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REPORT 956
AERO DATA REPORT 27

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NAVY DEPARTMENT
THE DAVID W. TAYLOR MODEL BASIN
AERODYNAMICS LABORATORY
WASHINGTON 7, D.C.

WIND-TUNNEL TESTS TO DETERMINE AERODYNAMIC FORCES AND
MOMENTS ON SHIPS AT ZERO HEEL

by

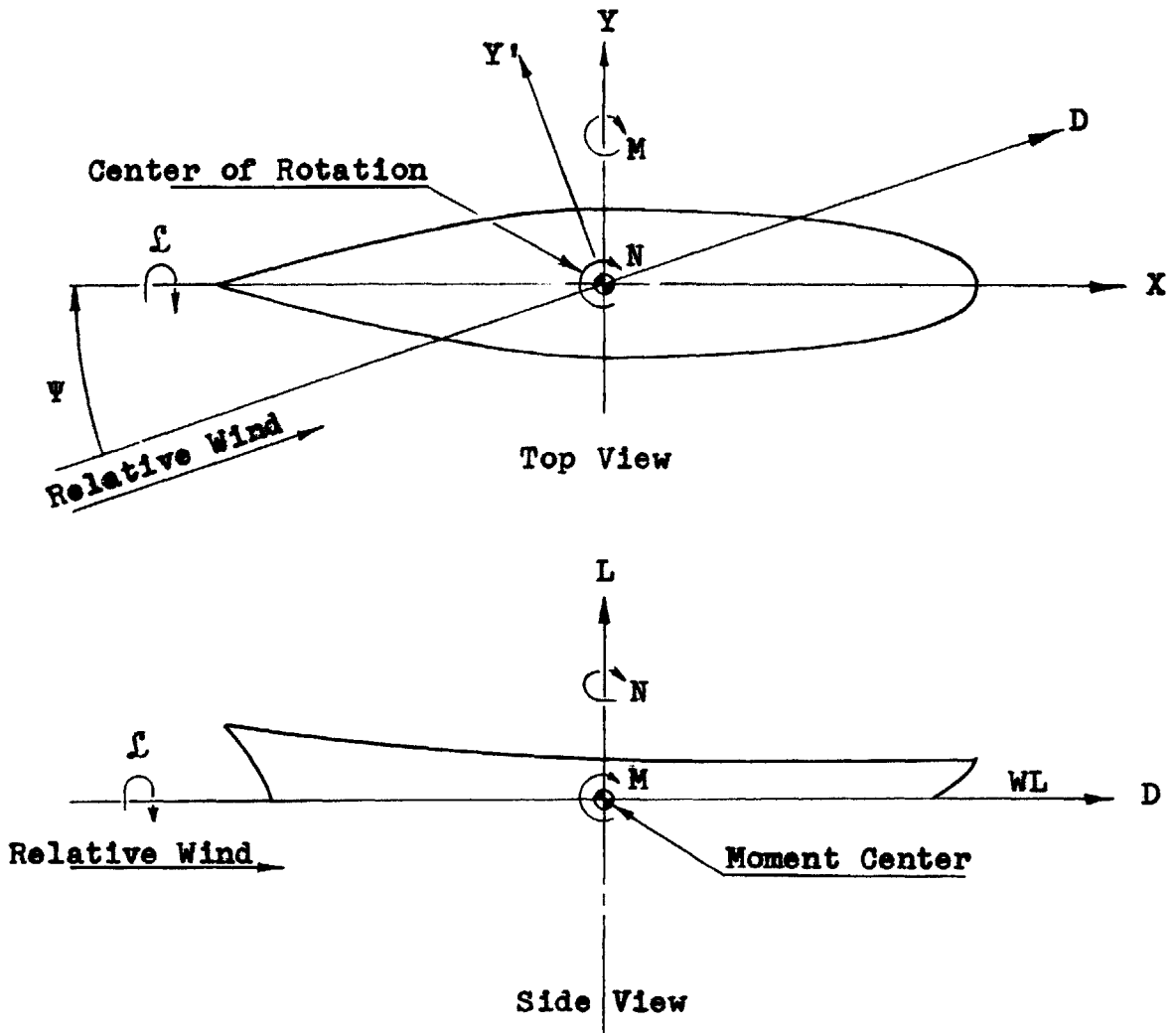
G. R. Mutimer



March 1955

NOTATION

Positive directions of axes, forces, moments, and angular displacements are shown by arrows



Axis	Force in pounds	Moment in pound-feet
X	X	\mathcal{L} (rolling)
Y	Y	M (pitching)
L	L	N (yawing)

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AERODYNAMICS LABORATORY
DAVID TAYLOR MODEL BASIN
UNITED STATES NAVY
WASHINGTON, D.C.

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INTRODUCTION

In connection with certain studies in ship stability-design criteria, currently being undertaken by the Bureau of Ships, it is necessary that wind heel effects upon surface ships be analyzed.

At the request of the Bureau of Ships (Reference 1), this report presents a compilation of data on nine ship models tested at 0° heel in the Taylor Model Basin, 8- by 10-foot wind tunnels during different periods from 1948 through 1953. Ship names are listed in Figure 1, and all test results are given in the form of forces in pounds and moments in pound-feet.

MODELS AND INSTALLATION

The model scale was varied for the different types of vessels so that the models of each type were as large as practicable in the 8- by 10-foot wind tunnels. Since only the

wind loads could be measured in these tests, the model hulls were cut off at the water line. Figure 1 gives pertinent information on model scale and location with respect to the center of rotation. The photographs in Figures 2 through 9 show the amount of detail in the construction of the different models. The USS SALEM (CAL39) is not shown.

The water surface was represented by a false floor built above the floor of the wind-tunnel, referred to hereafter as the ground board. The models were mounted directly on the wind-tunnel 6-component-balance system by means of a shielded strut extending downward through the ground board and wind-tunnel floor. Thus, the models were maintained in proximity to the ground board with approximately a 1/16-inch gap between the ground-board surface and the water-line plane of the model, as shown in Figure 1. An electric potential was imposed between the model and a metal fouling plate on the surface of the ground board to indicate if fouling should occur.

TESTS AND PROCEDURE

The tests were made in the 8- by 10-foot TMB closed-throat, atmospheric wind tunnels. Dynamic pressures, q , and approximate corresponding airspeeds, V , peculiar to each ship are listed in Figure 1. Most tests were made for a yaw range of 0° to 360° . All tests were made with a heel angle of 0° .

In testing the SS PENNSYLVANIA, the fouling plate was raised to determine the effect of the boundary layer across

the ground board. Figure 1 shows the location of the fouling plate and Figure 9 is a photograph of the ground-board installation and the SS PENNSYLVANIA with fouling plate raised.

RESULTS

All data were plotted against angle of yaw with forces in pounds and the moments in pound-feet and are presented in Figures 10 through 18. The data have been transferred to the model moment center shown in the notation. The moment center was always coincident with the center of rotation. There were no tare or interference corrections because of the method of mounting the model on the balance.

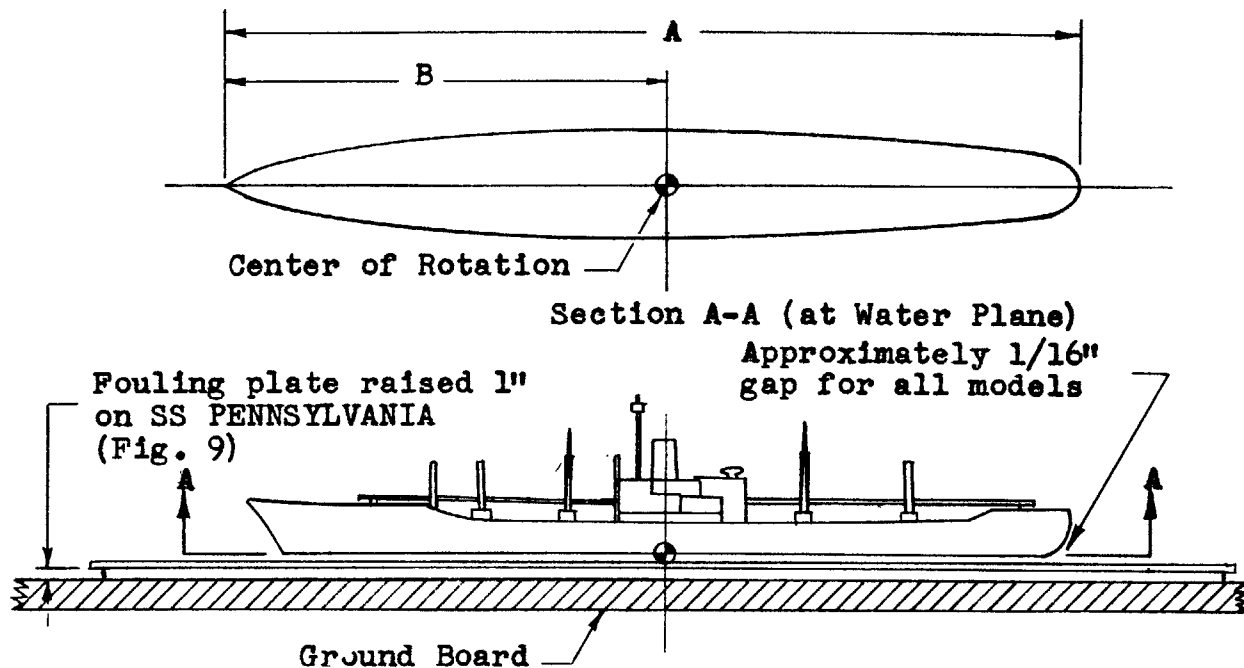
Methods for scaling model forces and moments to the full-size ship can be found in Reference 2, and a relation for computing the heeling moment due to the aerodynamic effects of beam winds is outlined in Reference 3. In order to have a basis for comparing forces on different types of ships, it may be desirable to reduce some of the data to dimensionless coefficient form as outlined in Reference 2.

It may be noted that the results of the tests on the DD692 model in this report compare favorably with test results of the same model given in References 2 and 3 even though the balance systems and model installations were different.

Aerodynamics Laboratory
David Taylor Model Basin
Washington, D.C.
March 1955

REFERENCES

1. BuShips ltr NP-5/A1(420) Ser 420-276 of 12 November 1953.
2. Long, M. E.: Wind-Tunnel Tests on Multiple Ship Moorings. Part III - Determination of Air Loads on Multiple Ship Moorings for Destroyers, Submarines, Liberty Ships, and Escort Carriers. TMB Rep. 830. Aero Rep. 714, Part III. Wash., Jul 1952. 24 l. illus.
3. Long, M. E. and Benedum, C. L.: Wind-Tunnel Tests to Determine Aerodynamic Forces and Moments on Ships Heeled in Beam Winds. Part I - DD692 Class Destroyers. TMB Rep. C-64 Aero Rep. 749, Part I. Wash., Dec 1947. 8 l. illus.



