

Resistance Tests of a Systematic Series of Planing Hull Forms

By Eugene P. Clement,¹ Associate Member and Donald L. Blount,² Associate Member

This paper presents the results of resistance tests of five planing boat models of different length-beam ratio. Each model was tested at a number of loads and LCG locations. The results are presented as curves of angle of attack and resistance-weight ratio versus Froude number. The resistance data have been corrected to boat weights of 10,000 and 100,000 lb. The measured values of wetted lengths, wetted surface, and rise of CG are also presented in tabular form. The conditions at which the models porpoised at high speed were determined and a graph defining the stable and unstable regions is included. A method was ascertained of collapsing the high-speed resistance data from the tests of the series into a single graph. A simplified prediction method was then developed which can be used to determine the high-speed resistance of planing hulls of a wide range of proportions, and of any gross weight from 1000 to 100,000 lb.

THE testing of a systematic series of ship or boat hull forms serves a number of useful purposes. The results show the effects on performance of changes in the design variables tested and also indicate optimum or desirable values for those variables. The data obtained can be used to predict the performance of projected new designs. Finally, the performance of the series can be used as a yardstick to gage the efficiency of new designs for which model tests have been made.

Several systematic series of hull forms for ships and boats of the displacement type have been tested, but only one series of hull forms for planing boats has been tested previously. This planing boat series was designated EMB Series 50; the test results were reported in Reference [1].³ Series 50 was designed at the United States Experimental Model Basin (the predecessor of the David Taylor Model Basin) and the tests were run on 40-in. models at the Experimental Towing Tank of Stevens Institute of Technology. Al-

though the results have been of some interest and use, they do have a number of drawbacks. The chief shortcoming is that the boundary flow of the models during the tests was evidently not fully turbulent. This is indicated by the fact that for some of the data points in the planing range the values of the total resistance coefficient are less than the values of frictional resistance coefficient for fully turbulent flow; i.e., the indicated result is that the wave-making resistance is negative. Another drawback of Series 50 concerns the parameters treated in the series. They have been found suitable for analysis and design of displacement ships, but they are not well suited for the analysis and design of planing craft. Finally, time has brought improvements in the design of planing hulls and, accordingly, the hull form of Series 50 has become somewhat old fashioned.

To fill an evident need a more up-to-date hull form has been developed at the David Taylor Model Basin to be the parent form for a systematic series of planing boat models. Five models of different length-beam ratio have been built and each has been tested for resistance at a number of loads and longitudinal center-of-gravity locations. The results of the tests of this series, designated TMB Series 62, are presented in this paper.

¹Supervisory Naval Architect, David Taylor Model Basin, Navy Department, Washington, D. C.

²Naval Architect, David Taylor Model Basin, Navy Department, Washington, D. C.

³Numbers in brackets designate References at end of paper.

Presented at the Annual Meeting, New York, N. Y., November 14-15, 1963, of THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

Development of the Parent

The background work leading to the design of the hull form utilized as the parent for this series is reported in [2]. Briefly, this work involved an analysis of the results of resistance tests of a number of previous designs and also of the features desirable for good steering qualities and good rough-water performance. As a result of these analyses, it was concluded that it would be desirable to depart from the hull form of Series 50 in the following particulars:

(a) The deadrise angle at the transom should be fairly high ($12\frac{1}{2}$ deg was selected).

(b) The after portion of the hull bottom should have a constant deadrise angle so that the high-speed planing area would be untwisted.

(c) The stern should be narrow, with the transom width equal to about 65 percent of the maximum chine width.

(d) The bow sections should be convex.

The lines of the hull form developed on the basis of these particulars and the results of model tests of the design are reported in [2].

The tests showed that the design had less resistance than any of the conventional stepless planing boat designs tested previously at the Model Basin, and from this point of view it seemed to be a satisfactory parent form for a systematic series. However, one change was made. The hull form as initially designed was quite close to being a form consisting entirely of developed surfaces. Accordingly, the keel, chine, and sheer lines of the design were maintained (in both plan and profile views) and the necessary changes were made to obtain a hull form which would consist entirely of developed surfaces.

When a model of the new design was built and tested, the resistance was found to be essentially unchanged. Therefore, the new model was utilized as the parent model for the series.

Fig. 1 shows the body plans of both the original and the modified design. This figure indicates that the convexity of the bow sections (a desirable feature) was reduced by the change to developed surfaces. However, the developed-surface feature offers important advantages in regard to ease and economy of construction when the skin material is to be plywood or sheet metal. Also, the forward ends of the buttocks of the revised design are less steep, a feature which will tend to diminish pounding in rough water.

The Model Basin has developed a method of presenting the important features of a planing-hull form by three dimensionless "form-characteristics" curves. These curves, for the parent model of the Series, are presented in Fig. 2.

Plan and Scope of Series

It has been explained in previous reports (reference [3], for example) that three of the most important parameters affecting the performance of planing hulls are the ratio of length to beam, the relationship between hull size and gross weight, and the longitudinal location of the center of gravity. For most purposes in this paper, length-beam ratio is defined as the ratio of the projected chine length L_P to the maximum breadth over the chines B_{PX} . For those cases where it is desired to be more precise, it is defined (in a manner analogous to the definition of aspect ratio for a wing or hydrofoil) as the ratio of L_P to the mean breadth over the chines B_{PA} . The relationship between hull size and gross weight is ex-

Nomenclature

A_P = projected planing bottom area, excluding area of external spray strips
 B_P = beam or breadth over chines, excluding external spray strips
 B_{PA} = mean breadth over chines, A_P/L_P
 B_{PT} = breadth over chines at transom, excluding external spray strips
 B_{PX} = maximum breadth over chines, excluding external spray strips
 BL = baseline
 b = breadth over spray strips at longitudinal location of center of gravity
 CL = centerline
 CG = center of gravity
 C_{Lb} = lift coefficient, $W/\frac{1}{2}\rho u^2 b^2$
 F_F = Froude number based on volume, $v/(g\nabla^{1/3})^{1/2}$
 g = acceleration due to gravity
 L_P = projected chine length
 L_{CG} = longitudinal center of gravity location
 l_{cp} = distance of center of pressure forward of transom

R = total resistance, lb
 S = wetted surface area (this is actual wetted surface underway including area of sides which is wetted at low speeds and wetted bottom area of external spray strips; however, area wetted by spray is excluded)
 v = speed, fps
 V = speed, knots
 W = displacement at rest, weight of
 w = density of water (weight per unit volume)
 λ = linear ratio, ship to model
 α = angle of attack of after portion of planing bottom, deg (models as they appear in Fig. 4 are at an angle of attack, α , of zero deg)
 β = dead rise angle of planing bottom in degrees. This angle is obtained by approximating each body plan section by a straight line
 ν = kinematic viscosity, sq ft/sec
 ρ = mass density of water, slugs/cu ft
 ∇ = displacement at rest, volume of

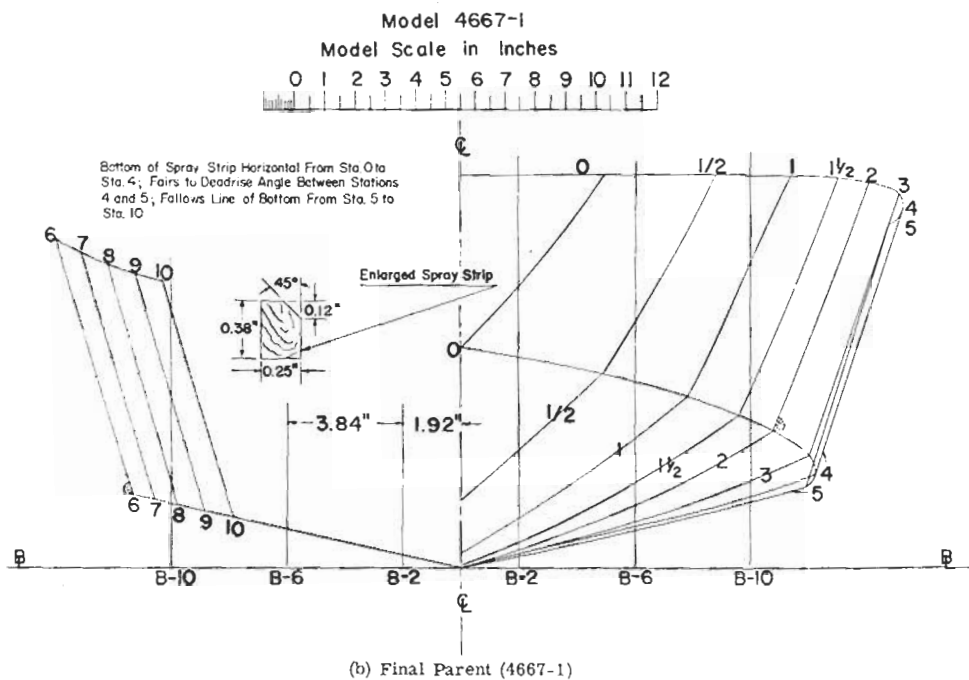
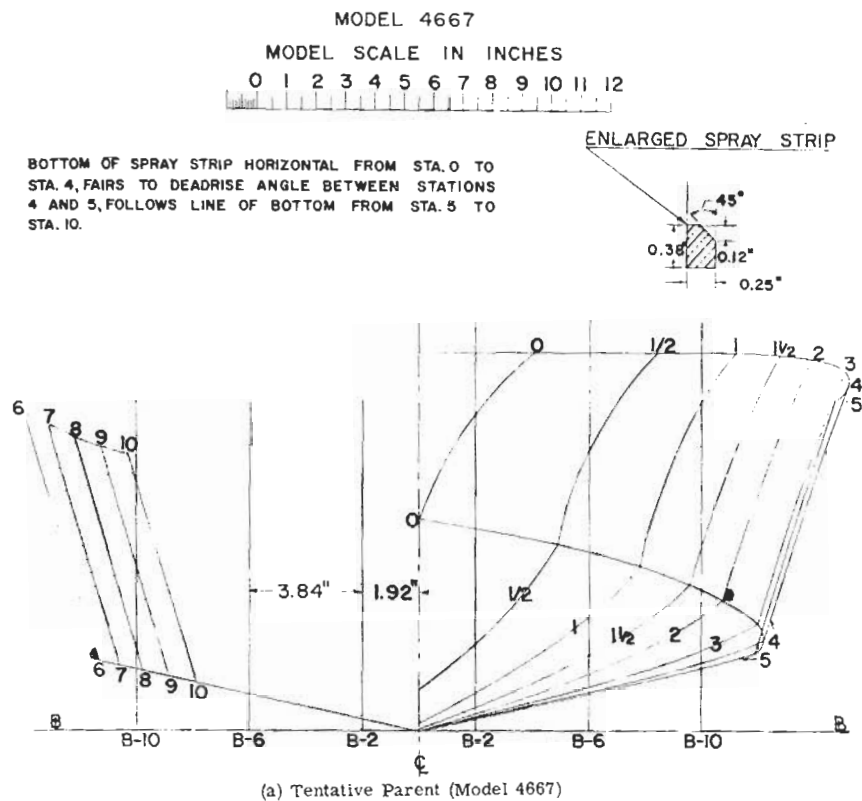


Fig. 1 Body plans of tentative and final parent models

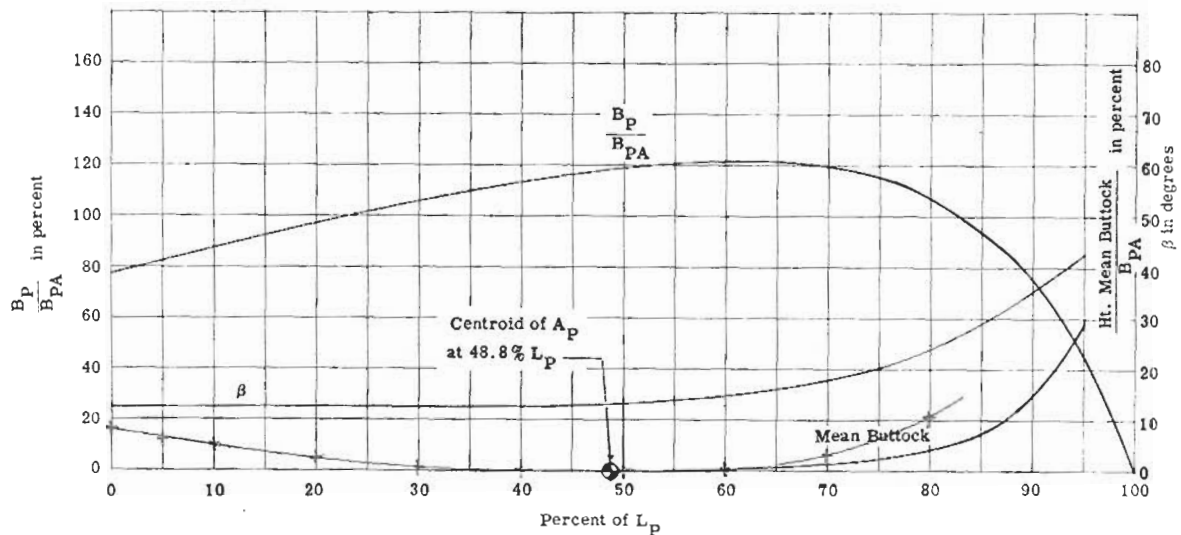


Fig. 2 Form characteristics curves for parent model

Table 1 Particulars of the Models of DTMB Series No. 62

Particulars	4665	4666	Model 4667-1	4668	4669
A_P , ft ²	6.469	9.715	12.800	9.518	7.479
L_P , ft.....	3.912	5.987	8.000	8.000	8.000
B_{PA} , ft.....	1.654	1.623	1.600	1.190	0.935
B_{PX} , ft.....	1.956	1.956	1.956	1.455	1.143
B_{PT} , ft.....	1.565	1.386	1.250	0.934	0.734
L_P/B_{PA}	2.365	3.69	5.00	6.72	8.56
L_P/B_{PX}	2.00	3.06	4.09	5.50	7.00
B_{PX}/B_{PA}	1.18	1.21	1.22	1.22	1.22
B_{PT}/B_{PX}	0.80	0.71	0.64	0.64	0.64
Centroid of A_P , % L_P fwd of transom	47.5	48.2	48.8	48.8	48.8
Angle of a-b chine in plan view, deg	5.0	5.0	5.0	3.7	2.9
Half-angle of waterline entrance, deg	58	49	46	39	37

pressed by the dimensionless ratio $A_P/\nabla^{2/3}$, where A_P is the projected planing bottom area and ∇ is the volume of water displaced at rest. As pointed out in [3], if hulls with different length-beam ratios are compared on the basis of equal $A_P/\nabla^{2/3}$, then the comparison will be on the sound basis of very nearly equal values of hull area, hull volume, and hull structural weight. Longitudinal CG location is defined as the distance of the LCG from the centroid of the area A_P , expressed as a percentage of the length L_P .

The present series was planned so as to explore in a systematic way the effects of a wide variation in the three variables just mentioned. This can be done relatively economically when compared with the method used for systematic investigations of displacement-hull forms. This is possible

because it is feasible to explore the effects of variation of loading and LCG location with a single model. Thus, different models are required only for exploration of the effect of length-beam ratio.

Five models, Models 4665, 4666, 4667-1, 4668, and 4669, were tested to explore the influence of length-beam ratio. They are shown in plan view in Fig. 3. Additional particulars of the models are given in Table 1. As can be seen, the values of length-beam ratio tested in the series correspond to values of L_P/B_{PX} of 2, 3.06, 4.09, 5.5 and 7. The extreme models are outside the generally accepted range of boat proportions, but one of the purposes of systematic-series work is to explore new and unfamiliar ground. The body plans for the five models are identical except for some slight



Model 4665 $L_p / B_{pX} = 2.00$



Model 4666 $L_p / B_{pX} = 3.06$



Model 4667-1 $L_p / B_{pX} = 4.09$

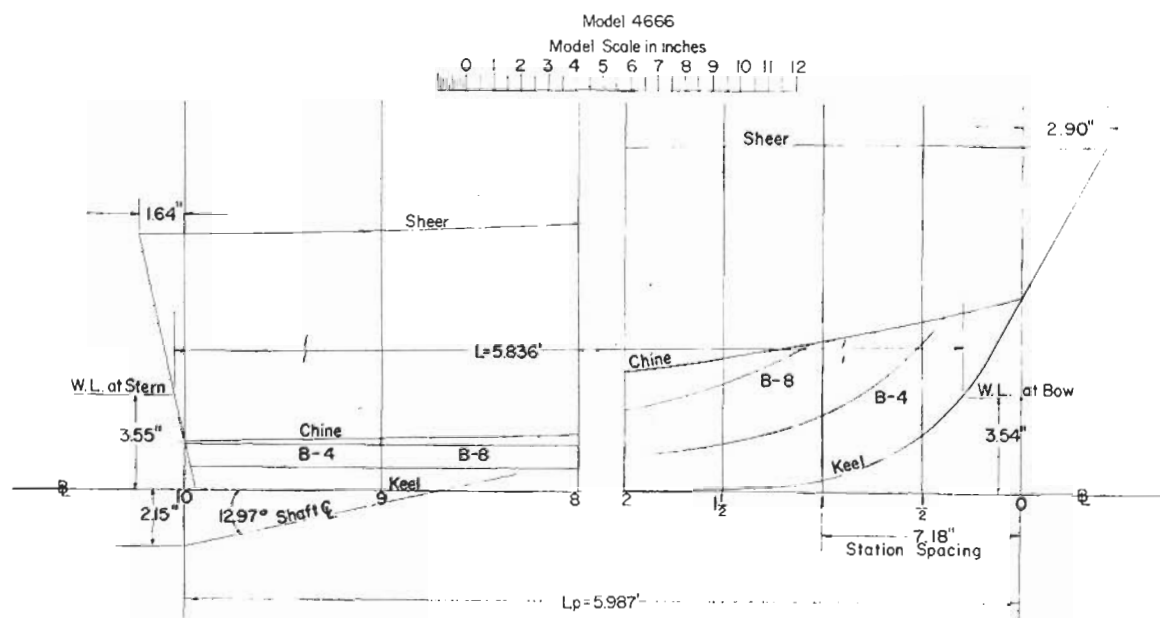
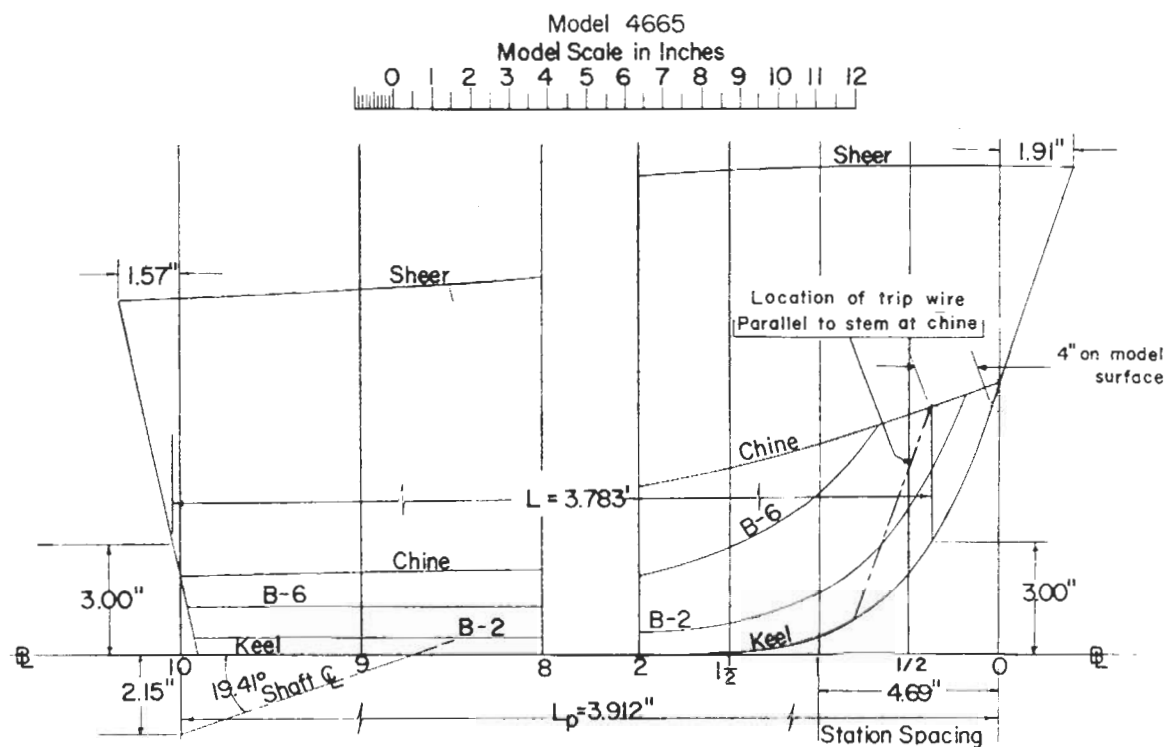


Model 4668 $L_p / B_{pX} = 5.50$



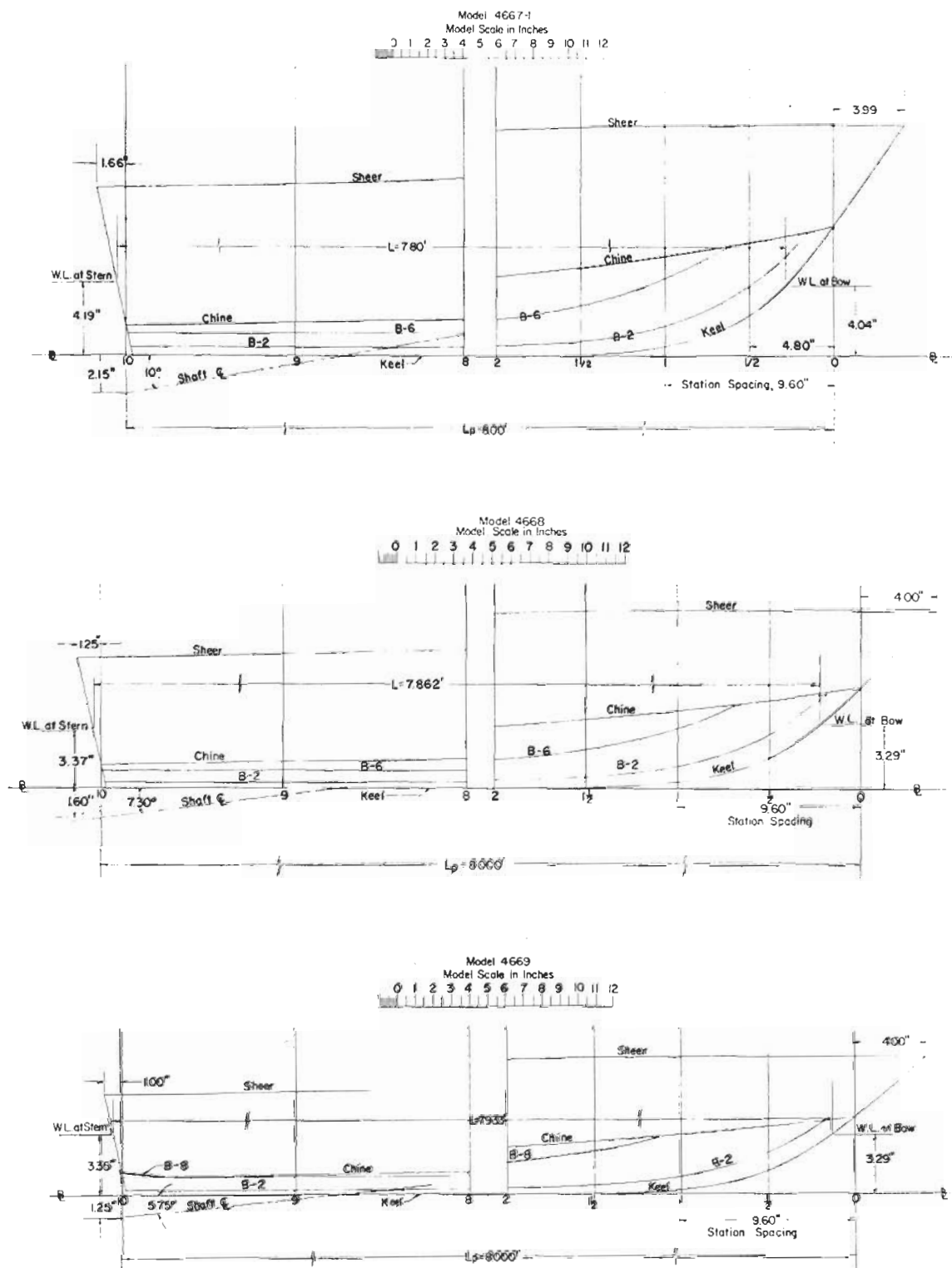
Model 4669 $L_p / B_{pX} = 7.00$

Fig. 3 Chine lines in plan view of five models of series



(a) Models 4665 and 4666

Fig. 4 Bow and stern endings of five models of series



(b) Models 4667-1, 4668, and 4669

Fig. 4 Concluded

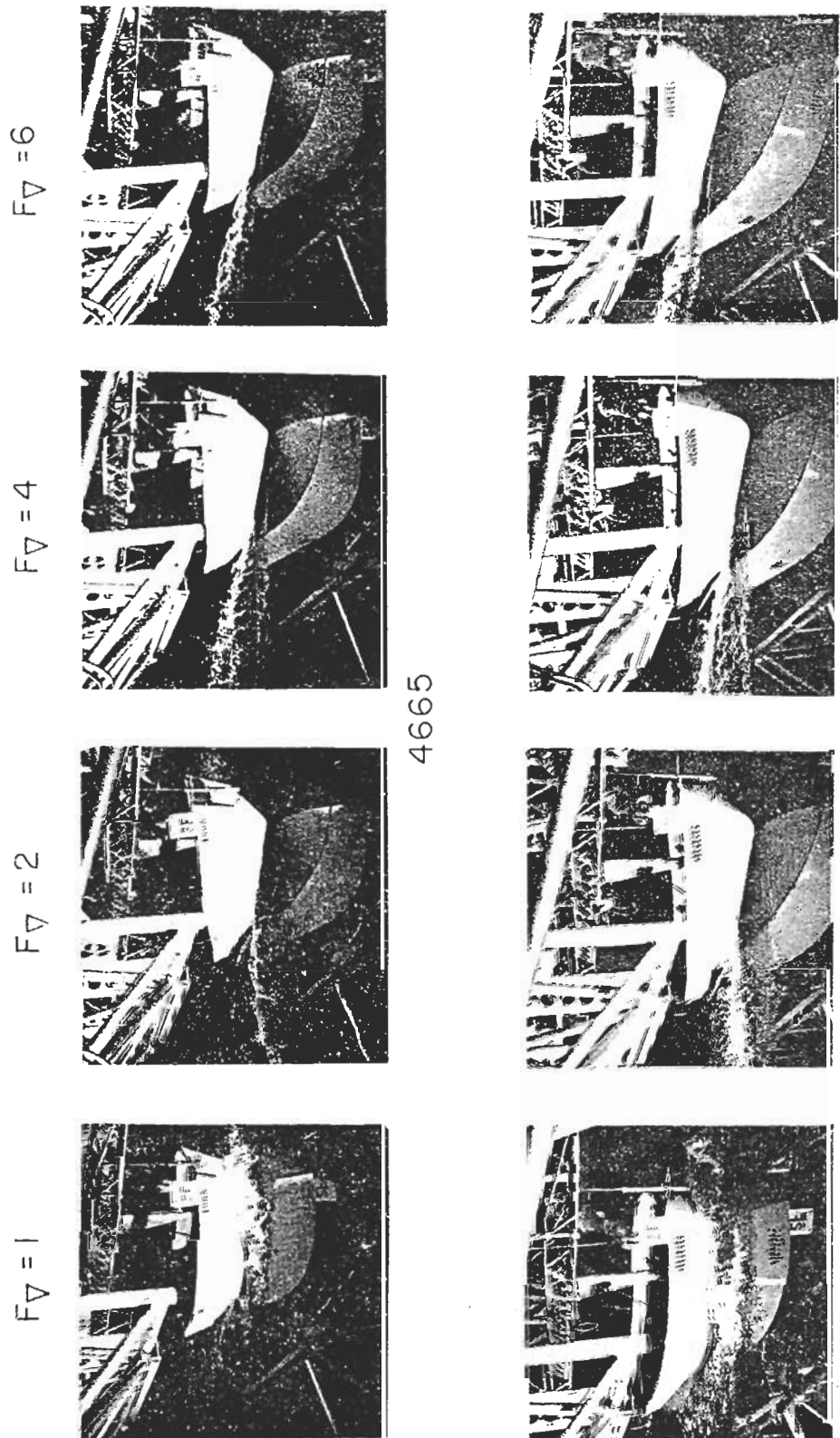
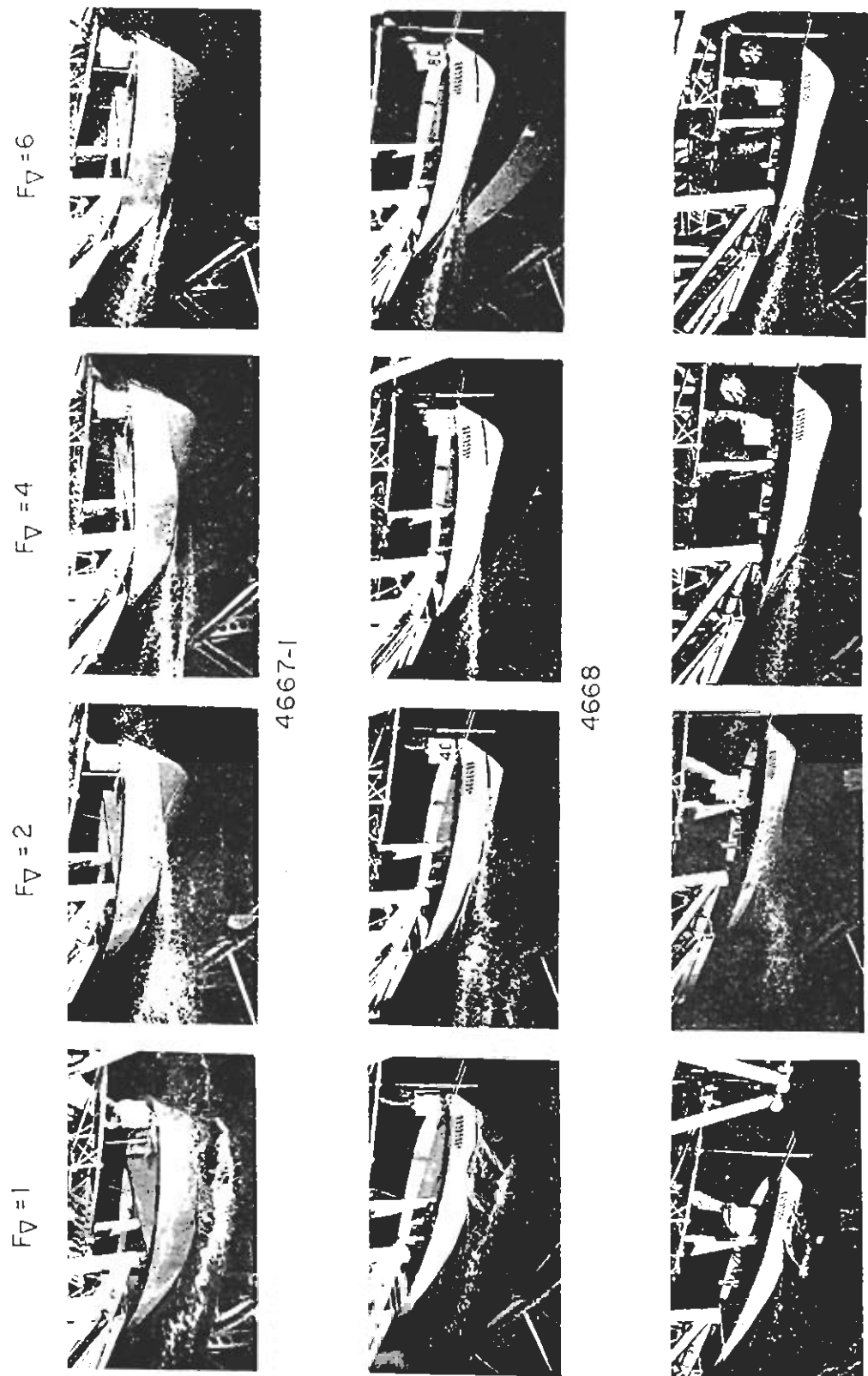


Fig. 5 Photographs of models at DTMB standard test condition (A, V^2) 7. LCG at 6 percent L_p aft of centroid of A_p



4669
Fig. 5 Concluded

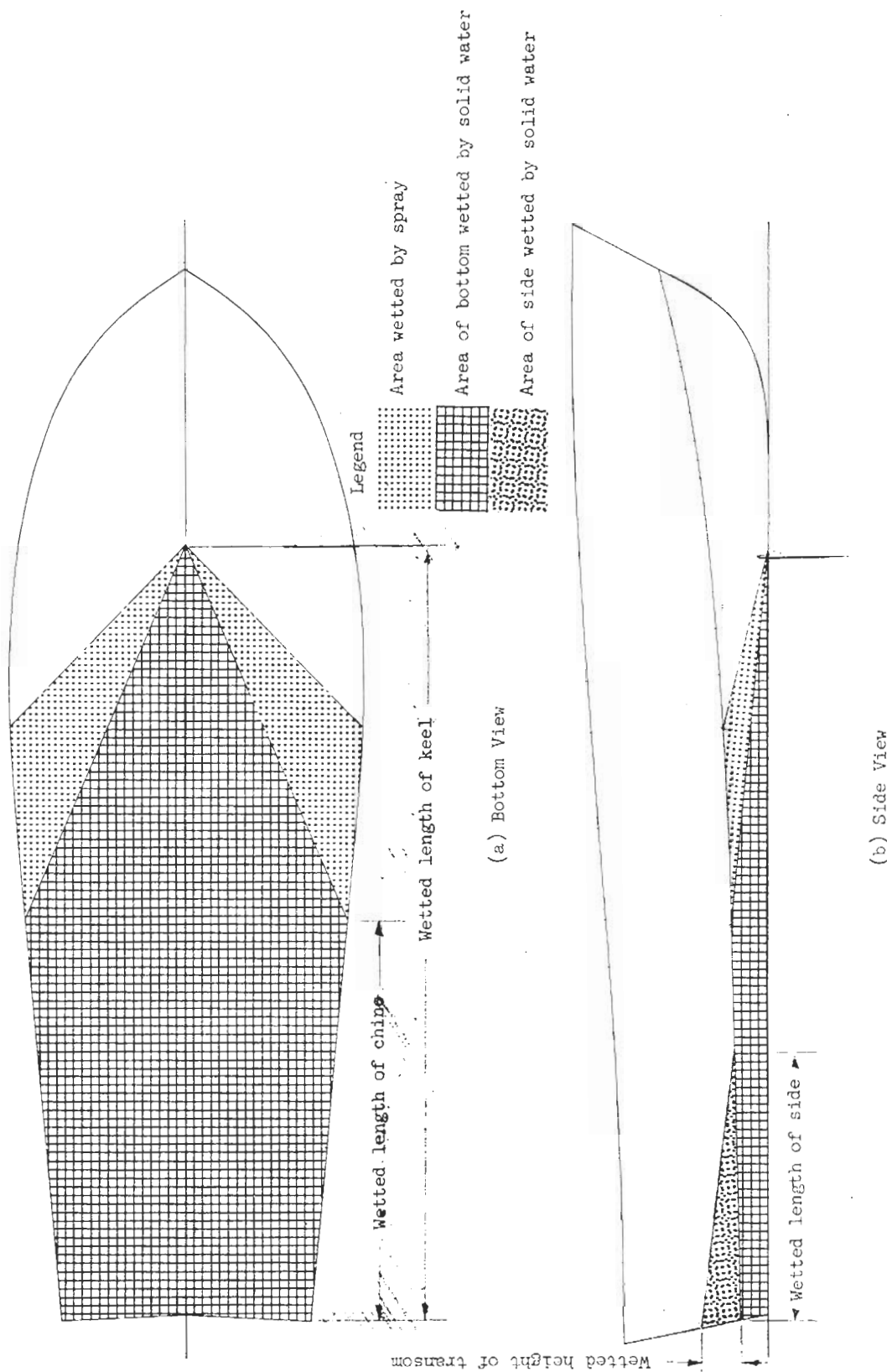


Fig. 6 Wetted lengths and wetted areas of a typical planing-boat mode

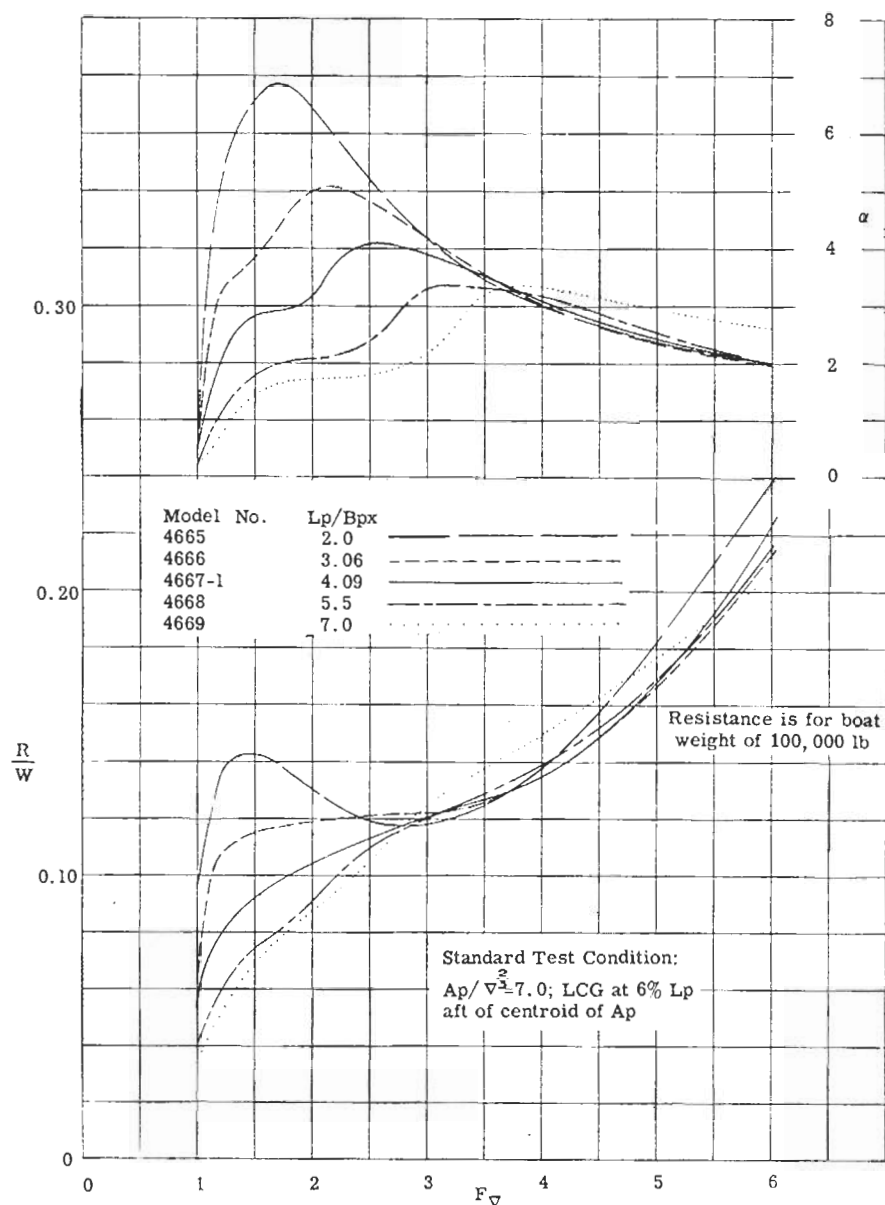


Fig. 7 Resistance/weight ratio and angle of attack versus speed coefficient for five models of series

after body variations in the models having length-beam ratios of 2 and 3.06. Essentially, the four additional models of the series were derived from the parent by maintaining the same shape of body plan but adjusting the station spacing and the size of the body plan to give the different length-beam ratios desired. However, this scheme was deviated from for the two models with the lowest values of length-beam ratio. The model with a length-beam ratio of 3.06 has proportions

similar to those for the smaller sizes of pleasure craft, which are propelled either by outboard motors attached to the transom or by the in-board-outboard type of drive with the engine in the extreme stern. For such craft, with their centers of gravity quite far aft, the narrow transom width dictated by the original scheme of variation provides insufficient buoyancy at the stern. The transom widths were therefore arbitrarily widened for the two models having the lowest ratios of

Model No.	Symbol	Hull Designation
3592-1	△	80 ft. PT 8
3626	□	70 ft. Elco PT Boat
3720	▽	79 ft. Higgins PT Boat
3722	△	80 ft. Elco PT Boat
3941	◇	77 ft. PT Boat
4300	○	Aircraft Rescue Boat
4309	△	43 ft. Aircraft Rescue Boat (Sea Sled)
4310	◇	43 ft. Aircraft Rescue Boat
4375	▽	90 ft. Aircraft Rescue Boat
4618-1	△	40 ft. LCP(L)
4708	◇	45 ft. Steel Utility Boat
4665	▼	Series 62 $L_P/B_{PX} = 2.00$
4666	▲	Series 62 $L_P/B_{PX} = 3.06$
4667-1	●	Series 62 $L_P/B_{PX} = 4.09$
4668	■	Series 62 $L_P/B_{PX} = 5.50$
4669	◆	Series 62 $L_P/B_{PX} = 7.00$

Resistance corrected to 100,000 lb displacement and salt water at 59° F using 1947 A. T. T. C. Model-Ship Correlation Line with zero roughness allowance.

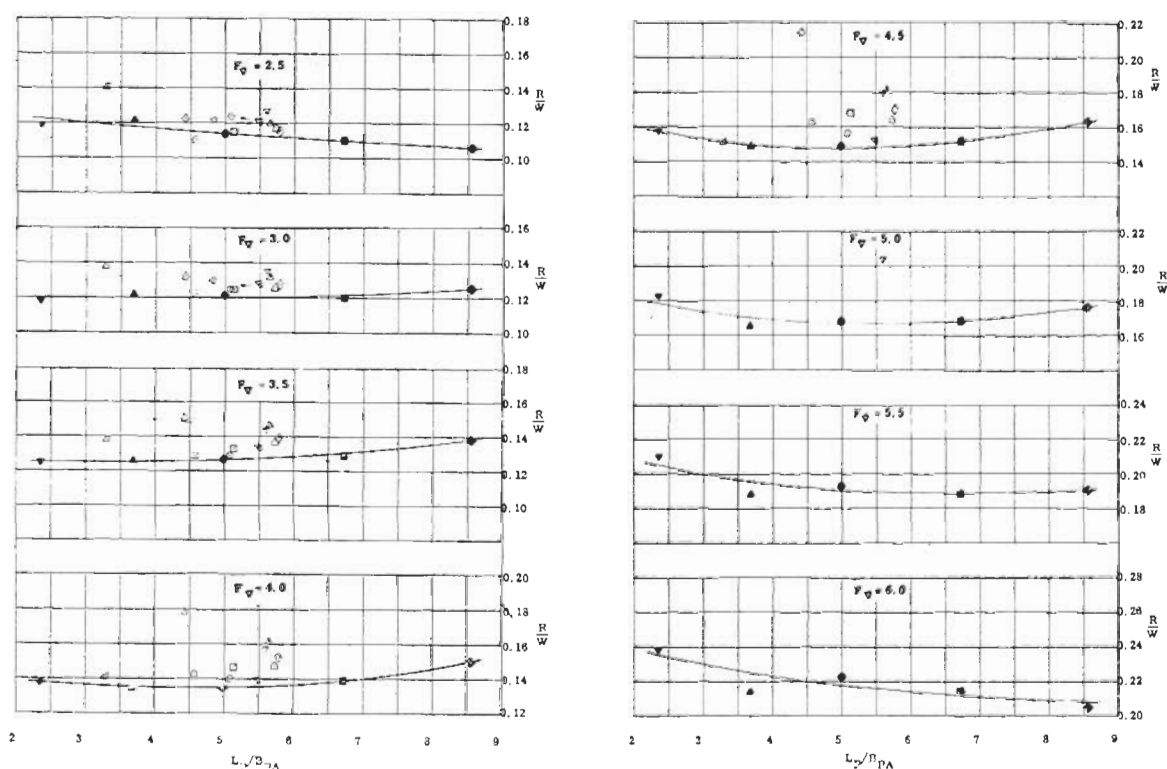
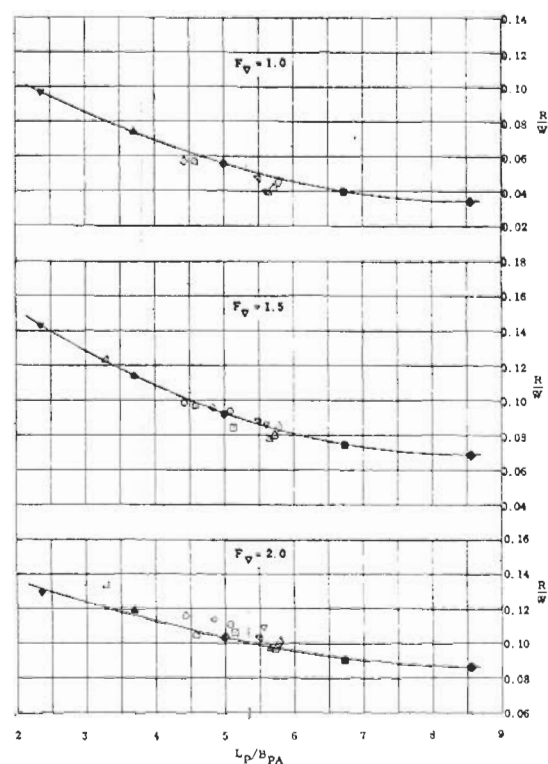
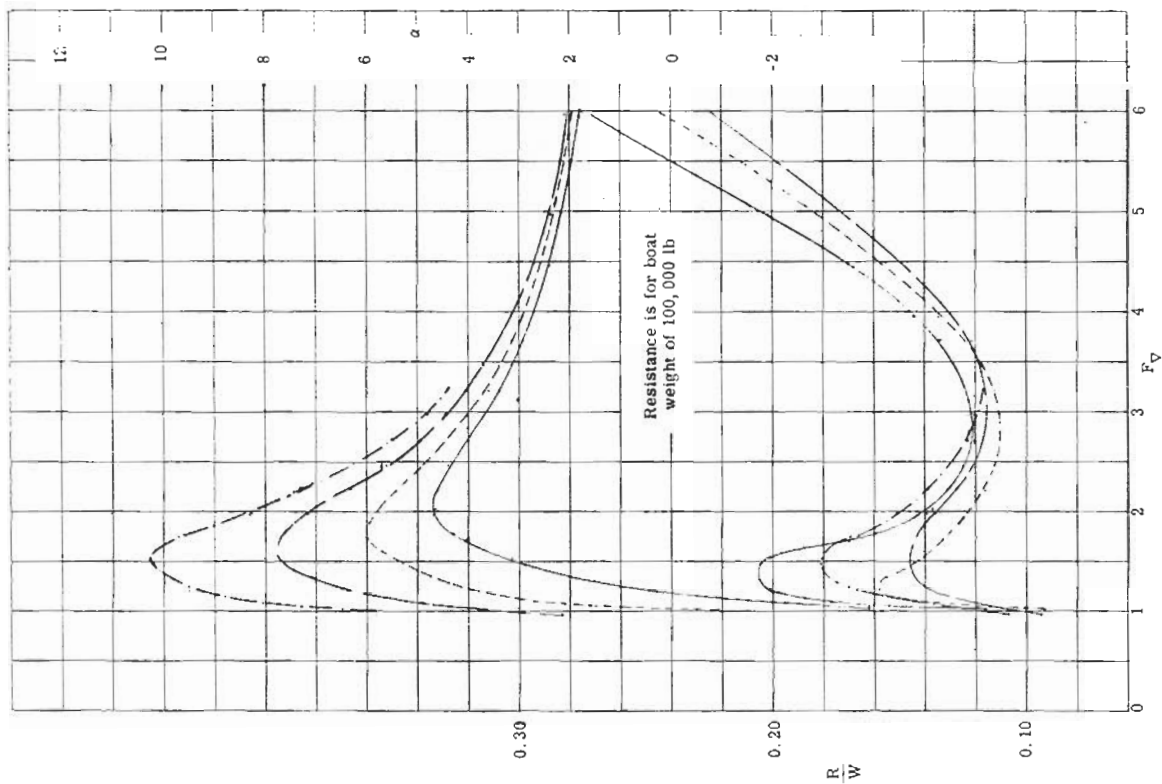
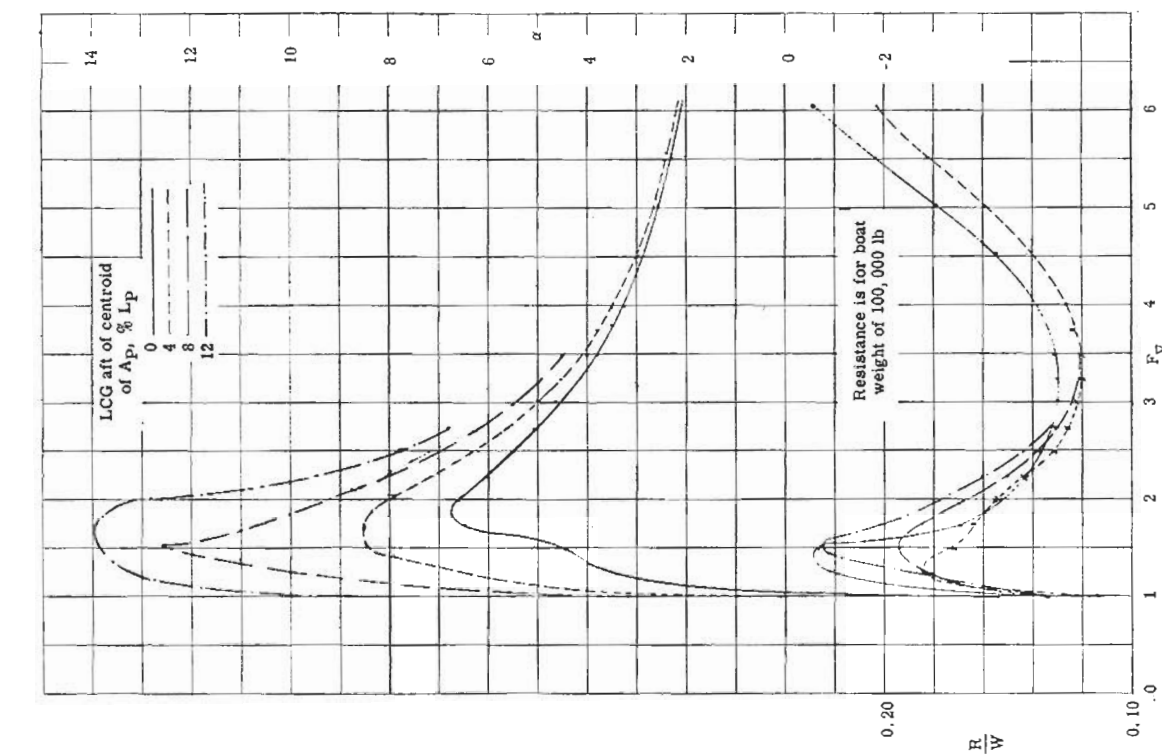


Fig. 8 Resistance/weight ratio for models of series and for other representative planing-boat designs

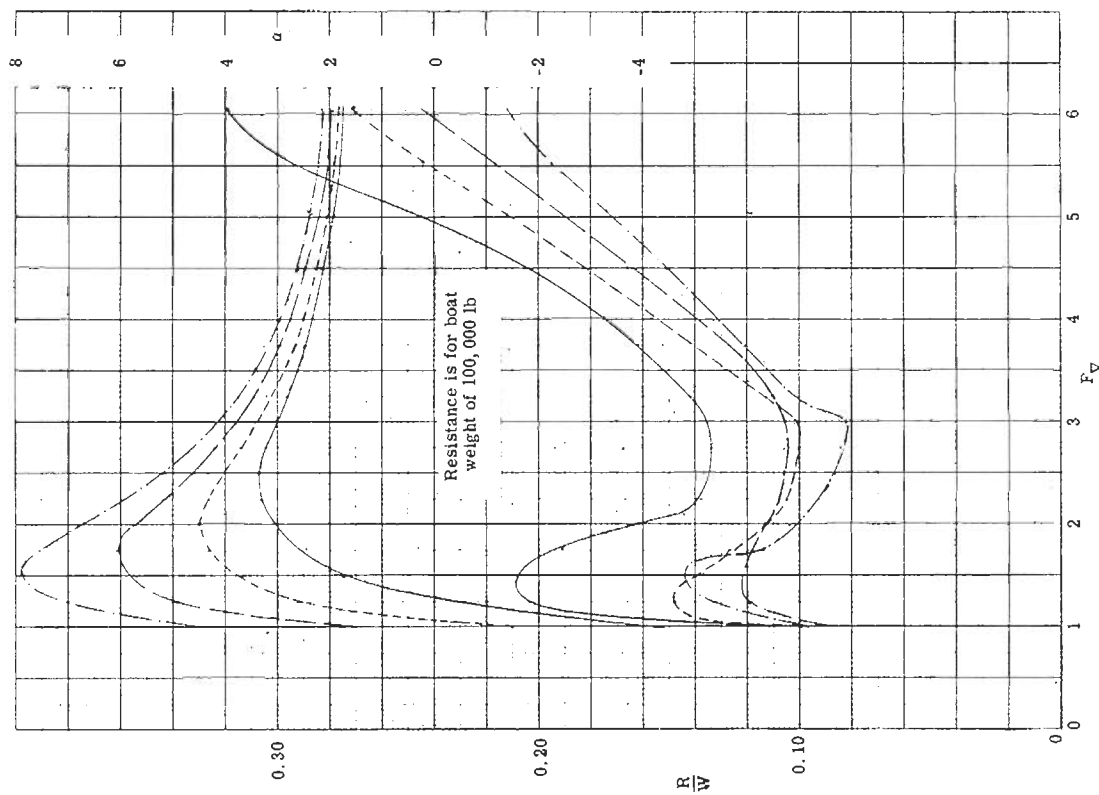


(a) $A_p/\sqrt{\frac{2}{3}} = 5.5$



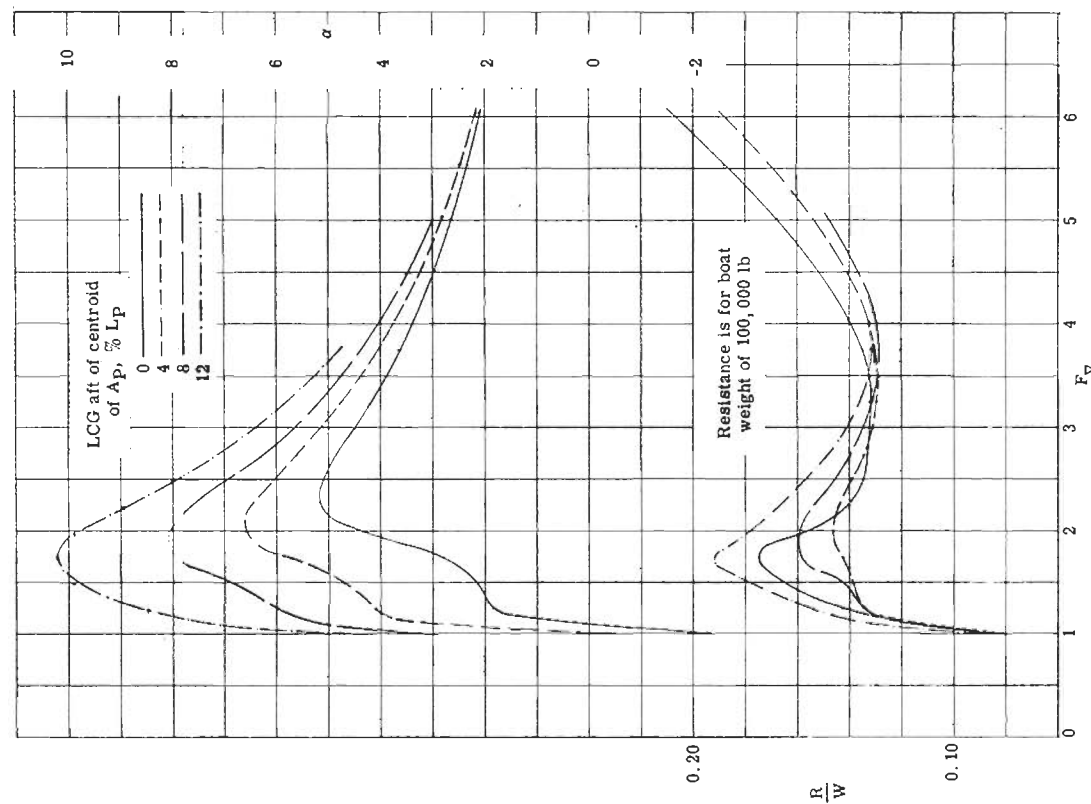
(b) $A_p/\sqrt{\frac{2}{3}} = 7.0$

Fig. 9 Resistance/weight ratio and angle of attack versus speed coefficient, $L_p/B_{px} = 2.00$



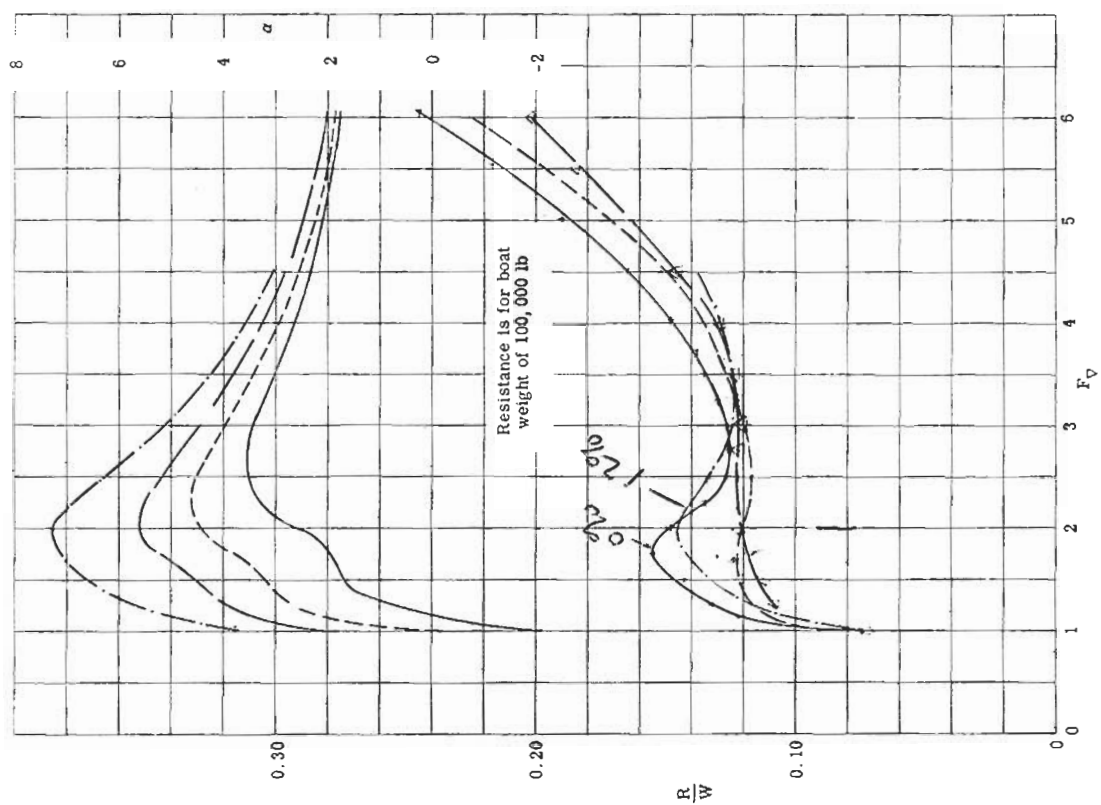
(c) $A_p/\nabla^{2/3} = 8.5$

Fig. 9 Continued



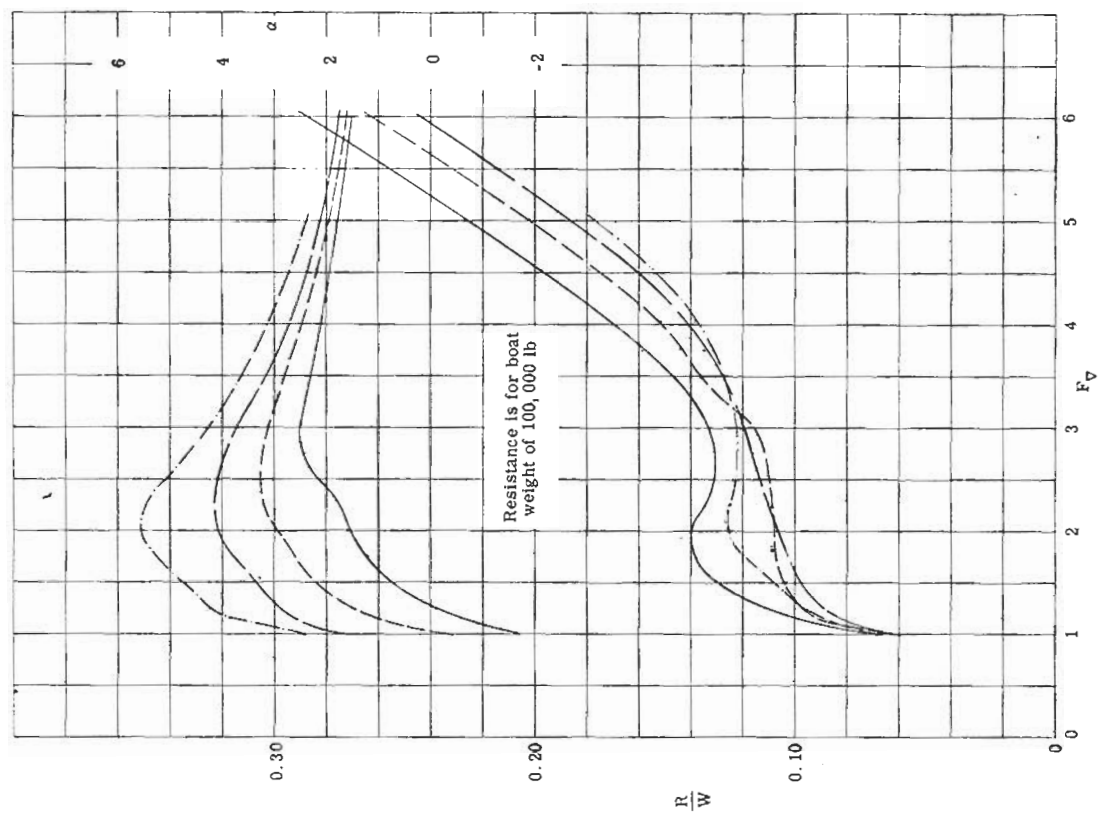
(a) $A_p/\nabla^{2/3} = 5.5$

Fig. 10 Resistance/weight ratio and angle of attack versus speed coefficient $L_p/B_{PX} = 3.06$



