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EXPERIMENTAL MODEL BASIN

NAVY YARD, WASHINGTON, D.C.

TEST OF MODEL OF S. S. SANTA ROSA
TO DETERMINE FORCES
DUE TO WIND

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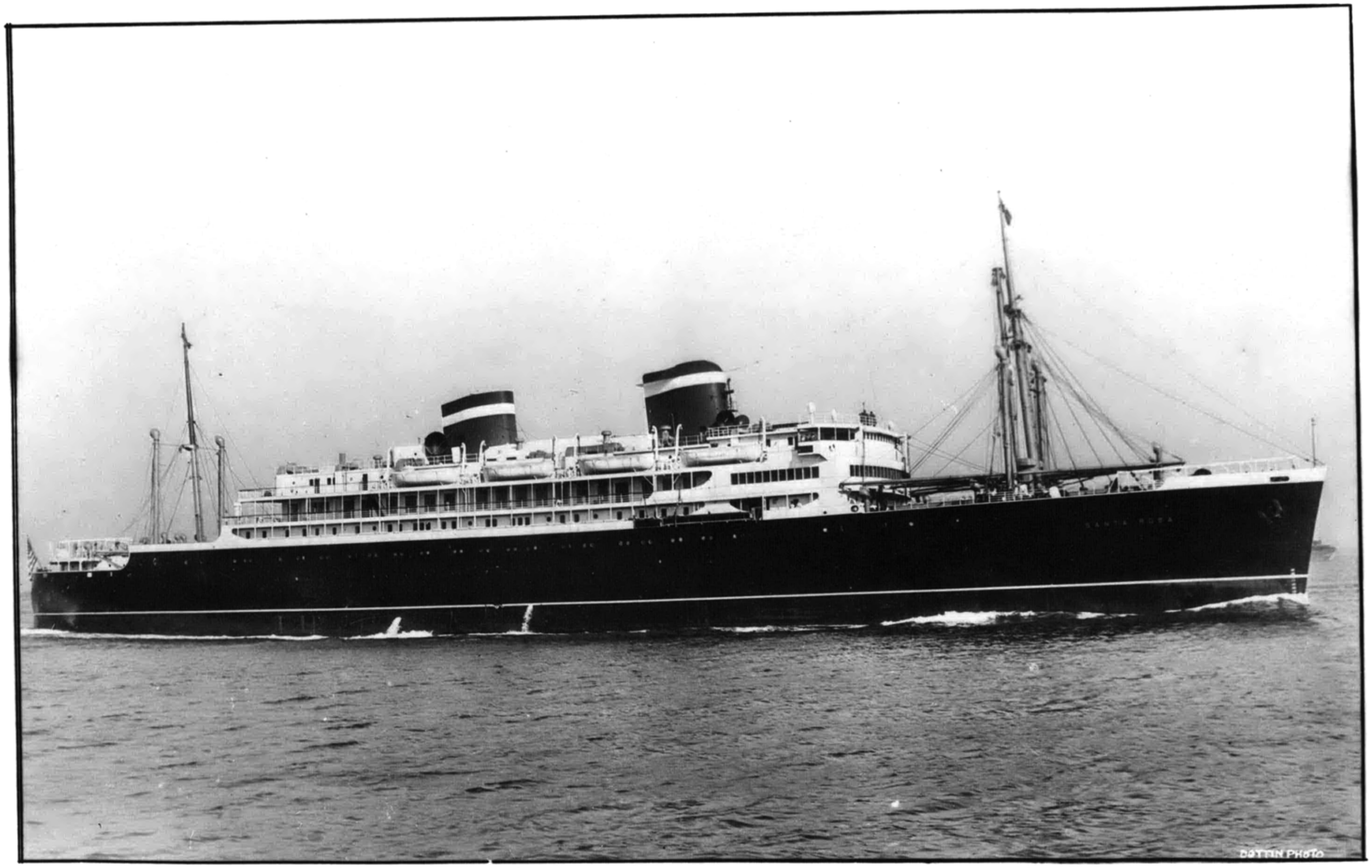

S.S. SANTA ROSA.

TEST OF MODEL OF S.S. SANTA ROSA
TO DETERMINE FORCES DUE TO WIND

Abstract

A model of the above water portion of the S.S. SANTA ROSA 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 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 fifth test of a model inverted to determine the forces due to wind. For this model, No. 3220, a linear ratio between ship and model of 62.5 was used, making the length of the model 96 inches on the load water line. This LWL corresponded to the designed draft of the ship, 25 ft. 3 in. even keel.

