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# DAVID TAYLOR MODEL BASIN

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## RESISTANCE AND FLOW DATA FOR A WHALEBACK STEAMER HULL FORM, MODEL 4760

by

A.H. Weaver, Jr.



HYDROMECHANICS LABORATORY

RESEARCH AND DEVELOPMENT REPORT

September 1960 Report 1449

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S-R009 01 01

## ABSTRACT

Tests were made on Model 4760 to determine the merits of a semi-submerged type hull form. Model 4760 represented the whaleback steamer FRANK ROCKEFELLER, built in 1896. Curves are given for resistance and ehp, and photographs show the wave profiles and flow about the hull.

## INTRODUCTION

As a part of the Fundamental Hydromechanics Research Program, NS 715-102 (now S-R009 01 01), a project was undertaken to investigate the merits of a semisubmerged type hull form.[1] The lines of a whaleback steamer, FRANK ROCKEFELLER, were chosen and with permission of the American Shipbuilding Company, Model 4760 (approximately 11.5 feet in length) was constructed according to their plan for Steamer No. 136, dated 9 November 1901. The scale for ship to model is 32.

This type of vessel, designed by Captain Alexander McDougall, was first put into service on the Great Lakes in 1888 and amazed the world in its great capabilities.[2] The CHRISTOPHER COLUMBUS operated as an excursion steamer between Chicago and Milwaukee from the year 1893 until recently and had a passenger capacity of 5000 people. The JOHN ERICSSON, a bulk freighter and the largest of the "whale backs," operated from 1896 until 1959. The FRANK ROCKEFELLER, now a tanker and renamed the METEOR, was put into service in 1896 and is still operating. Two barges, Barge 137 and the ALEXANDER HOLLEY, having the same features as the whaleback steamers with the exception of power plants, propellers, and aperture, are still in service. These ships generally operated at speeds of 10.5 to 11 miles per hour.

## DISCUSSION

The design draft for this vessel is assumed to be 18 feet, even keel. The displacement at this draft is 6880 tons. Other pertinent data for the ship and model are given in Figure 1.

## RESISTANCE

Bare hull resistance tests were conducted with Model 4760 at conditions corresponding to the design displacement and draft and for a heavy condition at a displacement of 7720 tons at a draft of 20 feet, even keel. For the first test at the design condition a trip wire was installed at 1/20 of the model length $L_{BP}$ to induce turbulent flow about the hull. Test 3, also at the design condition, and Test 4 at the heavy condition were conducted without turbulence stimulation. The model was in the bare hull condition and had no deck superstructure except

[1]References are listed on page 3.

for a fairing around the model towing bracket. The speed range was gradually increased until water over the deck hit the fairing around the towing bracket. The resultant curves of ehp predictions for these tests are presented in Figure 3. The Taylor ratio curve in Figure 2 indicates that the humps in the 0.68 and 0.80 speed-length-ratio range are large when compared to wave resistance of the Taylor form. Conversely, there is an appreciable reduction in the normally large unity hump.

A comparison of the sectional area curves (Figure 1) indicates a rather hard fore shoulder for Model 4760. This accounts, in part, for the change in the shape of the wave pattern. (See Figures 4, 5, 6.)

A comparison of the bow section and midship section with those of a comparable Taylor model indicates nothing more than what would be expected. The bow sections for Model 4760 (Figure 1) are intentionally elliptical rather than the more conventional shape of the Taylor model.[3] A fair average value for midship coefficient of the Taylor models is 0.923; the midship coefficient for Model 4760 is 0.981.

## FLOW STUDIES

An examination of the flow patterns in the vicinity of the hull was made with Model 4760 in the circulating-water channel. This test was conducted at the design condition. The model was fitted with dummy deck superstructure, the fairing around the towing bracket, and a "breakwater" forward of the fairing. Black tufts were secured to the skin of the hull and red tufts were secured to the end of the pins and extended from the hull a distance of 3 feet, ship scale. Blue dye, emitted through small orifices at the skin of the hull, was used as an additional aid to denote the flow patterns.

Still photographs were taken of the underwater portion of the hull at various simulated speeds. Figures 7 and 8 are reproductions of the photographs taken during this test. Figure 9 presents photographs of the model fitted for the flow tests.

## COMMENTS

The flow about this hull is considered very good within the speed range in which it was designed to operate. The flow around the bow is smooth, uninterrupted, and almost radial from the centerline. Flow studies indicate a "dead water area" just forward of where the propeller aperture would normally be, from about the 12-foot waterline to the water surface. At speeds above 18 knots the bow wave becomes quite large, as would be expected; however, at these speeds the flow about the stern improves.

Present plans are to make modifications of this design and conduct additional tests to determine the merits of these alterations. Additional data will be published in supplementary reports.