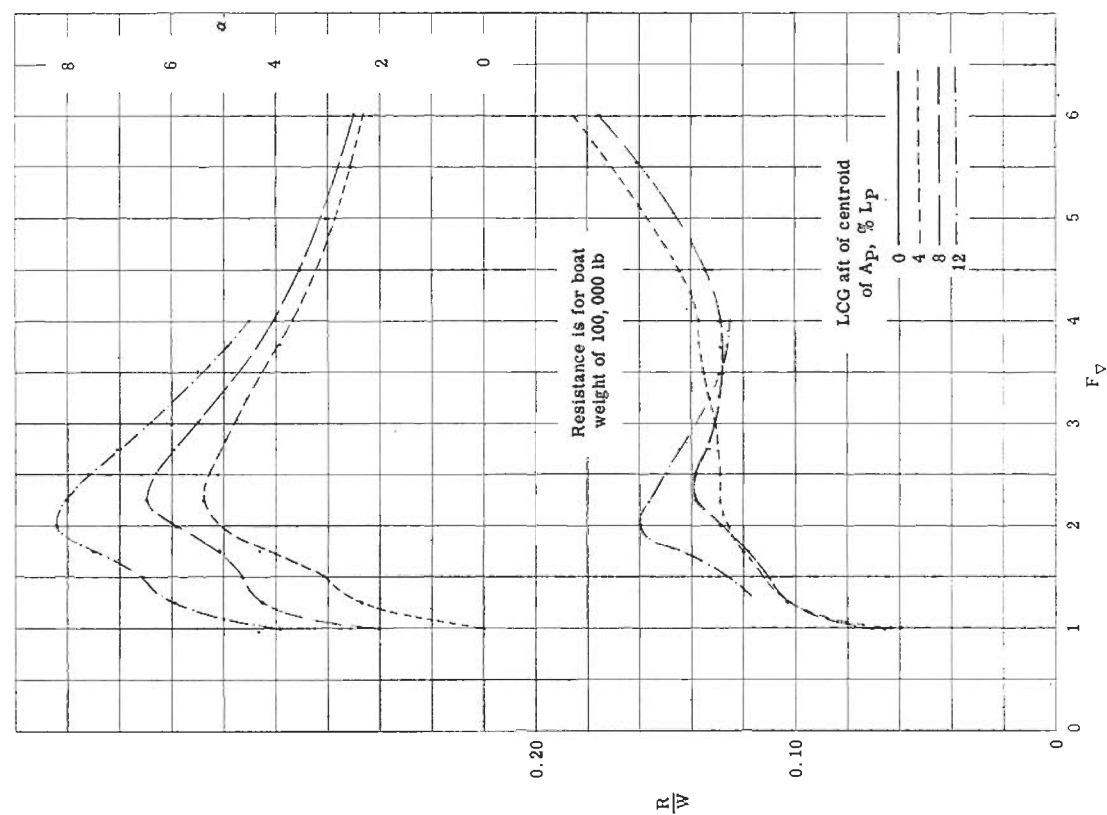
$$(b) A_p/v^2 = 7.0$$

Fig. 10 Continued

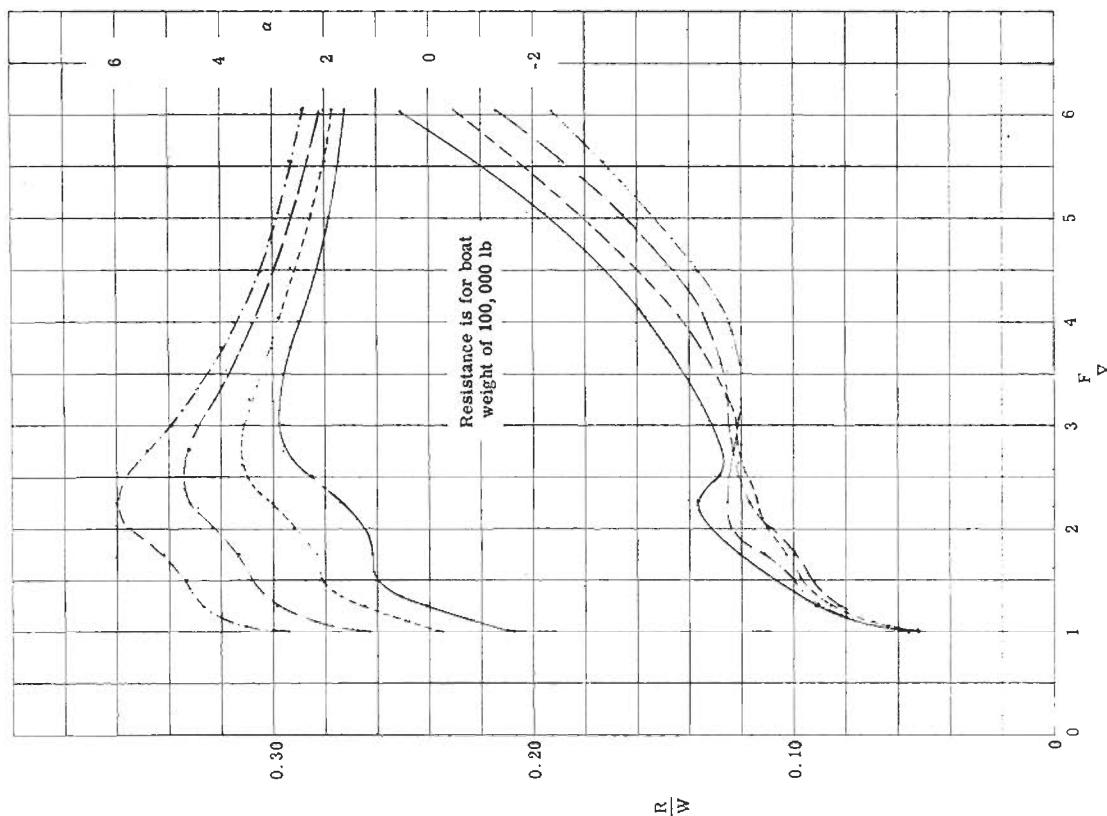


$$(c) A_p/v^2 = 8.5$$

Fig. 10 Concluded

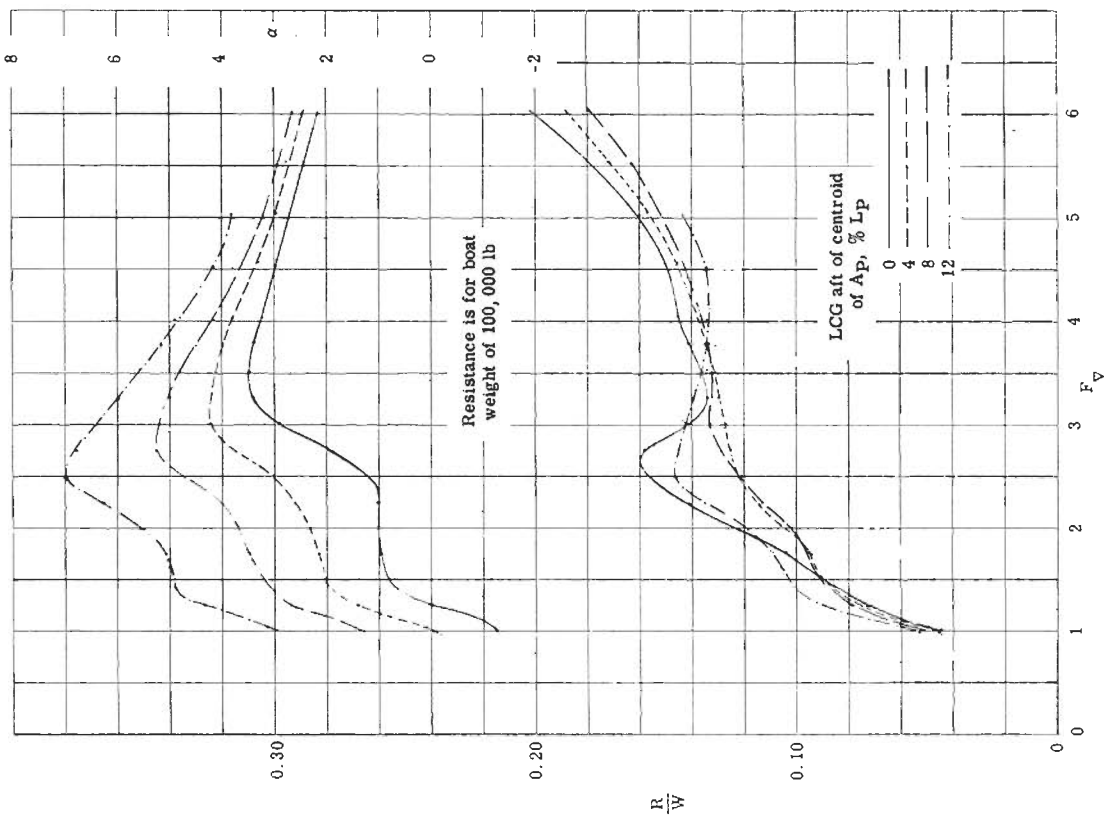


(a) $A_p/\nabla^2 = 5.5$

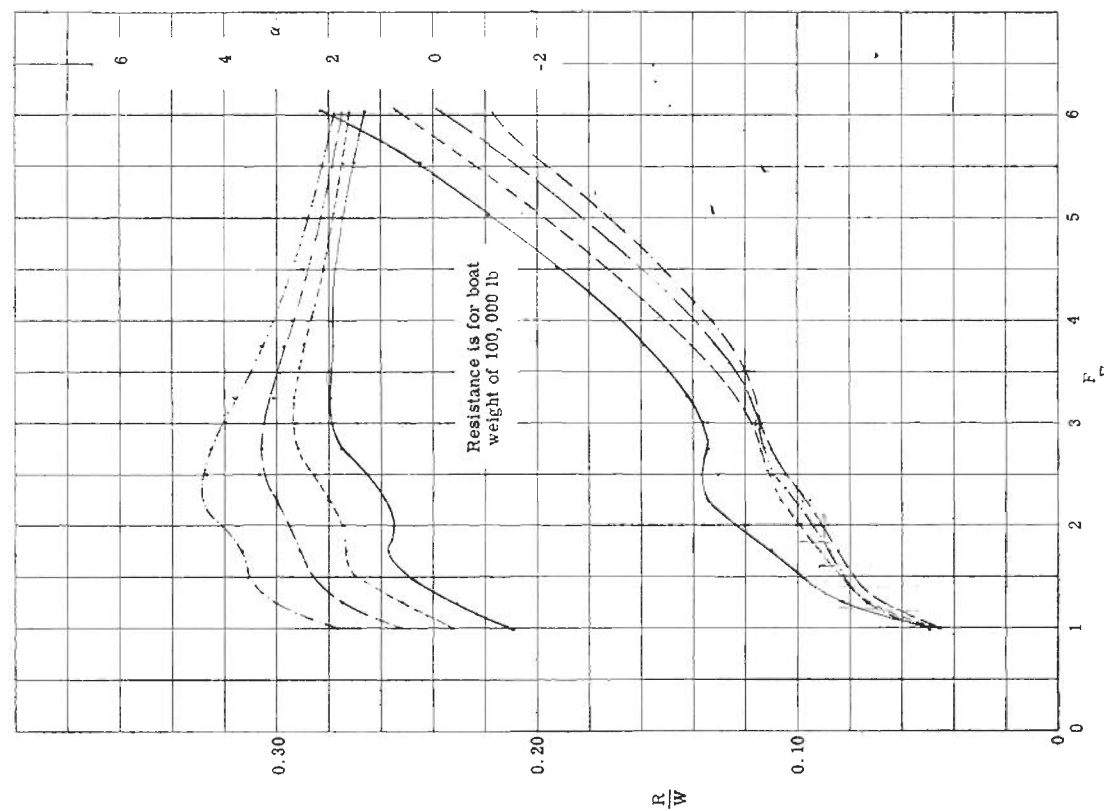


(b) $A_p/\nabla^2 = 7.0$

Fig. 11 Resistance/weight ratio and angle of attack versus speed coefficient $L_P/B_{PX} = 4.09$



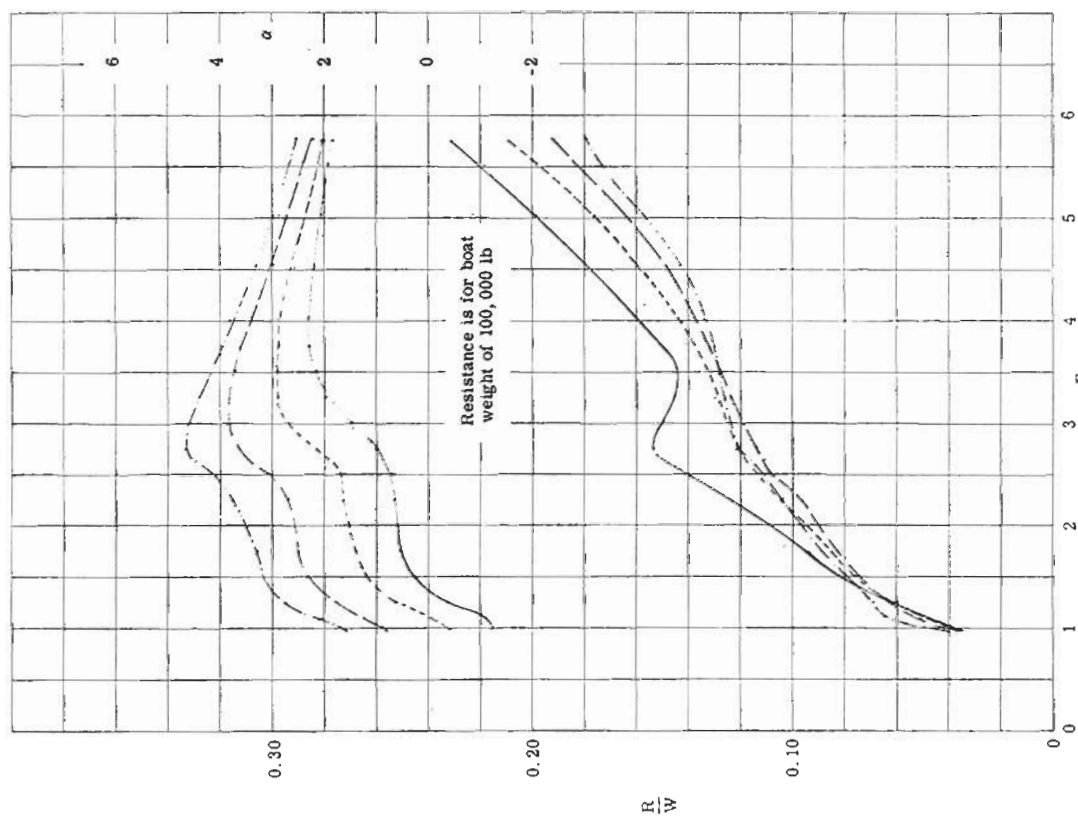
(a) $A_p/V^2 = 5.5$



(c) $A_p/V^2 = 8.5$

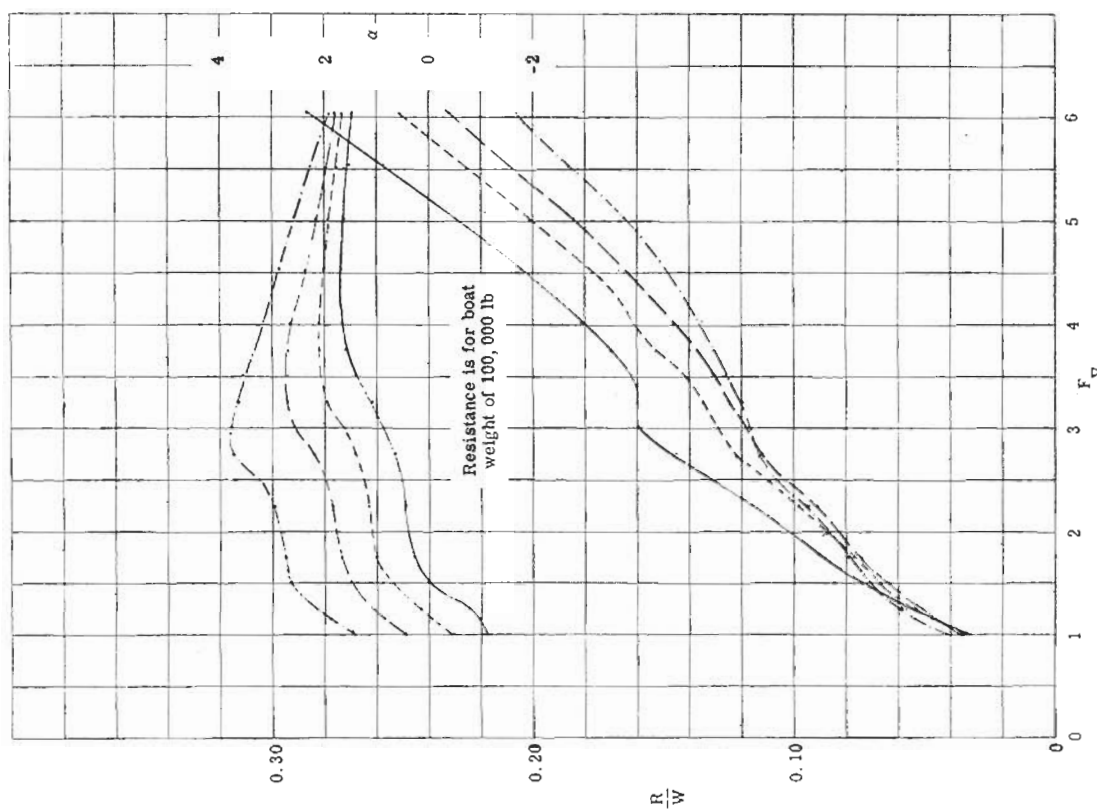
Fig. 11 Concluded

Fig. 12 Resistance/weight ratio and angle of attack versus speed coefficient $L_p/B_{PX} \approx 5.50$



(b) $Ap/V^3 = 7.0$

Fig. 12 Continued



(c) $Ap/V^3 = 8.5$

Fig. 12 Concluded

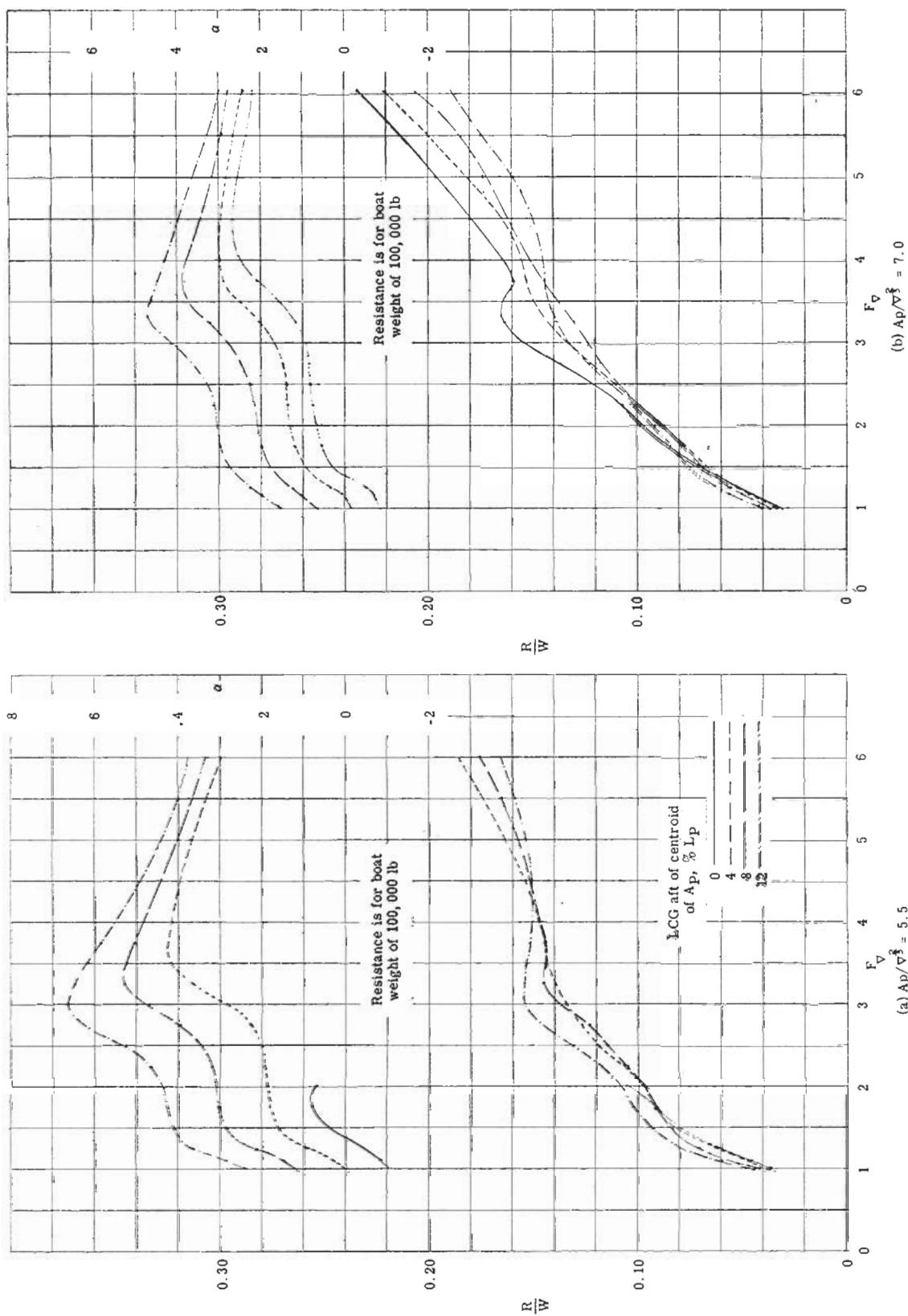


Fig. 13 Resistance/weight ratio and angle of attack versus speed coefficient
 $L_p/B_{PX} = 7.00$

Fig. 13 Continued
 $(b) A_p/V^2 = 7.0$

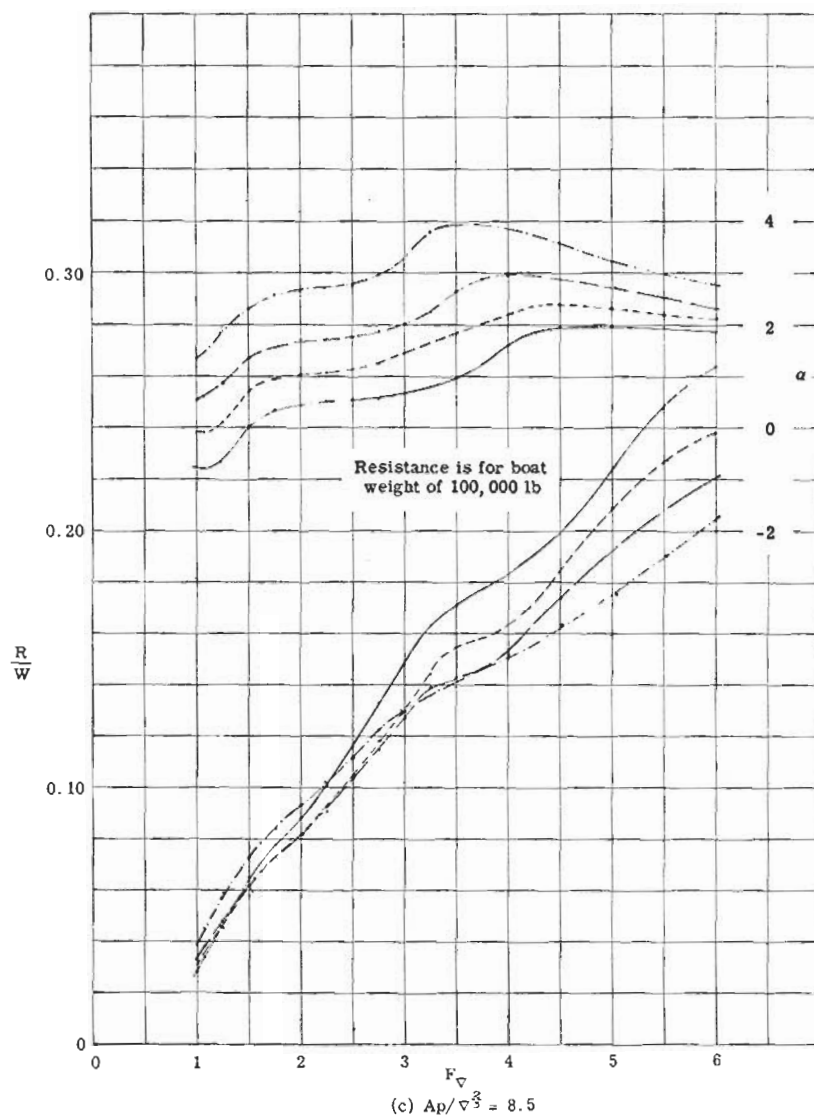


Fig. 13 Concluded

length to beam. The ratio of transom width to maximum chine width for the five models is given in Table 1. Table 1 also shows that the transom widths for Models 4665 and 4666 were selected so that the angle of the afterbody chine line in plan view would be the same as for the parent model (5 deg in each case). A check of the models of the series showed that the method of derivation had the desired effect of producing hull forms with developed surfaces.

Profiles of the bow and stern endings of the five models are shown in Fig. 4. The waterline shown for each model corresponds to the TMB standard test condition for planing hulls. Models 4667-1,

4668, and 4669 were each 8 ft long. However, Models 4665 and 4666 were made 4 ft and 6 ft long, respectively, to keep the model widths within the limits imposed by the carriage bay used for the tests. Spray strips were the only appendages fitted to the models. The shape of these strips is shown in Fig. 1. The ratio between spray-strip width and hull width was kept the same for all models of the series.

The values of $A_P/V^{2/3}$ tested were 5.5, 7 and 8.5. The speed range was from F_F equals about 0.2 up to F_F equals 6.0. In addition, tests were made in the lower part of this speed range with an area coefficient $A_P/V^{2/3}$ of 4. The LCG locations

were 0, 4, 8 and 12 percent L_P aft of the centroid. In general, all possible combinations were tested (a few conditions were found to be impractical) so that the planned program consisted of tests of each of the five models at sixteen different conditions for a total of 80 tests.

In order to provide a link with earlier work, each model was also tested at the TMB standard condition for planing craft. This condition corresponds to an area coefficient of 7 and to an LCG location at 6 percent L_P aft of the centroid. (This "standard condition" is discussed at some length in [3]).

Model Construction and Test Procedure

The parent model of the series was made of fiberglass and plastic so that it would be light enough for the self-propelled testing planned for the future. The remaining models were of wood. On each model, scales were marked along the keel, along one chine, and on one side of the transom for reading the solid-water wetted lengths on the bottom and the dimensions of the side area which was wetted at low speeds.

The models were tested in the high-speed basin at DTMB using Carriage 3. The high-speed basin is 20 ft wide and 2968 ft long, with a depth of 16 ft for the first 1800 ft (in the direction of travel for Carriage 3) and 10 ft for the remaining 1168 ft. Tests were made with one of the models of the series to determine the effect of the change in depth; this was found to be negligible.

Models 4666 through 4669 were considered to be of a size large enough to give accurate test results without the use of a device for stimulating turbulence. For Model 4665, the 4-ft model, trip wires 0.035 in. dia were fitted on each side of the stem as is shown in Fig. 4(a). Fig. 22 of reference [4] was used as a guide for the proper location of the turbulence-stimulation device.

The models were towed in the respective shaft lines indicated in Fig. 4. The shaft line for the parent model was located to correspond to a twin-shaft propulsion arrangement. For the other models, the depths of the shaft line at the various stations followed the same pattern of variation as the other body-plan dimensions and the shaft angle, accordingly, changed with change in length-beam ratio. The resistance recorded was the horizontal component of the towing force. Heave (rise) and pitch (change in trim angle) were recorded at each test speed. The intersections of the solid water with keel and chine and, at low speeds, the boundaries (at chine and transom) of the side wetted area were also recorded.

Results of Tests

The conditions at which the models were tested and the tabulated results of all the tests are given in the Appendix. The complete model test results are presented so that the user can extrapolate the data to any desired boat size. Photographs of the models underway are shown in Fig. 5.

The measured bottom wetted lengths are illustrated in Fig. 6 and tabulated in the Appendix. The principal wetted area to be taken into consideration in making the frictional-resistance correction for a planing boat is, of course, that part of the bottom area which is wetted by solid water, Fig. 6(a). The part of the bottom area which is wetted by spray is customarily neglected in making this correction. In the lower end of the speed range, a portion of the sides of a planing hull is also wetted and this area is illustrated in Fig. 6(b). This side wetted area is nearly triangular and, therefore, its magnitude can be approximated closely from the readings of the length and height of the wetted area on the scales marked on the side of the model. The values of the lengths and heights of the side wetted area have not been included in the tables in the Appendix, but in all cases this area has been added to the bottom area wetted by solid water to give the values of total wetted surface S which are shown in the tables. These total values are the ones used in making the frictional-resistance correction. The wetted length used for the calculation of Reynolds number is the arithmetic mean of the keel and chine wetted lengths given in the tables.

The resistance data of the series have been expanded to boat weights of 10,000 and 100,000 lb. The Schoenherr friction coefficients were used with zero roughness allowance. The heavier weight is representative of military planing craft, the lighter weight, of a medium-sized motor yacht. The resistance data for a boat weight of 100,000 lb are presented in Figs. 7 through 13 in the form of R/W versus F_v . The angle of attack α of the planing bottom is also presented in each figure. Graphs of R/W versus F_v for a 10,000-lb boat weight are presented in Figs. 14 through 18.

Fig. 7 compares values of resistance and angle of attack for the five models of the series. The data are taken from tests at the Model Basin's standard condition for planing craft. It is interesting to note that the model with the next to the highest value of length-beam ratio has quite a low drag not only in the range of F_v below 3.0, but also in the high-speed region above a F_v of 5.0. At high speed less drag would be

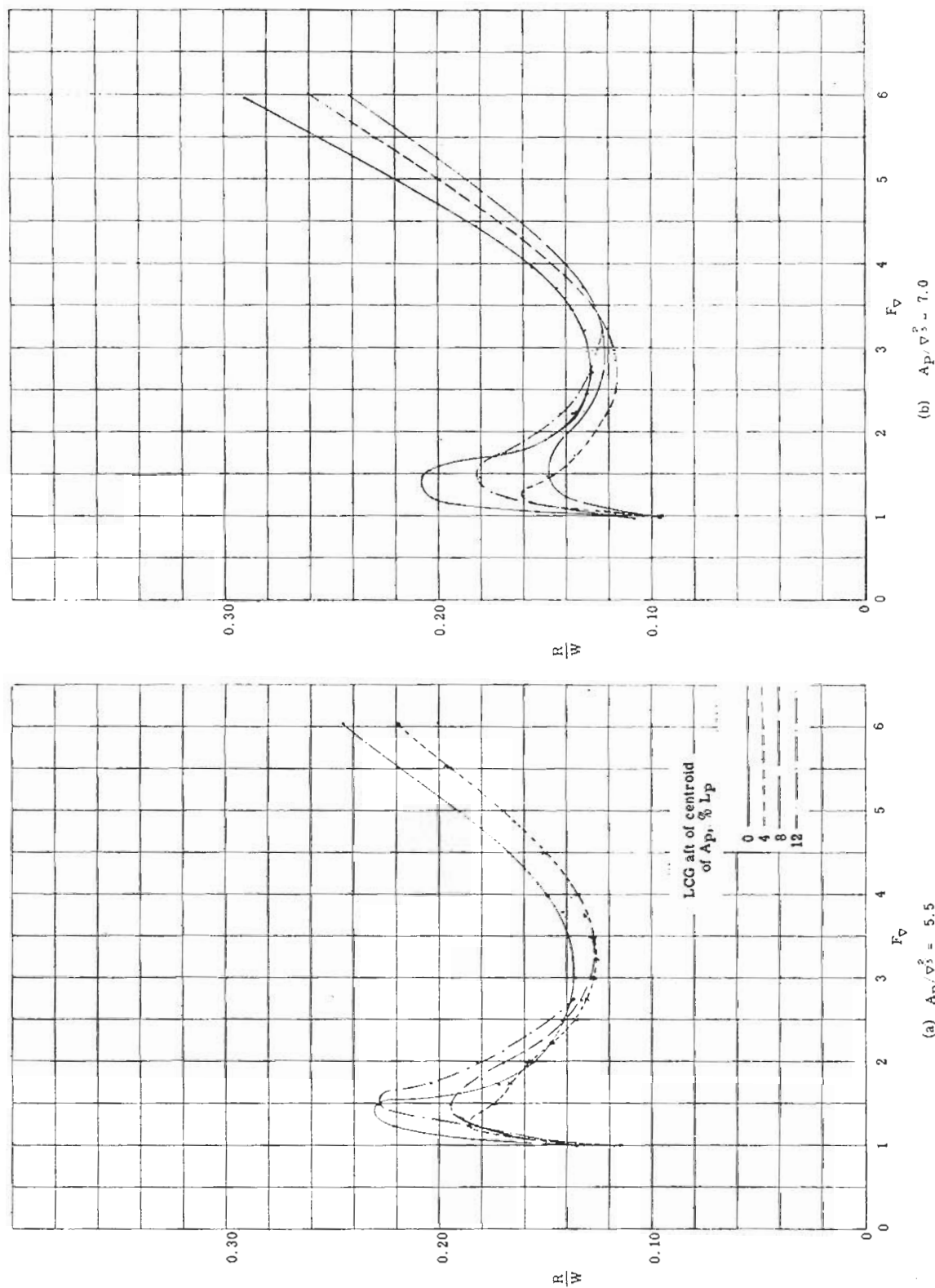
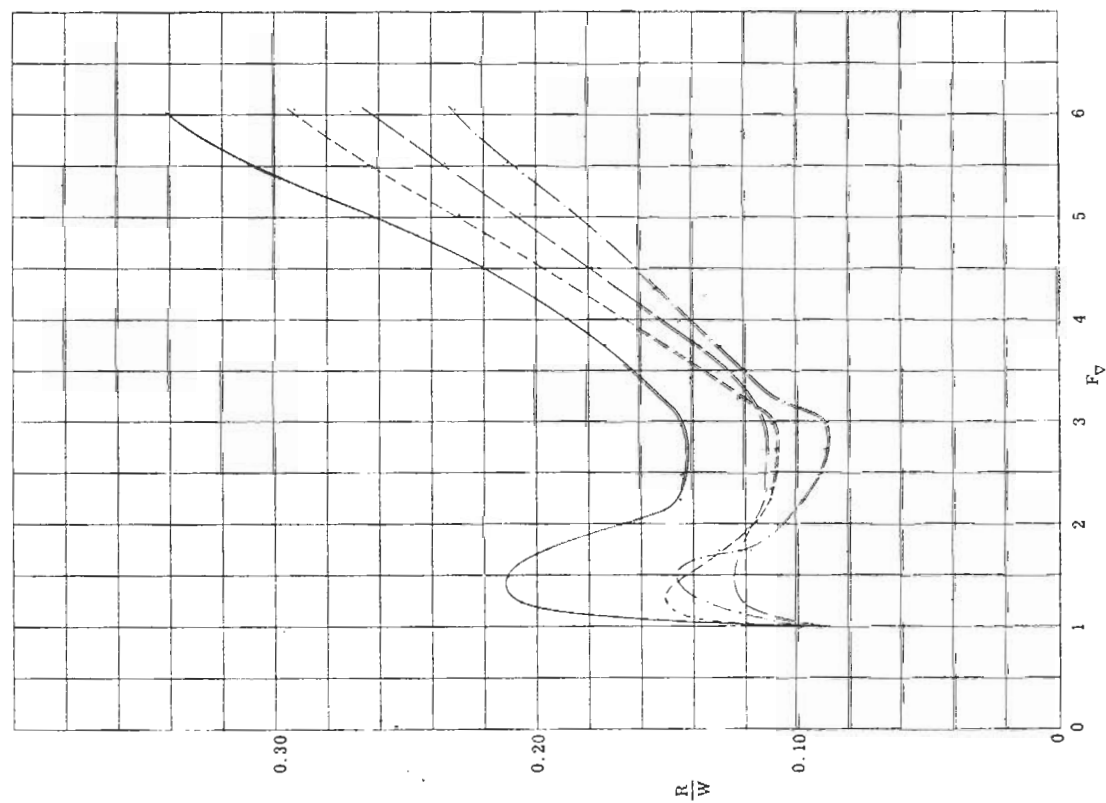


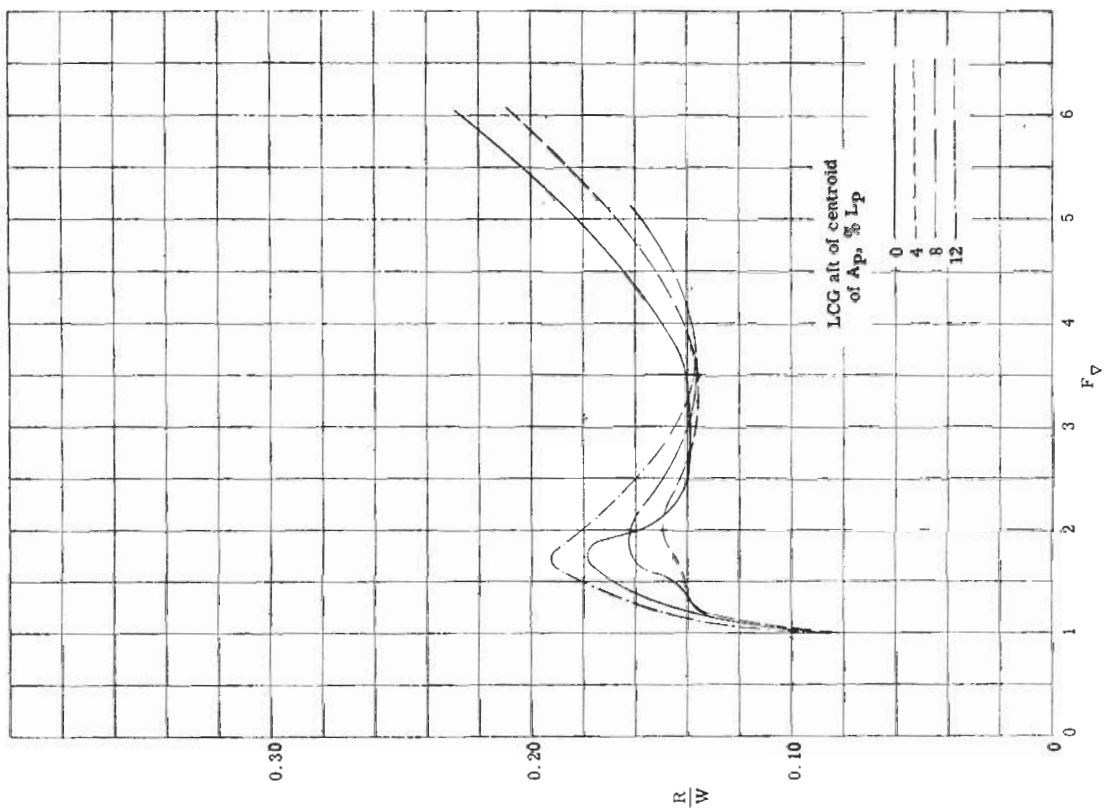
Fig. 14 Continued

Fig. 14 Resistance/weight ratio versus speed coefficient for a boat weight of 10,000 lb. $L_p/B_{px} = 2.00$



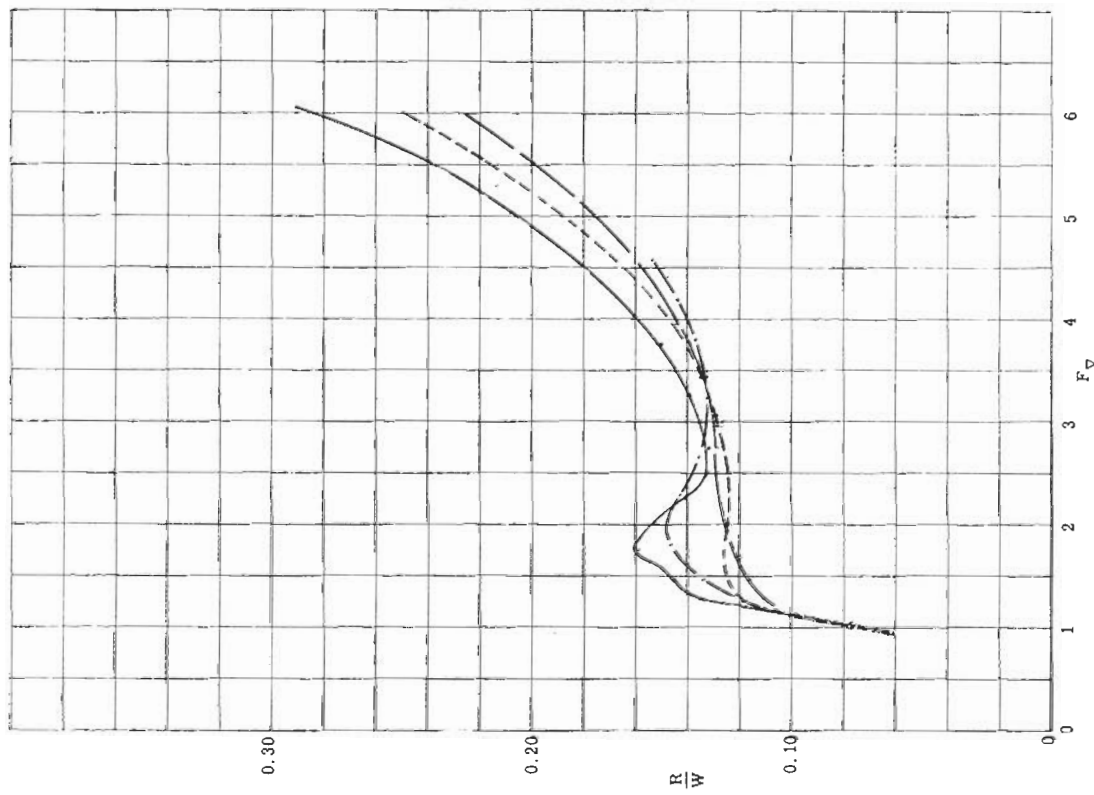
(c) $A_p/L_p = 8.5$

Fig. 14 Concluded

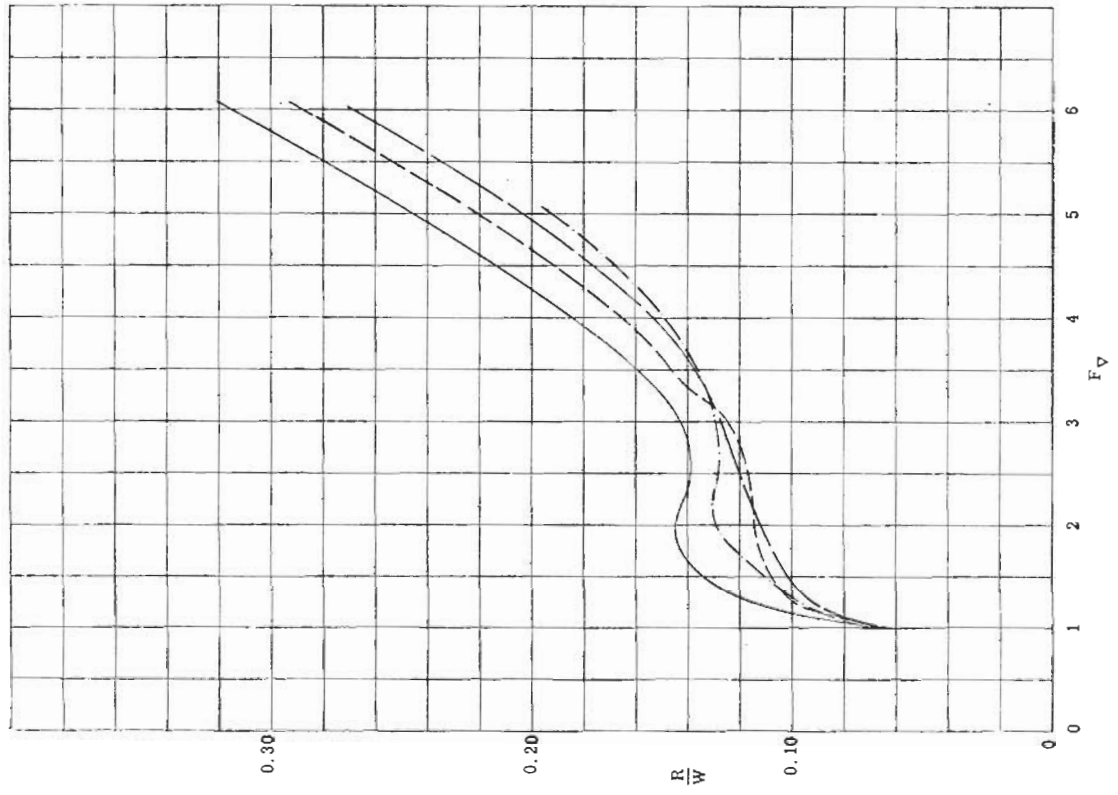


(a) $A_p/L_p = 5.5$

Fig. 15 Resistance/weight ratio versus speed coefficient for a boat weight of 10,000 lb. $L_p/B_{PX} \approx 3.06$



(b) $A_P/v^3 = 7.0$
Fig. 15 Continued



(c) $A_P/v^3 = 8.5$
Fig. 15 Concluded

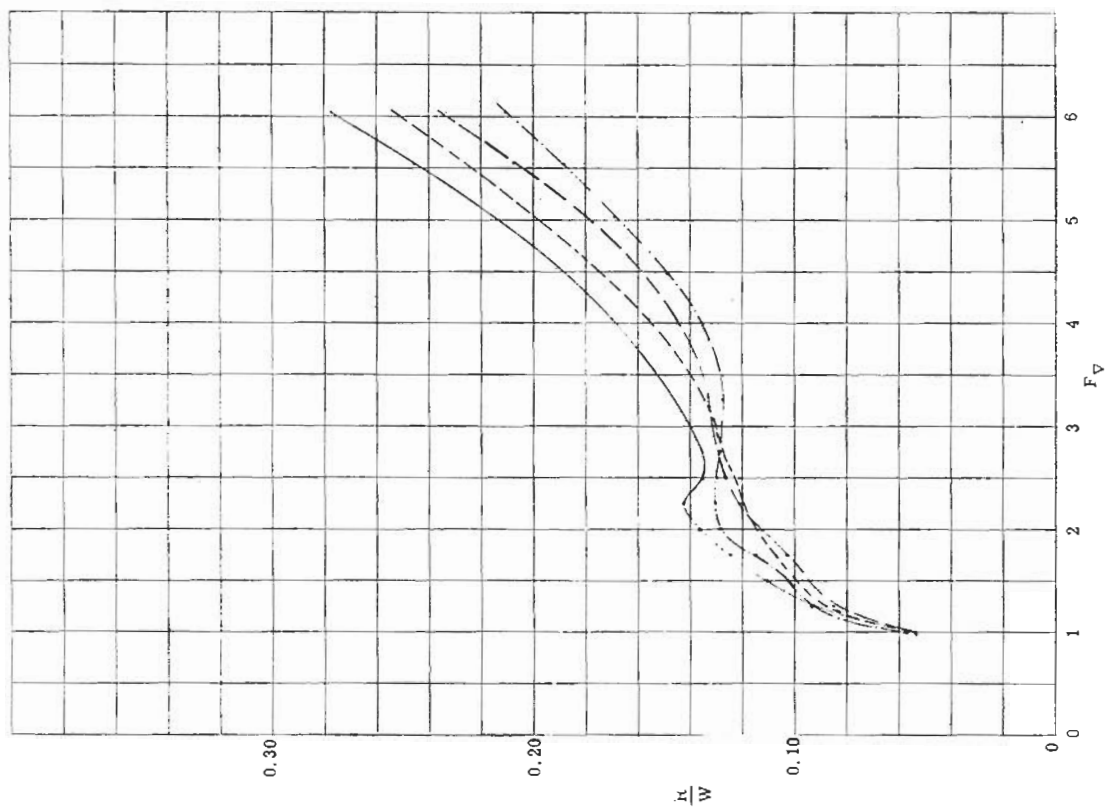


Fig. 16 Continued

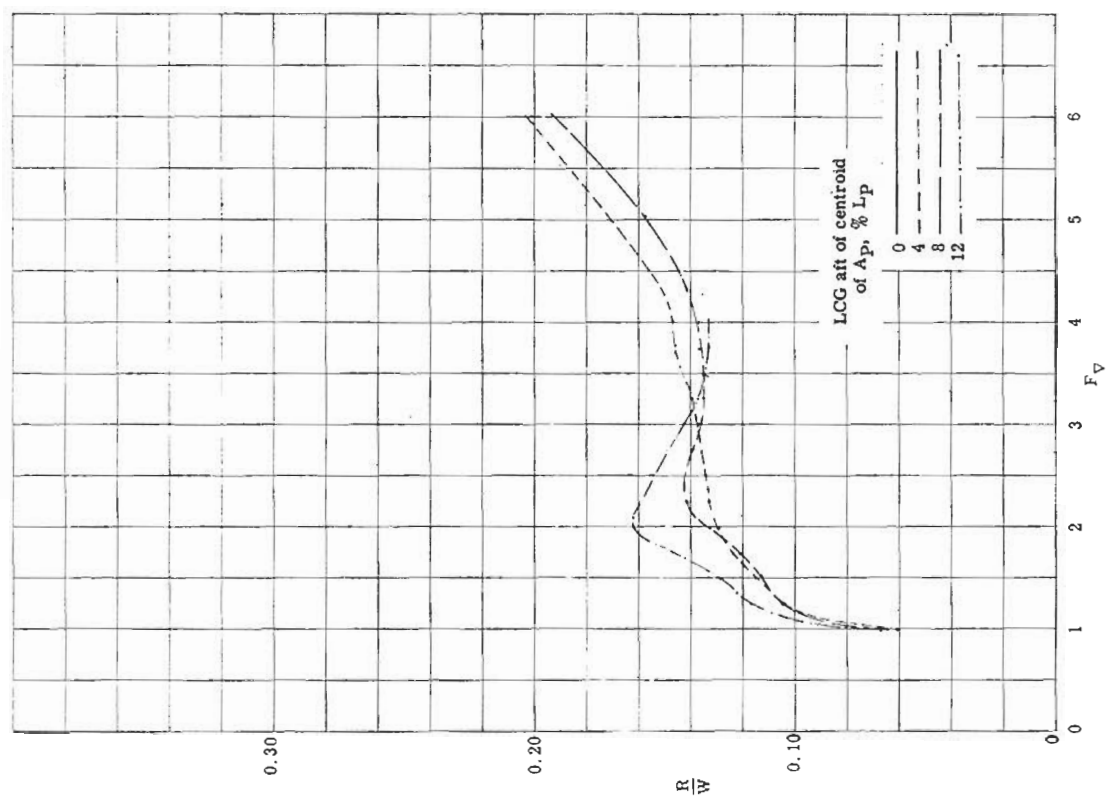
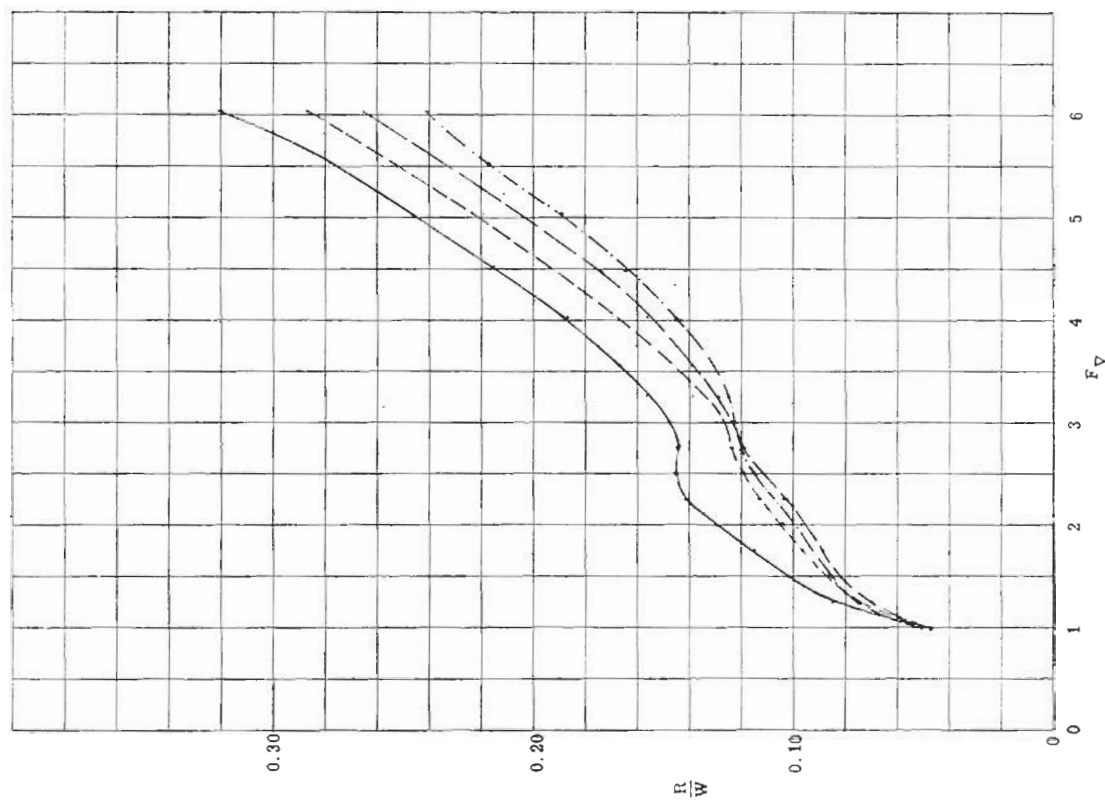
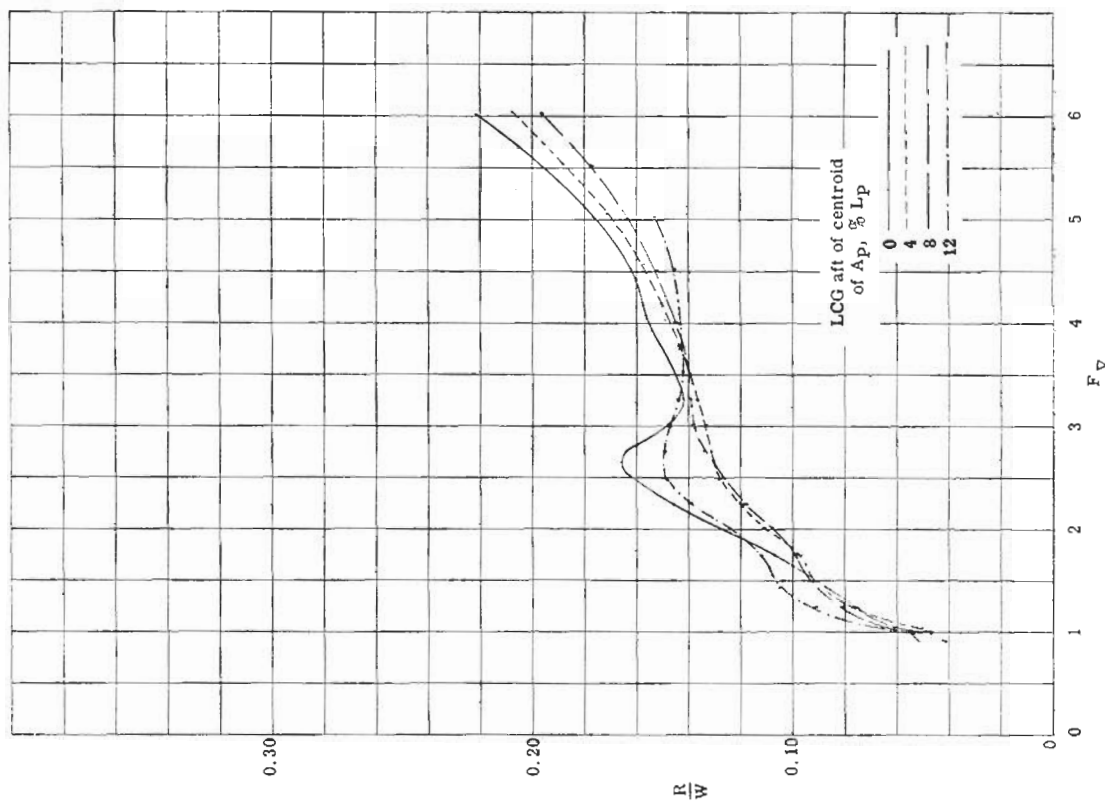


Fig. 16 Resistance/weight ratio versus speed coefficient for a boat weight of 10,000 lb. $L_P/B_{PX} = 4.09$



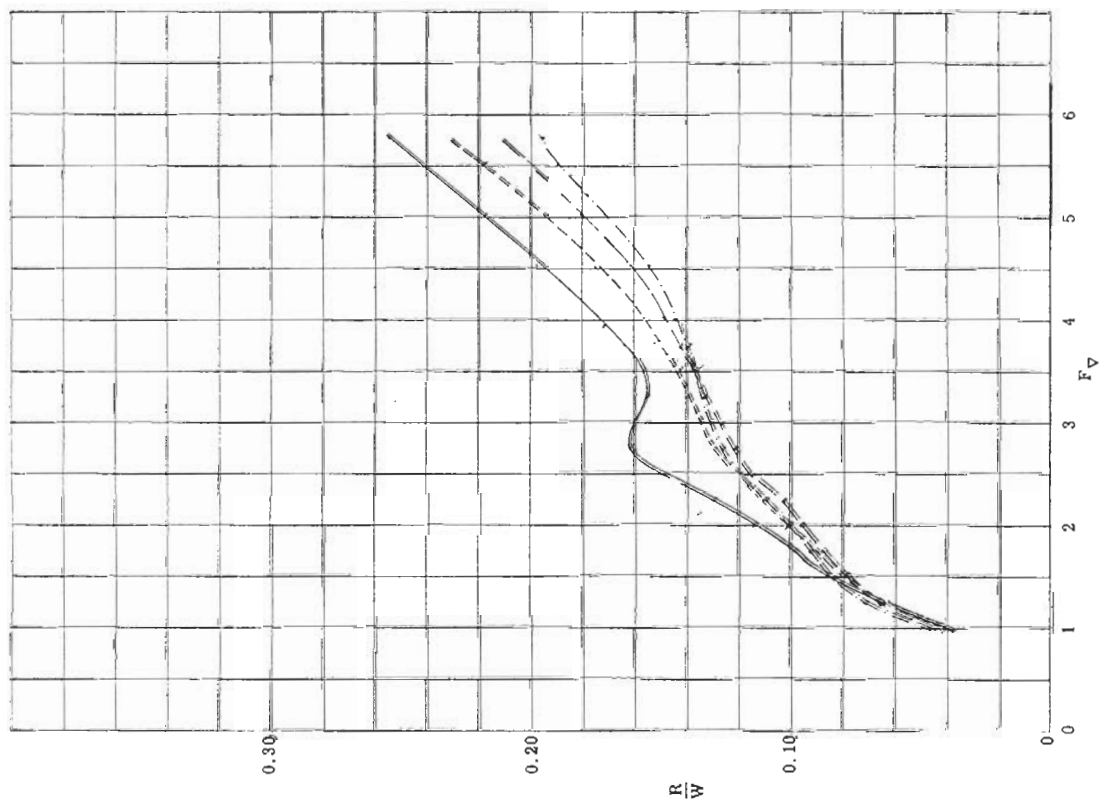
(c) $A_p/V^2 = 8.5$

Fig. 16 Concluded



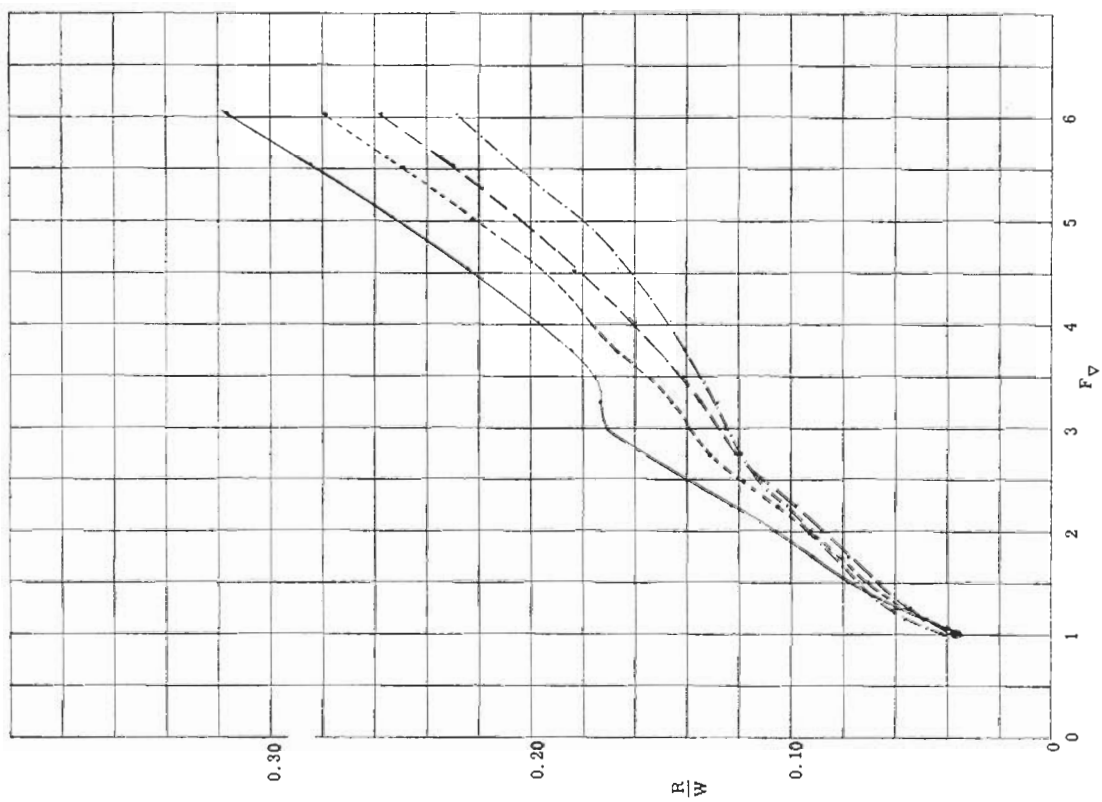
(a) $A_p/V^2 = 5.5$

Fig. 17 Resistance/weight ratio versus speed coefficient for a boat weight of 10,000 lb. $L_p/B_{PX} = 5.50$



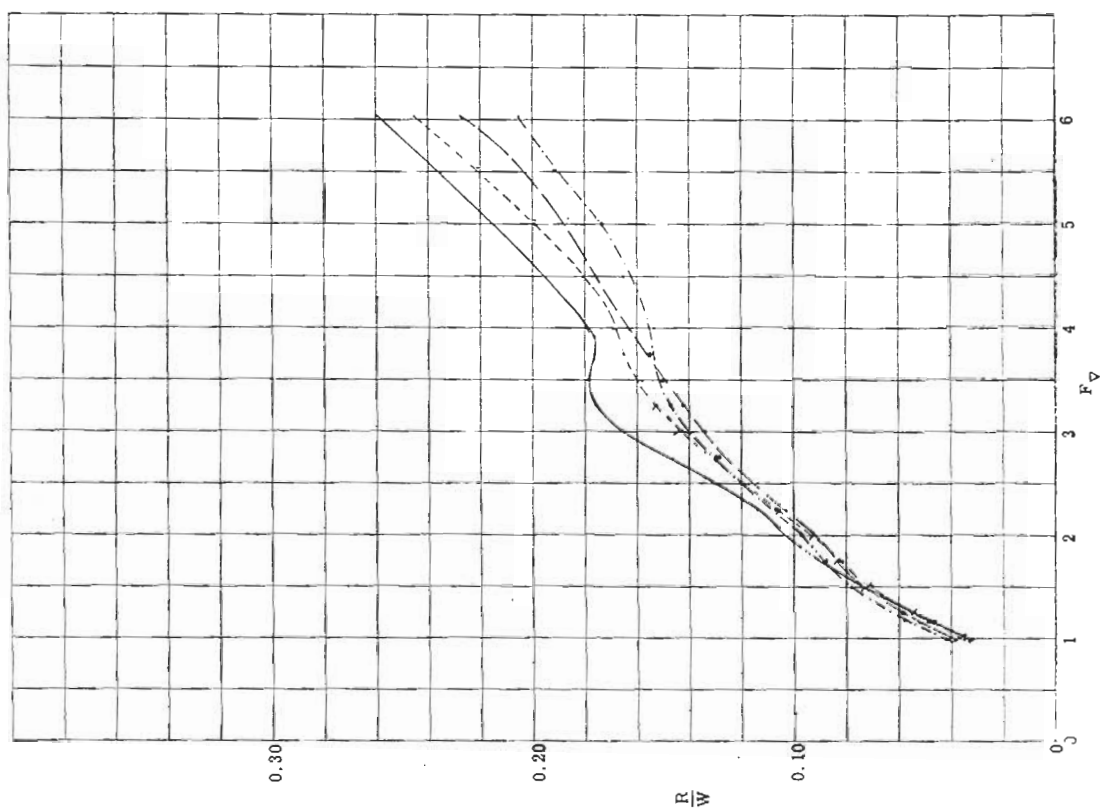
(b) $A_p/v^2 = 7.0$

Fig. 17 Continued

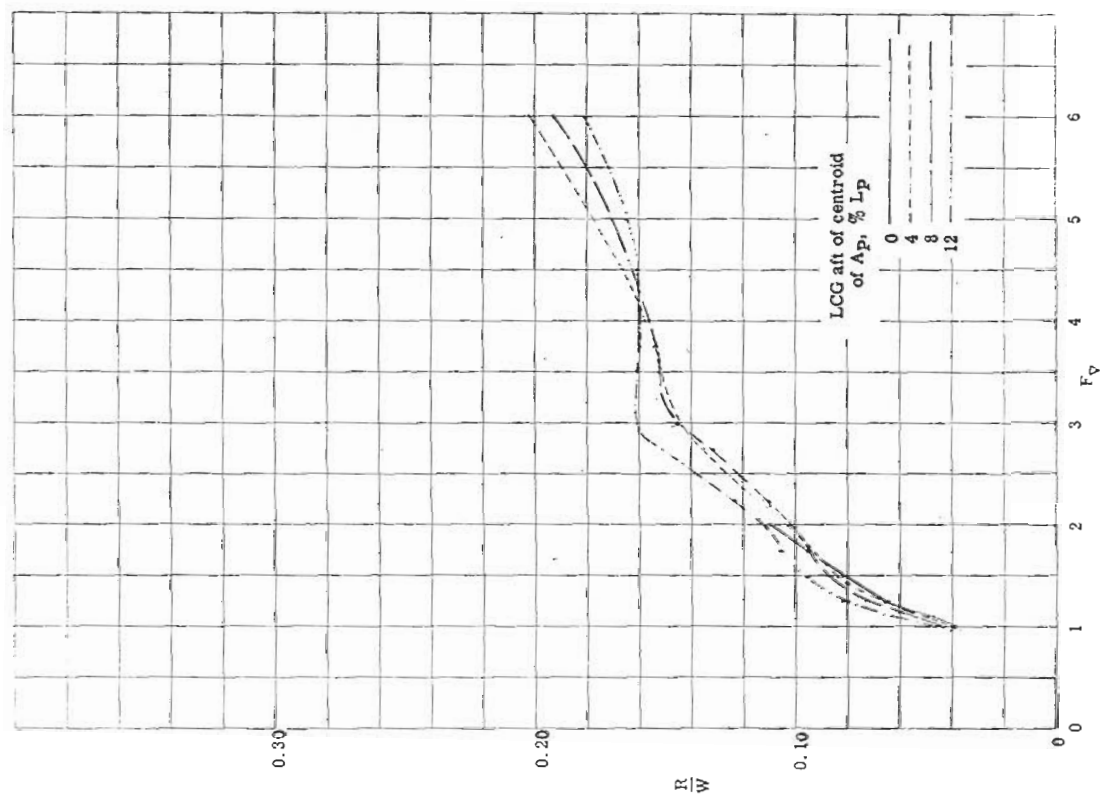


(c) $A_p/v^2 = 8.5$

Fig. 17 Concluded

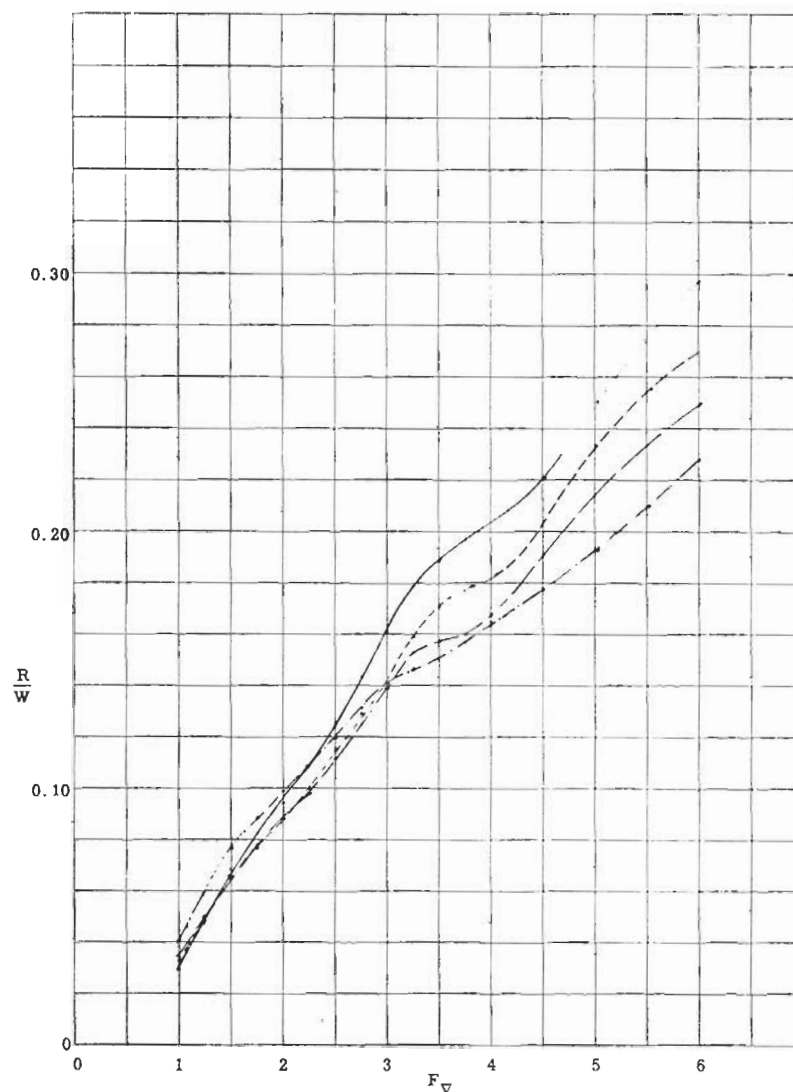


(a) $A_p/\nabla^2 = 5.5$



(b) $A_p/\nabla^2 = 7.0$

Fig. 18 Resistance/weight ratio versus speed] coefficient for a boat weight of 10,000 lb. $L_P/B_{PX} = 7.00$



(c) $A_P/\nabla^{2/3} = 8.5$

Fig. 18 Concluded

expected for a short, wide hull than for a long, narrow hull because of the higher aspect ratio of the former. The fact that some contrary results were obtained is believed to be attributable to the lower aerodynamic drag of the narrow hulls.

