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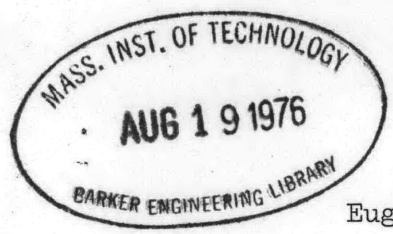
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HYDROMECHANICS

EFFECTS OF LONGITUDINAL BOTTOM SPRAY STRIPS
ON PLANING BOAT RESISTANCE

AERODYNAMICS

by



Eugene P. Clement

STRUCTURAL
MECHANICS

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NOTATION

B	Baseline
C	Centerline
C.G.	Center of gravity
F_{∇}	Froude number based on volume, $v/\sqrt{g\nabla^{1/3}}$
g	Acceleration due to gravity
L	Load waterline length from stem to transom
L_P	Projected chine length
R	Total resistance, lb
S	Wetted surface area (This is the actual wetted surface underway including the area of the sides, which is wetted at low speeds, and the wetted bottom area of external spray strips; however, the area wetted by spray is excluded .)
v	Speed, ft/sec
W	Displacement at rest, weight of
τ	Trim angle of hull with respect to attitude as drawn in degrees
∇	Displacement at rest, volume of

ABSTRACT

Experiments were made to determine the effects on planing boat resistance of several configurations of longitudinal bottom spray strips. It was found that such strips extending aft from the bow about 70 percent of the hull length decreased the resistance somewhat at high speed but increased the resistance at low speed. The performance was noticeably improved by sharpening the edges of the spray strips. An experiment was also made with bottom spray strips extending only forward of the high-speed stagnation line. This arrangement gave a 6-percent reduction in resistance at high speed with no increase in resistance at low speed.

INTRODUCTION

The Bureau of Ships requested¹ the David Taylor Model Basin to conduct tests to determine the effects of longitudinal bottom spray strips on the resistance of a planing boat. It was requested that this be done with an existing large-scale model already fitted with longitudinal spray strips extending aft from the bow about 70 percent of the hull length. This model (TMB Model 4770) had previously been used as the hull for a hydrofoil boat which was designed by BuShips.²

Reference 1 requested that the model be tested both with and without the longitudinal bottom spray strips and, also, that the effect of sharpening the spray strip edges be determined. During this work, however, consideration of the directions of the water flow on the bottom of a planing hull suggested to the author of this report that longitudinal bottom spray strips would be likely to be most beneficial if they were located only forward of

¹ References are listed on page 5.

the high-speed stagnation line. Accordingly, such an arrangement of longitudinal bottom spray strips was also tested. Further analysis of the action of the spray strips by the author has suggested how the full benefits can be obtained by very short lengths of strips. The proper disposition of such minimum-length spray strips is illustrated and explained.

TEST PROCEDURE AND RESULTS

The model used for the tests represented a 68-ft boat to a scale of 1/6. It was already fitted with longitudinal bottom spray strips of the type and length generally employed. Before making the present tests, the chines of this model were altered somewhat, and spray strips were added along the chines. The hull lines of the model, as revised for the present tests, are shown in Figure 1. The arrangement of the longitudinal bottom spray strips is shown in Figure 2. When the first of the present tests was made, the edges of the spray strips were in a slightly rounded condition due to repainting of the hull bottom and also to the lack of special care in keeping the edges sharp. Radius gages were used to check the radii of the spray strip edges. The radii were found to vary between 1/32 in. (0.031) and 3/64 in. (0.047), so that the average edge radius was about 0.04 in.

All of the tests were made at a model weight of 448 lb, corresponding to a full-scale displacement of 99,500 lb. The trim of the model at rest was even keel for each test. The corresponding waterline at rest is shown in Figure 1.

First, a resistance test was made with the edges of the spray strips in the condition described. Next, the edges of the spray strips were sharpened to an average radius of about 0.02 in., and the model was retested. The spray and wave formation at the forward end of the model was observed during these tests in order to ascertain the effects of the longitudinal spray strips on the different kinds of flow occurring there. The directions of water flow on the bottom of a planing hull are shown in Figure 3. As indicated in the figure, the direction of flow of the solid water behind the stagnation line is in an essentially fore-and-aft direction, while the

direction of flow of the water constituting the whisker spray is diagonally across the bottom. Accordingly, it appeared to the author that any beneficial effect from the longitudinal spray strips would probably arise from their action in deflecting a substantial part of the whisker spray away from the hull, thereby reducing the frictional resistance produced by the spray. Aft of the stagnation line, however, the direction of water flow is approximately along the length of the spray strips, and it seems evident that the probable contribution of the spray strips in this region would be to increase the drag by the addition of some wetted area and by the generation of eddies from cross flow over the edges of the strips. Observations of the model during the first two tests seemed to confirm these expectations.