## REFERENCES

1. Memorandum from Bureau of Ships, Code 106, to David Taylor Model Basin, Code 500, dated 6 Jul 1959.

2. Emberg, R.A., "Alexander McDougall, Man with a Mission," Ships and Sailing (Jan 1952).

3. Taylor, D.W., "The Speed and Power of Ships," Third Edition, page 182 (1943).

American Shipbuilding Company Steamer No. 136, Model 4760
Appendages: None

| Dimensions | | | LWL Coefficients | | | |
|---|---|---|---|---|---|---|
| | Ship | Model | $C_B$ | 0.807 | $C_{WF}$ | 0.90 |
| Length (LWL), ft | 368 | 11.50 | $C_P$ | 0.823 | $C_{WA}$ | 0.89 |
| Length (LBP), ft | 380 | 11.88 | $C_X$ | 0.981 | $L_E/L$ | 0.32 |
| Beam ($B_X$), ft | 45 | 1.41 | $C_W$ | 0.90 | $L_X/L$ | 0.38 |
| Draft (H), ft | 18 | 0.56 | $C_{PF}$ | 0.83 | $L_R/L$ | 0.30 |
| Displacement, tons | 6880 SW | 0.204 FW | $C_{PA}$ | 0.81 | L/B | 8.18 |
| Wetted Surf., sq ft | 25,300 | 24.71 | $C_{PE}$ | 0.74 | $B_X/H$ | 2.50 |
| Design V, knots | 9.5 | 1.68 | $C_{PR}$ | 0.69 | $\Delta/(0.01L)^3$ | 138.0 |
| $LCB_{LWL}$ = 0.49 Aft of F.P. | | | $C_{PV}$ | 0.90 | $S/\sqrt{\Delta L}$ | 15.9 |
| $LCB_{LBP}$ = Aft of F.P. | | | $C_{PVA}$ | 0.89 | f | 0 |
| W.L. Entrance Half Angle = 65 deg | | | $C_{PVF}$ | 0.91 | t | 0.44 |
| $\lambda$ = 32.0 $V/\sqrt{L_{LWL}}$ = 0.495 | | | LBP Coefficients | | | |
| (K) = 1.27 (P) = 0.41 | | | $C_B$ | 0.782 | L/B | 8.44 |
| Lines: Lines and Body Plan for FRANK ROCKEFELLER Steamer No. 136 Dated 9 Nov 1901 | | | $C_P$ | 0.797 | $\Delta/(0.01L)^3$ | 125.3 |

