[redacted]

TEST OF DRAWING ROOM MODEL
OF
U. S. DESTROYER HAMILTON
IN WATER
TO DETERMINE FORCES DUE TO WIND

U. S. EXPERIMENTAL MODEL BASIN
NAVY YARD, WASHINGTON, D. C.

[redacted]

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REPORT NO. 312

SUMMARY.

A drawing room model of the destroyer HAMILTON was made in two parts which separated on the load water line plane. The upper part, representing the parts exposed to the wind was towed inverted in water, with its center line at various angles with the direction of motion, and the flat surface representing the L.W.L. plane just above the surface of the water.

The model was fastened beneath a platform which was free to move horizontally, the size and direction of the force of the water tending to move the model being measured by the forces required to hold it in its original position.

The model was run at speeds up to two knots and with its centerline at angles varying by 5^{o} intervals from 0^{o} to 90^{o} with the direction of motion.

The forces were plotted on speed, cross faired on angle, and the resultant vectors found by graphic solution at three different speeds.

The ahead resistances, obtained by resolution of the vectors on the center line of the model, were plotted on angles and cross faired on speed, assuming that the resistance varies as V^2.

The curve of $\frac{\text{ahead res.}}{V^2}$ thus obtained was plotted in fraction of its value at 0° angle, thus the reading at any angle is a coefficient by which the "head on" resistance or the specific resistance may be multiplied to give the resistance at the desired speed and angle.

The curve of resistance for the ship at 0° angle was computed from the model results by using the formulae

$$R_S = R_m \times \lambda^3 \frac{\rho_{air}}{\rho_{water}} \quad \text{and} \quad V_S = V_m \sqrt{\lambda}$$

where λ = 48 = Linear ratio of ship to model.

This was reduced to specific resistance by dividing by the area of the silhouette projected on the athwartship plane and by the square of the speed.

The fore and aft positions of the center of pressure of the wind on the ship were obtained from the intersections of the vectors with the center line of the model, and were plotted as distance from the forward perpendicular in per cent of the length of the ship.

INTRODUCTORY.

This report concerns the second detailed test to determine the effect of wind at various angles with the center line of a ship.

The first test, using a model of a 10,000 ton light cruiser was described in report No. 276.

METHODS AND APPARATUS.

A drawing room model, to a scale of 1/4" = 1' had been made of the destroyer HAMILTON. This model was in two sections which separated along the load water line plane. The upper section shown on sheet I, and representing the parts exposed to the wind, was mounted on a pivot and secured to a wooden semicircle, three feet in diameter upon which angles from 0° to 90° were laid off at 5° intervals.

This model was fastened beneath a hanging platform as shown on sheets II and III and clamped at the desired angle. The platform was hung on four small wire ropes, the height being adjusted so that the load water plane of the inverted model was just above water.

The platform was towed by a wire from the carriage dynamometer which thus measured forces in the direction of Motion, and was held in its central position by cords from two wooden balances, upon which the lateral forces were measured. See sheet II.

The model was run at speeds ranging from 0.6 knots to 2.0 knots and with its center line at angles with the direction of motion varying from 0° to 90° by 5° intervals.

The readings for the forces were plotted on speed as shown on sheets IV to VIII and the resulting curves cross faired on angles. The faired values for the forces were then combined and the resulting vector found by graphic solution for each angle at speeds of 1.0, 1.4, and 1.8 knots. Sheet IX shows the diagram for the 50° angle and 1.4 Kn. speed.

The ahead resistance is the vector resolved on the center line of the model. This was obtained in each instance, and the results plotted on angle giving three curves for 1.0, 1.4 and 1.8 knots respectively. These curves, shown on sheet X were cross faired on speed, assuming that the resistance varies as V^2 and the resultant non-dimensional curve, sheet XI, computed for the force of the wind on the ship. This curve of ahead resistance for the range of angles was plotted in fraction of its value at 0° angle, thus a reading at any angle is a coefficient by which the resistance at 0° angle, sheet XIII or the specific resistance may be multiplied to give the ahead resistance at any angle and speed within the range of the experiment.

The curve of resistance on sheet XIII represents the wind resistance of the ship as derived from the resistance of the model in water by use of the formulae:

$$R_S = R_m \times \frac{\lambda^3}{\frac{\rho_w}{\rho_a}} \quad \text{and} \quad V_S = V_m \sqrt{\lambda}$$

where R = resistance

λ = linear ratio of ship to model

ρ = density

V = speed

Subscripts

w = water

a = air

S = ship

m = model

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

The specific resistance for the ship at 0° angle was found by dividing the resistance by the square of the speed and by the area of the silhouette projected on an athwartships plane.

$$\frac{R}{AV^2} = .0030$$

Where R = resistance in pounds, V = speed in knots and A = area above deck in square feet = 550 ft^2. If the total area, 904 ft^2 is used $\frac{R}{AV^2}$ = .0018

If the area $\frac{Beam^2}{2}$ = 480 ft^2 is used, $\frac{R}{AV^2}$ = .0034

The intersection of the resultant vector with the center line of the model, sheet IX, is considered the position of the center of pressure. This is plotted on sheet X for three speeds and an average curve drawn and used to obtain the non-dimensional curve on sheet XII.

RESULTS AND DISCUSSION.

The curve of ahead resistance, sheet XI, indicates a maximum at about 31° that is 65% higher than the value at 0°. This position of the maximum agrees very well with that obtained in the test of the light cruiser, reference No. 1, and with the results of the english test, reference No. 2, but the maximum value is greater than those reported in either.

The curve falls off to unity again at 49° which agrees very well with the english results but occurs at 13° less than in the test of the light cruiser.

The center of pressure moves aft as the angle of the wind increases reaching the greatest distance aft when the apparent wind is broadside, and is then about 13 ft. forward of amidships. This curve indicates that the center of pressure is much further forward at small angles than the positions reported for the light cruiser, agreeing more nearly with the results of the english test.

CONCLUSION.

This experiment shows, as did the one with the model of the light cruiser, that the greatest retarding effect of the wind on the ship is exerted when the apparent wind is about 30° off the bow.

To illustrate the proportionate amount of the resistance due to the wind at such an angle take the ship moving at a speed of 15 knots with a (true) beam wind of 10 knots. The apparent wind is at 33 1/2° and has a velocity of 18 knots.

Extending the curve on sheet XIII by assuming the resistance to vary as V^2, the wind resistance at 18 knots is 368 lbs. x $\frac{(18)^2}{(15)^2}$ = 530 lbs. From sheet XI the wind resistance at 33 1/2° = 1.62 x res. at 0° = 1.62 x 530 lbs. = 859 lbs. which at 15 knots

