UNITED STATES

EXPERIMENTAL MODEL BASIN

NAVY YARD, WASHINGTON, D.C.

TEST OF MODEL OF
U. S. S. SALINAS
INVERTED IN WATER
TO DETERMINE FORCES DUE TO WIND.

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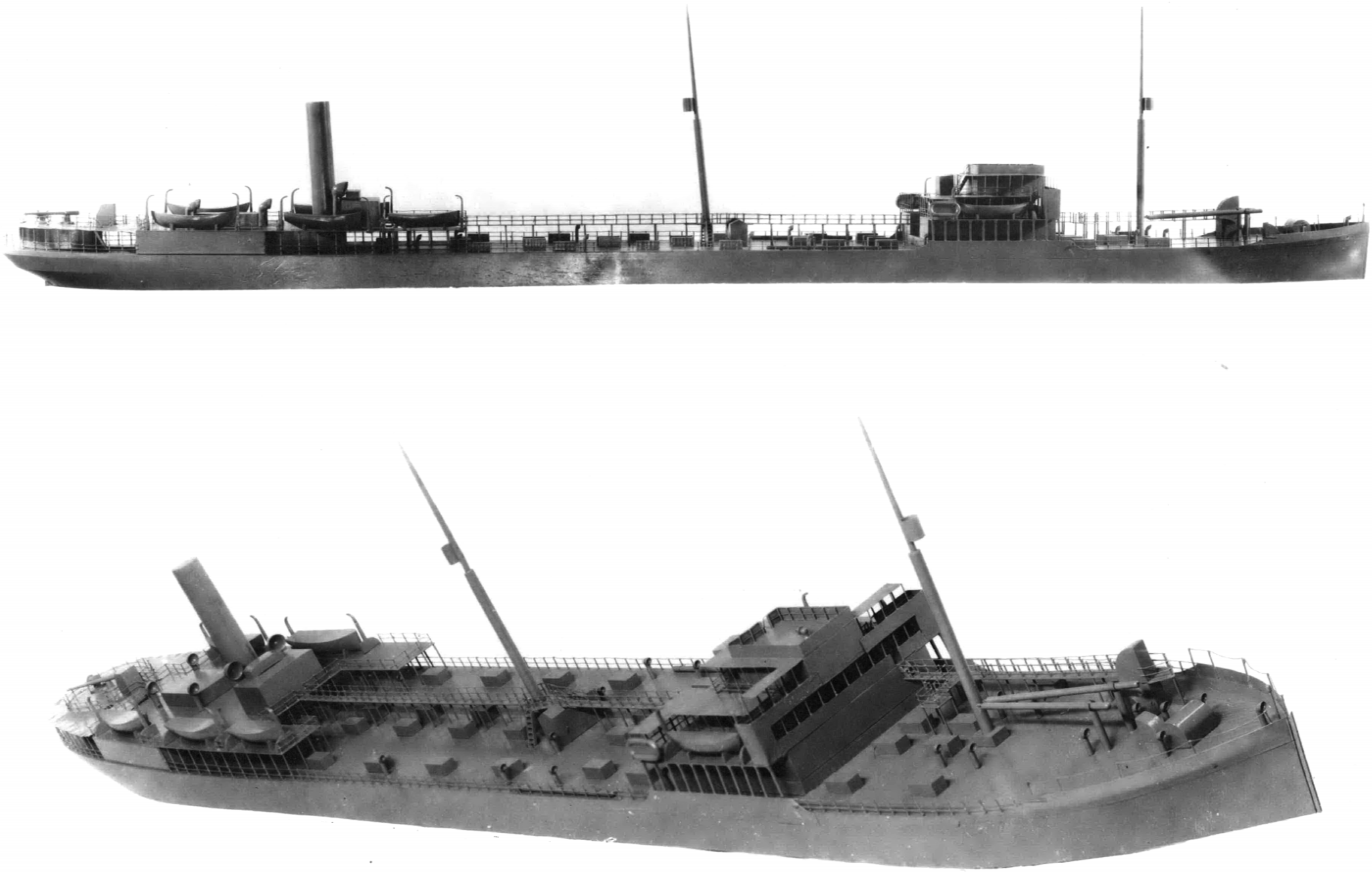


FIG. 1

TEST of MODEL of U.S.S. SALINAS
Inverted in Water to Determine Forces Due to Wind

Abstract

A model of the above water portion of the U.S.S. SALINAS was made for this test. The model was towed inverted in water with its center line at various angles with the direction of motion and with the flat surface representing the load water line plane just above the surface of the water.