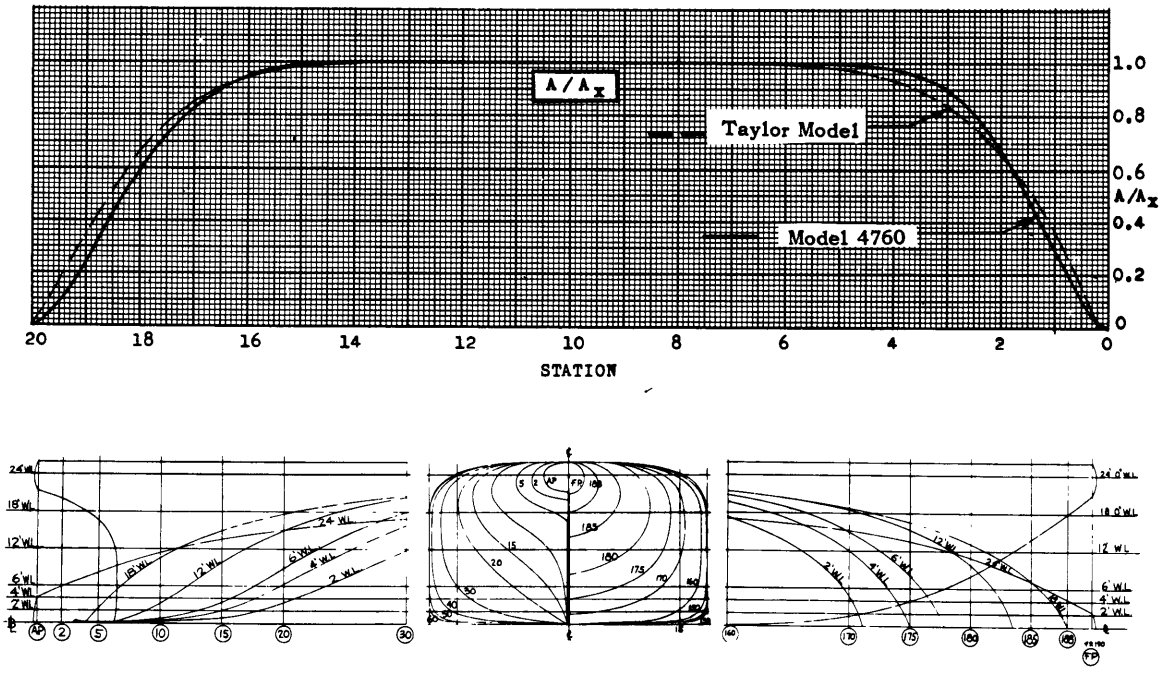



Figure 1 – Ship and Model Data for Whaleback Steamer

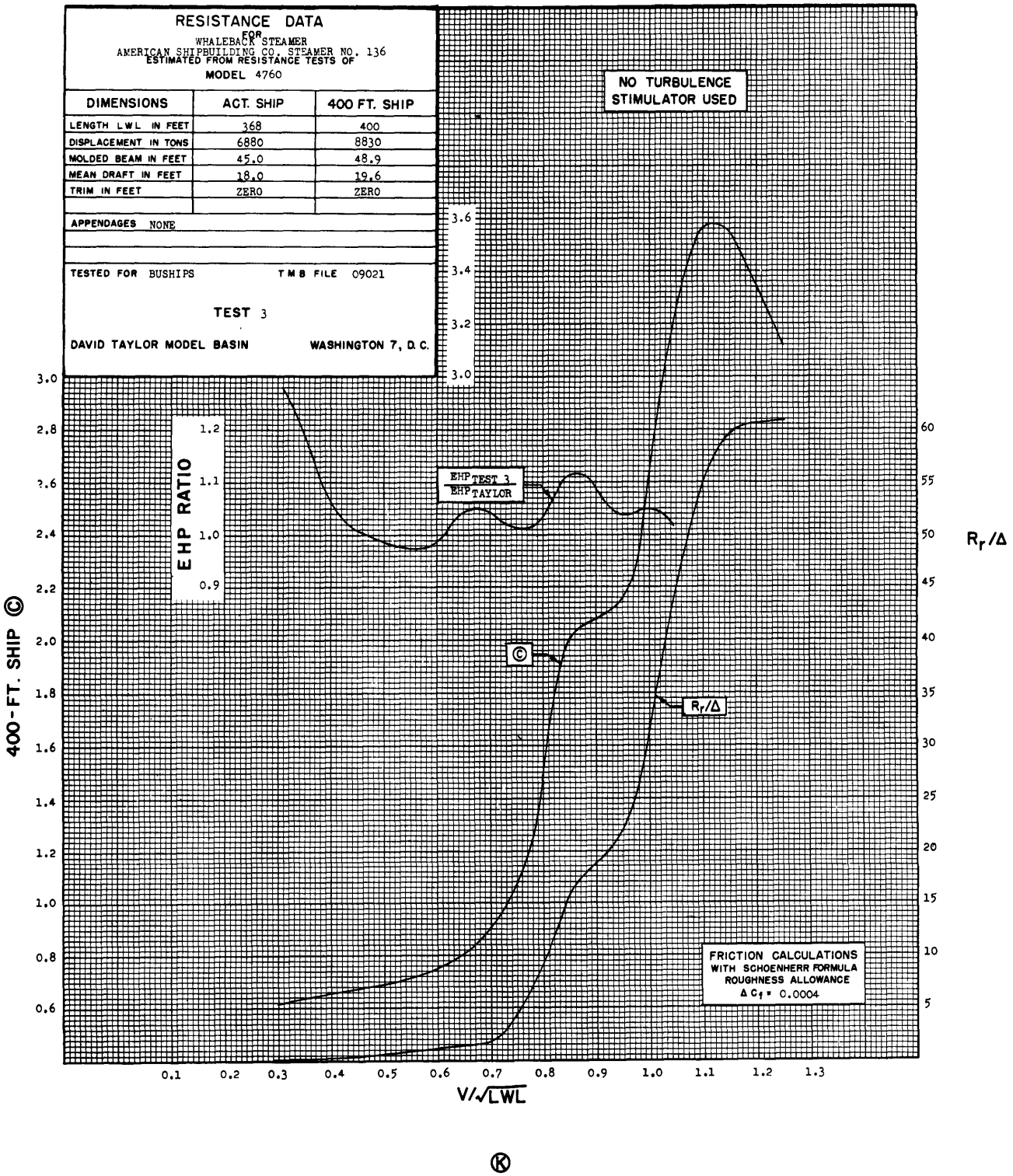

RESISTANCE DATA
FOR
WHALEBACK STEAMER
AMERICAN SHIPBUILDING CO. STEAMER NO. 136
ESTIMATED FROM RESISTANCE TESTS OF
MODEL 4760
DIMENSIONS | ACT. SHIP | 400 FT. SHIP
LENGTH LWL IN FEET | 368 | 400
DISPLACEMENT IN TONS | 6880 | 8830
MOLDED BEAM IN FEET | 45.0 | 48.9
MEAN DRAFT IN FEET | 18.0 | 19.6
TRIM IN FEET | ZERO | ZERO
APPENDAGES NONE
TESTED FOR BUSHIPS
T M B FILE 09021
TEST 3
DAVID TAYLOR MODEL BASIN
WASHINGTON 7, D. C.
NO TURBULENCE STIMULATOR USED
EHP RATIO
EHP TEST 3 / EHP TAYLOR
400-FT. SHIP ©
R_r/Δ
V/√LWL
FRICTION CALCULATIONS
WITH SCHOENHERR FORMULA
ROUGHNESS ALLOWANCE
Δ C_f = 0.0004