Methods and Apparatus

In Fig. 1 are shown three views of the model of the SANTA ROSA. In these may be seen the detailed reproduction of the upper works and appendages which were carried out in the construction of the model. In this connection it should be noted that the athwartships row of windows under the bridge were closed with a strip of celluloid to correspond with their condition during the ship's trial.

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 on the model, which represented 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 connection was a line of shafting containing two universal joints. 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, and the platform was returned to this position when under way by applying the necessary forces through the balances.

The model was run at speeds from 0.7 knot to 1.9 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 unfaired values were then used to find the resulting vector by graphic solution. Fig. 2 is a diagram from another experiment which shows the method used. The ahead resistance was thus determined for each angle and for speeds of 0.7 knot and 1.0 knot.

The position of the center of pressure on the model was considered to be the intersectior of the resultant vector with the center line of the model as shown on Fig. 2. The centers of pressure were found for two 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. 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 ahead motion with the 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:—

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

where R is resistance, lb.
λ is linear ratio of ship to model
ρ is density
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 specific resistance for the ship is 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, 4,640 ft.², is used, the specific resistance s 0.0020.

If the area of the silhouette above the deck, 2800 ft.², is used the specific resistance is 0.0033.

If the area $B^2/2$ = 2590 ft.² is used, the specific resistance is 0.0036.