The model was fastened to the underside of a suspended platform that was free to move horizontally. The amount and direction of the forces acting upon the model were measured by the forces required to hold it in its initial position.

The model was run at speeds up to two knots, with its center line at angles with the direction of motion varying by 5° intervals from 0° to 90°.

After the vector representing the force of the water was determined for each condition, the ahead resistance was obtained by resolving the vector along the center line of the model. The position of the center of pressure was fixed by the intersection of the vector with the center line of the model.

Introduction

This report describes the fourth test of a model inverted in water to determine the forces due to wind. The third test showed that a model 8 ft. long could be successfully handled with the gear, so for the SALINAS a linear ratio between ship and model of 60 was adopted, making the model 92.7 in. long on the load water line. This LWL corresponded to a draft for the ship of 25 ft. 10 in. forward and 26 ft. 10 in. aft, the same as the draft of the vessel during the 1932 trials.

Methods and Apparatus

In Fig. 1 are shown two views of the model of the SALINAS. These indicate the amount of detail observed in duplicating the deck erections and appendages.

The model was fastened, inverted, beneath a platform to a vertical shaft which allowed the model to be adjusted and secured with its center line at any desired angle with the direction of motion. This platform was hung from the towing carriage by four small wire ropes, so that it was free to move in any direction parallel to the water surface. The height was adjusted to bring the flat surface, representing the load water plane of the ship, just above the water. The platform was connected to the carriage dynamometer so as to measure forces in the direction of motion. The forces normal to the direction of motion were measured on two balances, five feet apart, which were connected to the platform by cords. The position of the platform when at rest was indicated by pointers. The platform was returned to its initial position when under way by applying the necessary forces through the balances.

The model was run at speeds from 0.5 knot to 2.0 knots, and with its center line at angles with the direction of motion varying by 5° intervals from 0° to 90°.

The observed forces were plotted on speed and cross-faired on angles; the faired values were then used to find the resulting vector by graphic solution. Fig. 2 shows a typical diagram. The ahead resistance was thus determined for each angle and for speeds of 0.8, 1.0 and 1.2 knots.

The position of the center of pressure on the model was considered to be the intersection of the resultant vector with the center line of the model, as shown on Fig. 2. The centers of pressure were found for three speeds and averaged as shown on Fig. 3, from which the non-dimensional curve shown on Fig. 4 was computed.

Fig. 5 gives the curves of ahead resistance cross-faired, assuming that the resistance varies as V^2, and Fig. 6 gives the same results in non-dimensional form. In the latter figure the resistance to ahead motion with the wind dead ahead is considered unity; the resistance to <u>ahead</u> motion with the apparent wind at various angles on the bow bears a certain relation to the resistance with the wind dead ahead, as indicated by the ordinate of the curve at the given angle of apparent wind.

The curve on Fig. 7 represents the wind resistance of the ship when headed directly into the wind. It was derived from the resistance of the model in water by use of the formulas:—

$$R_s = \frac{\rho_a}{\rho_w} \lambda^3 R_m \qquad \text{and} \qquad V_s = V_m \sqrt{\lambda}$$

where R is Resistance, lb.
λ is Linear ratio of ship to model.
ρ is Density, lb, ft^3
V is Speed, knots.

Subscripts
w for water
a for air
s for ship
m for model

The effect of the viscosity was considered small enough to be disregarded.

The resistance from the model test varied as V^2 up to about 10 knots ship speed. Above that speed the resistance of the model varied as a power higher than the square, but as this was judged to be due to wave making in the water which would be absent in the air, the V^2 relation was used throughout.

The specific resistance for the ship = R/AV^2

where R is Resistance, lb.
V is Speed, knots
A is Silhouette area, sq. ft.

If the total area of the silhouette, 2214 ft^2, is used, the specific resistance is 0.0036.

If the area above deck only, 1506 ft^2, is used, the specific resistance is 0.0053.

If the area $\frac{B^2}{2} = 1800$ ft^2 is used, where B is the beam of the ship in feet, the specific resistance is 0.0045.

Discussion of Results

As may be seen in Fig. 1, the SALINAS has two deck erections so widely separated that the forward structure masks the after one very little. The forward or bridge structure is much wider than it is long, so as the ship swings off the wind the area exposed is not greatly augmented. The freeboard is also very low, when compared with models previously tested, and any effect of a high bow is thus eliminated.

These considerations seem to account for the fact that the curve of resistance to ahead motion, Fig. 6, scarcely rises above its value at 0°, having a maximum of less than 1.05 at 25° and crossing unity again at 35°. The curve is thus even lower than that obtained for the CLAIRTON (3).