Name	Scale	A in feet	B in feet	q in lb/ft ²	V in knots
SS UNITED STATES	1:150	6.10	3.05	40.0	108
SS OLD COLONY MARINER	1:105	5.04	2.52	30.0	94
SS OLD COLONY MARINER	1:105	5.04	2.52	40.0	108
LST1156	1:73.6	4.98	2.49	30.0	94
LST1156	1:73.6	4.98	2.49	40.0	108
SS PENNSYLVANIA	1:120	4.89	2.44	60.0	132
DD692	1:73.8	5.00	2.50	53.0	125
USS ROANOKE (CL1145)	1:132.8	4.88	2.44	53.0	125
USS SALEM (CA139)	1:140	4.93	2.46	53.0	125
CV9 (ESSEX Class)	1:136.6	5.93	2.96	33.9	100
CV9 (ESSEX Class)	1:136.6	5.93	2.96	53.0	125
YTB500 (Tugboat)	1:20	4.48	2.24	33.9	100
YTB500 (Tugboat)	1:20	4.48	2.24	53.0	125

Figure 1 - Individual Model Scale and Location of Center of Rotation for Nine Ships on Ground Board



Figure 2 - One-Quarter Starboard View of a 1:73.8-Scale Model DD692-Class
Destroyer Mounted on Ground Board in Wind Tunnel

TMB 41327

22 August 1949

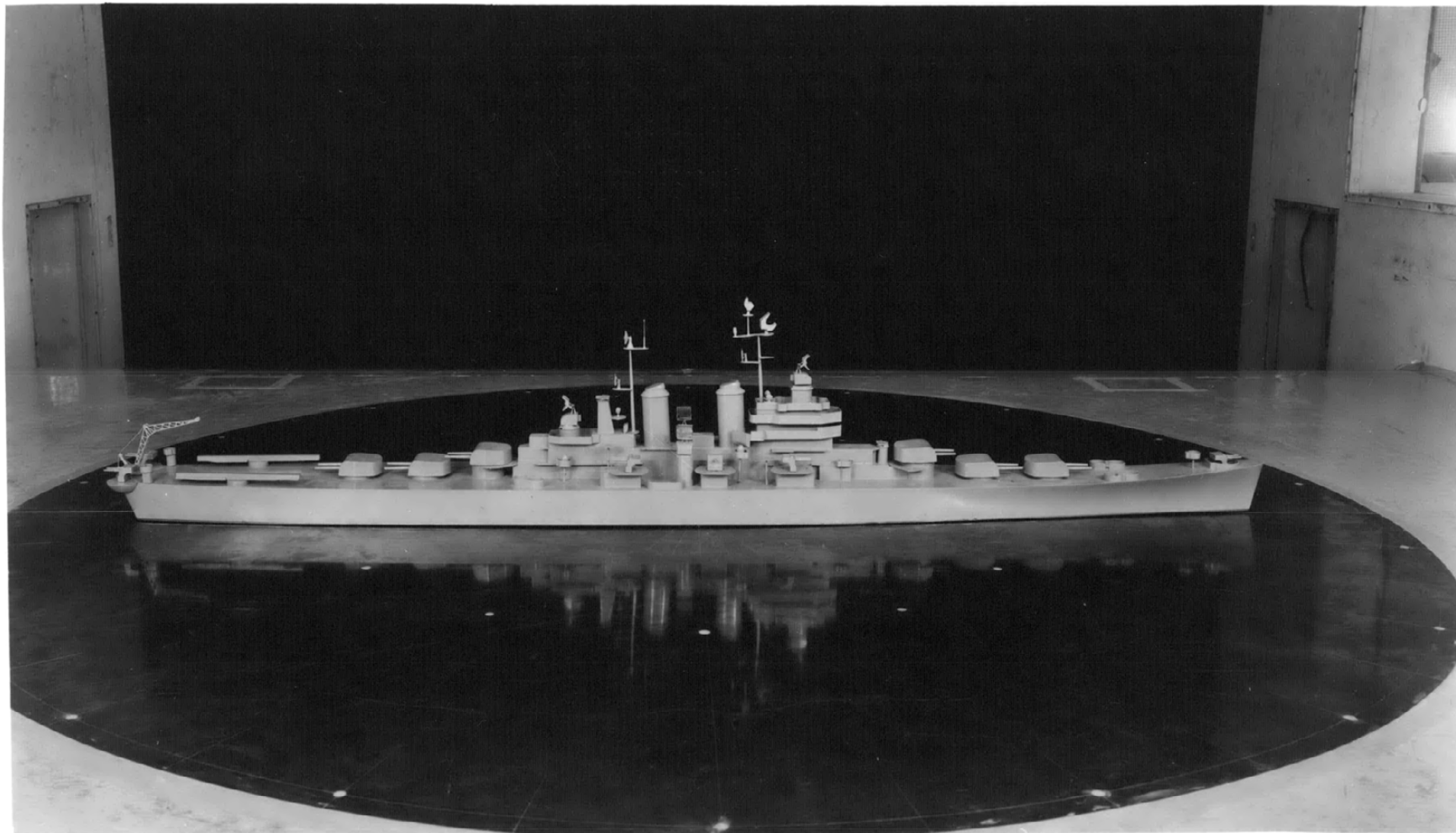


Figure 3 - Starboard View of a 1:132.8-Scale Model CL145-Class Cruiser
Mounted on Ground Board in Wind Tunnel

TMB 41326

19 August 1949

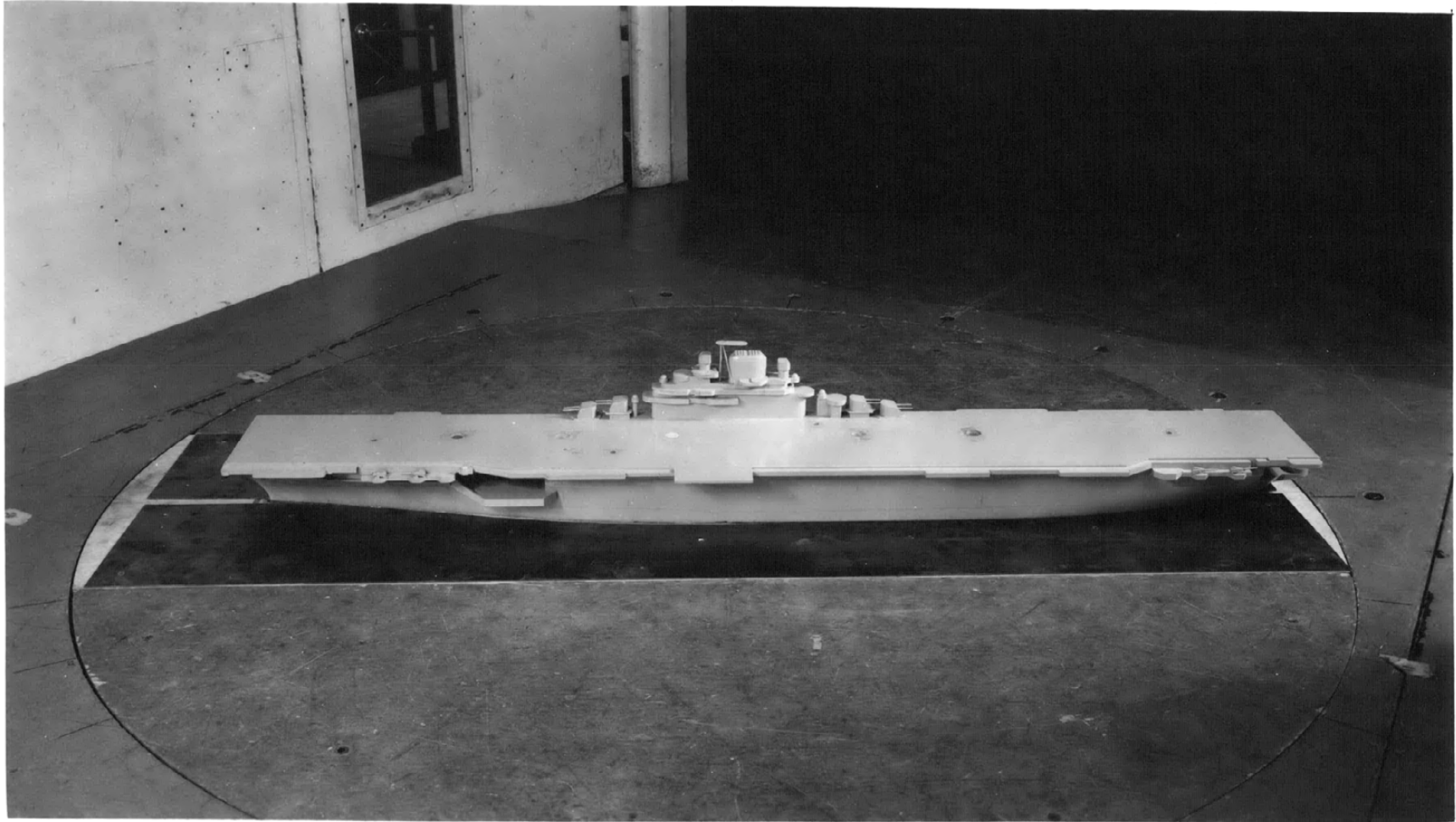


Figure 4 - Port View of a 1:136.6-Scale Model CV9-Class Aircraft Carrier
Mounted on Ground Board in Wind Tunnel