Accordingly, the next step was to remove those portions of the spray strips behind the high-speed stagnation line and then to retest the model. Finally, the longitudinal bottom spray strips were removed entirely and the model was again tested. The resistance data from the four model tests were converted to a full-scale displacement of 99,500 lb, using the Schoenherr coefficients of frictional resistance with zero roughness allowance.

The resulting resistance values are shown in Figure 4 in the form of percentage increases or decreases in resistance from the resistance of the smooth hull. It can be seen that the test results indicate that the effect of the original longitudinal bottom spray strips, with slightly rounded edges (about 1/4-in. radius, full scale), was to increase the resistance as much as 3 percent at low speed and to decrease the resistance about 1 percent at high speed. The effect of the sharpened spray strips (about 1/8-in. radius, full scale) was to increase the low-speed resistance a maximum of 3 percent and to decrease the high-speed resistance as much as 2 1/2 percent. Finally, with the spray strips extending only forward of the high-speed stagnation line, a maximum reduction in high-speed resistance of 6 percent was obtained, with no increase in low-speed resistance.

Additional data from the tests of the model with no bottom spray strips and with spray strips extending forward of the high-speed stagnation line are presented in Figure 5. The fact that the rise and trim values are nearly the same indicates that no significant lift component resulted from the deflection of the thin sheet of whisker spray.

EFFECTS ON THE PERFORMANCE OF A 34-FOOT BOAT

The benefits of longitudinal bottom spray strips which extend only forward of the high-speed stagnation line are obviously applicable to planing boats of a wide range of sizes. The model which was tested can, of course, be considered to represent a boat of any size. Therefore, for purposes of illustration the model data from the four tests considered here were corrected to correspond to a hull 34 ft long. For this case, the model was considered to be of one-third scale. The resulting resistance values are shown in Figure 6 in the form of percentage increases or decreases in resistance from the resistance of the smooth hull. Additional data for a 34-ft boat are shown in Figure 7. This figure shows that in the case of a 34-ft hull traveling at a speed of 30 knots, the resistance can be decreased about 100 lb by an appropriate arrangement of longitudinal bottom spray strips.

FULL BENEFIT WITH STRIPS OF MINIMUM LENGTH

Since each longitudinal bottom spray strip produces a dry area which extends from the spray strip to the chine (the sides of the dry area are parallel to the spray direction), it is evidently possible to achieve the full effectiveness of such strips, for a particular design speed, by means of short lengths disposed as shown in Figure 8. In any practical case there will, of course, be a range of variation of the operating speed and also of the weight of the boat. These factors, and also the motion in rough water, will produce fluctuations in the position of the stagnation and spray-boundary lines. Accordingly, the spray strip length should generally be greater than the minimum length indicated in Figure 8. The important point indicated by that figure, however, is that the full benefit of longitudinal bottom spray strips can be attained with strips which start considerably aft of the bow. Therefore, they need not be fitted in that portion of the bottom where the curvature is greatest, and where the fitting of the strips is particularly difficult and expensive.

It should be pointed out that the test results presented here, and the conclusions drawn, apply to boats having a conventional amount of deadrise. For planing boats having very high deadrise angles (20 deg or more) it is believed that longitudinal bottom spray strips have a different action and effect; therefore, the recommendations presented here are not believed to be applicable for that case.

A second report on longitudinal spray strips is being prepared at the Model Basin. This report will include graphs for determining the high-speed positions of the spray boundary and stagnation lines for planing hulls and will, accordingly, be of assistance to the designer in utilizing longitudinal bottom spray strips to the best advantage.

REFERENCES

1. Bureau of Ships ltr S-F014-0202 Ser 449-97 of 2 Oct 1962 to David Taylor Model Basin.
2. Blount, D. L., "Resistance Characteristics of a 70-Foot Hydrofoil Missile Range Patrol Boat," David Taylor Model Basin Report 1607 (Apr 1962).