Figure 2

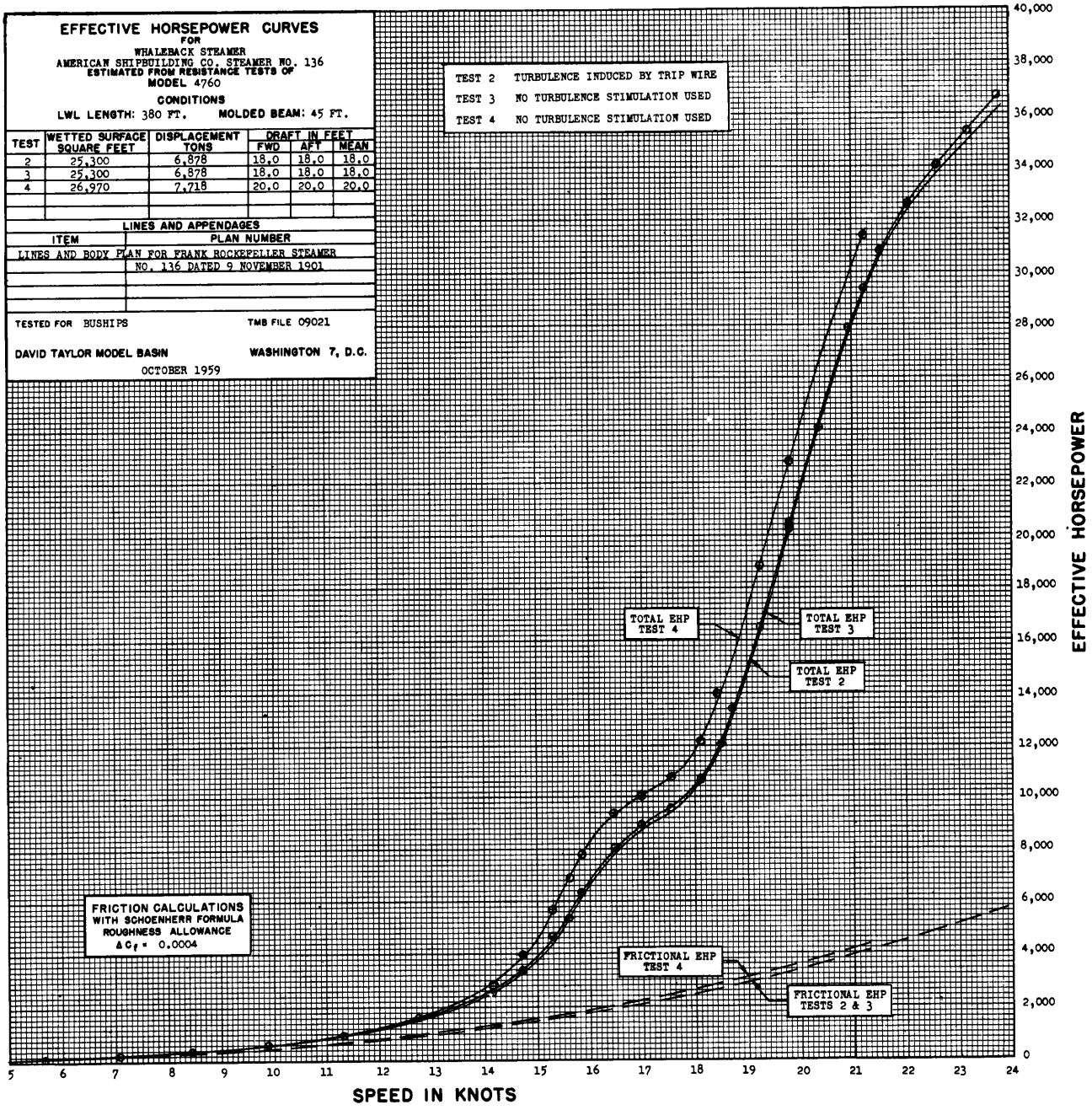

EFFECTIVE HORSEPOWER CURVES
FOR
WHALEBACK STEAMER
AMERICAN SHIPBUILDING CO. STEAMER NO. 136
ESTIMATED FROM RESISTANCE TESTS OF
MODEL 4760
CONDITIONS
LWL LENGTH: 380 FT. MOLDED BEAM: 45 FT.
TEST 2 TURBULENCE INDUCED BY TRIP WIRE
TEST 3 NO TURBULENCE STIMULATION USED
TEST 4 NO TURBULENCE STIMULATION USED
TEST | WETTED SURFACE SQUARE FEET | DISPLACEMENT TONS | DRAFT IN FEET FWD | AFT | MEAN
2 | 25,300 | 6,878 | 18.0 | 18.0 | 18.0
3 | 25,300 | 6,878 | 18.0 | 18.0 | 18.0
4 | 26,970 | 7,718 | 20.0 | 20.0 | 20.0
LINES AND APPENDAGES
ITEM | PLAN NUMBER
LINES AND BODY PLAN FOR FRANK ROCKEFELLER STEAMER | NO. 136 DATED 9 NOVEMBER 1901
TESTED FOR BUSHIPS
TMB FILE 09021
DAVID TAYLOR MODEL BASIN
WASHINGTON 7, D.C.
OCTOBER 1959
FRICTION CALCULATIONS
WITH SCHOENHERR FORMULA
ROUGHNESS ALLOWANCE
ΔCf = 0.0004
TOTAL EHP TEST 4
TOTAL EHP TEST 3
TOTAL EHP TEST 2
FRICTIONAL EHP TEST 4
FRICTIONAL EHP TESTS 2 & 3
EFFECTIVE HORSEPOWER
40,000
38,000
36,000
34,000
32,000
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
SPEED IN KNOTS

