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RESISTANCE TESTS OF TWO SMALL TORPEDO FORMS

by

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PERSONNEL

The tests described in this report were conducted by W.H. Bowers, who wrote the report. The work was carried out under the general direction of Comdr. E.A. Wright, USN, and Mr. L. Landweber, of the Hydromechanics Division.

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ABSTRACT

This report describes towing experiments with two torpedo forms, alike except for the afterbodies. The first form had an abrupt square termination of the full cylindrical middle body and the other had a tapered tail of slightly convex curvature, which was fitted with fins. The effect of the tail shape upon the resistance is shown.

In the course of these tests, the strut resistance and the interference between model and strut were investigated.

INTRODUCTION

At the oral request of members of National Defense Research Committee Project DIC-6187 at the Massachusetts Institute of Technology, resistance tests were made in the deep water basin at the David Taylor Model Basin on two small torpedo-shaped bodies provided by them. It was desired to learn the resistance of these forms in connection with a special project for the Bureau of Ships of the Navy Department.

In the course of these tests, the strut resistance and the interference between model and strut were investigated.

TEST APPARATUS AND PROCEDURE

The bodies tested were 3 inches in diameter and 32 inches long overall, and had the form shown in Figure 1. Both models had noses which were approximately 1 caliber ogival with rounded tips. They both also had long cylindrical middle bodies. Model 1 had an after end formed by a right angle cut-off of the cylindrical middle body. Model 2 had an after end similar to the noses, and four fins extending to the full diameter and as far back as the tip of the body. The models had steel walls and, although painted, the surfaces were unusually rough.

The resistance tests were made by towing the models from the dynamometer of the deep water basin carriage in the manner shown in Figure 1.

These tests were carried up to a maximum speed of about 12 knots. After the total resistance of each model and strut had been measured on the carriage dynamometer, the separate resistance of the struts alone, called tare resistance, was obtained by towing the strut at the same immersion as in tests of the models. The resistance of the models was found by subtracting the strut resistance from the total resistance of model and strut.

Later another set of strut-resistance readings was obtained with a curved plate soldered to the end of the strut in such a way as to represent

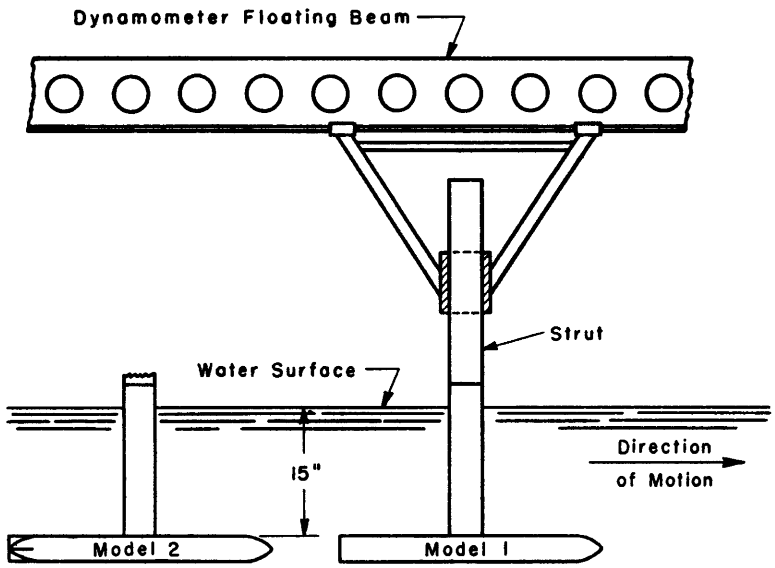

Figure 1 - Models and Towing Arrangement

Both models had a rough paint finish. The brass double-ogival towing struts were of 3/8-inch thickness and 4-inch chord, and were soldered to the models, which had metal walls.