The center of pressure, as shown in Fig. 4, moves through a greater range than any previously reported. It is 25¾ ft. aft of midships at 90° while at 5° it is only 40 ft. from the forward perpendicular. Its position at 10°, 16.5 per cent of the ship's length from the forward perpendicular, compares with 23.6 per cent reported for the CLAIRTON, 21 per cent for the HAMILTON (2), and 30.5 per cent for the light cruiser (1).

Areas used in formula	SPECIFIC RESISTANCE			
	SALINAS	CLAIRTON	HAMILTON	LIGHT CRUISER
Total silhouette	0.0036	0.0028	0.0018	0.0026
Silhouette above deck	0.0053	0.0038	0.0030	0.0038
$B^2/2$	0.0045	0.0047	0.0034	0.0044

From the above table it is seen that, for the four models tested, the specific resistances obtained by use of the area $B^2/2$ are the most nearly constant. The values derived by using silhouette areas are dependent on the shape and spacing of the deck erections; thus from the HAMILTON through the CLAIRTON to the SALINAS the relative freeboard at the bow becomes progressively smaller and the distance between deck erections greater. With lower freeboard a greater proportion of the silhouette area is composed of the flat forward sides of the deck erections, and with wider spacing these are more fully exposed to the wind, hence the increase in specific resistance.

Conclusion

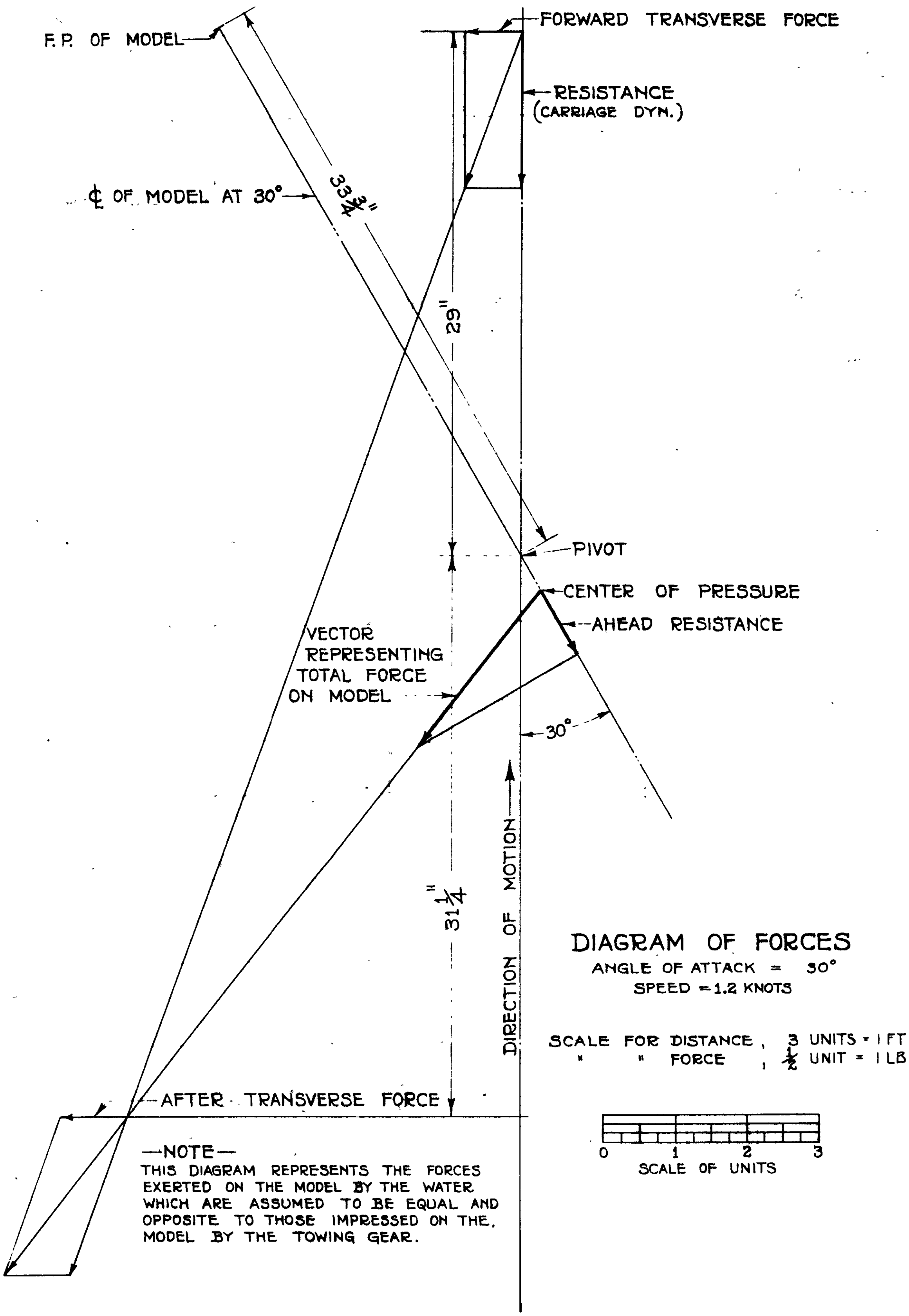
This test, like that of the CLAIRTON, shows the effect of short, widely spaced deck houses on the curve of ahead resistance. The value of the maximum resistance to ahead motion above its value with the wind dead ahead is very much reduced. In this case the value is only about 5 per cent greater, and the angle of apparent wind at which the maximum occurs is reduced to 25°. In the previous tests this angle averaged 32.5°.