TMB 30350

20 October 1948

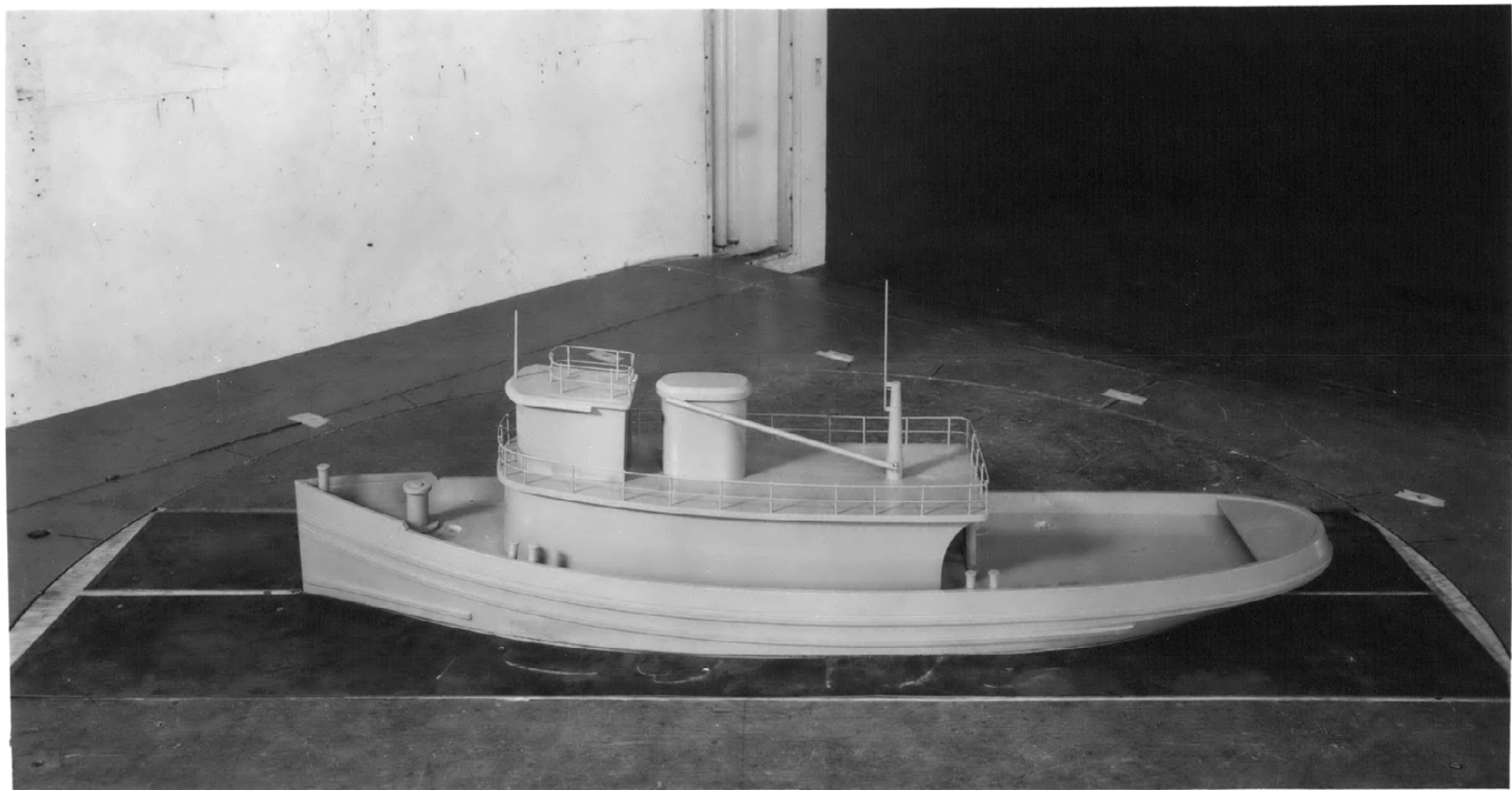


Figure 5 - Port View of 1:20-Scale Model YTB500 Tugboat Mounted on
Ground Board in Wind Tunnel

TMB 30293

14 October 1948

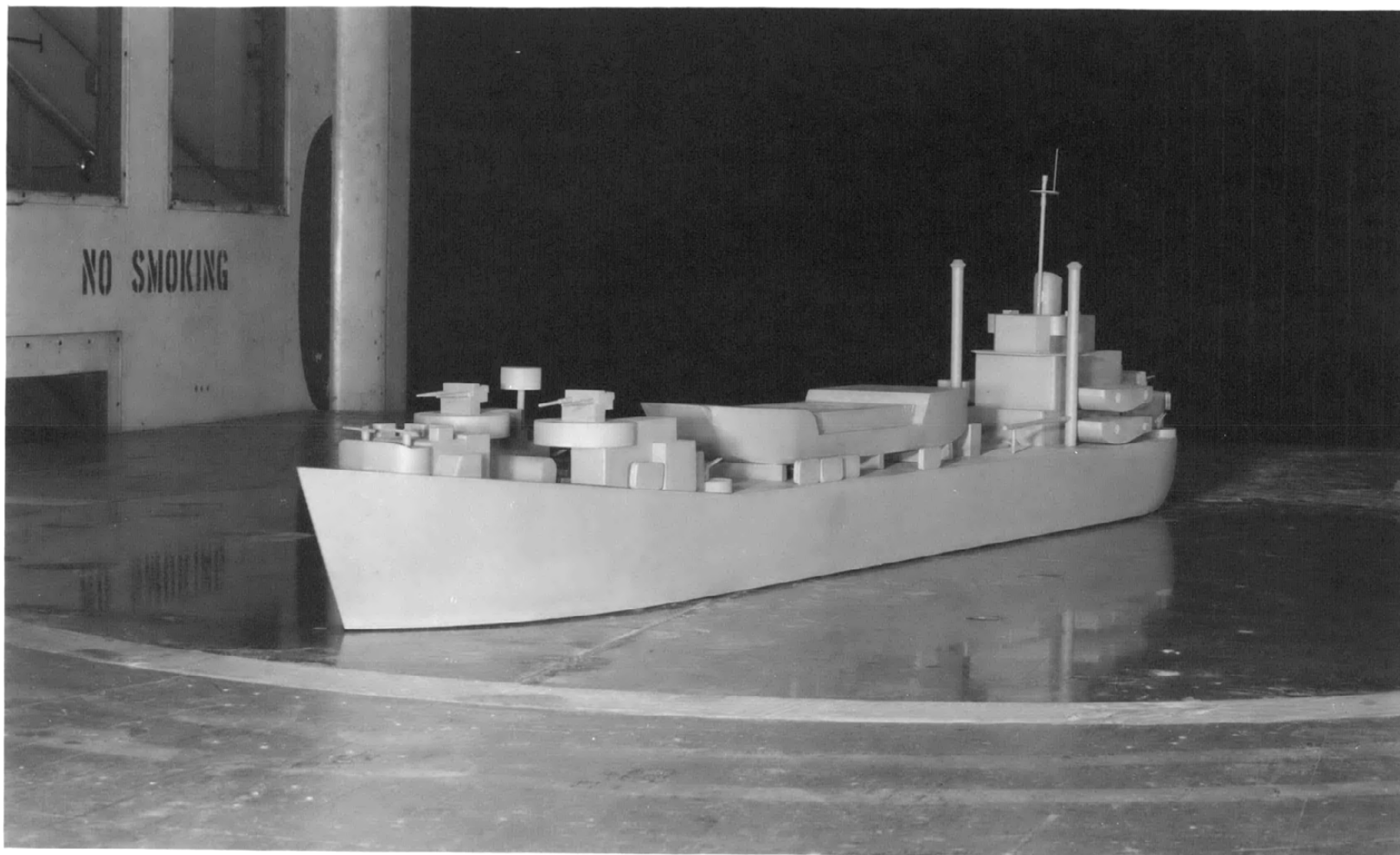


Figure 6 - One-Quarter Port View of a 1:73.6-Scale Model LST1156
Mounted on Ground Board in Wind Tunnel

NP21-51621

16 January 1953

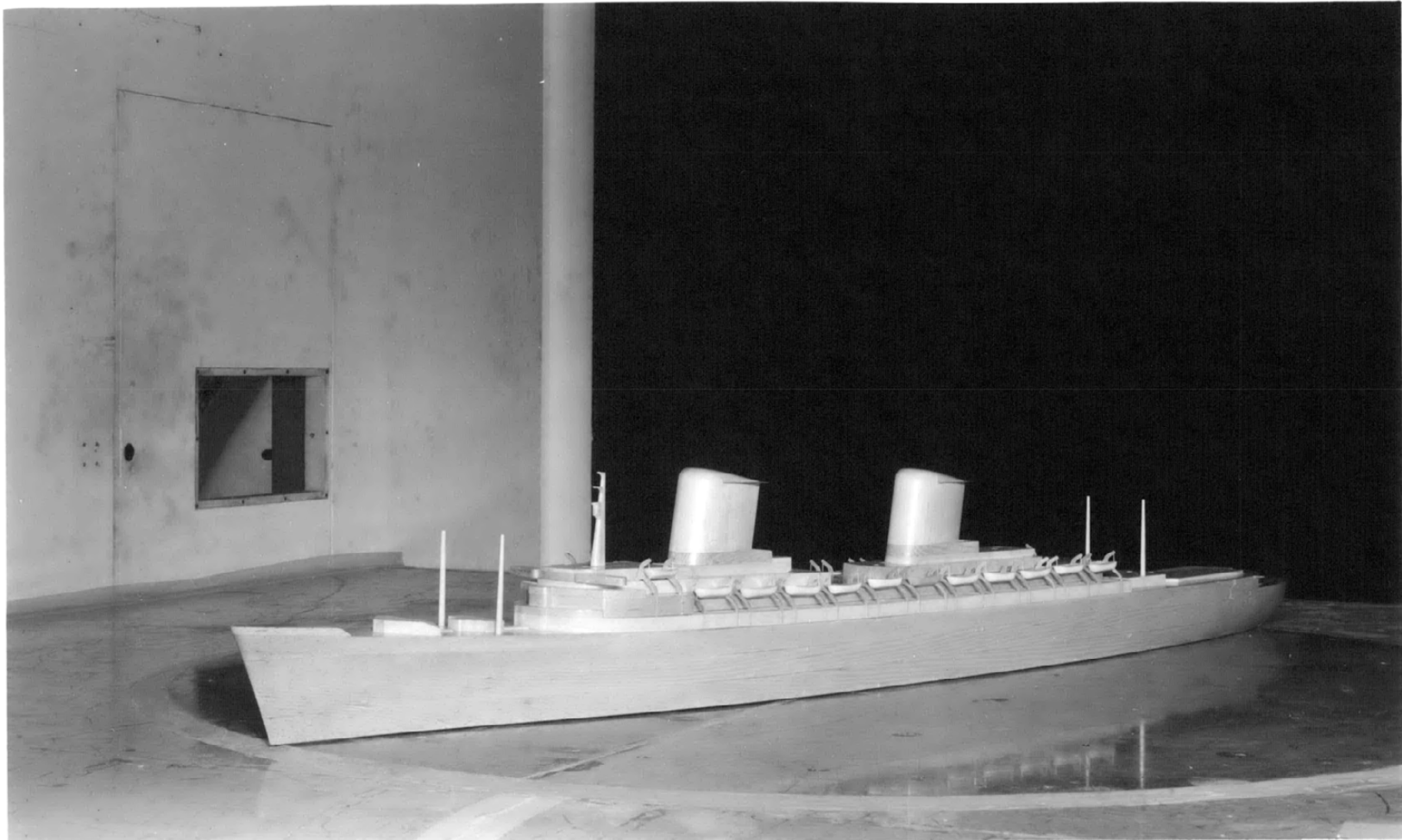


Figure 7 - One-Quarter Port View of a 1:150-Scale Model SS UNITED STATES
Mounted on Ground Board in Wind Tunnel