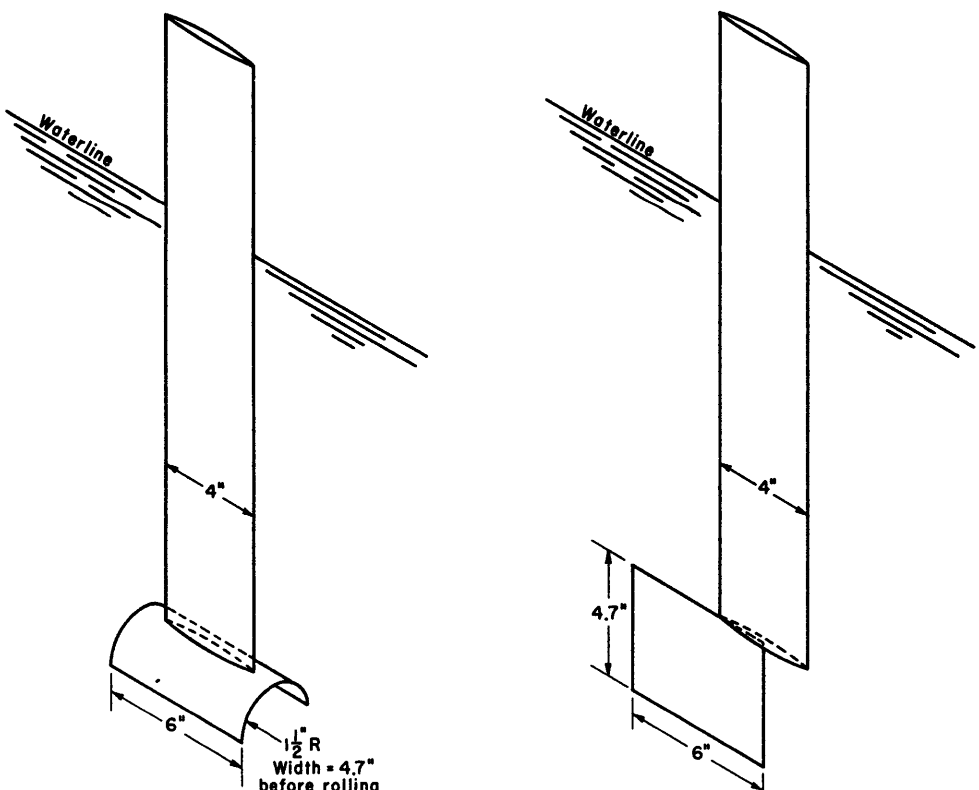

Figure 2a - Strut with Curved Plate

Figure 2b - Strut with Vertical Flat Plate

Figure 2 - Towing Arrangement of Strut with Brass Plates Attached

The thin plates were made from 1/16-inch sheet brass; the edges were left square.

the upper surface of the model in the vicinity of the strut end; see Figure 2a. This thin plate was 4.7 inches wide and was rolled to the same radius of curvature as the models, extending from 1 inch in front of to 1 inch behind the strut. It was used in an attempt to show the effect upon the strut resistance of "covering" the end of the strut.

In still another test a flat rectangular plate of the same area as the curved one was attached to the strut in the manner shown by Figure 2b. The purpose of this test was to determine the resistance of the strut and plate with the plate attached to the strut in such a way as to have a minimum interference effect between the two. By this means interference effects between the form and strut could be separated.

TEST RESULTS

The total resistance of each of the two models and of the towing struts is shown in Figure 3. These curves show that the resistance of Model 1, with the square afterbody, is not only higher than that of Model 2, as was to be expected, but that it is somewhat irregular.