In Fig. 8 the data in Fig. 7 have been cross-plotted against length-beam ratio. Resistance values from model tests of other representative planing-boat designs are also included in Fig. 8 in order to compare their performance with that of the series. At low speeds (below a F_v of 1.5), the hull forms of the series have slightly more drag than the other designs. At values of F_v of 2.0 and 2.5, the forms of the series have less drag than

most of the other designs, and at values of F_v of 3.0 and above, the hull forms of the series have less drag than any of the other designs.

Figs. 9 through 13, and also Figs. 14 through 18, are arranged in order of increasing length-beam ratio, so that the data for Model 4665 appear first. Three graphs, which correspond to three values of area coefficient, are shown for each model. The four sets of curves on each graph correspond to the four values of LCG location which were investigated.

A number of facts are evident from Figs. 9 through 13 (or from Figs. 14 through 18): A length-beam ratio of 2 is impracticably low be-

$A_P/\nabla^{2/3}$

Symbol

5.5	□	—	□	—	□
7.0	○	—	○	—	○
8.5	△	—	△	—	△

Model No.

 L_P/B_{PA}

4665	2.365
4666	3.69
4667-1	5.00
4668	6.72
4669	8.56

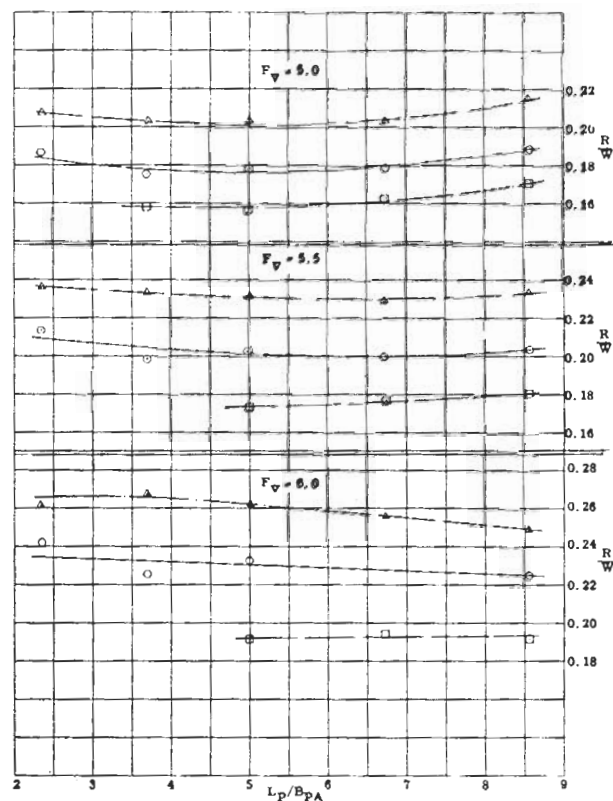
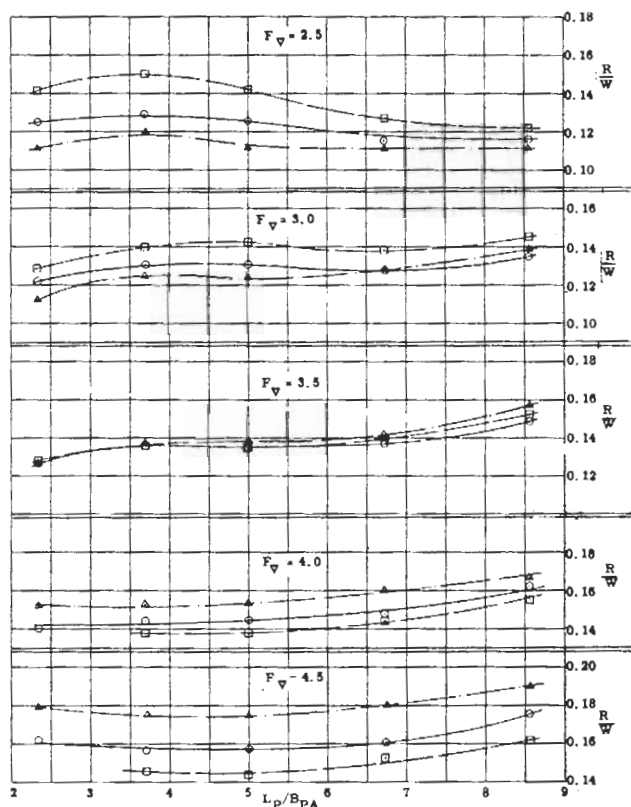
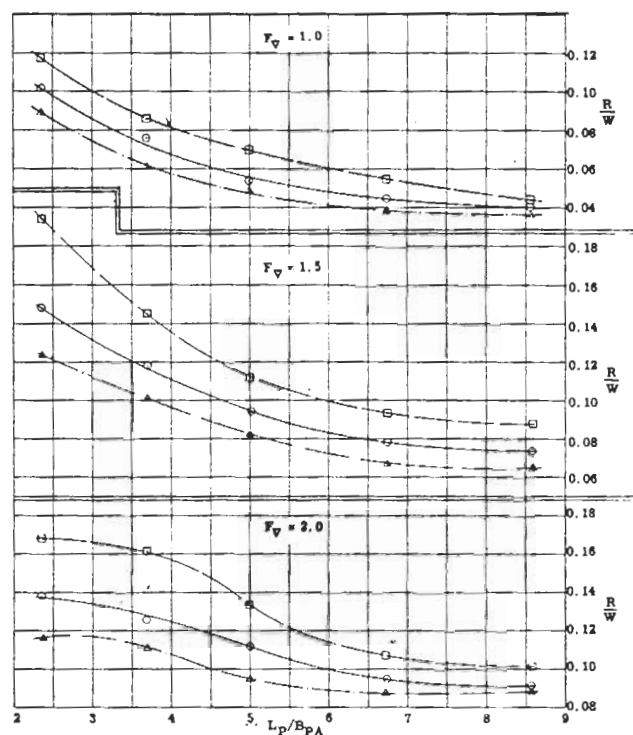


Fig. 19 Resistance/weight ratio versus length/beam (L_P/B_{PA}). 10,000 lb boat weight. LCG at 8 percent L_P aft of centroid of A_P

cause of the extreme hump in the drag curve. An LCG location at the centroid of the projected chine area (0 percent L_P aft of the centroid) is too far forward because the drag is consistently high throughout the speed range. At an area coefficient of 5.5 (which corresponds to a heavily loaded condition), an LCG location at 12 percent L_P aft of the centroid produces a pronounced hump in both the drag and trim curves and, therefore, this LCG location is too far aft. The graphs also indicate that for most of the range covered by the tests of this series, an LCG location between 4 and 8 percent L_P aft of the centroid will give good performance. However, the aftermost LCG location tested (12 percent) will always give the least drag at high speeds.

Resistance data from the tests of the different models, for one of the LCG locations investigated (8 percent L_P aft of the centroid), are cross-plotted against length-beam ratio in Fig. 19. This figure indicates a satisfactory consistency for the data from the different models. The figure also shows that for values of F_v below 3.5, a large hull (high value of area coefficient) will carry a given gross weight with the least resistance, whereas at values of F_v above 3.5, a small hull (low value of area coefficient) will give the least resistance for a boat of given gross weight.

For some of the tests of the series the models porpoised before the maximum intended speed ($F_v = 6$) was obtained. Porpoising is defined here to be the combined oscillation in pitch and heave which increases in amplitude with time at a constant speed of the model. For those tests in which porpoising occurred the recording of resistance, and so on, was necessarily confined to speeds below that at which porpoising began. Since the conditions which produce porpoising are of interest, an attempt was made to define the porpoising limit for the various models and test conditions. Accordingly, the speeds for inception of porpoising were determined for the various conditions of loading and LCG location by towing each model at gradually increasing small increments of speed until the model was observed to become unstable. For the most part, this work was done with Models 4665 and 4666, since these were the models which exhibited most of the porpoising instability for the test conditions of the series. Since porpoising is a dynamic phenomenon, it was considered at first that the moment of inertia of the models was a factor to be considered. Reference [5] indicates, however, that the moment of inertia does not affect the speed for the inception of porpoising of a planing hull, although it does affect the amplitude and frequency of the oscillation. Therefore the mo-

ment of inertia was not determined or closely controlled for the tests at the different weights and LCG locations.

The experimental values of the conditions corresponding to the inception of porpoising tended to collapse into a single curve when plotted in the form of $C_{Lb}/(l_{cp}/b)$ versus F_v . This plot is shown in Fig. 20, where the solid symbols correspond to the conditions at inception of porpoising. Some of the scatter is a result of the judgment involved in determining the point of porpoising inception. In order to obtain additional verification of the reliability of this line as a stability limit, selected points corresponding to stable operation at high speed for all five models were plotted on this figure using open symbols. These stable data points generally fell below the line defined by the porpoising-inception points and therefore, they tend to verify the validity of the line as a stability limit. The curve of the stability limit can be represented by the equation

$$\frac{C_{Lb}}{l_{cp}/b} = \frac{1.80}{(F_v)^{2.5}}$$

A need has been expressed for additional data on the resistance of hydrofoil boat hulls in the low-speed hullborne condition. Data on the resistance of heavily loaded amphibious craft are also needed. These additional data are necessary because previous tests of planing-boat models usually have not included measurements of test data at low speeds. Therefore, during the tests of this series, data were recorded at closely spaced increments of speed below a value of $F_v = 1.0$ in order to define carefully the low-speed drag. Resistance and angle-of-attack data for this low-speed range are presented in Figs. 21 through 25. The resistance data have been corrected to a boat weight of 100,000 lb.

Simplified Prediction Method

The complete model test results are presented in the Appendix so that the resistance of a boat of any size can be calculated from the results of any test. Accordingly, in those cases for which a projected new design corresponds closely enough to one of the tests of this series, the tabulated data can be used to predict the resistance of that particular boat. However, the spacing of the parameters investigated in the present study was quite wide, and therefore it will more generally be found that the values of length-beam ratio, area coefficient, and LCG location for a projected new design fall in between the values investigated.

Let us assume, for example, that the values selected for a projected new design are a weight of

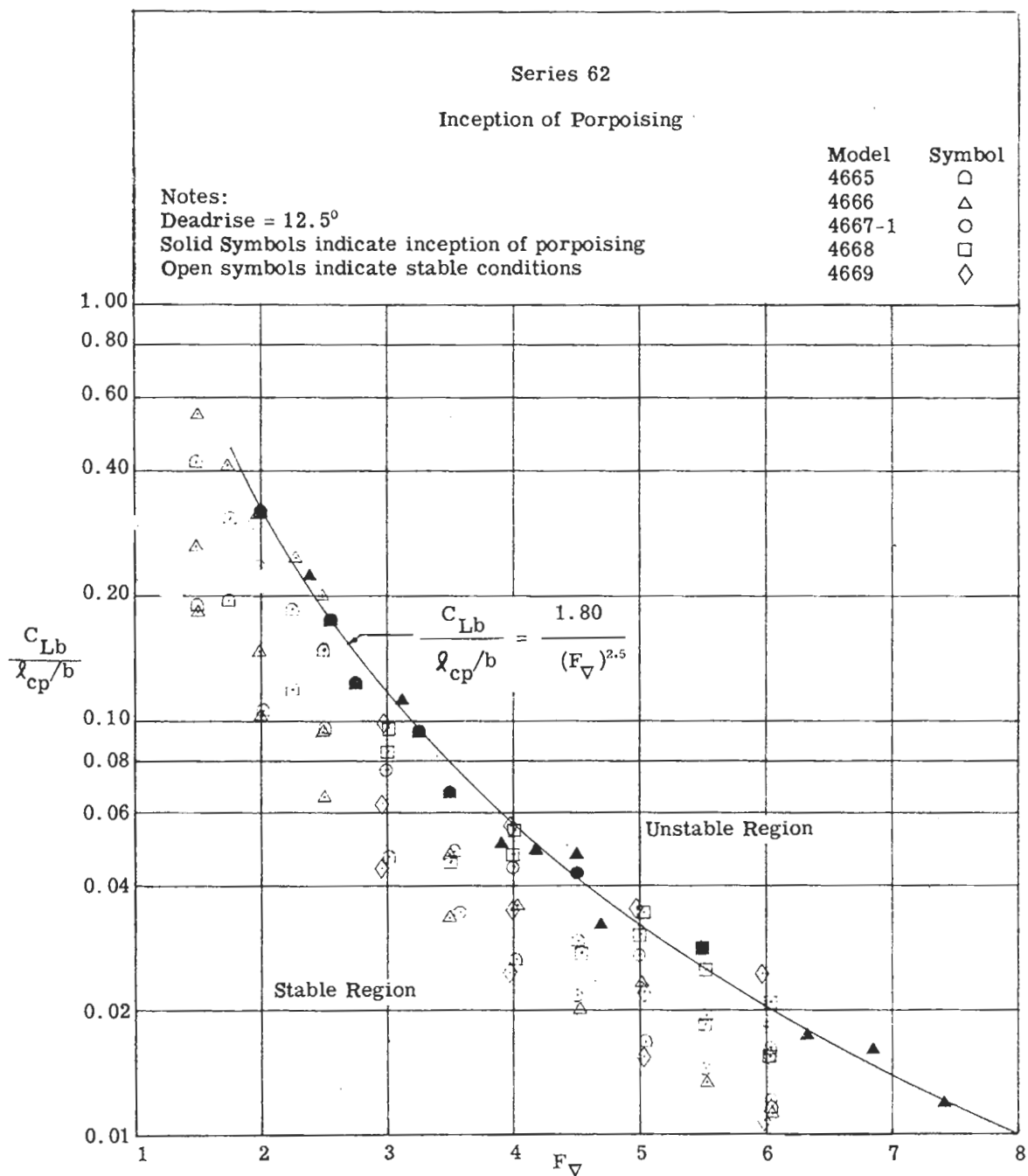


Fig. 20 Inception of porpoising for models of series 62

15,000 lb, a ratio of chine length to maximum chine beam of 3.5, and an area coefficient of 6.5. The data from the series have indicated that for most purposes the LCG location should fall into the relatively narrow range of from 4 to 8 percent L_P aft of the centroid. Therefore it seems reason-

able to simplify the present hypothetical design problem by assuming that the LCG location is to be at 8 percent L_P aft of the centroid (this LCG location was one of those investigated extensively during this series). Even with this simplifying assumption, the process of developing an accurate

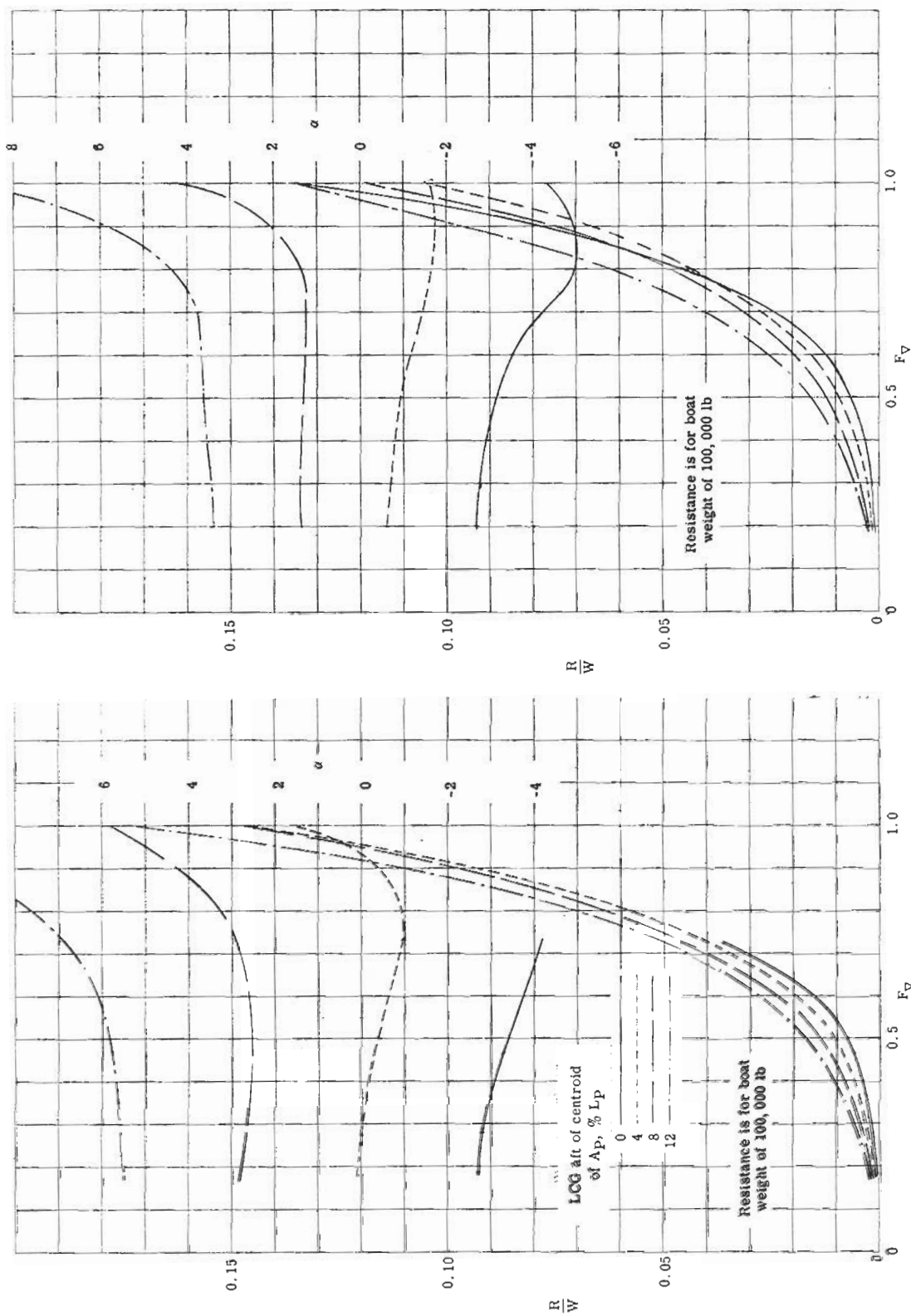
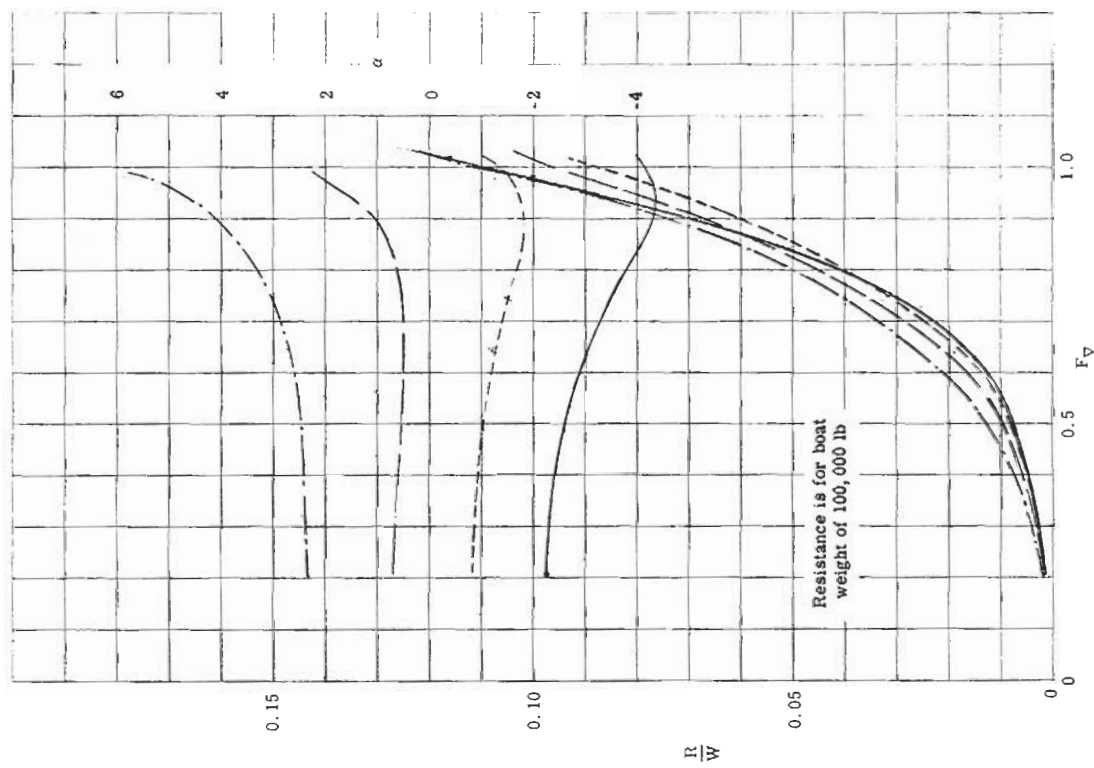


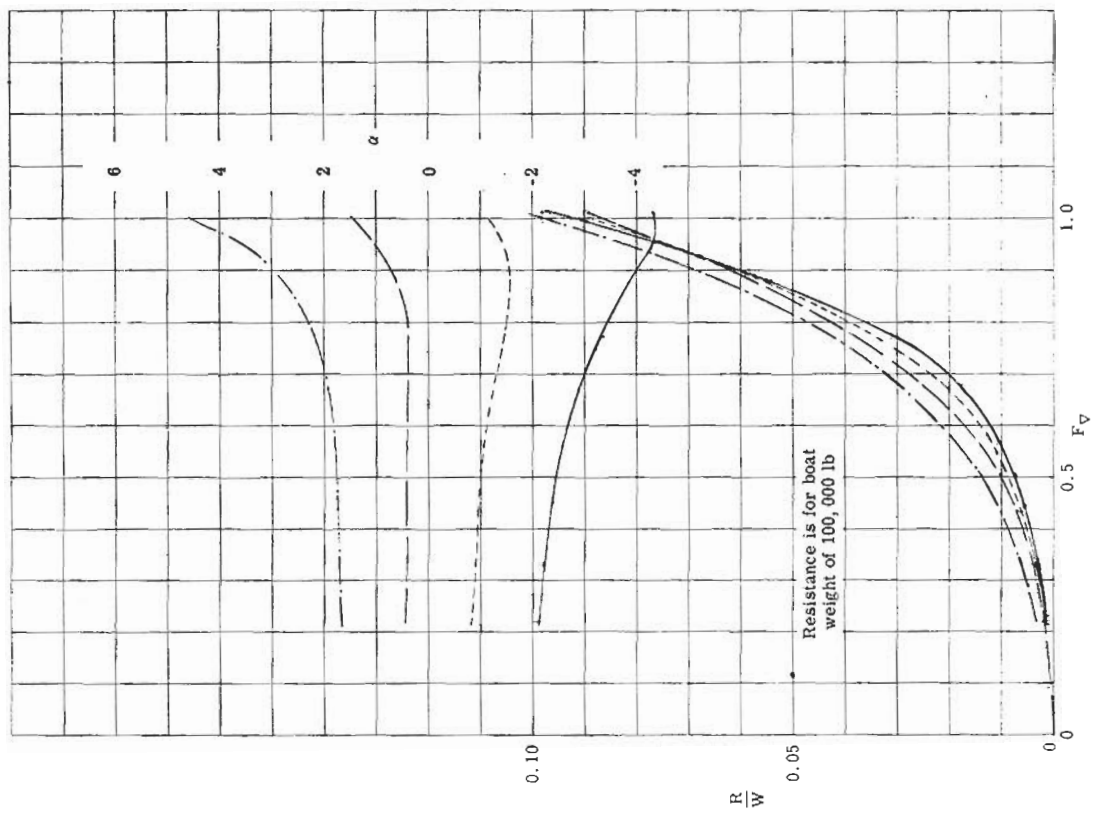
Fig. 21 Resistance/weight ratio and angle of attack at low speeds. $L_P/B_{PX} = 2.00$

Fig. 21 Continued



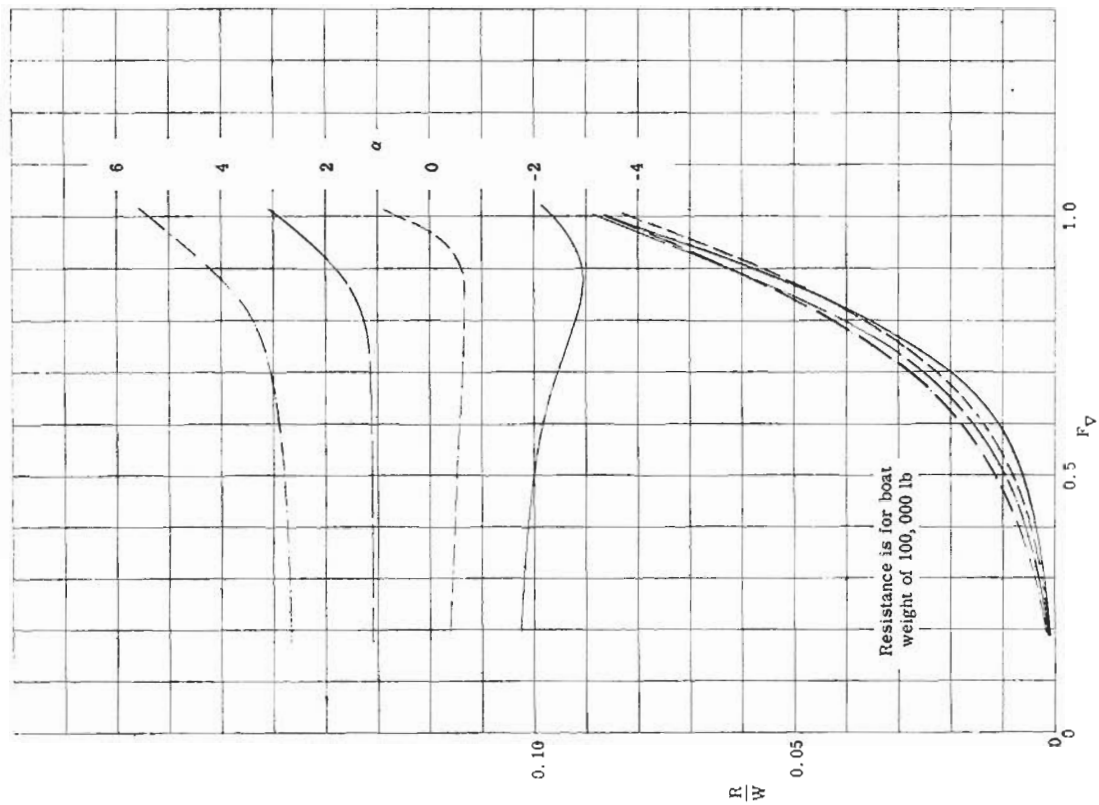
(c) $A_p/v^3 = 7.0$

Fig. 21 Continued



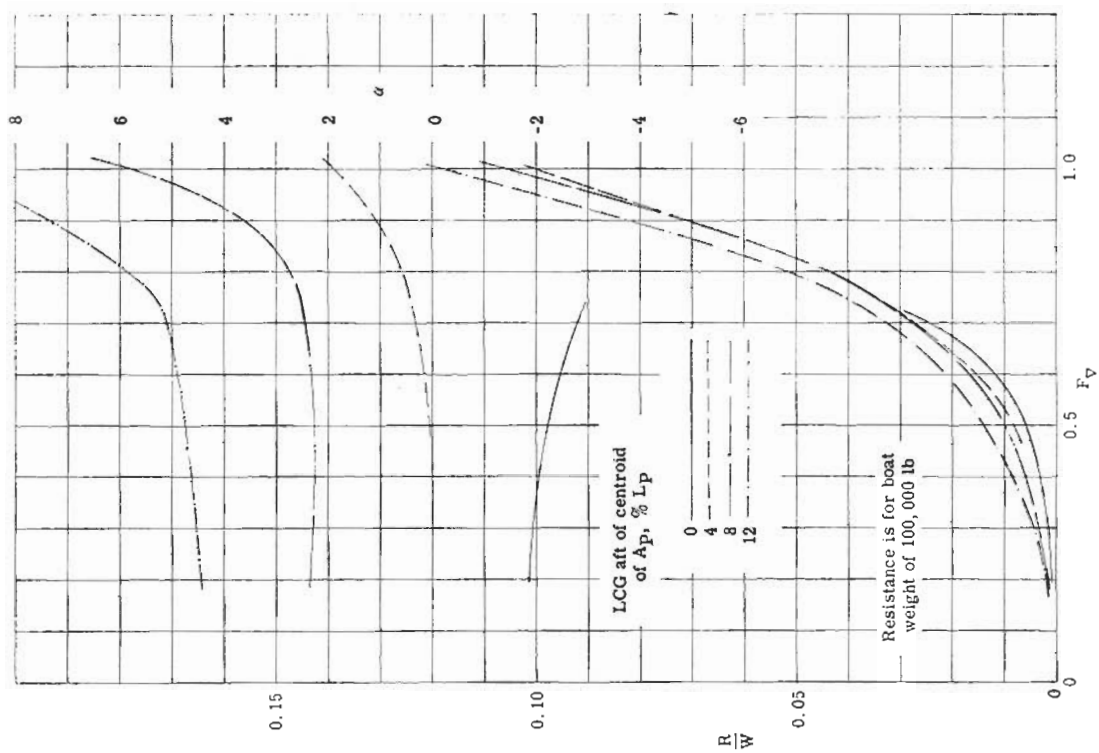
(d) $A_p/v^3 = 8.5$

Fig. 21 Concluded



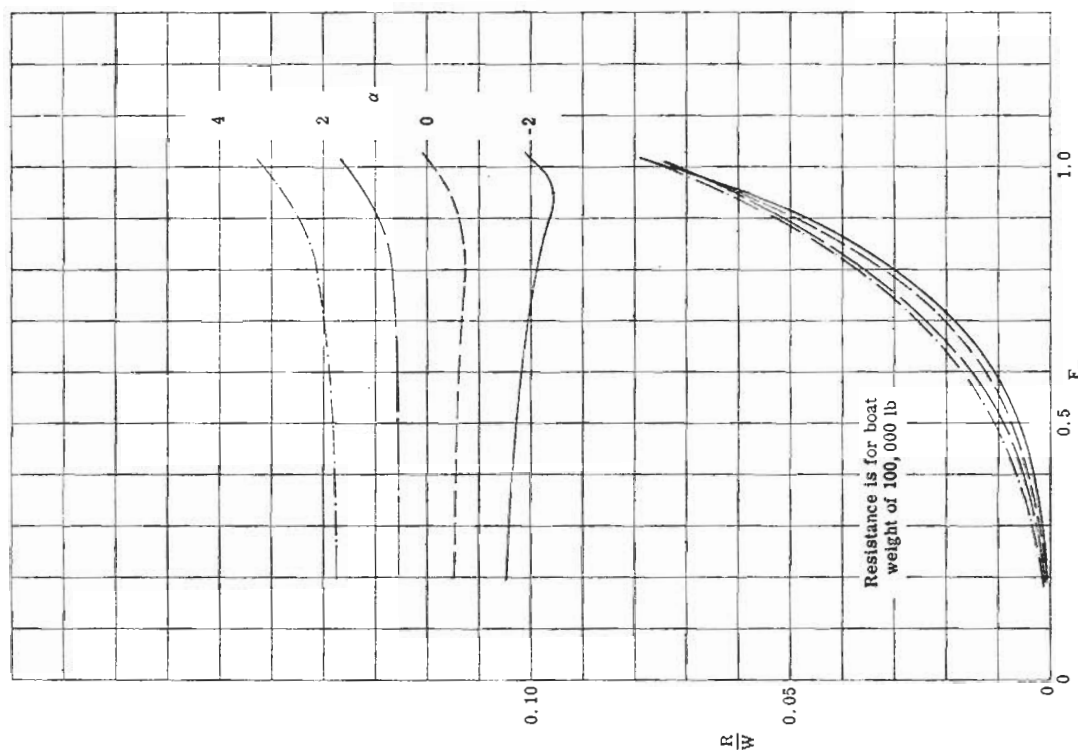
(b) $A_p/V^2 = 5.5$

Fig. 22 Continued



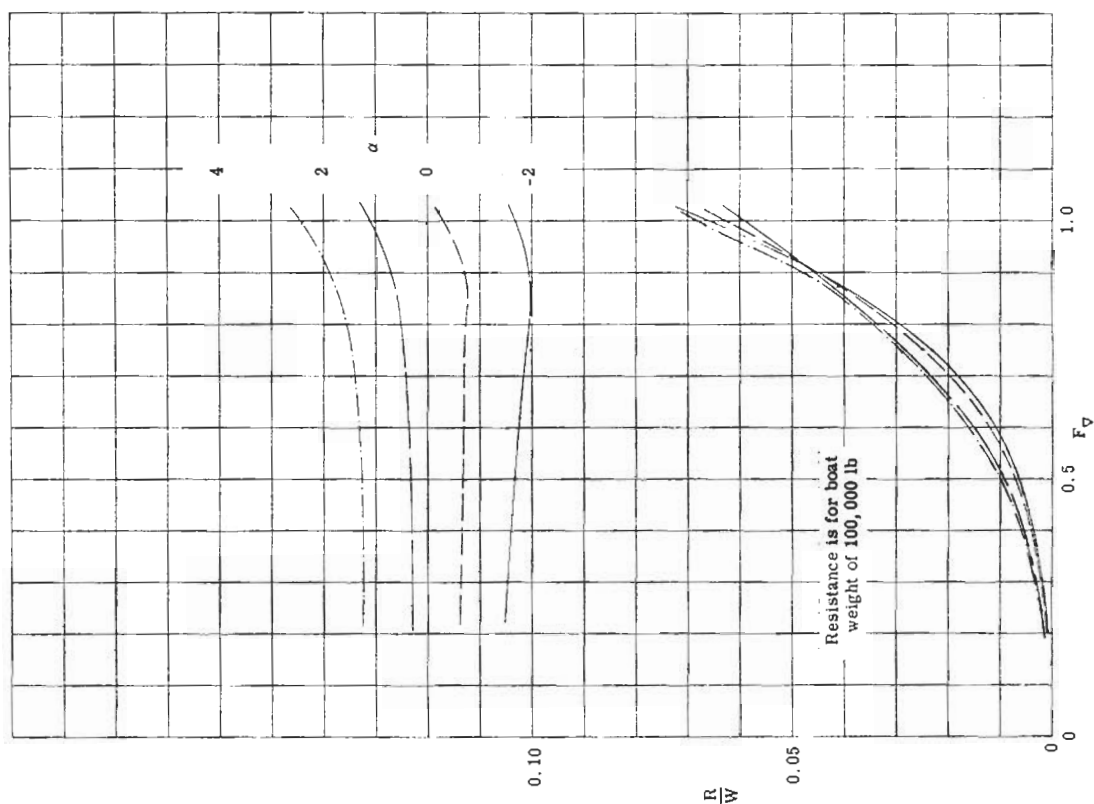
(a) $A_p/V^2 = 4.0$

Fig. 22 Resistance/weight ratio and angle of attack at low speeds. $L_P/B_{PX} = 3.06$



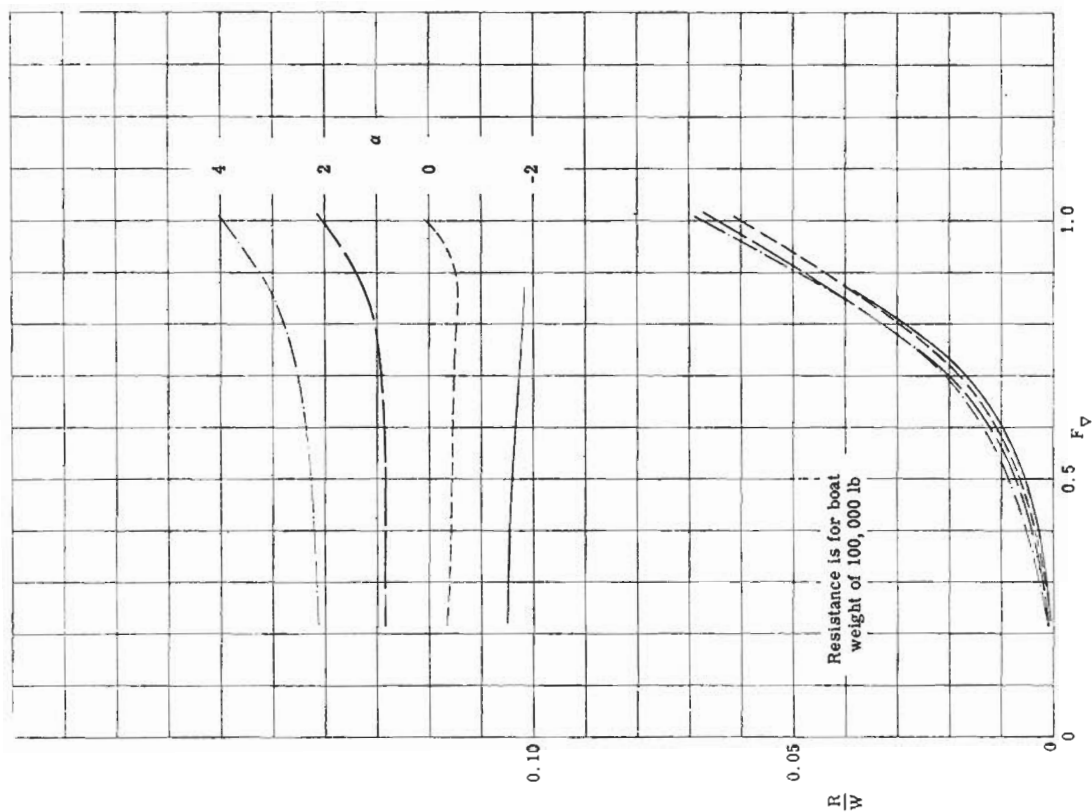
(c) $A_P/v^3 = 7.0$

Fig. 22 Continued

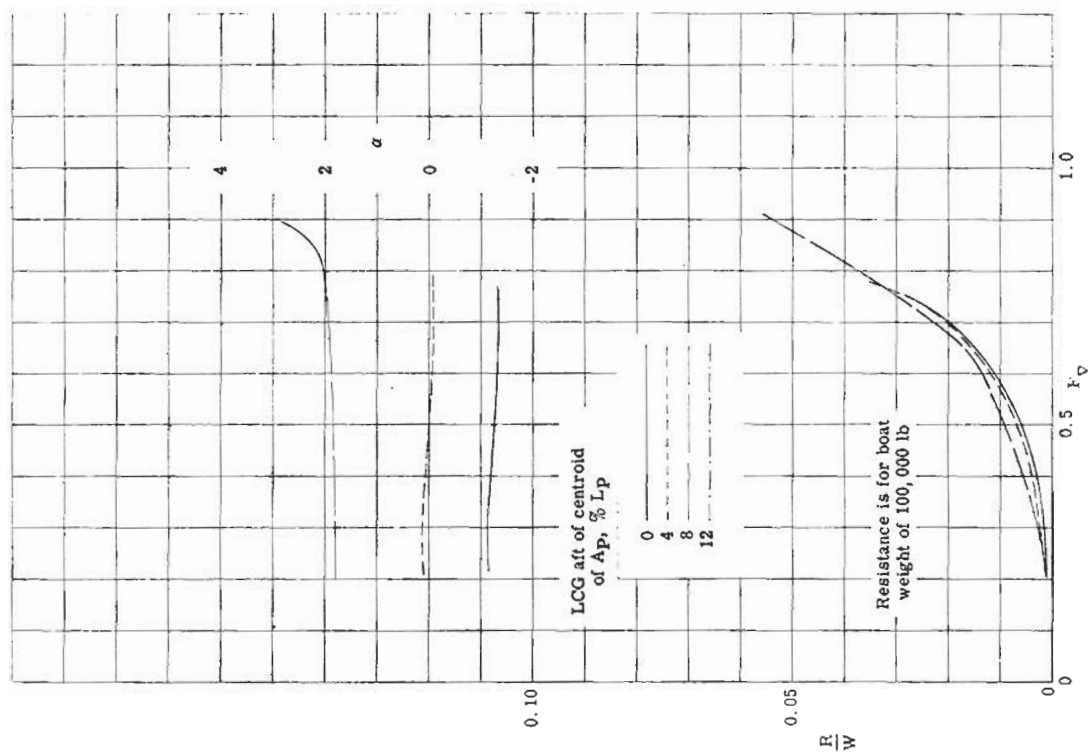


(d) $A_P/v^3 = 8.5$

Fig. 22 Concluded



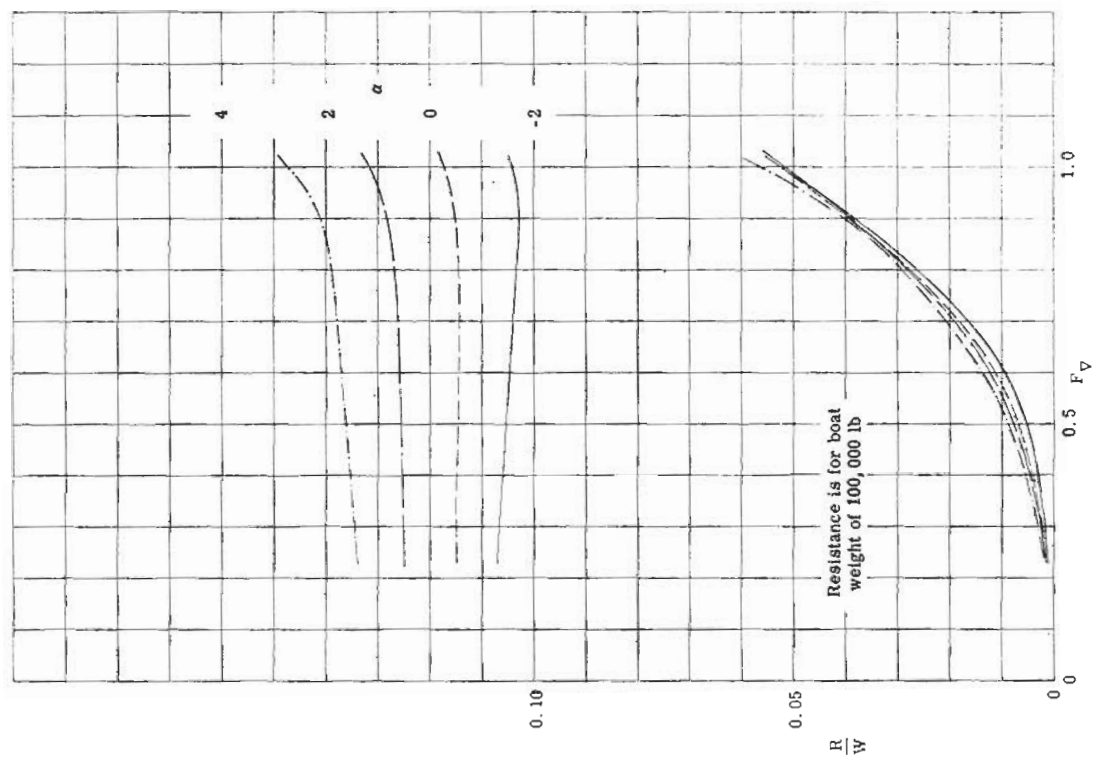
(a) $A_p/v^2 = 4.0$



(b) $A_p/v^2 = 5.5$

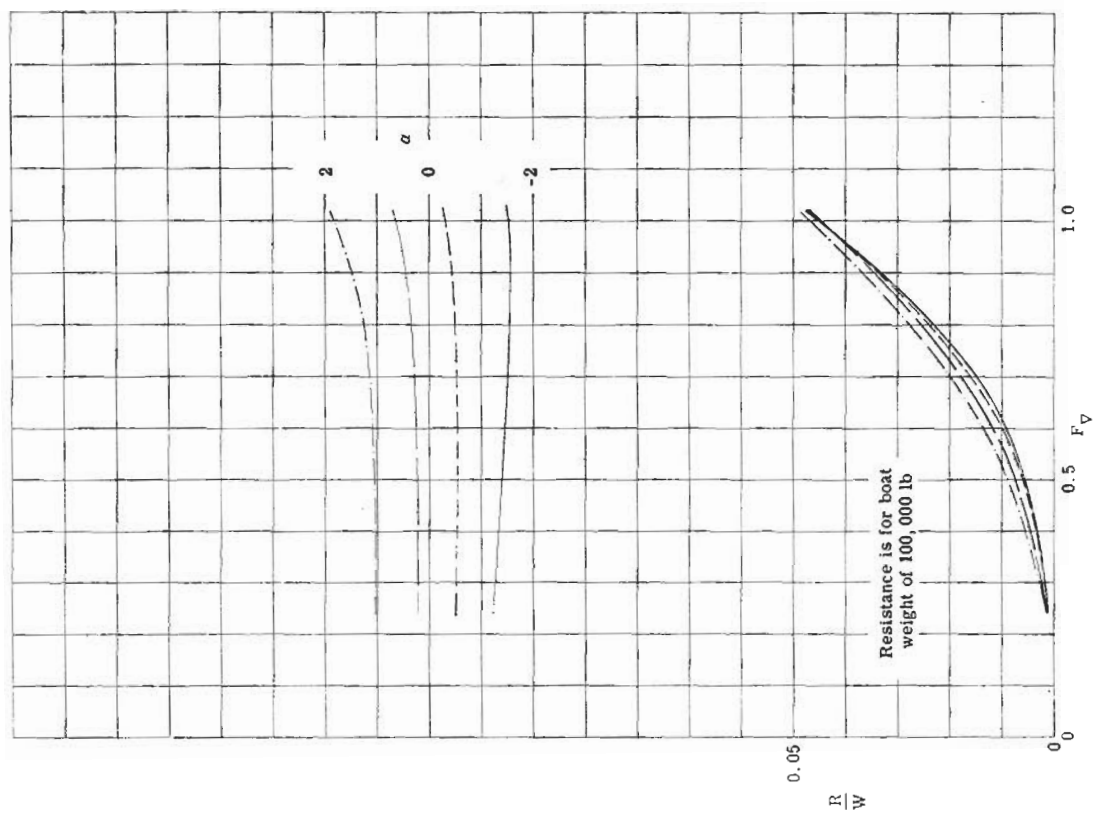
Fig. 23 Resistance/weight ratio and angle of attack at low speeds. $L_p/B_{px} = 4.09$

Fig. 23 Continued



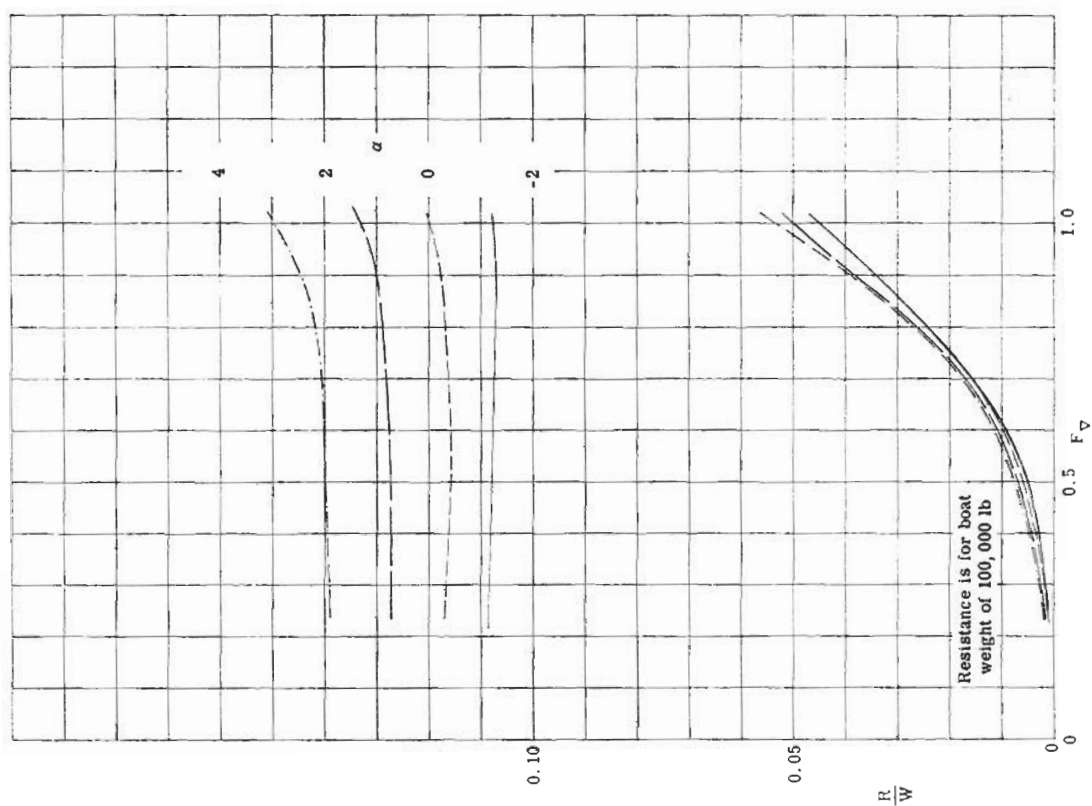
(c) $A_p/V^3 = 7.0$

Fig. 23 Continued



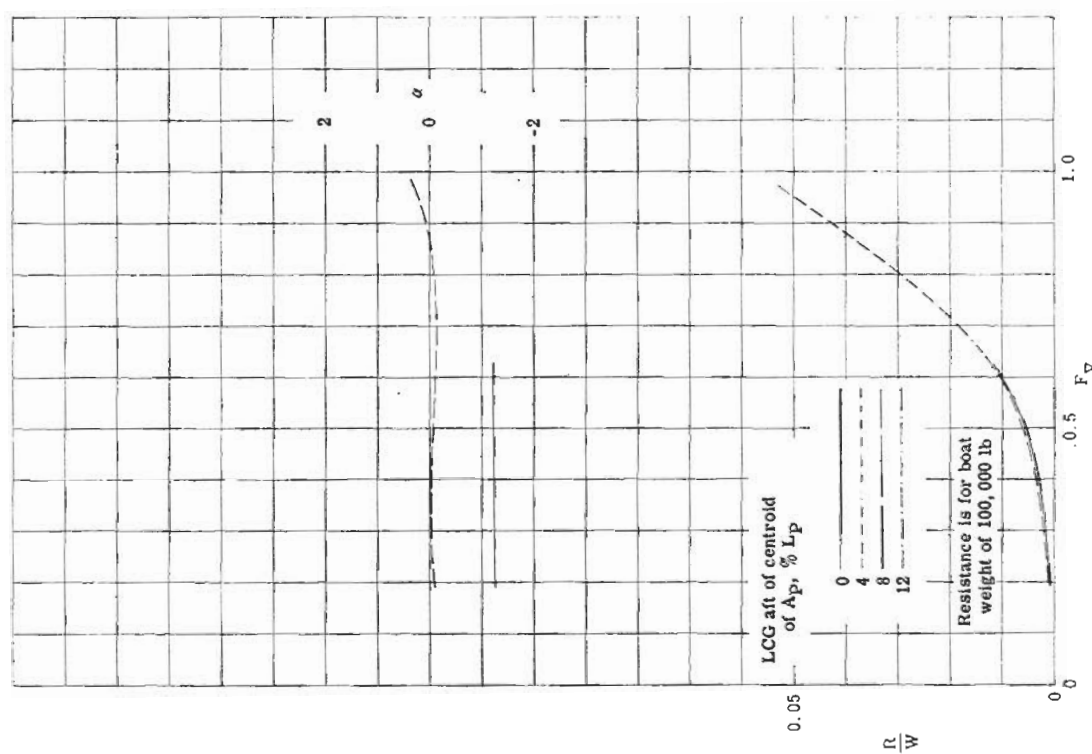
(d) $A_p/V^3 = 8.5$

Fig. 23 Concluded



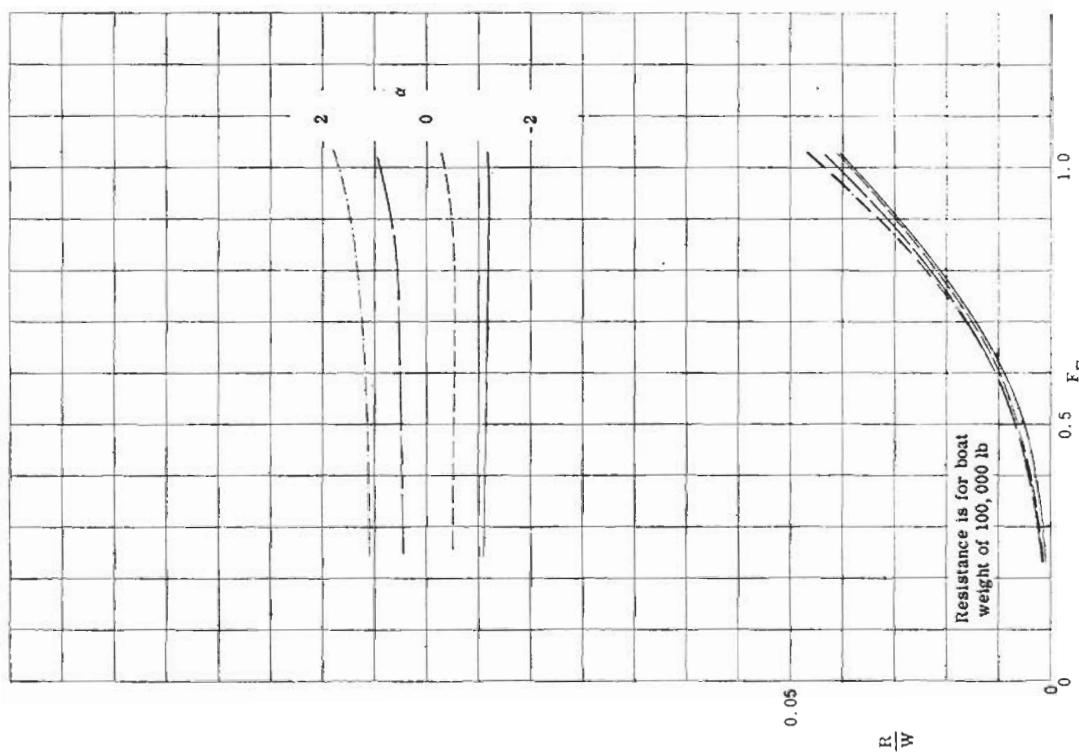
(b) $A_p/\nabla^2 = 5.5$

Fig. 24 Continued

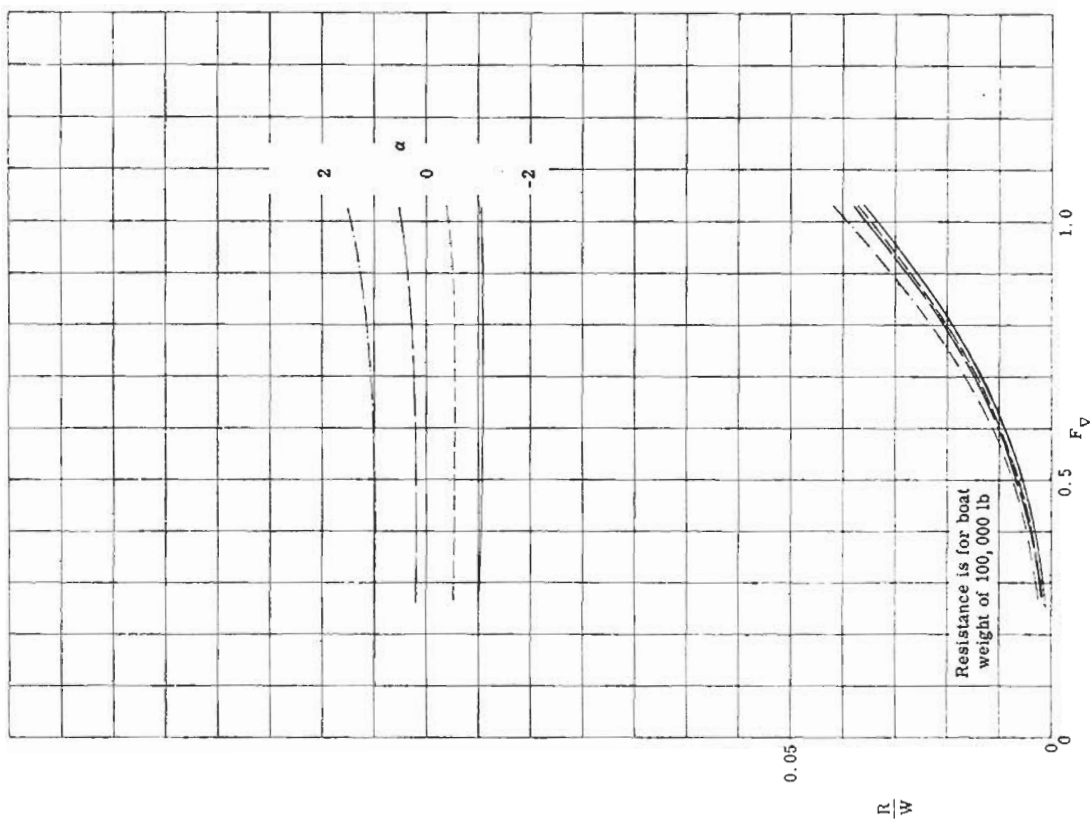


(a) $A_p/\nabla^2 = 4.0$
5.50

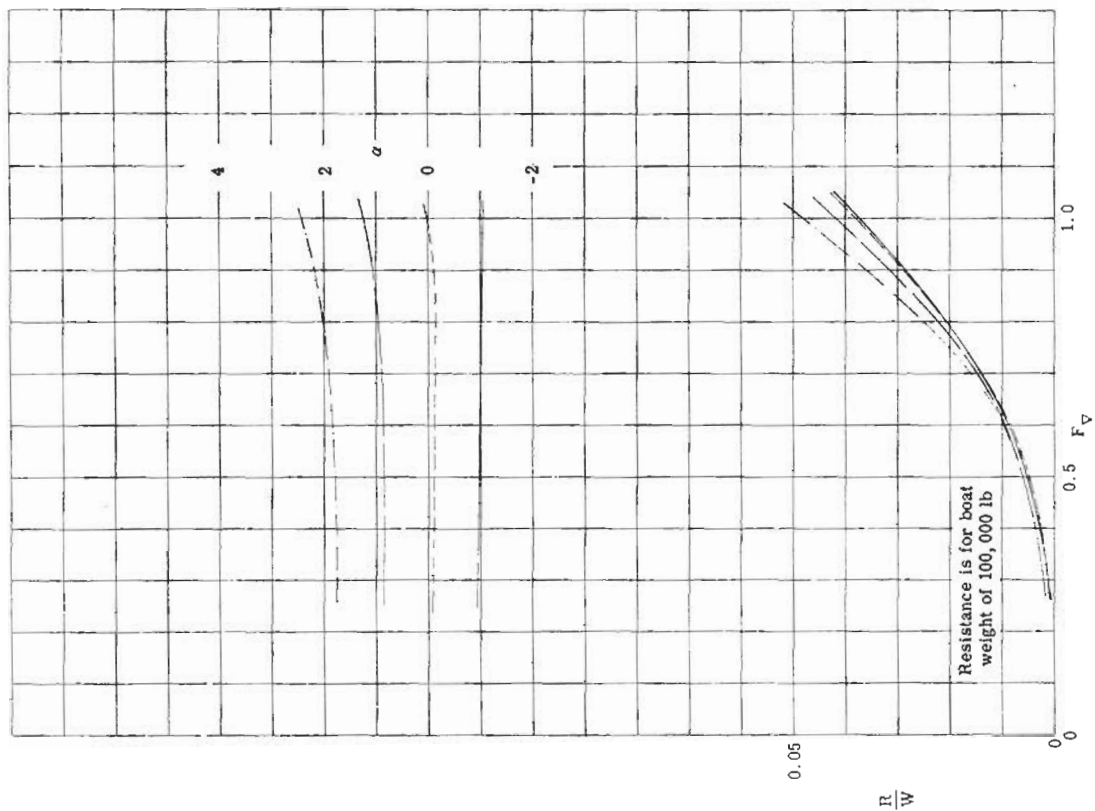
Fig. 24 Resistance/weight ratio and angle of attack at low speeds. $L_P/B_{PX} =$