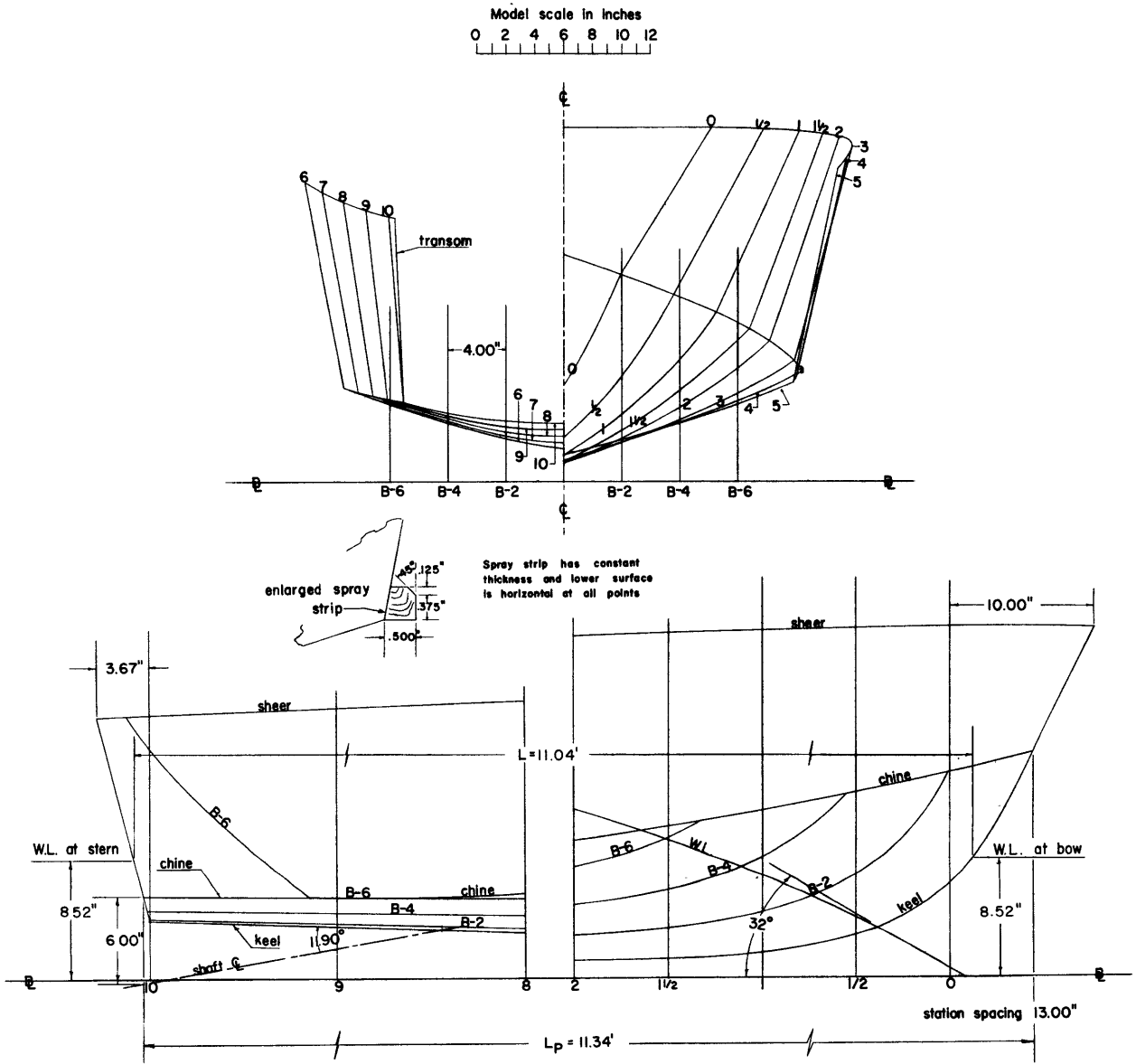


Figure 1—Hull Lines of the Model used for Tests of Longitudinal Bottom Spray Strips