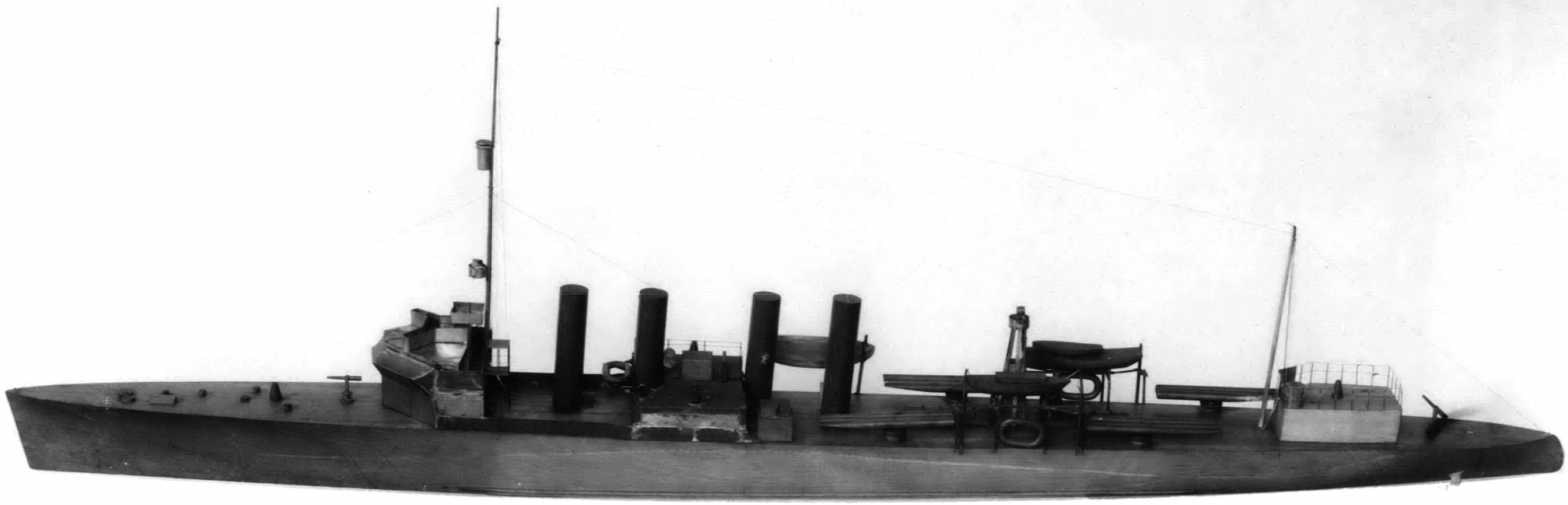
$$\approx \frac{859 \times 101\text{-}1/3 \times 15}{33,000} = 39.5 \text{ E.H.P.}$$

The E.H.P. of the HAMILTON at 15 knots = 900, so the increase due to the wind would be $\frac{39.5}{900.0}$ = 4%.

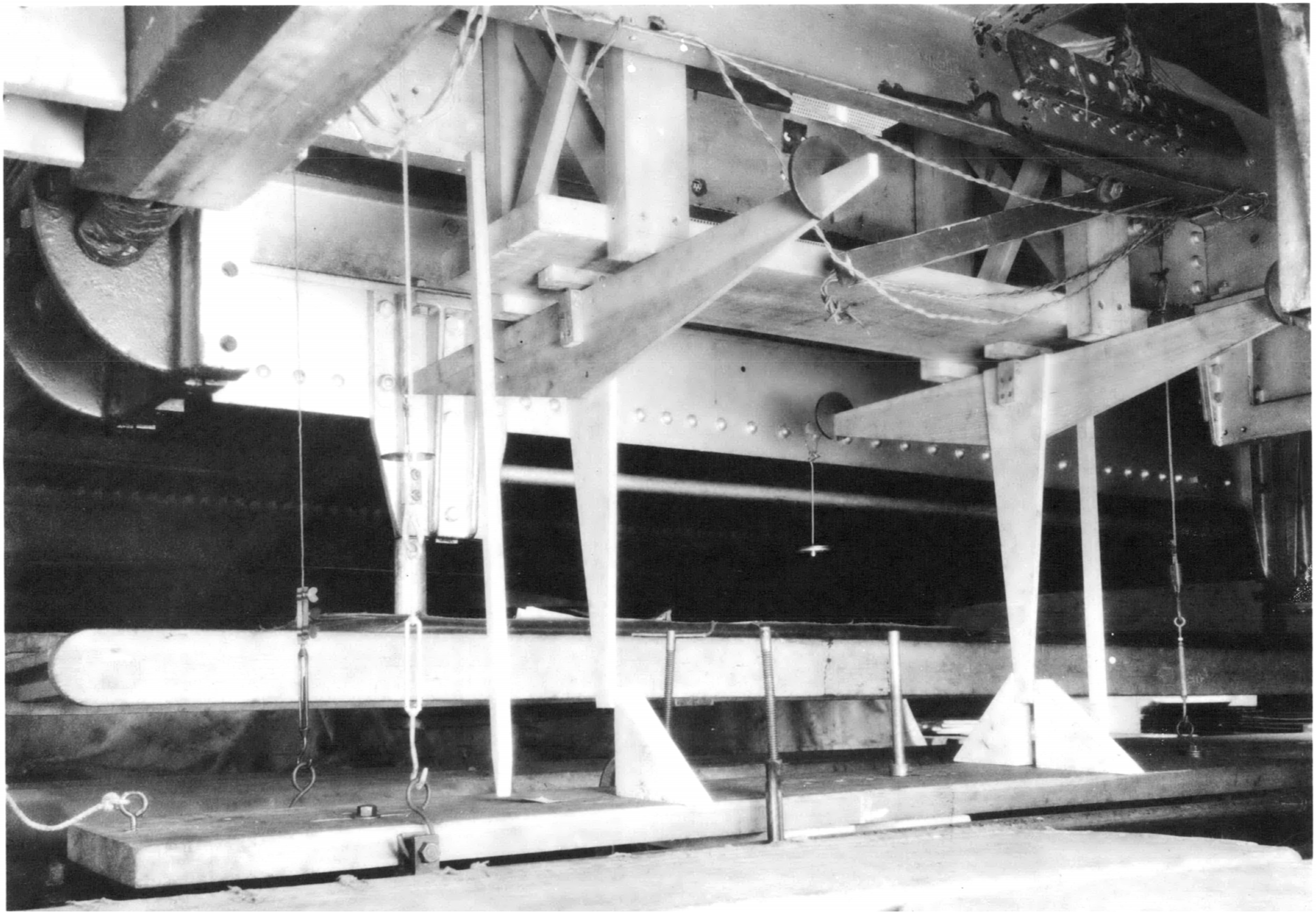
REFERENCES:

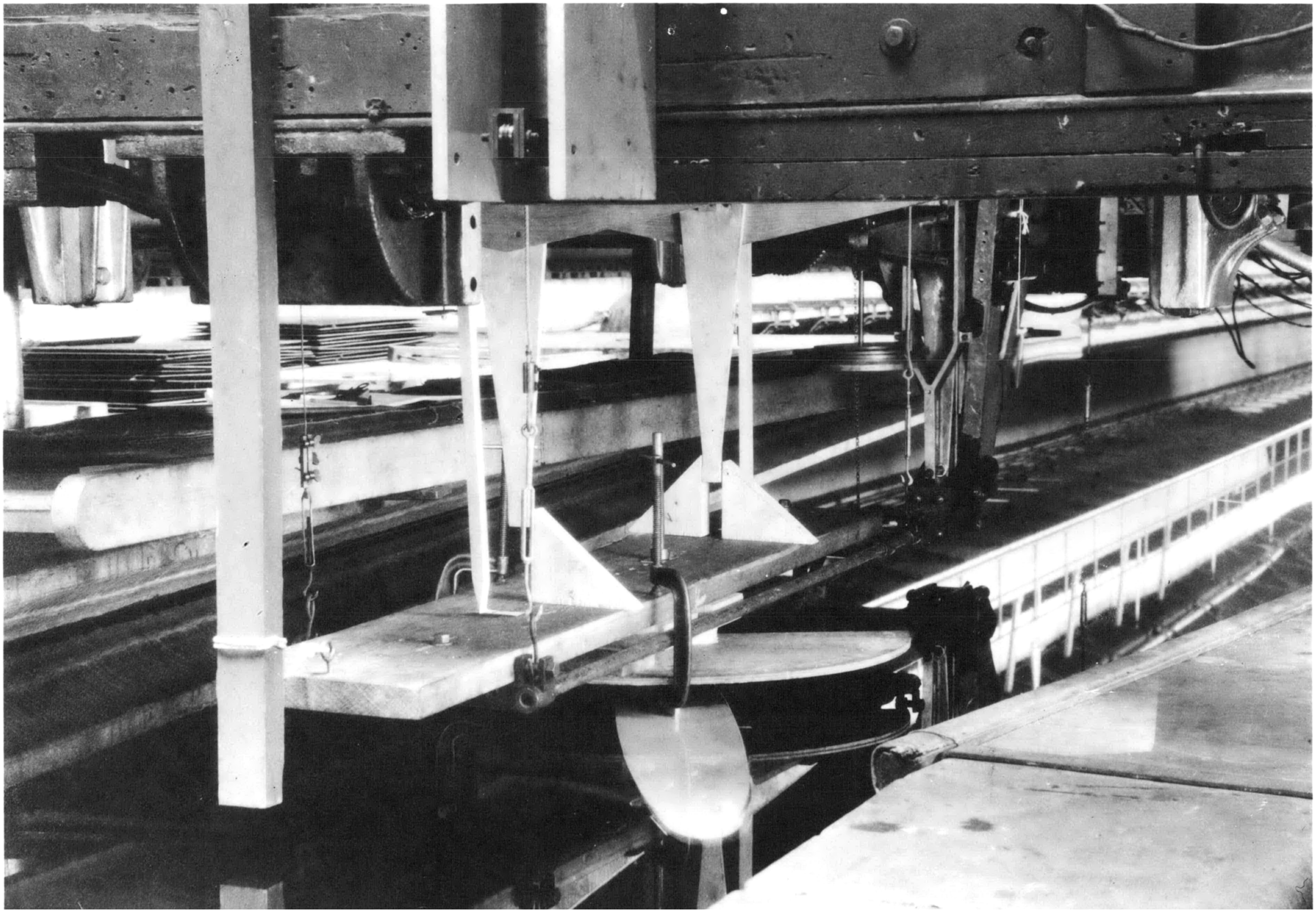
No. 1 Report No. 276 of Experimental Model Basin.

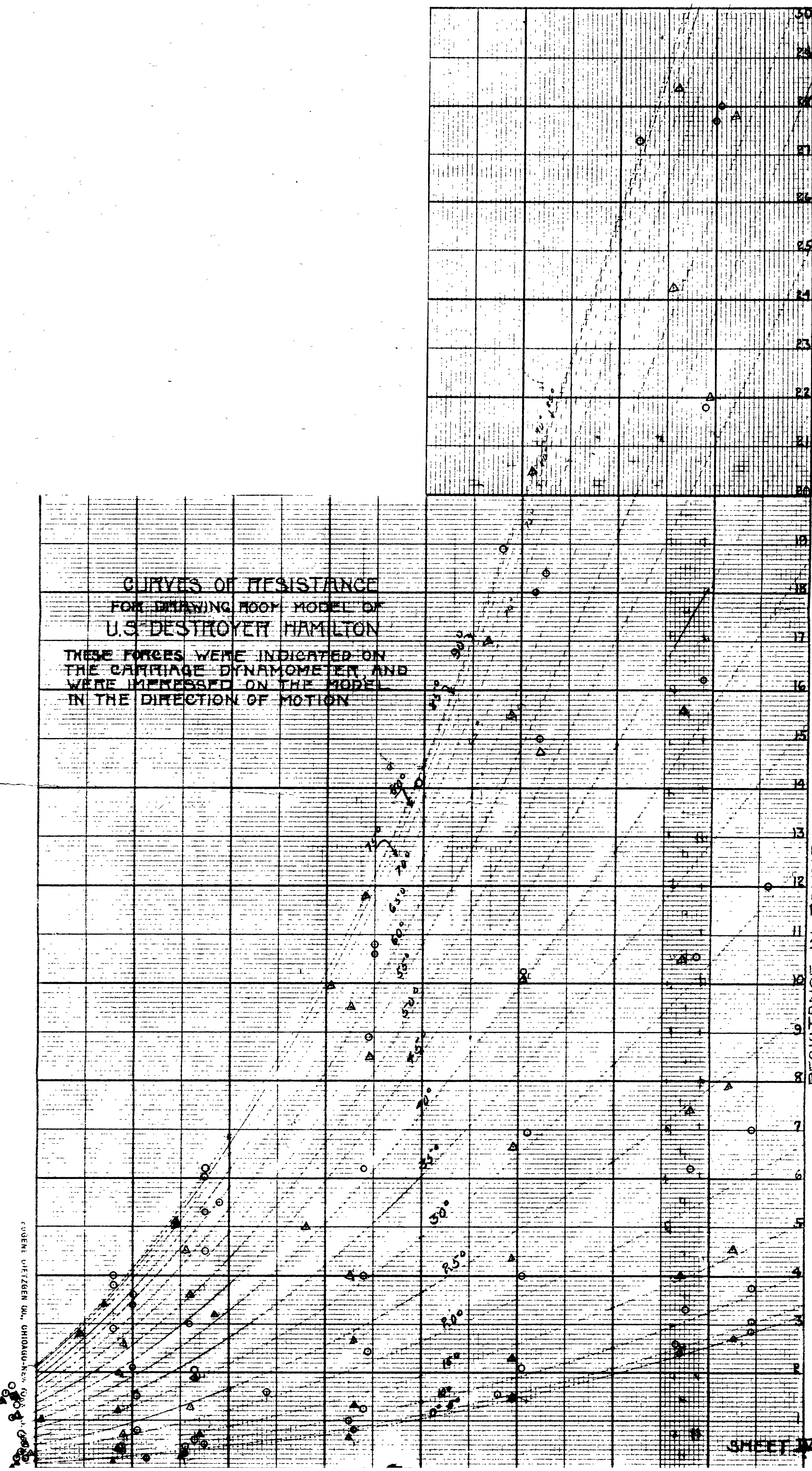
No. 2 Model Experiments on Wind Resistance of Ships by G. Hughes, Transactions of the Institution of Naval Architects July, 1930.