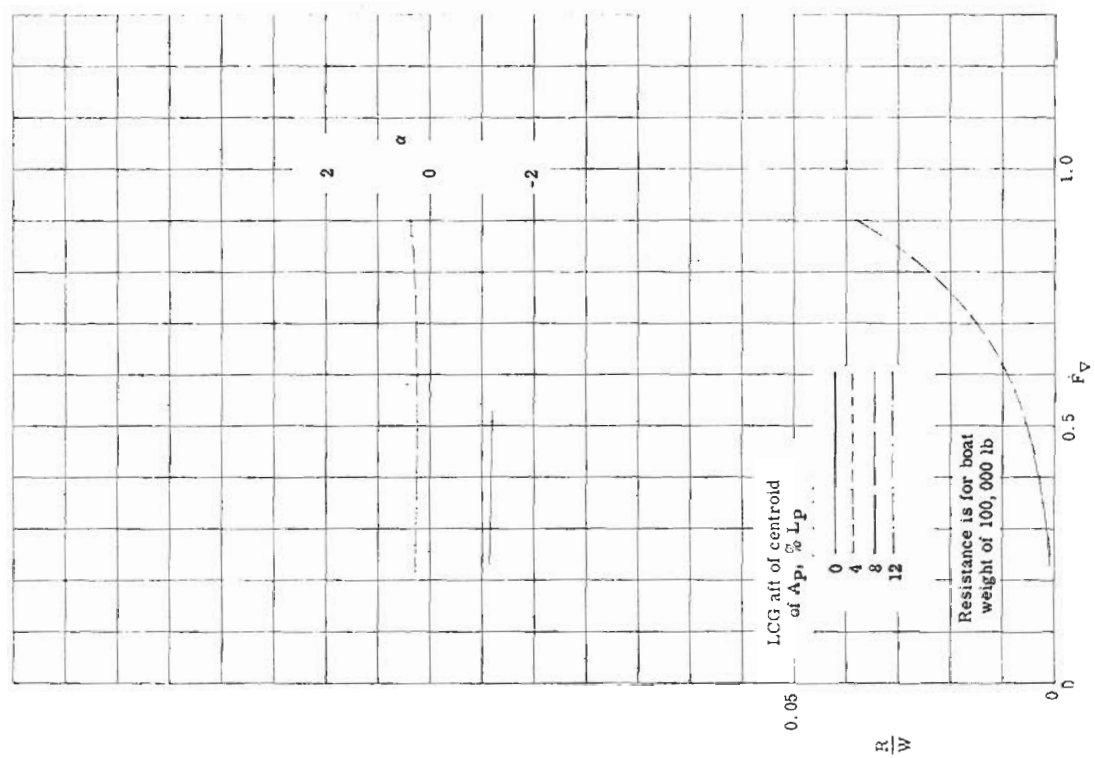
(c) $A_p/V^3 = 7.0$
Fig. 24 Continued



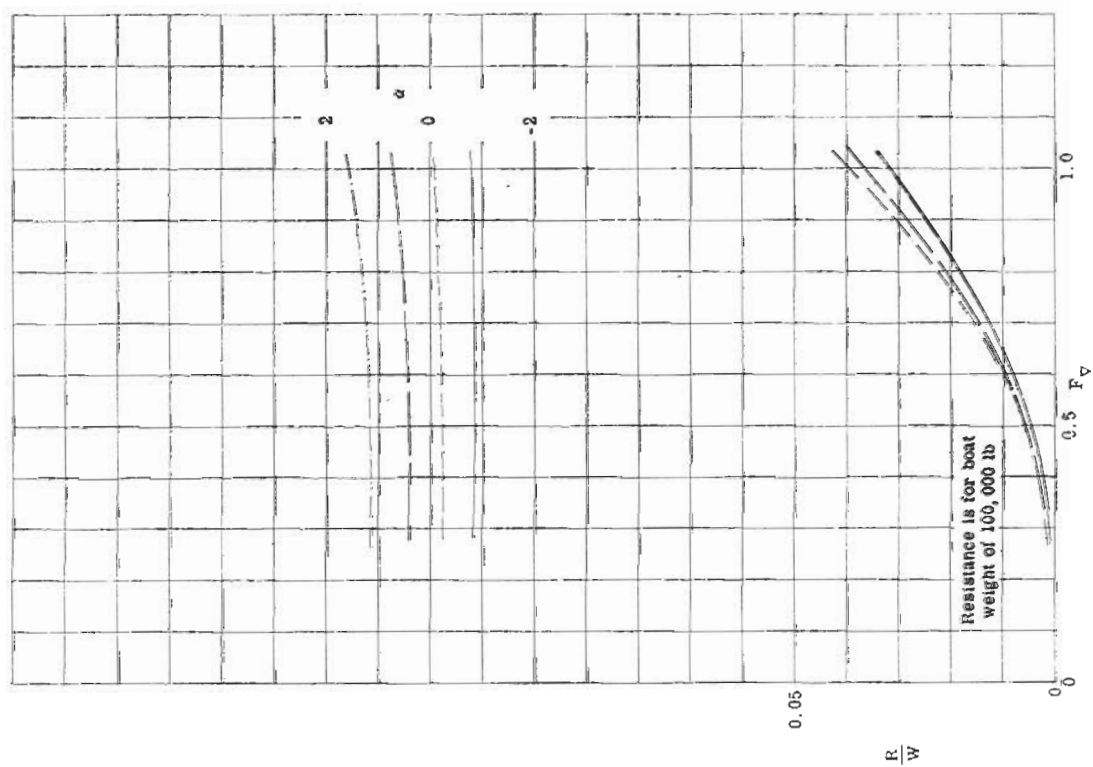
(d) $A_p/V^3 = 8.5$
Fig. 24 Concluded



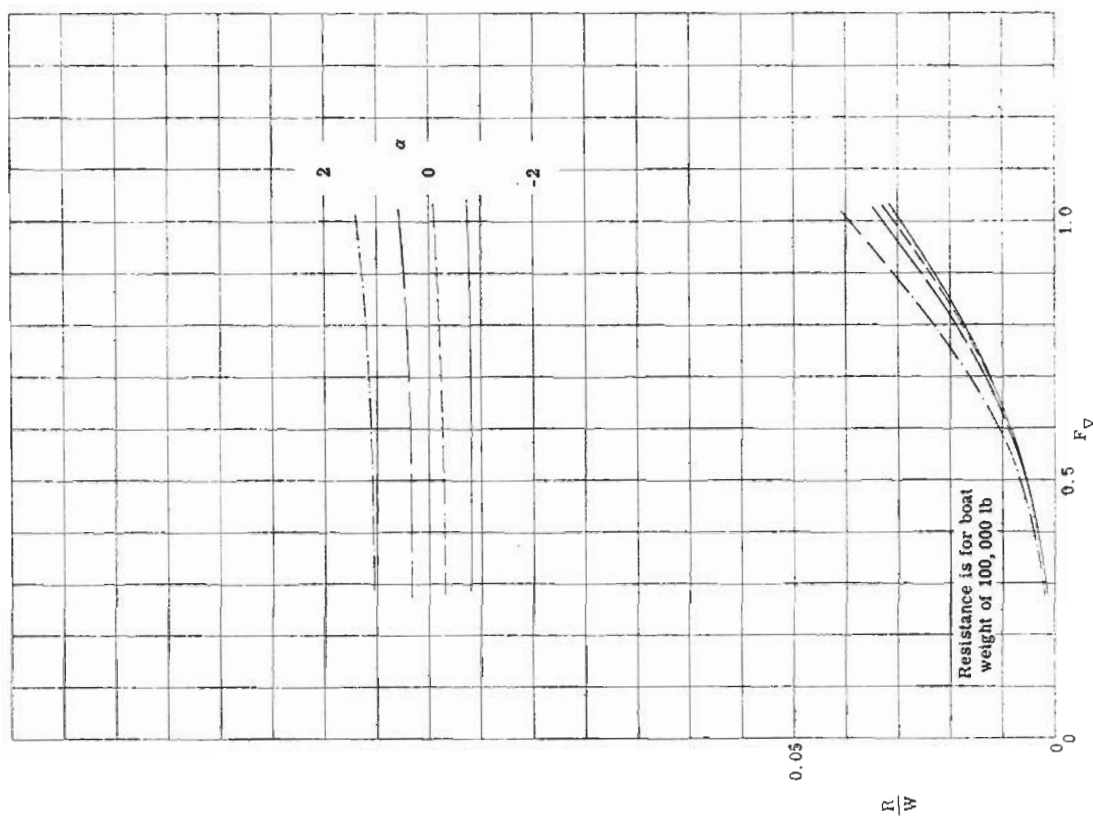
(b) $A_p/\nabla^3 = 5.5$
Fig. 25 Continued



(a) $A_p/\nabla^3 = 4.0$
Fig. 25 Resistance/weight ratio and angle of attack at low speeds.
 $L_F/B_{PX} = 7.00$



(c) $Ap/V^3 = 7.0$
Fig. 25 Continued



(d) $Ap/V^3 = 8.5$
Fig. 25 Concluded

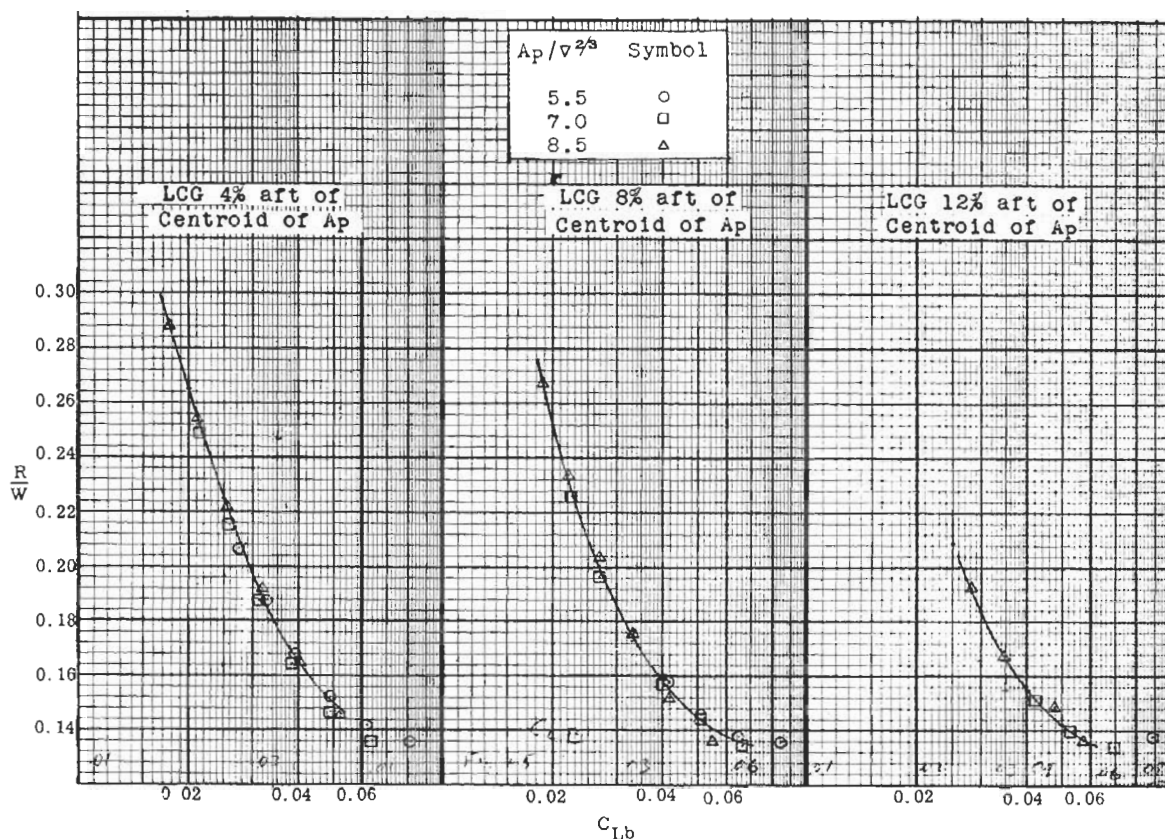


Fig. 26 Resistance/weight ratio versus lift coefficient (C_{Lb}), at high speed, from the tests of Model 4666. 10,000 lb boat weight

resistance curve for this arbitrary boat is a laborious task. Of the necessary steps, the first one would be to calculate the resistance of a boat of 15,000-lb displacement from each of those four tests which, in terms of length-beam ratio and area coefficient, bracket the assumed design values. After the four resistance curves for 15,000-lb displacement are obtained, the second step would be to interpolate between a pair of the curves (say between the curves for $L_P/B_{PX} = 3.06$ and $A_P/\nabla^{2/3} = 5.5$ and 7) to obtain a resistance curve for $L_P/B_{PX} = 3.06$ and $A_P/\nabla^{2/3} = 6.5$. The next step would be to interpolate between the two resistance curves for $L_P/B_{PX} = 4.1$ to obtain a curve for $L_P/B_{PX} = 4.1$ and $A_P/\nabla^{2/3} = 6.5$. The final step would be to interpolate between the two resistance curves for $A_P/\nabla^{2/3} = 6.5$ to obtain a curve for the assumed design values of $L_P/B_{PX} = 3.5$ and $A_P/\nabla^{2/3} = 6.5$.

A means of avoiding this laborious process is suggested by previous work at the Model Basin with equations for the high-speed performance of planing hulls. This work has shown that at high

speed the resistance of a planing hull of given weight can be presented as a function of only the three variables, deadrise angle, aspect ratio, and lift coefficient. The deadrise angle of the portion of the hull which is wetted at high speed is constant for the models of the present series ($12\frac{1}{2}$ deg); as a result, the possibility is suggested that resistance for a given boat weight can be presented as a function of only two variables. The resistance as presented in Figs. 7 through 18 is a function of the three variables, F_∇ , area coefficient, and LCG location. In this case, if the number of variables determining the high-speed resistance can be reduced from three to two, the number of curves required to present the high-speed resistance data can be reduced by a factor of about three or four.

The first step in establishing the validity of the suggested approach was to read off values of R/W for Model 4666 (at high speed) from the curves in Fig. 15 and then to plot them against the corresponding values of lift coefficient. Lift coefficient is defined here as $W/(\rho/2)v^2b^2$, where b is the breadth over the spray strips at the

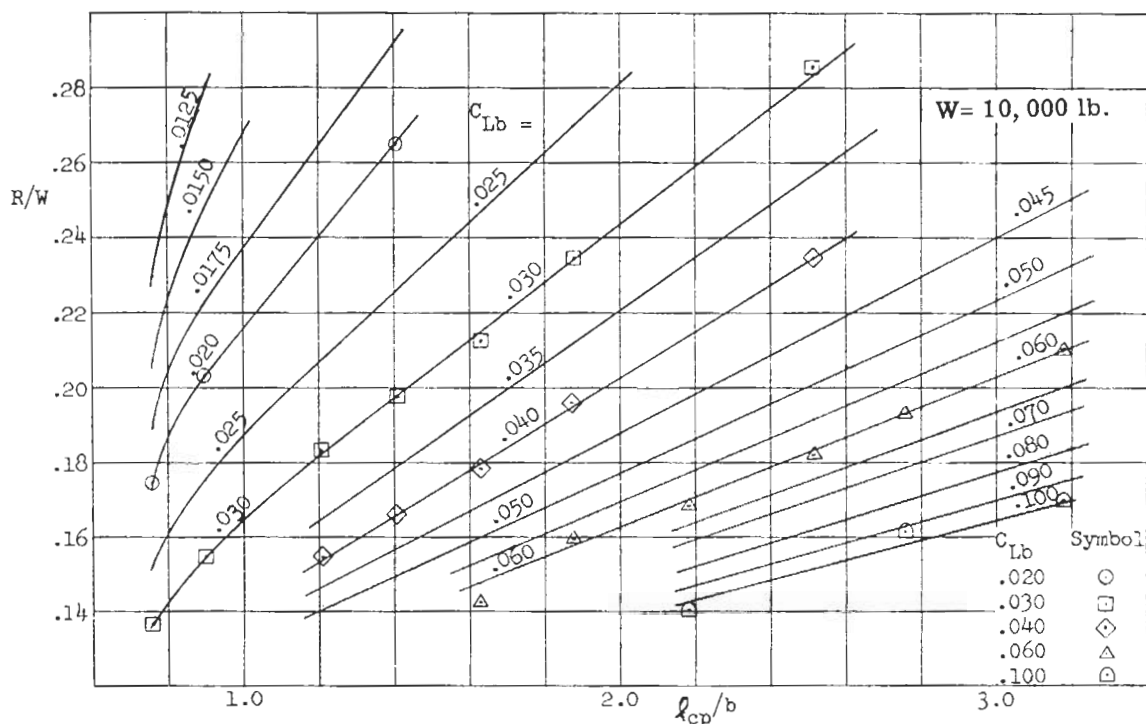


Fig. 27 Resistance/weight ratio versus l_{cp}/b with C_{Lb} as parameter

longitudinal location of the center of gravity. The resulting graph, Fig. 26, shows that the experimental results do, in fact, conform to what was indicated by the equations of resistance referred to previously. The resistance data from the tests at different loads, i.e., different area coefficients, collapse onto a single curve so that the resistance can be presented as a function of only two variables; that is, lift coefficient and LCG location. The data from the tests at the forwardmost LCG location (0 percent L_P aft of the centroid) did not collapse when plotted against lift coefficient. The assumption is that this is because the curved bow portion of the hull is wetted with this CG location. It was pointed out previously that this LCG location is outside the useful range because of the poor resistance characteristics.

The high-speed resistance data from the tests of the other models (except the 0 percent LCG data) were also plotted against lift coefficient. Values of R/W at suitable intervals of lift coefficient were then read off the resulting graphs (all were similar to Fig. 26), and plotted against l_{cp}/b , where l_{cp} is the distance of the center of pressure (or center of gravity) forward of the transom.

Fig. 27 is the graph obtained from this plotting. It can be seen that for any one value of lift coefficient, a single curve can be drawn through

the R/W -values from the tests of all five models.

From Fig. 27, it is possible to determine accurate values of resistance at high speed for a 10,000-lb planing boat with the same body plan as that of the series, but with any arbitrary value of the ratio l_{cp}/b (therefore any arbitrary length-beam ratio) and any arbitrary condition of loading. Since Fig. 26 is limited to one particular boat weight, the procedure just explained was repeated for boat weights of 1000, 3000, 30,000 and 100,000 lb. Thus a graph similar to Fig. 27 was obtained for each of the boat weights treated.

Because of the way in which the data from the tests at the different loads had been found to collapse onto a single curve, Fig. 26, and the way in which the data from the tests of the different models then fell into line when plotted against l_{cp}/b , Fig. 27, it was necessary to utilize only a small number of the available tests in order to prepare the graphs for the different boat weights. More specifically, only the data for LCG locations of 4 and 12 percent L_P aft of the centroid were used, and at each LCG location the data for only one load, i.e., one area coefficient, were used. Therefore, only ten tests were utilized, rather than the forty-five tests which were available.

After a graph had been prepared for each of the various boat weights, the cross curves shown in

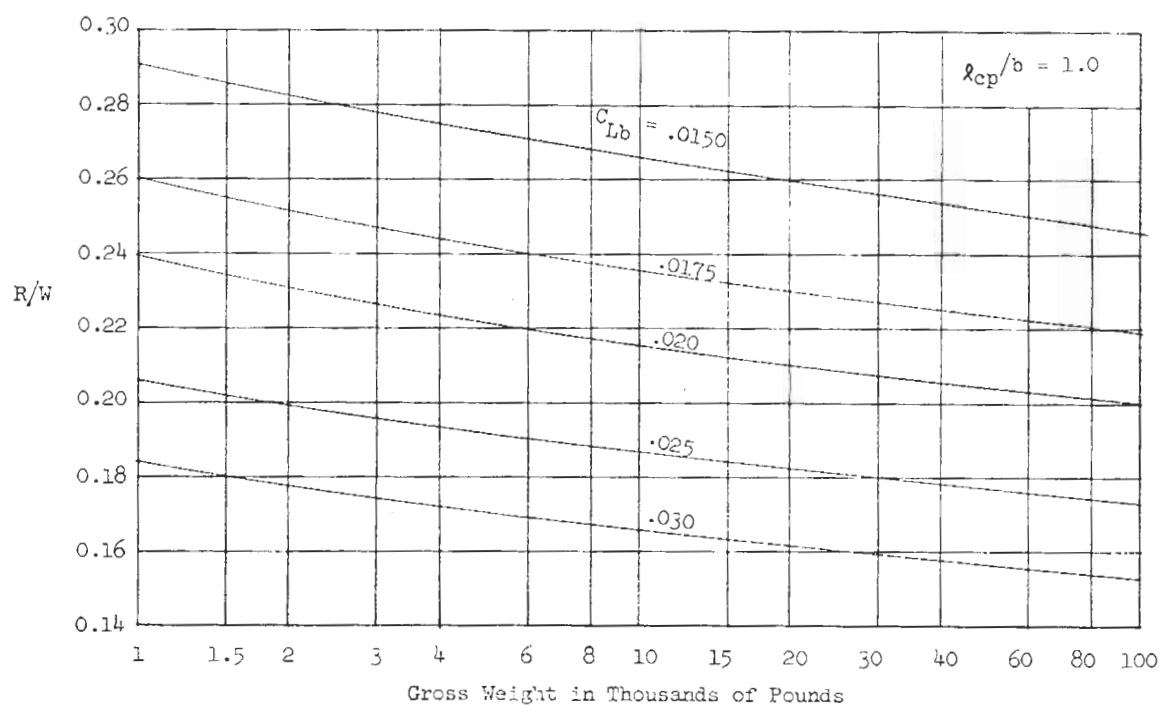
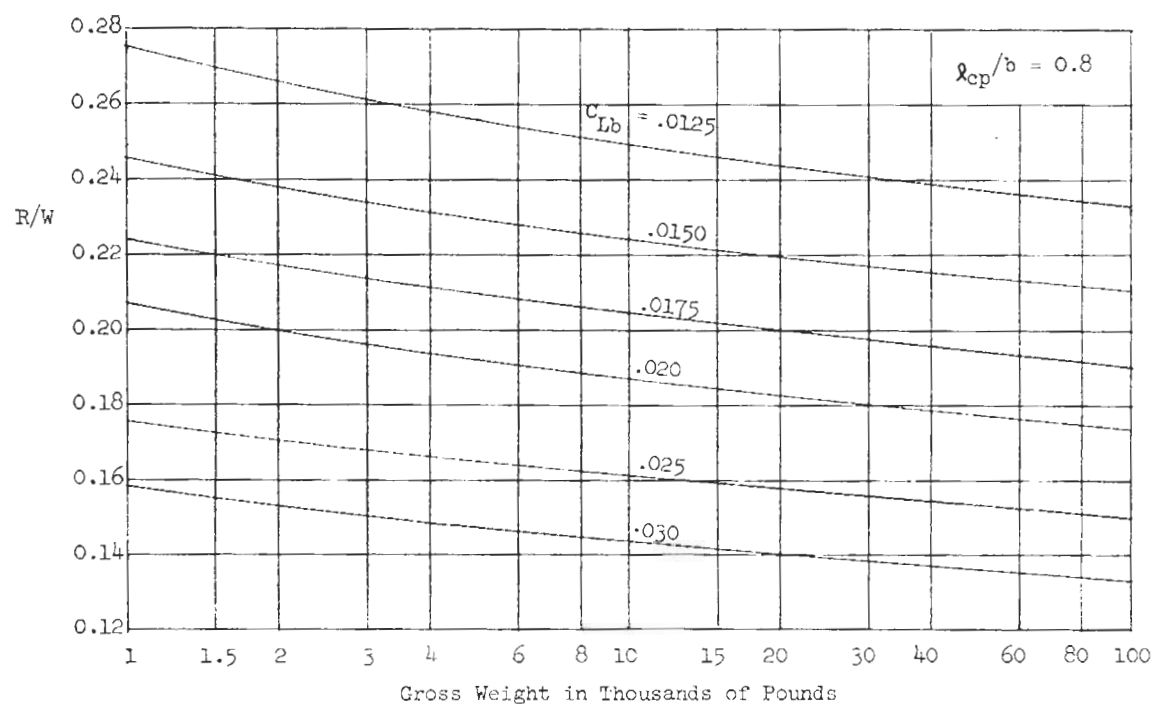


Fig. 28 Resistance/weight ratio versus gross weight of boat, with C_{Lb} as parameter

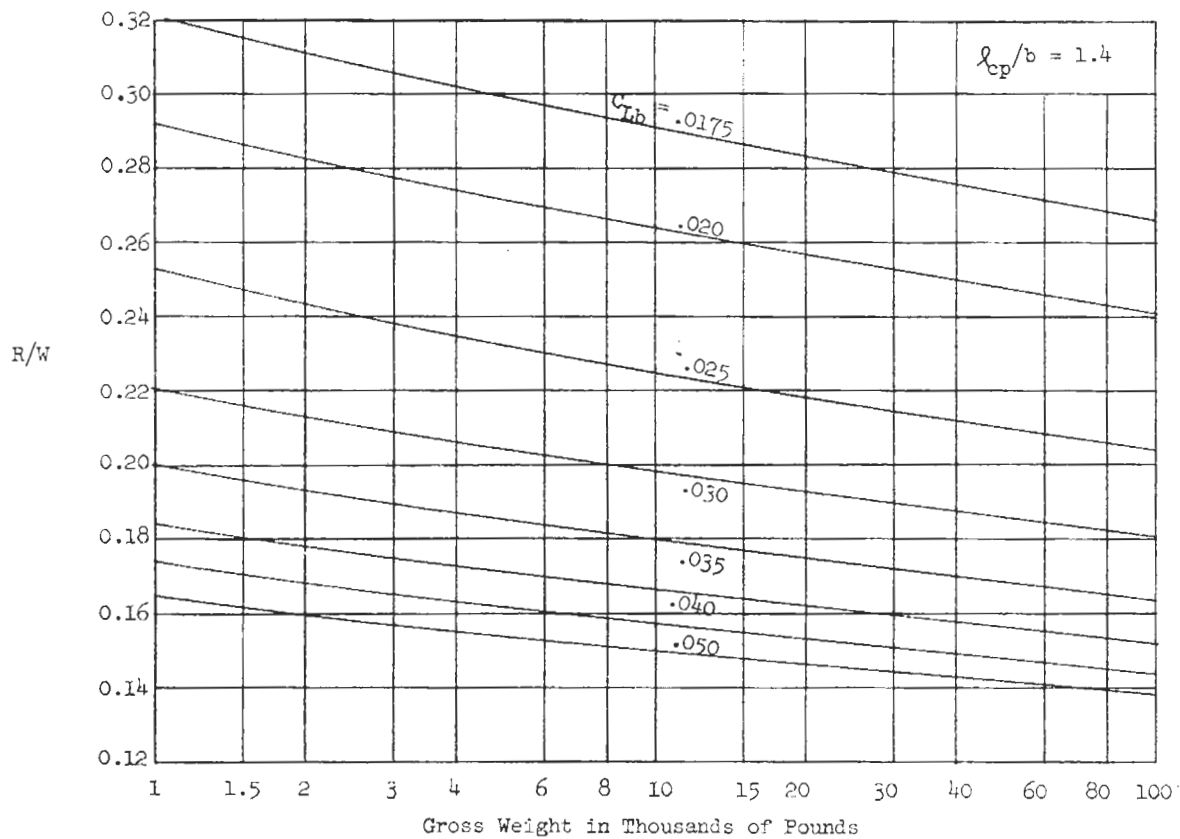
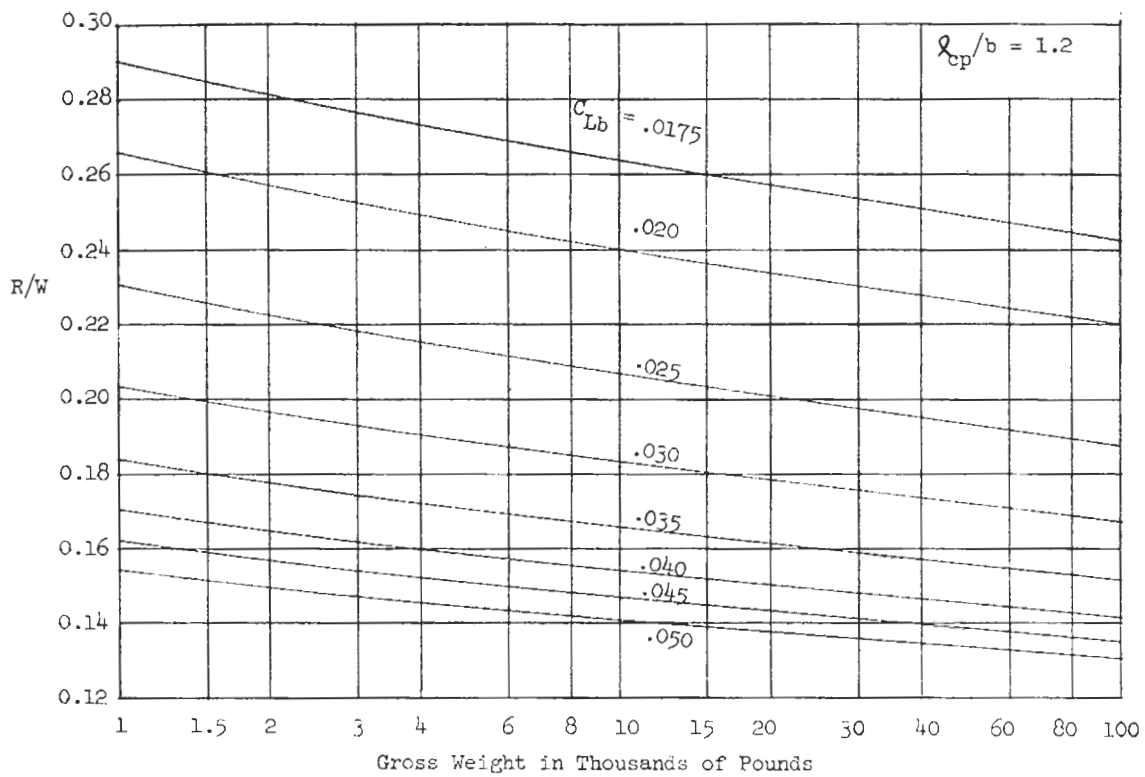


Fig. 28 Continued

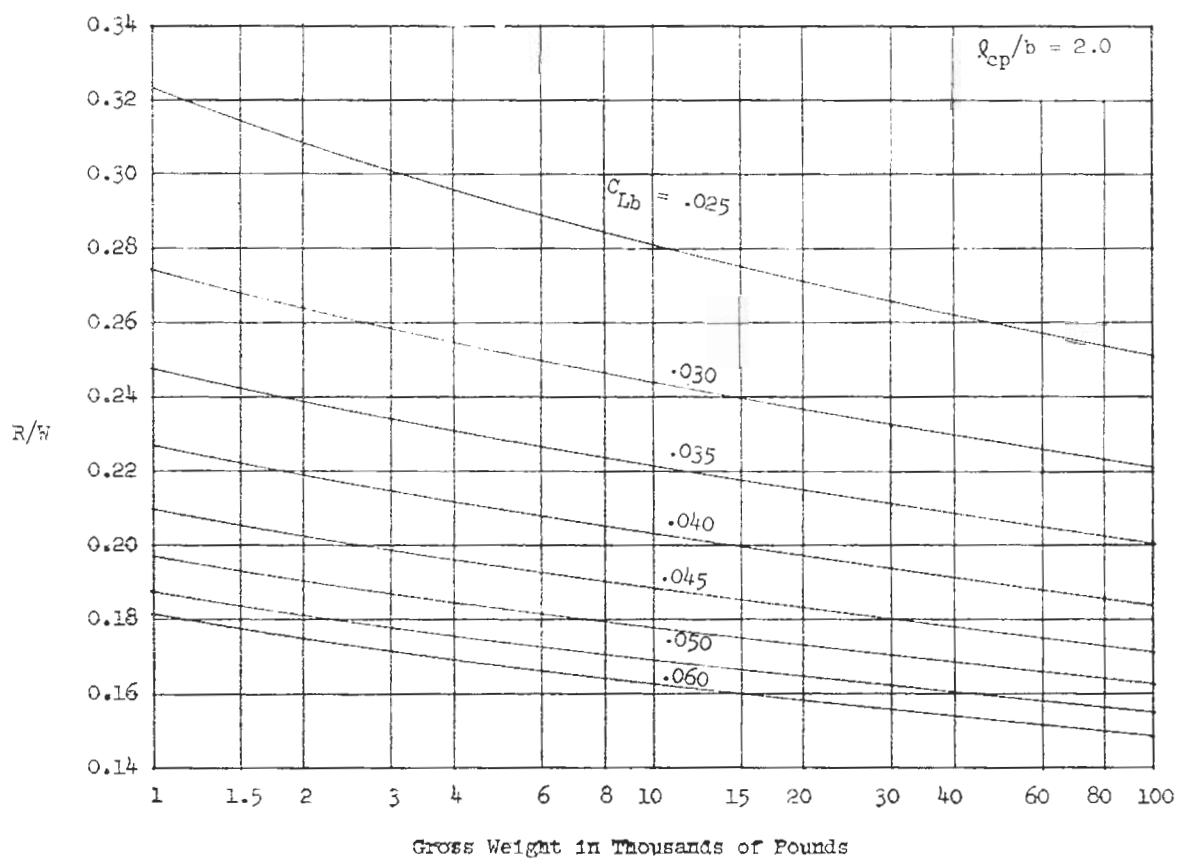
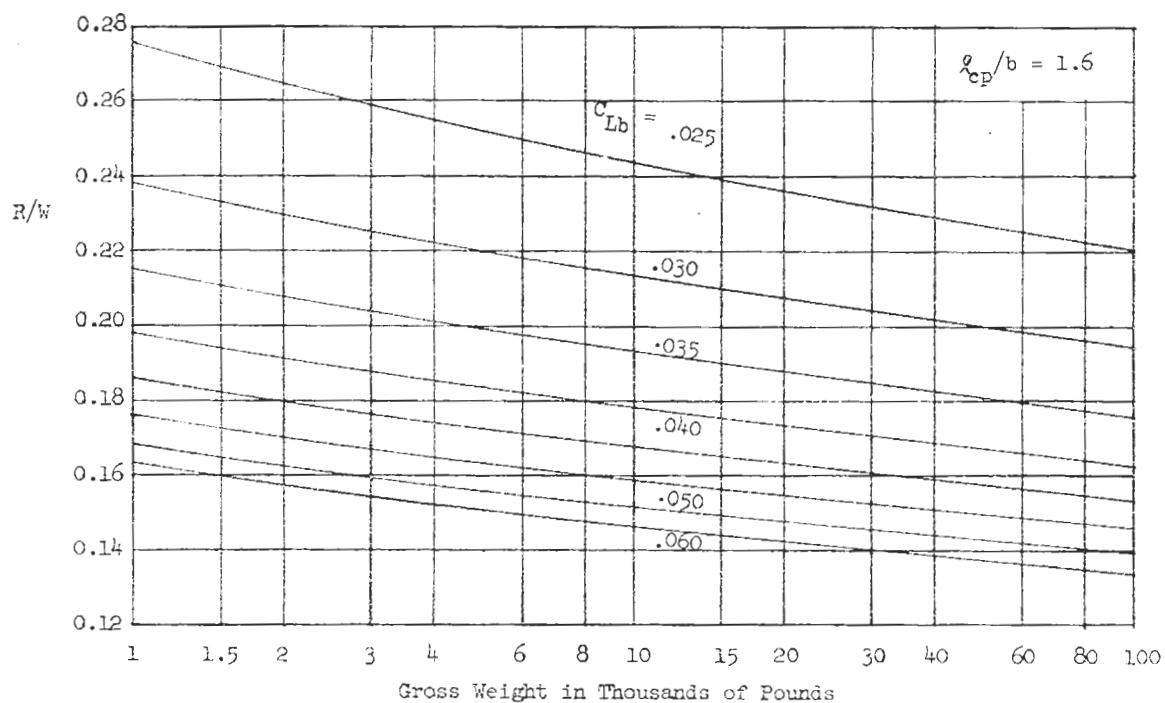


Fig. 28 Continued

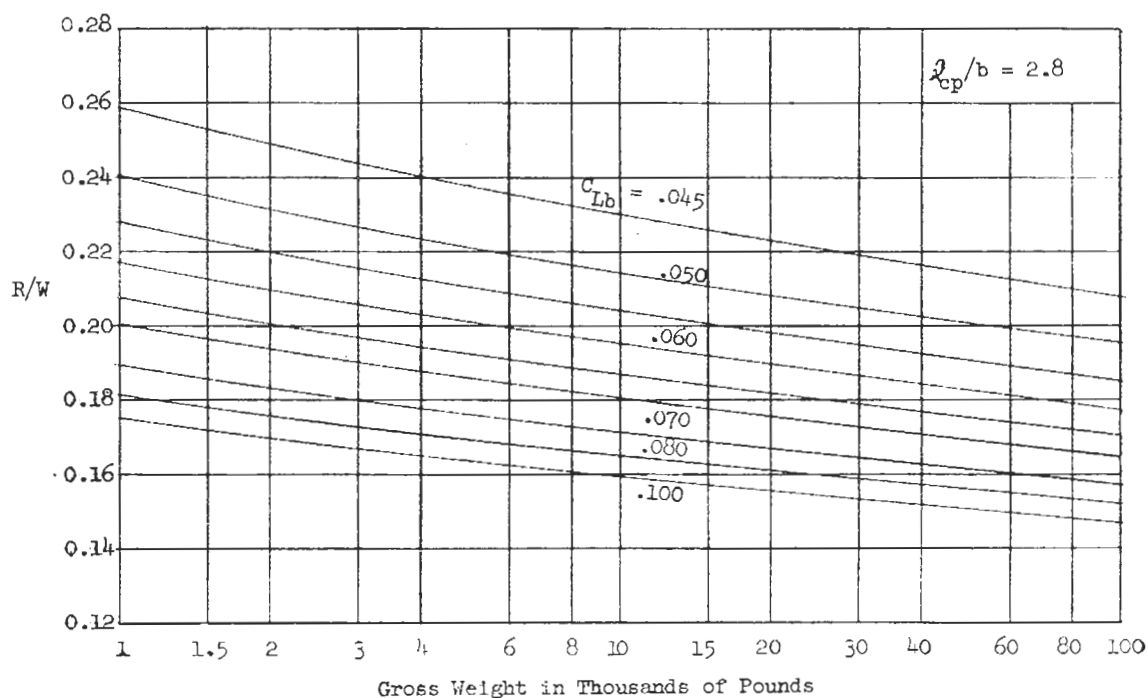
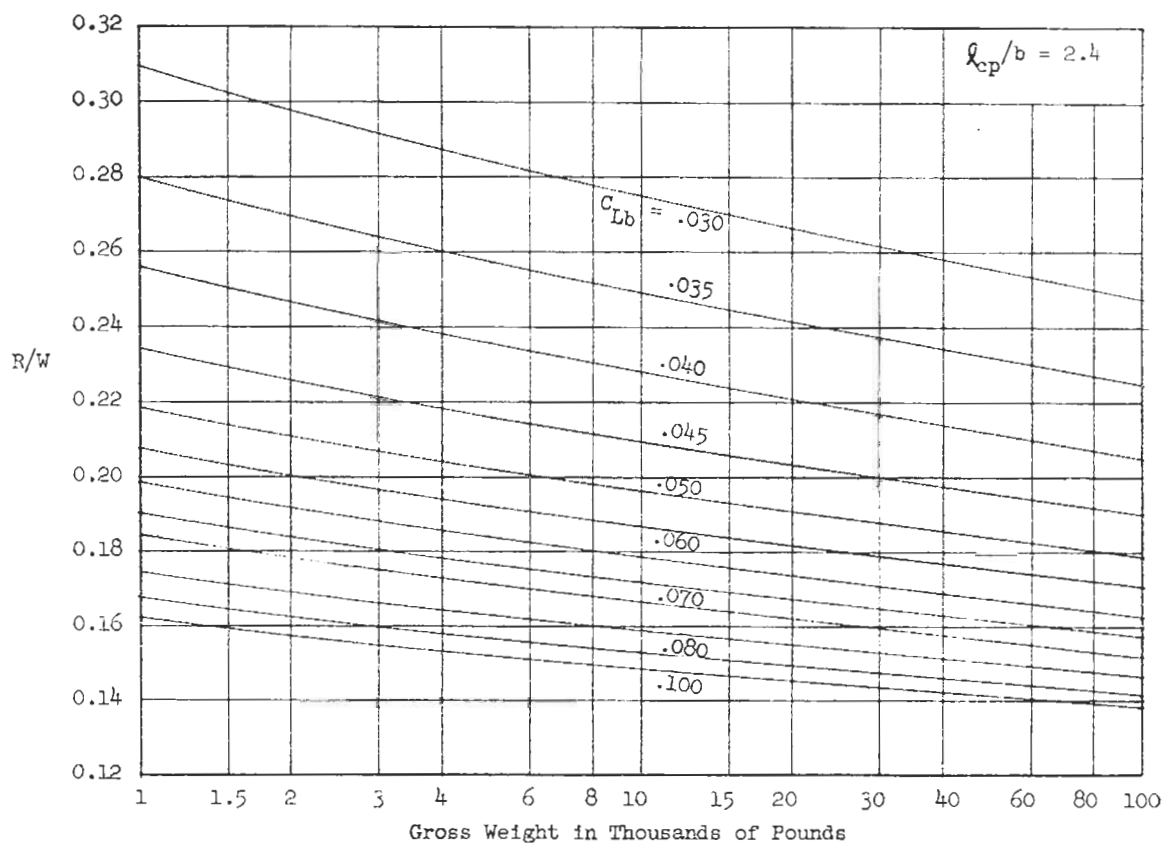
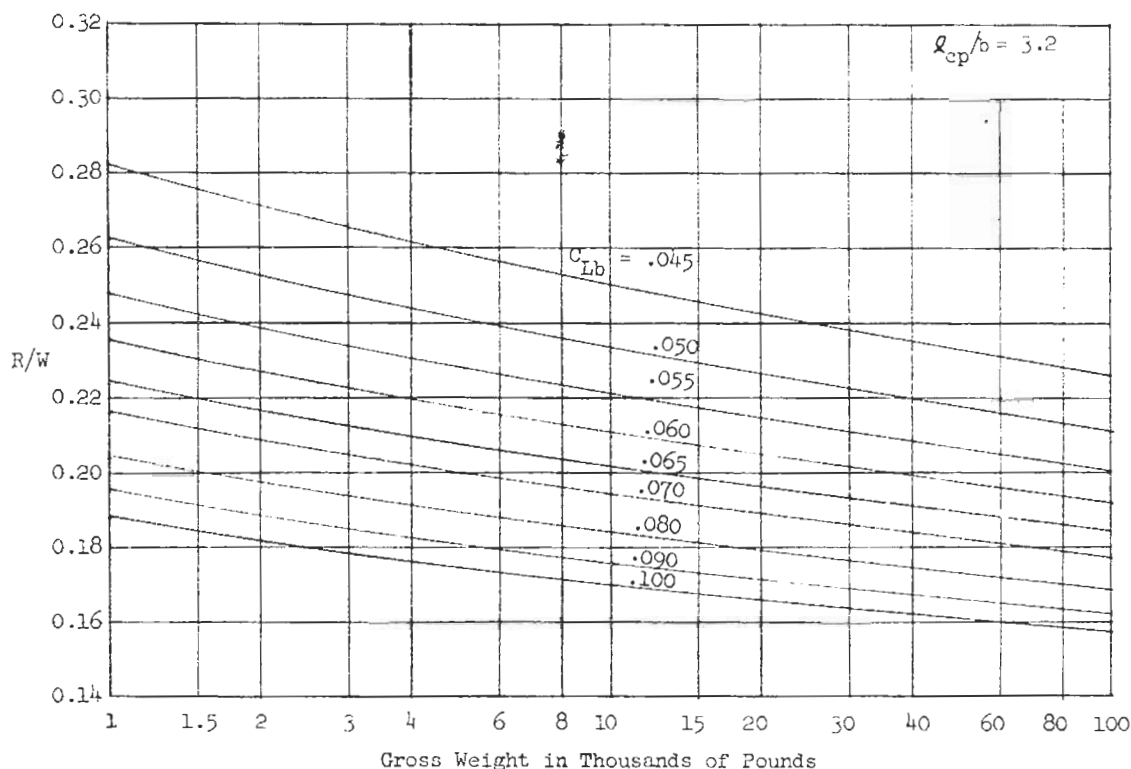


Fig. 28 Continued



(e) $l_{cp}/b = 3.2$

Fig. 28 Concluded

Table 2						
A	B	C	D	E	F	G
C_{Lb}	$\frac{R}{W}$	R	$\frac{1}{C_{Lb}}$	$\left(\frac{1}{C_{Lb}}\right)^{1/2}$	$v = \frac{W^{1/2}}{b} \left(\frac{1}{C_{Lb}}\right)^{1/2}$	$V, \text{ knots}$
0.020	0.260	3900	50.00	7.071	79.53	47.12
0.025	0.221	3315	40.00	6.324	71.12	42.14
0.030	0.195	2925	33.33	5.773	64.93	38.47
0.035	0.177	2655	28.57	5.345	60.12	35.62
0.040	0.164	2460	25.00	5.000	56.24	33.32
0.045	0.155	2325	22.22	4.714	53.01	31.41
0.050	0.148	2220	20.00	4.472	50.26	29.78

Fig. 28 were prepared. These curves can be used to calculate the high-speed resistance of boats related to the present series in regard to shape of body plan, but of any size from 1000 to 100,000 lb, and for any ratio of l_{cp}/b from 0.8 to 3.2.

The procedure for carrying out this calculation is as follows: Assume that the resistance in the high-speed range is to be determined for a boat having a gross weight of 15,000 lb, a width over the spray strips of 10.9 ft, and a center of gravity located 15.3 ft forward of the transom. Then

$$l_{cp}/b = 15.3/10.9 = 1.4$$

Fig. 28(b) is then utilized since this figure applies to the particular LCG location of the present case.

The succeeding steps are shown in the table of calculations, Table 2. First, the values of C_{Lb} for which the curves in Fig. 27 were prepared are entered in Column A. Next, Fig. 28 is entered with the given boat weight of 15,000 lb and a value of R/W is read off at each value of C_{Lb} . These values are entered in Column B. Next, multiplying the values of R/W by the boat weight, which is 15,000 lb, gives the values of boat resistance in pounds. These values are in Column C. The remaining step is to solve for the corresponding values of boat speed in the relationship

$$C_{Lb} = \frac{W}{\frac{1}{2}\rho v^2 b^2}$$

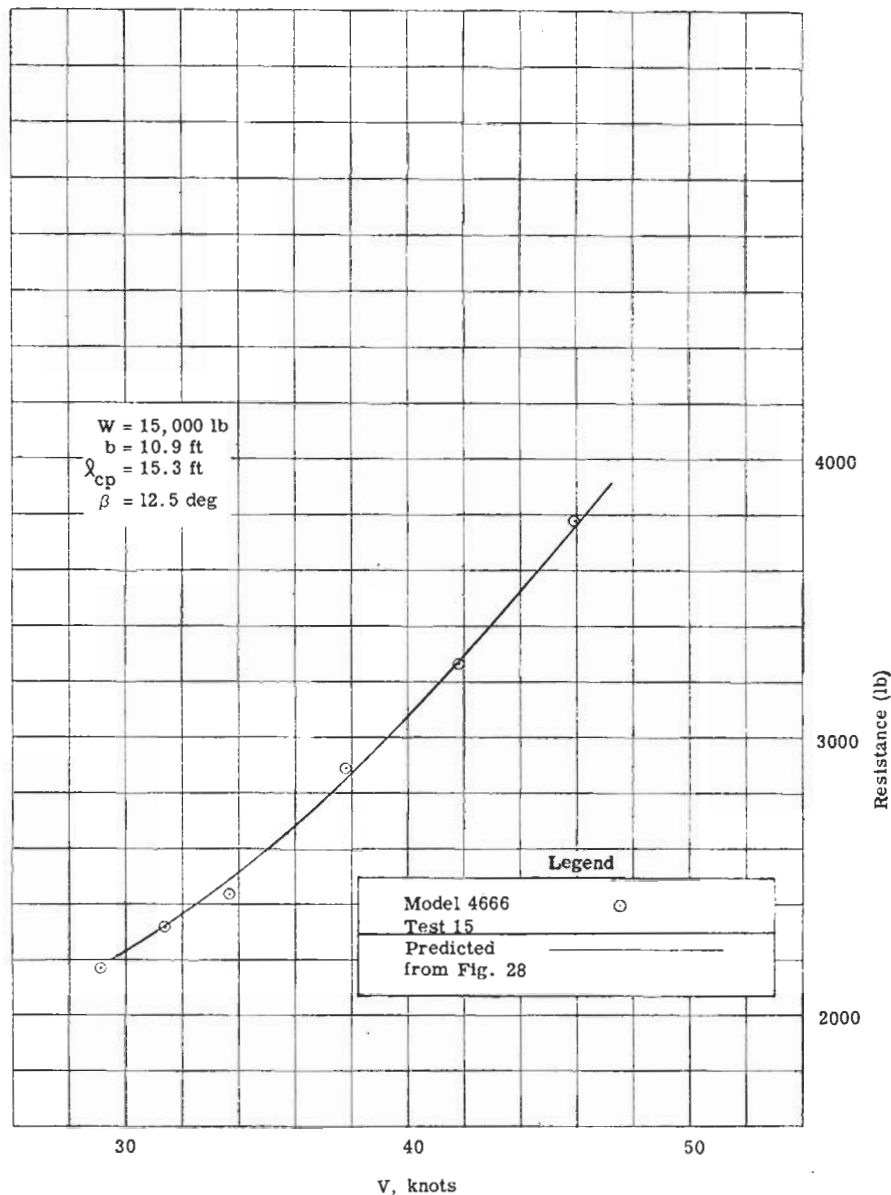


Fig. 29 Comparison of resistance of boat at high speed as predicted from Fig. 28, and as obtained from a model test of the series

Since $\frac{1}{2}\rho$ equals 1.00 for salt water, this simplifies to

$$C_{Lb} = \frac{W}{v^2 b^2}$$

Then

$$v = \frac{1}{b} \left(\frac{W}{C_{Lb}} \right)^{1/2}$$

Values of v are entered in Column F (intermediate steps are given in Columns D and E) and V in knots is put into Column G.

The hypothetical case selected for this sample

calculation was chosen to correspond to one of the tests of the series, Test 15 of Model 4666. This was done, of course, to compare a prediction of performance from the curves in Fig. 28 with the prediction from an actual model test. Fig. 29 shows this comparison. The curve in the figure represents values from Table 2 and the symbols are test spots from Test 15 of Model 4666 (these have been corrected by the usual method to a boat weight of 15,000 lb). From the close agreement, it is concluded that the simple method

proposed will give accurate predictions of the high-speed resistance of planing boats of a wide ranges of sizes and proportions.

Acknowledgments

This work had been carried out as part of the Fundamental Hydromechanics Research Program of the Bureau of Ships, which is directed and administered for the Bureau by the Taylor Model Basin. The authors would like at this time to express their particular thanks to Mr. Jacques B. Hadler for his support and encouragement during the carrying out of this project.

This paper represents the work of numerous people besides the authors. Special mention should be made of the contribution of Mr. Charles W. Tate, who did a large part of the work of testing, calculating, and preparing figures. The assistance of Mr. John Pothier and Mr. John Gonnerman in this work is also very much appreciated. The authors are also indebted to Morris Engineering for assistance in the prepara-

tion of graphs and tables, and to Mrs. Shirley Childers for preparation of the manuscript.

References

- 1 K. S. M. Davidson and A. Suarez, "Tests of Twenty Related Models of V-Bottom Motor Boats—EMB Series 50," DTMB Report R-47, March 1949.
- 2 E. P. Clement, "Development and Model Tests of an Efficient Planing Hull Design," DTMB Report 1314, April 1959.
- 3 E. P. Clement, "How to use the SNAME Small Craft Data Sheets for Design and for Resistance Prediction," SNAME Technical and Research Bulletin No. 1-23.
- 4 C. Ridgley-Nevitt, "The Resistance of Trawler Hull Forms of 0.65 Prismatic Coefficient," TRANS. SNAME, vol. 64, 1956, pp. 433-468.
- 5 W. Sottorf, "Systematic Model Researches on the Stability Limits of the DVL Series of Float Designs," NACA Technical Memorandum 1254, December 1949.