Figure 3

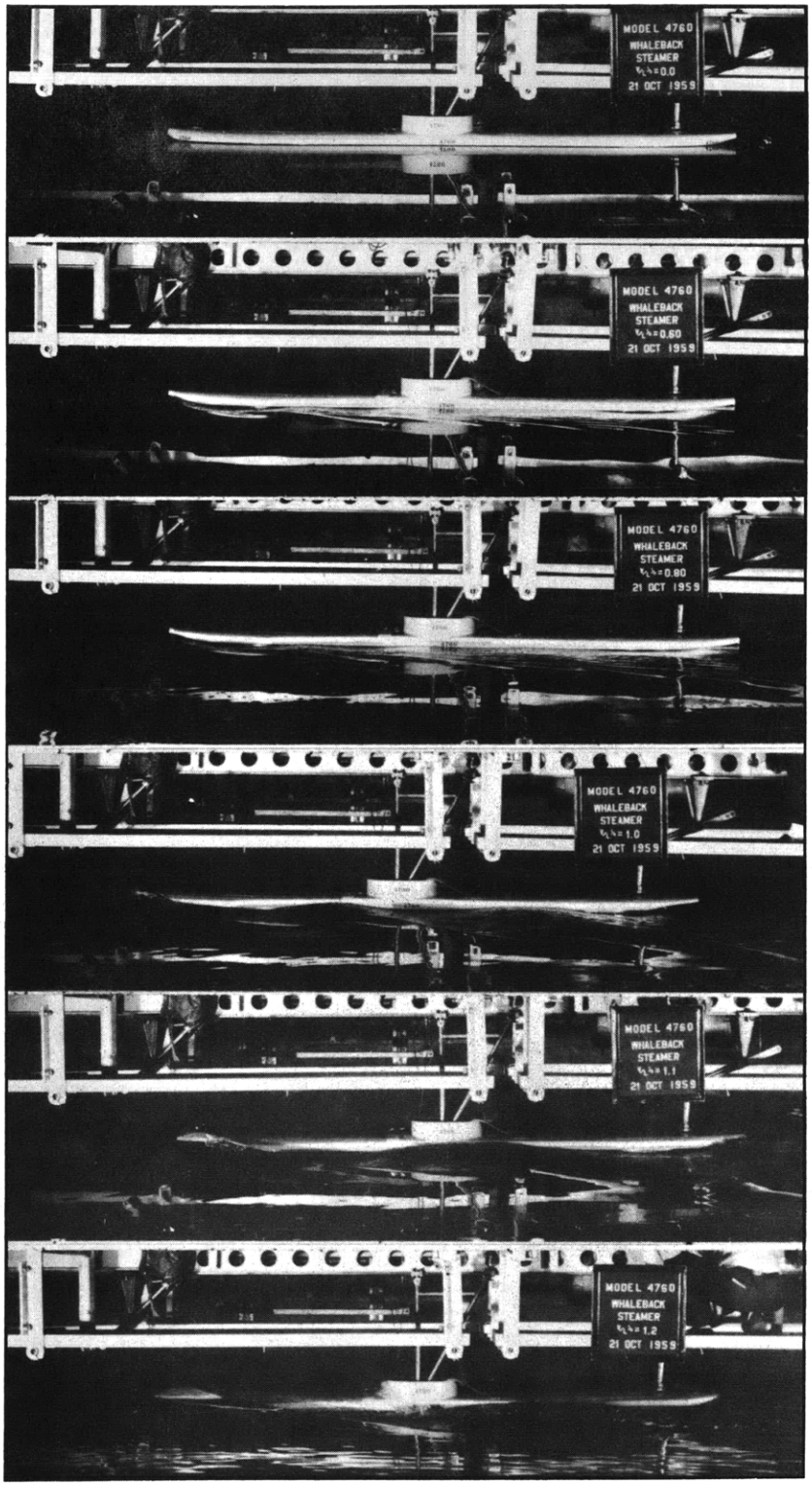
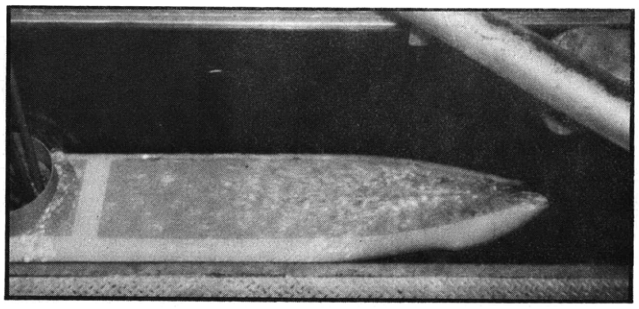
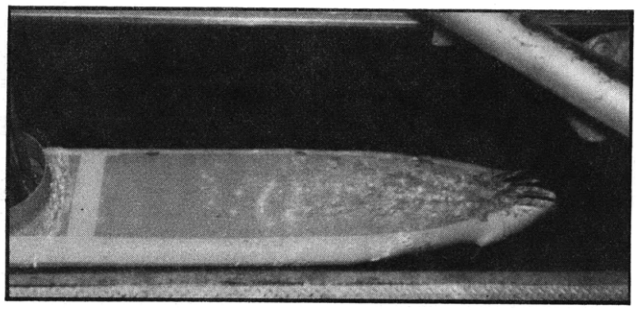