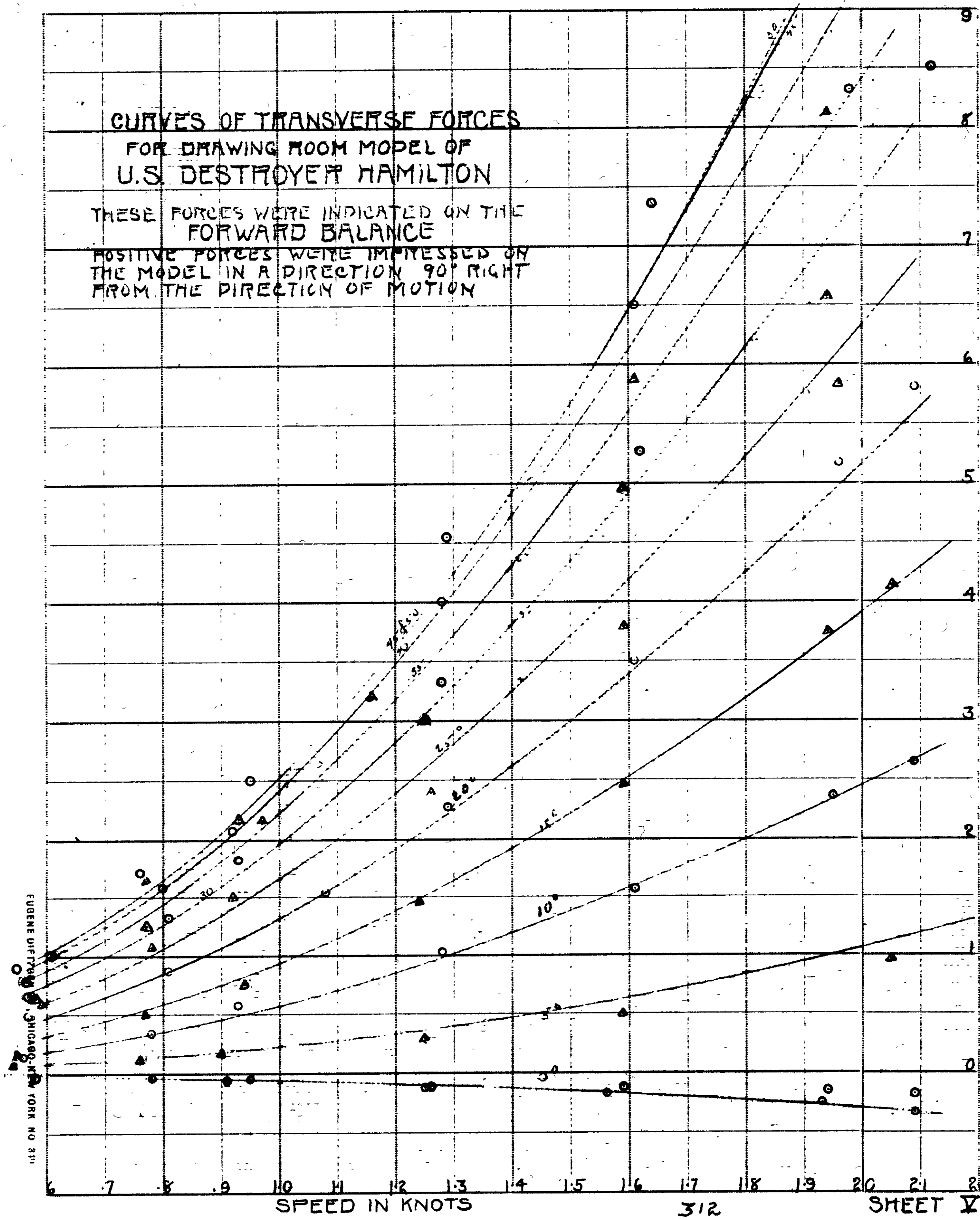
SHEET I



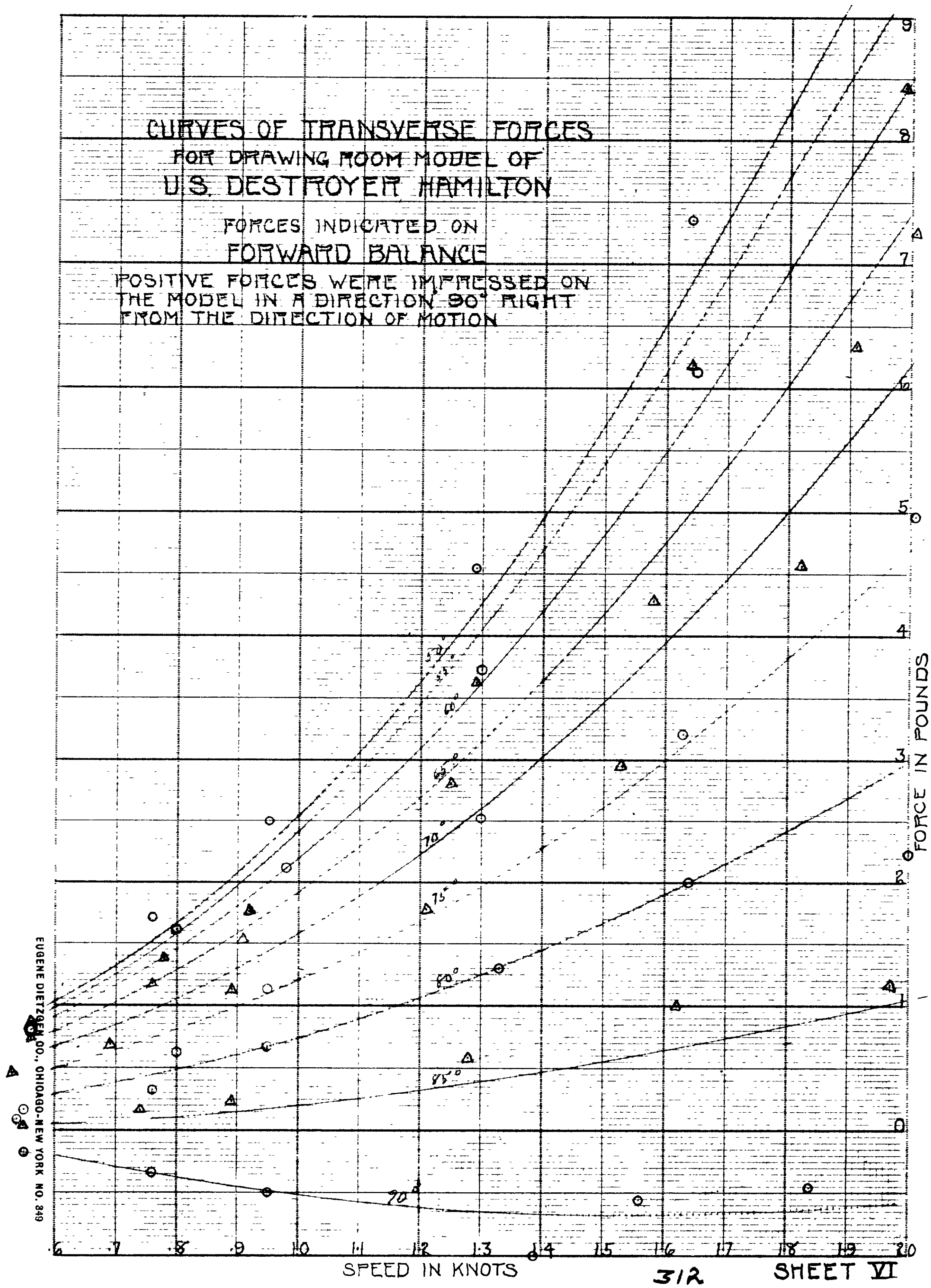



CURVES OF RESISTANCE
FOR DRAWING ROOM MODEL OF
U.S. DESTROYER HAMILTON
THESE FORCES WERE INDICATED ON THE CARRIAGE DYNAMOMETER, AND WERE IMPRESSED ON THE MODEL IN THE DIRECTION OF MOTION
RESISTANCE IN POUNDS
SHEET IV

SHEET IV



CURVES OF TRANSVERSE FORCES
FOR DRAWING ROOM MODEL OF
U.S. DESTROYER HAMILTON
THESE FORCES WERE INDICATED ON THE
FORWARD BALANCE
POSITIVE FORCES WERE IMPRESSED ON
THE MODEL IN A DIRECTION 90° RIGHT
FROM THE DIRECTION OF MOTION
FORCE IN POUNDS
SPEED IN KNOTS
SHEET V



CURVES OF TRANSVERSE FORCES
FOR DRAWING ROOM MODEL OF
U.S. DESTROYER HAMILTON
FORCES INDICATED ON
FORWARD BALANCE
POSITIVE FORCES WERE IMPRESSED ON THE MODEL IN A DIRECTION 90° RIGHT FROM THE DIRECTION OF MOTION
FORCE IN POUNDS
SPEED IN KNOTS
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
0 1 2 3 4 5 6 7 8 9
55° 60° 65° 70° 75° 80° 85° 90°
EUGENE DIETZGEN CO., CHICAGO-NEW YORK NO. 349