Tables of Test Conditions and Data follow

Model 4665 - Test Conditions

Test No.	Model Weight, lb	$A_p \nabla^{2/3}$	α_a , deg.	LCG Fwd of Sta. 10, ft	LCG Alt of Centroid of $A_p \nabla^{2/3}$ Lp, in.	Draft above $\bar{G}$ at Sta. 10, in.	Water temp., deg F.
1	54.50	7.1	0.00	1.62	6	3.09	65.5
2	129.08	4.0	-2.60	1.86	0	4.17	64.5
3	129.08	4.0	0.10	1.70	4	5.37	64.5
4	129.08	4.0	2.77	1.55	8	6.45	64.5
5	129.08	4.0	5.45	1.39	12	7.65	64.5
6	80.07	5.5	-2.05	1.86	0	3.09	64.5
7	80.07	5.5	-0.63	1.70	4	3.69	64.5
8	80.07	5.5	1.35	1.55	8	4.53	64.5
9	80.07	5.5	3.30	1.39	12	5.25	64.5
10	55.77	7.0	-2.19	1.86	0	2.49	64.5
11	54.50	7.1	-0.76	1.70	4	2.97	65.5
12	54.50	7.1	0.80	1.55	8	3.57	65.5
13	54.50	7.1	2.38	1.39	12	4.05	65.5
14	41.35	8.5	-2.05	1.86	0	2.25	65.5
15	41.35	8.5	-0.82	1.70	4	2.49	65.5
16	41.35	8.5	0.42	1.55	8	2.97	65.5
17	41.35	8.5	0.64	1.39	12	3.45	65.5

Model 4666 - Test Conditions

Test No.	Model Weight, lb	$A_p \nabla^{2/3}$	α_a , deg.	LCG Fwd of Sta. 10, ft	LCG Alt of Centroid of $A_p \nabla^{2/3}$ Lp, in.	Draft above $\bar{G}$ at Sta. 10, in.	Water temp., deg F.
1	101.80	7.0	0.02	2.53	6	3.68	70.0
2	235.70	4.0	-1.85	2.89	0	5.12	67.0
3	235.70	4.0	0.25	2.65	4	6.44	67.0
4	235.70	4.0	2.30	2.41	8	7.52	67.0
5	235.70	4.0	4.40	2.17	12	8.60	67.0
6	146.20	5.5	-1.70	2.89	0	3.56	67.0
7	146.20	5.5	-0.30	2.65	4	4.40	67.0
8	146.20	5.5	1.12	2.41	8	5.24	67.0
9	146.20	5.5	2.68	2.17	12	6.18	67.0
10	101.80	7.0	-1.53	2.89	0	2.72	70.0
11	101.80	7.0	-0.53	2.65	4	3.32	70.0
12	101.80	7.0	0.55	2.41	8	3.92	70.0
13	101.80	7.0	0.85	2.41	8	3.92	70.0
14	101.80	7.0	1.75	2.17	12	4.64	67.0
15	76.10	8.5	-1.41	2.89	0	2.48	67.0
16	76.10	8.5	-0.82	2.65	4	2.84	67.0
17	76.10	8.5	0.28	2.41	8	3.20	67.0
17	76.10	8.5	1.23	2.17	12	3.80	67.0

Model 4668 - Test Conditions

Test No.	Model Weight, lb	$A_p \nabla^{2/3}$	α_a , deg.	LCG Fwd of Sta. 10, ft	LCG Alt of Centroid of $A_p \nabla^{2/3}$ Lp, in.	Draft above $\bar{G}$ at Sta. 10, in.	Water temp., deg F.
1	98.70	7.0	-0.15	3.47	5	3.25	74.0
2	228.60	4.0	-1.25	3.91	0	4.70	74.0
3	228.60	4.0	-0.05	3.59	4	5.78	74.0
4	141.80	5.5	-1.15	3.91	0	3.14	74.0
5	141.80	5.5	-0.30	3.59	4	3.90	74.0
6	141.80	5.5	0.70	3.27	8	4.70	74.0
7	141.80	5.5	1.87	2.95	12	5.54	74.0
8	98.70	7.0	-1.10	3.91	0	2.54	74.0
9	98.70	7.0	-0.48	3.59	4	3.14	74.0
10	98.70	7.0	0.44	3.27	8	3.74	74.0
11	98.70	7.0	1.09	2.95	12	4.22	74.0
12	73.80	8.5	-1.00	3.91	0	2.06	74.0
13	73.80	8.5	-0.52	3.59	4	2.54	74.0
14	73.80	8.5	0.17	3.27	8	3.02	74.0
15	73.80	8.5	0.95	2.95	12	3.62	74.0

Model 4667-1 - Test Conditions

Test No.	Model Weight, lb	$A_p \nabla^{2/3}$	α_a , deg.	LCG Fwd of Sta. 10, ft	LCG Alt of Centroid of $A_p \nabla^{2/3}$ Lp, in.	Draft above $\bar{G}$ at Sta. 10, in.	Water temp., deg F.
1	154.00	7.0	0.10	3.43	6	3.98	67.0
1A	154.00	7.0	0.10	3.43	6	3.98	74.0
2	356.50	4.0	-1.10	3.91	0	5.06	74.0
3	356.50	4.0	0.17	3.59	4	7.22	74.0
4	356.50	4.0	1.80	3.27	8	8.30	74.0
6	221.10	5.5	-1.45	3.91	0	3.74	74.0
7	221.10	5.5	-0.32	3.59	4	4.46	74.0
8	221.10	5.5	0.65	3.27	8	5.54	74.0
9	221.10	5.5	2.16	2.95	12	6.62	74.0
10	154.00	7.0	-1.42	3.91	0	3.02	74.0
11	154.00	7.0	-0.50	3.59	4	3.62	74.0
12	154.00	7.0	0.50	3.27	8	4.22	74.0
13	154.00	7.0	1.50	3.59	12	5.06	74.0
14	115.10	8.5	-1.18	3.91	0	2.42	74.0
15	115.10	8.5	-0.50	3.59	4	3.02	75.0
16	115.10	8.5	0.22	3.27	8	3.50	75.0
17	115.10	8.5	1.00	2.95	12	4.22	75.0

Model 4669 - Test Conditions

Test No.	Model Weight, lb	$A_p \nabla^{2/3}$	α_a , deg.	LCG Fwd of Sta. 10, ft	LCG Alt of Centroid of $A_p \nabla^{2/3}$ Lp, in.	Draft above $\bar{G}$ at Sta. 10, in.	Water temp., deg F.
1	68.80	7.0	0.05	3.43	6	3.10	75.0
2	159.20	4.0	-1.13	3.91	0	4.18	75.0
3	159.20	4.0	0.30	3.59	4	5.38	75.0
4	101.80	5.5	-0.93	3.91	0	3.10	75.0
5	101.80	5.5	-0.10	3.59	4	3.58	75.0
6	101.80	5.5	0.82	3.27	8	4.42	75.0
7	101.80	5.5	1.75	2.95	12	5.26	75.0
8	68.80	7.0	-0.82	3.91	0	2.58	75.0
9	68.80	7.0	-0.25	3.59	4	2.74	75.0
10	68.80	7.0	0.92	3.27	8	3.34	75.0
11	68.80	7.0	1.15	2.95	12	3.82	75.0
12	51.40	8.5	-0.80	3.91	0	2.02	75.0
13	51.40	8.5	-0.35	3.59	4	2.38	75.0
14	51.40	8.5	0.33	3.27	8	2.74	75.0
15	51.40	8.5	1.05	2.95	12	3.34	75.0

Model 4665 Test No. 1

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Rex 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.69	0.10	3.75	2.30	0.315	5.89	12.793	0.00	0.00	0.21
1.06	0.20	3.75	2.30	0.483	5.89	10.809	-0.05	-0.08	0.32
1.39	0.40	3.75	2.30	0.634	5.88	12.604	-0.10	-0.12	0.42
1.63	0.59	3.75	2.30	0.743	5.84	13.857	-0.10	-0.07	0.50
1.76	0.74	3.80	2.60	0.849	6.18	14.045	-0.15	-0.15	0.54
2.10	1.21	3.80	2.40	0.981	5.98	16.587	-0.30	-0.20	0.64
2.43	1.99	3.85	2.20	1.108	5.84	20.849	-0.40	-0.32	0.74
2.78	3.06	3.85	2.40	1.144	6.02	20.205	-0.40	-0.27	0.74
2.82	3.06	3.85	2.00	1.225	5.69	25.188	-0.45	-0.40	0.85
3.23	5.37	3.80	3.20	1.704	6.60	28.257	0.70	-0.53	0.98
4.08	8.21	3.60	2.60	1.906	5.98	29.863	5.40	-0.14	1.24
4.92	8.24	3.40	2.20	2.076	5.33	23.094	6.55	0.39	1.50
5.54	8.32	3.15	2.00	2.150	4.78	20.526	6.90	0.87	1.69
6.54	8.04	3.00	1.80	2.365	4.38	15.539	6.50	1.20	1.99
7.32	7.76	2.90	1.60	2.482	4.03	13.011	5.90	1.39	2.23
8.14	7.63	2.90	1.50	2.659	3.91	10.648	5.30	1.54	2.48
8.98	7.64	2.90	1.40	2.909	3.80	9.030	4.70	1.68	2.73
9.72	7.86	2.90	1.20	3.003	3.57	8.431	4.25	1.83	2.96
10.56	8.21	2.90	1.10	3.183	3.46	7.711	3.85	1.76	3.22
11.42	8.66	3.00	1.00	3.442	3.46	6.955	3.50	1.87	3.43
12.22	9.16	3.10	0.90	3.683	3.46	6.426	3.28	1.84	3.72
13.11	9.85	3.15	0.80	3.902	3.40	6.103	3.00	1.83	3.99
14.74	11.44	3.20	0.60	4.220	3.23	5.890	2.65	1.94	4.49
16.38	13.12	3.20	0.40	4.443	3.02	5.864	2.33	2.05	4.99
18.02	15.06	3.25	0.20	4.584	2.86	5.863	2.14	2.06	5.49
19.64	16.90	3.30	0.00	4.883	2.71	5.848	2.00	2.05	5.98

Model 4665 Test No. 3

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Rex 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.69	0.20	3.85	3.30	0.367	7.47	20.622	-0.02	0.01	0.18
1.06	0.45	3.85	3.30	0.583	7.43	19.616	-0.10	-0.07	0.28
1.39	0.72	3.90	3.40	0.754	7.48	18.082	-0.15	-0.16	0.37
1.76	1.25	3.90	3.60	0.981	7.55	19.349	-0.38	-0.29	0.46
1.90	1.60	3.90	3.60	1.059	7.60	21.039	-0.45	-0.22	0.50
2.09	2.05	3.90	3.90	1.211	7.78	21.828	-0.55	-0.44	0.55
2.43	3.60	4.00	4.00	1.444	7.82	28.187	-0.85	-0.55	0.64
2.75	5.29	4.00	4.00	1.635	8.02	31.586	-1.10	-0.67	0.73
2.78	5.59	4.00	4.00	1.653	8.02	32.658	-1.10	-0.82	0.73
3.00	18.63	4.10	4.10	2.315	8.04	58.070	1.40	-1.12	1.00
4.77	30.01	3.80	3.40	2.552	7.08	67.412	7.50	-0.09	1.26
5.70	29.88	3.40	2.60	2.541	5.74	58.011	12.95	1.76	1.50
6.63	28.18	3.20	2.30	2.709	5.17	44.870	12.20	2.68	1.75
7.60	25.86	3.00	2.10	2.860	4.72	34.293	10.90	2.86	2.00
8.54	23.72	2.60	1.90	2.856	4.03	29.204	9.55	3.51	2.25
9.69	21.76	2.50	1.80	3.096	3.90	22.078	9.15	3.48	2.56
10.42	20.74	2.70	1.70	3.407	3.91	17.659	9.30	3.82	2.75
11.36	19.84	2.70	1.60	3.630	3.80	14.645	6.55	4.00	3.00
12.30	19.37	2.70	1.50	3.839	3.68	12.580	5.80	4.17	3.24

Model 4665 Test No. 2

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Rex 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.69	0.18	3.90	3.60	0.385	7.36	18.507	-0.05	0.01	0.18
1.06	0.30	3.95	3.60	0.595	7.39	12.970	-0.15	-0.06	0.28
1.35	0.52	4.00	3.95	0.797	7.46	13.728	-0.35	-0.10	0.36
1.76	0.89	4.00	4.00	1.046	7.46	13.985	-0.65	-0.22	0.46
1.90	1.15	4.00	4.00	1.129	7.46	15.478	-1.00	-0.15	0.50
2.10	1.53	4.05	4.00	1.256	7.42	16.919	-1.00	-0.42	0.55
2.42	3.09	4.10	4.05	1.466	7.38	25.836	-1.55	1.54	0.64
2.76	4.93	4.10	4.10	1.682	7.59	30.875	-1.55	-0.96	0.73
2.77	4.98	3.90	4.10	1.647	7.64	30.760	-1.25	-1.15	0.73

Model 4665 Test No. 4

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Rex 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.69	0.30	3.80	3.00	0.349	7.41	30.677	0.03	-0.01	0.18
1.06	0.55	3.80	3.00	0.536	7.38	23.911	-0.07	0.02	0.28
1.39	1.00	3.80	3.10	0.713	7.48	24.939	-0.07	-0.08	0.37
1.73	1.64	3.85	3.20	0.906	7.57	26.247	-0.17	-0.14	0.46
1.90	1.99	3.85	3.20	0.981	7.51	26.596	0.13	-0.24	0.50
2.10	2.42	3.90	3.20	1.108	7.60	28.120	-0.27	-0.26	0.55
2.44	4.09	3.90	3.40	1.324	7.49	33.170	-0.07	-0.38	0.64
2.74	5.98	3.90	3.60	1.527	7.66	37.634	-0.01	-0.40	0.72
2.78	6.08	3.90	3.60	1.549	7.66	37.167	0.13	-0.54	0.73
3.81	19.46	3.80	3.60	2.095	7.80	62.218	3.01	0.03	1.00
4.75	33.14	3.30	2.60	2.082	5.95	89.365	4.45	3.49	1.25
5.70	33.47	3.00	2.20	2.202	4.84	77.057	13.05	2.00	1.50
6.60	30.04	2.80	2.00	2.354	4.38	56.992	11.35	2.92	1.74
7.60	27.10	2.60	1.80	2.485	3.91	43.383	9.38	3.48	2.00
8.50	24.51	2.40	1.70	2.589	3.57	34.399	6.15	4.41	2.24
9.64	22.46	2.40	1.60	2.865	3.46	25.305	6.13	4.32	2.54

Model 4665 Test No. 5

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Rex 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.69	0.38	3.70	2.70	0.328	7.20	40.041	0.10	-0.04	0.18
1.05	0.70	3.70	2.80	0.507	7.35	31.154	0.15	-0.05	0.28
1.36	1.30	3.75	2.70	0.652	7.26	34.902	0.25	-0.14	0.36
1.83	2.09	3.75	2.80	0.891	7.44	30.406	0.35	-0.17	0.48
1.89	2.79	3.75	2.80	0.920	7.32	38.639	0.45	-0.16	0.50
2.09	3.19	3.80	2.80	1.025	7.33	36.038	0.45	-0.11	0.55
2.43	4.54	3.80	2.80	1.192	7.38	37.643	0.75	-0.37	0.64
2.75	7.03	3.80	2.80	1.349	7.46	45.090	1.55	-0.45	0.73
2.78	6.98	3.80	2.80	1.363	7.17	45.564	1.50	-0.43	0.73
3.79	22.64	3.40	2.80	1.746	6.51	87.686	8.21	0.00	1.00
4.73	38.39	2.80	2.20	1.757	4.85	128.050	14.45	1.53	1.25
5.69	37.04	2.40	1.90	1.818	3.80	108.990	13.30	2.83	1.50
6.60	33.67	2.20	1.70	1.913	3.34	83.631	10.85	3.58	1.74
7.59	28.85	2.00	1.60	2.030	3.02	60.044	9.30	4.22	2.00

Model 4665 Test No. 6

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.70	0.20	3.85	3.10	0.361	22.260	-0.05	-0.09	0.20
1.06	0.20	3.85	3.10	0.547	9.635	-0.15	-0.06	0.30
1.39	0.40	3.85	3.20	0.728	11.061	-0.30	-0.11	0.40
1.77	0.59	3.90	3.20	0.934	6.70	-0.55	-0.24	0.51
2.05	0.67	3.90	3.20	1.082	6.73	-0.55	-0.24	0.59
2.10	1.19	3.95	3.95	6.92	14.113	-0.85	-0.36	0.60
2.42	2.14	4.00	4.00	1.439	19.067	-1.50	-0.57	0.69
2.62	2.88	4.00	4.00	1.557	21.537	-1.95	-0.65	0.75
2.78	3.68	4.05	4.05	1.673	7.10	-2.30	-0.75	0.79
3.51	11.12	4.10	4.10	2.139	7.38	-1.65	-1.43	1.00
4.36	18.15	4.00	4.00	2.592	49.242	6.05	-0.21	1.25
5.23	18.93	3.80	3.20	2.720	37.151	7.10	0.09	1.49
6.12	14.51	3.70	2.50	2.819	5.91	9.25	1.02	1.75
7.00	13.58	3.40	2.30	2.965	18.622	9.16	1.44	2.00
7.86	12.79	3.30	2.10	3.154	5.06	8.65	1.86	2.24
8.76	12.48	3.30	1.90	3.365	4.84	12.168	8.15	2.50
9.64	12.26	3.20	1.80	3.561	4.61	10.357	7.75	2.75
10.54	12.36	3.20	1.70	3.837	4.49	8.975	7.25	3.01
11.38	12.77	3.30	1.60	4.143	4.49	7.937	6.85	3.25
12.24	13.06	3.30	1.50	4.463	4.38	7.206	6.50	3.50
13.32	13.49	3.50	1.40	4.652	4.26	6.455	6.15	3.80
14.00	14.29	3.35	1.30	4.837	4.20	6.276	5.90	4.00
15.84	16.15	3.35	1.10	5.237	3.97	5.864	5.75	4.52
17.62	18.49	3.40	0.80	5.499	3.68	5.852	5.20	5.03
19.34	21.08	3.40	0.70	5.892	3.57	5.713	4.95	5.52
21.18	23.63	3.40	0.50	6.138	3.34	5.700	4.75	6.05

Model 4665 Test No. 7

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.69	0.11	3.75	2.80	0.336	12.730	0.03	-0.11	0.20
1.07	0.34	3.80	2.90	0.533	16.097	-0.02	-0.09	0.31
1.39	0.50	3.80	2.90	0.692	14.006	-0.17	-0.15	0.40
1.75	0.87	3.85	2.90	0.878	6.63	-0.27	-0.22	0.50
1.76	1.89	3.85	2.90	0.883	33.313	-0.32	-0.20	0.50
2.09	1.49	3.85	2.70	1.017	19.206	-0.52	-0.34	0.60
2.42	2.42	3.90	3.90	1.403	7.05	-0.87	-0.44	0.69
2.64	3.13	3.90	3.90	1.530	22.875	-0.97	-0.51	0.75
2.79	3.68	3.95	3.95	1.638	7.12	-0.97	-0.66	0.80
3.54	9.57	4.00	4.00	2.104	37.053	0.73	-1.02	1.01
4.37	15.35	3.70	3.10	2.208	6.63	43.901	7.08	1.25
5.22	14.51	3.45	2.50	2.308	5.78	33.353	9.03	1.49
6.14	13.98	3.10	2.20	2.418	4.95	27.118	9.23	1.45
6.98	13.33	3.00	2.00	2.593	4.61	21.472	8.63	1.99
7.84	12.64	2.90	1.90	2.796	4.38	16.999	7.78	2.24
8.72	11.90	2.90	1.70	2.860	4.15	13.664	6.98	2.49
9.58	11.61	2.90	1.60	3.203	4.03	11.363	6.23	2.74
10.52	11.51	2.90	1.50	3.439	3.91	9.619	5.63	3.00
11.34	11.57	2.90	1.40	3.623	3.80	8.570	5.18	3.24
12.24	11.88	2.90	1.30	3.820	3.68	7.792	4.63	3.50
13.16	12.40	3.00	1.20	4.107	3.68	7.035	4.43	3.76
14.06	12.89	3.10	1.10	4.368	3.68	6.405	4.13	4.02
15.82	14.80	3.20	0.90	4.819	3.57	5.995	3.63	4.52
17.58	16.60	3.20	0.70	5.094	3.34	5.810	3.28	5.02
19.32	18.93	3.30	0.50	5.455	3.23	5.674	2.78	5.52
19.34	18.98	3.20	0.50	5.317	3.13	5.874	3.08	5.52
21.18	21.26	3.30	0.40	5.823	3.13	5.488	2.72	6.05

Model 4665 Test No. 8

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.69	0.20	3.70	2.60	0.323	23.564	0.00	0.00	0.20
1.04	0.40	3.75	2.60	0.491	6.47	20.579	0.00	0.30
1.38	0.67	3.75	2.70	0.661	6.53	19.382	0.00	0.39
1.75	1.09	3.80	2.70	0.845	6.57	19.663	-0.05	0.50
1.77	1.09	3.80	2.70	0.855	6.59	19.148	-0.05	0.51
2.08	1.79	3.85	2.60	0.997	6.50	23.022	-0.05	0.59
2.43	2.79	3.85	2.50	1.147	6.42	26.577	-0.15	0.69
2.62	3.48	3.85	2.40	1.217	6.34	28.967	-0.15	0.75
2.78	3.98	3.90	3.90	1.611	7.24	25.749	0.00	0.79
3.50	9.82	3.80	3.40	1.872	6.98	41.574	2.95	1.00
4.34	14.98	3.40	2.50	1.903	5.94	48.473	8.55	1.24
5.20	16.13	3.00	2.20	2.009	4.84	44.628	11.22	0.41
6.11	15.49	2.60	1.90	2.043	4.03	37.246	9.13	1.61
6.96	14.26	2.40	1.80	2.172	3.68	28.912	7.95	2.01
7.86	13.06	2.50	1.70	2.453	3.68	20.771	6.75	2.31
8.74	12.30	2.60	1.50	2.663	3.57	16.329	5.75	2.45
9.58	11.71	2.60	1.40	2.847	3.46	13.363	4.85	2.74
10.52	11.46	2.70	1.30	3.127	3.46	10.846	4.15	2.69
11.42	11.46	2.70	1.20	3.309	3.34	9.510	3.55	3.26
12.26	11.71	2.80	1.10	3.553	3.34	8.430	3.15	3.50

Model 4665 Test No. 9

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.69	0.22	3.70	2.30	0.308	26.794	0.10	-0.04	0.20
1.06	0.50	3.70	2.30	0.473	6.22	25.784	0.15	0.30
1.39	0.88	3.75	2.30	0.625	6.28	26.109	0.20	0.40
1.75	1.37	3.75	2.30	0.787	6.26	25.999	0.25	0.50
1.76	1.49	3.75	2.30	0.791	6.26	27.842	0.30	0.50
2.09	2.19	3.75	2.40	0.955	6.34	28.630	0.40	0.60
2.42	3.29	3.80	2.40	1.115	6.43	31.596	0.60	0.69
2.61	4.48	3.80	2.30	1.183	6.31	37.757	1.00	0.75
2.78	4.83	3.75	2.30	1.250	6.26	36.163	1.20	0.79
3.50	11.17	3.55	2.20	1.495	5.81	56.785	5.50	1.00
4.38	15.01	2.90	2.20	1.650	4.93	57.391	10.00	1.25
5.22	18.31	2.50	1.90	1.707	4.91	62.132	10.35	1.49
6.10	16.86	2.40	1.70	1.858	3.57	45.924	10.72	1.62
6.98	15.14	2.20	1.50	1.919	3.13	35.970	9.28	1.99
7.84	13.78	2.20	1.40	2.097	3.02	26.882	5.70	2.24
8.74	12.65	2.20	1.30	2.273	2.91	20.574	4.50	2.50
9.60	11.86	2.30	1.20	2.497	2.91	15.987	3.50	2.74

Model 4665 Test No. 10

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v	
0.68	0.00	3.75	2.70	6.09	-0.114	-0.06	0.02	0.21	
0.69	0.12	3.75	2.60	6.01	15.062	-0.06	0.02	0.21	
1.05	0.30	3.75	2.60	6.01	16.256	-0.11	-0.17	0.32	
1.40	0.35	3.80	2.70	6.14	10.388	-0.26	-0.13	0.42	
1.62	0.49	3.80	2.70	6.14	9.782	-0.41	-0.19	0.49	
1.75	0.51	3.80	2.70	6.14	9.877	-0.51	-0.26	0.53	
2.09	0.99	3.85	2.50	6.01	13.642	-0.81	-0.27	0.63	
2.11	1.24	3.90	3.90	1.223	6.86	14.694	-0.99	-0.08	0.64
2.40	1.64	3.90	3.90	1.391	6.80	15.117	-1.31	-0.43	0.73
2.42	1.69	3.90	3.90	1.403	6.80	15.320	-1.26	-0.44	0.73
2.50	1.96	3.90	3.90	1.449	6.80	16.731	-1.36	-0.41	0.76
2.78	2.78	3.90	3.90	1.611	6.80	19.152	-1.86	-0.57	0.84
3.22	3.97	3.95	3.95	1.890	6.90	30.212	-2.06	-0.92	0.98
3.38	6.85	3.95	3.95	1.984	6.90	31.473	-1.71	-1.02	1.03
4.06	11.76	3.90	3.90	2.353	6.88	37.503	-2.79	-0.89	1.23
4.88	12.14	3.70	3.00	2.429	6.35	28.635	5.09	0.01	1.48
5.07	11.94	3.70	2.60	2.449	6.18	27.209	5.34	0.09	1.54
5.66	10.32	3.60	2.50	2.565	5.80	20.086	6.24	0.58	1.72
5.91	9.81	3.60	2.40	2.635	5.69	17.874	5.49	0.95	1.79
6.50	9.01	3.55	2.20	2.777	5.44	14.201	6.89	1.05	1.97
6.72	8.73	3.50	2.20	2.846	5.38	13.001	7.34	0.92	2.04
7.34	8.56	3.45	2.00	2.972	5.12	11.242	6.79	1.28	2.23
8.14	8.38	3.40	1.90	3.206	4.95	9.246	6.59	1.44	2.47
8.96	8.29	3.40	1.70	3.395	4.72	7.913	6.19	1.65	2.72
9.76	8.63	3.40	1.50	3.554	4.49	7.315	5.89	1.83	2.96
10.60	9.91	3.40	1.40	3.781	4.38	6.827	5.59	1.82	3.22
11.42	9.41	3.40	1.30	3.988	4.26	6.128	5.34	1.89	3.46
12.24	9.93	3.40	1.20	4.184	4.15	5.786	5.11	1.85	3.71
13.04	10.78	3.40	1.10	4.360	4.03	5.692	5.04	1.87	3.96
14.70	12.59	3.40	0.90	4.697	3.80	5.550	4.59	2.00	4.46
16.40	13.90	3.40	0.70	4.996	3.57	5.655	4.39	2.08	4.98
18.04	17.43	3.40	0.50	5.228	3.34	5.796	4.19	2.11	5.47
19.64	19.68	3.40	0.30	5.399	3.13	5.906	3.99	2.07	5.96

Model 4665 Test No. 13

MODEL 4000—TEST NO. 10									
V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.69	0.05	3.70	2.10	0.301	5.74	6.498	0.02	-0.01	0.21
1.04	0.25	3.70	2.10	0.454	5.73	14.475	0.07	-0.02	0.32
1.39	0.55	3.70	2.10	0.607	5.73	17.851	0.12	-0.04	0.42
1.66	0.79	3.70	2.20	0.738	5.86	17.791	0.02	-0.01	0.51
1.76	1.04	3.75	2.20	0.799	5.95	20.782	0.22	-0.08	0.54
2.09	1.64	3.75	2.20	0.937	5.86	23.173	0.42	-0.25	0.64
2.42	2.34	3.75	2.10	1.066	5.76	25.051	0.62	-0.22	0.74
2.43	2.49	3.75	2.20	1.089	5.85	26.051	0.62	-0.22	0.74
2.79	3.58	3.70	2.10	1.219	5.71	29.147	1.27	-0.35	0.85
3.25	6.17	3.60	2.40	1.469	5.88	35.982	3.42	-0.26	0.99
4.07	9.51	3.10	2.10	1.594	5.03	41.569	7.12	0.18	1.24
4.91	10.29	2.40	1.80	1.554	3.68	41.933	7.90	0.91	1.50
5.80	9.61	2.30	1.60	1.704	3.34	30.927	7.22	1.45	1.77
6.55	8.89	2.30	1.40	1.826	3.13	23.956	5.92	1.81	1.99
7.33	8.36	2.30	1.30	1.988	3.02	18.661	4.92	1.91	2.23
8.98	7.79	2.30	1.10	2.300	2.81	12.442	3.12	2.10	2.73
9.76	7.75	2.40	1.00	2.500	2.81	10.481	2.42	2.14	2.97
10.62	7.76	2.40	0.90	2.640	2.71	9.185	2.02	2.18	3.23

Model 4665 Test No. 11

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S _t , ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.69	0.10	3.75	2.40	0.320	5.95	12.659	-0.04	0.01	0.21
1.05	0.25	3.75	2.40	0.486	5.95	13.661	-0.09	-0.02	0.32
1.62	0.39	3.80	2.40	0.757	5.97	9.105	-0.19	-0.04	0.49
1.62	0.59	3.80	2.40	0.757	5.98	13.705	-0.34	0.00	0.49
1.77	0.64	3.80	2.50	0.840	6.04	12.295	-0.39	-0.08	0.54
2.11	1.17	3.85	2.40	0.993	5.99	15.860	-0.49	-0.26	0.64
2.44	1.99	3.85	2.20	1.112	5.82	20.737	-0.74	-0.28	0.74
2.45	1.93	3.85	2.30	1.135	5.89	19.697	-0.74	-0.38	0.75
2.79	3.02	3.85	2.40	1.314	6.02	23.342	-1.04	-0.50	0.85
3.34	5.47	3.85	3.20	1.774	6.62	26.839	-0.19	0.36	1.02
4.07	9.11	3.70	3.00	2.054	6.37	31.243	4.96	0.81	1.34
4.90	8.49	3.60	2.40	2.215	5.77	22.196	5.96	0.52	1.49
5.72	8.02	3.45	2.10	2.391	5.22	16.974	6.76	0.98	1.74
6.58	7.69	3.25	1.90	2.553	4.78	13.444	6.56	1.34	2.00
7.34	7.44	3.15	1.80	2.737	4.55	10.982	6.16	1.56	2.24
8.14	7.35	3.10	1.60	2.882	4.26	9.418	5.66	1.81	2.48
8.94	7.24	3.10	1.40	3.031	4.03	8.140	5.16	1.76	2.72
9.78	7.65	3.10	1.30	3.242	3.91	7.399	4.81	1.76	2.98
10.62	8.01	3.20	1.20	3.520	3.91	6.566	4.36	1.80	3.23
11.42	8.46	3.20	1.10	3.699	3.60	6.183	4.06	1.89	3.48
12.22	8.91	3.25	1.00	3.912	3.74	5.775	3.91	1.83	3.72
13.00	9.81	3.30	0.90	4.064	3.63	5.795	3.66	1.91	3.96
14.70	11.51	3.30	0.70	4.429	3.46	5.577	3.26	2.03	4.48
16.42	13.45	3.30	0.50	4.700	3.23	5.582	3.05	2.09	5.00
18.04	15.45	3.35	0.30	4.960	3.07	5.595	2.86	2.05	5.49
19.66	17.54	3.35	0.10	5.109	2.86	5.740	2.71	2.09	5.99

Model 4665 Test No. 12

Model 4003				TEST NO. 12					
V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _V
0.69	0.10	3.70	2.30	0.312	5.54	13.609	-0.10	-0.07	0.21
1.06	0.20	3.70	2.30	0.479	5.54	11.498	-0.15	-0.05	0.32
1.39	0.45	3.75	2.30	0.633	5.59	14.926	-0.20	-0.03	0.42
1.62	0.69	3.75	2.30	0.738	5.59	17.111	0.00	-0.05	0.49
1.77	0.79	3.75	2.40	0.820	5.71	16.045	-0.25	-0.07	0.54
2.09	1.34	3.80	2.40	0.976	5.75	19.290	-0.25	-0.12	0.64
2.41	2.14	3.80	2.20	1.089	5.52	24.135	0.00	-0.25	0.73
2.42	2.09	3.80	2.40	1.130	5.79	22.264	-0.25	-0.27	0.74
2.76	3.08	3.85	2.60	1.351	6.09	23.686	-0.10	-0.37	0.85
3.23	5.50	3.75	3.00	1.642	5.46	29.568	1.35	-0.46	0.98
4.06	8.01	3.50	2.50	1.835	5.47	32.143	5.55	-0.08	1.24
4.92	8.54	3.20	2.10	1.964	4.40	29.012	6.80	0.49	1.50
5.70	8.52	2.90	1.90	2.061	3.58	26.507	6.90	1.06	1.74
6.52	8.19	2.70	1.70	2.161	3.01	23.183	6.35	1.35	1.99
7.36	7.86	2.70	1.50	2.329	2.74	19.158	5.50	1.63	2.24
8.10	7.65	2.70	1.40	2.502	2.61	16.143	4.80	1.77	2.47
8.96	7.59	2.70	1.30	2.700	2.49	13.735	4.15	1.79	2.73
9.78	7.73	2.80	1.20	2.947	2.49	11.741	3.65	1.86	2.98
10.62	8.01	2.80	1.10	3.120	2.38	10.820	3.25	1.90	3.23
11.42	8.26	2.85	1.00	3.312	2.32	9.889	2.90	1.91	3.48
12.22	8.71	2.90	0.90	3.498	2.26	9.329	2.60	1.97	3.72
13.10	9.31	3.00	0.70	3.651	2.16	9.093	2.35	1.95	3.99
14.74	10.74	3.65	0.50	4.608	2.68	6.679	1.90	2.05	4.49
16.38	12.58	3.20	0.40	4.442	2.06	8.242	1.60	2.16	4.99
18.04	14.37	3.20	0.20	4.620	1.88	8.489	1.40	2.17	5.49
19.64	16.10	3.20	0.00	4.734	1.74	8.690	1.30	2.21	5.98

Model 4665 Test No. 14

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Rex 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.69	0.10	3.70	2.20	0.307	5.59	13.478	-0.06	-0.03	0.22
1.04	0.20	3.75	2.20	0.466	5.64	11.731	-0.16	-0.05	0.33
1.40	0.30	3.80	2.30	0.643	5.78	9.436	-0.33	-0.11	0.45
1.59	0.39	3.80	2.40	0.743	5.88	9.602	-0.40	-0.09	0.51
1.76	0.49	3.85	2.40	0.829	5.92	9.722	-0.50	-0.16	0.56
2.10	0.69	3.85	2.30	0.973	5.83	12.520	-0.83	-0.26	0.67
2.35	1.29	3.85	2.20	1.071	5.74	14.701	-1.16	-0.32	0.75
2.42	1.49	3.85	2.10	1.085	5.64	16.285	-1.33	-0.32	0.77
2.78	2.48	3.90	3.40	1.529	6.65	17.480	-1.78	-0.50	0.89
3.16	4.38	3.90	3.20	1.690	6.55	24.222	-2.29	-0.10	1.01
3.94	8.91	3.80	3.00	2.018	6.37	32.621	-1.47	0.13	1.26
4.70	9.24	3.70	2.80	2.301	6.14	24.686	3.80	-0.18	1.50
5.52	8.72	3.65	2.40	2.516	5.76	17.989	4.50	0.23	1.76
6.30	7.70	3.60	2.10	2.705	5.42	12.963	5.07	0.56	2.01
7.04	6.87	3.55	1.90	2.890	5.12	9.811	5.37	0.83	2.24
7.84	6.96	3.50	1.70	3.071	4.84	8.511	5.39	1.02	2.50
8.62	7.06	3.50	1.50	3.247	4.61	7.459	5.27	1.16	2.75
9.44	7.25	3.50	1.40	3.485	4.49	6.552	5.07	1.26	3.01
10.20	7.73	3.40	1.20	3.535	4.15	6.487	4.87	1.37	3.25
11.00	8.39	3.40	1.10	3.729	4.03	6.225	4.67	1.38	3.51
11.82	8.99	3.40	1.00	3.918	3.91	5.949	4.52	1.42	3.77
12.58	9.69	3.45	0.80	4.028	3.74	5.924	4.37	1.46	4.01
14.18	11.38	3.45	0.60	4.326	3.51	5.830	4.17	1.52	4.52
15.82	13.45	3.45	0.40	4.588	3.29	5.913	3.97	1.63	5.04
17.36	15.67	3.45	0.10	4.642	2.97	6.344	3.82	1.62	5.54
18.98	17.26	3.45	0.00	4.933	2.86	6.060	3.77	1.63	6.05

Model 4665 Test No. 15

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Rex 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.68	0.10	3.70	2.10	0.297	5.50	14.107	0.00	0.00	0.22
1.04	0.20	3.75	2.10	0.458	5.54	11.930	-0.08	0.02	0.33
1.38	0.35	3.75	2.10	0.608	5.55	11.844	-0.13	-0.01	0.44
1.59	0.49	3.75	2.10	0.701	5.55	12.750	-0.18	-0.05	0.51
1.78	0.59	3.80	2.30	0.818	5.79	11.688	-0.18	-0.15	0.57
2.08	1.19	3.80	2.40	0.971	5.68	16.936	-0.43	-0.17	0.66
2.33	1.39	3.85	2.10	1.044	5.64	16.398	-0.63	-0.21	0.74
2.46	1.48	3.85	2.30	1.112	5.84	16.521	-0.63	-0.26	0.77
2.70	2.48	3.85	1.90	1.196	5.51	21.404	-0.78	-0.42	0.88
3.14	4.08	3.80	3.40	1.703	6.70	22.344	-0.33	-0.50	1.00
3.94	6.81	3.70	2.80	1.929	6.18	24.960	3.42	-0.32	1.26
4.72	6.94	3.60	2.60	2.098	5.63	18.021	4.47	0.17	1.51
5.50	6.02	3.50	2.10	2.320	5.29	13.617	5.12	0.57	1.75
6.26	5.60	3.45	1.90	2.523	5.01	10.332	5.32	0.81	2.00
7.04	5.42	3.35	1.70	2.678	4.67	8.486	5.12	1.02	2.24
7.86	5.44	3.30	1.50	2.842	4.38	7.280	4.82	1.16	2.51
8.62	5.56	3.30	1.40	3.052	4.26	6.352	4.52	1.35	2.75
9.42	5.77	3.30	1.20	3.193	4.03	5.841	4.22	1.39	3.00
10.20	6.33	3.30	1.10	3.381	3.91	5.627	4.02	1.50	3.25
11.00	7.24	3.30	0.90	3.480	3.68	5.877	3.67	1.50	3.51
11.76	7.84	3.30	0.80	3.632	3.57	5.750	3.47	1.56	3.75
12.58	8.79	3.30	0.70	3.791	3.46	5.816	3.32	1.51	4.01
14.18	10.33	3.35	0.50	4.115	3.29	5.644	3.07	1.53	4.52
15.78	11.90	3.35	0.30	4.339	3.07	5.632	2.87	1.69	5.03
17.40	13.61	3.35	0.10	4.522	2.86	5.686	2.72	1.69	5.55
18.98	15.16	3.35	0.00	4.790	2.76	5.518	2.62	1.72	6.05

Model 4665 Test No. 16

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Rex 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.68	0.10	3.70	1.90	0.287	5.34	14.533	0.00	0.00	0.22
1.04	0.20	3.70	1.90	0.439	5.34	12.391	-0.02	0.06	0.33
1.39	0.40	3.75	1.90	0.582	5.38	13.776	-0.02	0.01	0.44
1.69	0.54	3.75	1.90	0.719	5.39	12.771	0.00	0.00	0.54
1.76	0.69	3.75	2.10	0.776	5.60	14.437	-0.07	0.02	0.56
2.08	1.17	3.75	2.10	0.917	5.59	17.490	-0.02	-0.04	0.66
2.34	1.64	3.80	2.00	1.022	5.56	19.467	-0.02	-0.13	0.75
2.42	1.71	3.80	2.00	1.057	5.57	18.935	-0.07	-0.13	0.77
2.78	2.64	3.80	1.80	1.173	5.36	23.066	0.18	-0.26	0.89
3.16	3.98	3.70	1.80	1.309	5.28	27.276	1.13	-0.38	1.01
3.90	5.36	3.60	2.30	1.733	5.70	22.382	4.48	-2.92	1.24
4.72	5.64	3.45	2.10	1.973	5.28	17.366	5.28	0.31	1.51
5.50	5.57	3.15	1.80	2.051	4.55	14.648	5.63	0.69	1.75
6.24	5.45	2.95	1.60	2.139	4.09	12.393	5.28	0.91	1.99
7.02	5.37	2.85	1.50	2.300	3.86	10.235	4.78	1.18	2.24
7.83	5.44	2.85	1.30	2.448	3.63	8.860	4.23	1.31	2.50
8.62	5.61	2.85	1.20	2.630	3.51	7.777	3.51	1.42	2.75
9.40	5.59	2.90	1.10	2.832	3.46	6.627	3.38	1.45	3.00
10.18	6.23	3.00	0.90	2.991	3.34	6.508	3.03	1.57	3.25
11.00	6.49	3.00	0.80	3.149	3.23	6.000	2.83	1.54	3.51
11.78	7.19	3.05	0.70	3.328	3.18	5.898	2.53	1.59	3.76
12.51	7.61	3.10	0.60	3.487	3.13	5.634	2.33	1.56	3.99
14.16	9.33	3.10	0.40	3.733	2.91	5.780	2.03	1.61	4.52
15.78	10.75	3.15	0.20	3.982	2.76	5.662	1.92	1.70	5.03
17.37	12.22	3.20	0.00	4.187	2.61	5.607	1.58	1.81	5.54
18.92	14.15	3.20	0.00	4.561	2.61	5.474	1.53	1.78	6.03

Model 4665 Test No. 17

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Rex 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.69	0.15	3.65	1.80	0.283	5.26	21.546	0.01	0.00	0.22
1.06	0.30	3.70	1.80	0.439	5.30	18.090	0.06	0.02	0.34
1.39	0.55	3.70	1.80	0.576	5.28	19.348	0.06	-0.02	0.44
1.59	0.69	3.70	1.80	0.659	5.30	18.762	0.16	-0.06	0.51
1.76	0.94	3.70	1.80	0.729	5.30	20.789	0.16	-0.06	0.56
2.10	1.34	3.70	2.00	0.902	5.50	20.002	0.31	-0.11	0.67
2.36	1.84	3.65	2.00	1.005	5.46	21.860	0.51	-0.18	0.75
2.44	2.01	3.65	1.90	1.020	5.35	22.786	0.51	-0.18	0.78
2.98	2.98	3.65	1.90	1.246	5.36	22.626	1.16	-0.26	0.95
3.15	3.33	3.60	2.00	1.329	5.44	29.012	2.91	-0.28	1.00
3.94	4.91	3.20	2.00	1.543	4.94	27.888	5.36	-0.10	1.26
4.72	6.44	2.80	1.80	1.636	4.15	25.247	6.21	0.65	1.51
5.50	5.32	2.60	1.70	1.782	3.80	18.767	5.91	1.11	1.75
6.26	4.97	2.40	1.40	1.792	3.23	14.193	5.16	1.37	2.00
7.06	4.62	2.40	1.20	1.915	3.02	11.119	4.31	1.47	2.25
7.84	4.44	2.40	1.10	2.067	2.91	8.977	3.56	1.69	2.50
8.64	4.51	2.50	1.00	2.278	2.91	7.501	3.01	1.63	2.76
9.38	4.57	2.50	0.90	2.402	2.81	6.692	2.56	1.84	2.99
10.20	5.93	2.60	0.80	2.612	2.81	7.340	2.11	1.75	3.25
11.06	6.18	2.60	0.70	2.749	2.71	6.750	1.79	1.87	3.53
11.76	6.69	2.70	0.60	2.923	2.71	6.461	1.61	1.73	3.75
12.57	7.27	2.70	0.50	3.030	2.61	6.373	1.31	1.74	4.01
14.13	8.38	2.80	0.30	3.300	2.52	6.033	0.96	1.71	4.51
15.77	9.65	2.80	0.00	3.347	2.25	6.152	0.71	1.85	5.06
17.37	10.97	2.80	0.00	3.664	2.25	5.838	0.56	1.95	5.54
18.98	12.16	2.80	0.00	4.003	2.25	5.423	0.51	1.87	6.05

Model 4666 Test No. 1

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in.	F _V
0.85	0.26	5.80	4.00	0.674	9.530	13.252	0.00	0.00	0.24
1.31	0.51	5.80	4.00	1.027	9.530	11.292	-0.02	-0.01	0.36
1.75	1.01	5.85	4.10	1.394	9.530	12.541	-0.05	-0.04	0.48
1.85	1.13	5.80	4.10	1.466	9.490	12.613	-0.07	-0.08	0.51
2.18	1.86	5.85	4.30	1.771	9.740	14.552	-0.09	-0.15	0.60
2.62	3.11	5.85	4.00	2.065	9.420	17.407	-0.12	-0.25	0.72
2.78	3.51	5.85	4.00	2.191	9.450	17.383	-0.10	-0.23	0.76
3.08	4.90	5.80	5.20	2.711	10.360	18.064	-0.04	-0.32	0.84
3.48	7.30	5.80	5.20	3.064	10.420	20.941	0.38	-0.56	0.95
3.68	8.32	5.80	5.40	3.298	10.660	20.875	0.80	-0.39	1.01
4.61	11.98	5.60	4.50	3.726	9.750	20.949	3.40	-0.06	1.26
5.32	12.78	5.55	4.20	4.307	9.300	16.942	3.78	0.22	1.51
6.39	13.31	5.45	3.90	4.781	8.840	13.348	4.33	0.51	1.75
7.31	13.60	5.10	3.50	5.031	7.870	11.714	4.93	0.96	2.01
8.21	13.97	4.80	3.20	5.256	7.220	10.394	5.01	0.13	2.25
9.98	14.18	4.60	3.00	5.322	6.800	9.153	4.88	0.16	2.49
10.04	14.72	4.40	2.90	5.865	6.490	8.151	4.45	0.18	2.76
10.98	14.82	4.40	2.70	6.239	6.280	7.085	4.17	0.19	3.01
11.66	16.01	4.40	2.60	6.644	6.180	6.670	3.91	0.20	3.25
12.60	15.91	4.40	2.50	7.068	6.080	5.787	3.63	0.22	3.51
13.66	16.87	4.40	2.30	7.324	5.870	5.376	3.41	0.20	3.75
14.62	17.64	4.45	2.20	7.780	5.820	5.134	3.21	0.21	4.01
16.46	19.91	4.90	2.00	8.562	5.670	4.694	2.75	0.22	4.52
18.30	23.06	4.60	1.80	9.373	5.570	4.477	2.43	0.25	5.02
20.20	26.44	4.70	1.60	10.184	5.470	4.288	2.11	0.26	5.54
22.00	29.74	4.80	1.40	10.916	5.370	4.142	1.95	0.26	6.04

Model 4666 Test No. 2

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in.	F _V
0.85	0.27	6.00	5.80	0.770	11.91	11.394	0.00	1.13	0.20
1.35	0.54	6.00	6.00	1.244	11.98	8.971	-0.10	1.08	0.32
1.72	1.09	6.00	6.00	1.583	11.92	11.205	-0.20	1.01	0.41
2.15	1.80	6.00	6.00	1.982	11.92	11.844	-0.45	0.87	0.51
2.61	3.45	6.00	6.00	2.406	11.86	15.479	-0.70	0.72	0.62
3.02	7.17	6.00	6.00	2.784	11.68	24.399	-1.00	0.55	0.72

Model 4666 Test No. 3

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in.	F _V
2.10	2.19	6.00	6.00	1.936	12.52	14.379	-0.23	-0.22	0.30
3.16	8.88	6.00	6.00	2.913	12.52	25.749	-0.70	-0.67	0.75
4.18	24.15	6.00	6.00	3.94	13.32	37.010	1.80	-1.13	1.06
5.22	41.72	5.80	5.40	4.492	11.75	47.236	6.20	-0.39	1.25
6.28	43.50	5.60	4.90	5.066	10.94	36.547	7.40	0.54	1.50
7.30	46.39	5.00	4.10	5.104	8.75	36.064	9.70	1.55	1.74
8.32	46.74	4.50	3.70	5.242	7.45	32.854	10.00	2.48	1.99
9.38	45.14	4.30	3.50	5.621	7.00	26.358	9.10	3.01	2.24
10.48	42.63	4.20	3.30	6.039	6.70	21.000	8.13	3.40	2.50
11.52	40.56	4.10	3.20	6.461	6.50	17.044	7.50	3.76	2.75
12.56	38.84	4.10	3.00	6.851	6.30	14.093	6.78	4.07	3.00
13.56	37.36	4.10	2.80	7.293	6.20	11.879	6.02	4.41	3.24
14.74	36.56	4.10	2.90	7.814	6.10	9.999	5.85	5.10	3.52
15.80	36.27	4.10	2.70	8.255	6.00	8.778	5.40	5.26	3.77
16.80	36.47	4.10	2.70	8.777	6.00	7.807	5.05	5.18	4.01

Model 4666 Test No. 5

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in.	F _V
0.85	0.60	5.75	4.60	0.666	11.86	25.408	0.05	0.02	0.20
1.30	1.30	5.80	4.70	1.048	12.15	22.953	0.15	-0.03	0.31
1.72	2.29	5.80	4.70	1.387	12.15	23.103	0.25	0.01	0.41
2.09	3.59	5.85	4.60	1.676	11.87	25.103	0.31	-0.06	0.50
2.15	3.99	5.85	4.70	1.744	12.07	25.929	0.35	-0.15	0.51
2.59	5.98	5.90	4.60	2.069	12.01	26.908	0.53	-0.17	0.62
3.03	8.88	5.80	5.00	2.514	12.55	27.942	0.75	-0.37	0.72
3.13	10.08	5.80	5.20	2.645	12.66	29.464	0.95	-0.28	0.75
3.43	13.97	5.80	6.40	3.215	13.30	32.366	1.75	-0.44	0.82
4.18	28.35	5.55	4.80	3.327	12.43	47.320	4.70	-0.46	1.00
5.21	50.72	4.80	4.00	3.522	9.47	71.524	8.33	-0.28	1.24
6.28	60.08	4.20	3.40	3.667	6.80	81.210	11.00	0.84	1.50
7.28	59.34	3.60	3.10	3.747	6.00	67.646	11.00	2.13	1.74
8.32	55.34	3.60	2.90	4.155	5.70	50.842	10.20	3.35	1.99
9.38	50.36	3.60	2.70	4.540	5.50	37.724	8.68	3.10	2.24

Model 4666 Test No. 4

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in.	F _V
0.86	0.45	5.85	4.90	0.710	12.05	18.397	0.03	0.01	0.21
1.29	1.00	5.85	5.00	1.074	12.17	17.901	0.00	0.00	0.31
1.72	1.69	5.90	5.00	1.440	12.20	16.979	0.00	-0.10	0.41
2.10	2.59	5.90	5.00	1.758	12.16	17.509	0.00	-0.10	0.50
2.14	2.79	5.95	5.00	1.802	12.21	18.092	-0.04	-0.22	0.51
2.60	4.78	6.00	6.00	2.397	12.72	20.152	0.05	-0.27	0.62
3.04	8.18	6.00	6.00	2.802	12.58	25.507	0.13	-0.43	0.73
3.12	8.78	6.00	6.00	2.876	12.58	25.991	0.23	-0.38	0.74
3.44	12.07	6.00	6.00	3.171	12.56	29.439	0.35	-0.63	0.82
4.19	25.45	5.80	5.60	3.670	12.79	41.085	3.50	-0.60	1.00
5.21	43.52	5.40	4.60	4.003	11.06	52.548	7.25	-0.10	1.24
6.29	49.38	4.90	4.00	4.301	8.15	55.513	9.31	0.99	1.50
7.29	53.34	4.40	3.50	4.425	7.10	51.243	10.65	2.23	1.74
8.32	50.19	4.00	3.30	4.666	6.50	40.435	9.33	3.09	1.99
9.38	46.94	3.80	3.10	4.973	6.10	31.703	8.40	3.65	2.24
10.44	43.88	3.60	2.90	5.214	5.70	25.603	7.25	4.06	2.49
11.54	40.96	3.60	2.80	5.674	5.58	19.981	6.35	4.52	2.75
12.54	38.79	3.60	2.70	6.070	5.50	16.258	5.43	4.78	2.99

Model 4666 Test No. 5										Model 4666 Test No. 7									
V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _V	V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _V
0.84	0.21	5.90	5.20	0.716	10.75	10.056	-0.05	-0.03	0.22	0.86	0.30	5.85	4.60	0.689	10.48	14.050	-0.10	-0.10	0.22
1.26	0.45	5.90	5.00	1.055	10.62	9.681	-0.10	-0.06	0.33	1.29	0.60	5.90	4.80	1.060	10.72	12.198	-0.15	-0.13	0.33
1.72	0.81	6.00	5.20	1.480	10.77	9.219	-0.25	-0.14	0.44	1.72	1.04	5.90	4.80	1.414	10.67	11.945	-0.20	-0.06	0.44
1.92	1.14	6.00	5.00	1.622	10.60	10.577	-0.33	-0.17	0.50	1.92	1.37	5.90	4.70	1.563	10.48	12.859	-0.22	-0.12	0.50
2.12	1.49	6.00	4.60	0.615	10.25	11.726	-0.35	-0.20	0.55	2.12	1.79	6.00	4.60	1.726	10.56	13.674	-0.11	-0.11	0.55
2.61	2.78	6.10	6.10	2.446	10.88	13.598	-0.58	-0.44	0.67	2.61	3.18	6.00	4.40	2.085	10.30	16.430	-0.32	-0.27	0.67
2.89	4.14	6.10	6.10	2.709	10.86	16.546	-0.90	-0.47	0.75	2.89	4.64	6.00	4.20	2.264	10.14	19.862	-0.33	-0.27	0.75
3.03	5.38	6.10	6.10	2.840	10.86	19.598	-0.95	-0.53	0.78	3.03	5.33	6.00	4.00	2.328	9.96	21.132	-0.40	-0.41	0.78
3.43	8.97	6.20	6.20	3.268	10.94	23.532	-1.25	-0.77	0.89	3.43	8.07	6.00	3.80	2.590	9.83	25.151	-0.38	-0.58	0.89
3.82	13.16	6.00	6.00	3.577	10.99	28.834	-0.68	-0.99	1.00	3.86	12.46	6.00	6.00	3.559	11.92	25.433	-0.30	-1.15	1.00
4.52	21.84	6.00	6.00	4.296	11.40	29.892	3.55	-0.57	1.25	4.85	20.64	5.70	5.00	3.987	10.66	29.839	4.37	-0.31	1.25
5.78	24.95	6.00	6.00	5.151	11.04	24.522	3.83	-0.18	1.49	5.78	21.50	5.60	4.70	4.574	10.08	23.143	5.00	0.27	1.49
6.72	27.41	5.60	5.20	5.576	10.51	20.935	4.48	0.34	1.74	6.72	22.16	5.40	4.20	4.956	9.25	19.230	6.00	0.75	1.74
7.72	24.72	5.60	4.40	5.931	9.45	15.910	6.00	0.94	2.00	7.70	23.02	5.00	3.80	5.206	8.04	17.505	6.88	1.36	1.99
8.62	22.68	5.40	3.90	6.159	8.55	12.941	6.82	1.52	2.23	8.69	22.98	4.70	3.40	5.408	7.32	15.069	6.78	1.90	2.25
9.61	22.18	5.20	3.60	6.497	8.65	10.815	6.78	1.94	2.48	9.60	22.38	4.50	3.20	5.679	6.90	12.757	6.35	2.17	2.48
10.61	22.22	5.10	3.40	6.929	7.73	9.256	6.53	2.19	2.74	10.60	22.12	4.45	3.10	6.157	6.75	10.572	5.90	2.38	2.74
11.98	22.50	5.00	3.30	7.385	7.52	8.088	6.18	2.50	2.99	11.60	21.90	4.40	2.90	6.506	6.50	9.076	5.45	2.59	3.00
12.94	22.88	4.90	3.10	7.708	7.21	7.315	5.90	2.52	3.24	12.58	21.93	4.30	2.80	6.862	6.30	7.973	5.08	2.69	3.25
13.56	23.26	4.90	3.00	8.231	7.12	6.440	5.60	2.60	3.51	13.50	22.26	4.30	2.70	7.261	6.20	7.141	4.60	2.93	3.49
14.56	24.18	4.80	2.90	8.725	7.01	5.898	5.35	2.75	3.76	14.58	23.18	4.30	2.60	7.729	6.10	6.480	4.30	2.97	3.77
15.60	25.54	4.90	2.80	9.229	6.98	5.450	5.05	2.95	4.03	15.60	23.84	4.40	2.50	8.270	6.10	5.821	4.05	3.11	4.03
17.44	28.50	4.90	2.50	9.916	6.60	5.146	4.65	2.94	4.51	17.94	26.30	4.40	2.30	9.235	5.88	5.038	3.45	3.11	4.51
19.42	31.69	5.00	2.40	11.042	6.60	4.615	4.35	2.99	5.02	19.44	29.09	4.50	2.10	9.858	5.75	4.853	3.10	3.13	5.02
21.38	35.95	5.10	2.20	11.992	6.60	4.386	4.00	3.01	5.53	21.44	32.66	4.60	1.90	10.707	5.70	4.518	2.77	3.05	5.54
23.36	40.30	5.20	2.00	12.923	6.40	4.183	3.78	2.96	6.04	23.32	36.40	4.70	1.80	11.646	5.70	4.257	2.45	2.95	6.03

Model 4666 Test No. 8										Model 4666 Test No. 9									
V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _V	V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _V
0.86	0.33	3.78	4.40	0.672	10.50	15.435	-0.02	-0.01	0.22	0.86	0.35	5.70	4.10	0.647	10.30	16.672	0.02	0.01	0.22
1.29	0.65	5.62	4.35	1.007	10.46	13.541	-0.02	-0.01	0.33	1.30	0.80	5.75	4.10	0.984	10.33	16.618	0.07	0.03	0.34
1.71	1.20	5.87	4.50	1.361	11.10	13.405	-0.02	-0.01	0.44	1.84	1.43	5.77	4.20	1.408	10.37	14.768	0.07	0.03	0.48
1.93	1.64	5.85	4.45	1.527	10.48	15.235	-0.02	-0.02	0.50	1.94	1.87	5.78	4.20	1.487	10.35	17.408	0.12	0.47	0.50
2.13	2.09	5.90	4.40	1.701	10.46	15.672	-0.02	-0.02	0.56	2.15	2.39	5.80	4.20	1.651	10.46	17.922	0.17	0.06	0.56
2.60	3.38	5.95	4.20	2.628	10.27	16.694	0.03	-0.01	0.67	2.60	3.98	5.85	4.10	1.989	10.39	20.542	0.32	0.11	0.67
2.90	4.39	5.90	4.00	2.205	10.00	21.508	0.08	-0.02	0.75	2.90	5.49	5.85	3.90	2.174	10.21	23.178	0.49	0.17	0.75
3.02	5.78	6.00	3.90	2.297	10.66	22.838	0.06	0.00	0.78	3.02	6.38	5.85	3.80	2.236	10.01	25.333	0.62	0.21	0.78
3.42	9.02	6.00	3.70	2.948	9.86	28.353	0.33	0.19	0.88	3.45	9.47	5.85	3.80	2.555	10.02	28.786	1.44	0.52	0.88
3.88	13.26	6.00	6.00	3.577	11.38	28.058	1.83	0.73	1.03	3.86	13.16	5.85	4.70	3.131	10.94	29.267	1.57	0.58	1.00
4.82	20.47	5.50	4.40	3.666	9.33	32.165	4.88	2.08	1.25	4.82	23.44	5.70	4.50	3.777	10.06	36.356	5.82	2.25	1.25
5.80	21.90	5.30	4.00	4.144	9.27	25.437	3.68	2.48	1.50	5.79	27.00	5.56	4.30	4.386	9.65	30.254	7.22	2.60	1.50
6.72	24.39	4.80	3.60	4.337	7.82	25.036	6.88	3.07	1.74	6.71	28.61	4.20	3.10	3.763	6.50	35.437	7.57	3.06	1.73
7.82	24.65	4.40	3.30	4.626	6.90	21.177	6.98	3.17	2.02	7.70	27.15	3.50	2.90	3.786	5.60	29.641	7.22	3.01	1.99
8.63	28.05	4.20	3.10	4.831	6.50	17.925	6.33	3.03	2.24	8.68	24.28	3.20	2.70	3.934	5.05	23.132	6.27	2.68	2.24
9.60	33.43	4.00	2.90	5.089	6.10	13.103	5.86	2.77	2.48	9.61	24.58	3.20	2.50	4.208	4.90	19.690	5.32	2.33	2.48
10.60	22.50	3.80	2.75	5.342	5.75	12.624	5.18	2.50	2.74	10.60	22.58	3.20	2.42	4.577	4.80	15.674	4.52	2.04	2.74
11.60	21.97	3.60	2.60	5.526	5.40	10.965	4.58	2.26	3.00	11.60	22.48	3.20	2.30	4.902	4.70	12.885	3.72	1.75	3.00
12.58	21.83	3.60	2.50	5.896	5.28	9.470	4.13	2.06	3.25	12.60	22.05	3.30	2.20	5.324	4.70	10.712	3.12	1.53	3.25
13.53	21.81	3.50	2.40	6.133	5.08	8.501	3.68	1.87	3.50	13.52	21.86	3.30	2.10	5.609	4.60	9.424	2.62	1.34	3.49
14.58	22.28	3.50	2.30	6.497	5.00	7.598	3.18	1.67	3.77	14.51	21.98	3.30	2.05	5.975	4.60	8.227	2.12	1.14	3.75
15.58	22.74	3.80	2.20	6.943	5.00	6.792	2.88	1.36	4.03										
17.40	24.80	3.80	2.00	7.754	5.00	5.938	2.38	1.35	4.50										
19.36	27.19	4.00	1.87	8.746	5.08	5.176	1.88	1.13	5.00										

Model 4666 Test No. 10

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in.	F _v
0.88	0.16	5.85	4.50	0.730	7.610	0.00	0.10	0.24
1.30	0.36	5.85	4.50	1.077	7.974	0.10	0.14	0.36
1.74	0.71	5.90	4.60	1.462	8.577	0.17	0.10	0.51
1.85	0.71	5.90	4.60	1.554	8.800	0.21	-0.12	0.48
2.18	1.31	5.90	4.60	1.832	9.680	0.29	0.30	0.60
2.63	2.36	5.90	4.60	2.484	10.610	0.46	-0.12	0.72
2.78	2.87	5.90	4.60	2.625	10.620	0.51	-0.30	0.76
3.06	4.10	5.90	4.60	2.890	10.600	0.72	-0.37	0.84
3.49	6.75	5.90	4.60	3.296	10.710	0.62	-0.48	0.96
3.68	8.20	5.90	4.60	3.475	10.420	0.56	-0.63	1.01
4.60	14.26	5.80	4.50	4.791	10.080	0.30	-0.17	1.26
5.45	15.66	5.80	4.50	5.104	9.900	0.33	-0.03	1.50
6.39	17.24	5.75	4.40	5.395	9.300	0.38	0.33	1.75
7.24	17.08	5.60	4.30	5.736	8.440	0.48	0.68	1.99
7.32	16.80	5.60	4.30	5.789	8.440	0.48	0.68	2.01
8.20	15.84	5.30	3.90	6.037	8.240	0.48	1.02	2.25
8.21	15.67	5.30	3.90	6.045	8.240	0.48	1.02	2.25
9.10	15.38	5.40	3.60	6.564	7.840	0.53	1.34	2.50
9.11	15.22	5.40	3.60	6.562	7.890	0.53	1.34	2.50
10.00	15.58	5.30	3.30	6.882	7.740	0.51	1.43	2.74
10.04	15.37	5.35	3.30	6.950	7.740	0.51	1.43	2.76
10.94	15.87	5.30	3.20	7.442	7.430	0.60	1.58	3.00
10.96	15.65	5.30	3.20	7.455	7.740	0.60	1.58	3.01
11.88	16.64	5.20	3.00	7.786	7.320	0.74	1.87	3.26
12.74	17.52	5.20	2.90	8.238	7.220	0.83	1.91	3.50
13.64	18.32	5.20	2.80	8.733	7.010	0.94	2.59	3.74
14.64	19.76	5.20	2.60	9.139	6.800	1.02	2.38	4.02
16.48	22.46	5.20	2.40	10.023	6.590	1.23	2.23	4.52
18.24	25.97	5.20	2.20	10.802	6.390	1.47	2.30	5.01
20.18	29.84	5.20	2.00	11.628	6.180	1.55	2.38	5.54
20.18	29.84	5.20	2.00	11.628	6.386	1.55	2.38	5.54
22.02	33.79	5.20	1.80	12.335	6.179	1.87	3.78	6.04
22.04	33.79	5.20	1.80	12.347	6.179	1.87	3.78	6.05

Model 4666 Test No. 12

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in.	F _v
0.86	0.19	5.73	2.77	0.562	8.130	0.00	0.00	0.24
1.29	0.50	5.78	2.89	0.860	8.310	0.00	0.00	0.35
1.73	0.91	5.80	2.92	1.160	8.340	0.00	0.00	0.47
1.83	1.09	5.83	2.92	1.231	8.350	0.05	-0.08	0.50
2.15	1.71	5.87	3.00	1.566	8.580	0.05	-0.08	0.59
2.60	2.79	5.90	2.89	1.760	8.400	0.10	-0.15	0.71
2.75	3.36	5.95	2.85	1.860	8.400	0.10	-0.15	0.75
3.04	4.55	6.00	4.50	2.790	9.830	0.17	-0.22	0.83
3.45	6.58	6.00	4.50	3.230	9.870	0.60	-0.41	0.95
3.65	7.92	6.00	4.50	3.294	9.960	0.65	-0.48	1.00
4.53	11.76	5.60	4.20	3.428	9.540	0.45	-0.33	1.25
5.45	12.61	5.50	4.00	3.961	9.270	0.50	-0.24	1.50
5.46	12.61	5.45	4.00	3.967	9.040	0.50	-0.14	1.50
6.35	13.29	5.20	3.70	4.345	8.540	0.65	0.95	1.74
6.36	13.29	5.43	4.00	4.611	9.360	0.65	0.95	1.74
7.28	14.26	4.70	3.30	4.478	7.220	0.55	1.29	2.00
7.29	14.26	4.70	3.20	4.428	7.120	0.55	1.29	2.00
8.17	14.49	4.40	3.10	4.711	6.700	0.732	1.59	2.24
8.18	14.53	4.40	3.10	4.717	6.700	0.732	1.59	2.24
9.06	14.53	4.20	2.90	4.946	6.260	1.029	1.35	2.49
9.08	14.58	4.30	2.90	5.027	6.390	1.022	1.35	2.49
10.02	14.78	4.00	2.80	5.239	5.970	0.818	1.81	2.75
10.03	14.70	4.10	2.70	5.244	5.970	0.858	1.81	2.75
10.92	14.92	4.10	2.70	5.709	5.970	0.782	3.93	3.00
10.92	14.92	4.10	2.70	5.709	5.970	0.782	3.93	3.00
11.86	15.23	4.20	2.59	5.964	6.572	3.50	2.20	3.25
12.76	15.71	4.20	2.40	6.552	5.970	3.30	2.40	3.50
12.76	15.71	4.20	2.40	6.552	5.771	3.25	2.37	3.75
14.62	17.37	4.20	2.32	7.329	5.690	2.70	2.31	4.01