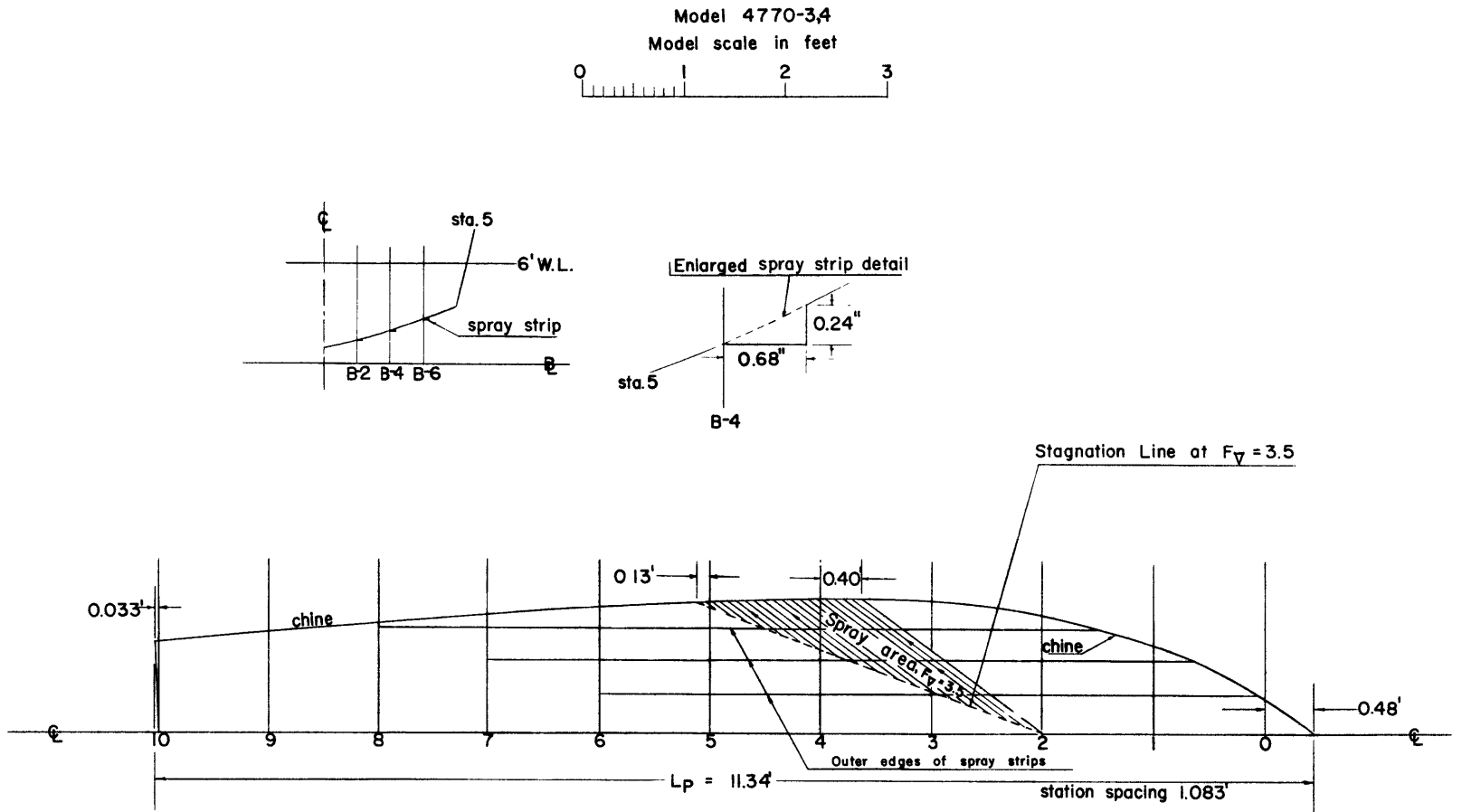


Figure 2—Arrangement of the Longitudinal Bottom Spray Strips.