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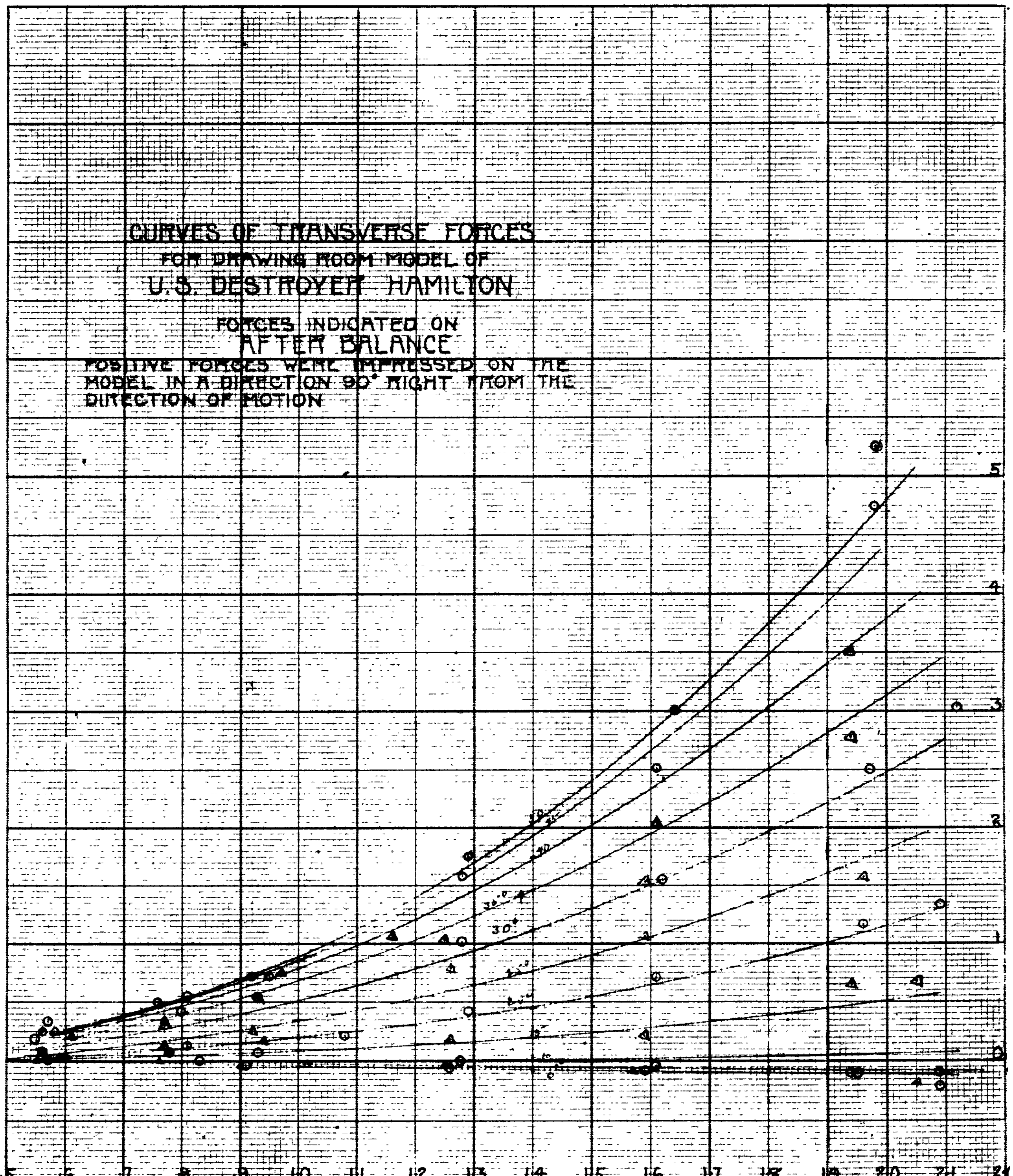
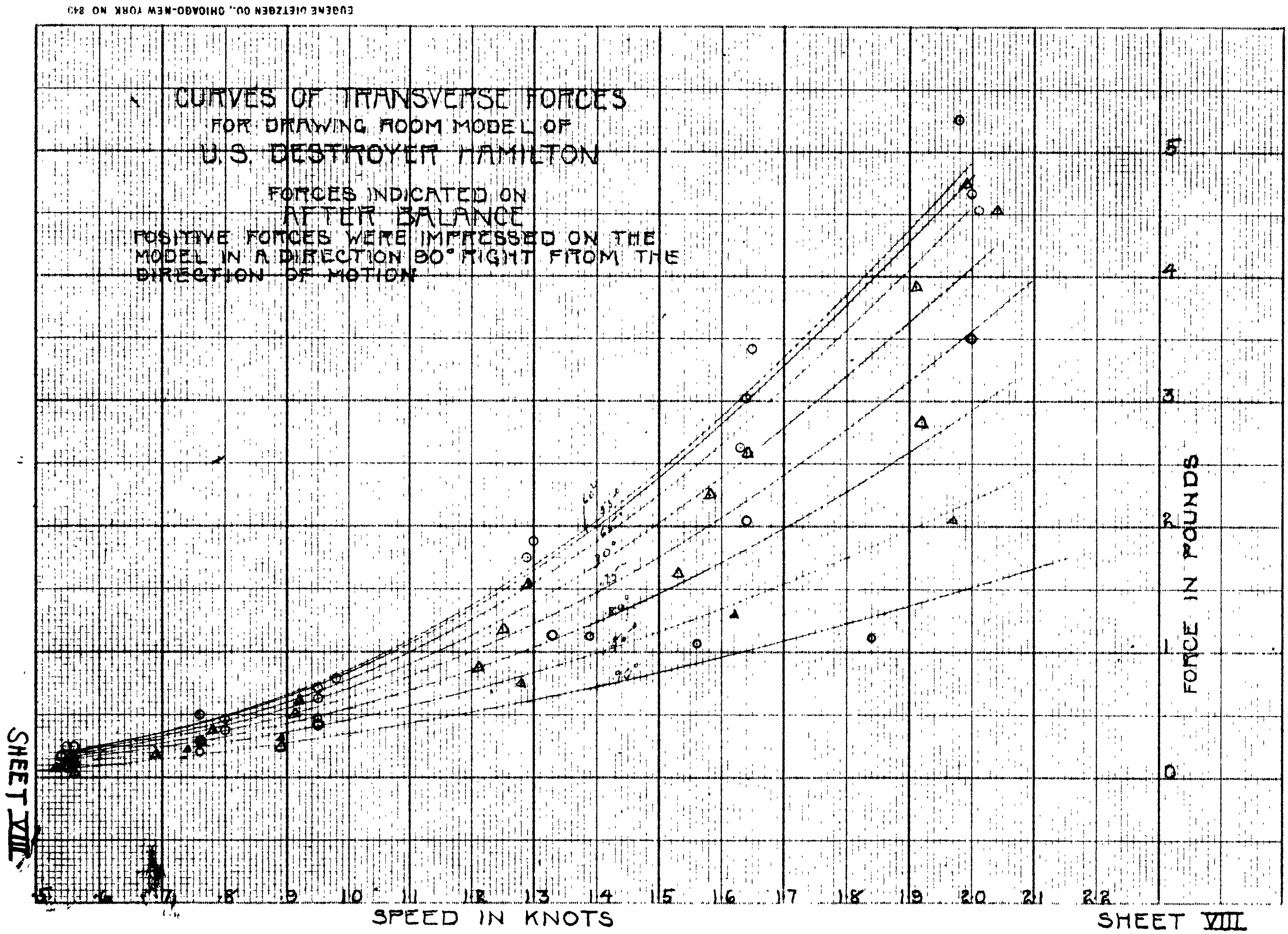
SHEET VI