NP21-54326

17 September 1953

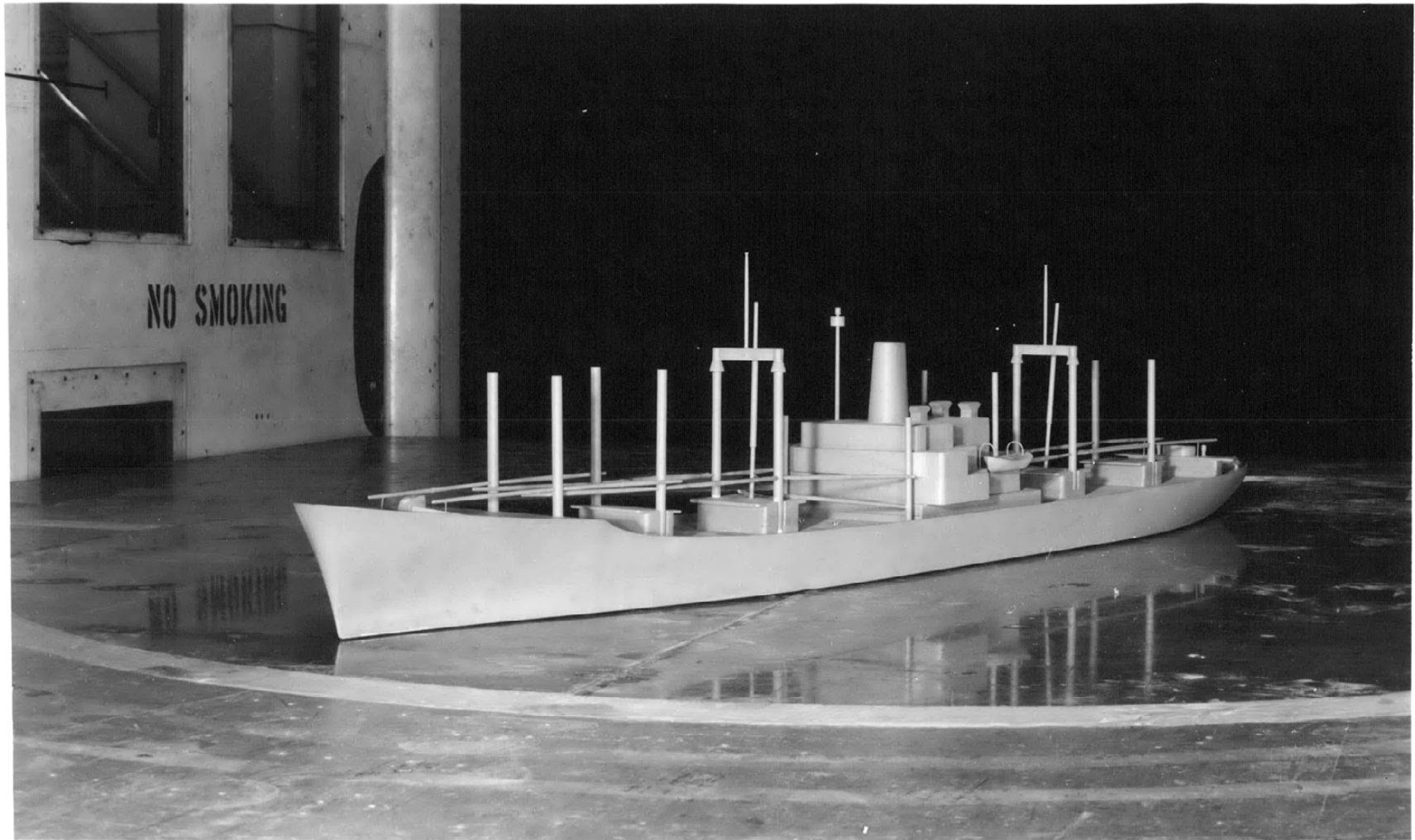
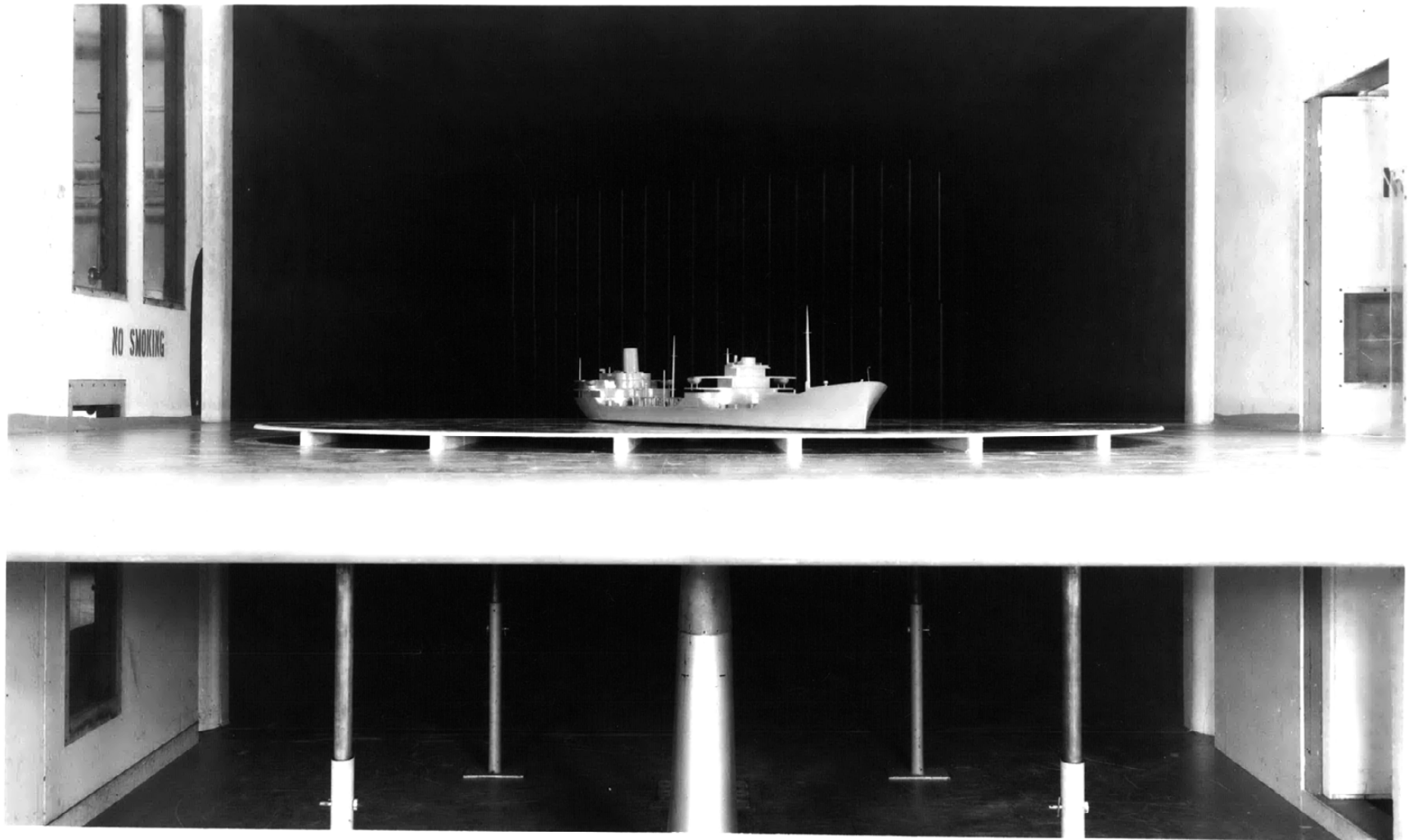


Figure 8 - One-Quarter Port View of a 1:105-Scale Model SS OLD COLONY
MARINER Mounted on Ground Board in Wind Tunnel