<u>References</u>

(1) Test of drawing room model of 10,000 ton light cruisers (24 – 25) in water to determine forces due to wind. U.S. Experimental Model Basin Report No. 276, dated December, 1930.

(2) Test of drawing room model of U.S. Destroyer HAMILTON in water to determine forces due to wind. U.S. Experimental Model Basin Report No. 312, dated October, 1931.

(3) Test of model of S.S. CLAIRTON to determine forces due to wind. U.S. Experimental Model Basin Report No. 334, dated August, 1932.



F.P. OF MODEL
FORWARD TRANSVERSE FORCE
RESISTANCE (CARRIAGE DYN.)
℄ OF MODEL AT 30°
33¾"
29"
PIVOT
CENTER OF PRESSURE
AHEAD RESISTANCE
VECTOR REPRESENTING TOTAL FORCE ON MODEL
30°
DIRECTION OF MOTION
31¼"
AFTER TRANSVERSE FORCE
—NOTE—
THIS DIAGRAM REPRESENTS THE FORCES EXERTED ON THE MODEL BY THE WATER WHICH ARE ASSUMED TO BE EQUAL AND OPPOSITE TO THOSE IMPRESSED ON THE MODEL BY THE TOWING GEAR.
DIAGRAM OF FORCES
ANGLE OF ATTACK = 30°
SPEED = 1.2 KNOTS
SCALE FOR DISTANCE, 3 UNITS = 1 FT
" " FORCE, ½ UNIT = 1 LB
0
1
2
3
SCALE OF UNITS