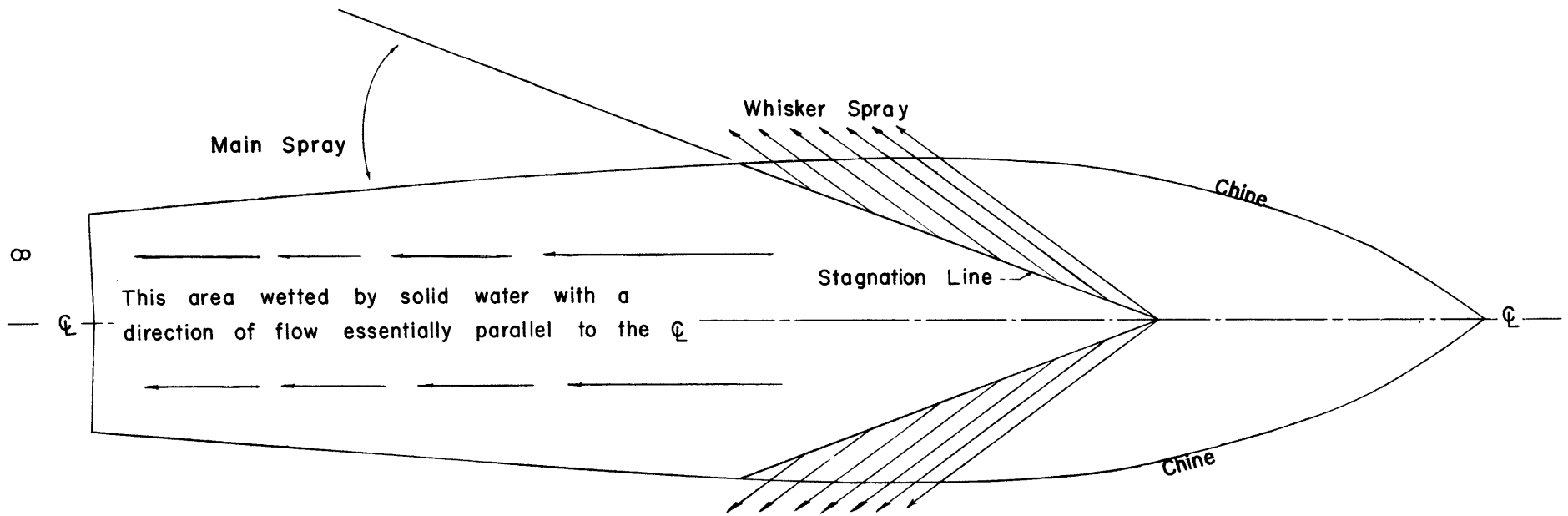


Figure 3—Directions of Water Flow on the Bottom of a Planing Hull

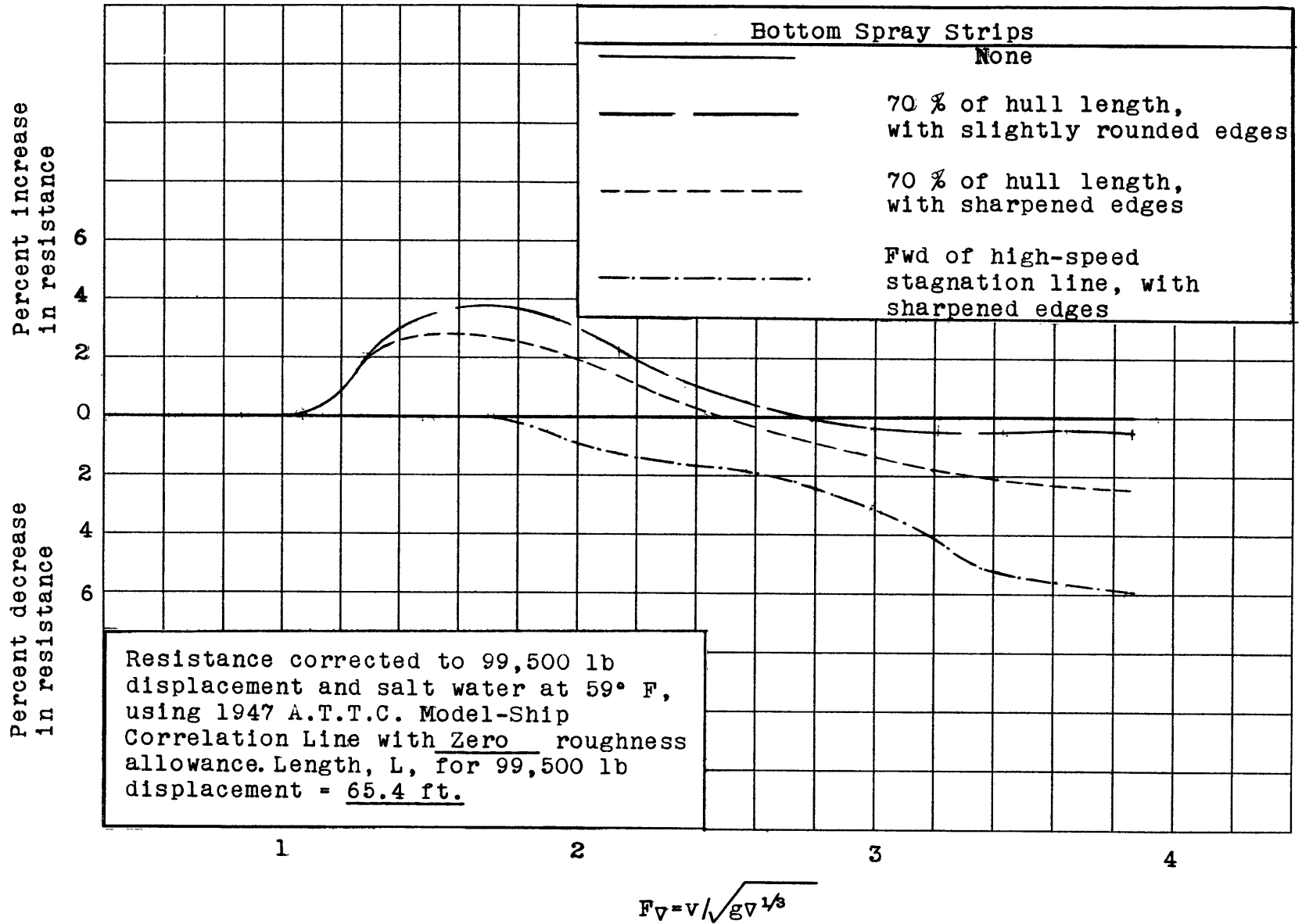


Figure 4 - Effects on Resistance of the Three Different Spray Strip Configurations Tested