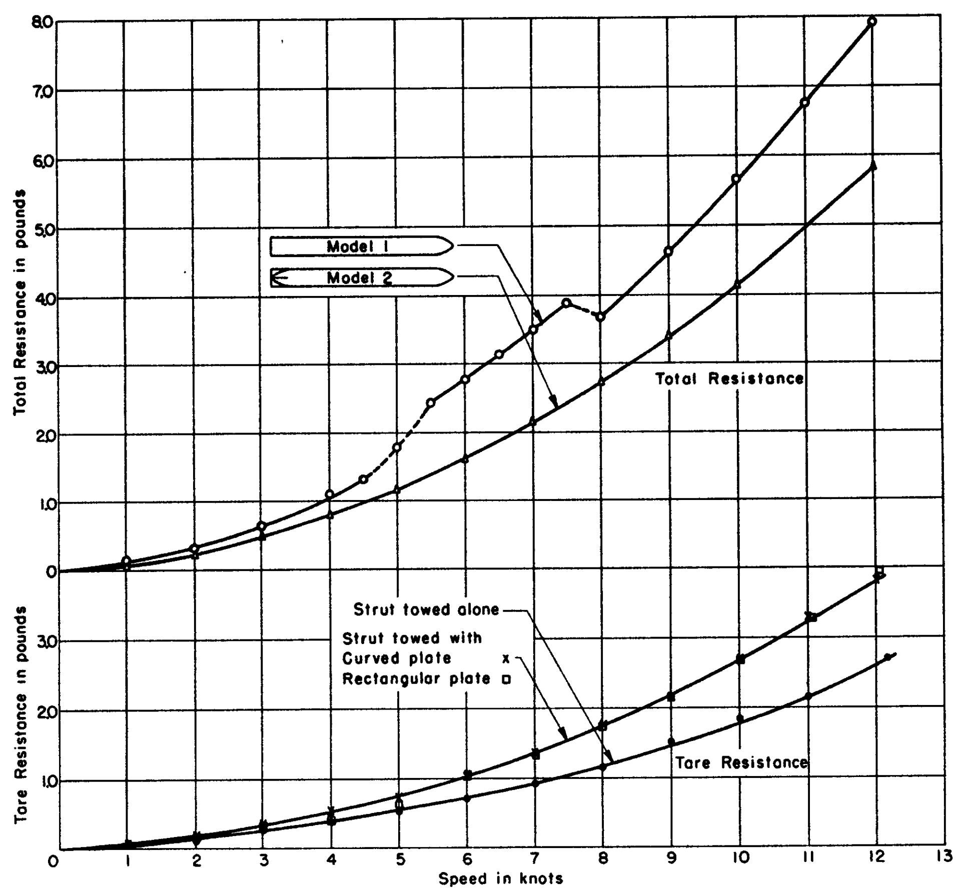

Figure 3 - Resistance Curves for Two Torpedo Forms, and for the Towing Strut with 3 End Arrangements