FIG 2

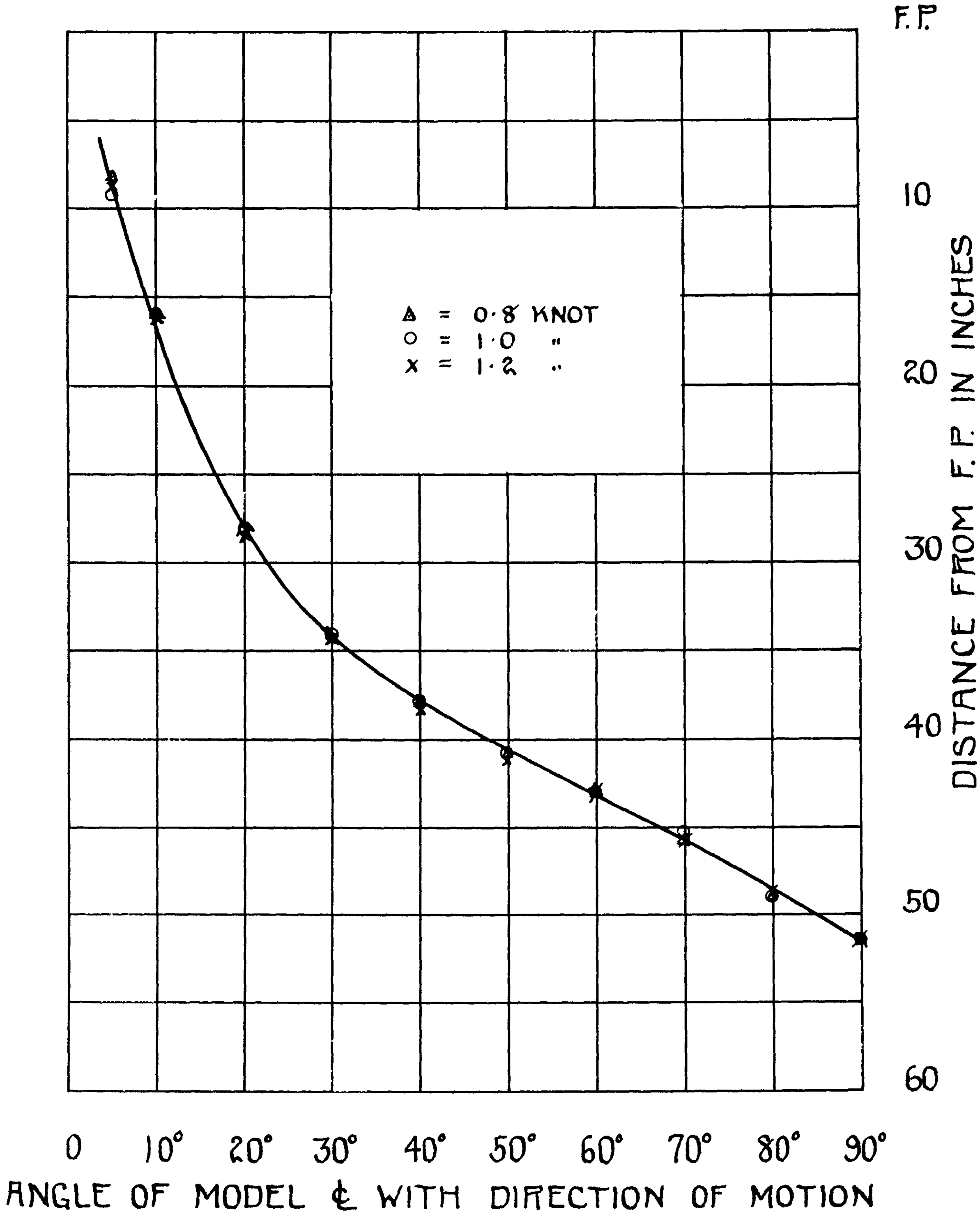


FIG. 3. LOCUS OF POINT OF APPLICATION
Of Total Resultant Force on Model
For model of S.S. SALINAS