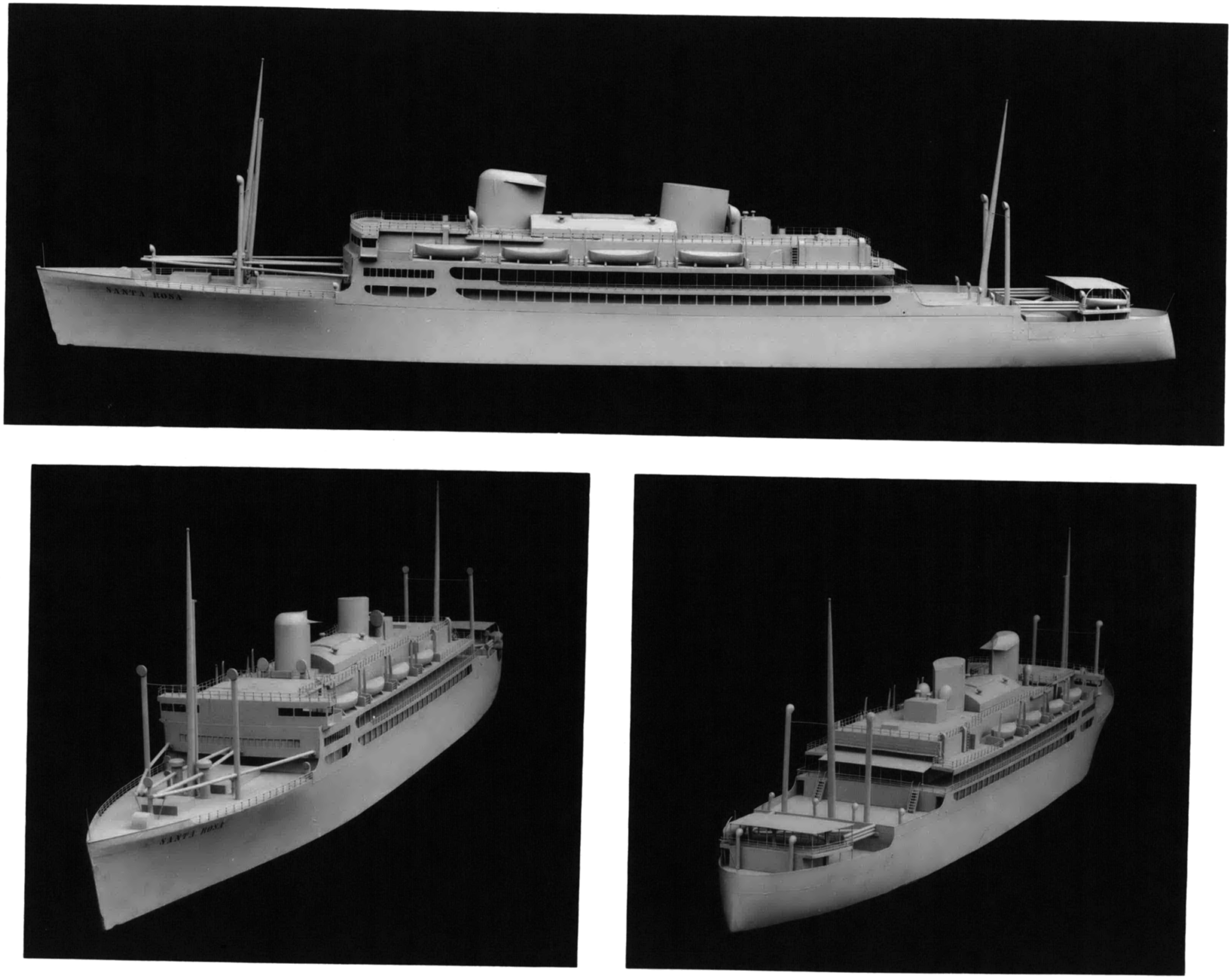

FIG. 1 SANTA ROSA MODEL

Discussion of Results

As may be seen in Fig. 1 the superstructure of the SANTA ROSA is practically one continuous structure, and thus there is no second deck house to be exposed as the ship turns away from the wind. This would lead one to expect no great increase in ahead resistance as the angle of the apparent wind increased.

The center of pressure as shown in Fig. 4 moves through a somewhat smaller range than those previously reported. Its position at 10°, 23% of the ship's length from the forward perpendicular, compares with 16.5 per cent reported for the SALINAS (4), 23.6 per cent for the CLAIRTON (3), 21 per cent for the HAMILTON (2), and 30.5 per cent for the light cruiser (1).

AREAS USED	SPECIFIC RESISTANCE					
IN FORMULA	LIGHT CRUISER	HAMILTON	CLAIRTON	SALINAS	SANTA ROSA	
Total Silhouette	0.0026	0.0018	0.0028	0.0036	0.0020	
Silhouette above deck	0.0038	0.0030	0.0038	0.0053	0.0033	
$\frac{Beam^2}{2}$	0.0044	0.0034	0.0047	0.0045	0.0036	0.0041 Average

The above table shows the specific resistances obtained for the models so far tested. The values for the SANTA ROSA are very similar to those for the HAMILTON.

Conclusion

The model of the SANTA ROSA is the first one tested for wind resistance that had a long continuous deck structure. It seems reasonable to suppose that this type of superstructure may produce its own particular type of resistance curve, and thus explain the difference in the character of the curve from those previously reported.

References

(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.

(4) Test of model of U.S.S. SALINAS to determine forces due to wind. U.S. Experimental Model Basin Report No. 345 dated January, 1933.