Figure 4 – Wave Profile Photographs of Model 4760



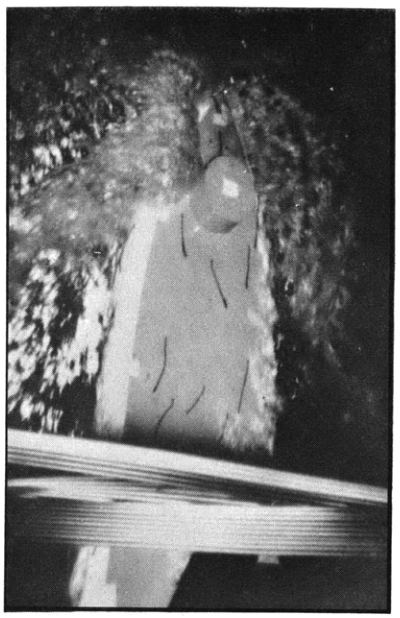
19 knots



21 knots

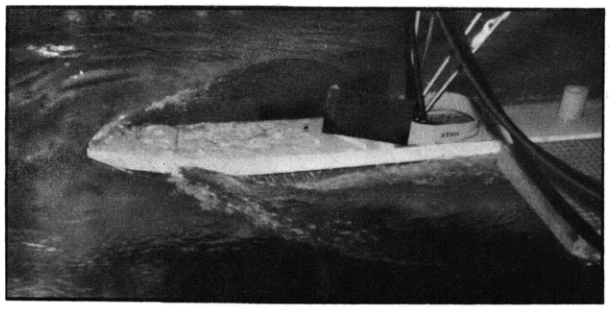
Top of Model 4760 Viewed from the Carriage

30 knots

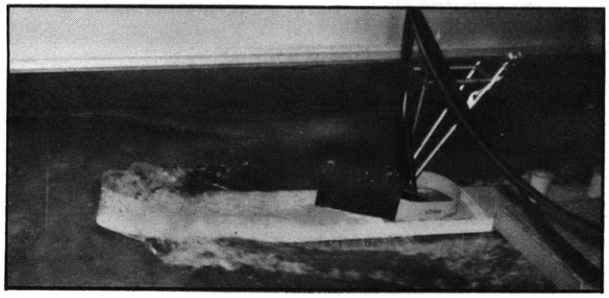


34 knots

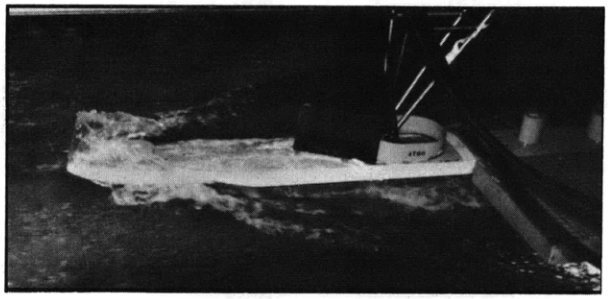
Figure 5 – Top of Model 4760 Viewed in Circulating-Water Channel