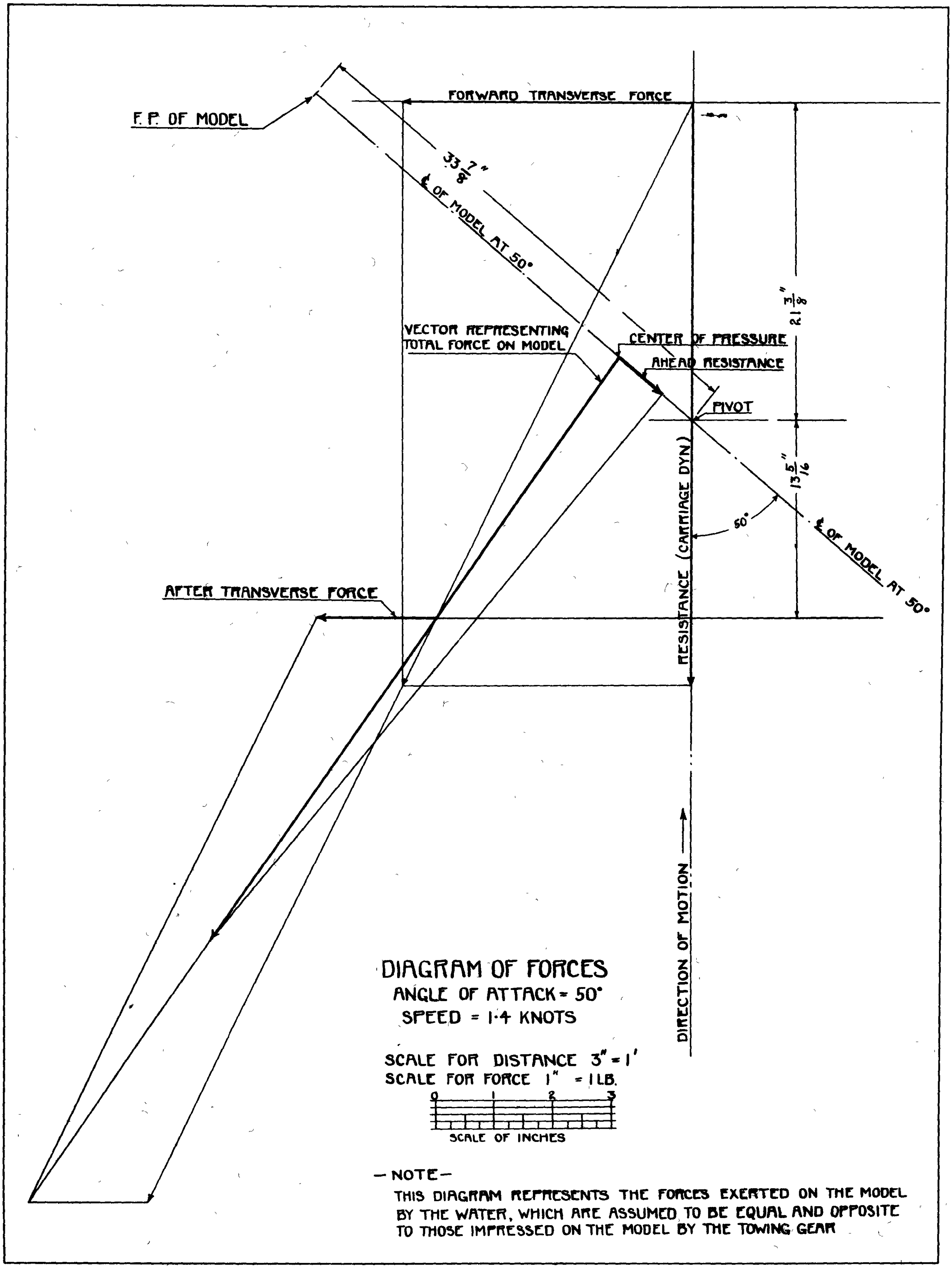


CURVES OF TRANSVERSE FORCES
FOR DRAWING ROOM MODEL OF
U.S. DESTROYER HAMILTON
FORCES INDICATED ON
AFTER BALANCE
POSITIVE FORCES WERE IMPRESSED ON THE
MODEL IN A DIRECTION 90° RIGHT FROM THE
DIRECTION OF MOTION
SPEED IN KNOTS