NP21-51622

16 January 1953

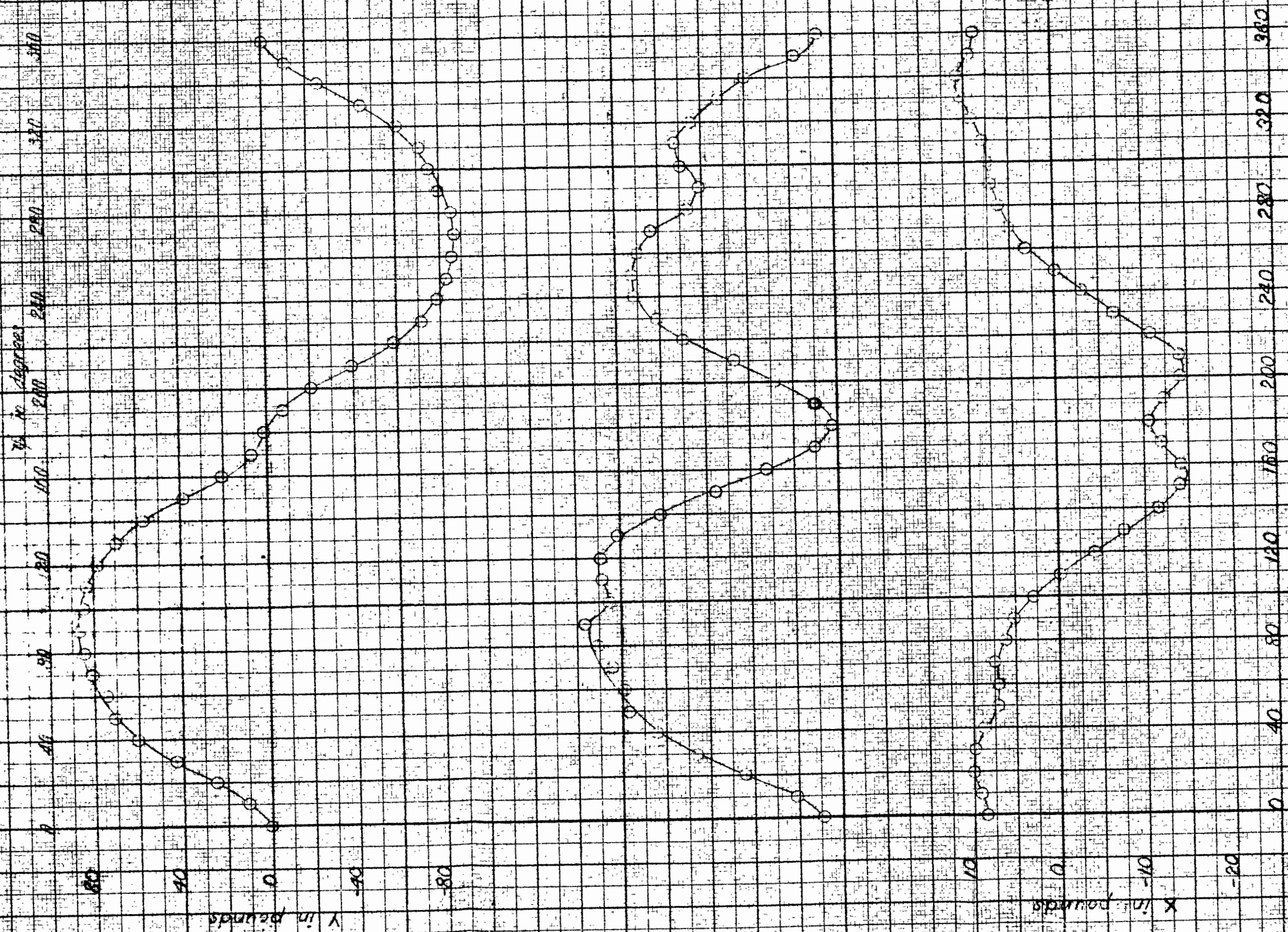


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Figure 9 - One-Quarter Starboard View of a 1:120-Scale Model SS PENNSYLVANIA
Showing Ground-Board and Fouling-Plate Installation in Wind Tunnel

TMB 44025

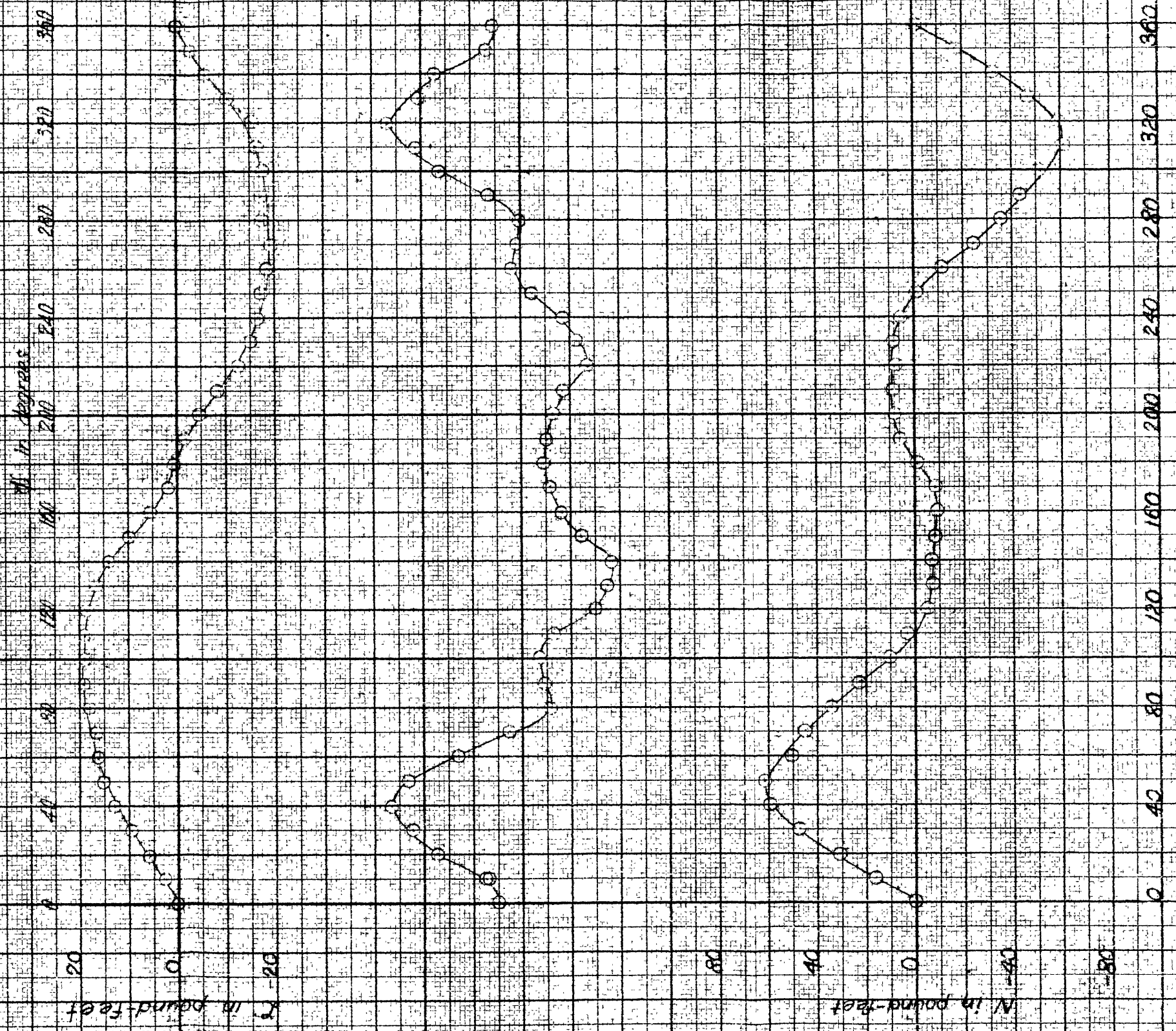
3 November 1950



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FIGURE 10

FIGURE 10 - AERODYNAMIC FORCES AND MOMENTS OF A 1/3.8 SCALE MODEL D1092 CROSS DESTROYER
 $\mu = 53.0 \text{ lb/ft}^2$

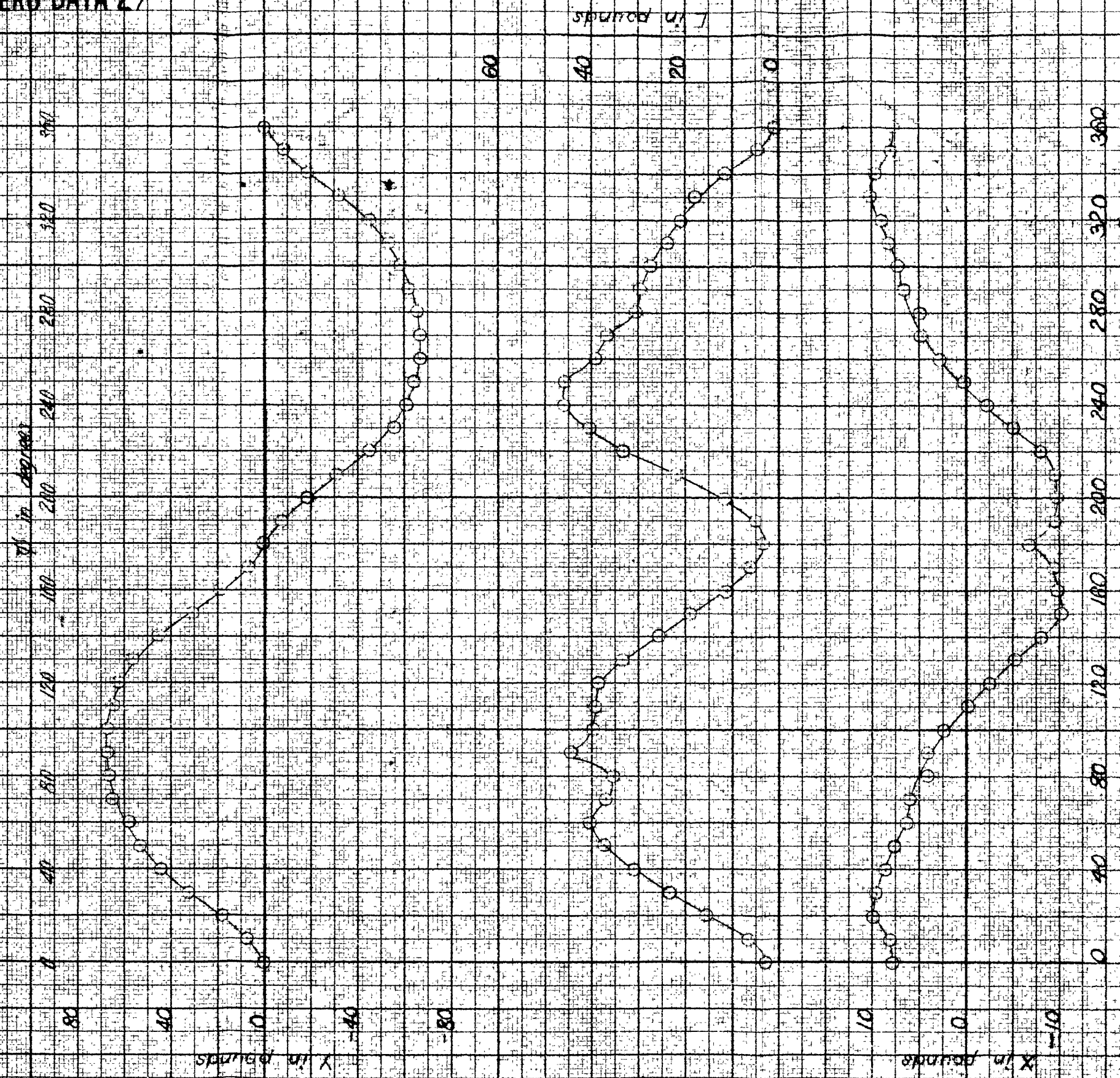


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FIGURE 10 (Continued)

W in degrees
Figure 10 (Continued)