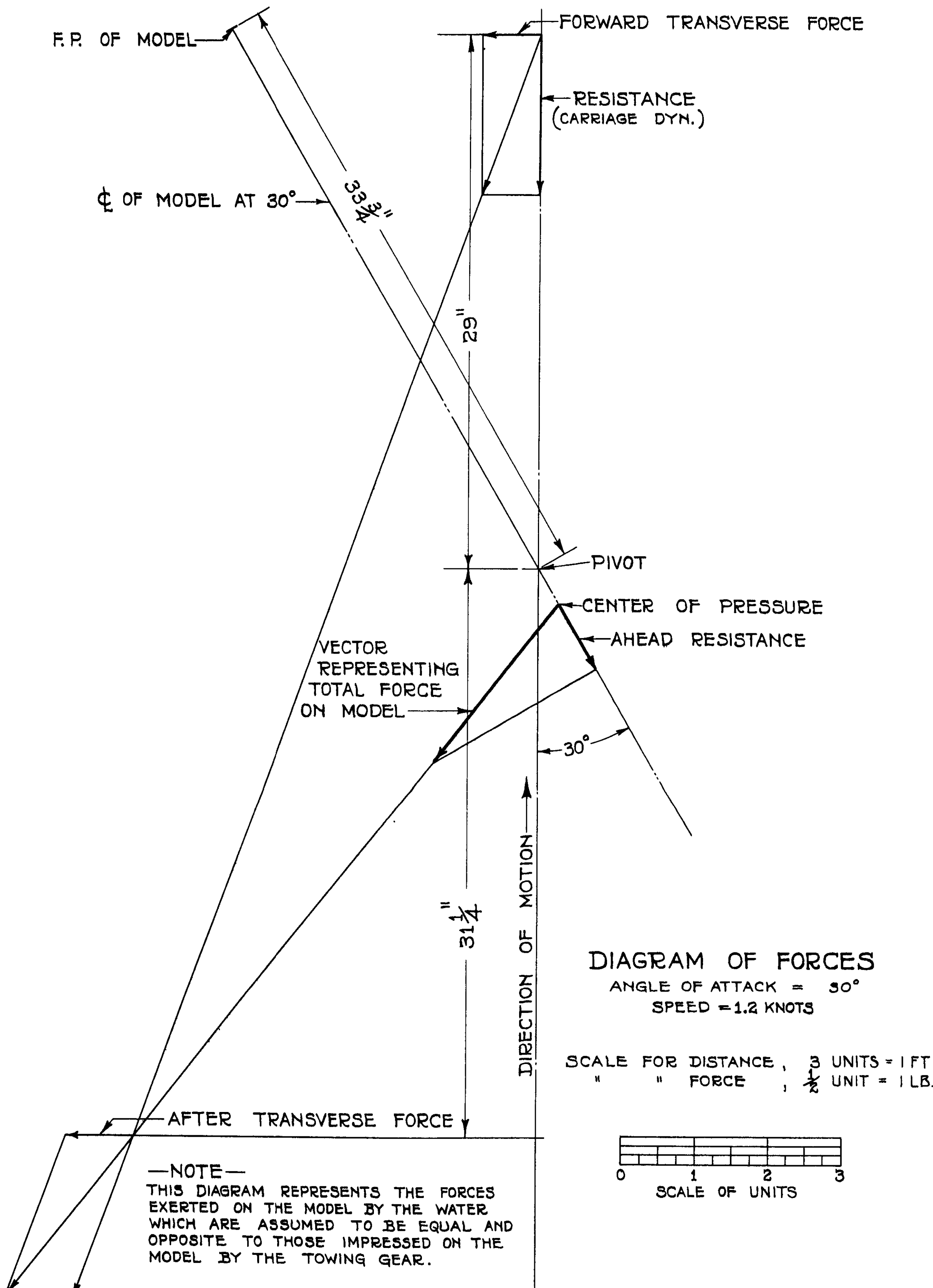
F.P. OF MODEL
FORWARD TRANSVERSE FORCE
RESISTANCE (CARRIAGE DYN.)
℄ OF MODEL AT 30°
33 3/4"
29"
PIVOT
CENTER OF PRESSURE
AHEAD RESISTANCE
VECTOR REPRESENTING TOTAL FORCE ON MODEL
30°
DIRECTION OF MOTION
31 1/4"
AFTER TRANSVERSE FORCE
DIAGRAM OF FORCES
ANGLE OF ATTACK = 30°
SPEED = 1.2 KNOTS
SCALE FOR DISTANCE, 3 UNITS = 1 FT
" " FORCE, 1/2 UNIT = 1 LB.
0
1
2
3
SCALE OF UNITS
—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.