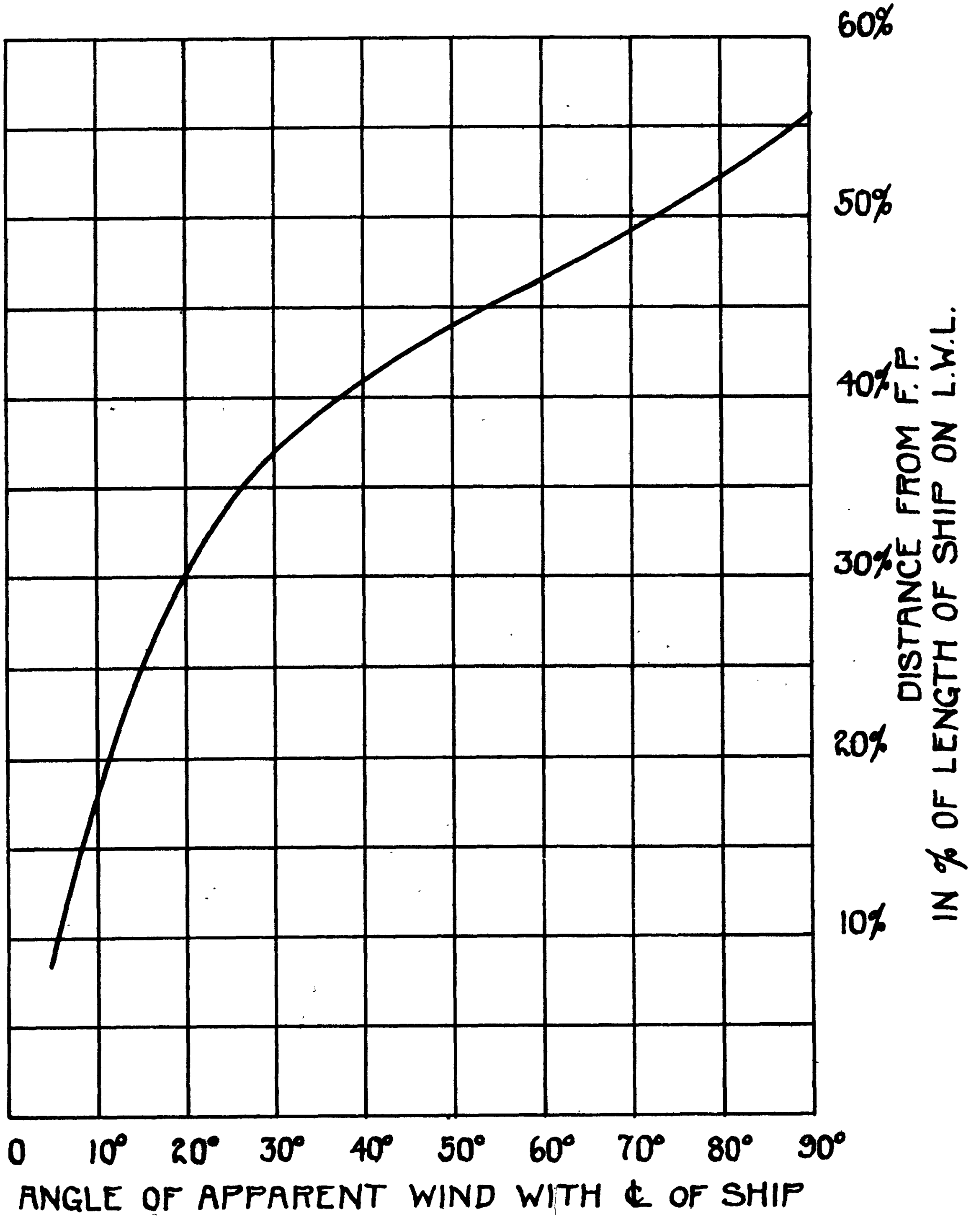


FIG. 4. LOCUS OF CENTER OF PRESSURE
Due to wind S. S. SALINAS

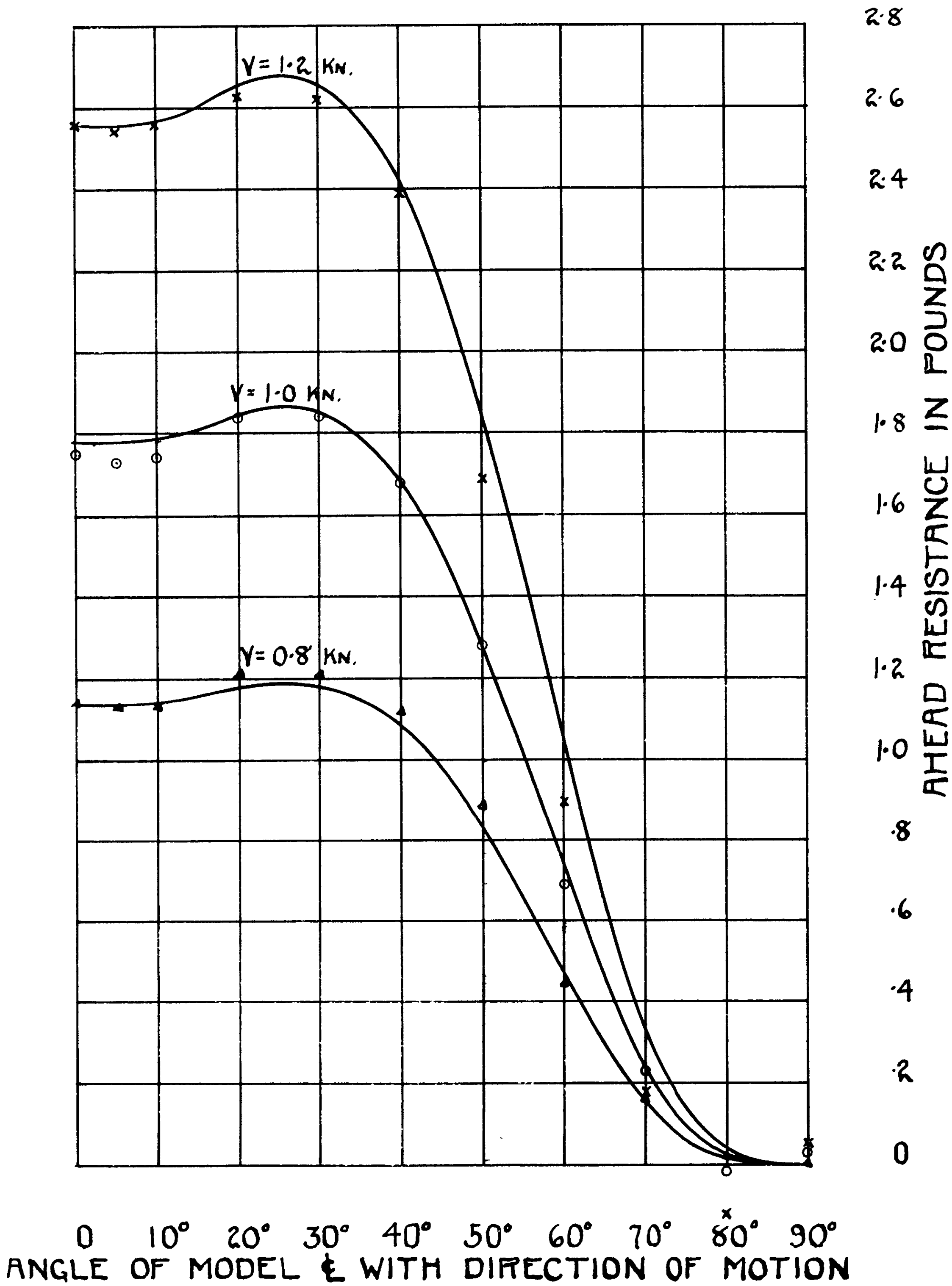


FIG. 5. CURVES OF AHEAD RESISTANCE
cross faired, making res. $\backsim V^2$
for model of S. S. SALINAS