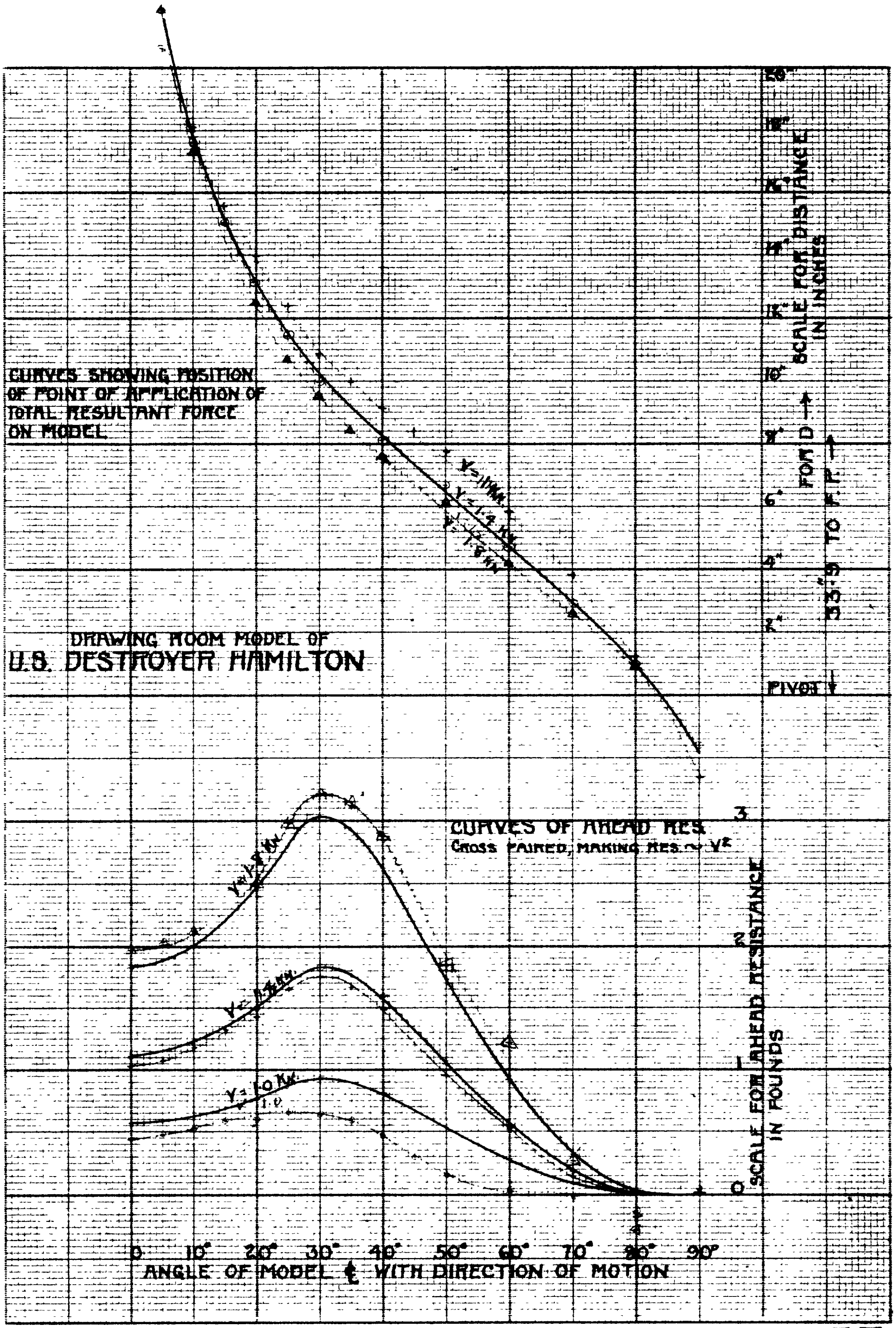
SHEET V

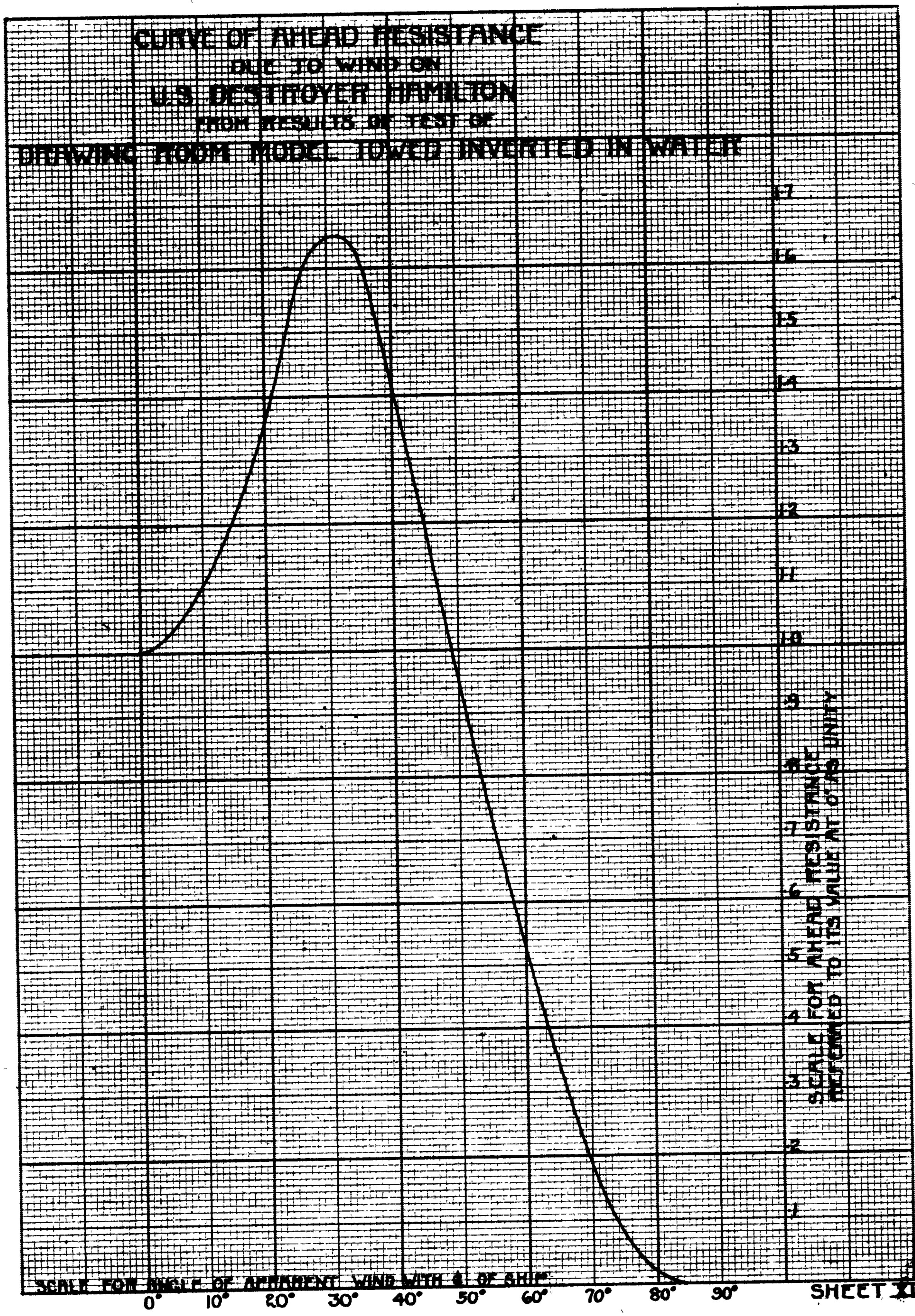

CURVES OF TRANSVERSE FORCES
FOR DRAWING ROOM MODEL OF
U.S. DESTROYER HAMILTON
FORCES INDICATED ON
AFTER BALANCE
POSITIVE FORCES WERE IMPRESSED ON THE MODEL IN A DIRECTION 90° RIGHT FROM THE DIRECTION OF MOTION
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
SPEED IN KNOTS
0 1 2 3 4 5
FORCE IN POUNDS
SHEET VIII