FIG 2

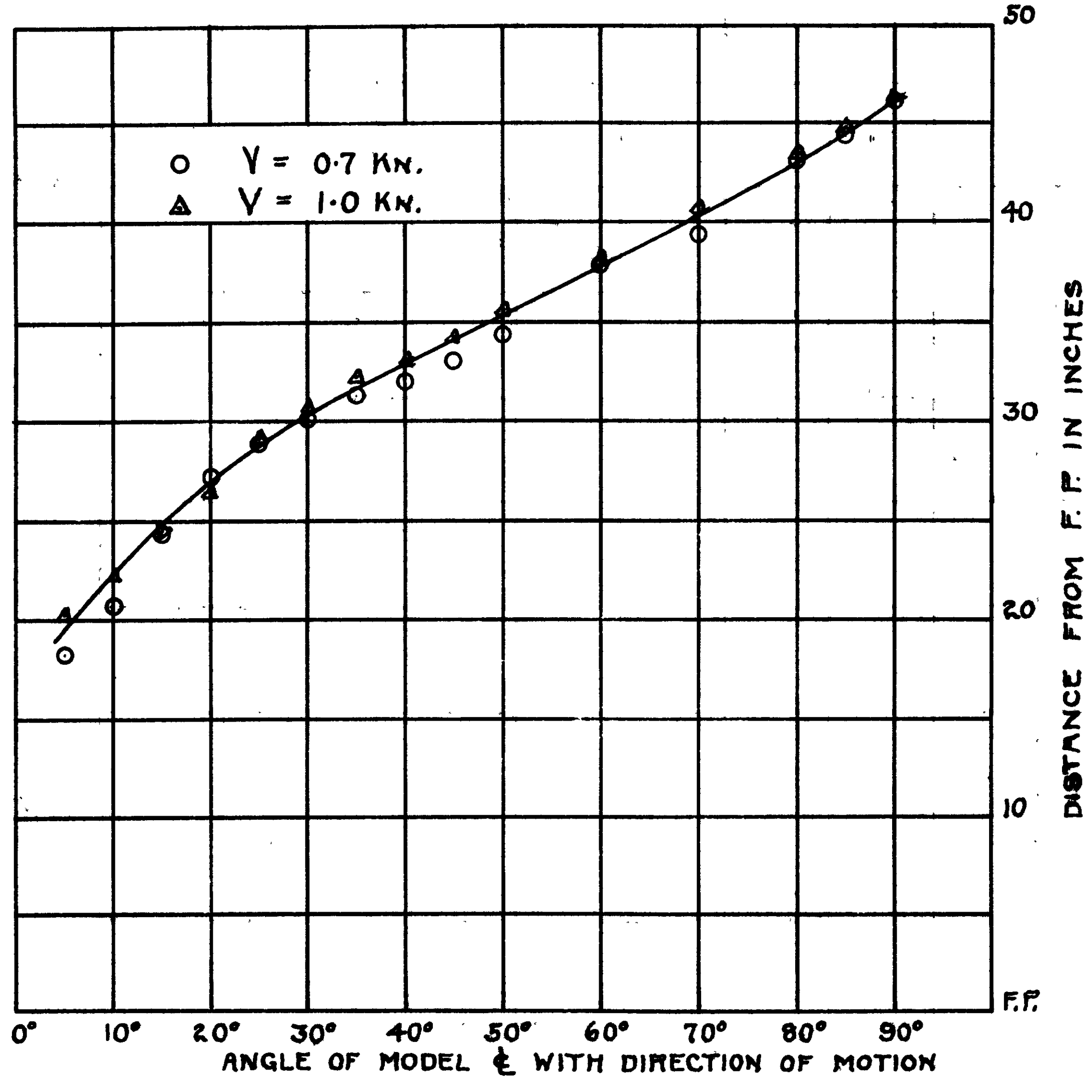

FIG. 3

LOCUS OF CENTER OF PRESSURE

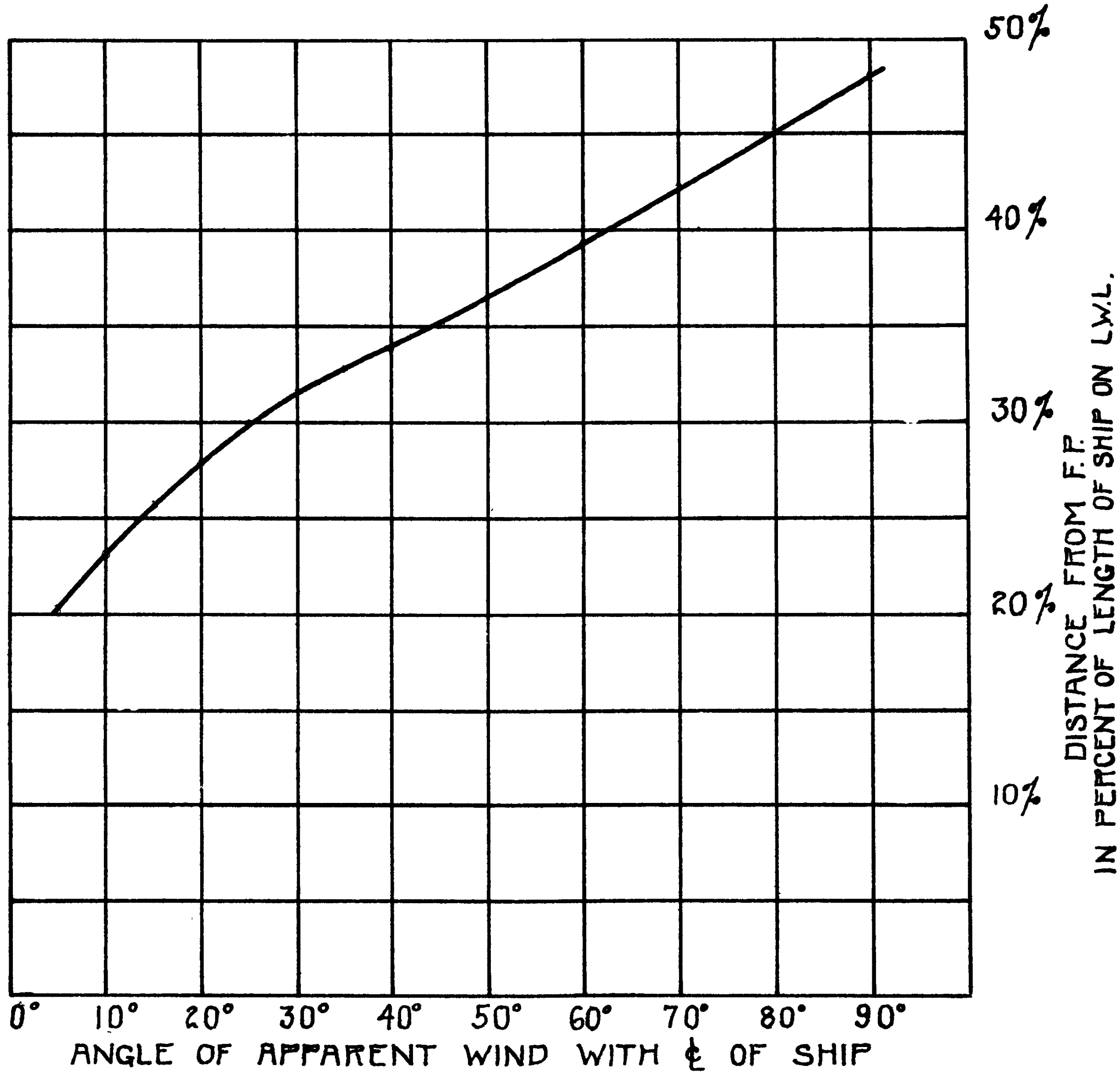

FIG. 4

LOCUS OF CENTER OF PRESSURE