SEM 26 Nov 54



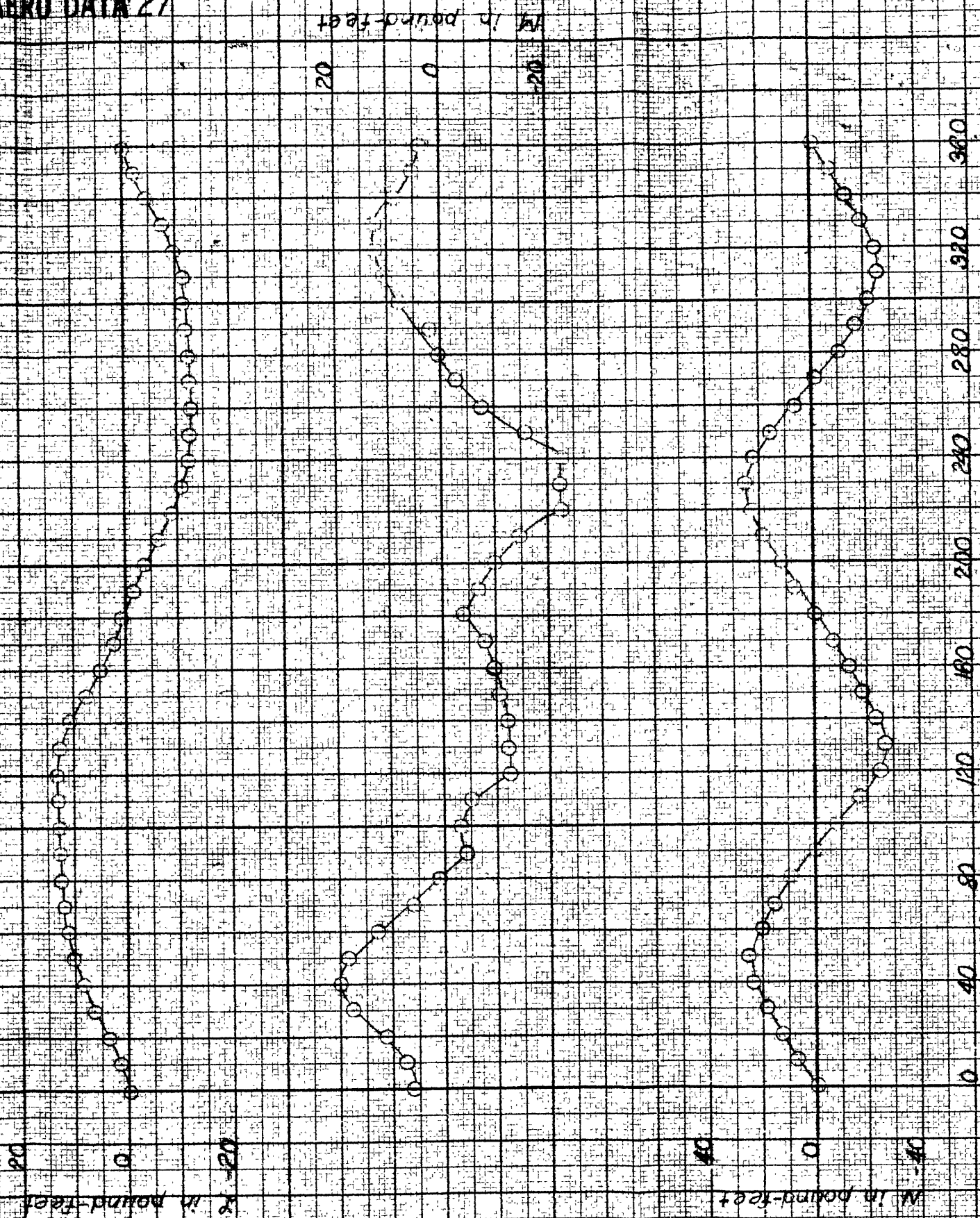
α in degrees

Figure 16 Aerodynamic Forces and Moments on a 1/400 Scale Model CA130 Class Cruiser

$q = 53.0 \text{ lb/ft}^2$

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W in degrees

Figure 11 (concluded)

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FIGURE 11 (concl)

α in degrees

360

320

280

240

200

160

120

80

40

0

-40

-80

Y in pounds

80

40

0

-40

-80

Z in pounds

60

40

20

0

10

X in pounds

0

-10

360

320

280

240

200

160

120

80

40

0

-40

-80

α in degrees

Figure 12 - Aerodynamic Forces and Moments on a B32A-Scout Model C1A5-Class Cruiser

$q = 53.0 \text{ lb/ft}^2$

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20
0
-20
Lb in pound-feet

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20
0
M in pound-feet

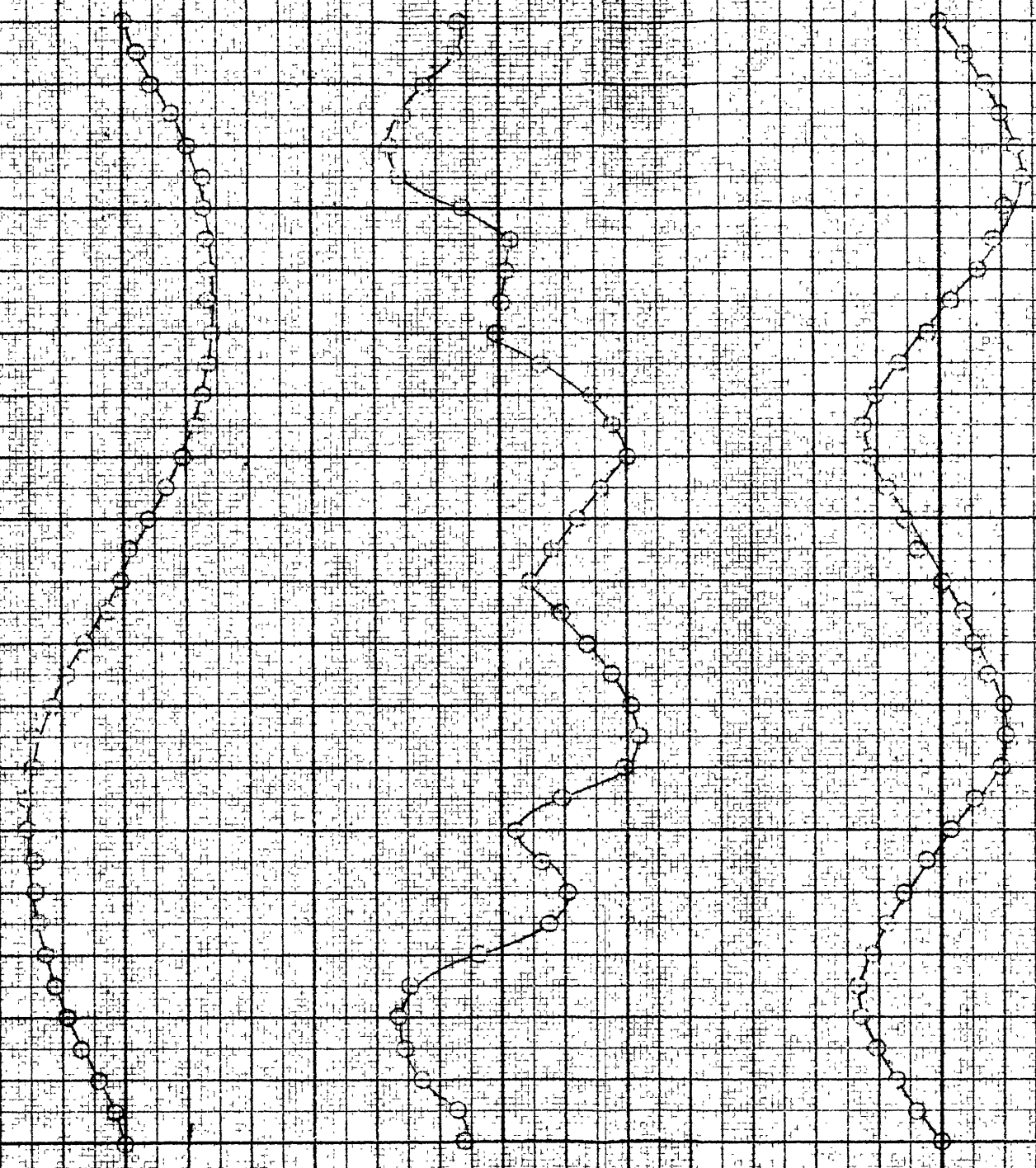
40
0
-40
N in pound-feet

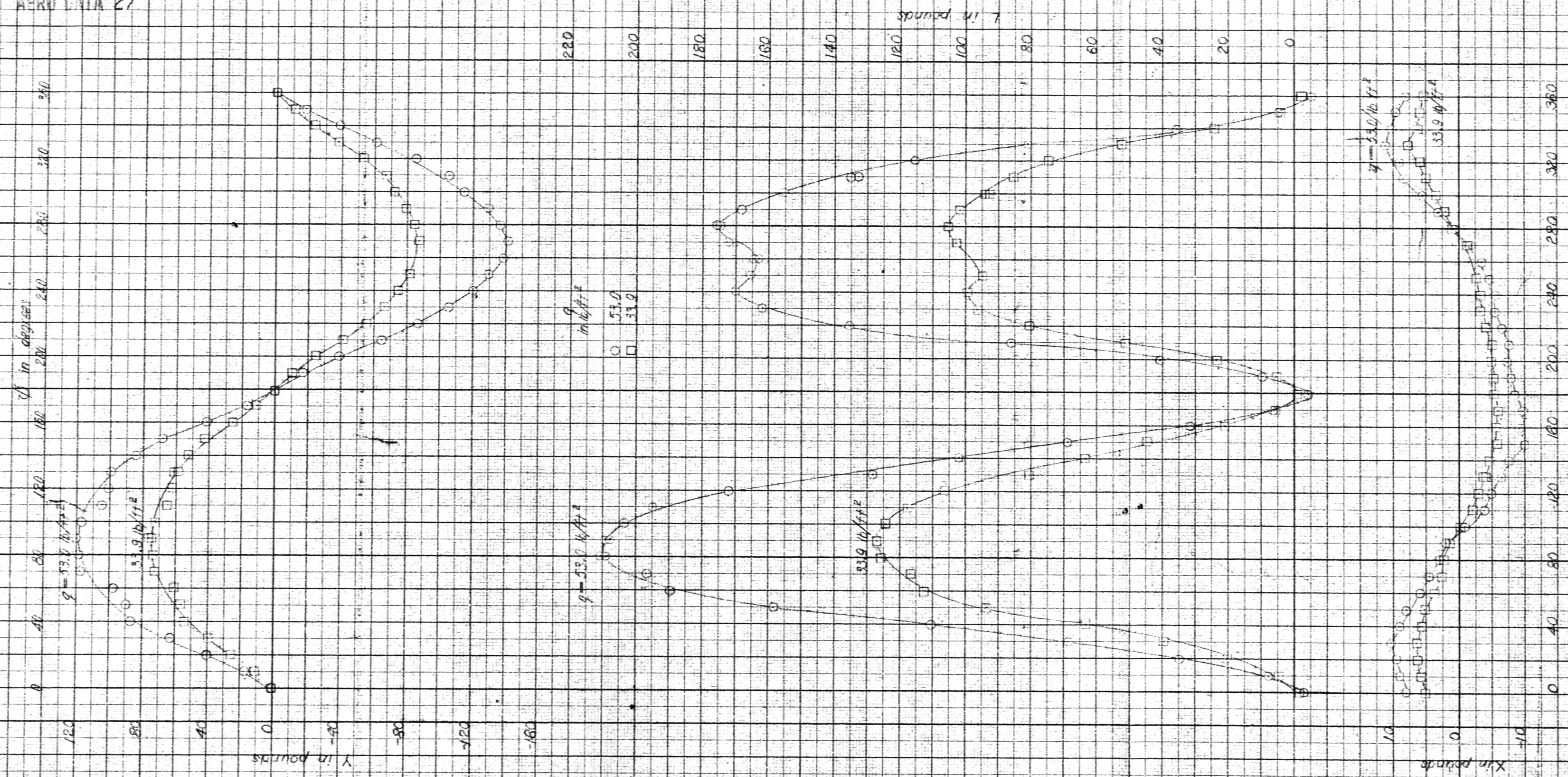
FIGURE 12 (cont'd)