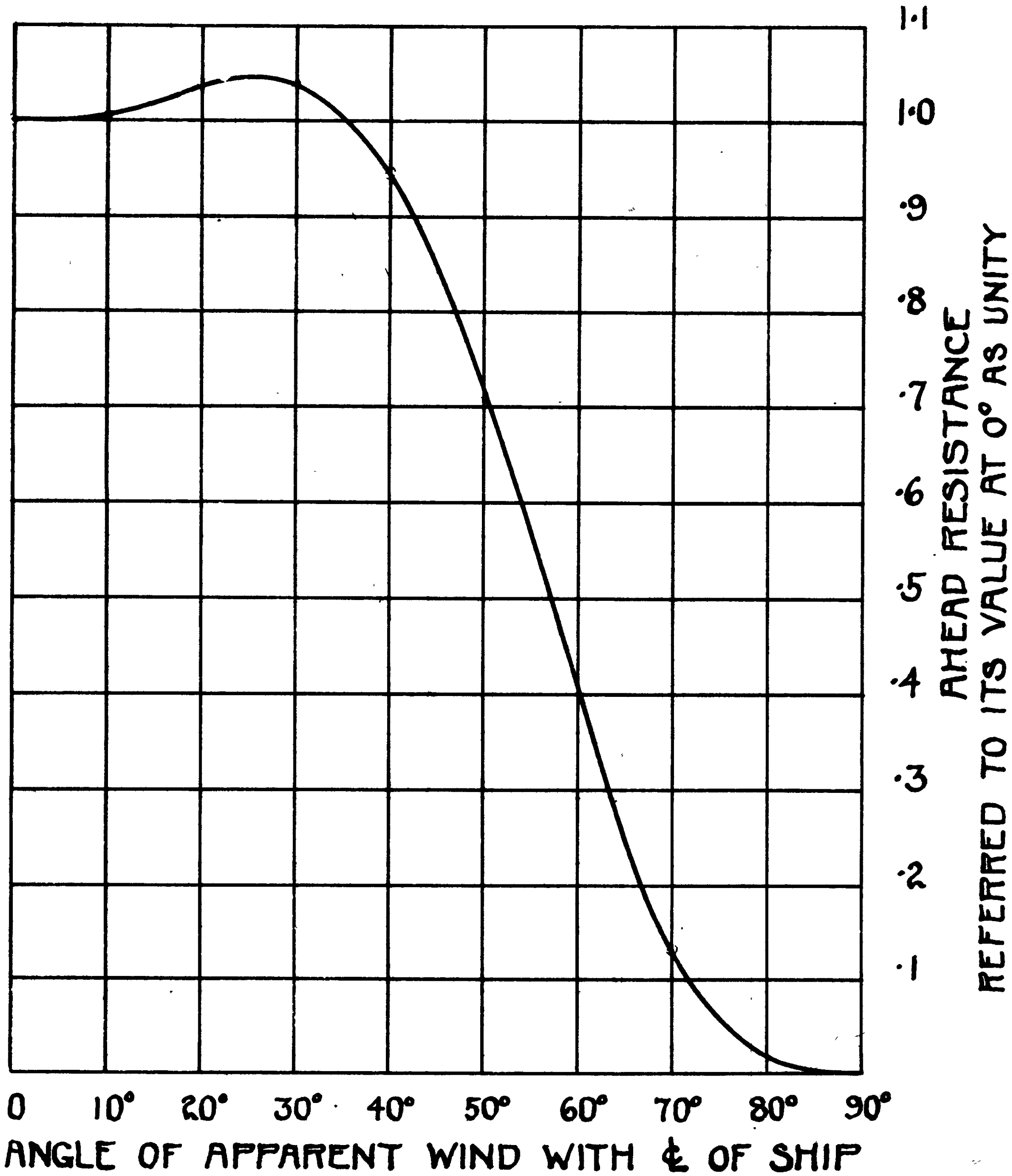


FIG. 6. CURVE OF AHEAD RESISTANCE
Due to wind S. S. SALINAS

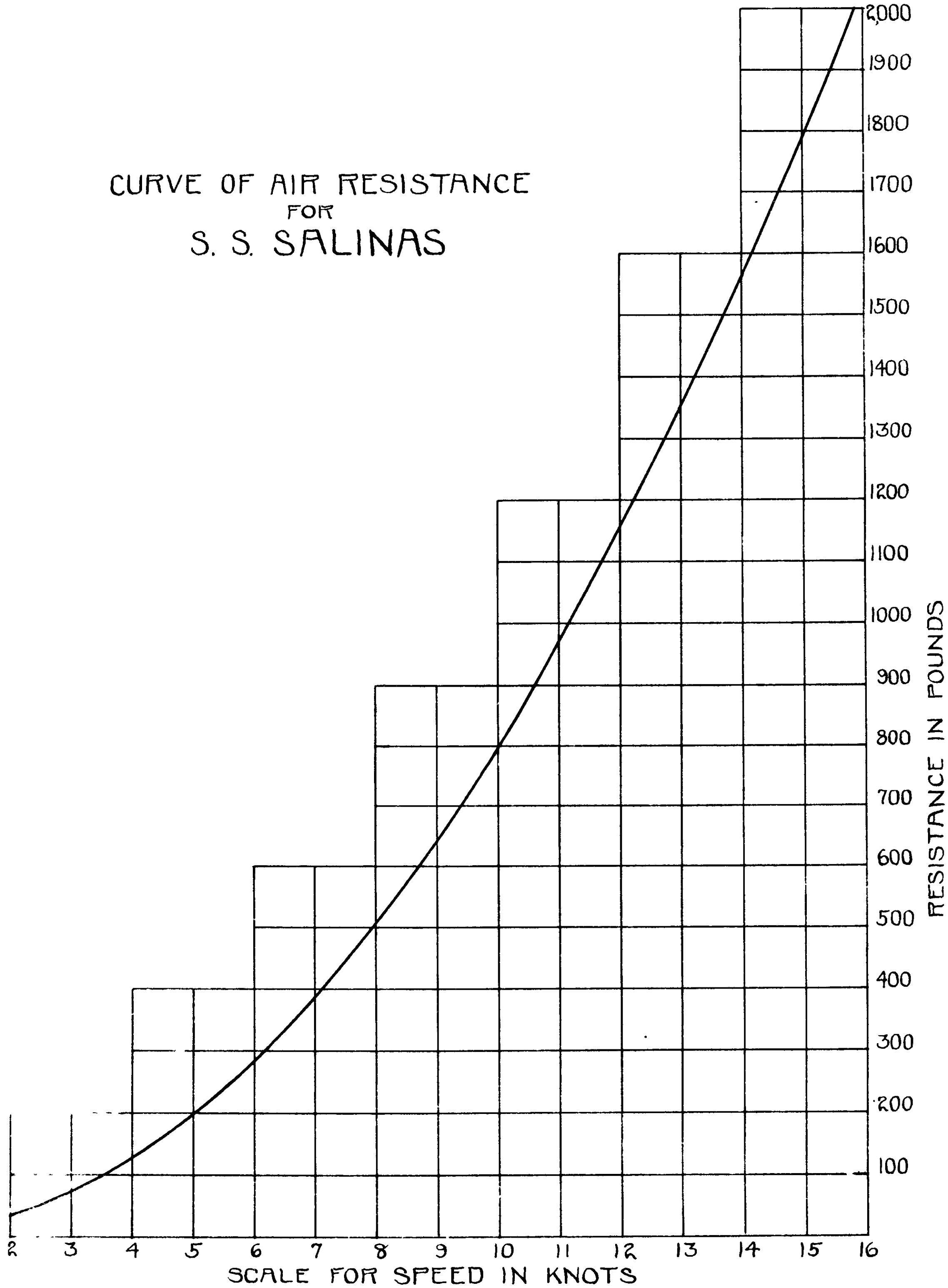

CURVE OF AIR RESISTANCE
FOR
S. S. SALINAS
2,000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
RESISTANCE IN POUNDS
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
SCALE FOR SPEED IN KNOTS

FIG. 7