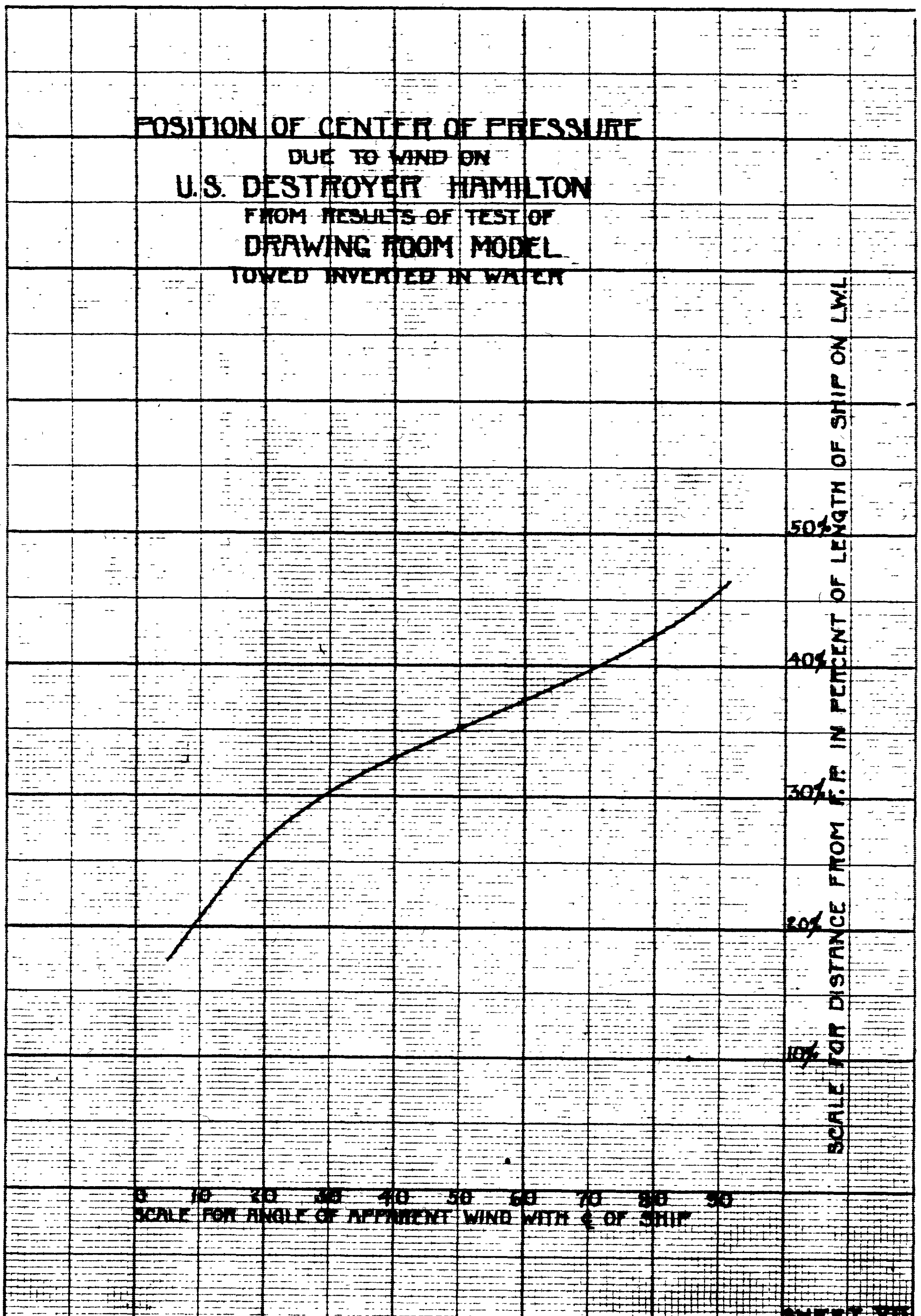
SHEET VIII


F.P. OF MODEL
FORWARD TRANSVERSE FORCE
33 7/8"
℄ OF MODEL AT 50°
21 3/8"
VECTOR REPRESENTING
TOTAL FORCE ON MODEL
CENTER OF PRESSURE
AHEAD RESISTANCE
PIVOT
13 5/16"
50°
RESISTANCE (CARRIAGE DYN)
℄ OF MODEL AT 50°
AFTER TRANSVERSE FORCE
DIRECTION OF MOTION
DIAGRAM OF FORCES
ANGLE OF ATTACK = 50°
SPEED = 1·4 KNOTS
SCALE FOR DISTANCE 3" = 1'
SCALE FOR FORCE 1" = 1 LB.
0 1 2 3
SCALE OF INCHES
— 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

SHEET IX


CURVES SHOWING POSITION OF POINT OF APPLICATION OF TOTAL RESULTANT FORCE ON MODEL
DRAWING ROOM MODEL OF
U.S. DESTROYER HAMILTON
SCALE FOR DISTANCE IN INCHES
FOR D → 33.5 TO F.P.
PIVOT
CURVES OF AHEAD RES.
CROSS FAIRED, MAKING RES. ~ V²
SCALE FOR AHEAD RESISTANCE IN POUNDS
ANGLE OF MODEL ℄ WITH DIRECTION OF MOTION
0 10° 20° 30° 40° 50° 60° 70° 80° 90°


CURVE OF AHEAD RESISTANCE
DUE TO WIND ON
U.S. DESTROYER HAMILTON
FROM RESULTS OF TEST OF
DRAWING ROOM MODEL TOWED INVERTED IN WATER
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
SCALE FOR AHEAD RESISTANCE
REFERRED TO ITS VALUE AT 0° AS UNITY
SCALE FOR ANGLE OF APPARENT WIND WITH ℄ OF SHIP
0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
SHEET XI.


POSITION OF CENTER OF PRESSURE
DUE TO WIND ON
U.S. DESTROYER HAMILTON
FROM RESULTS OF TEST OF
DRAWING ROOM MODEL
TOWED INVERTED IN WATER
50%
40%
30%
20%
10%
SCALE FOR DISTANCE FROM F.P. IN PERCENT OF LENGTH OF SHIP ON L.W.L.
0 10 20 30 40 50 60 70 80 90
SCALE FOR ANGLE OF APPARENT WIND WITH ℄ OF SHIP
SHEET XII

(8)

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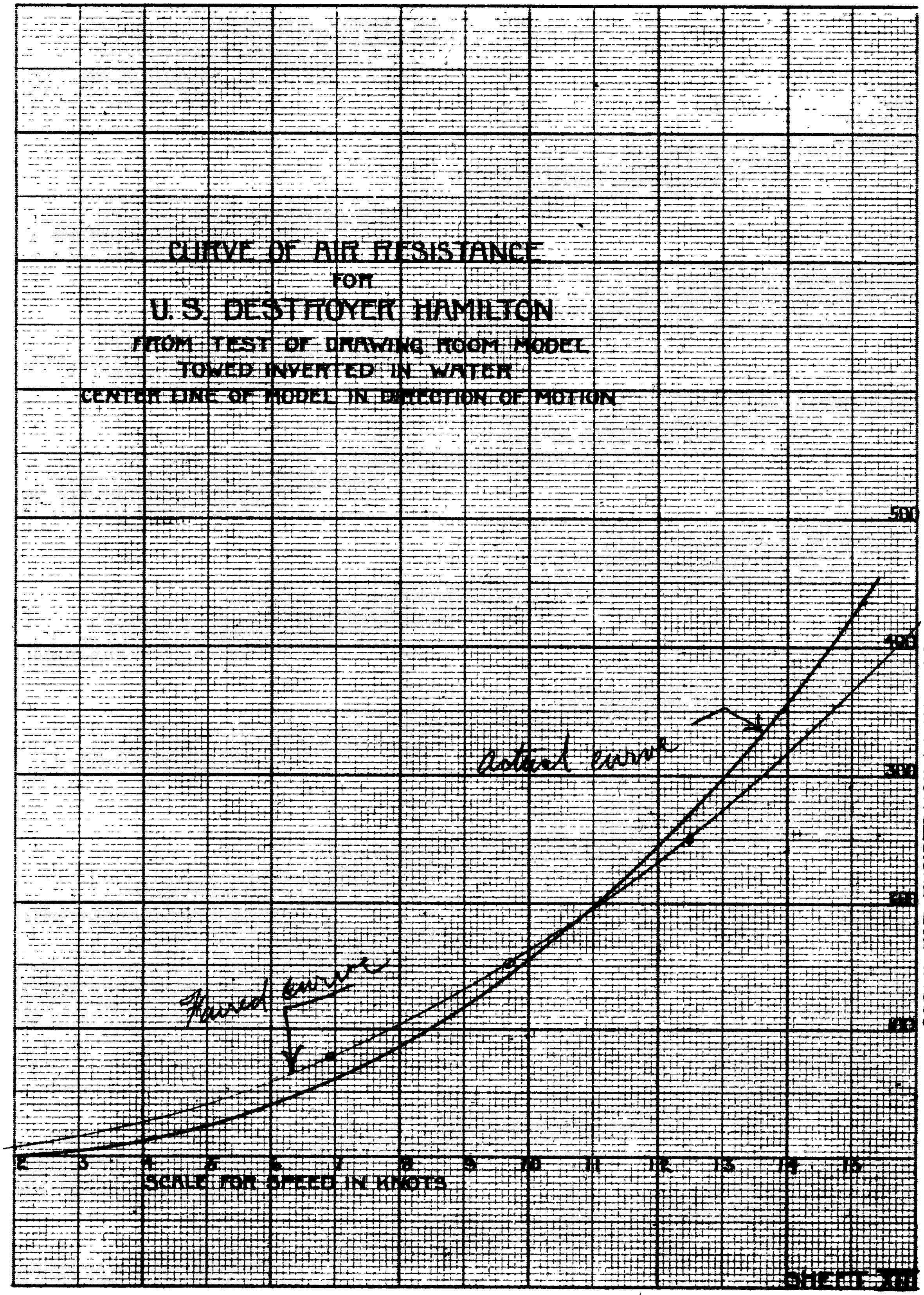
CURVE OF AIR RESISTANCE
FOR
U.S. DESTROYER HAMILTON
FROM TEST OF DRAWING ROOM MODEL
TOWED INVERTED IN WATER
CENTER LINE OF MODEL IN DIRECTION OF MOTION
500
400
300
200
100
SCALE FOR RESISTANCE IN POUNDS
Actual curve
Faired curve
2
3
4
5
6
7
8
9
10
11
12
13
14
15
SCALE FOR SPEED IN KNOTS
SHEET