DUE TO WIND ON
S. S. SANTA ROSA

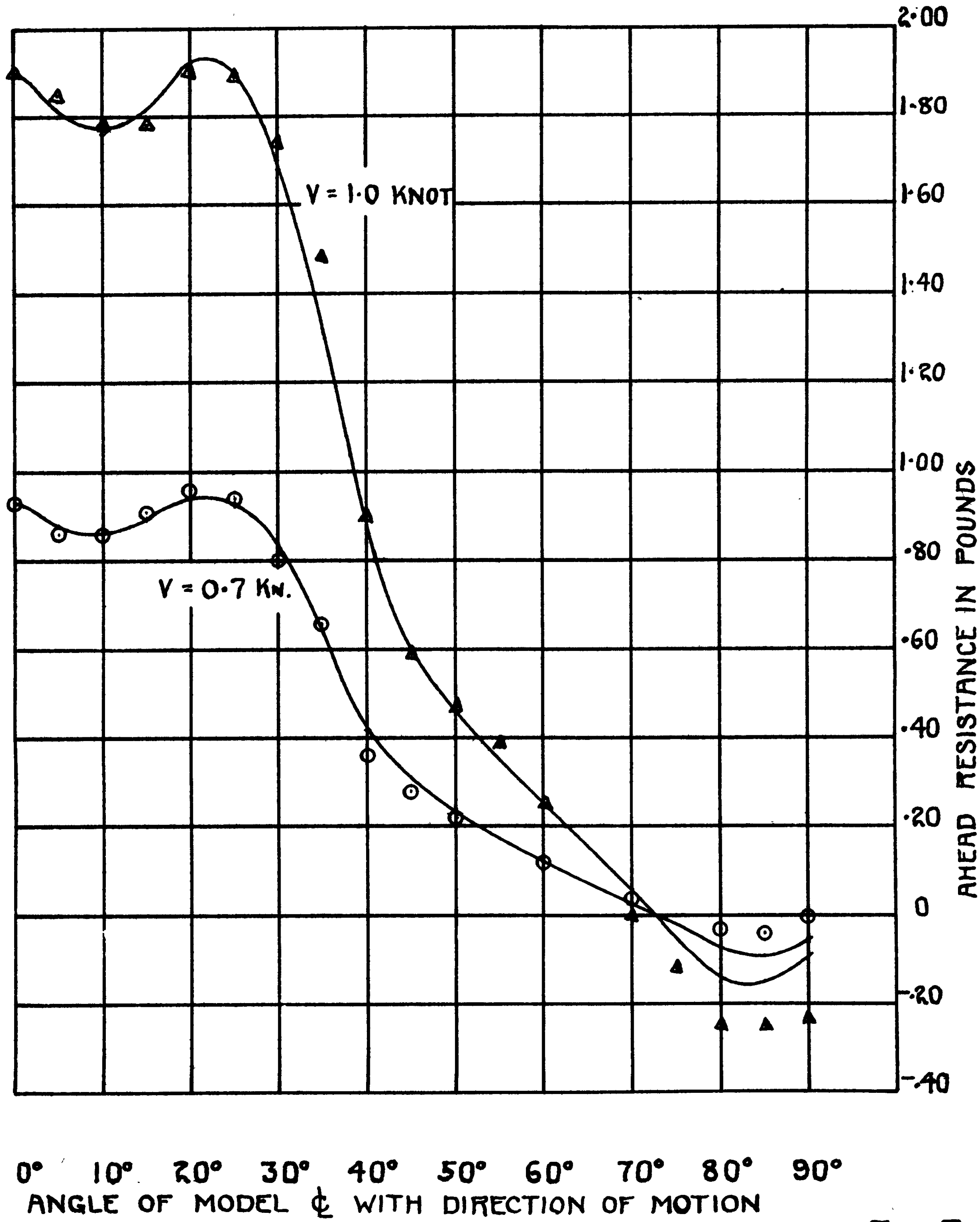

FIG. 5

CURVES OF AHEAD RESISTANCE
CROSS FAIRED, MAKING RES. ~ V^2
FOR MODEL OF
S. S. SANTA ROSA