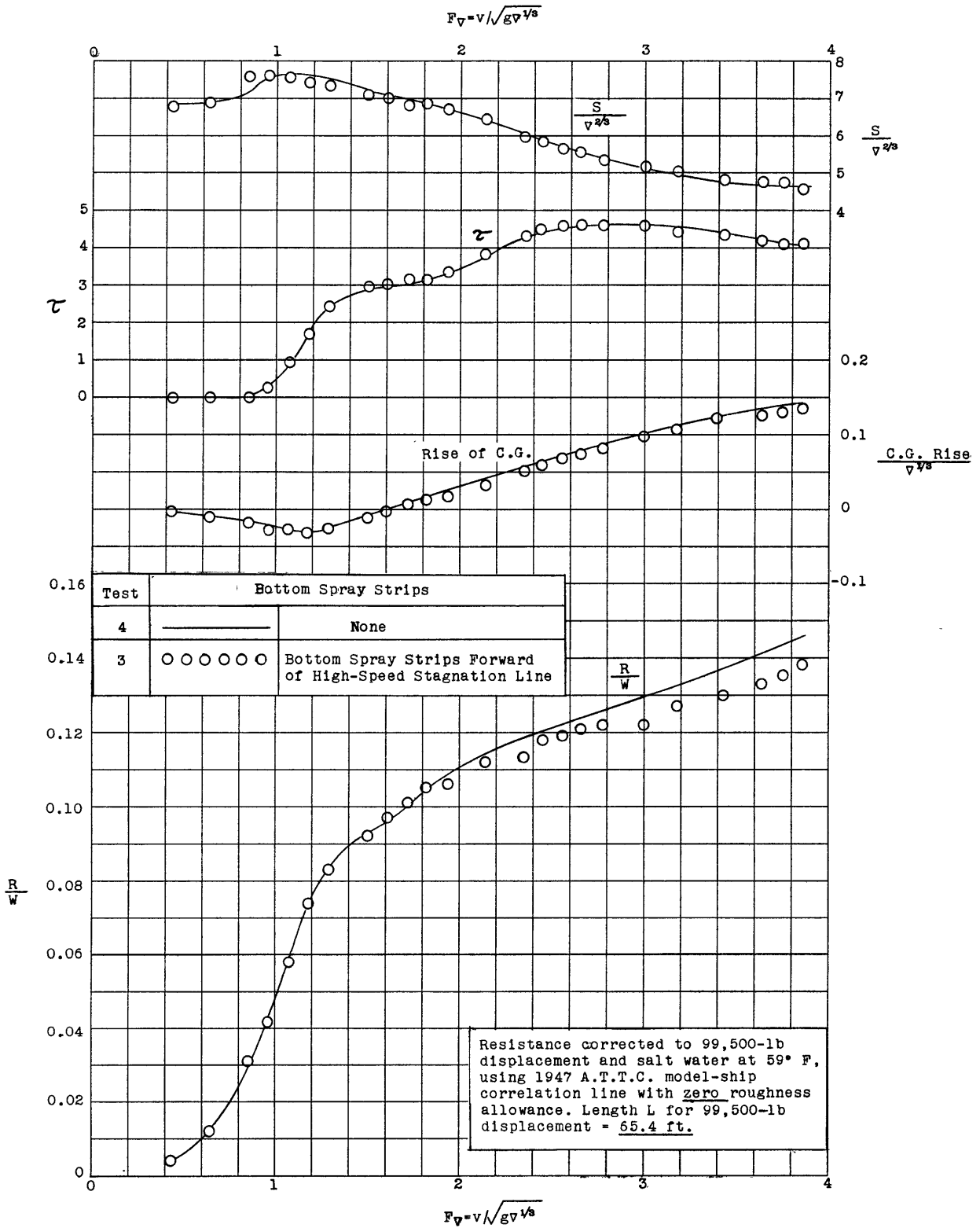


Figure 5 - Comparison of Performance with No Bottom Spray Strips and with Bottom Spray Strips Extending Only Forward of the High-Speed Stagnation Line