0 40 80 120 160 200 240 280 320 360

W in degrees

Figure 12 (Concluded)

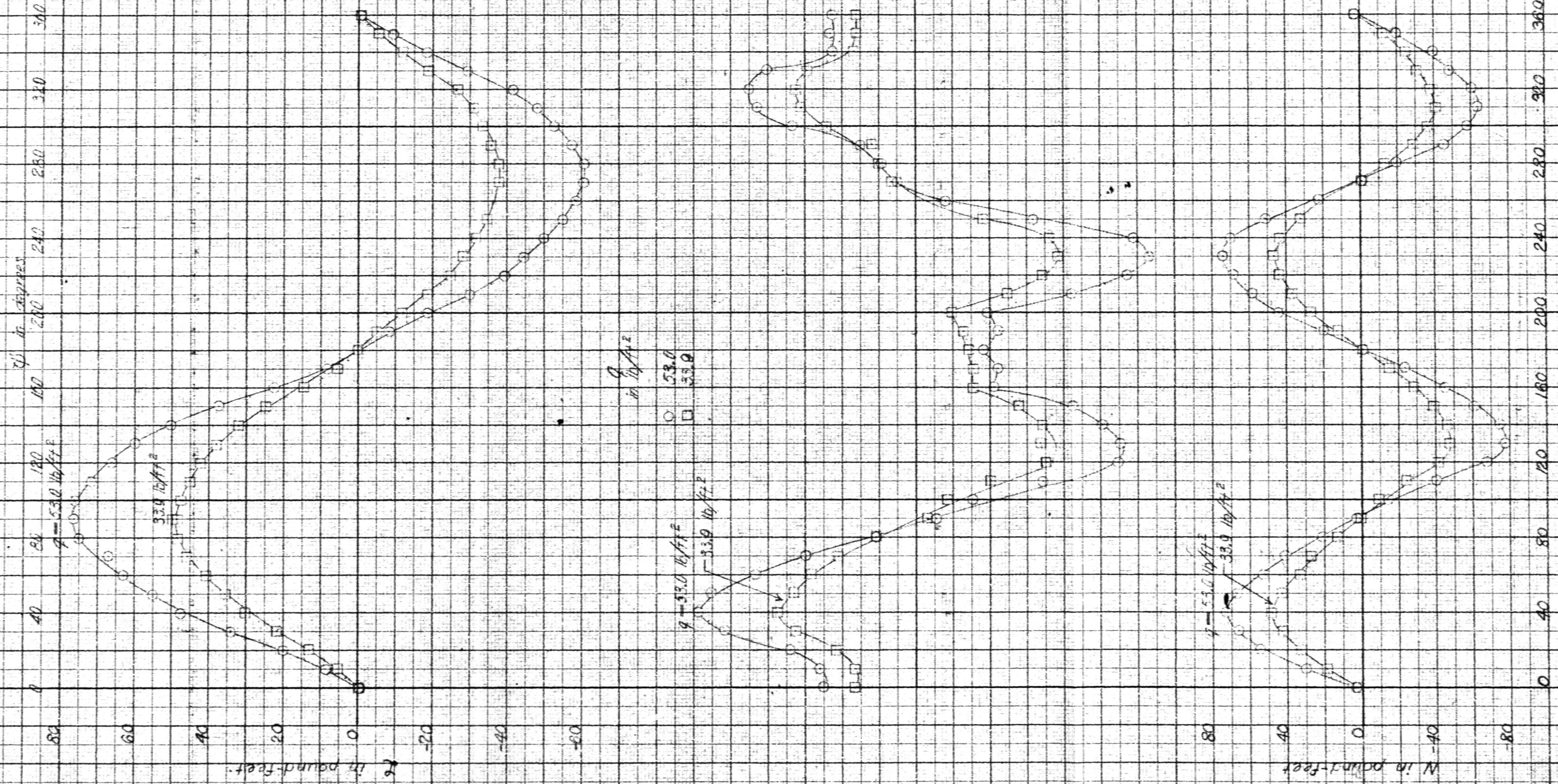




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FIGURE 13

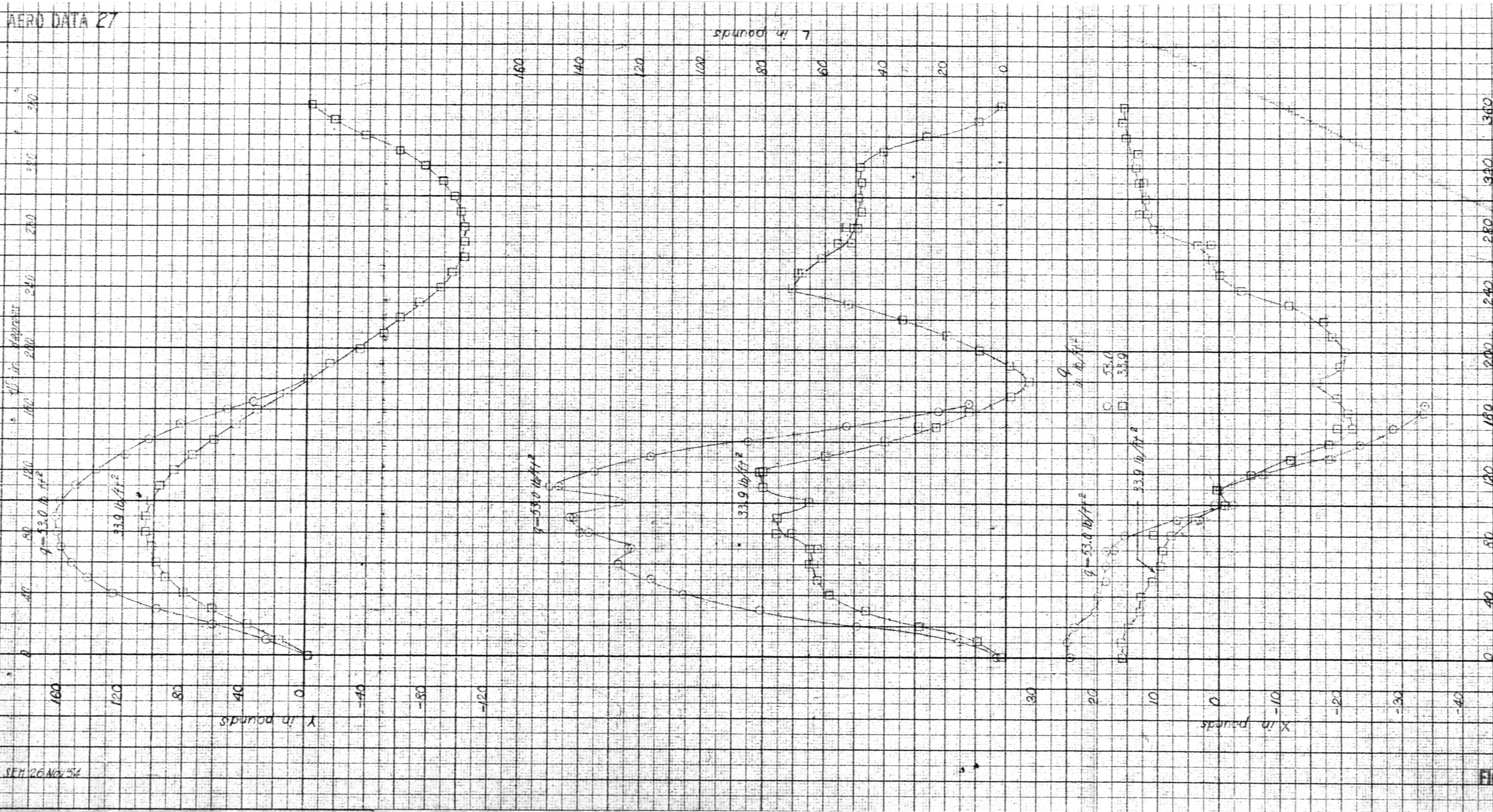
Figure 13 - Aerodynamic Forces and Moments on a 1/80.0 - Scale Model Aircraft Carrier CW9



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FIGURE 13 (cont)