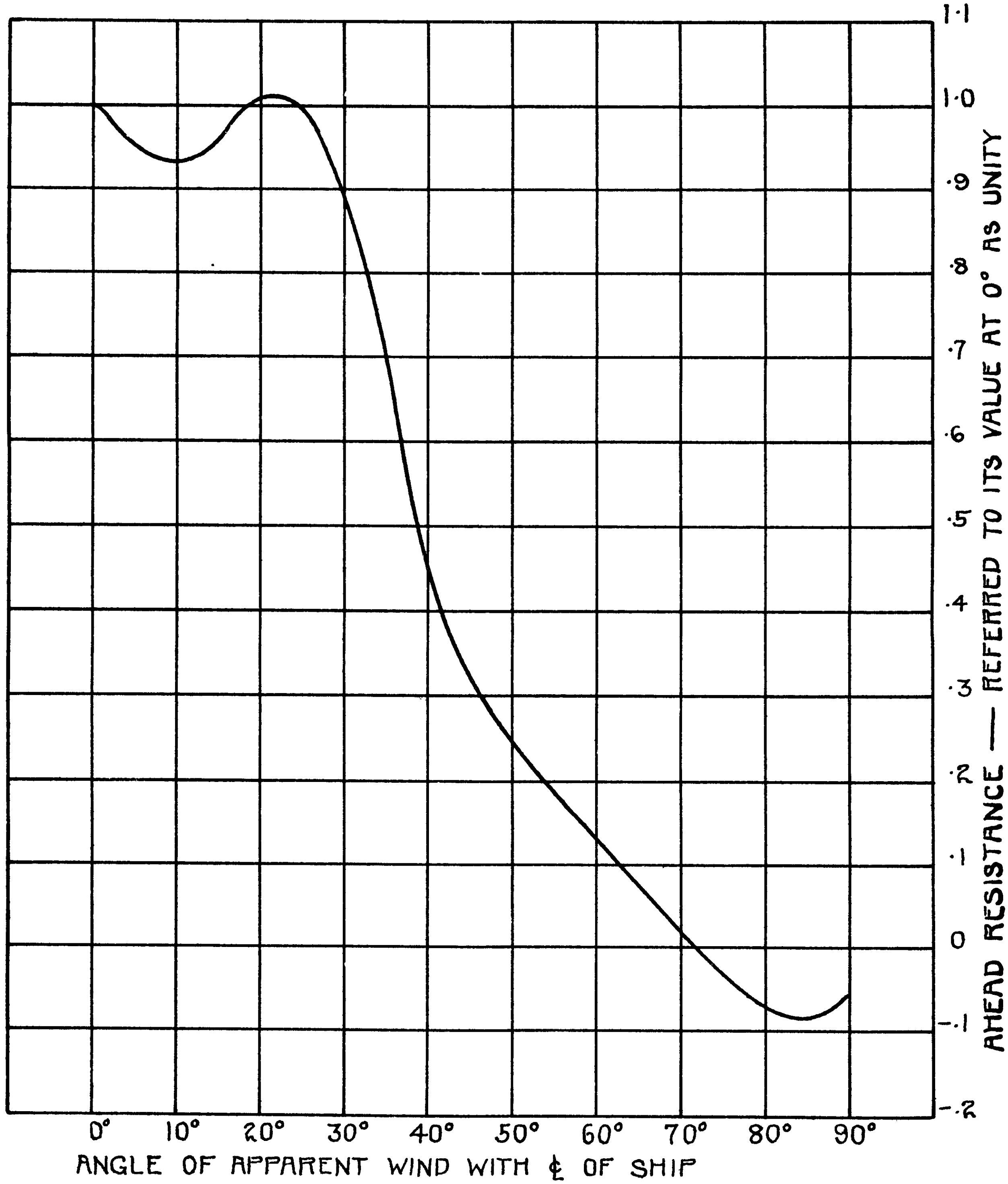

FIG. 6

CURVE OF AHEAD RESISTANCE
DUE TO WIND ON
S.S. SANTA ROSA

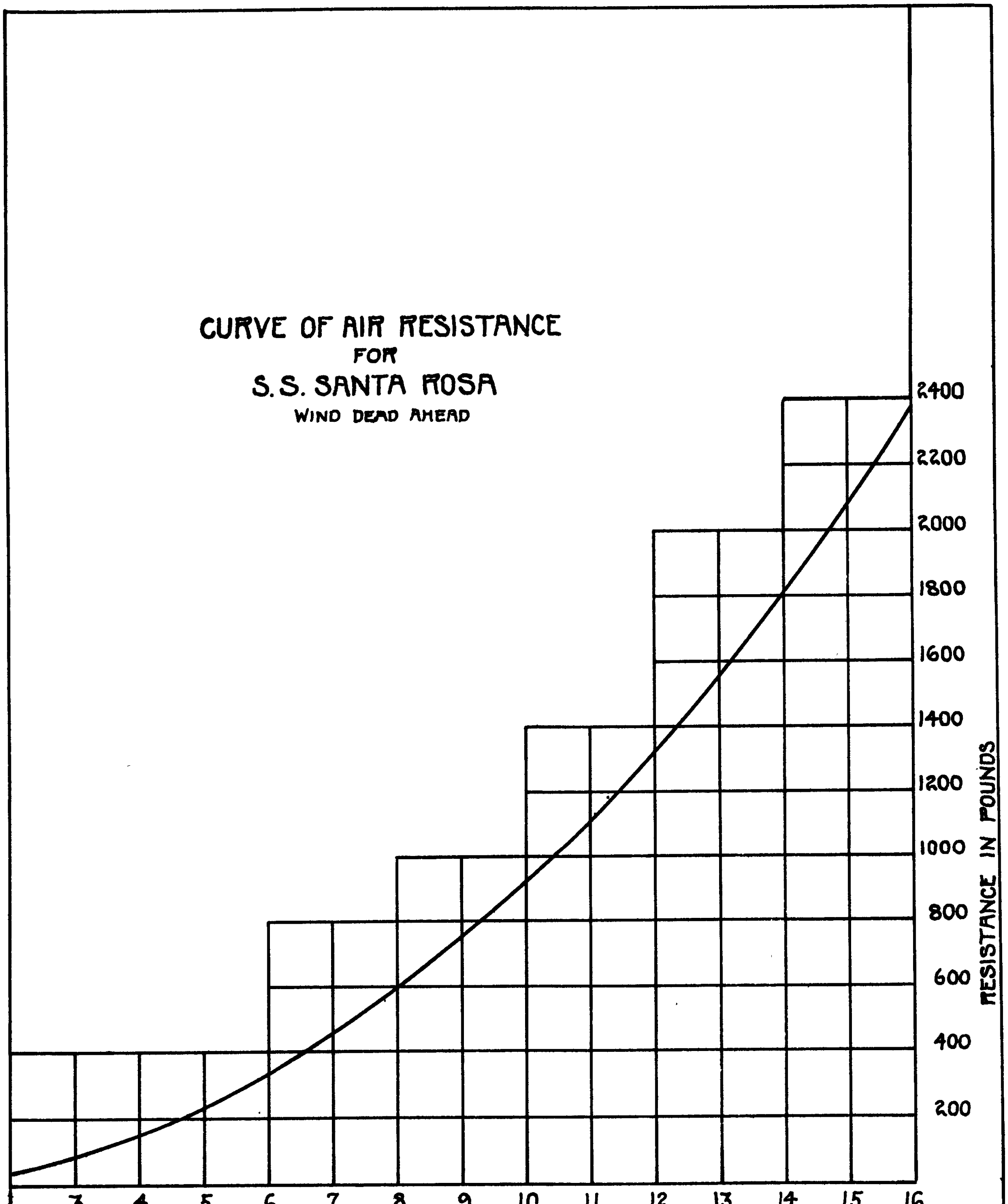
CURVE OF AIR RESISTANCE
FOR
S.S. SANTA ROSA
WIND DEAD AHEAD
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
RESISTANCE IN POUNDS
3
4
5
6
7
8
9
10
11
12
13
14
15
16
SPEED IN KNOTS

FIG. 7