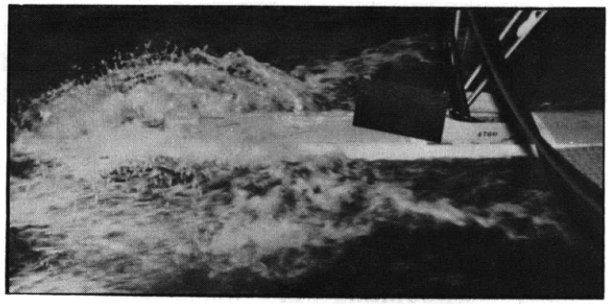
18 knots



22 knots



26 knots



34 knots

Figure 6 – Top of Model 4760 Viewed in Circulating-Water Channel

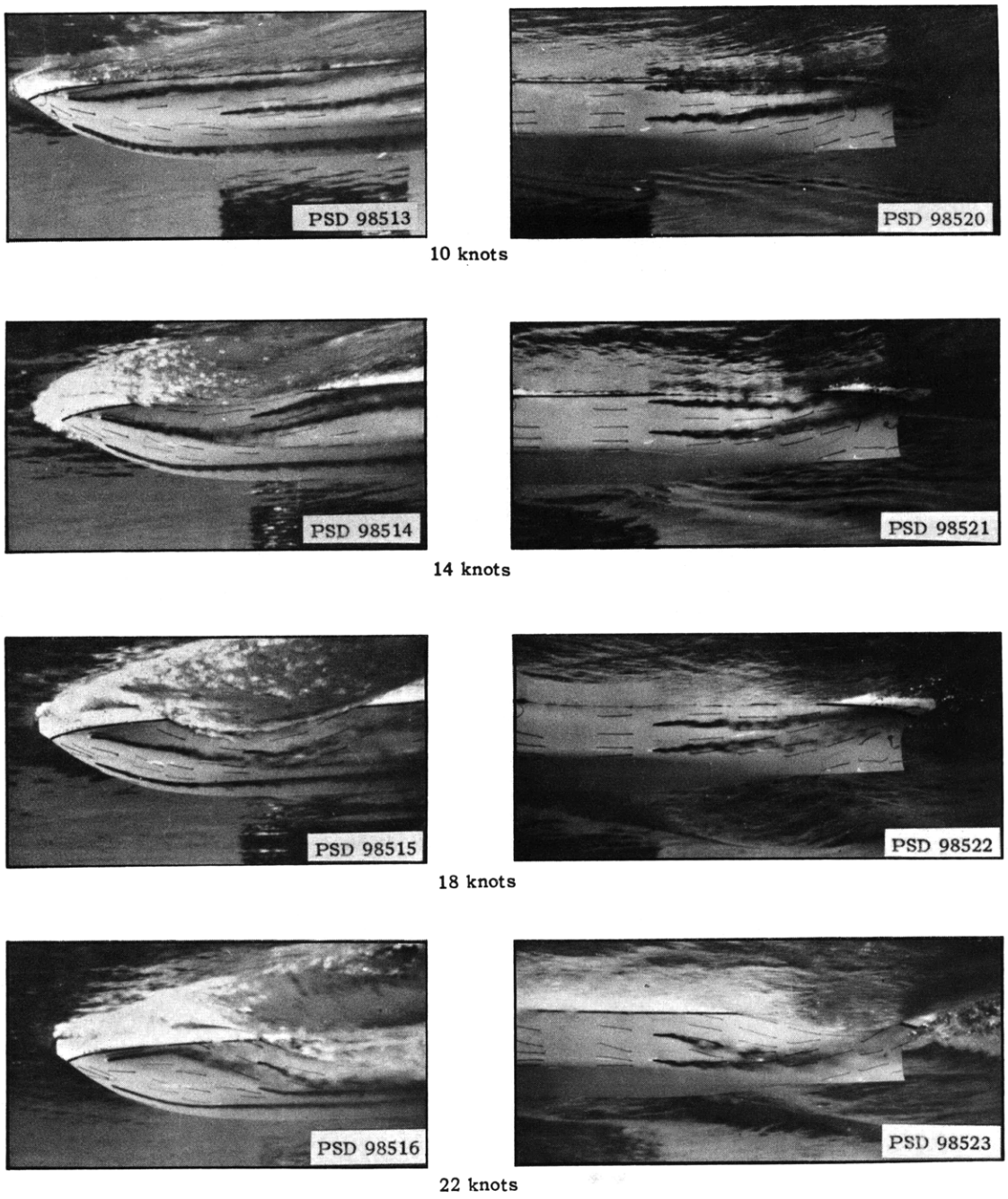
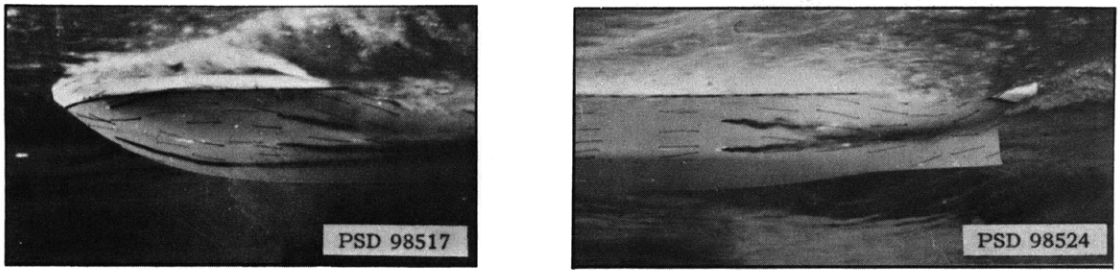
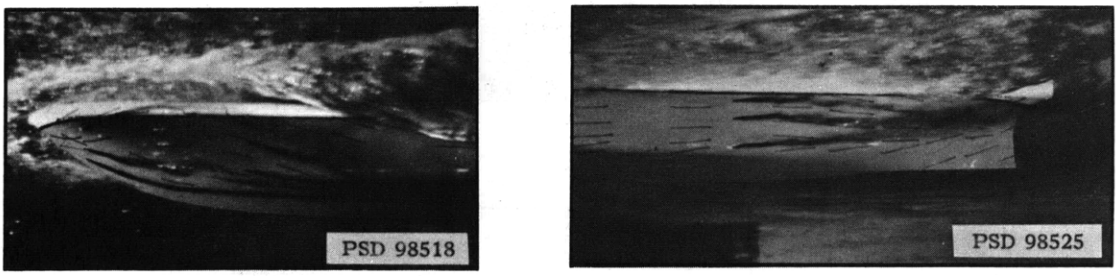