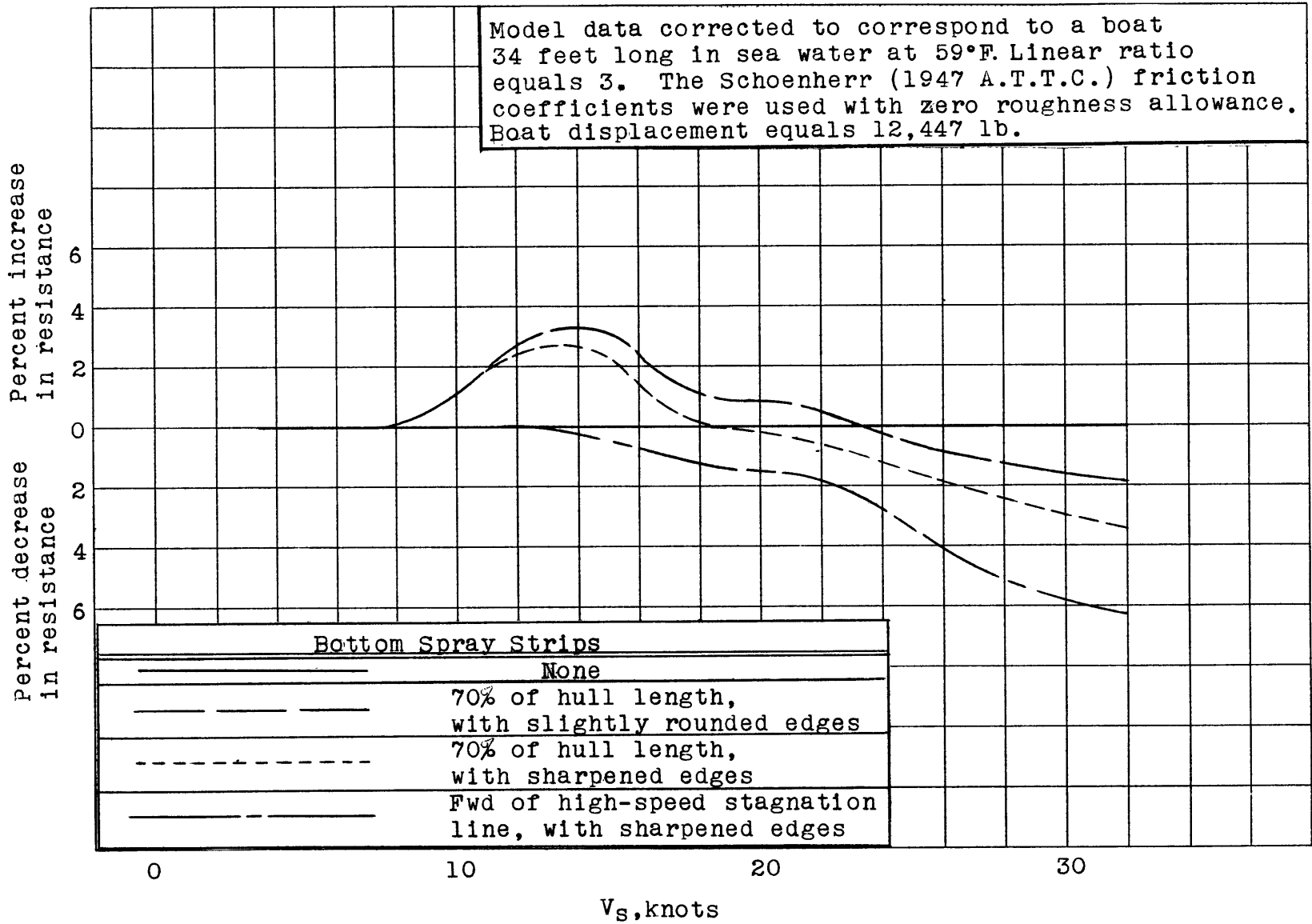


Figure 6 - Effects on the Resistance of a 34-Foot Boat of the Three Different Spray Strip Configurations Tested