Model 4666 Test No. 11

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in.	F _v
0.86	0.20	5.80	4.20	0.688	9.600	0.00	0.00	0.24
1.29	0.46	5.80	4.20	1.032	9.580	-0.07	-0.09	0.35
1.74	0.86	5.85	4.20	1.399	9.580	-0.10	-0.10	0.46
1.84	0.94	5.85	4.20	1.460	9.580	-0.12	-0.06	0.50
2.15	1.46	5.85	4.40	1.764	9.750	-0.17	-0.19	0.59
2.62	2.61	5.85	4.00	2.065	9.330	-0.23	-0.23	0.72
2.78	3.06	5.85	3.80	2.147	9.170	-0.27	-0.19	0.76
3.06	4.31	5.85	3.80	2.865	10.720	-0.30	-0.36	0.84
3.45	6.10	5.85	3.80	3.230	10.770	-0.12	-0.46	0.95
3.67	8.10	5.80	3.80	3.407	10.680	0.21	-0.49	1.01
4.59	12.68	5.75	3.50	3.949	10.210	0.30	-0.40	1.26
5.45	13.36	5.50	3.40	4.429	9.530	0.36	0.05	1.50
6.39	13.99	5.55	3.40	4.986	9.290	0.40	0.32	1.75
7.31	13.70	5.40	3.80	5.382	8.480	0.47	0.76	2.01
8.20	13.67	5.20	3.50	5.703	7.940	0.49	1.03	2.25
9.10	14.02	5.05	3.20	6.038	7.430	0.49	1.38	2.50
10.04	14.67	4.90	3.00	6.348	7.120	0.47	1.53	2.76
10.94	15.02	4.70	2.90	6.654	6.800	0.45	1.80	3.00
11.82	15.68	4.70	2.70	7.000	6.590	0.42	1.97	3.24
12.76	16.34	4.60	2.60	7.352	6.390	0.40	1.99	3.50
13.64	17.24	4.70	2.50	7.859	6.390	0.38	1.99	3.74
14.64	18.24	4.80	2.40	8.436	6.390	0.36	2.12	4.02
14.64	18.16	4.80	2.40	8.436	6.390	0.36	2.10	4.02
16.48	20.58	4.80	2.10	9.100	6.070	0.32	2.23	4.52
18.34	23.59	4.80	1.90	9.894	5.870	0.32	2.32	5.03
20.16	27.41	4.90	1.80	10.809	5.870	0.28	2.40	5.53

Model 4666 Test No. 13

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in.	F _v
0.85	0.27	5.70	3.60	0.607	9.25	0.00	0.00	0.23
1.30	0.58	5.70	3.60	0.928	9.23	0.00	0.00	0.36
1.72	1.09	5.73	3.60	1.231	9.18	0.05	0.05	0.47
1.83	1.31	5.75	3.65	1.321	9.25	0.10	-0.08	0.50
2.14	1.92	5.80	3.80	1.578	9.42	0.13	-0.08	0.59
2.60	3.03	5.80	3.70	1.897	9.33	0.25	-0.15	0.71
2.74	3.63	5.80	3.60	1.978	9.28	0.25	-0.15	0.75
3.04	4.73	5.80	3.50	2.172	9.22	0.45	-0.30	0.83
3.41	6.82	5.80	3.50	2.508	9.45	0.65	-0.71	0.95
3.65	8.12	5.70	4.20	2.776	9.71	1.95	0.64	1.00
4.56	12.74	5.30	3.80	3.168	8.92	0.05	-0.34	1.25
5.45	14.32	4.80	3.50	3.475	7.94	0.20	0.20	1.50
6.70	15.74	4.15	3.10	3.727	6.54	0.55	0.66	1.84
7.28	15.94	3.90	2.90	3.803	5.99	0.55	1.20	2.00
8.18	15.53	3.70	2.60	3.959	5.50	0.55	1.48	2.25
9.08	15.12	3.60	2.50	4.255	5.29	0.55	1.81	2.49
10.02	14.89	3.60	2.40	4.619	5.19	0.35	1.99	2.75
10.93	14.88	3.60	2.20	4.870	5.00	0.35	2.03	3.00
11.87	14.85	3.60	2.10	5.198	4.90	0.25	2.26	3.26
12.76	15.35	3.60	2.00	5.490	4.80	0.25	2.14	3.50
13.64	15.77	3.60	1.90	5.764	4.70	0.25	2.21	3.75
14.60	16.35	3.60	1.80	6.037	4.60	0.25	2.30	4.01
16.49	18.16	3.70	1.60	6.715	4.50	0.25	2.52	4.53

Model 4666 Test 12R

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in.	F _v
4.58	11.88	5.60	4.30	3.629	9.530	3.48	-0.31	1.26
5.47	12.51	5.50	4.00	4.159	9.120	3.93	0.03	1.50
6.36	13.24	5.25	3.70	4.555	8.510	4.55	0.40	1.75
7.30	13.98	4.75	3.30	4.703	7.380	3.06	0.74	2.00
8.20	14.27	4.50	3.10	4.957	6.880	4.95	1.15	2.25
20.16	24.67	4.50	1.50	9.680	5.180	4.278	1.75	5.53
22.02	28.44	4.50	1.30	10.221	4.890	4.256	1.55	6.04

Model 4666 Test No. 14

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _V
0.85	0.16	5.80	3.80	0.626	8.82	9.119	-0.03	1.24	0.25
1.30	0.32	5.80	3.80	0.958	8.82	7.785	-0.08	1.21	0.37
1.72	0.59	5.80	3.80	1.268	8.82	8.200	-0.13	1.18	0.50
1.75	0.61	5.80	4.00	1.317	9.02	8.009	-0.13	1.18	0.50
2.15	1.09	5.80	4.00	1.618	9.02	9.477	-0.18	1.05	0.62
2.60	2.00	6.00	3.80	1.957	9.02	11.891	-0.28	1.09	0.75
2.60	2.04	6.00	3.80	1.957	9.02	12.128	-0.33	1.07	0.75
3.03	3.46	6.00	3.50	2.211	8.73	15.650	-0.50	0.87	0.87
3.45	5.49	6.00	3.10	2.412	8.33	20.025	-0.33	0.79	0.99
3.50	5.37	6.00	4.80	2.904	9.89	16.666	-0.23	0.83	1.01
4.32	9.55	5.60	4.00	2.921	8.04	23.072	1.37	1.65	1.25
5.20	10.60	5.80	4.60	4.155	9.71	14.635	2.67	1.22	1.50
6.05	11.75	5.80	4.00	4.555	9.18	12.676	2.67	1.36	1.74
6.95	12.21	5.60	4.00	5.126	8.98	10.204	3.07	1.65	2.00
7.80	12.22	5.80	3.80	5.753	8.97	8.117	3.17	1.70	2.25
8.68	12.13	5.80	3.50	6.002	8.24	7.083	3.77	2.35	2.50
9.50	12.56	5.80	3.20	6.350	7.94	6.354	3.87	2.30	2.74
10.40	12.86	5.40	3.00	6.712	7.62	5.656	3.97	2.16	3.00
11.25	13.72	5.40	2.80	7.088	7.42	5.286	3.87	1.91	3.24
12.12	14.64	5.30	2.70	7.450	7.21	5.011	3.77	1.65	3.49
13.00	16.05	5.30	2.60	7.891	7.11	4.842	3.67	2.68	3.75
13.90	17.18	5.30	2.40	8.223	6.90	4.671	3.57	2.73	4.01
14.70	20.23	5.20	2.10	8.806	6.50	4.577	3.47	2.96	4.52
17.40	23.31	5.20	1.90	9.492	6.30	4.430	3.17	3.05	5.01
19.20	26.67	5.20	1.70	10.179	6.09	4.306	3.17	3.09	5.53
20.96	30.17	5.30	1.40	10.790	7.94	3.135	2.87	3.01	6.04

Model 4666 Test No. 15

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _V
0.84	0.18	5.75	3.60	0.604	10.67	8.577	0.00	0.00	0.24
1.30	0.35	5.80	3.60	0.938	10.52	7.140	-0.03	-0.02	0.37
1.72	0.69	5.82	3.65	1.252	10.35	8.171	-0.06	-0.03	0.50
1.75	0.69	5.83	3.60	1.269	10.26	7.963	-0.06	-0.04	0.50
2.13	1.27	5.85	3.90	1.597	10.64	9.539	-0.08	-0.05	0.61
2.60	2.16	5.90	3.70	1.917	10.27	11.279	-0.08	-0.05	0.75
2.61	2.17	5.90	3.70	1.925	10.27	11.245	-0.08	-0.05	0.75
3.03	3.55	6.00	3.50	2.211	10.11	13.909	-0.10	-0.07	0.87
3.45	5.22	6.00	3.10	2.412	10.33	15.391	0.22	0.07	0.99
3.49	5.32	6.00	3.10	2.440	10.24	15.462	0.42	0.17	1.01
4.32	8.15	5.85	4.50	3.438	8.00	19.789	2.12	0.97	1.25
5.20	8.97	5.70	4.00	3.875	10.57	11.376	2.87	1.37	1.50
6.02	9.73	5.60	3.80	4.348	8.90	10.935	3.22	1.31	1.74
6.91	9.91	5.47	3.60	4.810	8.54	8.810	3.52	1.73	1.99
7.79	10.07	5.35	3.35	5.207	8.65	6.954	3.82	1.90	2.25
8.65	10.48	5.23	3.13	5.556	7.62	6.663	3.90	1.95	2.49
9.60	10.64	5.10	2.90	5.901	7.21	5.804	3.82	1.94	2.77
10.30	11.98	5.00	2.70	6.093	6.90	5.932	3.72	1.91	2.97
11.29	12.56	4.90	2.60	6.506	6.70	5.331	3.57	1.84	3.25
12.12	13.66	4.90	2.45	6.854	6.60	5.107	3.42	1.79	3.49
13.06	14.70	4.90	2.45	7.365	6.60	4.734	3.27	1.72	3.76
14.00	15.63	4.90	2.20	7.637	6.30	4.588	3.10	1.64	4.03
15.73	18.48	4.90	1.90	8.218	5.99	4.520	2.72	1.47	4.53
17.40	21.03	4.90	1.70	8.823	5.79	4.349	2.54	1.39	5.01
19.10	24.30	5.00	1.43	9.451	5.60	4.312	2.37	1.32	5.50
21.00	27.72	5.10	1.25	10.262	5.60	4.069	2.22	1.25	6.05

Model 4666 Test No. 16

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _V
0.84	0.20	5.70	3.50	0.593	8.81	11.674	0.05	0.02	0.24
1.30	0.41	5.75	3.50	0.922	8.81	9.988	0.03	-0.08	0.37
1.72	0.80	5.80	3.40	1.215	8.76	11.192	0.05	-0.10	0.50
1.75	0.84	5.75	3.40	1.238	10.44	9.418	0.04	-0.08	0.51
2.14	1.44	5.80	3.70	1.562	9.01	12.654	0.17	-0.10	0.62
2.60	2.48	5.75	3.60	1.869	8.89	14.960	0.24	-0.21	0.75
2.60	2.43	5.70	3.30	1.797	8.51	15.314	0.12	-0.14	0.75
3.06	3.58	5.70	3.20	2.092	8.40	16.502	0.27	-0.32	0.88
3.44	4.97	5.70	4.00	2.722	9.78	15.568	0.77	-0.45	0.99
3.49	5.62	5.70	4.40	2.708	9.70	17.459	0.87	-0.37	1.01
4.35	7.55	5.60	4.10	3.242	9.23	15.586	2.65	-0.31	1.25
5.19	8.40	5.50	3.80	3.708	8.79	12.861	3.04	-0.03	1.50
6.08	8.78	5.40	3.60	4.204	8.40	10.250	3.49	0.29	1.75
6.94	9.36	5.10	3.30	4.479	7.66	9.197	3.82	0.54	2.00
7.78	9.99	4.80	3.00	4.662	7.01	8.535	3.87	0.77	2.24
8.64	10.40	4.60	2.80	4.912	6.60	7.652	3.77	1.02	2.49
9.52	10.84	4.45	2.60	5.295	6.40	6.774	3.62	1.24	2.74
10.40	11.38	4.40	2.50	5.513	6.09	6.263	3.46	1.36	3.00
11.24	11.79	4.40	2.30	5.786	5.89	5.743	3.15	1.51	3.24
12.16	12.61	4.40	2.20	6.166	5.66	5.339	2.87	1.48	3.75
13.00	13.55	4.40	2.10	6.490	5.69	5.108	2.67	1.48	4.01
13.90	14.33	4.40	1.90	6.728	5.50	4.888	2.50	1.59	4.53
15.72	16.73	4.50	1.70	7.488	5.39	4.553	2.07	1.78	5.02
17.42	19.31	4.50	1.50	8.298	5.39	4.279	1.87	1.79	5.52
19.16	22.30	4.60	1.30	8.685	5.09	4.326	1.62	1.87	6.04
20.96	25.52	4.70	1.10	9.340	5.00	4.211	1.47	1.79	6.04

Model 4666 Test No. 17

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _V
0.86	0.20	5.65	3.30	0.592	8.69	11.292	0.02	0.01	0.25
1.29	0.45	5.70	3.30	0.892	8.69	11.281	0.02	0.01	0.37
1.71	0.84	5.70	3.30	1.182	8.69	11.988	0.04	-0.08	0.49
1.76	0.94	5.70	3.30	1.230	8.69	12.662	0.02	-0.09	0.51
2.13	1.54	5.70	3.40	1.483	8.74	14.082	0.12	-0.15	0.61
2.60	2.48	5.75	3.40	1.829	8.84	15.045	0.22	-0.20	0.75
2.60	2.48	5.70	3.50	1.837	8.88	14.978	0.22	-0.20	0.75
3.03	3.68	5.70	3.00	2.025	8.33	17.446	0.52	-0.27	0.87
3.43	5.27	5.60	2.80	2.213	7.99	20.325	1.12	-0.31	0.99
3.47	5.57	5.60	2.80	2.239	8.00	20.962	1.22	-0.37	1.00
4.31	8.15	5.40	3.70	3.013	8.65	16.386	3.02	-0.29	1.24
5.18	8.82	5.20	3.50	3.462	8.22	14.496	3.52	0.03	1.49
6.04	10.00	4.70	3.20	3.666	7.27	13.668	4.02	3.01	1.74
6.91	10.66	4.20	2.90	3.769	6.30	12.846	4.32	2.95	1.99
7.78	10.87	4.00	2.70	4.005	5.89	11.053	4.22	1.12	2.24
8.65	10.86	3.90	2.50	4.253	5.60	9.413	3.82	1.25	2.49
9.50	11.04	3.80	2.30	4.452	5.29	8.382	3.52	1.51	2.74
10.40	11.23	3.80	2.20	4.794	5.19	7.252	2.97	1.47	3.00
11.24	11.79	3.80	2.10	5.095	5.09	6.646	2.72	1.76	3.24
12.14	12.26	3.80	2.00	5.410	5.00	6.031	2.47	1.76	3.50
13.02	13.15	3.60	1.90	5.702	4.90	5.739	2.12	1.70	3.75
14.00	13.83	3.60	1.80	6.024	4.80	5.329	1.82	1.77	4.03
15.74	15.78	3.90	1.60	6.651	4.70	4.912	1.52	1.94	4.54
17.40	18.21	4.00	1.40	7.219	4.60	5.090	1.12	1.87	5.01

Model 4667-1 Test No. 1A

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.01	0.30	6.90	7.27	1.070	13.30	8.020	0.00	0.00	0.26
2.02	1.44	7.27	7.55	2.256	13.88	9.217	0.00	0.00	0.52
3.02	4.15	7.55	7.83	3.503	14.30	11.535	0.05	0.20	0.77
4.00	9.54	7.60	8.00	4.671	14.55	14.854	0.70	-0.31	1.03
6.97	17.15	6.58	7.83	7.047	12.68	10.098	2.90	0.21	1.79
7.98	18.66	6.38	7.823	7.823	12.50	8.497	3.25	0.42	2.04
8.959	21.85	5.30	8.959	9.40	6.964	3.95	1.44	2.82	3.08
11.00	22.48	5.15	9.504	9.11	6.201	3.85	1.61	3.08	3.87
12.01	22.48	5.15	11.365	8.42	4.864	3.15	1.92	3.87	4.11
15.12	25.83	4.90	11.839	8.28	4.595	2.90	2.02	4.11	4.89
16.05	27.04	4.80	13.692	8.00	4.126	2.40	2.13	4.89	5.15
19.08	33.15	4.67	14.579	8.08	3.943	2.20	2.08	5.15	5.91
20.10	35.51	4.72	15.605	7.55	3.984	1.95	2.30	5.91	
23.08	44.20	4.40							

Model 4667-1 Test No. 3

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.37	7.95	7.40	1.229	16.79	7.988	-0.07	-0.04	0.22
1.51	1.23	8.00	7.60	1.856	16.79	11.647	-0.08	-0.03	0.34
1.99	2.00	8.00	8.00	2.446	16.79	10.905	-0.14	0.01	0.44
2.23	2.89	8.00	8.00	2.741	16.79	12.550	-0.17	0.00	0.50
2.52	3.64	8.00	8.00	3.098	16.79	12.376	-0.21	0.00	0.56
2.99	6.43	8.00	8.00	3.675	16.79	15.528	-0.26	0.05	0.67
3.37	10.67	8.00	8.00	4.143	16.79	20.286	-0.27	0.12	0.75
3.49	12.67	8.00	8.00	4.290	16.79	22.458	-0.27	0.13	0.78

Model 4667-1 Test No. 6

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.35	7.95	7.20	1.229	14.99	8.464	-0.05	-0.03	0.24
1.51	0.70	8.00	7.426	1.856	14.99	7.426	-0.08	-0.04	0.36
2.00	1.38	8.00	8.343	2.458	14.99	8.343	-0.14	-0.07	0.48
2.08	1.49	8.00	8.330	2.557	14.99	8.330	-0.15	-0.10	0.50
2.50	2.59	8.00	10.022	3.073	14.99	10.022	-0.20	-0.09	0.60
3.00	4.58	8.00	12.305	3.688	14.99	12.305	-0.28	-0.33	0.72
3.08	5.28	8.00	13.460	3.786	14.99	13.460	-0.30	-0.30	0.74
3.23	6.28	8.00	14.558	3.970	14.99	14.558	-0.34	-0.36	0.78
3.51	8.37	8.00	16.429	4.315	14.99	16.429	-0.41	-0.32	0.85

Model 4667-1 Test No. 1

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
3.88	8.75	8.00	7.40	4.591	14.55	14.481	0.50	0.15	0.99
4.86	13.83	7.70	6.65	5.362	14.61	14.528	2.10	-0.38	1.25
5.83	15.66	7.55	6.10	6.110	13.55	12.326	2.75	-0.16	1.49
6.82	16.95	7.46	5.82	6.959	12.70	10.401	2.85	0.06	1.75
7.81	18.29	7.37	5.45	7.693	12.55	8.661	3.15	0.29	2.00
8.80	19.32	7.06	5.20	8.289	11.68	7.743	3.70	0.63	2.26
9.76	20.30	6.62	4.70	8.489	10.10	7.648	4.00	0.66	2.50
10.74	21.26	6.40	4.43	8.945	9.60	6.960	3.95	1.10	2.75
11.72	22.17	6.20	4.23	9.401	9.20	6.359	3.85	1.31	3.00
12.70	23.10	6.05	4.10	9.914	8.92	5.820	3.65	1.43	3.25
13.68	24.00	6.00	3.90	10.406	8.67	5.362	3.45	1.59	3.51
14.70	25.36	6.00	3.75	11.023	8.54	4.981	3.30	1.78	3.77
15.70	26.61	6.00	3.60	11.560	8.35	4.687	3.00	1.85	4.02
17.64	29.89	6.00	3.30	12.605	8.04	4.331	2.60	1.97	4.52
19.62	34.54	6.18	3.15	14.050	8.05	4.040	2.35	2.06	5.03
21.60	40.13	6.35	2.95	15.434	8.04	3.873	2.15	2.14	5.54
23.56	45.88	6.50	1.95	15.278	7.18	4.143	1.85	2.17	6.04

Model 4667-1 Test No. 2

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.50	8.00	8.00	1.239	16.27	11.140	-0.04	-0.02	0.22
1.51	1.00	8.00	8.00	1.856	16.27	9.773	-0.09	-0.07	0.34
2.00	1.80	8.00	8.00	2.438	16.27	10.026	-0.13	-0.14	0.45
2.24	2.39	8.00	8.00	2.753	16.27	10.614	-0.15	0.00	0.50
2.49	3.59	8.00	8.00	3.081	16.27	12.901	-0.22	-0.26	0.55
2.98	6.18	8.00	8.00	3.663	16.27	15.505	-0.22	-0.28	0.66
3.23	8.68	8.00	8.00	3.970	16.27	18.539	-0.22	-0.28	0.72
3.35	9.97	8.00	8.00	4.118	16.27	19.794	-0.23	0.13	0.75

Model 4667-1 Test No. 4

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.55	7.85	7.03	1.149	17.05	11.693	0.00	0.00	0.22
1.51	1.35	7.90	7.05	1.735	17.05	14.455	0.00	-0.01	0.34
1.96	2.75	7.95	7.05	2.275	17.05	14.916	0.02	0.10	0.44
2.51	4.54	8.00	8.00	2.885	17.05	15.322	0.02	-0.16	0.56
2.98	7.03	8.00	8.00	3.425	17.05	16.831	0.08	-0.23	0.66
3.52	13.22	8.00	8.00	4.046	17.05	22.655	0.20	-0.36	0.78
3.99	19.21	8.00	8.00	4.586	17.05	25.654	0.88	-0.45	0.89

Model 4667-1 Test No. 7

V. knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.35	7.90	6.70	1.121	14.74	8.607	-0.04	-0.04	0.24
1.51	0.75	7.90	6.70	1.693	14.67	8.130	-0.07	-0.06	0.36
1.99	1.32	7.90	6.70	2.232	14.67	9.485	-0.10	-0.12	0.48
2.07	1.70	7.85	6.70	2.315	14.55	9.887	-0.13	-0.82	0.50
2.50	2.87	7.90	6.70	2.804	14.60	11.400	-0.17	-0.24	0.60
3.00	4.78	7.90	6.70	3.365	14.54	13.241	-0.18	-0.27	0.72
3.07	5.58	8.00	6.60	3.443	14.58	14.721	-0.18	-0.27	0.74
3.25	6.58	8.00	7.00	3.745	14.87	15.187	-0.22	-0.35	0.78
3.50	8.67	8.00	7.30	4.114	15.16	16.923	-0.23	-0.40	0.84
4.12	13.96	8.00	8.00	5.065	15.71	18.977	0.32	-0.54	0.99
5.18	23.93	8.00	8.00	6.368	16.43	19.677	2.67	-0.56	1.25
6.20	26.49	8.00	6.60	6.955	14.91	16.754	3.34	-0.21	1.50
7.22	28.75	7.60	6.40	7.766	14.43	13.855	4.62	0.51	1.74
8.24	30.31	7.40	6.00	8.484	13.18	12.278	5.22	0.99	1.99
9.26	31.25	7.40	5.40	9.107	12.05	10.963	5.72	1.42	2.23
10.36	31.69	7.10	5.00	9.631	10.90	9.819	5.42	1.26	2.50
11.38	33.03	7.00	4.70	9.968	10.20	9.064	5.37	1.93	2.75
12.58	33.03	6.40	4.50	10.535	9.68	7.816	5.07	1.86	3.04
13.46	33.66	6.30	4.35	11.024	9.45	7.169	4.89	2.12	3.25
14.44	34.88	6.10	4.20	11.428	9.06	6.693	4.62	2.50	3.48
15.64	35.87	6.00	4.05	12.089	8.83	6.020	4.22	2.61	3.77
16.64	36.38	6.00	3.90	12.657	8.68	5.487	3.99	2.61	4.01
18.68	39.46	6.00	3.70	13.922	8.45	4.851	3.45	2.70	4.51
20.73	43.40	6.10	3.40	15.131	8.24	4.443	3.32	2.97	4.99
22.80	46.65	6.20	3.30	16.642	8.24	4.134	2.90	3.01	5.53
24.88	52.55	6.40	3.10	18.161	8.24	3.735	2.50	3.05	6.00

Model 4667-1 Test No. 9

V. knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.99	0.52	7.65	5.80	1.022	14.57	13.209	-0.01	0.04	0.24
1.51	1.30	7.65	5.80	1.559	14.57	12.006	0.04	0.02	0.36
2.00	2.05	7.65	5.80	2.065	14.57	12.750	0.09	-0.05	0.48
2.08	2.25	7.70	6.00	2.189	14.80	12.740	0.09	0.03	0.50
2.50	3.49	7.72	6.20	2.673	15.04	13.458	0.17	-0.15	0.60
3.00	5.65	7.75	6.40	3.264	15.35	14.824	0.44	-0.15	0.72
3.09	6.13	7.75	6.40	3.361	15.36	15.152	0.44	-0.17	0.75
3.23	7.28	7.70	6.50	3.524	15.45	16.373	0.57	-0.17	0.78
3.50	9.27	7.70	6.50	3.818	15.55	17.641	0.69	-0.27	0.84
4.13	15.46	7.60	6.60	4.506	15.77	20.835	1.76	-0.44	1.00
5.15	25.67	7.20	5.80	5.144	13.55	26.901	3.79	-0.39	1.24
6.20	29.39	6.80	5.40	5.811	12.35	22.441	4.39	0.09	1.50
7.21	33.40	5.50	4.40	5.484	8.65	26.925	5.34	0.32	1.74
8.29	36.59	5.00	4.10	5.796	7.80	24.965	6.04	1.30	2.00
9.29	36.35	4.80	3.90	6.210	7.42	20.576	5.84	2.78	2.24
10.30	35.58	4.70	3.70	6.647	7.15	17.003	5.44	2.11	2.49
11.40	34.51	4.60	3.50	7.217	6.97	13.810	4.89	2.59	2.75
12.48	33.44	4.60	3.40	7.767	6.80	11.445	4.24	2.59	3.01
13.50	32.76	4.60	3.40	8.298	6.75	9.653	3.64	2.75	3.26
14.54	32.32	4.60	3.30	8.740	6.65	8.512	3.34	2.94	3.47
15.64	32.32	4.60	3.20	9.493	6.65	7.202	2.14	3.13	3.77
16.68	32.62	4.70	3.10	9.996	6.55	6.489	2.34	3.24	4.02

Model 4667-1 Test No. 8

V. knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.45	7.80	6.10	1.068	14.38	11.343	0.00	-0.04	0.24
1.51	0.97	7.80	6.10	1.612	14.38	9.705	0.00	-0.04	0.36
1.99	1.54	7.80	6.10	2.136	14.38	9.705	0.00	-0.04	0.48
2.07	2.07	7.85	6.20	2.233	14.59	11.600	-0.01	-0.08	0.50
2.50	3.11	7.87	6.40	2.754	14.86	12.043	0.05	-0.15	0.61
3.02	5.48	7.90	6.60	3.364	15.10	14.425	0.10	-0.21	0.73
3.09	6.13	7.90	6.60	3.442	15.03	15.485	0.15	-0.19	0.75
3.24	7.38	7.90	6.80	3.634	15.34	16.614	0.20	-0.26	0.78
3.51	9.32	7.90	7.00	3.964	15.61	17.567	0.25	-0.32	0.85
4.12	14.96	7.40	7.40	4.843	16.21	19.709	1.16	0.43	0.99
5.15	24.12	7.80	6.60	5.698	15.07	21.875	3.40	-0.34	1.24
6.19	25.99	7.40	6.10	6.420	13.54	18.160	3.81	-0.03	1.49
7.20	28.15	7.20	5.70	7.136	12.94	15.212	4.23	0.31	1.74
8.23	30.75	6.70	5.20	7.525	11.68	14.090	5.05	0.70	1.99
9.26	32.85	5.90	4.70	7.541	9.36	14.837	5.65	1.23	2.23
10.36	33.18	5.70	4.40	8.039	8.85	12.662	5.45	1.66	2.50
11.36	32.82	5.50	4.20	8.466	8.45	10.910	5.13	1.55	2.74
12.44	32.44	5.30	4.10	8.984	8.15	9.323	4.65	1.47	3.00
13.44	32.52	5.40	3.95	9.665	8.10	8.057	4.15	2.76	3.24
14.44	32.78	5.30	3.80	10.096	7.60	7.306	3.97	2.71	3.48
15.66	33.41	5.30	3.60	10.709	7.67	6.439	3.54	2.81	3.78
16.64	33.90	5.30	3.50	11.251	7.53	5.894	3.18	2.91	4.01
18.78	36.60	5.40	3.30	12.554	7.33	5.063	2.67	2.99	4.53
20.88	40.01	5.50	3.10	13.797	7.43	4.538	2.17	3.13	5.04
22.88	45.05	5.50	3.00	14.943	7.23	4.315	1.66	3.64	5.52
24.95	49.95	5.80	2.80	16.486	7.33	3.968	1.63	3.16	6.02

Model 4667-1 Test No. 10

V. knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.25	7.83	6.00	1.063	13.10	6.918	0.12	0.07	0.26
1.50	0.60	7.83	6.00	1.595	13.10	7.380	0.02	0.01	0.38
1.97	1.13	7.90	6.40	2.164	13.54	7.798	-0.04	-0.02	0.50
2.00	1.12	7.83	6.00	2.126	13.10	7.748	-0.13	-0.12	0.51
2.50	2.15	7.83	6.00	2.658	13.10	9.519	-0.20	-0.20	0.64
2.91	3.66	7.95	7.95	3.555	14.50	10.806	-0.20	-0.16	0.75
3.00	3.83	7.83	6.00	3.190	13.10	11.775	-0.23	-0.22	0.77
3.22	4.94	7.83	6.00	3.424	13.10	13.184	-0.27	-0.28	0.83
3.50	5.32	7.83	6.00	3.721	13.10	12.017	-0.30	-0.30	0.90
3.90	8.81	8.00	8.00	4.794	14.50	14.480	-0.20	-0.39	1.00
4.88	15.02	7.80	7.00	5.549	14.21	16.090	1.47	-0.40	1.25
5.83	18.05	7.80	7.00	6.629	14.35	13.415	2.42	-0.15	1.49
6.84	20.45	7.60	6.60	7.462	13.79	11.490	2.52	0.09	1.75
7.82	22.74	7.60	6.60	8.532	13.79	9.775	2.57	0.23	2.00
8.80	24.05	7.60	6.20	9.331	13.69	8.223	3.12	0.54	2.26
9.80	23.29	7.50	5.60	9.864	13.03	6.746	3.67	3.35	2.51
10.78	23.42	7.35	5.20	10.403	11.48	6.364	4.22	3.49	2.76
11.74	24.30	7.20	4.90	10.914	10.90	4.752	4.22	1.20	3.01
12.68	26.11	7.15	4.70	11.594	10.70	5.501	4.27	1.40	3.25
13.64	26.63	7.05	4.50	12.157	10.48	4.989	4.22	1.76	3.50
14.68	28.86	7.00	4.35	12.658	10.20	4.759	4.07	1.89	3.76
15.78	30.69	7.00	4.20	13.579	10.09	4.468	3.92	2.03	4.04
17.64	34.78	7.00	3.90	14.773	9.68	4.186	3.52	2.06	4.52
19.71	39.47	7.00	3.65	16.144	9.45	3.897	3.32	2.16	5.05
21.60	45.19	7.00	3.40	17.260	9.15	3.837	3.12	2.22	5.54
23.56	51.06	7.00	3.20	18.464	8.99	3.709	3.02	2.36	6.04

Model 4667-1 Test No. 11

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length ofchine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.40	7.00	3.80	1.044	11.788	0.00	0.00	0.26
1.51	0.70	7.80	3.80	1.577	9.049	-0.02	-0.03	0.39
1.99	1.30	7.88	3.60	1.991	10.463	0.00	-0.02	0.49
2.51	2.44	7.80	3.80	2.079	9.676	-0.05	-0.09	0.51
2.92	3.88	7.90	3.60	2.622	11.414	-0.10	-0.15	0.64
3.99	4.08	7.80	3.028	3.028	13.500	-0.04	-0.18	0.75
4.99	4.08	7.80	3.124	12.30	13.450	-0.05	-0.21	0.77
5.99	4.08	7.80	3.364	12.30	14.781	0.00	-0.23	0.83
6.99	6.49	7.80	3.678	12.30	15.438	0.00	-0.31	0.90
7.99	8.76	7.80	4.656	13.62	15.250	0.25	-0.34	1.00
8.97	14.26	7.85	5.650	13.45	16.205	1.70	-0.43	1.25
9.84	15.30	7.70	6.60	6.416	13.430	2.58	-0.18	1.50
10.76	21.78	6.90	4.70	9.590	10.40	6.557	4.10	2.63
11.76	22.69	6.70	4.50	10.120	10.00	5.947	4.06	2.51
12.72	23.72	6.60	4.30	10.655	9.67	5.486	3.93	2.01
13.64	24.93	6.40	4.15	11.067	9.35	5.199	3.52	3.50
14.72	26.74	6.40	4.00	11.762	9.15	4.869	3.32	3.77
15.74	28.07	6.40	3.85	12.384	9.02	4.553	3.39	4.03
16.66	32.79	6.45	3.60	13.623	8.82	4.321	3.15	2.03
17.62	36.58	6.50	3.30	14.773	8.55	4.029	2.76	4.03
18.64	42.83	6.50	3.10	16.128	8.43	3.923	2.50	5.35
19.60	47.91	6.70	2.90	17.408	8.23	3.709	2.35	9.05

Model 4667-1 Test No. 12

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length ofchine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.01	0.39	7.70	5.50	1.024	12.95	0.01	0.00	0.26
1.52	0.75	7.70	5.50	1.541	12.95	0.01	-0.06	0.39
1.94	1.45	7.80	5.10	1.922	12.92	0.05	-0.11	0.50
2.00	1.48	7.70	5.50	2.028	12.92	0.03	-0.07	0.51
2.50	2.58	7.70	5.50	2.535	12.78	0.06	-0.21	0.64
2.93	4.18	7.70	5.20	2.904	12.59	0.14	-0.25	0.75
3.00	4.08	7.70	5.50	3.042	12.56	0.15	-0.18	0.77
3.24	5.27	7.70	5.50	3.286	12.41	0.20	-0.19	0.83
3.50	6.55	7.70	5.50	3.549	12.34	0.30	-0.29	0.90
3.91	8.76	7.70	5.50	4.175	13.74	0.67	-0.42	1.00
4.87	13.89	7.40	6.20	5.089	13.75	15.440	-0.41	1.25
5.86	15.62	7.40	5.60	5.853	12.65	2.91	-0.14	1.50
6.84	17.12	7.30	5.30	6.622	12.35	10.741	3.15	1.75
7.82	18.95	7.00	5.00	7.210	12.10	9.283	3.65	2.00
8.81	20.43	6.40	4.60	7.446	10.55	9.044	4.10	2.26
9.80	21.22	6.00	4.20	7.680	8.97	8.929	4.20	2.51
10.78	21.89	5.80	4.00	8.117	8.55	7.983	4.10	2.76
11.78	22.54	5.80	3.80	8.689	8.35	7.051	3.95	3.02
12.62	23.03	5.50	3.60	8.963	7.83	6.487	3.60	3.29
13.74	23.44	5.50	3.50	9.501	7.73	5.622	3.37	3.52
14.74	25.20	5.40	3.40	9.966	7.54	5.576	3.08	3.78
15.74	25.81	5.40	3.20	10.400	7.32	5.159	2.78	4.03
16.70	29.07	5.40	3.10	11.560	7.24	4.646	2.45	4.54
17.62	32.72	5.40	2.90	12.512	7.04	4.377	2.15	5.03
18.62	37.83	5.60	2.60	13.621	6.94	4.227	1.80	5.54
19.60	42.50	5.80	2.90	14.132	6.55	4.230	1.50	6.04

Model 4667-1 Test No. 14

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length ofchine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.25	7.85	4.80	0.971	11.66	7.772	-0.07	0.27
1.50	0.50	7.90	5.50	1.544	11.33	7.110	-0.12	0.40
1.86	0.85	7.85	4.80	1.809	11.69	7.621	-0.32	0.50
2.00	0.95	7.90	5.90	2.120	12.70	6.779	-0.12	0.54
2.50	1.84	7.95	5.80	2.643	12.72	8.390	-0.35	0.67
2.80	2.35	8.00	5.80	2.968	12.73	9.262	-0.37	0.75
3.00	3.13	8.00	5.50	3.111	12.45	10.126	-0.35	0.81
3.50	4.94	8.00	4.90	3.469	11.90	12.284	-0.40	0.94
3.72	6.02	8.00	8.00	4.573	13.92	11.329	-0.37	1.00
4.00	7.03	8.05	4.20	5.761	11.25	14.157	-0.22	1.08
4.66	10.44	8.00	5.60	6.869	12.64	13.788	0.73	1.25
5.58	12.71	8.00	6.60	6.259	13.62	10.864	1.63	1.50
6.49	14.48	7.90	7.20	7.210	13.03	9.564	2.03	1.75
7.42	16.43	7.85	7.85	8.951	13.17	8.214	1.93	2.00
8.31	18.20	7.80	7.80	9.960	13.37	7.146	2.08	2.24
9.28	19.15	7.50	7.60	10.838	13.81	5.837	2.43	2.50
10.18	19.42	7.50	7.40	11.654	13.35	5.088	2.93	2.74
11.18	20.23	7.40	7.20	12.541	13.11	4.475	3.13	3.01
12.12	21.62	7.30	6.90	13.223	12.81	4.165	3.13	3.26
13.20	23.38	7.25	6.60	14.037	12.52	3.885	3.13	3.55
13.92	24.23	7.20	6.40	14.546	12.30	3.685	3.08	3.74
14.96	26.52	7.20	6.10	15.288	12.05	3.565	3.08	4.02
16.80	30.86	7.10	5.90	16.781	11.77	3.367	3.03	4.52
18.64	35.58	7.10	5.70	18.332	11.59	3.203	2.93	5.01
20.56	40.55	7.10	5.60	20.063	11.50	3.024	2.68	5.53
22.40	46.75	7.00	5.50	21.514	11.30	2.989	2.48	6.03

Model 4667-1 Test No. 13

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length ofchine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.45	7.80	5.10	0.977	11.51	14.172	-0.03	0.26
1.50	0.90	7.80	5.15	1.470	11.57	12.533	-0.03	0.38
1.90	1.60	7.80	5.20	1.907	11.60	13.287	0.15	0.50
1.99	1.60	7.80	5.20	1.957	11.60	12.627	0.13	0.51
2.49	2.81	7.80	5.15	2.441	11.57	14.200	0.20	0.64
2.93	4.23	7.80	5.10	2.859	12.87	14.099	0.50	0.78
3.00	4.48	7.80	5.15	2.941	11.57	15.595	0.33	0.77
3.22	8.50	7.80	6.20	3.409	12.47	15.421	0.40	0.83
3.50	6.37	7.80	6.50	3.791	12.73	15.272	0.59	0.90
3.89	9.36	7.90	7.60	4.632	14.79	15.160	1.20	1.00
4.51	13.47	7.33	7.15	5.128	13.30	18.019	2.35	1.16
4.88	15.16	7.90	6.90	5.286	14.09	16.378	2.85	1.25
4.89	15.19	7.30	6.80	5.297	14.09	16.343	2.85	1.25
5.84	16.70	7.00	6.30	5.988	12.99	13.664	3.15	1.50
6.89	18.71	6.90	5.80	6.511	11.10	12.871	3.60	1.77
7.81	21.01	5.50	5.60	6.661	9.90	12.612	4.25	2.00
8.80	21.58	5.20	5.20	7.234	9.48	10.655	4.50	2.26
9.72	21.73	5.20	4.90	7.543	8.83	9.421	4.30	2.49
10.72	21.76	4.90	4.70	7.961	6.33	8.129	3.90	2.76
11.74	22.92	4.70	4.50	8.296	7.93	7.266	3.43	3.01
12.72	22.12	4.60	4.40	8.796	7.73	6.411	3.30	3.26
13.64	22.40	4.40	4.20	9.013	7.33	5.938	2.75	3.50
14.68	23.41	4.30	4.10	9.474	7.14	5.515	2.50	3.76
15.72	24.17	4.20	4.00	9.904	6.94	5.199	2.35	4.03
16.82	26.74	4.05	3.83	10.634	6.63	4.799	1.70	4.33
17.82	30.52	3.90	3.70	11.468	6.33	4.317	1.33	4.44
18.64	34.13	3.70	3.50	11.960	5.96	4.441	1.13	4.60
19.60	38.33	3.60	3.40	12.693	5.80	4.301	0.99	4.83

Model 4667-1 Test No. 15

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Rex 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.25	7.75	3.10	0.388	12.02	7.539	0.00	0.00	0.27
1.50	0.50	7.80	5.15	1.493	12.16	6.624	-0.02	-0.01	0.40
1.86	0.87	7.82	5.10	1.846	12.06	7.548	0.00	0.00	0.50
2.00	1.08	7.82	5.20	2.00	12.46	7.855	-0.05	-0.05	0.54
2.50	1.97	7.90	5.40	2.554	12.40	9.214	-0.05	-0.06	0.67
2.79	2.78	7.90	5.40	2.851	12.40	10.440	0.00	-0.04	0.75
3.00	3.23	7.90	5.30	3.042	12.82	10.148	0.00	-0.13	0.81
3.50	4.87	8.00	4.80	3.442	11.83	12.182	0.10	-0.16	0.94
3.72	5.87	8.00	4.40	3.544	11.55	13.314	0.15	-0.26	1.00
4.00	8.81	8.00	4.10	3.718	12.31	12.533	0.35	-0.24	1.08
4.63	9.16	7.90	3.20	3.948	10.30	13.039	1.10	-0.88	1.25
5.56	11.01	7.70	7.70	6.579	14.12	9.143	2.00	0.00	1.90
6.48	12.35	7.85	7.65	7.617	13.93	7.654	2.15	0.17	1.74
7.42	13.70	7.60	7.60	8.665	13.88	6.499	2.20	0.29	2.00
8.34	14.95	7.55	7.40	9.586	13.38	5.823	2.50	0.37	2.24
9.84	15.94	7.35	7.00	10.195	12.95	5.226	2.76	0.51	2.49
10.22	16.85	7.00	6.40	10.758	12.37	4.727	3.08	0.87	2.75
11.15	17.73	7.00	6.00	11.137	11.77	4.392	3.15	0.56	3.00
12.12	19.27	6.90	5.65	11.696	11.37	4.182	3.14	1.20	3.26
13.28	19.79	6.90	5.00	12.142	10.70	3.802	3.05	1.31	3.57
14.86	21.97	6.80	4.95	12.718	10.62	3.837	2.96	1.40	3.76
16.96	23.98	6.80	4.80	13.351	10.40	3.725	2.80	1.40	4.03
18.74	27.65	6.80	4.60	14.963	10.20	3.507	2.59	1.28	4.50
20.52	31.76	6.80	4.40	16.109	10.00	3.285	2.37	1.69	5.04
22.42	36.58	6.80	4.30	17.501	9.88	3.187	2.20	1.75	5.52
24.4	39.46	6.80	4.20	18.374	9.77	3.098	2.15	1.81	5.85
26.42	41.77	6.80	4.20	18.949	9.77	3.083	2.10	1.79	6.03

Model 4667-1 Test No. 16

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Rex 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.30	7.70	4.40	0.929	10.90	9.977	0.00	-0.02	0.27
1.50	0.60	7.70	4.20	1.371	11.32	8.539	0.00	-0.07	0.40
1.86	1.02	7.72	4.90	1.803	11.87	9.007	0.02	-0.08	0.50
2.00	1.25	7.75	4.90	1.942	12.01	9.432	0.04	-0.09	0.54
2.50	2.14	7.80	5.10	2.477	12.22	10.157	0.04	-0.15	0.67
2.80	2.75	7.80	5.10	2.775	12.19	10.735	0.06	-0.16	0.75
3.00	3.43	7.80	5.60	3.088	11.75	11.757	0.12	-0.21	0.81
3.50	4.87	7.80	4.60	3.334	11.70	12.317	0.25	-0.24	0.94
3.72	5.82	7.80	4.40	3.487	11.55	13.200	0.42	-0.16	1.00
4.00	6.65	7.83	3.70	3.540	10.87	13.881	0.66	-0.39	1.08
4.63	8.82	7.70	7.70	5.478	14.01	10.646	1.50	-0.37	1.25
5.56	10.43	7.50	7.40	6.376	13.91	8.761	2.06	-0.21	1.50
6.48	11.48	7.45	7.20	7.321	13.66	7.210	2.33	0.06	1.75
7.42	12.75	7.30	6.90	8.095	13.36	6.283	2.52	0.17	2.00
8.34	13.58	7.10	6.10	8.448	12.43	5.707	2.78	0.38	2.24
9.24	14.66	6.80	5.40	8.661	11.00	5.736	3.10	0.60	2.49
10.20	15.85	6.50	5.20	9.169	10.50	5.293	3.06	0.76	2.74
11.12	16.82	6.40	5.00	9.740	10.20	4.834	3.02	0.85	2.99
12.06	17.75	6.20	4.90	10.285	9.90	4.469	2.83	1.26	3.24
13.24	19.08	6.00	4.70	10.885	9.48	4.162	2.70	1.29	3.56
14.00	20.40	6.00	4.65	11.467	9.45	3.992	2.62	1.34	3.77
14.98	21.93	5.60	4.50	11.625	8.88	3.989	2.48	1.43	4.03
16.62	24.78	5.60	4.30	12.642	8.67	3.751	2.25	1.59	4.47
18.64	28.23	5.80	4.10	14.179	8.67	3.517	1.92	1.58	5.01
20.52	33.25	5.80	3.95	15.368	8.53	3.356	1.68	1.70	5.52
22.40	37.17	5.60	3.90	16.350	8.25	3.255	1.52	1.71	6.03

Model 4667-1 Test No. 17

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Rex 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.30	7.61	4.65	0.941	11.79	9.224	0.06	0.02	0.27
1.50	0.72	7.63	4.65	1.417	11.86	9.764	0.05	0.02	0.40
1.86	1.20	7.62	4.65	1.714	11.77	11.159	0.05	-0.08	0.49
1.99	1.33	7.63	4.70	1.889	11.89	10.394	0.06	0.02	0.54
2.50	2.38	7.67	4.90	2.412	12.05	11.504	0.12	-0.13	0.67
2.79	2.78	7.65	4.90	2.692	12.03	11.923	0.17	-0.18	0.75
3.00	3.23	7.70	4.80	2.862	11.97	12.380	0.23	-0.12	0.80
3.50	4.87	7.70	4.50	3.280	11.63	13.155	0.60	-0.17	0.94
3.72	5.87	7.65	4.20	3.384	11.41	14.395	0.84	-0.28	1.00
4.00	6.65	7.60	4.00	4.610	14.13	11.480	1.12	-0.26	1.08
4.63	9.16	7.42	7.00	5.118	13.56	11.743	2.00	-0.24	1.24
5.56	10.76	7.20	6.50	5.767	12.79	9.865	2.55	0.06	1.50
6.48	11.78	7.00	5.90	6.442	12.20	8.284	2.66	0.19	1.75
7.42	13.34	6.60	5.40	6.832	11.20	7.863	3.04	0.49	1.99
8.30	13.40	6.02	5.10	7.015	9.78	7.209	3.45	0.90	2.23
9.22	15.06	4.90	5.60	7.438	9.27	6.928	3.32	1.11	2.46
10.22	15.69	5.20	4.60	7.695	8.55	6.369	3.25	1.13	2.75
11.12	16.24	5.00	4.40	8.031	8.15	5.841	2.95	1.04	2.99
12.07	16.77	4.80	4.25	8.383	7.78	5.363	2.79	1.50	3.25
13.24	17.58	4.70	4.05	8.911	7.50	4.709	2.49	1.53	3.56
14.86	18.72	4.60	4.00	9.211	7.37	4.738	2.26	1.57	3.75
15.00	19.98	4.50	3.90	9.681	7.15	4.502	2.06	1.69	4.03
16.64	22.73	4.40	3.70	10.356	6.80	4.376	1.74	1.79	4.48
18.68	26.46	4.50	3.55	11.568	6.81	4.006	1.40	1.87	5.02
20.52	30.51	4.60	3.40	12.613	6.75	3.884	1.10	1.92	5.52
22.40	34.12	4.50	3.25	13.769	6.70	3.679	0.87	1.91	6.03

Model 4667-1 Test No. 18

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Rex 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.20	7.83	6.40	1.199	10.54	6.884	-0.03	-0.07	0.28
1.51	0.50	7.85	6.40	1.811	10.54	7.549	-0.14	-0.13	0.42
1.80	0.78	7.85	6.40	2.159	10.54	8.289	-0.16	-0.14	0.50
2.00	0.99	7.85	6.40	2.399	10.48	8.568	-0.18	-0.15	0.55
2.50	1.74	7.85	6.00	2.914	10.18	9.923	-0.11	-0.16	0.69
2.74	2.19	7.85	7.60	3.563	10.91	9.701	-0.01	-0.16	0.76
3.00	2.83	7.80	7.60	3.891	10.85	10.514	0.06	-0.17	0.83
3.51	4.02	7.75	7.60	4.541	10.81	10.952	0.12	-0.27	0.97
3.60	4.37	7.80	7.60	4.670	10.83	11.296	0.14	-0.27	0.99
4.00	5.43	7.70	7.60	5.155	10.70	11.507	0.46	-0.37	1.10
4.54	6.82	7.70	7.40	5.774	10.60	11.326	1.09	-0.35	1.25
5.42	8.49	7.70	7.00	6.711	10.67	9.827	1.64	-0.33	1.50
6.30	9.62	7.65	6.80	7.663	10.49	8.363	1.87	-0.16	1.74
7.22	10.85	7.60	6.50	8.575	10.26	7.360	1.91	-0.01	1.99
8.16	12.05	7.60	6.30	9.554	10.03	6.552	2.05	0.08	2.25
9.00	13.29	7.50	5.90	10.459	9.74	6.112	2.24	0.30	2.46
10.00	14.40	7.35	5.50	10.816	9.23	5.660	2.63	0.37	2.76
10.88	15.05	7.10	5.10	11.181	8.95	5.154	3.11	0.61	3.00
11.78	15.58	6.80	4.80	11.510	7.74	5.263	3.24	0.76	3.25
12.68	16.41	6.30	4.30	11.856	7.36	5.031	3.26	1.07	3.50
13.62	17.15	6.30	4.30	12.161	7.00	4.792	3.23	1.28	3.76
14.64	18.35	6.20	4.20	12.825	6.84	4.541	3.14	1.41	4.04
16.40	20.59	6.00	3.90	13.676	6.46	4.299	2.92	1.68	4.53
18.22	23.11	5.90	3.70	14.734	6.23	4.054	2.61	1.73	5.03
20.04	26.04	5.80	3.50	15.868	6.07	3.876	2.37	1.80	5.53
20.84	27.43	5.90	3.45	16.431	6.06	3.781	2.32	1.88	5.75

Model 4668 Test No. 2

V, knots	R _t , lb	Wetted length of keel, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.37	8.10	1.364	10.45	12.647	0.00	0.00	0.24
1.51	0.68	8.20	2.085	10.45	10.358	0.00	0.00	0.36
2.00	1.23	8.30	2.796	10.44	10.687	0.00	-0.02	0.48
2.51	2.51	8.78	3.712	10.45	13.835	0.00	-0.04	0.60

Model 4668 Test No. 7

V, knots	R _t , lb	Wetted length of keel, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.26	7.90	1.255	11.81	7.987	-0.01	-0.01	0.26
1.52	0.59	7.95	1.913	11.82	7.841	-0.10	-0.06	0.39
1.94	1.05	8.00	2.434	11.44	8.851	-0.15	-0.11	0.50
2.00	0.98	8.00	2.527	11.77	7.552	-0.12	-0.07	0.52
2.50	2.03	8.00	3.327	11.90	9.953	-0.16	-0.18	0.65
2.92	2.26	8.00	3.686	11.61	8.284	-0.05	-0.18	0.76
3.00	3.51	8.00	3.992	11.77	12.022	-0.02	-0.21	0.78
3.52	5.49	8.00	4.744	11.62	13.835	0.10	-0.22	0.91
3.86	7.06	8.00	5.137	11.33	15.174	0.28	-0.44	1.00
4.00	7.56	8.00	5.323	11.48	14.933	0.40	-0.42	1.04
4.78	11.54	7.60	6.120	11.47	15.976	1.70	-0.51	1.24
5.76	13.86	7.80	7.278	11.29	13.423	2.33	-0.34	1.50
6.74	14.87	7.70	8.402	11.27	10.538	2.43	-0.68	1.75
7.74	17.03	7.65	9.480	11.35	9.334	2.60	0.14	2.01
8.60	18.50	7.60	10.359	10.83	8.383	2.90	0.39	2.23
9.52	19.95	7.45	11.007	9.97	8.851	4.40	-0.11	2.49
10.82	20.57	7.15	11.399	9.07	8.156	4.15	0.92	2.76
11.58	20.96	6.60	11.413	7.51	7.261	4.50	1.14	3.01
12.54	21.66	6.20	11.725	7.36	6.790	4.49	1.51	3.26
13.50	22.18	6.50	12.168	7.12	6.201	4.38	1.77	3.51
14.54	23.14	5.90	12.738	6.84	5.896	4.28	2.10	3.76
15.50	24.20	5.80	13.187	6.60	5.537	4.10	2.29	4.03
17.57	25.91	5.70	14.504	6.38	4.773	3.53	2.47	4.56
19.38	28.49	5.65	16.874	6.27	4.389	3.28	2.65	5.04
21.30	31.52	5.65	18.758	6.07	4.180	3.06	2.83	5.53
23.22	35.02	5.70	18.180	6.00	3.927	2.70	2.61	6.03

Model 4668 Test No. 3

V, knots	R _t , lb	Wetted length, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.35	8.03	1.352	10.52	12.072	0.01	0.01	0.24
1.52	0.79	8.05	2.061	10.51	11.811	0.02	0.00	0.36
2.00	1.42	8.19	2.729	10.51	12.256	0.00	-0.02	0.48
2.50	2.67	8.29	3.453	10.51	14.750	-0.05	-0.15	0.60
3.00	4.88	8.78	4.437	10.53	18.684	-0.05	-0.24	0.72
3.50	8.97	8.78	5.177	10.53	25.232	-0.08	-0.34	0.84
4.00	11.81	8.78	5.916	10.57	25.338	0.30	-0.53	0.96

Model 4668 Test No. 6

V, knots	R _t , lb	Wetted length, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.25	8.78	1.479	11.54	7.860	-0.01	-0.01	0.26
1.50	0.50	8.78	2.218	11.54	6.988	-0.04	-0.03	0.39
1.92	0.98	8.78	2.840	11.54	8.360	-0.07	-0.14	0.50
2.00	0.99	8.78	2.958	11.54	7.781	-0.09	-0.06	0.52
2.50	2.03	8.78	3.698	11.45	10.292	-0.11	-0.16	0.65
2.90	3.16	8.78	4.289	11.54	11.813	-0.13	-0.19	0.75
3.00	3.48	8.78	4.437	11.45	12.252	-0.10	-0.25	0.78
3.50	5.47	8.78	5.177	11.45	14.149	-0.13	-0.29	0.91
3.84	6.96	8.78	5.680	11.60	14.513	-0.10	-0.35	1.00
4.00	7.61	8.78	5.916	11.80	14.624	-0.07	-0.46	1.04
4.78	11.19	8.78	7.679	12.33	14.411	1.15	-0.68	1.24
5.76	13.91	8.78	8.520	12.15	12.520	1.95	-0.47	1.50
6.76	16.37	8.78	9.999	12.33	10.541	2.13	-	1.76
7.64	19.23	8.78	11.301	11.98	9.977	2.15	-0.10	1.98
8.62	22.38	8.78	12.750	11.98	9.502	2.15	0.03	2.24
10.60	25.37	7.30	13.036	9.77	8.385	3.05	0.28	2.75
11.58	23.31	6.77	13.207	9.08	6.946	4.03	0.94	3.01
12.58	22.64	6.35	13.458	8.55	6.071	4.55	1.36	3.27
13.54	23.38	6.10	13.915	8.17	5.663	4.60	1.67	3.51
14.58	24.50	5.90	14.492	7.88	5.315	4.53	1.85	3.79
15.54	25.50	5.72	14.975	7.62	5.028	4.35	2.02	4.04
17.40	26.96	5.50	16.123	7.28	4.438	4.13	2.37	4.52
19.34	29.50	5.35	17.432	7.08	4.042	3.83	2.49	5.02
21.30	33.92	5.25	18.839	6.92	3.920	3.55	2.56	5.53
23.14	37.62	5.15	20.577	6.75	3.776	3.29	2.59	6.01

Model 4668 Test No. 8

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length ofchine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.30	7.83	6.40	1.197	11.36	9.581	0.02	0.01	0.26
1.50	0.65	7.85	6.40	1.799	11.37	9.219	0.00	-0.02	0.39
2.00	1.22	7.85	6.40	2.394	11.49	0.039	0.02	-0.04	0.50
2.50	1.32	7.87	6.60	2.435	11.56	10.357	0.04	-0.06	0.52
3.00	2.18	7.87	7.00	3.268	11.72	10.713	0.08	-0.10	0.65
3.50	3.53	7.85	7.60	3.797	11.78	12.732	0.13	-0.14	0.76
4.00	3.78	7.87	7.60	3.906	11.73	12.990	0.17	-0.19	0.78
4.50	6.17	7.85	7.60	4.552	11.61	15.740	0.30	-0.32	0.91
5.00	6.66	7.83	7.60	4.987	11.66	16.027	0.59	-0.38	1.00
5.50	8.31	7.80	7.60	5.189	11.67	16.147	0.78	-0.42	1.04
6.00	12.12	7.73	7.10	6.000	11.35	16.815	1.97	-0.52	1.25
6.50	13.96	7.60	6.70	6.914	11.40	13.485	2.49	-0.38	1.49
7.00	15.12	7.50	6.40	7.915	10.78	11.136	2.78	-0.05	1.76
7.50	16.53	7.40	6.20	8.844	10.38	9.694	2.99	0.22	2.01
8.00	18.20	7.20	5.80	9.461	9.94	8.969	3.30	0.38	2.24
8.50	19.63	6.83	5.30	9.601	9.07	8.520	4.00	0.73	2.49
9.00	20.77	5.90	4.80	9.574	7.80	8.566	4.55	1.14	2.76
9.50	21.41	5.60	4.30	9.852	6.60	8.777	4.30	1.40	3.01
10.00	21.64	5.40	4.30	10.279	6.30	7.875	4.30	1.72	3.27
10.50	21.96	5.40	4.20	10.917	6.23	7.017	4.10	2.04	3.51
11.00	22.64	5.30	4.10	11.481	6.07	6.436	3.79	2.28	3.77
11.50	23.30	5.20	3.90	11.705	5.88	6.031	3.45	2.31	4.01
12.00	24.81	5.10	3.70	12.676	5.63	5.299	3.08	2.59	4.51
12.50	26.34	5.10	3.60	14.100	5.55	4.757	2.50	2.64	5.00
13.00	29.67	5.20	3.40	15.387	5.47	4.362	2.22	2.80	5.52
13.50	32.85	5.20	3.30	16.626	5.24	4.218	1.95	2.83	6.03

Model 4668 Test No. 10

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length ofchine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.18	7.90	7.00	1.255	10.54	6.196	-0.02	0.09	0.28
1.50	0.43	7.90	7.00	1.882	10.54	6.580	-0.02	0.07	0.41
2.00	0.85	7.90	7.00	2.274	10.58	6.881	-0.03	-0.06	0.50
2.50	1.61	7.90	7.00	2.510	10.54	7.056	-0.05	0.15	0.55
3.00	2.06	7.80	7.00	3.137	10.47	8.927	-0.09	0.03	0.69
3.50	3.97	7.90	7.00	3.449	10.58	9.460	-0.09	-0.28	0.75
4.00	5.29	7.90	7.00	3.765	10.47	10.242	-0.09	-0.06	0.83
4.50	6.86	7.90	7.00	4.430	10.47	11.041	-0.12	-0.18	0.97
5.00	9.15	7.90	7.00	5.020	10.61	11.306	0.00	-0.30	1.10
5.50	9.15	7.90	7.00	5.685	10.75	11.283	0.72	1.25	1.25
6.00	10.71	7.90	7.00	6.076	11.16	10.126	0.85	-0.35	1.50
6.50	12.49	7.90	7.00	6.092	10.98	8.860	1.65	-0.04	1.74
7.00	14.31	7.40	7.00	8.770	10.62	8.163	1.70	-0.09	2.00
7.50	16.11	7.60	7.20	10.135	10.78	7.287	1.77	0.05	2.24
8.00	18.11	7.80	7.20	11.422	10.55	6.906	1.80	0.28	2.49
8.50	20.53	7.60	6.80	12.106	10.12	6.519	2.10	0.68	2.75
9.00	23.51	7.60	6.40	12.854	9.70	5.714	2.57	0.56	3.01
9.50	26.01	7.30	6.00	13.021	9.15	5.109	3.09	0.56	3.26
10.00	28.72	7.30	5.80	13.393	8.40	4.840	3.24	0.61	3.51
10.50	30.56	7.20	5.20	14.017	6.17	4.595	3.38	0.90	3.76
11.00	32.85	6.86	4.80	14.340	7.90	4.423	3.36	1.23	4.03
11.50	35.43	6.80	4.40	15.453	7.43	4.274	3.24	1.51	4.52
12.00	38.72	6.60	4.10	16.404	7.07	4.030	3.13	1.74	5.02
12.50	42.85	6.20	3.90	17.016	6.62	3.113	3.00	1.80	5.52
13.00	47.81	6.40	3.80	17.871	6.68	3.836	2.91	1.79	5.74