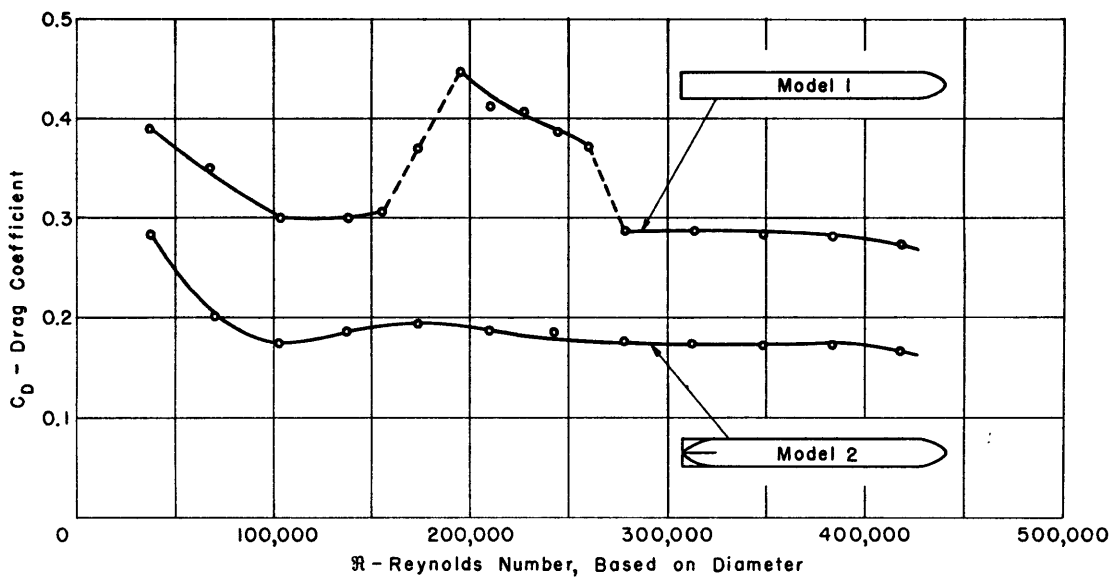

Figure 4 - Curves of Drag Coefficient for the Two Torpedo Forms as a Function of the Reynolds Number

Figure 3 also presents the curves of tare resistance. The close agreement between the tare readings with the curved plate and with the rectangular plate attached to the strut permitted a single curve to be drawn for both tests.

The curves of Figure 4 are values of the drag coefficient C_D plotted against Reynolds number $\mathfrak{R}$.* These parameters are defined as follows:

$$C_D = \frac{D}{\frac{\rho}{2} A V^2}$$

and

$$\mathfrak{R} = \frac{Vl}{\nu}$$

where D is the drag in pounds,

ρ is the density of the medium in slugs per cubic foot,

A is the area of cross section in square feet,

V is the velocity in feet per second,

l is a linear dimension, which is the diameter in this case, and

ν is the kinematic viscosity in feet squared per second.

The net resistances for computing the coefficients and plotting the curves were obtained by subtracting the tare values for the strut alone, taken from Figure 3, from the curves of total resistance.

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* It should be noted that the surfaces of the models were unusually rough. This is a factor leading to relatively high drag coefficients. If the coefficients are to be compared with those for similar smooth bodies, this fact should be taken into consideration.

DISCUSSION AND CONCLUSIONS

The irregularity of the higher curve in Figures 3 and 4, belonging to Model 1, is difficult to explain satisfactorily. It was noticed that, during this test, considerable torsional vibration of the strut occurred at speeds in or near this range. The exciting forces causing this vibration were probably due to eddies shed periodically at the square stern of the model.

In the case of two-dimensional flow around a cylinder towed at right angles to the direction of motion the resistance is known to be increased by lateral vibration of the cylinder, see Reference (1). Torsional vibration of the strut in the present case would have much the same effect. Also the accompanying longitudinal oscillations of the model must produce an analogous effect in three-dimensional flow.

Tare readings obtained by towing a strut alone are usually too low since this method neglects interference effects. The interference effects consist not only of the effect of the model upon the strut resistance, but the effect of the strut upon the model resistance. In both cases the changes in resistance are caused by whatever modifications are produced in the lines of flow.

The strut was towed with the curved plate attached in the expectation that the effect of the model upon the strut resistance could be shown by subtracting the frictional resistance of the plate. Later it was suspected that this plate, having a thickness of 1/16 inch, had an appreciable form resistance. To determine whether this was the case, the rectangular plate shown in Figure 2b was towed. It was expected that the rectangular plate would have the same frictional and form resistance as the curved plate but that the resistances in the two cases would differ by the end effect on the strut resistance. Since the two tests gave almost identical results, it is concluded that the interference effect of the model upon the strut was small. Although no attempt was made to assess the effect of the strut upon the model, it too is thought to have been small because of the fineness of the strut.

REFERENCE

(1) "Flow about a Pair of Adjacent, Parallel Cylinders Normal to a Stream - Theoretical Analysis," by L. Landweber, TMB Report 485, July 1942. See Example 2, Appendix 2.