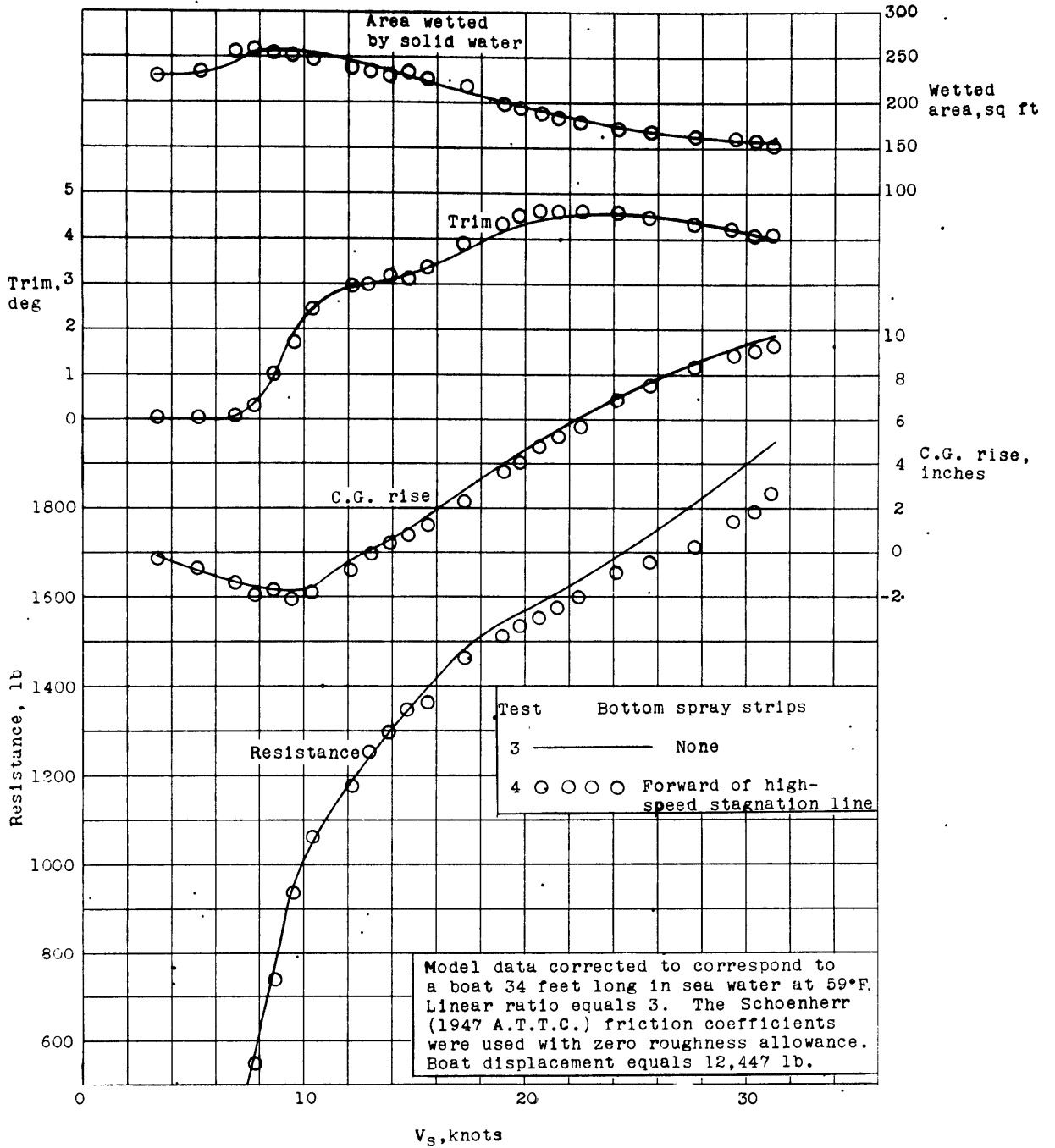


Figure 7 - Effects on the Performance of a 34-Foot Boat of Bottom Spray Strips Located Forward of the High-Speed Stagnation Line

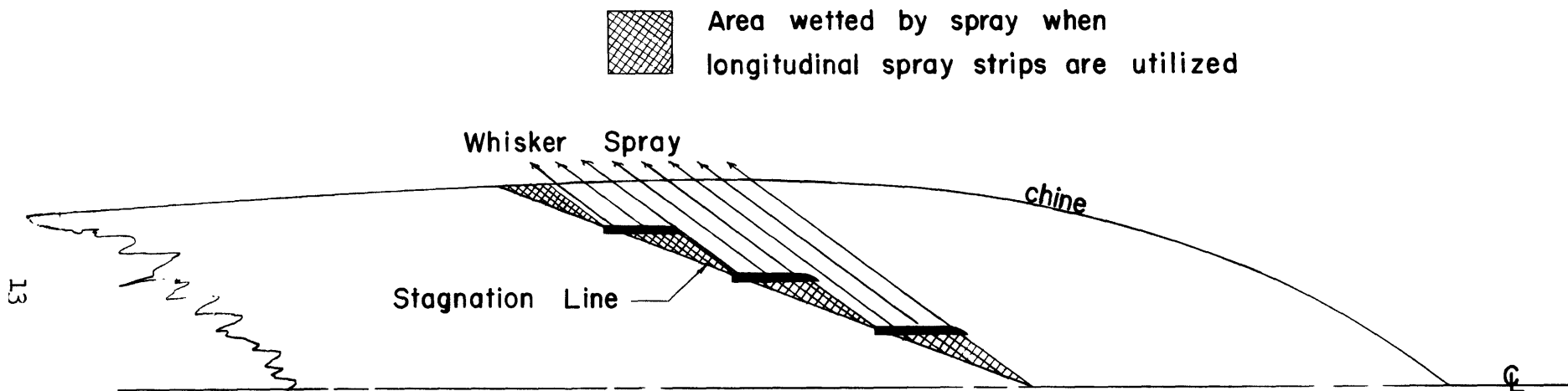


Figure 8 — Full Effect of Bottom Spray Strips Achieved With Short Lengths Disposed as Shown

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Experiments were made to determine the effects on planing boat resistance of several configurations of longitudinal bottom spray strips. It was found that such strips extending aft from the bow about 70 percent of the hull length decreased the resistance somewhat at high speed but increased the resistance at low speed. The performance was noticeably improved by sharpening the edges of the spray strips. An experiment was also made with bottom spray strips extending only forward of the high-speed stagnation line. This arrangement gave a 6-percent reduction in resistance at high speed with no increase in resistance at low speed.

1. Spray strips
 2. Planing boats--Resistance--Spray
 3. Ship models--Model TMB 4770
- I. Clement, Eugene P.
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