Model 4668 Test No. 9

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length ofchine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.39	7.65	6.00	1.148	11.32	12.499	0.03	-0.01	0.26
1.50	0.78	7.70	6.00	1.742	11.35	10.939	0.05	-0.06	0.39
2.00	1.28	7.75	6.00	2.199	11.37	11.316	0.11	-0.05	0.49
2.50	1.36	7.73	6.00	2.311	11.36	10.859	0.11	-0.05	0.52
3.00	2.28	7.75	6.00	2.893	11.37	11.641	0.15	-0.11	0.65
3.50	3.78	7.75	7.20	3.674	11.86	11.841	0.23	-0.20	0.76
4.00	3.78	7.75	7.20	3.775	11.86	12.848	0.26	-0.27	0.78
4.50	6.35	7.70	7.00	4.358	11.68	15.920	0.66	-0.30	0.91
5.00	8.08	7.65	6.80	4.670	11.64	17.080	1.08	-0.40	1.00
5.50	9.06	7.60	6.80	4.852	11.67	17.604	1.28	-0.40	1.04
6.00	13.54	7.40	6.20	5.337	10.95	19.472	1.47	-0.94	1.25
6.50	15.57	7.20	5.90	6.091	10.59	17.507	3.03	-0.22	1.43
7.00	15.57	7.10	5.80	6.280	10.94	16.777	3.03	-0.20	1.50
7.50	18.08	7.05	5.70	6.428	10.09	16.115	3.08	-0.12	1.56
8.00	16.79	7.00	5.70	6.654	9.99	15.320	3.13	-0.08	1.62
8.50	18.63	6.80	5.60	7.061	9.53	13.988	3.22	0.13	1.76
9.00	20.80	6.30	5.20	7.439	8.80	13.022	3.68	0.44	2.00
9.50	22.38	5.70	4.20	7.188	7.03	14.447	4.41	0.83	2.24
10.00	22.38	5.10	4.30	7.585	6.07	14.575	5.13	1.23	2.49
10.50	22.52	4.90	4.10	8.028	5.77	12.626	4.91	1.73	2.75
11.00	22.31	4.70	3.90	8.403	5.46	11.017	4.52	2.03	3.01
11.50	22.14	4.60	3.70	8.781	5.23	9.736	4.11	2.44	3.26
12.00	22.11	4.50	3.70	9.394	5.15	8.421	3.68	2.61	3.53
12.50	22.39	4.50	3.50	9.785	5.01	7.691	3.28	2.78	3.77
13.00	22.60	4.40	3.40	10.144	4.85	7.092	3.01	2.78	4.01
13.50	23.46	4.40	3.30	11.286	4.78	5.881	2.28	2.95	4.52
14.00	25.09	4.40	3.10	12.231	4.65	5.223	1.93	3.16	5.03

Model 4668 Test No. 11

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length ofchine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.25	7.85	6.50	1.207	10.55	8.597	-0.02	-0.01	0.28
1.50	0.50	7.85	6.50	1.823	10.55	7.543	-0.04	-0.04	0.42
2.00	0.80	7.90	6.50	2.159	10.58	8.661	-0.03	-0.04	0.49
2.50	0.99	7.87	6.50	2.419	10.49	8.560	-0.06	-0.06	0.55
3.00	1.69	7.87	6.10	2.939	10.22	9.600	-0.08	-0.11	0.69
3.50	2.16	7.90	7.60	3.577	10.89	9.586	-0.06	-0.22	0.76
4.00	2.73	7.90	7.60	3.917	10.85	10.143	-0.02	-0.21	0.83
4.50	3.99	7.90	7.60	4.569	10.85	10.892	0.06	-0.27	0.97
5.00	3.99	7.65	7.60	5.202	10.89	11.161	0.43	-0.35	1.10
5.50	6.89	7.85	7.50	5.840	10.86	11.267	1.10	-0.36	1.25
6.00	6.79	7.80	7.40	5.787	10.70	11.269	1.08	-0.32	1.25
6.50	8.53	7.75	7.10	6.800	10.89	9.603	1.68	-0.27	1.50
7.00	9.79	7.70	6.80	7.719	10.67	8.334	1.88	-0.10	1.74
7.50	11.06	7.65	6.60	8.506	10.36	7.471	1.98	0.06	1.99
8.00	12.31	7.60	6.40	9.576	10.14	6.560	2.12	0.24	2.24
8.50	13.58	7.55	6.10	10.375	9.86	6.128	2.10	0.23	2.49
9.00	14.66	7.40	5.70	10.946	9.32	5.799	2.61	0.31	2.74
9.50	15.35	7.20	5.30	11.485	8.58	5.504	3.15	0.59	3.00
10.00	16.09	7.00	4.90	11.808	7.95	5.291	3.35	0.95	3.25
10.50	16.53	6.70	4.70	12.234	7.59	4.868	3.38	1.17	3.52
11.00	17.79	6.40	4.50	12.542	7.22	4.791	3.35	1.35	3.77
11.50	18.48	6.30	4.30	13.018	6.98	4.519	3.35	1.45	4.02
12.00	20.86	6.20	4.00	14.074	6.68	4.223	3.03	1.67	4.52
12.50	23.31	6.00	3.80	15.178	6.46	3.952	2.82	1.85	5.02
13.00	26.37	6.00	3.60	16.206	6.23	3.969	2.55	1.94	5.53
13.50	27.96	6.00	3.60	16.833	6.23	3.749	2.32	1.95	5.75

Model 4668 Test No. 13

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.25	7.70	5.55	1.115	10.25	8.849	0.01	0.00	0.28
1.51	0.55	7.70	5.55	1.684	10.30	8.582	0.03	0.01	0.42
1.81	0.90	7.70	5.60	2.027	10.31	9.669	0.04	0.02	0.50
2.00	1.04	7.70	5.40	2.207	10.02	9.414	0.05	0.02	0.55
2.50	1.81	7.70	5.40	2.758	10.02	10.487	0.13	-0.04	0.69
2.71	2.19	7.70	5.50	3.024	10.11	11.109	0.21	-0.01	0.75
3.00	2.80	7.70	5.30	3.290	9.93	11.976	0.25	-0.10	0.83
3.50	4.17	7.70	5.30	4.216	9.75	13.259	0.48	-0.20	0.97
3.62	4.65	7.70	5.30	4.342	9.63	14.002	0.56	-0.25	1.00
3.99	5.63	7.70	5.30	4.649	10.41	13.091	0.94	-0.37	1.10
4.52	6.99	7.70	5.30	5.243	10.53	12.660	1.87	-0.33	1.25
5.40	8.39	7.70	5.30	6.010	10.23	10.741	2.06	-0.27	1.50
6.32	9.52	7.70	5.30	6.814	9.52	9.532	2.19	-0.01	1.74
7.20	10.49	7.70	5.30	7.480	9.00	8.468	2.39	0.27	1.99
8.12	11.43	7.70	5.30	8.042	8.46	7.767	2.69	0.41	2.25
9.02	12.92	7.70	5.30	8.206	7.48	7.667	2.98	0.53	2.49
10.00	13.69	7.70	5.30	8.154	6.30	8.031	3.56	0.86	2.75
10.84	14.25	7.70	5.30	8.431	5.93	7.469	3.51	1.18	3.00
11.78	14.98	7.70	5.30	8.915	5.77	6.793	3.30	1.38	3.25
12.74	15.68	7.70	5.30	9.257	5.50	6.270	3.01	1.45	3.51
13.56	16.40	7.70	5.30	9.757	5.40	5.776	2.89	1.70	3.75
14.56	17.30	7.70	5.30	10.092	5.16	5.511	2.71	2.02	4.01
16.40	19.03	7.70	5.30	11.107	5.02	4.866	2.21	2.14	4.53
18.20	21.46	7.70	5.30	12.006	4.77	4.555	1.89	2.23	5.02
20.04	24.22	7.70	5.30	12.858	4.73	4.327	1.56	2.35	5.51
20.86	25.31	7.70	5.30	13.354	4.71	4.156	1.43	2.34	5.76

Model 4668 Test No. 12

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.25	7.77	5.90	1.150	9.41	9.638	0.00	-0.10	0.28
1.50	0.50	7.80	5.90	1.731	9.43	8.553	0.03	-0.08	0.41
1.78	0.85	7.80	5.90	2.054	10.49	9.280	0.02	0.01	0.49
2.00	1.04	7.80	5.90	2.308	9.36	10.078	0.06	-0.10	0.55
2.50	1.84	7.80	5.80	2.864	10.24	10.431	0.09	-0.05	0.69
2.71	2.19	7.80	7.20	3.424	10.51	10.295	0.11	-0.14	0.75
3.00	2.80	7.80	7.20	3.790	10.89	10.365	0.21	-0.22	0.87
3.50	4.17	7.75	7.20	4.404	10.83	11.404	0.36	-0.10	0.97
3.62	4.65	7.75	7.20	4.555	10.53	12.227	0.45	-0.25	1.00
3.99	5.63	7.75	7.20	5.021	10.80	11.880	0.78	-0.30	1.10
4.52	6.99	7.67	6.80	5.505	10.56	11.755	1.35	-0.38	1.25
5.40	8.39	7.55	6.40	6.341	10.32	10.115	1.86	-0.29	1.49
6.32	9.52	7.47	6.10	7.219	10.14	8.528	2.06	0.06	1.74
7.20	10.49	7.40	6.00	8.127	9.84	7.461	1.16	-0.35	1.99
8.12	11.43	7.30	5.60	8.823	9.31	6.756	2.26	0.37	2.24
9.02	12.92	7.10	5.30	9.421	8.91	6.466	2.61	0.35	2.49
10.00	13.69	6.45	4.80	9.468	7.82	6.351	3.21	0.77	2.76
10.84	14.25	6.00	4.50	9.587	6.92	6.358	3.41	0.96	2.99
11.78	14.98	5.80	4.30	10.022	6.61	5.925	3.36	1.34	3.25
12.74	15.68	5.60	4.10	10.409	6.30	5.563	3.26	1.58	3.52
13.56	16.40	5.50	3.90	10.737	6.08	5.322	3.16	1.51	3.74
14.56	17.30	5.40	3.80	11.283	5.93	4.993	2.94	1.67	4.02
16.40	19.03	5.30	3.60	12.295	5.68	4.519	2.54	1.81	4.53
18.20	21.46	5.30	3.40	13.338	5.54	4.243	2.41	2.04	5.02
20.04	24.22	5.30	3.20	14.349	5.39	4.059	1.96	2.11	5.53
20.86	25.31	5.30	3.10	14.760	5.30	3.982	1.76	2.15	5.76

Model 4668 Test No. 14

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.99	0.20	7.85	6.30	1.179	9.91	7.473	-0.02	-0.01	0.29
1.51	0.36	7.85	6.30	1.798	9.85	5.818	-0.03	-0.02	0.44
1.72	0.57	7.85	6.30	2.048	9.85	7.099	-0.02	-0.01	0.50
1.99	0.74	7.88	6.30	2.376	9.82	6.905	-0.09	-0.06	0.58
2.50	1.34	7.88	6.30	2.986	9.87	7.882	-0.09	-0.06	0.72
2.61	1.54	7.85	5.90	3.020	9.57	8.571	-0.04	-0.16	0.76
2.99	2.08	7.90	5.40	3.349	9.24	9.136	-0.07	-0.25	0.87
3.42	2.87	7.85	5.27	3.779	9.12	9.762	-0.10	-0.57	0.99
3.52	2.92	7.90	5.00	3.825	8.93	9.575	-0.10	-0.25	1.02
4.00	4.01	7.90	4.60	4.211	8.68	10.476	0.01	-0.30	1.16
4.32	4.78	7.90	4.40	4.476	8.60	10.806	0.22	-0.37	1.25
5.18	6.43	7.80	7.20	6.545	10.39	8.368	1.02	-0.34	1.50
6.02	7.70	7.75	7.20	7.576	10.29	7.792	1.30	-0.15	1.74
6.89	8.97	7.75	7.20	8.555	10.26	6.682	1.39	-0.02	2.00
7.78	10.48	7.70	6.80	9.502	10.09	6.226	1.45	0.04	2.25
8.60	11.98	7.70	6.70	10.432	10.01	5.871	1.50	0.14	2.49
9.48	13.39	7.65	6.50	11.291	9.88	5.471	1.65	0.24	2.75
10.32	14.89	7.60	6.20	11.996	9.62	5.273	1.88	0.35	2.99
11.22	15.28	7.55	6.00	12.608	9.20	4.787	2.10	0.48	3.25
12.14	15.67	7.45	5.30	13.028	8.57	4.501	2.40	0.66	3.52
12.94	16.56	7.40	5.00	13.298	8.18	4.386	2.60	0.77	3.75
13.88	17.84	7.30	4.70	14.030	8.03	4.184	2.64	0.87	4.02
15.64	20.49	7.15	4.00	14.676	7.72	3.937	2.64	1.15	4.53
17.37	23.32	7.10	4.10	16.388	7.45	3.764	2.60	1.15	5.03
19.11	26.28	7.00	3.60	17.385	7.15	3.652	2.50	1.32	5.54
20.84	29.38	6.90	3.60	18.433	6.92	3.547	2.45	1.49	6.04

Model 4668 Test No. 15

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.20	7.80	5.70	1.137	9.69	7.488	-0.01	-0.02	0.29
1.51	0.40	7.80	5.70	1.717	9.63	6.611	-0.01	-0.05	0.44
1.72	0.60	7.80	5.70	1.955	9.63	7.643	0.00	0.00	0.50
1.99	0.79	7.80	5.70	2.263	9.52	7.516	-0.02	-0.06	0.56
2.51	1.39	7.80	5.70	2.854	9.52	8.409	-0.02	-0.11	0.73
2.60	1.54	7.80	5.70	2.956	9.58	8.628	0.00	-0.11	0.75
2.99	2.18	7.80	5.30	3.299	9.20	9.617	0.04	-0.18	0.87
3.44	2.97	7.80	4.90	3.680	8.94	10.187	0.04	-0.26	1.00
3.52	3.07	7.80	4.90	3.765	8.94	10.056	0.12	-0.23	1.02
3.99	3.96	7.80	4.40	4.100	8.70	10.373	0.46	-0.21	1.16
4.32	4.60	7.75	4.20	4.345	8.35	10.710	0.70	0.10	1.25
5.14	5.88	7.70	6.90	6.321	10.20	7.917	1.20	-0.31	1.49
6.03	6.90	7.65	6.60	7.233	9.93	6.934	1.53	-0.11	1.75
6.88	7.97	7.60	6.40	8.113	9.76	6.259	1.61	0.08	1.99
7.72	9.08	7.60	6.10	8.909	9.63	5.740	1.66	0.18	2.24
8.58	10.26	7.55	5.90	9.713	9.43	5.373	1.75	0.28	2.49
9.44	11.54	7.50	5.60	10.496	9.26	5.074	1.92	0.37	2.74
10.36	12.92	7.40	5.20	10.996	8.76	4.781	2.18	0.47	3.00
11.22	13.05	7.25	4.90	11.474	8.13	4.626	2.48	0.61	3.25
12.06	13.11	7.15	4.70	12.028	7.92	4.375	2.57	0.85	3.49
12.98	15.11	7.00	4.40	12.464	7.60	4.281	2.61	0.87	3.76
13.86	16.05	6.80	4.20	12.842	7.28	4.421	2.62	1.01	4.02
15.66	18.09	6.60	3.90	13.851	6.92	3.867	2.52	1.23	4.54
17.31	20.60	6.50	3.70	14.873	6.68	3.734	2.43	1.42	5.01
19.02	23.23	6.40	3.50	15.861	6.45	3.612	2.29	1.48	5.51
20.80	25.21	6.30	3.30	16.820	6.30	3.489	2.16	1.61	6.03

Model 4659 Test No. 16

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length ofchine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _V
1.00	0.20	7.73	5.40	1.105	9.61	7.551	0.01	-0.04	0.29
1.51	0.45	7.75	5.40	1.671	9.62	7.445	0.01	-0.04	0.44
1.72	0.66	7.75	5.40	1.903	9.62	8.417	0.02	-0.02	0.50
2.00	0.84	7.75	5.40	2.213	9.51	8.011	0.03	-0.08	0.58
2.51	1.45	7.75	5.40	2.778	9.51	8.781	0.08	-0.14	0.73
2.61	1.65	7.75	5.40	2.888	9.31	9.498	0.10	-0.05	0.76
3.00	2.18	7.75	5.20	3.270	9.29	9.460	0.19	-0.15	0.87
3.43	3.05	7.75	4.80	3.623	9.00	10.452	0.28	-0.19	0.99
3.51	3.10	7.75	4.80	3.707	9.04	10.099	0.30	-0.23	1.02
4.00	3.95	7.75	4.40	4.090	8.79	10.216	0.87	-0.29	1.16
4.31	4.45	7.65	6.60	5.170	10.15	8.553	0.85	-0.35	1.25
4.55	5.56	7.60	6.20	6.021	9.66	7.625	1.33	-0.29	1.50
6.02	6.65	7.50	5.90	6.795	9.56	6.954	1.51	-0.14	1.74
6.88	7.57	7.50	5.65	7.615	9.31	6.232	1.62	0.04	1.99
7.76	8.53	7.40	5.45	8.393	9.10	5.648	1.83	0.14	2.25
8.60	9.67	7.30	5.20	9.055	8.72	5.440	1.81	0.24	2.49
9.51	10.64	7.15	4.90	9.645	8.37	5.100	2.03	0.30	2.76
10.36	11.31	6.80	4.60	9.948	7.73	4.946	2.42	0.50	3.00
11.24	11.96	6.40	4.30	10.130	7.07	4.866	2.53	0.65	3.26
12.12	12.67	6.20	4.10	10.620	6.94	4.575	2.53	0.91	3.51
12.95	13.66	6.00	3.95	10.850	6.47	4.561	2.52	0.99	3.75
13.84	14.44	5.80	3.80	11.190	6.23	4.390	2.47	1.08	4.01
15.60	16.64	5.70	3.50	12.090	5.92	4.190	2.18	1.25	4.52
17.36	18.42	5.65	3.30	12.920	5.64	3.932	1.96	1.38	5.03
17.36	18.42	5.65	3.20	12.930	5.64	3.932	1.96	1.38	5.03
19.10	21.33	5.65	3.10	14.060	5.37	3.898	1.82	1.46	5.33
20.84	23.93	5.65	2.90	14.990	5.43	3.681	1.63	1.56	5.94

Model 4659 Test No. 1

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length ofchine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _V
1.00	0.21	7.83	6.70	1.238	8.72	8.738	0.00	0.00	0.29
1.50	0.44	7.85	6.80	1.873	8.74	8.131	0.00	0.00	0.44
1.70	0.55	7.87	6.80	2.129	8.79	7.837	0.00	0.00	0.50
1.98	0.75	7.87	7.87	2.658	8.96	7.749	0.00	0.06	0.58
2.50	1.32	7.90	7.90	3.359	8.91	8.602	0.02	-0.04	0.73
2.57	1.37	7.90	7.90	3.464	8.91	8.448	0.05	-0.03	0.75
3.00	2.04	7.90	7.90	4.043	8.85	8.293	0.12	-0.07	0.88
3.38	2.80	7.90	7.90	4.536	8.81	10.085	0.20	-0.05	0.99
3.50	2.93	7.90	7.90	4.717	8.78	9.885	0.25	-0.07	1.03
4.00	3.79	7.85	7.85	5.357	8.77	8.900	0.52	-0.24	1.17
4.24	4.23	7.80	7.80	5.642	8.33	9.222	0.82	-0.34	1.24
5.00	5.49	7.75	7.75	6.730	8.36	8.215	1.35	-0.20	1.49
5.05	5.46	7.70	7.70	7.817	8.28	7.124	1.55	-0.05	1.74
6.78	7.31	7.65	7.60	8.815	8.20	6.272	1.65	0.87	1.99
7.65	8.29	7.60	7.50	9.854	8.12	5.636	1.70	0.04	2.24
8.54	9.33	7.55	7.45	10.928	8.05	5.129	1.75	0.38	2.50
9.35	10.40	7.50	7.35	12.037	8.07	4.759	1.88	0.32	2.74
10.22	11.39	7.40	7.00	12.555	9.05	4.372	2.12	0.30	3.00
11.05	12.22	7.20	6.50	12.915	8.84	4.108	2.65	0.52	3.24
11.95	12.78	6.70	5.80	12.754	8.50	3.814	3.08	0.76	3.51
12.80	12.99	6.20	5.50	12.176	6.10	4.680	3.23	0.83	3.75
13.64	13.63	5.90	5.30	13.033	5.83	4.560	3.26	1.98	4.00
15.35	15.15	5.50	4.90	13.619	5.35	4.361	3.10	1.64	4.50
16.57	16.57	5.30	4.80	15.026	5.29	3.867	2.90	1.69	5.01
17.80	18.22	5.30	4.60	15.878	5.05	3.604	2.73	1.92	5.51
20.50	18.44	5.00	4.40	16.439	4.75	3.534	2.55	2.95	6.01

Model 4658 Test No. 17

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length ofchine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _V
1.00	0.25	7.63	4.95	1.059	9.39	9.659	0.03	0.01	0.29
1.50	0.55	7.63	4.95	1.589	9.34	9.498	0.05	0.02	0.43
1.72	0.70	7.63	4.95	1.822	9.35	9.185	0.05	-0.07	0.50
2.00	0.99	7.63	5.00	2.126	9.33	9.624	0.05	-0.07	0.58
2.51	1.54	7.63	5.10	2.689	9.38	9.455	0.13	-0.11	0.73
2.60	1.74	7.63	5.00	2.763	9.29	10.052	0.15	-0.11	0.75
3.00	2.43	7.60	4.90	3.158	9.28	10.556	0.27	-0.18	0.87
3.42	3.35	7.60	4.70	3.543	8.93	11.637	0.47	-0.25	0.99
3.52	3.42	7.60	4.70	3.647	9.05	11.067	0.52	-0.25	1.02
3.98	4.51	7.35	4.30	3.902	8.58	12.040	0.93	-0.35	1.15
4.30	4.97	7.47	5.50	4.694	9.45	10.320	1.18	-0.36	1.25
5.14	6.13	7.30	5.40	5.498	9.27	9.081	1.68	-0.18	1.49
6.02	6.92	7.15	5.10	6.207	8.82	7.855	1.80	0.03	1.74
6.92	7.79	7.00	4.95	6.960	8.44	6.993	1.85	0.13	2.01
7.76	8.63	6.75	4.70	7.478	8.04	6.467	2.00	0.39	2.25
8.62	9.63	6.10	4.40	7.624	7.15	6.576	2.36	0.43	2.50
9.46	10.12	5.60	4.10	7.729	6.30	6.512	2.79	0.72	2.74
10.36	10.74	5.40	3.90	8.116	6.00	6.051	2.80	0.87	3.00
11.20	11.13	5.10	3.70	8.302	5.62	5.728	2.70	1.11	3.24
12.10	11.87	4.90	3.50	8.561	5.40	5.447	2.61	1.19	3.51
12.94	12.43	4.80	3.40	8.938	5.16	5.220	2.35	1.18	3.75
13.90	13.06	4.80	3.25	9.414	5.03	4.876	2.19	1.32	4.03
15.66	14.97	4.80	3.00	10.289	4.85	4.566	1.89	1.55	4.54
17.36	16.57	4.80	2.80	11.126	4.71	4.225	1.62	1.70	5.04
19.06	18.78	4.80	2.65	11.945	4.60	4.077	1.28	1.73	5.52
20.82	21.08	7.55	4.30	12.978	4.55	3.878	0.93	1.77	6.03

Model 4659 Test No. 2

V, knots	R _t , lb	Wetted length, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _V
1.00	0.24	8.03	1.393	13.06	6.568	-0.01	-0.01	0.25
1.52	0.53	8.03	2.118	12.96	6.425	-0.03	-0.02	0.39
1.93	0.90	8.03	2.687	12.79	6.858	-0.07	-0.05	0.49
2.00	0.93	8.03	2.784	12.79	6.596	-0.07	-0.16	0.51

Model 4659 Test No. 3

V, knots	R _t , lb	Wetted length, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _V
1.00	0.30	8.05	1.373	13.04	8.348	0.00	0.11	0.25
1.52	0.57	8.06	2.090	13.04	6.867	-0.03	-0.02	0.39
1.98	1.04	8.06	2.722	13.04	7.383	-0.05	-0.03	0.50
2.00	1.10	8.06	2.750	13.04	7.652	-0.05	-0.03	0.51
2.54	2.18	8.06	3.493	13.04	9.403	-0.07	-0.16	0.65
2.96	3.36	8.01	4.045	12.53	11.767	0.00	-0.23	0.75
3.00	3.61	8.01	4.100	12.53	11.615	0.00	-0.28	0.76
3.50	6.32	8.01	4.783	12.53	14.940	0.05	-0.31	0.89

Model 4669 Test No. 6

V, knots	R _t , lb	Wetted length of keel, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.10	8.05	1.373	9.32	3.893	0.00	0.00	0.27
1.54	0.45	8.07	2.120	9.32	7.392	-0.02	-0.01	0.42
1.81	0.66	8.10	2.501	9.25	7.903	-0.05	-0.04	0.50
2.00	0.84	8.10	2.764	9.17	8.309	-0.05	-0.04	0.55
2.52	1.64	8.10	3.482	9.25	10.132	-0.09	-0.07	0.69
2.75	1.95	8.12	3.810	9.25	10.116	-0.10	-0.07	0.76
3.02	2.63	8.14	4.194	9.25	11.312	-0.07	-0.16	0.83
3.53	3.97	8.15	4.908	9.17	12.603	-0.12	-0.25	0.97
3.63	4.22	8.16	5.054	9.25	12.564	-0.10	-0.30	1.00
4.00	5.21	8.18	5.562	9.50	12.437	0.10	-0.37	1.10
4.54	7.02	8.20	6.352	9.60	12.874	--	--	1.25
5.40	8.96	8.30	7.647	9.85	11.319	1.33	--	1.48
6.32	10.49	8.30	8.950	9.77	9.754	1.73	-0.19	1.74
7.22	12.25	8.30	10.224	9.77	8.727	1.68	-0.12	1.98

Model 4669 Test No. 7

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.18	7.96	--	1.358	9.50	6.875	0.00	0.00	0.27
1.50	0.41	8.00	7.95	2.039	9.61	6.881	0.00	0.00	0.41
1.80	0.61	8.00	8.00	2.456	9.57	7.140	-0.03	-0.02	0.49
2.00	0.78	8.00	8.00	2.730	9.48	7.464	-0.03	-0.03	0.55
2.50	1.67	8.02	8.02	3.421	9.33	10.392	-0.03	-0.13	0.69
2.75	2.00	8.02	8.02	3.763	9.37	10.243	-0.03	-0.13	0.76
3.00	2.69	8.02	8.02	4.105	9.27	11.699	0.01	-0.22	0.82
3.50	4.05	8.04	8.04	4.801	9.56	12.548	0.03	-0.32	0.96
3.65	4.27	8.04	8.04	5.007	9.72	11.966	0.05	-0.36	1.00
4.00	5.43	8.05	8.05	5.494	10.04	12.265	0.40	-0.24	1.10
4.50	7.15	8.10	8.10	6.219	10.22	12.536	1.03	-0.45	1.24
5.42	9.19	7.90	7.90	7.305	10.23	11.096	1.70	-0.57	1.49
6.35	10.51	7.90	7.90	8.559	10.15	9.318	1.90	-0.27	1.74
7.22	11.55	7.80	7.80	9.608	10.13	7.936	1.97	-0.11	1.98
8.12	12.82	7.80	7.70	10.737	9.85	7.163	2.03	-0.02	2.23
9.00	14.40	7.75	7.70	11.870	9.81	6.575	2.10	0.14	2.47
9.98	15.76	7.68	7.60	13.009	10.04	5.719	2.37	0.26	2.74
10.90	17.17	7.50	7.30	13.762	10.20	5.141	2.93	0.40	2.99
11.80	17.69	7.20	6.60	13.892	9.50	4.852	3.75	0.77	3.24
12.70	17.72	6.40	6.00	13.435	6.53	6.105	4.30	1.07	3.49
13.60	17.87	5.10	5.70	13.691	6.16	5.691	4.33	1.54	3.73
14.55	18.59	5.90	5.60	14.275	6.00	5.310	4.23	1.64	3.99
16.38	19.82	5.60	5.30	15.231	5.65	4.744	4.03	2.07	4.50
18.20	21.52	5.40	6.05	16.210	5.37	4.390	3.80	2.37	5.00
20.00	23.57	5.45	4.90	17.642	5.32	4.019	3.37	2.53	5.49
21.80	25.60	5.37	4.70	18.709	5.14	3.798	3.10	2.69	5.99

Model 4669 Test No. 8

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.21	7.85	7.00	1.266	9.65	7.896	0.03	0.02	0.27
1.52	0.50	7.88	7.05	1.934	9.65	8.139	0.03	0.02	0.42
1.80	0.70	7.90	7.90	2.426	9.86	7.952	0.03	0.02	0.49
2.00	0.87	7.90	7.90	2.695	9.83	8.028	0.05	-0.08	0.55
2.51	1.69	7.92	7.92	3.391	9.72	10.015	0.05	-0.14	0.69
2.75	2.02	7.95	7.95	3.730	9.73	9.962	0.08	-0.12	0.76
3.00	2.78	7.95	7.95	4.069	10.25	10.934	0.15	-0.19	0.82
3.51	4.44	7.95	7.95	4.761	10.25	12.758	0.31	-0.27	0.96
3.65	4.77	7.93	7.93	4.938	10.24	12.688	0.40	-0.27	1.00
4.00	5.90	7.90	7.90	5.391	10.46	12.791	0.68	-0.45	1.10
4.52	7.95	7.86	7.80	6.038	10.45	13.512	1.31	-0.53	1.24
5.40	9.45	7.70	7.65	7.066	10.40	11.307	2.03	-0.45	1.48
6.32	10.54	7.62	7.50	8.152	10.05	9.527	2.20	-0.29	1.74
7.22	11.49	7.53	7.40	9.190	9.91	8.070	2.26	-0.09	1.98
8.15	12.61	7.45	7.20	10.179	9.75	7.065	2.38	0.26	2.24
9.03	14.07	6.20	7.35	10.430	9.76	6.415	2.61	0.39	2.48
9.97	15.33	7.05	6.55	11.567	9.38	5.966	3.13	0.58	2.74
10.92	16.58	6.40	6.00	11.552	7.65	6.595	3.88	0.95	3.00
11.78	17.25	5.88	5.55	11.476	5.95	7.581	4.48	1.08	3.23
12.70	17.30	5.63	5.30	11.831	5.66	6.876	4.41	1.43	3.49
13.68	17.79	5.63	5.15	12.581	5.58	6.181	4.23	1.66	3.76
14.55	18.20	5.33	5.00	12.810	5.30	5.886	4.11	2.04	3.99
16.40	19.35	5.30	4.75	14.047	5.13	5.089	3.56	2.33	4.50
18.10	20.53	5.23	4.60	15.163	5.01	4.539	3.18	2.56	4.97
20.00	21.94	4.87	4.40	15.799	4.66	4.265	2.93	2.88	5.49
21.84	23.67	5.30	4.30	17.887	4.50	3.996	2.48	2.77	6.00

Model 4669 Test No. 9

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.22	7.73	6.40	1.204	9.60	8.315	0.02	0.01	0.27
1.50	0.52	7.75	6.50	1.822	9.56	8.772	0.02	0.01	0.41
1.79	0.80	7.76	6.50	2.177	9.55	9.489	0.05	0.03	0.49
2.00	0.97	7.76	6.50	2.433	9.55	9.214	0.05	-0.03	0.55
2.50	1.73	7.76	7.73	3.301	9.91	10.136	0.15	-0.09	0.69
2.70	2.29	7.77	7.77	3.579	9.91	11.502	0.22	-0.11	0.74
2.98	3.08	7.77	7.77	3.950	9.91	12.699	0.30	-0.18	0.82
3.44	4.73	7.75	7.70	4.531	9.89	14.666	0.52	-0.24	0.94
3.62	5.03	7.75	7.70	4.768	10.72	12.993	0.65	-0.34	0.99
4.00	6.66	7.70	7.60	5.221	10.80	13.985	1.12	-0.33	1.10
4.52	8.85	7.55	7.40	5.761	10.24	15.350	1.90	-0.39	1.24
5.40	10.37	7.20	7.00	6.606	9.88	13.060	2.35	-0.38	1.48
6.33	11.67	7.20	6.70	7.506	9.63	10.974	2.50	-0.14	1.74
7.20	12.45	7.00	6.50	8.292	9.37	9.300	2.62	0.20	1.96
8.13	13.82	6.75	6.20	8.975	8.96	8.467	2.92	0.35	2.23
9.00	15.37	6.20	5.90	9.290	8.36	8.236	3.50	0.64	2.47
10.83	17.66	5.00	5.10	9.331	5.17	10.567	4.88	1.33	2.97
11.78	17.79	4.80	4.90	9.748	4.93	9.435	4.70	1.69	3.23
12.70	17.92	4.60	4.70	10.076	4.68	8.614	4.40	2.04	3.49
13.64	17.95	4.50	4.60	10.589	4.57	7.660	4.10	2.34	3.75
14.50	18.67	4.40	4.50	11.009	4.45	7.240	---	---	3.96
16.35	18.70	4.20	4.30	11.856	4.23	6.000	3.22	2.85	4.49
18.20	19.52	4.10	4.10	12.732	4.05	5.280	2.72	3.04	5.00
20.00	20.54	3.90	3.90	13.308	3.82	4.877	2.25	3.48	5.49
21.80	21.90	4.00	3.85	14.395	3.77	4.435	1.98	3.38	5.95

Model 4669 Test No. 10

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.10	7.93	7.30	1.300	4.185	0.00	0.00	0.29
1.51	0.33	7.96	7.96	2.050	5.975	0.00	0.11	0.44
1.70	0.45	7.98	7.98	2.314	6.426	0.00	0.00	0.50
2.00	0.69	8.00	8.00	2.730	7.194	-0.03	-0.19	0.59
2.48	1.21	8.00	8.00	3.385	8.67	-0.05	-0.04	0.73
2.57	1.29	8.00	8.00	3.508	8.68	-0.05	-0.04	0.75
3.00	1.93	8.05	8.05	4.120	9.090	0.00	-0.23	0.88
3.40	2.49	8.05	8.05	4.669	9.217	-0.01	-0.18	1.00
3.52	2.73	8.06	8.06	4.840	9.395	-0.01	-0.26	1.03
4.00	3.66	8.10	8.10	5.528	9.855	0.12	-0.27	1.17
4.25	4.12	8.15	8.15	5.910	9.602	0.32	-0.29	1.25
5.12	5.66	8.00	8.00	6.988	9.15	1.12	-0.33	1.49
5.95	6.86	7.90	7.90	8.033	9.12	1.37	-0.31	1.75
6.80	8.04	7.90	7.90	9.165	9.19	1.47	-0.31	1.99
7.68	9.06	7.85	7.85	10.286	9.08	1.37	-0.31	2.25
8.57	10.39	7.85	7.85	11.478	9.06	1.62	-0.29	2.51
9.33	11.80	7.80	7.80	12.417	9.03	1.65	-0.30	2.73
10.22	13.43	7.80	7.70	13.514	9.14	1.72	-0.29	3.00
11.11	14.56	7.70	7.60	14.501	9.35	1.99	-0.31	3.26
11.90	15.09	7.60	7.45	15.268	9.30	2.37	-0.31	3.49
12.81	15.34	7.40	7.05	15.780	9.33	2.91	-0.31	3.75
13.65	15.17	7.15	6.40	15.767	7.27	3.29	-0.30	4.00
15.40	16.86	6.80	5.80	16.554	6.65	3.45	-0.27	4.51
17.09	18.53	6.40	5.45	17.262	6.18	3.75	-0.24	5.01
18.75	20.43	6.20	5.20	18.235	5.95	3.12	-0.22	5.50
20.60	22.69	6.00	5.00	19.331	5.70	2.99	-0.20	6.04

Model 4669 Test No. 11

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.99	0.10	7.90	6.60	1.224	4.325	-0.05	-0.03	0.29
1.51	0.33	7.90	7.00	1.919	6.032	-0.10	-0.07	0.44
1.68	0.43	7.90	6.95	2.126	6.371	-0.10	-0.18	0.49
2.00	0.70	7.90	7.95	2.695	7.175	-0.10	-0.07	0.59
2.48	1.31	7.95	7.95	3.364	8.75	-0.05	-0.20	0.73
2.57	1.31	7.95	7.95	3.486	8.75	-0.05	-0.20	0.75
2.98	1.99	8.00	8.00	4.067	9.304	0.05	-0.19	0.87
3.40	2.68	8.00	8.00	4.640	9.669	0.10	-0.16	1.00
3.54	2.77	8.00	8.00	4.832	9.220	0.10	-0.16	1.04
4.00	3.71	8.00	8.00	5.460	9.593	0.30	-0.37	1.17
4.29	4.18	7.95	7.95	5.819	8.89	0.57	-0.41	1.26
5.15	5.45	7.80	7.80	6.854	9.38	1.18	-0.46	1.51
6.00	6.42	7.80	7.70	7.934	9.26	1.45	-0.17	1.76
6.81	7.40	7.75	7.70	8.970	9.23	1.50	-0.14	2.00
7.64	8.52	7.70	7.65	9.998	9.19	1.58	-0.03	2.24
8.58	9.69	7.70	7.65	11.189	9.24	1.62	0.11	2.51
9.38	10.67	7.65	7.50	12.275	9.20	1.72	0.06	2.75
10.23	12.00	7.58	7.42	13.061	9.17	1.93	0.20	3.00
11.10	12.94	7.48	7.10	13.806	9.30	2.28	0.26	3.25
11.90	13.59	7.25	6.60	14.050	9.12	2.73	0.39	3.49
12.80	13.74	6.80	5.90	13.868	6.70	4.542	0.55	3.75
13.60	14.10	6.40	5.30	14.039	6.35	4.556	0.88	3.99
15.40	15.43	5.50	5.30	15.108	6.00	3.935	1.30	4.51
17.10	17.03	5.50	5.00	15.317	5.42	3.899	1.56	5.01
18.84	19.05	5.40	4.80	16.394	5.23	3.723	2.88	5.52
20.53	21.17	5.20	4.60	17.181	5.00	3.638	1.31	6.02

Model 4669 Test No. 12

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.99	0.14	7.80	6.45	1.202	6.004	0.00	0.00	0.29
1.50	0.44	7.80	6.40	1.817	8.63	0.00	0.00	0.44
1.68	0.55	7.82	6.60	2.066	8.68	0.00	0.10	0.49
2.00	0.75	7.82	6.40	2.426	8.60	0.00	0.00	0.59
2.51	1.36	7.84	7.84	3.357	9.08	0.05	0.03	0.74
2.55	1.39	7.85	7.85	3.415	9.09	0.08	0.04	0.75
3.00	2.18	7.86	7.86	4.023	8.95	0.18	0.04	0.88
3.40	2.90	7.86	7.86	4.559	8.96	0.25	-0.12	1.00
3.50	3.07	7.86	7.86	4.693	8.94	0.30	-0.10	1.03
4.00	3.96	7.83	7.80	5.337	9.05	0.61	-0.24	1.17
4.25	4.43	7.80	7.80	5.656	9.251	0.83	-0.27	1.25
5.14	5.62	7.70	7.65	6.726	8.177	1.36	-0.25	1.51
5.98	6.57	7.60	7.50	7.703	7.153	1.58	-0.13	1.75
6.80	7.38	7.55	7.40	8.667	6.274	1.65	0.05	1.99
7.63	8.47	7.50	7.25	9.594	5.09	1.71	0.08	2.24
8.51	9.33	7.45	7.10	10.556	8.99	1.80	0.13	2.49
9.52	10.65	7.30	6.80	11.451	9.01	2.10	0.29	2.79
10.25	11.34	7.15	6.40	11.840	8.86	2.36	0.42	3.00
11.10	12.14	6.60	5.80	11.742	8.47	2.78	0.54	3.25
12.00	12.21	5.90	5.40	11.568	5.90	3.33	0.87	3.52
12.80	12.71	5.55	5.20	11.684	5.53	3.38	0.90	3.75
13.65	13.42	5.40	5.00	12.111	4.885	3.43	1.17	4.00
15.40	14.69	5.20	4.75	13.059	5.07	3.03	1.47	4.51
17.10	16.08	4.90	4.60	13.859	4.80	2.73	1.66	5.01
18.90	17.44	4.80	4.40	14.834	4.63	2.48	1.78	5.54
20.60	19.50	4.50	4.20	15.289	4.34	2.31	1.94	6.04

Model 4669 Test No. 13

V, knots	R _t , lb	Wetted length of keel, ft	Wetted length of chine, ft	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
0.99	0.15	7.70	5.60	1.123	6.695	0.00	0.00	0.29
1.50	0.41	7.70	5.70	1.714	7.909	0.03	0.02	0.44
1.70	0.56	7.70	5.90	1.972	8.331	0.03	0.02	0.50
2.00	0.77	7.70	6.00	2.337	8.51	0.05	-0.09	0.59
2.50	1.41	7.70	5.85	2.987	8.36	0.10	-0.01	0.73
2.57	1.42	7.70	5.50	3.332	8.583	0.10	-0.06	0.75
3.00	2.32	7.70	7.60	3.915	9.11	0.267	-0.22	0.88
3.40	3.17	7.70	7.60	4.437	9.09	0.40	-0.08	1.00
3.52	3.31	7.70	7.60	4.594	9.14	0.45	-0.17	1.03
3.99	4.38	7.55	7.55	5.174	9.12	0.86	-0.30	1.17
4.24	4.44	7.58	7.45	5.433	9.08	1.10	-0.46	1.24
5.10	6.00	7.45	7.10	6.326	9.07	1.63	-0.24	1.49
5.98	6.81	7.30	6.80	7.193	8.61	2.025	-0.09	1.75
6.80	7.62	7.20	6.50	7.947	8.34	1.88	-0.12	1.99
7.65	8.52	7.10	6.40	8.810	8.18	1.98	0.16	2.24
8.50	9.49	6.80	6.00	9.282	7.62	2.55	0.16	2.49
9.35	10.45	6.60	5.70	9.811	7.19	2.57	0.28	2.74
10.20	11.17	5.70	5.35	9.606	6.10	2.97	0.20	2.99
11.10	11.59	5.10	4.90	9.469	5.12	3.55	1.01	3.25
11.95	11.97	5.00	4.80	9.991	5.00	3.48	1.20	3.50
12.75	12.42	4.80	4.60	10.224	4.75	3.32	1.29	3.74
13.65	12.53	4.70	4.50	10.713	4.63	3.13	1.53	4.00
15.38	13.69	4.50	4.25	11.467	4.36	2.80	1.98	4.51
17.10	14.63	4.30	4.10	12.254	4.15	2.53	2.30	5.01
18.80	16.27	4.20	3.90	12.991	4.00	2.53	2.30	5.51
20.58	17.57	3.94	3.80	13.569	3.77	3.993	2.39	6.03

Model 4669 Test No. 14

V, knots	R _t , lb	Wetted length of keel, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.11	7.90	1.211	7.50	5.322	0.00	0.00	0.31
1.50	0.32	7.90	1.893	8.24	6.263	0.00	0.00	0.46
1.60	0.36	7.90	2.143	8.48	6.020	-0.03	-0.02	0.49
2.00	0.56	7.90	2.693	8.51	5.968	0.00	-0.06	0.82
2.40	0.94	7.95	3.255	8.46	7.001	0.00	-0.11	0.74
2.46	1.01	7.95	3.336	8.45	7.167	0.00	-0.09	0.76
3.00	1.59	7.95	4.069	8.47	7.559	0.02	-0.12	0.92
3.24	1.79	8.00	4.422	8.47	7.306	0.02	-0.10	1.00
3.48	2.16	8.00	4.750	8.46	7.650	0.00	-0.15	1.07
4.00	2.83	8.00	5.460	8.49	7.559	0.12	-0.19	1.33
4.04	2.96	8.00	5.514	8.52	7.724	0.15	-0.17	1.24
4.88	4.05	7.90	6.577	8.50	7.260	0.80	-0.20	1.50
5.70	4.99	7.85	7.634	8.94	6.233	1.13	0.04	1.75
6.50	5.79	7.80	8.650	8.92	5.574	1.23	0.06	2.00
7.28	6.74	7.80	9.688	8.92	5.173	1.30	0.00	2.24
8.10	7.80	7.75	10.669	8.90	4.902	1.35	0.20	2.49
8.96	9.05	7.70	11.802	8.87	4.611	1.37	0.27	2.76
9.64	10.13	7.70	12.615	8.85	4.469	1.47	0.23	2.97
10.58	11.42	7.70	13.846	8.85	4.183	1.60	0.38	3.26
11.36	12.24	7.65	14.673	8.90	3.867	1.75	0.44	3.50
12.20	13.05	7.53	15.528	8.90	3.575	2.03	0.42	3.75
12.90	14.01	7.40	15.847	8.68	3.511	2.40	0.52	3.97
14.70	14.64	7.10	16.679	7.94	3.492	2.75	0.89	4.52
16.34	16.59	6.83	17.174	6.48	3.479	2.77	1.19	5.03
17.80	18.28	6.60	17.919	6.16	3.398	2.72	1.38	5.48
19.48	20.18	6.40	20.441	6.25	3.087	2.63	1.48	5.99

Model 4669 Test No. 15

V, knots	R _t , lb	Wetted length of keel, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.10	7.82	1.153	7.79	4.658	0.05	0.09	0.31
1.50	0.35	7.82	1.730	7.79	7.249	0.05	0.03	0.46
1.60	0.38	7.84	1.968	8.12	6.473	0.05	0.03	0.50
2.00	0.60	7.85	2.446	8.20	6.637	0.10	-0.01	0.62
2.40	0.62	7.85	2.610	8.20	6.859	0.10	0.01	0.62
2.42	0.99	7.87	3.249	8.68	7.067	0.15	0.04	0.74
2.42	1.04	7.88	3.388	8.74	6.800	0.15	-0.01	0.78
2.52	1.66	7.88	4.033	8.66	7.728	0.20	0.08	0.92
3.00	1.96	7.90	4.367	8.64	7.842	0.25	-0.06	1.00
3.24	2.22	7.90	4.717	8.66	7.593	0.25	-0.17	1.08
3.50	2.22	7.90	5.391	8.58	7.559	0.45	-0.15	1.23
4.00	2.86	7.90	5.417	8.51	7.579	0.50	-0.23	1.25
4.06	2.93	7.80	6.468	9.07	6.674	1.05	-0.10	1.50
4.88	3.94	7.75	7.481	8.87	6.023	1.28	-0.06	1.75
5.68	4.75	7.75	8.528	9.02	5.227	1.38	0.01	2.00
6.50	5.49	7.70	9.439	8.93	4.878	1.45	0.05	2.23
7.26	6.37	7.65	9.327	8.99	4.828	1.42	0.15	2.24
7.88	6.34	7.63	10.583	8.87	4.525	1.50	0.25	2.50
8.14	7.33	7.60	10.486	8.87	4.513	1.55	0.12	2.50
8.14	7.31	7.60	11.547	8.82	4.267	1.58	0.36	2.75
8.94	8.29	7.55	12.387	8.84	4.012	1.80	0.28	2.98
9.68	9.16	7.45	13.358	8.77	3.848	2.08	0.52	3.26
10.58	10.41	7.40	13.897	8.69	3.669	2.08	0.35	3.50
11.36	11.34	7.40	14.051	8.42	3.448	2.38	0.44	3.75
12.20	12.91	7.20	13.974	7.68	3.438	2.48	0.50	4.00
13.00	12.30	6.90	14.672	6.10	3.669	2.72	1.11	4.52
14.70	13.40	6.40	15.296	5.70	3.772	2.65	1.18	5.02
16.30	15.76	6.00	15.296	5.70	3.659	2.52	1.43	5.54
18.00	17.34	5.64	15.864	5.05	3.505	2.45	1.61	5.98
19.45	18.48	5.33						

Model 4669 Test No. 16

V, knots	R _t , lb	Wetted length of keel, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.10	7.75	1.120	7.78	4.664	0.00	0.00	0.31
1.50	0.30	7.75	1.732	7.80	6.202	0.00	-0.11	0.46
1.60	0.36	7.76	1.885	7.91	6.911	0.00	-0.11	0.50
2.00	0.63	7.77	2.347	7.90	7.234	0.02	-0.16	0.62
2.42	1.02	7.79	2.803	7.81	8.093	0.05	-0.14	0.74
2.50	1.08	7.80	2.900	8.32	7.536	0.07	-0.13	0.77
3.00	1.71	7.80	3.992	8.58	8.035	0.15	-0.14	0.92
3.24	2.06	7.80	4.311	8.58	8.300	0.19	-0.17	1.00
3.50	2.36	7.80	4.638	8.63	8.101	0.27	-0.29	1.08
4.00	2.97	7.73	5.268	8.64	7.795	0.54	-0.36	1.23
4.06	3.02	7.73	5.347	8.63	7.704	0.60	-0.27	1.25
4.88	3.92	7.66	6.327	8.85	6.805	1.02	-0.31	1.50
5.68	4.73	7.58	7.278	8.69	6.122	1.22	-0.30	1.75
6.50	5.47	7.54	8.196	8.54	5.501	1.37	-0.10	2.00
7.28	6.16	7.50	9.191	8.44	4.997	1.37	0.07	2.24
8.08	7.11	7.45	10.091	8.31	4.755	1.42	0.04	2.49
8.96	8.01	7.40	11.007	8.19	4.420	1.52	0.15	2.76
9.68	9.02	7.30	11.561	8.46	4.129	1.67	0.24	2.98
10.54	9.97	7.10	11.869	8.07	4.035	1.90	0.32	3.24
11.36	10.42	6.70	11.920	7.69	3.810	2.32	0.51	3.50
12.18	10.28	6.10	11.783	5.92	4.247	2.54	0.69	3.75
13.00	10.81	5.80	12.022	5.60	4.144	2.62	0.74	4.00
14.68	12.38	5.40	12.649	5.17	4.032	2.52	1.13	4.52
16.32	13.71	5.00	13.923	5.12	3.648	2.37	1.38	5.02
17.68	15.63	5.52	14.979	5.01	3.586	2.27	1.44	5.50
19.56	17.07	5.80	16.687	5.12	3.162	1.97	1.49	6.02

Model 4669 Test No. 17

V, knots	R _t , lb	Wetted length of keel, ft	Re x 10 ⁻⁶	S, ft ²	10 ³ C _t	Change of trim, deg	CG rise, in	F _v
1.00	0.18	7.63	1.110	7.79	8.384	0.00	0.00	0.31
1.51	0.39	7.65	1.679	7.75	8.008	0.04	-0.04	0.46
1.62	0.45	7.65	1.802	7.75	8.031	0.04	-0.04	0.50
2.00	0.75	7.65	2.235	7.78	8.745	0.07	-0.13	0.62
2.42	1.16	7.65	2.712	7.84	9.168	0.11	-0.11	0.74
2.51	1.29	7.65	2.800	7.78	9.550	0.14	-0.10	0.77
3.00	1.97	7.65	3.311	7.62	10.423	0.24	-0.14	0.92
3.24	2.32	7.63	3.549	7.52	10.665	0.31	-0.12	1.00
3.50	2.68	7.62	3.780	7.47	10.628	0.42	-0.27	1.08
3.99	3.41	7.55	5.051	8.61	9.027	0.79	-0.33	1.23
4.07	3.56	7.52	5.124	8.55	9.121	0.89	-0.28	1.25
4.87	4.48	7.40	5.941	8.41	8.150	1.24	-0.22	1.50
5.68	5.26	7.25	6.658	8.31	7.119	1.52	-0.13	1.75
6.50	5.98	7.15	7.397	8.11	6.333	1.59	-0.04	2.00
7.28	6.59	7.00	8.073	7.56	5.968	1.64	0.10	2.24
8.12	7.35	6.85	8.728	7.32	5.526	1.69	0.24	2.50
8.96	8.17	6.50	9.249	7.09	5.208	1.89	0.39	2.76
9.68	8.68	6.10	9.414	6.60	5.093	2.19	0.43	2.98
10.58	9.10	5.40	9.296	5.77	5.112	2.74	0.71	3.26
11.40	9.27	5.00	9.433	4.93	5.250	2.84	0.88	3.51
12.16	9.78	4.50	9.647	4.68	5.128	2.79	1.08	3.74
13.00	10.32	4.75	10.136	4.58	4.838	2.79	1.19	4.00
14.66	11.36	4.60	10.880	4.34	4.419	2.54	1.47	4.51
16.36	12.49	4.40	11.612	4.11	4.120	2.14	1.76	5.03
17.94	13.77	4.30	12.397	4.00	3.881	1.89	1.86	5.52
19.60	15.07	4.20	13.109	3.83	3.716	1.67	1.98	6.03

Discussion

Capt. Francis X. Forest, USN (Ret), Member: This paper and the author's preceding works in this field provide information which is almost indispensable for the design of some types of high-speed craft, where the predicted speeds under unusual and sometimes rigid requirements and the choice of engines and propellers are limited and critical. The author presents information directly applicable to the selection of a form, the estimate of resistance, and the shape of the resistance curves. The information is specific and enables the designer to identify critical problem areas and factors. Information relating to the resistance at "hump" speeds under various conditions of loading may be of particular importance. The planing-type hull must be able to surmount the hump resistance before it may proceed to maximum speed. The thrust at maximum speed may well be less than the thrust required to surmount the hump.

The resistance data are presented in a very usable form. From a design standpoint it would be of considerable interest to know to what degree these data may correlate with corresponding model tests of this type of craft in other model basins and in particular whether any relationship with full-scale performance has been attempted or planned.

In this connection, although the resistance data have been presented in considerable detail, it may be pointed out that in using these data the designer is faced ultimately with an evaluation of thrust and wake factors in order to obtain the delivered horsepower or the shaft horsepower. This is a matter of considerable concern, since some test data of model self-propelled craft of this type have indicated that wake and thrust factors as high as 0.20 and 0.30, respectively, may be encountered. That these factors may not be attributable to any deficiency in instrumentation seems to be borne out in at least two instances where the full-scale craft with propellers designed on the basis of factors of this magnitude have performed essentially as predicted from model tests. It might be hoped that the resistance data of this paper may later be supplemented by some information concerning the propulsion factors to be expected.

The simplified interpolation method suggested by the author, for example, Fig. 28, might well be extended to a greater range of $C_{1.b}$. For example values of 0.037 have been encountered for some of the charts and of 0.092 others. With reference

to these curves and to the precise method of interpolation described by the author, it is to be noted that many other uncertainties are involved in the final determination of power requirements. The differences in R/W involved in interpolation are relatively small. Interpolation between the 100,000 and the 10,000 points on the resistance contours might be made with satisfactory accuracy by a direct interpolation in terms of displacement or, since the difference is largely due to Reynolds number, an interpolation proportional to the cube roots of the displacement might be a reasonable basis.

The resistance data covers area load factors as low as 5.5. It would be desirable for some of the work for which this paper is particularly valuable to have data for craft planing at load factors as low as 4.3 and volumetric Froude numbers of the order of 4.0.

In previous papers the author has included a plot showing the relationship of Froude numbers, speed, and displacement. It would be desirable that such a plot be added to the present paper.

The resistance data are supported by model tests and the variables are well selected for design purposes. Some comparisons of the curves are of considerable interest. For example Fig. 15 and following text indicate the following.

$A_p \nabla^{2/3}$	5.5	8.5
Maximum hump R/W	0.194	0.145
Minimum hump.....	0.15	No "hump"
R/W at $F_\nabla = 4.5$	0.165	0.19

These results appear to indicate that care in the arrangement and balance of heavily loaded craft can reduce the hump resistance to values which are of the same order as those of lighter loaded craft. The further implication that at high Froude numbers heavily loaded craft might be designed with less total resistance for a given speed than the lighter loaded craft is a far cry from the conventional design concept.

Further, in these two cases it is of interest to note that the maximum hump at an area load factor of 5.5 occurs with the center of gravity 12 percent aft of the centroid, while with an area load factor of 8.5, the maximum hump is considerably reduced and occurs with the center of gravity at the centroid.

Fig. 15 indicates that with a load factor of 5.5, moving the center of gravity forward from the 12 percent to the 4 percent point reduces the hump resistance (and the corresponding engine

torque) by approximately 17 percent. Fig. 14 indicates that by moving the center of gravity from the centroid to a position 8 percent aft of the centroid the reduction in hump resistance is of the order of 40 percent.

Such information is obviously of the greatest value to the designer, particularly when the engine, even though of extremely high powers such as are available in the modern gas turbine may be pressed to its limit to meet extreme performance demands. It need not be pointed out that under such widely varying conditions of thrust the need for special considerations such as controllable-pitch propellers may well be brought out by study of these data.

Some comment will no doubt be made concerning the lines of the hull. The narrowed transom probably improves performance in quartering seas and reduces the tendency to broach. At the same time it also limits the space which may be needed for multiple engine and shaft installations. Heavily loaded craft such as amphibians are more often than not restricted in overall dimensions. It may be preferable to continue the maximum beam to the stern in order to obtain every possible square foot of planing area. This does not necessarily incur a penalty since the area-load coefficient is increased. In one case it appears from model tests that the attendant increase in load coefficient resulted in decrease in resistance coefficient at the hump.

The convex bow sections may not meet the approval of many who are familiar with the excellent performance of some craft using concave sections. The convex sections have several advantages, however, and are perhaps an essential for surf performance in the amphibian craft to which the author refers. They have been doing well in a heavily loaded planing hull at speeds of about 40 knots.

Cdr. Peter Du Cane, RN (Ret), Member: We are familiar with the Series 50 methodical series but the present series is of greater value for the reasons set forth in this paper.

It is true that the Davidson Laboratory of the Stevens Institute, through Korvin-Kroukovsky, Savitsky, and others, has developed a very elegant method whereby the performance of any given hull form may be approximated and remarkably consistent results can be obtained. It is, however, the unexpected or nonlinear behavior which is difficult to predict in this way.

An example given in the paper is the difficulty to account for the fact that over a considerable range the form with greater length/beam ratio will represent the optimum.

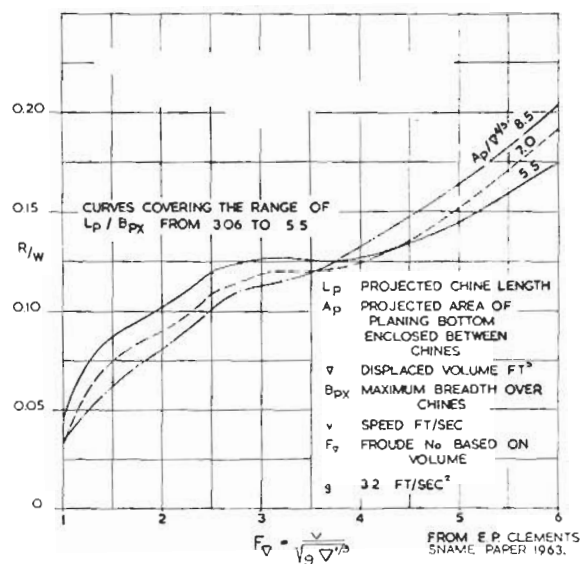


Fig. 30

Of course in any of these methods it is remarkably difficult to predict hump and propulsion characteristics which can be critical.

The practical designer, on the whole, does not find any readily and simply used method of deciding upon optimum form and dimensions.

If this work has a fault so far as the ordinary worker in the field is concerned it is that it is a bit complicated owing to the necessity for deciding upon the various nondimensional parameters, some of which are unfamiliar to us as an every day criterion. This refers perhaps particularly to the Froude relationship used here. No one will question its validity, which is based upon the two-thirds power of the volume of displaced water. However, compared to the normal speed-length relationship in terms of which most of us probably think it is abstruse and requires a bit of arithmetic before we know where we are.

With a view to making all this excellent information even more readily available—in other words to make it unnecessary to go right through the many pages of this work in order to obtain a first-order answer—I have had prepared what may be termed a distillation or envelope consisting of three curves, which can be used quite readily by the designer to give him at least a quick idea of possibilities by glancing at one graph only.

The three curves shown here, Fig. 30, make quite clear the tendency so far as L/B is concerned as well as the influence of loading on planing efficiency.

Of course, from the practical designer's point of view, these tables are best considered as a use-

ful aid in the preliminary design stage, but it has to be clearly understood in this light.

To start with these are maxima. The curves depict the best that can be expected. I will make no secret of the fact that they represent a better hull form resistance-wise than any we have so far used in craft we have produced to order for seagoing.

While the author mentions this point in his text it is still necessary to point out that the utilization of this hull must be very dependent upon the performance in a seaway and at speed.

It is here we might cast some slight doubt, based on simple towing trials carried out from the end of an outrigger and towed by a speedboat at scale speed in the upper reaches of Portsmouth Harbour. Here we found in comparison with two of our forms which are known to be good all round performers there seemed an element of slamming as well as propensity for covering the decks with spray. The latter can probably be dealt with by suitable spray suppressor.

The slamming tendency, which we suspect to be there can, we believe, be eliminated to a considerable extent by raising the run of the chine forward thereby presenting a deeper vee to the oncoming wave system.

The results postulated here, which show among other things that the greatest beam-to-length ratio is by no means synonymous with efficiency are most interesting and in marked contrast to one work on the naval architecture of planing hulls published in this country where the most dogmatic statements on this subject are made.

Strangely enough this work has received considerable popularity among the semi-technical and at least one type of fast patrol boat has been designed based on these principles, where resistance qualities are by no means outstanding and comparatively speaking the slamming is considerable.

That there is no such simple solution as to say, for instance, that beam always leads us to an optimum is very pleasant but quite misleading as our authors' results show. Many factors other than resistance qualities come into this consideration, not least of which is the tendency to slam, a probably increased structural problem leading to greater weight per cubic number and the tendency towards a nasty resistance hump early in the speed range.

It is here we should mention the use of adjustable transom flaps which, besides helping a hull through a hump speed range, can do quite a lot to improve performance in a head sea. Some forms can even be improved in their resistance qualities by what is virtually an approach to the

"Sottori" concave buttocks effect as set out in "High Speed Small Craft," 2nd edition, page 48.

Finally there is one feature of our distillate or envelope curves which is worth mentioning. This is the fact that if we make use of a planing form running in the range below $F_v = 3.0$ it will be seen R/W becomes quite favorable, in fact more so than most practical hydrofoils, and I suspect this applies also to the hovercraft as so far developed. What is required here is, of course, a long craft which in turn requires the very high power now available from gas-turbine units such as the Bristol-Siddeley Olympus.

Nevertheless if the real operating efficiency taking into account L/D and propulsive efficiency is known it is quite remarkable how well such forms compare even so far as real seakeeping is concerned. The price advantage and lack of complication are impressive.

Russell F. Colton,⁴ Visitor: The authors' comments about the 62 Series shape being designed for "good steering qualities and good rough-water performance" brought to mind the tests which our laboratory had performed on a full-scale 25-ft Bertram hull. This boat is considered to be the ultimate in handling and riding qualities by the open water racing enthusiasts. Our experience with this boat has further verified these qualities, but at the expense of a considerable amount of performance.