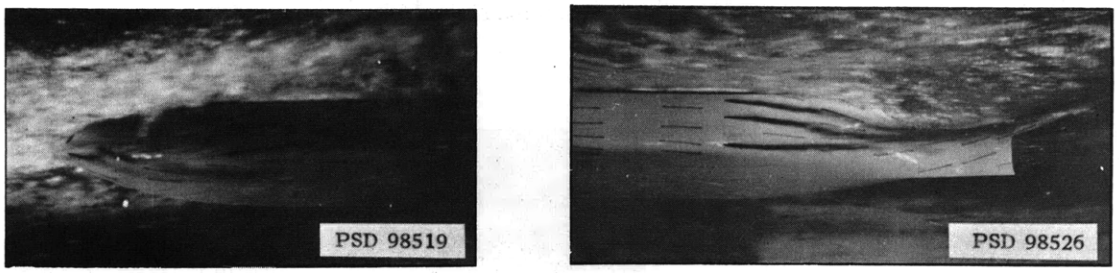

Figure 7 – Circulating-Water Channel Photographs




26 knots




30 knots




34 knots

Figure 8 – Circulating-Water Channel Photographs

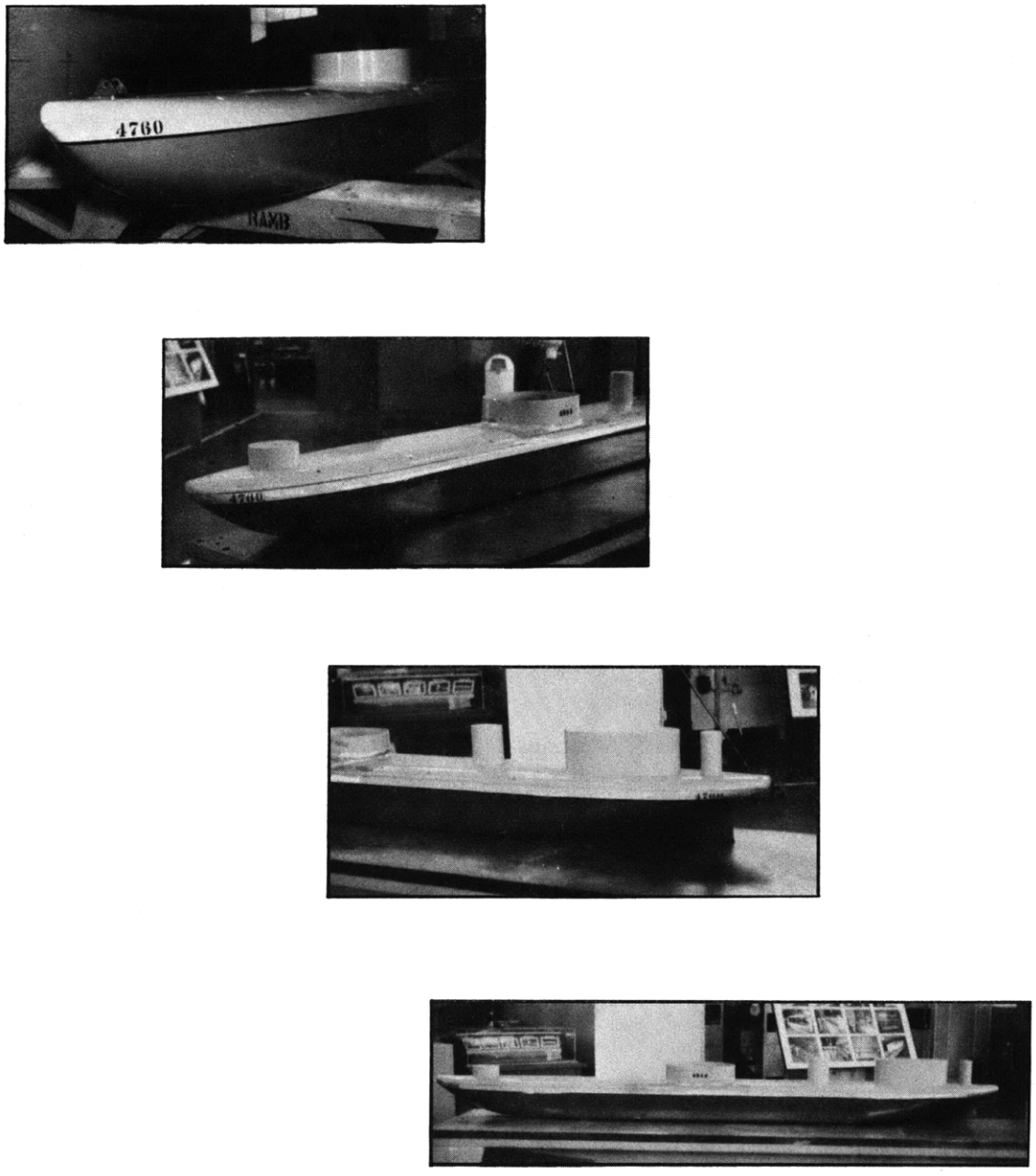



Figure 9 – Fitting-Room Photographs of Model 4760

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