C_T}{C_Q} \times \frac{1-S}{2\pi}$
$S = \frac{P_n - v}{P_n}$
Q = TORQUE IN LB. FT.
T = THRUST IN LBS
n = R.P.S.
v = SPEED OF ADVANCE FT./SEC
P = PITCH IN FT.
D = DIAMETER IN FT.
SCALE FOR THRUST COEFFICIENT (C_T) AND EFFICIENCY (e)
SCALE FOR TORQUE COEFFICIENT (C_Q)
SCALE FOR SLIP RATIO
-.20 -.10 0 .10 .20 .30 .40 .50
10 20 30 40 50 60 70
.01 .02 .03 .04 .05 .06 .07 .08 .09 .10 .11 .12 .13 .14 .15 .16 .17 .18

PLATE 8

Stern of Model 3705 with Ice Guards

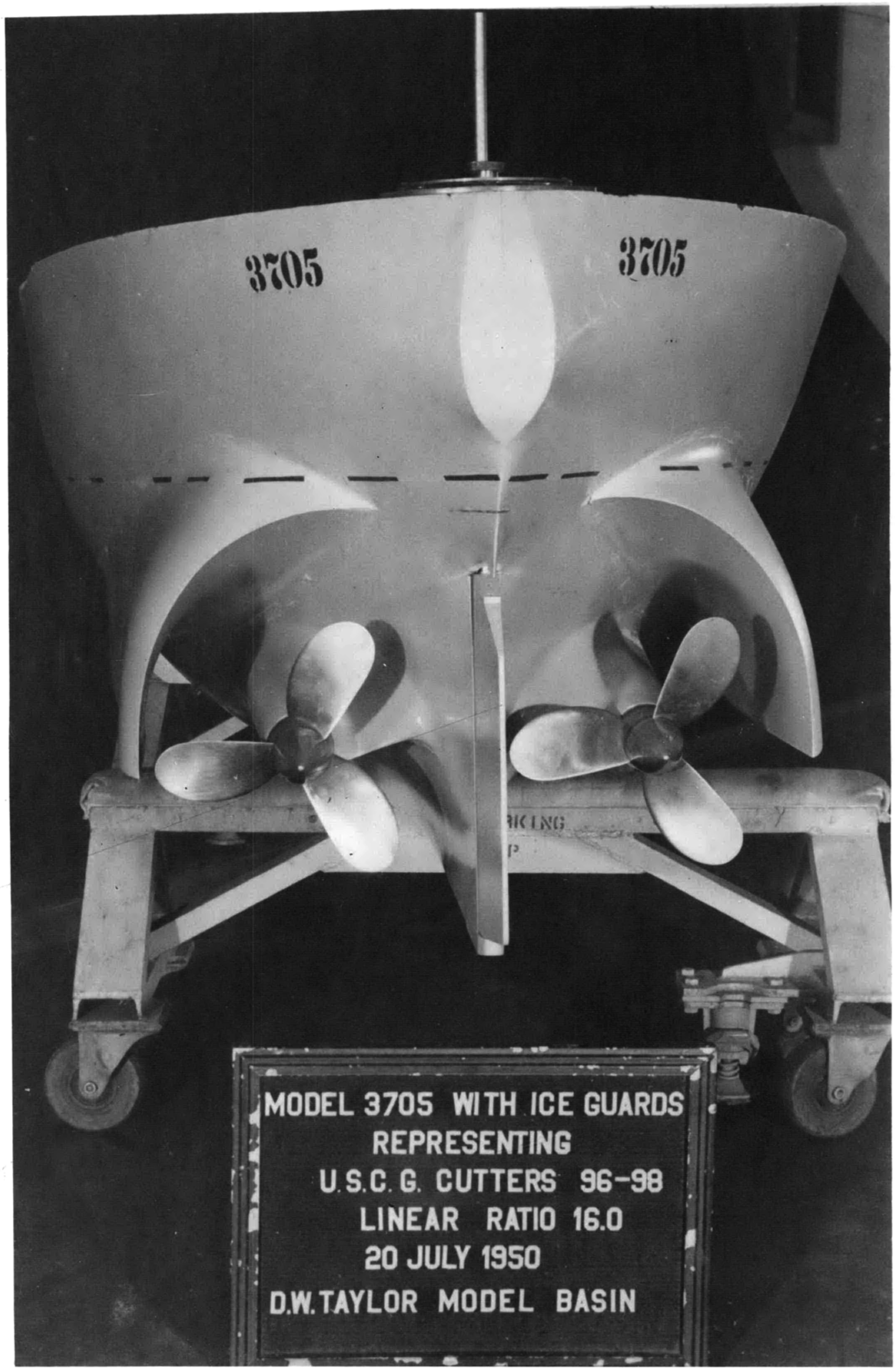


PLATE 9

Side of Model 3705 with Ice Guards

PLATE 10

Wave Profile of Model 3705

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