Fig. 31 of this discussion has been prepared to

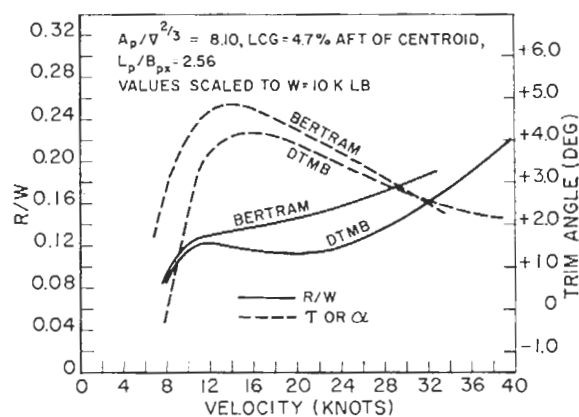


Fig. 31 Comparison of V-25 Bertram with DTMB Series 62

illustrate the performance discrepancy between the Bertram and the 62 Series hulls both converted to a 10,000-lb boat. While the Bertram boat would have considerably more air drag (because of

⁴ Marine Laboratory, Collins Radio Company, Cedar Rapids, Iowa.

the additional superstructure) than the 62 Series, there can be no doubt which boat would win a race—everything else being equal. I think this graph indicates that the authors do indeed have a high-performance planing vessel, while the riding and handling characteristics must certainly be better than the so-called “pounding” hull of the 50 Series.

I note with interest the fact that the narrower hulls tend to show a marked improvement in performance at the higher Froude numbers. Since this is contrary to experience, I made a few checks of the data to determine the cause for this seeming contradiction. From my rather hurried calculations it appears that air drag may indeed account for most of this difference, as the authors suggest, but there still seems to be an additional element which defies explanation. The fact that the drag decreases with the narrower boats regardless of its origin would point to the use of this shape as a high-speed hull, providing roll stability is not overcompromised. It appears that further study of the causes for this drag reduction may be in order.

The authors' presentation of the stability limits encountered in their research is refreshing in view of the simple method in which they were able to present the results. This should prove to be a valuable asset to those using these charts for further design work.

After having gone through the set of calculations presented earlier in this discussion, I fully appreciate the authors' remark about the “laborious process” necessary to extrapolate a boat design from the original sets of curves. The final set of design curves, in terms of $C_{L,b}$, R/W , l_{cp}/b , and weight should greatly facilitate this process.

Finally, I would like to suggest to Taylor Model Basin generally, and the authors specifically, that this excellent work be extended. As many readers know, there is a conspicuous absence of good data on prismatic planing surfaces. It is true that there have been a number of reports written on this topic, but they all seem to lack in one way or another; insufficient range of variables, too much scatter, too small a Reynolds number, model data not available, certain measurements missing, and so on. My suggestion would be to conduct tests with the range of variables and model size used here, but on a series of simple unwarped, straight, prismatic surfaces in deadrisers of 5, 10, 15, 20 and 25 deg. Particular attention should be paid to the very low and intermediate Froude-number range. These data are necessary before we can establish a complete understanding of the mechanics involved in planing-hull performance.

James L. Moss, Associate Member: The authors present R/W curves for the models tested expanded to two different full-scale displacements; viz., 10,000 and 100,000 lb. Differences in specific resistance in each case, at identical volume Froude numbers, are obviously owing to the different methods by which the frictional and residual-resistance components are scaled. Also presented are curves of angle of attack, or trim, but for only one full-scale displacement with the assumption that angle of attack for the model and any full-size hull should be the same at corresponding Froude numbers. By dimensional analysis there is no reason to suspect otherwise. However, for the same reason that R/W decreases with increasing size, it would seem that there ought to be a scale effect involved re-

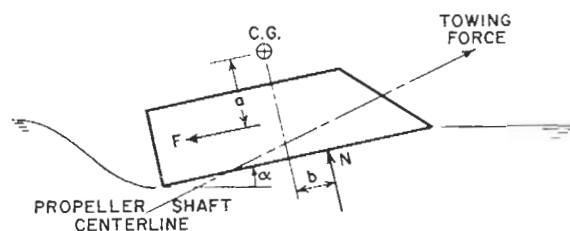


Fig. 32 Free-body diagram of towed planing surface

garding trim. A free body diagram for the wetted portion of the bottom of a planing surface is shown in Fig. 32, herewith.

The horizontal drag is

$$R = F \cos \alpha + N \sin \alpha \quad (1)$$

In equation (1), the first term on the right hand side represents the horizontal friction drag (the total friction drag component is assumed to act parallel to the keel) and the second term is the induced or residual drag. The trimming moment, taken positive counterclockwise about the center of gravity, which is not to be interpreted as meaning the boat trims about the center of gravity, is

$$M = Nb - Fa \quad (2)$$

Assuming for constant Froude number that the distances a and b scale in the ordinary fashion, then M scales according to the relative magnitudes of F and N which differ as the size of hull changes. Owing to the increasing proportion of total drag of the induced-drag component with increasing size, the positive contribution to trimming moment in equation (2) becomes proportionately greater when going from model to full scale. Therefore, model tests would tend to

underpredict trim angle. One would expect that as trim changes the distances a and b , as well as the drag components, would also change with further complications resulting. The addition of propellers under the boat might also tend to increase the trim by a decrease in bottom pressure loading near the transom owing to the increased water velocity caused by the propellers.

In that the authors have presented data which, in many cases, exhibit rather small changes in resistance resulting from relatively major changes in LCG position, loading, and length-beam ratio, the possibility exists that scale effect on trim and the resulting changes in the force components, though perhaps small, might have important consequences. Their comments on this matter would be appreciated.

Peter M. Kimon, Member: It is felt that the variation in the deadrise angle should form a part of TMB Series 62. The effect of deadrise angle on resistance at high speeds is at least as important as the L_P/B_{PA} ratio.

Approximate resistance values for deadrise angles of 0 and 20 deg at an L_P/B_{PA} ratio of 4.6 have been superimposed on the author's Fig. 8 and are shown here in Fig. 33. The data were

obtained from Clement.⁵ At the high speeds, $F_v = 5.5$, $F_v = 6.0$, the R/W values were adjusted to show approximate differences above and below the resistance line which represents the 12.5-deg deadrise angle of TMB Series 62. In order to establish the applicability of these values, a comparison was made between the resistance of the prismatic surfaces of the earlier report⁵ and the TMB Series 62.

The similarity of loading between a prismatic surface and the TMB Series 62 models could be established by a load coefficient based on projected wetted area and it is defined here as $W/\rho g P_A^{3/2}$. The symbols W , ρ , and g have already been defined by the authors and P_A is the principal wetted area projected on a plane parallel to the keel. An approximate mean wetted length could be assumed equal to $l_{cp}/0.70$. Accordingly, the area P_A has been defined as the projected area aft of the $l_{cp}/0.70$ length.

The load coefficient $W/\rho g P_A^{3/2}$ for the standard test condition of the Series 62, at $L_P/B_{PA} = 4.6$, is approximately equal to 0.100. Similarly the prismatic surface of the previous report⁵ has

⁵E. P. Clement, "Analyzing the Stepless Planing Boat," DTMB Report 1093, April 1956.

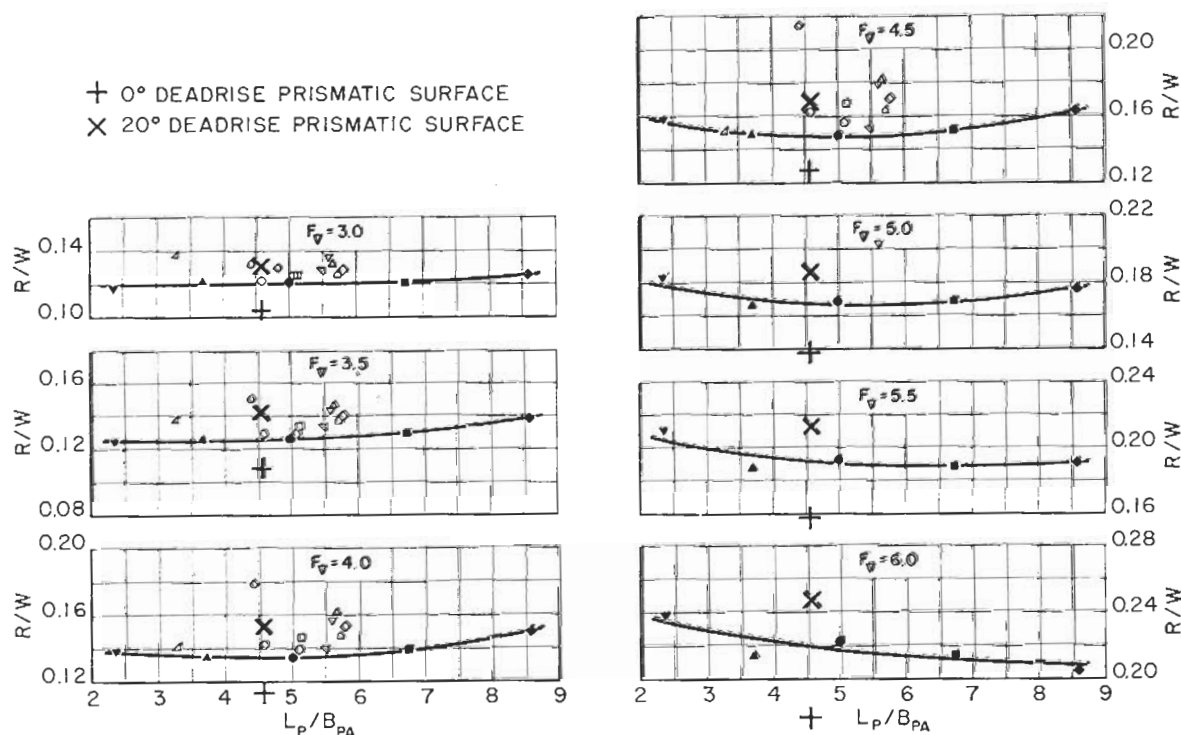


Fig. 33 Resistance/weight ratio for models of TMB Series 62, 0 and 20-deg deadrise, prismatic surfaces, and other representative planing-boat designs

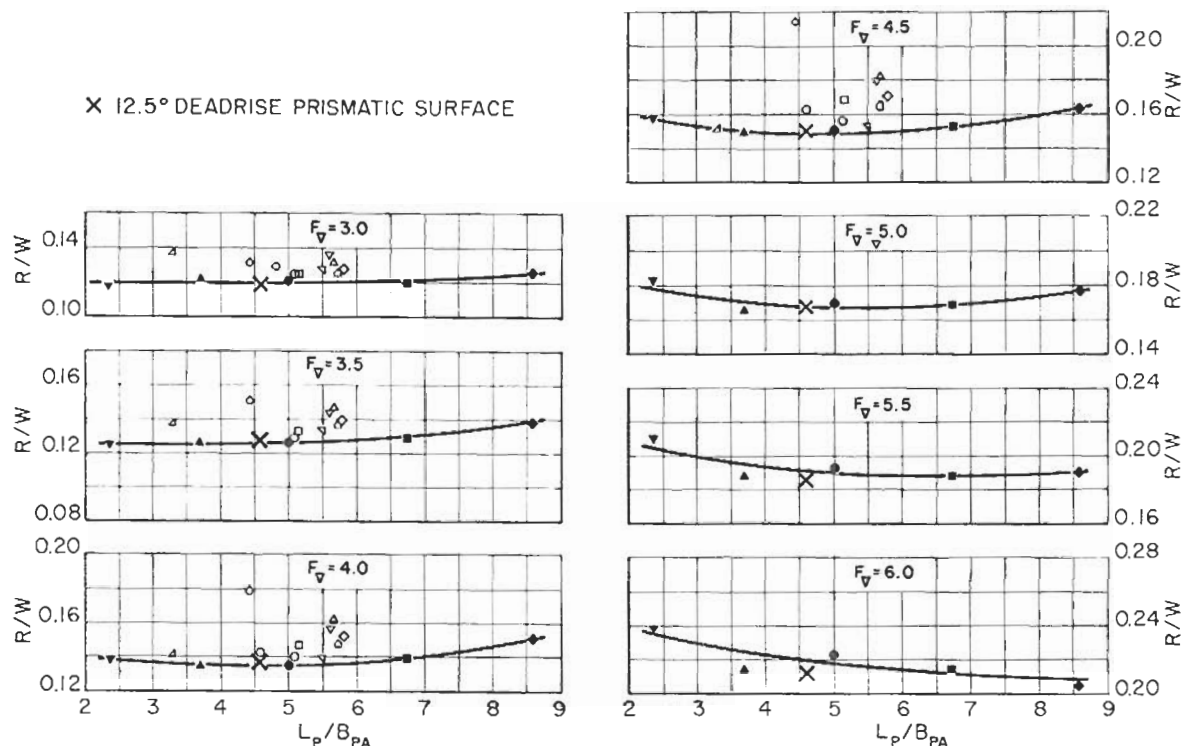


Fig. 34 Resistance/weight ratio for models of TMB Series 62, a 12.5-deg deadrise prismatic surface and other representative planing-boat designs

a load coefficient of

$$W/(bl_{cp}/0.70)^{3/2} \rho g = 0.098$$

The difference between these two values is sufficiently small to permit direct comparison without additional corrections.

From Fig. 15,⁵ the R/W values of a prismatic surface, having a deadrise angle of 12.5 deg and an l_{cp}/b ratio of 1.69, were obtained by cross fairing. It can be shown that the l_{cp}/b ratio of 1.69, when compared with the TMB Series 62 at standard conditions, corresponds approximately to $L_p/B_{pA} = 4.6$. Accordingly, the R/W values of a 12.5-deg deadrise prismatic surface have been superimposed on Fig. 8 of the paper at $L_p/B_{pA} = 4.6$. The results, shown in Fig. 34, herewith are interesting in that they indicate almost perfect agreement with the experimental results of TMB Series 62.

The data for the prismatic surface do not include air drag. This would partly explain the small discrepancy in resistance at the very high speeds of $F_v = 5.5$ and $F_v = 6.0$.

In general, the results suggest that resistance at high speeds, for quite a range in L_p/b ratios and with variations in the shape of the projected

planing bottom area, can be accurately estimated from planing characteristics of prismatic surfaces.

It is suggested that the authors, by the use of available data and data from a limited number of new tests of prismatic surfaces, could extend the usefulness of TMB Series 62 results by including a method for obtaining resistance values at other deadrise angles.

Young H. Chey, Associate Member: The writer recently tested, in smooth water and in irregular waves, three hard-chine models and three round-bottom models, with length-beam ratios of 3, 4 and 5 in each model group. The work was performed under a contract with the Bureau of Ships, U.S. Navy.

The characteristics of the models tested by the writer are shown in Tables 3 and 4 of this discussion.

The specific resistances and the angles of attack of the after portions of the planing bottoms are shown in Fig. 35; the resistances are for a displacement of 100,000 lb. In expanding the model-resistance data for the full-size boat, the Schoenherr friction coefficients were used, with zero roughness allowance. The wetted areas of

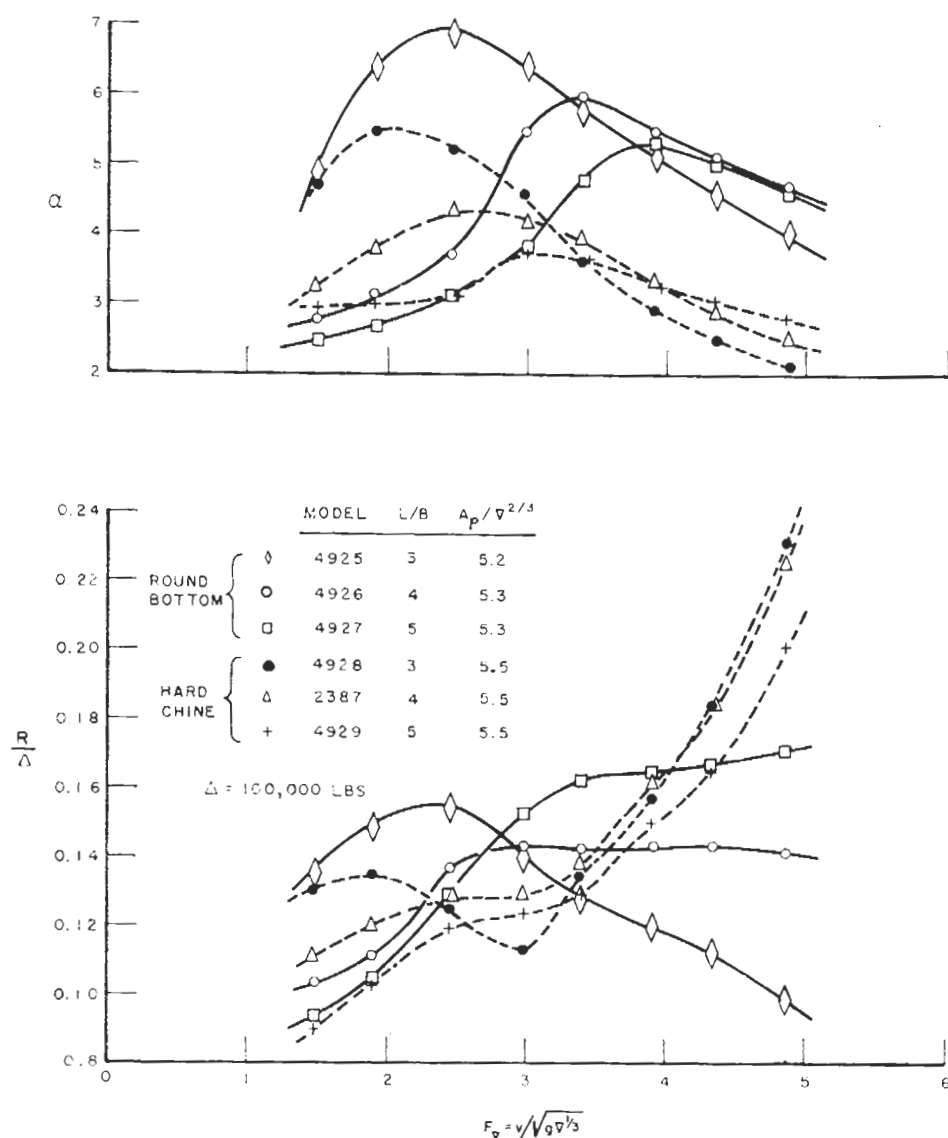


Fig. 35 Specific resistance and α of three round-bottom hulls and three hard-chine hulls

Table 3 Characteristics of Round-Bottom Models

	Model		
	4925	4926	4927
LWL, in.....	31.2	36.05	40.45
Beam at WL, in.....	10.5	9.035	8.0
LWL/BWL.....	2.97	4.0	5.05
LCG abaft amidships in percent of LWL.....	9.9	7.8	9.4

Table 4 Characteristics of Hard-Chine Models

	Model		
	4928	2387	4929
LWL, in.....	31.6	36.0	40.45
Beam at WL, in.....	10.5	9.15	8.25
LWL/BWL.....	3.0	3.94	4.90
LCG abaft amidships in percent of LWL.....	6.6	6.1	5.9

the models were obtained by using a method identical with that described in the paper.

The pattern, with respect to speed, of the hard-chine trim angles of the hull and specific resist-

ances in smooth water, as tested by the writer, appears to be very like that of the models tested by the authors. However, the figure indicates that the round-bottom hulls maintained trim

angles consistently larger than those of the hard-chine hulls—particularly at Froude numbers above 3.5.

It may be noted, also, that the round-bottom hulls had less resistance than the hard-chine hulls, in the same Froude-number range. In comparing Fig. 35 with Fig. 7 of the paper, one finds that the round-bottom hulls are better as far as resistance in smooth water is concerned.

The point the writer would like to bring out in making the comparison, is that the hull having a trim angle closest to an optimum angle will have the least resistance. The optimum angle of trim, in terms of angle of attack of mean stern buttock lines with respect to resistance in smooth water, was discussed in great detail by A. B. Murray in a paper presented at the February 1950 meeting of the New England Section of the Society. This angle ranges from 4 to 5½ deg, the exact angle depending upon dead rise. Therefore, from a purely hydrodynamic point of view, the most important consideration is how to maintain this angle throughout the speed-range of interest. It appears to be almost impossible to solve this problem in design of the main hull alone. A possible solution may be a moment control device, such as a small hydrofoil near the stern, either incorporated with rudders, or separated from rudders. With the latter arrangement, a retractable device would be preferable.

Following a study of the results of the resistances and seakeeping qualities of the six models tested in rough water, it was felt, also, that attention should be directed to the desirability of controlling trim moment. It was found that the superior resistance characteristics of the round-bottom models, in smooth water, disappeared almost completely when they were tested in waves. These round-bottom models, which maintained higher mean trim angle than the hard-chine hulls, had, also, relatively large heave amplitudes and acceleration amplitudes in waves.

The primary cause of this poor performance of the round-bottom hulls in a seaway is believed to be the large attack angle of the stern bottoms. Therefore one cannot guarantee, always, that a hull having superior resistance characteristics in smooth water will be the best performer in a seaway also.

It has been the general practice of the Davidson Laboratory to use the wetted keel lengths of planing-boat models for the calculation of Reynolds numbers. The authors used the arithmetic mean of the keel and chine wetted lengths, in their calculation of Reynolds numbers. For the sake of easy comparison, it would be desirable to settle on one method.

In their nomenclature, the authors define l_{cp} as the distance of the center of pressure forward of the transom; but for computing l_{cp}/b , the distance between the transom and the center of gravity was substituted for l_{cp} , on page 539 of the paper. It would be desirable to clarify this point.

Daniel Savitsky, Member: The present paper on the TMB Series 62 hard-chine planing hulls is of extreme interest to the Davidson Laboratory, since, for the past 15 years, we have conducted continuous fundamental studies on hard-chine prismatic planing forms under the sponsorship of the Office of Naval Research. The results of some of these studies are contained in the available literature^{6,7,8} and are presented in such a form as to define the significance of hull geometric and operating parameters on planing performance and further are presented in a form intended for rapid prediction of the power requirements and stability of planing hulls such as the present TMB Series 62.

These methods have been used with great success by the Davidson Laboratory in analyzing planing-hull forms tested at our laboratory. As will be shown, we were equally successful in predicting the high-speed test results contained in the present paper.

Time does not permit a presentation of the Stevens' method for prediction of planing performance—but these are readily found in the literature. In summary the prediction method is based on use of the following equations for the lift, drag, and wetted areas of prismatic planing surfaces:

Lift

$$C_L = \frac{\Delta}{\frac{1}{2} \rho V^2 b^2} = \tau^{1.1} \left[0.0120 \lambda^{1/2} + \frac{0.0055 \lambda^{3/2}}{C_v^2} \right]$$

Center of Pressure

$$C_p = 0.75 - \frac{1}{5.21 (C_v^2/\lambda^2) + 2.39}$$

Drag

$$R = \Delta \tan \tau + \frac{1}{2} \rho V^2 \lambda b^2 C_f$$

⁶ Daniel Savitsky and Joseph Neidinger, "Wetted Area and Center of Pressure of Planing Surfaces at Very Low Speeds," Davidson Laboratory, Stevens Institute of Technology Report 493, July 1954 (published by IAS).

⁷ B. V. Korvin-Kroukovsky, Daniel Savitsky, and W. F. Lehman, "Wetted Area and Center of Pressure of Planing Surfaces," Davidson Laboratory, Stevens Institute of Technology Report 360, August 1949 (published by IAS).

⁸ A. B. Murray, "The Hydrodynamics of Planing Hulls," paper presented at Feb. 1950 meeting of New England Section of SNAME.

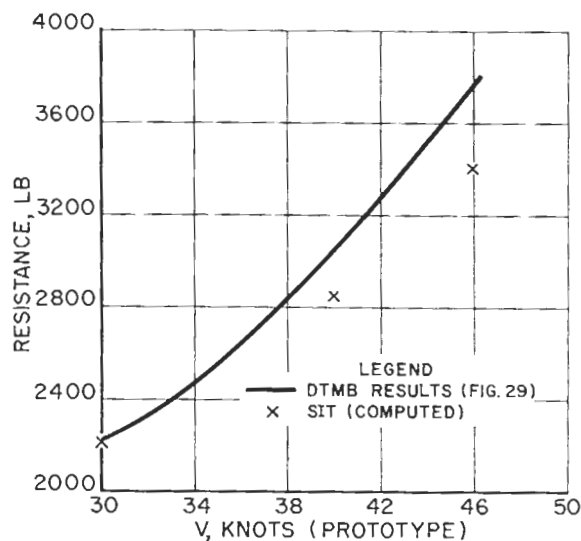


Fig. 36 Comparison of high-speed planing resistance. Computed by Davidson Laboratory; measured by DTMB. (TMB Model 4666-Test 15)

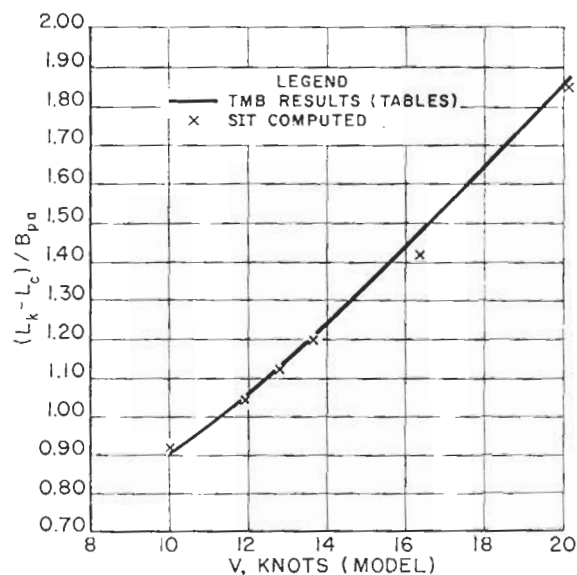


Fig. 38 Comparison of high speed wetted areas. Computed by Davidson Laboratory; measured by TMB. (TMB Model 4666-Test No. 1)

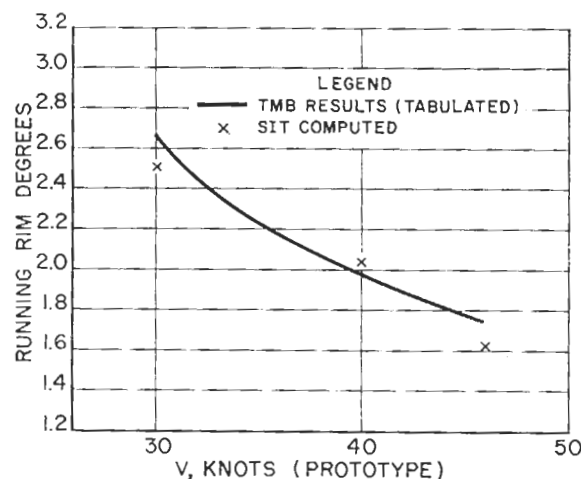


Fig. 37 Comparison of high speed planing trim. Computed by Davidson Laboratory; measured by TMB. (TMB Model 4666-Test 15)

where

- Δ = weight of planing boat
- λ = mean wetted length-beam ratio of planing area
- τ = trim angle of after portion of planing area, deg
- b = beam of planing boat, ft
- C_v = speed coefficient = $V/\sqrt{gb}$
- V = speed, fps
- C_p = distance from transom to center of pressure divided by beam
- C_f = Schoenherr friction coefficient

For any deadrise hull, center of gravity position, thrust-line location, speed, and weight of boat the foregoing equations can be used to predict the wetted bottom area, running trim, resistance, and porpoising stability. The accompanying illustrations show a comparison of measured TMB results and those predicted by the SIT method.

Fig. 36 of this discussion compares the resistance contained in Fig. 29 of the paper with those calculated by SIT. (Allowance is made for the air tare of the DTMB test results.) It is seen that the calculated results at low speed are in agreement with the DTMB results. At the higher speeds (40 and 46 knots) the computed values are approximately 7 percent lower than the DTMB values. This difference may be attributed to the spray drag which has not been accounted for in SIT computation.

A comparison was made of the computed and measured high-speed running trim for TMB model 4666, Test No. 15. These results are given in Fig. 37 for full-scale speeds of 30, 40 and 46 knots. It is seen that the agreement between Stevens' computed and TMB measured trim angle is within 10 percent.

The high-speed wetted-bottom areas (designated pressure area by the authors) were also computed by the Stevens' method and compared with those measured by TMB. As an example, TMB model 4666—Test No. 1 is used and comparisons made between measured and calculated values of the difference in wetted keel and chine

length as given in the tabulation of data. The calculated values are given by the equation

$$L_K - L_c = \frac{B_{PA} \tan \beta}{\pi \tan \tau}$$

The comparison in Fig. 38 shows excellent agreement between computed and measured values of wetted lengths.

Porpoising limits can be predicted similarly but the writer has not had the opportunity to make the calculations for the TMB models. He would like to discuss these results with the authors at some future time.

In summary then, it appears that analytical methods for predicting the high-speed performance of prismatic planing surfaces are well in hand. These latest data again confirm the adequacy of the existing procedure. It appears to me that further planing research should be directed to the problems of loads on typical bow forms where the deadrise and buttock lines are not of constant angle. The low-speed data of the paper are particularly useful in this regard.

Joseph G. Koelbel, Jr., Associate Member: One impressive feature of the paper is the care with which the work has been done and with which the data have been presented. The fact that the method of turbulence stimulation is detailed and discussed, that the water temperature for each run is given, and that all data have been carefully reported, gives the reader great confidence in the tests. A specific benefit of the Series 62 tests, in addition to those mentioned by the authors, is that they give resistance, wetted area and trim angle measurements for forward CG locations at low speeds. For these conditions the existing sea-plane material (based on tests of prismatic surfaces) gives wetted lengths in excess of the normal boat length, and consequently neither the wetted area nor the trim-angle prediction is strictly applicable.

The following opinions are based on considerable successful experience with rough-water planing hulls, but any critical remarks among them are not intended as a general criticism of the Series 62 parent form, which is an excellent hull design.

The 12½-deg deadrise at the transom is good. A few degrees more would not have hurt, but twice that amount, for example, would have been excessive. An advantage of greater deadrise is that the hull can run with the chines dry at the higher speeds, especially if spray rails are fitted properly. This reduces the wetted area at high speeds, as though the hull were narrower, but still provides the beam required to get over the

hump without too much resistance. However, excessive deadrise causes tenderness in roll at planing speeds, even with spray rails.

The bottom could perhaps have been warped some in the afterbody to give more deadrise amidships and at the bow. To more closely represent the best in modern practice, the chine planform should not have been so full forward. These changes would produce a better sea boat without hurting the planing performance. The narrow stern is in general very good. However, for a boat designed to operate at the low end of the planing range, or for any boat where getting over the hump without excessive trim is a problem, a wide transom is better. At hump speeds, when a large percentage of the lift is buoyant, a broad stern moves the center of buoyancy aft thereby producing a lower trim angle and less resistance. Convex bow sections are definitely very good. The convexity could have been carried farther aft in conjunction with increasing the deadrise.

The authors state that making the buttocks less steep in the forebody will reduce pounding. While this is true in some cases, as in changing the forebody shape by increasing the station spacing, it is the writer's opinion that stating the matter in this way may lead to wrong conclusions. For example, it is easy to picture a forebody with rather flat easy buttocks which also has flat sections and will therefore pound badly. In the case of the parent form of this series, it does not seem appropriate to say that the increased pounding due to straightening the sections will be ameliorated because the buttocks have incidentally been flattened, especially when the convexity of the sections was near the chine where it is much more effective than when near the keel.

The coefficients used at DTMB are, of course, dimensionally correct and useful for comparing the boats of this series. However, it is felt that they do not give a valid comparison among boats with differing hull forms and are inconvenient for data-reduction purposes. The reason for this is that the length and area measurements are made on parts of the boat which are out of water at all speeds, particularly at planing speeds. Because of this, the length, shape, and area of the chine planform (and hence the values of $A_p/\nabla^{2/3}$, L/B , and l_{cg} aft of the centroid of A_p) can be varied without affecting the planing performance of the boat. Conversely, it is possible to hold these parameters constant while radically changing the planing performance. While no system of coefficients is perfect, the scaplane coefficients, based on beam and l_{cg} measured from the transom, seem to be better in this respect. The authors apparently bear this out since they have found their

data to correlate better when the seaplane coefficients are used.

In Fig. 7, for Froude number 6, which is high speed, the narrowest hull is shown to have less resistance than the widest one. As the authors point out, this is the opposite of what would be expected. It is stated in the paper that air resistance may account for this. Using the information in the paper and a guess at the drag coefficient, the air resistance was calculated to be, at most, 3.4 lb for the wide model and 1.3 lb for the narrow model. Subtracting these values from the measured total resistances does not reverse their relative positions.

However, it was noted that the wetted area tabulated in the Appendix does not include the area wetted by spray. The measured total resistance, of course, includes the contribution of the spray wetted area. If the resistance of the spray wetted area is eliminated by calculating the frictional resistance due only to the solid wetted area, and adding the wave-making resistance (which is equal to the displacement multiplied by the tangent of the trim angle) the resistances of the wide and narrow models become 11.8 lb and 18.5 lb respectively. Dividing each by the appropriate displacement gives R/W values of 0.216 and 0.269 which have the relative magnitudes one would expect. It appears that the spray wetted area puts a definite limit on the advantage that may be gained by a high aspect ratio in a deadrise surface.

The matter of spray wetted area has important implications in the expansion of model data to full size. The standard procedure is to calculate the frictional resistance of the model, subtract this from the total measured resistance, and assume that the residual resistance is mostly wave making. For the fully planing model, the wave-making resistance can be calculated directly, as noted. Spot checks were made on a number of the runs tabulated in the Appendix, calculating the wave making from the trim angle and the frictional resistance from the tabulated wetted area. In each case, this was considerably less than the tabulated total resistance, sometimes by as much as 16 percent. The calculations were repeated increasing the wetted area to include the spray wetted area, according to an earlier report,⁹ and in each case then the total calculated resistance agreed well with the total tabulated resistance. If this analysis is correct, use of the tabulated

wetted area when expanding to full size results in Froude scaling an appreciable percentage of the frictional resistance. Therefore, it would seem that the spray wetted area should have been included in the tables of the Appendix. At low speeds, where the wave-making resistance cannot be calculated directly, the standard procedure can be used to good advantage but again the correct wetted area should be used.

On the other hand, simply including the spray wetted area with the solid wetted area in the frictional-resistance calculation does not produce the accuracy this discussion may seem to imply. Differences in Reynolds number, in the amount of air entrained, and in the direction of flow make the calculations only approximate. The authors are aware of these and other considerations and it would therefore be helpful to know more of the background of their decision to present the wetted area as they did.

The prediction method shown in Fig. 28 is excellent and very simple to use, but is confined to a narrow range of high speeds. The unique feature of this paper is that it presents accurate data on boat shaped models extending well into the displacement speed range and it will be a great help to naval architects when these data have been reduced to a prediction method which will cover the complete range of speeds. The prediction must also include the trim angle because proper running attitude is often more important than low resistance. The authors have probably given some thought to this and it would be of interest to know if development of such a prediction method is planned at DTMB.

J. F. Stoltz,¹⁰ Visitor: In discussing Fig. 7, the authors have made one statement which I do not understand: "At high speed less drag would be expected for a short, wide hull than for a long, narrow hull because of the higher aspect ratio of the former." I am sure the authors will agree that, based on our present knowledge of the mathematics of planing surfaces and on actual observation, the optimum length-beam ratio from the standpoint of minimum drag at high speeds is not that of the short, wide hull with maximum aspect ratio. On the contrary, strictly from the standpoint of minimum drag alone, the optimum beam becomes narrower with higher speed. Minimum drag for the planing surface is achieved when the combination of parameters is such that it produces an optimum angle of attack. For a flat (zero deadrise) surface this angle is very close to $4.75/b^{1/8}$ deg (where b is the beam, in feet).

¹⁰ Address: 448 S. Kensington Ave., La Grange, Ill.

⁹ Daniel Savitsky and E. W. Ross, "Turbulence Stimulation in the Boundary Layer of Planing Surfaces—Part II—Preliminary Experimental Investigation," Davidson Laboratory, Stevens Institute of Technology, Experimental Towing Tank Report No. 444, August 1952.

For the deadrise surface, this value is slightly greater (obtained by dividing the foregoing expression by the 2.1 root of a fraction representing the ratio of lift for the deadrise surface to the lift for an equivalent flat surface).

It is not surprising, therefore, that the long narrow hull may have less resistance at the low, subplaning speeds and again at higher speeds where the narrow beam results in a more favorable angle of attack.

While it cannot be denied that the proposed definition of the porpoising limit for the series in question seems to be supported by the data, I would like to question the use of a plot of the lift coefficient divided by LCG in beams, versus the Froude number (based on volume) for this purpose.

To illustrate the basis for my question, this type of relationship implies (a) progressively less porpoising stability with increasing speed, and (b) progressively greater porpoising stability with increasing beam (other parameters remaining the same). Speed-trim curves developed at Davidson Laboratory as well as an empirical relationship based on wetted-area dimensions which I developed separately and actual observations on prototype hulls all indicate that (a) deadrise surfaces which are not deep into the porpoising range often regain stability at higher speeds and (b) under no circumstances is porpoising stability improved with a higher aspect ratio (wider beam). The absence of data deep in the unstable region indicates that the phenomenon of regained stability was not explored.

From the standpoint of almost idle curiosity I compared the authors' prediction of resistance for a 15,000-lb boat of 10.9 ft beam and 12½-deg deadrise with an approximation equation which I formulated and presented for laymen (in slightly different form) in *Motor Boating* in 1961-1962. The equation is

$$R = 0.0175W \left[\frac{25W}{V_M^2 b^2} + \frac{B}{15} \right] + \frac{V_M^2 b^2}{100}$$

where

R = resistance, lb
 W = gross weight, lb
 B = deadrise angle, deg
 V_M = speed, statute miles per hr
 b = beam, ft

The expression in the brackets is an approximation of the angle of attack, T , (in degrees) the first term, $0.0175WT$, is the wave-making resistance, and the second term is an approximation of the skin-friction resistance. I thought the

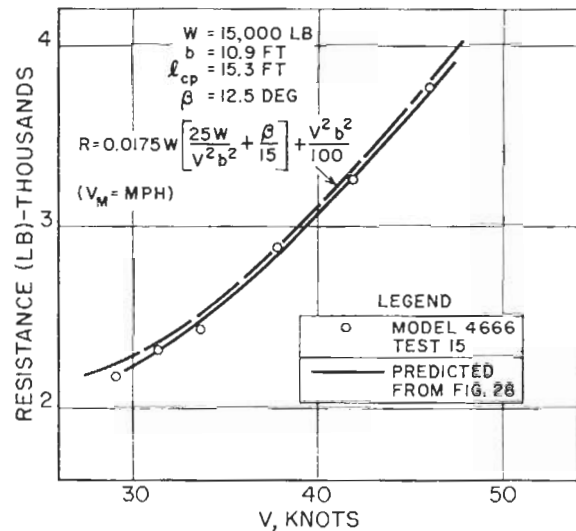


Fig. 39

authors might be interested in seeing this equation, Fig. 39, as plotted and superimposed on their Fig. 29. Obviously, the close agreement is more coincidence than science since the equation is based on (a) a relatively small and constant buoyant component of lift, (b) frictional resistance based on a considerably smaller hull, and (c) an LCG location farther aft (1¼ beams forward of the transom). The two latter deviations are compensating in this instance.

By more classical methods of calculating resistance, I found reasonably close agreement with Fig. 29, the degree of variance being within the range of accuracy for the aerodynamic drag.

John H. Nachtsheim, Member: In Fig. 29 of the paper the authors prove the validity of their method by sampling some of the data used to derive the method against the method derived. It seems that if the method is a good method it should also stand the test of data other than that upon which it was derived. In order to test it in that way and actually to try the method suggested, I selected a recent model test of a similar hull, the 52-ft LCSR, for comparison. From the LCSR dimensions I used the method in the paper to predict the resistance for the conditions of 34,000 lb and for the standard 100,000-lb condition. Then, from the actual model tests of the LCSR, I plotted the resistance predictions for both conditions. Fig. 40 of this discussion shows the corresponding curves for the 100,000-lb condition. The model test prediction is about 20 percent higher than the prediction

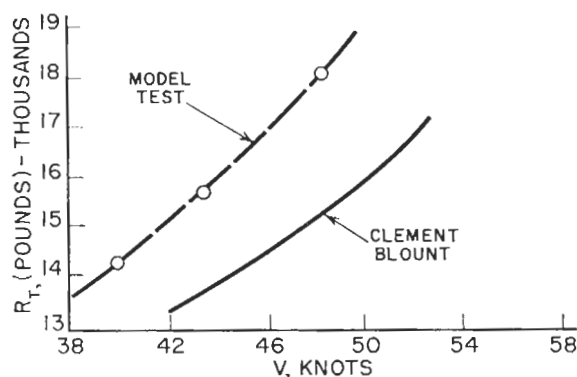


Fig. 40

based on the author's method. Can the authors explain this rather wide discrepancy?

If there are features designed into boats which takes them this far from the resistance predicted utilizing the paper, should not some precautions be suggested by the authors for potential users of the paper? Otherwise the impression is made that this paper is all that's needed to predict accurately the resistance of a planing hull form.

David D. Beach, Member: The writer has used the basic design philosophy presented by the first author in reference [2] of the paper, and is most gratified to see that that basic hull form, of proven suitability for runabouts and high-performance express cruisers, has been further developed in this paper.

As to the parent form and the final form of DTMB 4667-1, the only comment seems to be to areas other than hull efficiency. First, the topsides, while fine for plywood and wrapped-on metal plates, is a little less than esthetic. While this has no bearing at all on the bottom, in boats and yachts we do get involved with appearance, and some slight concavity to the topsides forward produces the fuller deckline demanded in boats nowadays, and this is important in the yacht market. Also, the narrow transom with increasing beam at amidships will play considerable havoc with the problems of suitable accommodations aft. This is not important except in larger craft where the length-beam ratio is highest. We all like to have full-width berths, port and starboard, and space between them, and it is a considerable chore to do this with the rapidly tucking in of the chine.

The authors have modified the basic transom beam to maximum beam ratio to provide for buoyancy aft in the case of outboard powered

boats and larger craft with stern installations of their propulsive machinery and tanks. This is an appreciated concession to the pleasure boat design problem, but it remains to be seen if the concession is adequate. Appreciating the basic design premise, as stated in [2], as to the need, or lack thereof, for transom beam and planing area aft, this designer feels that, in yachts and pleasure craft, the arrangement requirements will continue to outweigh the power requirements.

The writer feels that this narrow beam at the transom is responsible for the extreme range of trim attitudes which several of the tests indicate. While conventional, parallel chine craft may not, as is indicated in Fig. 8, be as efficient, these craft—or at least some of them—do not exhibit the extreme “bow-up” attitude during acceleration or part throttle cruising. It appears that the data establish another dilemma in small-boat design, i.e., “if you want to run flat out when wide open, you’ll never be able to see over the bow when you ease up on the throttle.”

However, as a final comment, we in the small pleasure boat and yacht field have only meager model test and full-scale trial data to use as a check against the academic approach. However, I have assured myself, through checking against the trial data and model test results, of three essentially prismatic afterbody craft, that the procedure outlined and illustrated in the concluding paragraphs of the paper does, indeed, produce a highly satisfactory result. The correlation is good.

If a gracious management and a proper budget allotment can be obtained, it is not unlikely that a full-scale evaluation of this form will be undertaken later this winter or early in the spring in Baltimore and I will look forward to the results to be obtained therefrom.

Charles Garland, Associate Member: In 1958, a model entitled SC-1 was constructed and tested at the Robinson Model Basin at Webb Institute. This model was similar in many respects to model 4666 of the paper. However, the expanded resistance of SC-1 for a 10,000-lb displacement (salt water) was about 10 percent lower than that of model 4666. Table 5 gives a comparison of these two models.

Would the authors comment on the difference in resistance? Has there been any work done on the effect of chine area distribution to resistance? Could the difference in resistance be partially due to deadrise?

The writer has compared different hull forms on the basis of equal loading factor $A_p/\nabla^{2/3}$ and believes this to be a sound basis of comparison.

Table 5

	Model 4666	Model SC-1
L_p/B_{pa}	3.69	3.96
L_p/B_{pz}	3.06	3.15
B_{pz}/B_{pa}	1.21	1.26
B_{pz}/B_{pz}	.71	.877
Centroid of A_p % L_p	48.2	57.3
fwd		
B_{pz} fwd % L_p	60	38
Deadrise midships/ transom	13°/12½°	11°/5°
Shaft angle, deg.....	12.97	12
Model WL length, ft	5.987	2.3875
Extrapolation to 10,000 lb.....	Schoenherr $\Delta C_f = 0(?)$	1957ITTC $\Delta C_f = 0.0001$
Turbulence stimulation.....	None	Strut before model
Hull lines.....	Developable surface	Developable surface

RESISTANCE DATA

	Model 4666 $A_p/\nabla^{2/3} = 8.0$ LCG 8% aft centroid AP	Model SC-1 $A_p/\nabla^{2/3} = 8.0$ LCG 2% aft centroid AP
F_v	R/W	R/W
1.5.....	0.107	0.095
2.....	0.116	0.108
2.5.....	0.123	0.112
3.....	0.128	0.120
3.5.....	0.136	0.123
4.....	0.148	0.138
4.5.....	0.172	0.153
5.....	0.196	
5.5.....	0.224	
6.....	0.258	

As revealed by the test data of this series, the loading factor really relates to the actual wetted surface measurement. At F_v values above 3.5, high hull loading factors show larger model wetted-surface areas than lower hull loading factors. Since frictional resistance is the governing measure at these high speeds, the hull loading factor, which is a still water measurement, does relate to actual measured wetted surface at high speeds.

The writer has compared different models of similar L_p/B_{pa} at the same loading factor in regular wave trains. These tests were run at the MIT model basin on an equal power basis. In waves the wetted surface is, of course, a variable coupled with ship motions. However, these tests revealed roughly equal speed losses in waves for hulls with similar loading factors.

Although the dimensionless variables presented appear to describe adequately planing-hull resistance in still water, the designer is still faced with several problems. Take the 10,000-lb boat for instance. This corresponds roughly to a 30-ft-long pleasure craft. A practical speed range for this craft is, say 25 to 35 knots. This would correspond to F_v values of 3.2 to 4.5. The parent hull at 35 knots has an EHP of 170. To propel a

30-ft boat at 35 knots, this would roughly require 350 to 400 shp on two screws. This engine and fuel installation would weigh roughly 4000 lb. Therefore, the practical power limits are rapidly reached. To further complicate the design issue, at $F_v = 3.2$ to 4.5 resistance differences of less than 7 percent are noted for L_p/B_{pz} from 2.00 to 5.50. For this size pleasure craft, this generally important variable does not appear to be a strong design variable for this hull series. Of course, all tests are run in still water and a type of rough-water criterion needs to be applied. The authors' comments would be appreciated on this subject.

Paul R. Van Mater, Jr., Associate Member: The authors have made a straightforward presentation of data together with an extremely simple and convenient method for resistance prediction. For the most part the reader is left to form his own conclusions as to the effect of form and proportion. In particular the authors do not emphasize the importance of trim angle in planing-boat performance. To illustrate the trim-dependent nature of the planing boat, cross plots of angle of attack, α versus R/W have been prepared for one loading condition and two LCG locations, using values picked from Figs. 9 through 12. The curves are presented only for the case of fully developed planing, the inception of which is indicated by I on the plots, Figs. 41 and 42. Inspection of these curves leads to the following observations:

(a) The lowest R/W values occur at an angle of attack of about $4\frac{1}{4}^\circ$. This optimum angle of attack appears to be largely independent of LCG location and L/B , except that as the models become longer and narrower the angle of attack never becomes large enough to approach the optimum.

(b) There is a serious resistance penalty associated with small angles of trim. In reducing the trim from 4 to 2 deg resistance increases of 80-100 percent are noted.

(c) It is well known that planing efficiency is increased as aspect ratio is increased. The plots confirm this and indicate that one reason is that the higher aspect ratios (lower L/B ratios) permit the model to operate in the optimum trim range.

It is anticipated that further cross plotting will confirm the foregoing trends for the remainder of the series. The existence of an optimum angle of attack that is largely independent of form variations has been known for some time, but has not received popular acceptance. It does, however, suggest some interesting possibilities. Form changes such as an increase of deadrise or round-

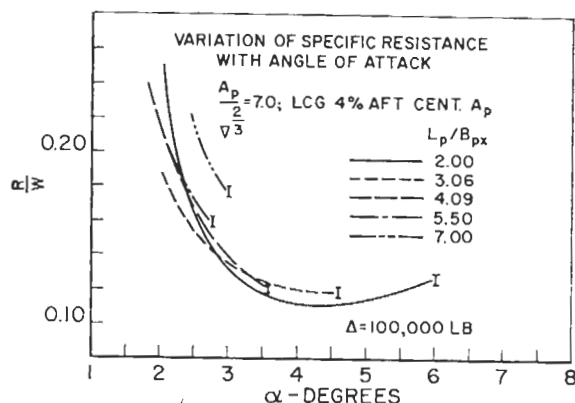


Fig. 41 Variation of specific resistance with angle of attack

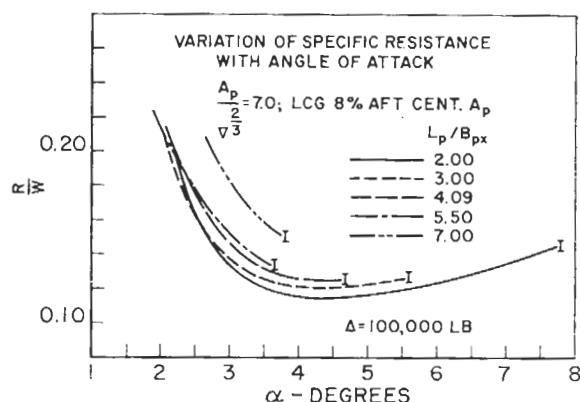


Fig. 42 Variation of specific resistance with angle of attack

Table 6 Comparison of Model Test With Semi-Empirical Method

Based on Test No. 12 DTMB Model 4667-1				
MODEL CHARACTERISTICS				
$L_P/B_{PX} = 4.09$ $A_P/\nabla^{2/3} = 7.00$ LCG = 8 percent aft centroid of A_P				
	Model test		Semi-empirical	Model test
Displacement, lb.....	154.00			100,000
Speed, knots.....	12.82			37.56
F_{∇}	3.29			3.29
R_t , lb.....	23.03	22.41	12,500	12,000
α , deg.....	4.10	4.00	4.10	4.08

ing of bilges which result in loss of lift but an increase in running trim angle may actually produce a net gain in resistance by permitting the boat to operate nearer the optimum trim angle. On the other hand the addition of wedges or the presence of a hook in the after buttocks tending to reduce the trim can be expected to be uniformly detrimental in the fully developed planing region. These features will show an advantage only in the transitional region where trim angles may be excessive.

In a discussion of this paper Moss has questioned the possibilities of scale effects in trim predictions based on model tests. In light of the foregoing discussion it is clear that if the model does not accurately reflect the full-size trim behavior then the validity of the entire model test procedure is in doubt. In order to check this possibility a prediction method was employed in which the trim angle is determined explicitly for any scale ratio. In this method frictional and pressure forces are calculated as a function of trim angle using the semi-empirical equations of Savitsky and Neidinger.⁶ Two simultaneous equations representing the center of pressure as a

function of trim angle are solved graphically. One equation locates the center pressure based on the character of the pressure distribution over the bottom. The other equation is simply a statement of force and moment balance. Four forces—thrust, weight, normal pressure force, and frictional resistance—appear in this later equation. Any change in the magnitude of the frictional force relative to the other forces will affect the final solution for trim angle.

A data point in Test 12 of Model 4667-1 was selected as representative and the foregoing calculation procedure applied for both model size and the 100,000-lb expansion. Results are given in Table 6 herewith. The calculated value of R_t and α for model size are within about 2½ percent of the model test data point. The prediction of trim angle increases from 4.00 deg for the model to 4.08 deg for the 100,000-lb boat, the difference being due to the differing proportion of frictional resistance present in full size. In short, it appears that scale effects are present in trim predictions, but they will not seriously affect the prediction unless the scale ratio becomes very large.

The implication by the authors that the center of gravity and the center of pressure are at the same location is not fully understood. If this were the case then as speed increases a planing boat would not undergo the large changes of trim that are characteristic of its behavior. As a matter of fact, for the 100,000-lb example calculated in the foregoing the separation between weight and pressure forces is 0.134 ft.

In closing, the authors' comments on the following questions regarding scale effects are invited:

(a) Is there any consistent trend when comparing model test trim predictions with trial results?

(b) Side wetting often appears in model tests. Does this also appear on the full-size boat?

(c) Will the absence of propeller suction in a towed model test seriously affect the trim?

Guiseppe Scarpa, Life Associate Member: The present paper should be of great interest to naval architects owing to the few studies on this subject leading to useful conclusions. In this brief note I shall limit myself to a consideration of the variables in function of which the resistance is expressed. Essentially they are A_P ; B_{PX} ; F_V ; L_P ; $\nabla^{2/3}$ and X_G , horizontal length from LCG to after end of L_P .

I believe that it is possible to do without the variable L_P , as this length does not matter in planing, while what matters is the actual length, a function of the fore-and-aft position of LCG. Similarly it is possible to do without A_P since it is substituted by functions of X_G and B_{PX} . Consequently, there would be only four variables and with these, the three ratios

$$\frac{X_G}{\nabla^{1/3}}, \quad \frac{B_{PX}}{\nabla^{1/3}}, \quad F_V$$

thus greatly simplifying the procedure.

Authors' Closure

In replying to the numerous stimulating comments on their paper, the authors would like first of all to acknowledge that there are more interesting points about the hydrodynamics of planing hulls in the comments than in the paper itself.

In this connection, Captain Forest's commentary on the important hump region is particularly appreciated since it fills a noticeable gap in the text of the original paper. A graph, Fig. 43, of volume Froude number (F_V) as a function of boat

speed and weight has been added in accordance with Captain Forest's suggestion.

The performance data on the Bertram boat which were included in Mr. Colton's discussion, and the performance data on the high-speed designs tested at the Davidson Laboratory, which were presented by Mr. Young Chey, will obviously be of considerable interest to the readers of the paper.

The authors acknowledge with appreciation the numerous valuable suggestions for future research on planing hulls. In this connection, Mr. Kimon's points in regard to extending the work to include other deadrise angles seem particularly well taken. Mr. Kimon's proposed scheme for extending the series to include other deadrise angles seems extremely good.

Mr. Moss has raised an interesting question in regard to trim angle. The Model Basin has examined the question of scale effect on both resistance and trim by testing a geometric series of planing hull forms. One of the surprising results obtained was that the trim angle was consistently lower for a large model than for a smaller model. This is contrary to the result indicated by Mr. Moss's analysis, which seems to us to be correct. We are not able to explain the anomaly.

Mr. Young Chey and also Mr. Van Mater asked about center-of-pressure location versus center-of-gravity location. The authors believe that no significant error will result from the assumption that the pressure force on the bottom of the hull passes through the hull center of gravity, and therefore that the above two dimensions can be used interchangeably.

Mr. Koelbel has offered an interesting and well-informed commentary, and the authors agree with most, though not all, of the opinions which he has expressed. Mr. Koelbel stresses the importance of spray-wetted area. During the time which has elapsed since the graphs and tables of this paper were prepared, the Model Basin has also devoted some attention to this subject. One result of this work is David Taylor Model Basin Report 1818, which shows how spray drag of planing boats can largely be eliminated by an appropriate arrangement of longitudinal spray strips. Also, it is now our standard practice to include tabulated values of spray-wetted lengths in the Model Basin data sheets for planing craft. In answer to Mr. Koelbel's question as to why the authors treated the wetted area as they did, the answer is simply that they followed the well-trodden path of conventional past practice. Furthermore, as Mr. Koelbel's comments indicate, it is not clear even at this considerably later date, that a better or more accurate method is known.

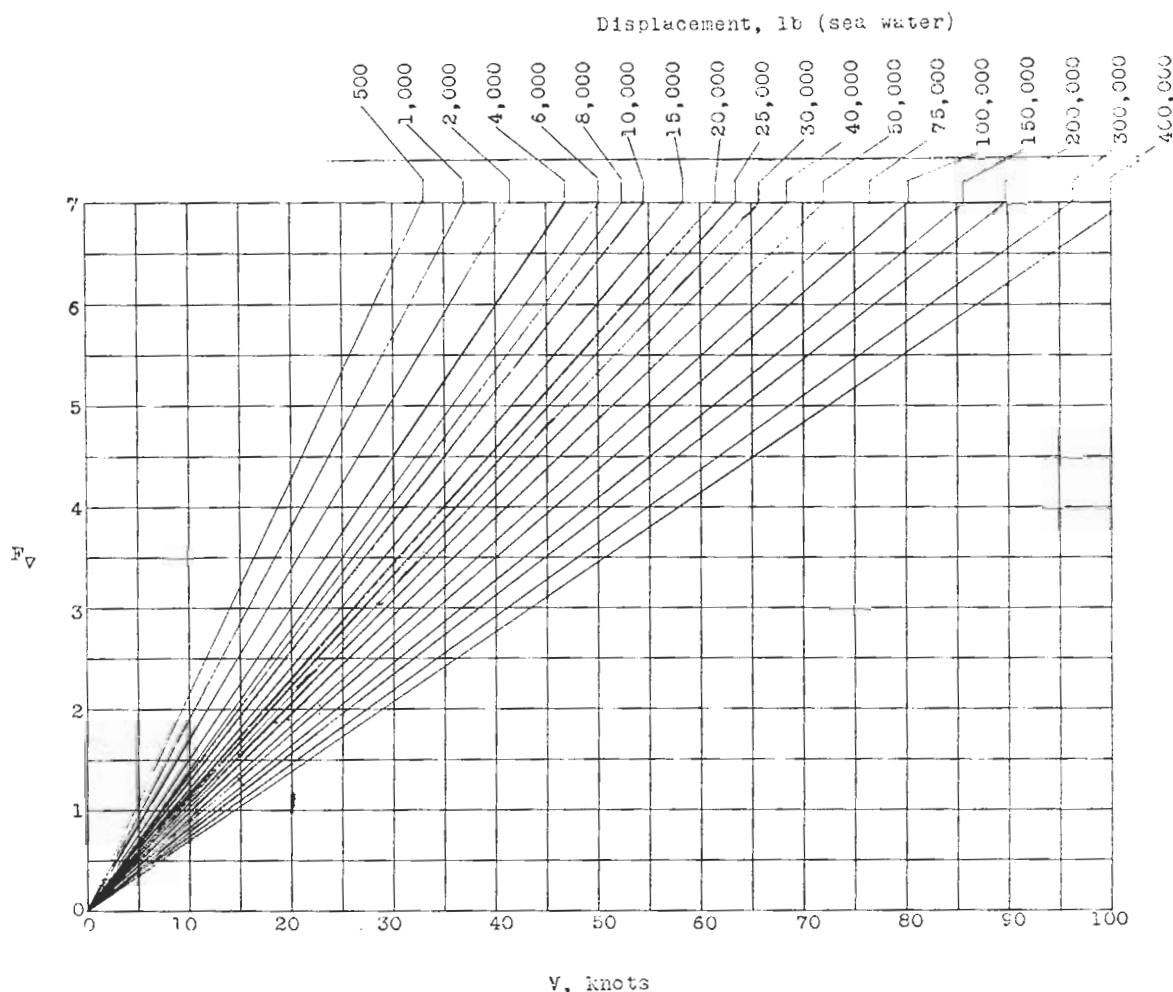


Fig. 43 Variation of volume Froude number with speed and displacement

Mr. Stoltz is puzzled as to why we expected less drag at high speed for a short wide hull than for a long narrow hull. An important point here is that the comparisons in this paper between hulls having different length-beam ratios were made on the basis of equal planform area. Therefore, when we visualize a short wide hull being altered in the direction of a higher length-beam ratio, we consider that if the width is reduced by dividing it by a number greater than one, the length is to be multiplied by the same number in order to keep the planform area unchanged. Mr. Stoltz in raising his question evidently considers change in length-beam ratio as a change in width with the length held constant. When the length-beam ratio is varied in this manner, we entirely agree with Mr. Stoltz that increase in length-beam ratio would lead to less drag at high speed.

Mr. Stoltz's remark that a porpoising deadrise surface will often regain stability at a higher speed is an interesting one. He is correct in his assumption that this phenomenon of regained stability was not explored during the tests of this planing-boat series.

Mr. Nachtsheim's point is clearly a valid one. The hull form of Series 62 was the result of a considerable amount of time and effort directed toward the development of a design having low drag at planing speeds. The hull forms for which the series test results can be used to predict performance would necessarily be similar to the design of the series and would therefore also have the features giving low drag at planing speeds. With that restriction, the data can be used as stated to predict the resistance of boats of a wide range of sizes and proportions.

Planing hull studies at the Model Basin have

shown that for low drag at high speeds the planing bottom should have a narrow stern and straight parallel buttocks: i.e., no twist or hook. The LCSR design which Mr. Nachtsheim has utilized for his comparison has, on the other hand, a wide stern, and both twist and buttock hook in the planing area. These are evidently the reasons why the high-speed drag of the LCSR design is considerably greater than that of the corresponding Series 62 design.

The resistance of Mr. Garland's planing boat design, as predicted from tests of a model 2.4 ft long, seems remarkably low. The authors strongly suspect that the reason is either laminar flow or experimental error. If the resistance data were valid the design would be a very remarkable one.

Mr. Van Mater has contributed interesting discussions of optimum angle of attack for planing hulls and of the influence of scale effect on trim angle. To the best of the authors' knowledge data are not available on which to base satisfactory answers to the questions raised by Mr. Van Mater at the conclusion of his comments.

In reply to Professor Savitsky, the authors would like first of all to acknowledge their in-

debtedness to Professor Savitsky and his colleagues at the Davidson Laboratory for the many fundamental studies of the hydrodynamics of planing forms which they have made available. Their work is, of course, well known, and is of invaluable aid to all serious students of the subject. The authors are also familiar with Professor Savitsky's equation for predicting the resistance of planing hulls, but have found it to be less accurate for high speeds than an equation developed at the Taylor Model Basin. The DTMB equation has the important advantage of including a term for spray drag. A significant difference between the two equations is that Professor Savitsky's takes account of buoyancy and Froude-number effects and accordingly is meaningful down to quite low speeds. The DTMB resistance equation is applicable only for high speeds where buoyancy and Froude-number effects become negligible. However, since a smaller number of variables is involved, it lends itself readily to the development of design charts for the optimization of planing hull performance. The DTMB resistance equation for planing hulls and some design guides which have been developed from it can be found in DTMB Report 1490.