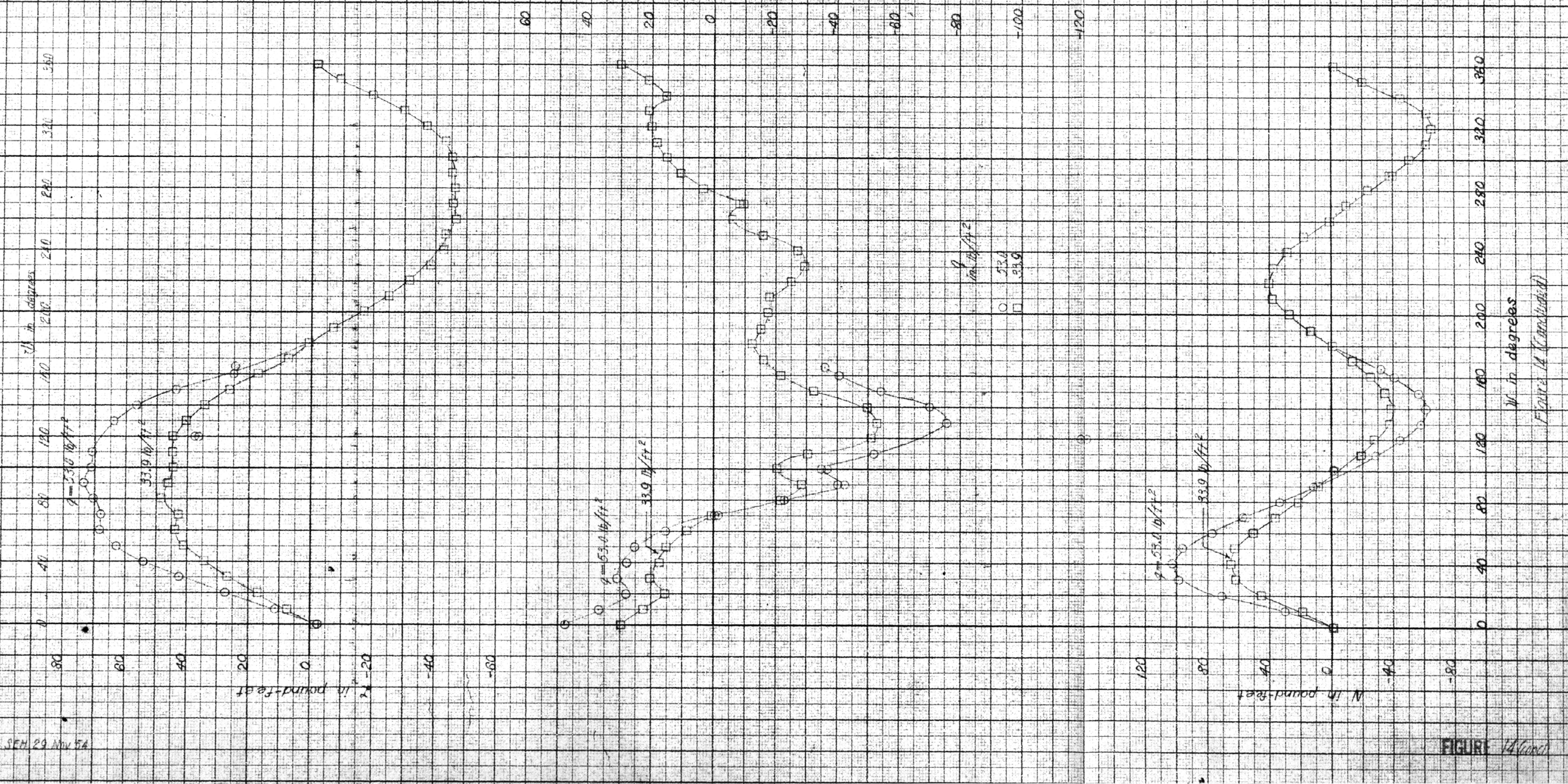
Figure 13 (concluded)



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FIGURE 14

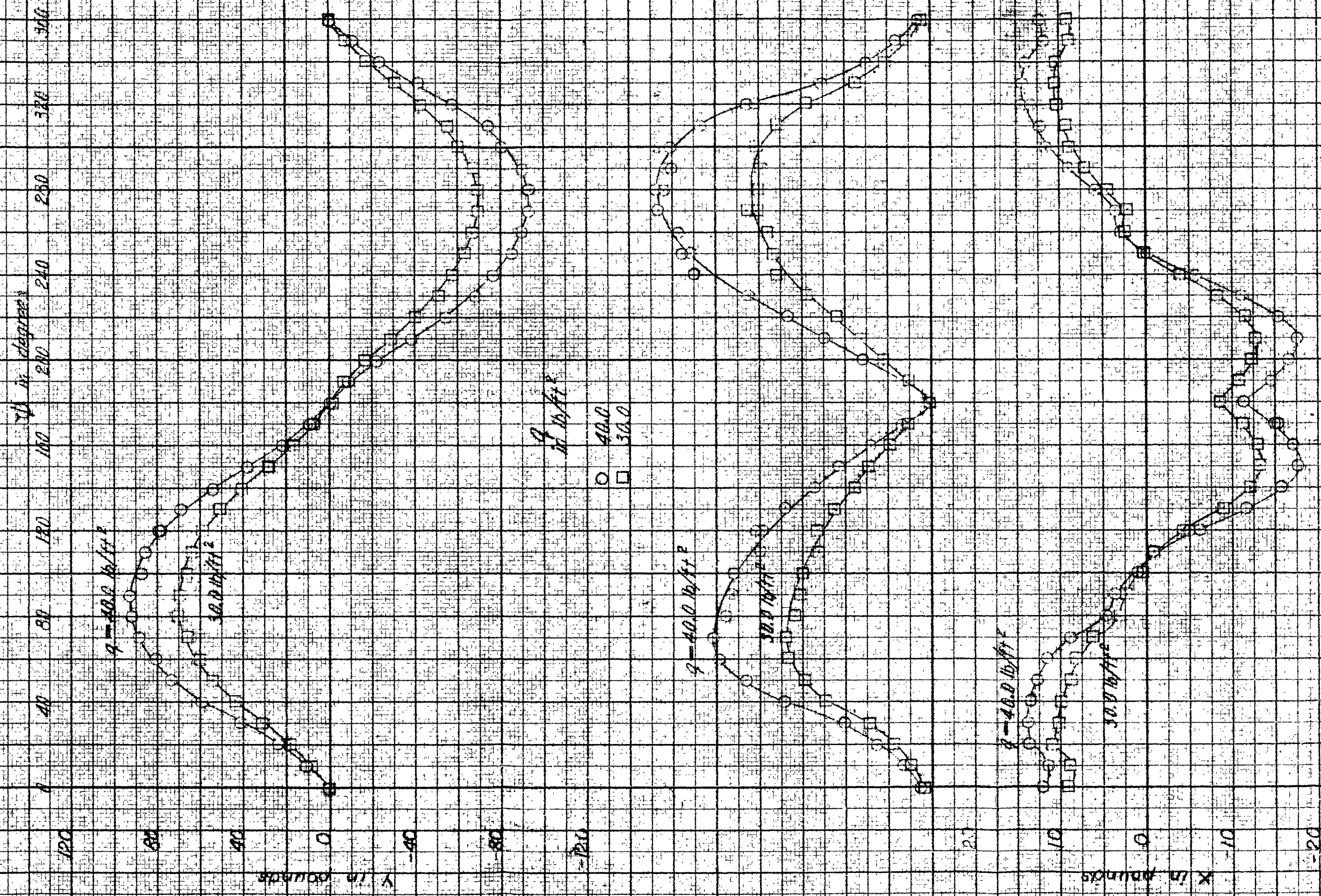
Figure 14 - Aerodynamic Forces and Moments on a 1/20-Scale Model YTB500 Tipback



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Figure A (Continued)

FIGURE 14 (Cont)

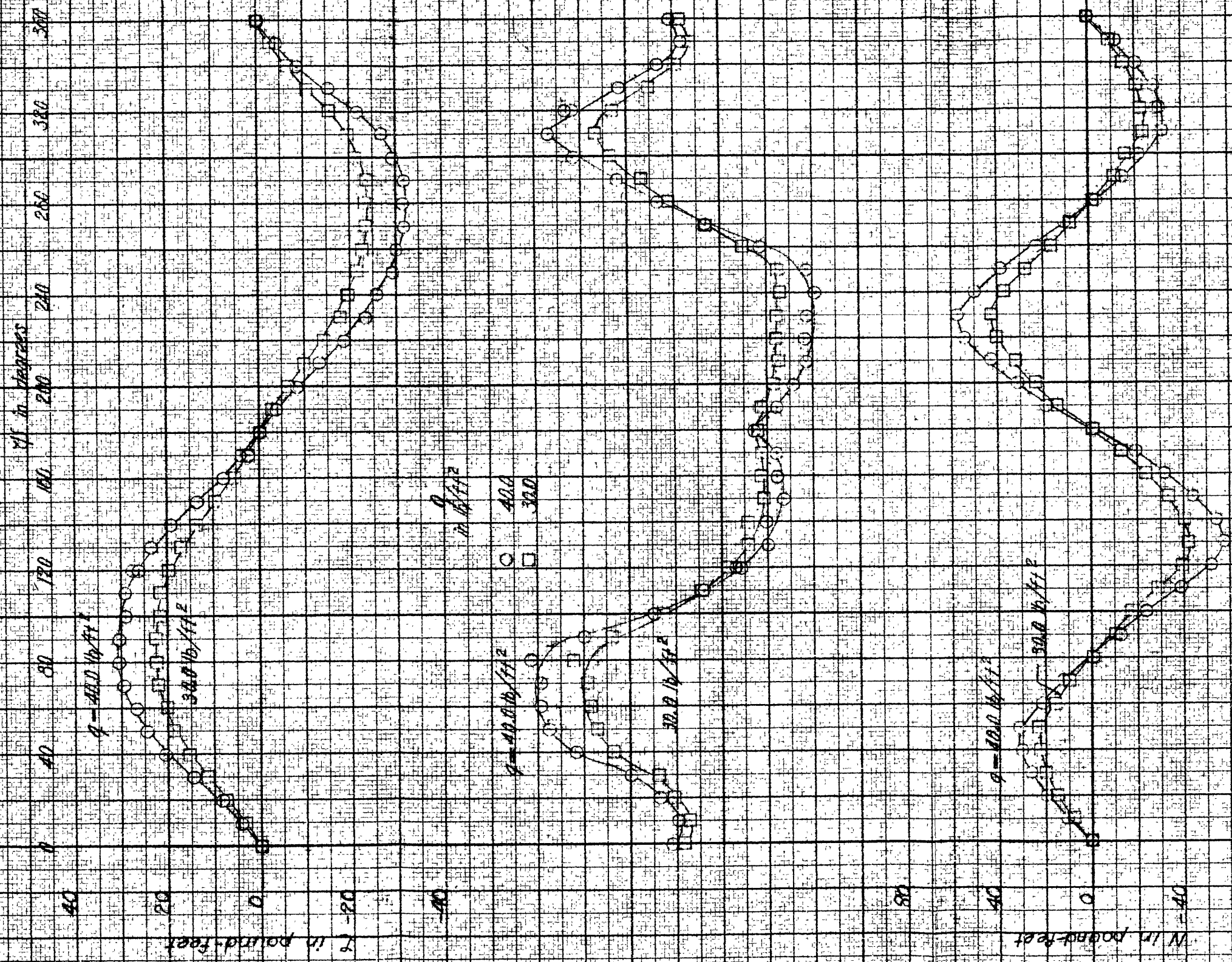


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FIGURE 15

Figure 15 - Aerodynamic Forces and Moments on a 1/3.6 Scale Model LS7158

α in degrees

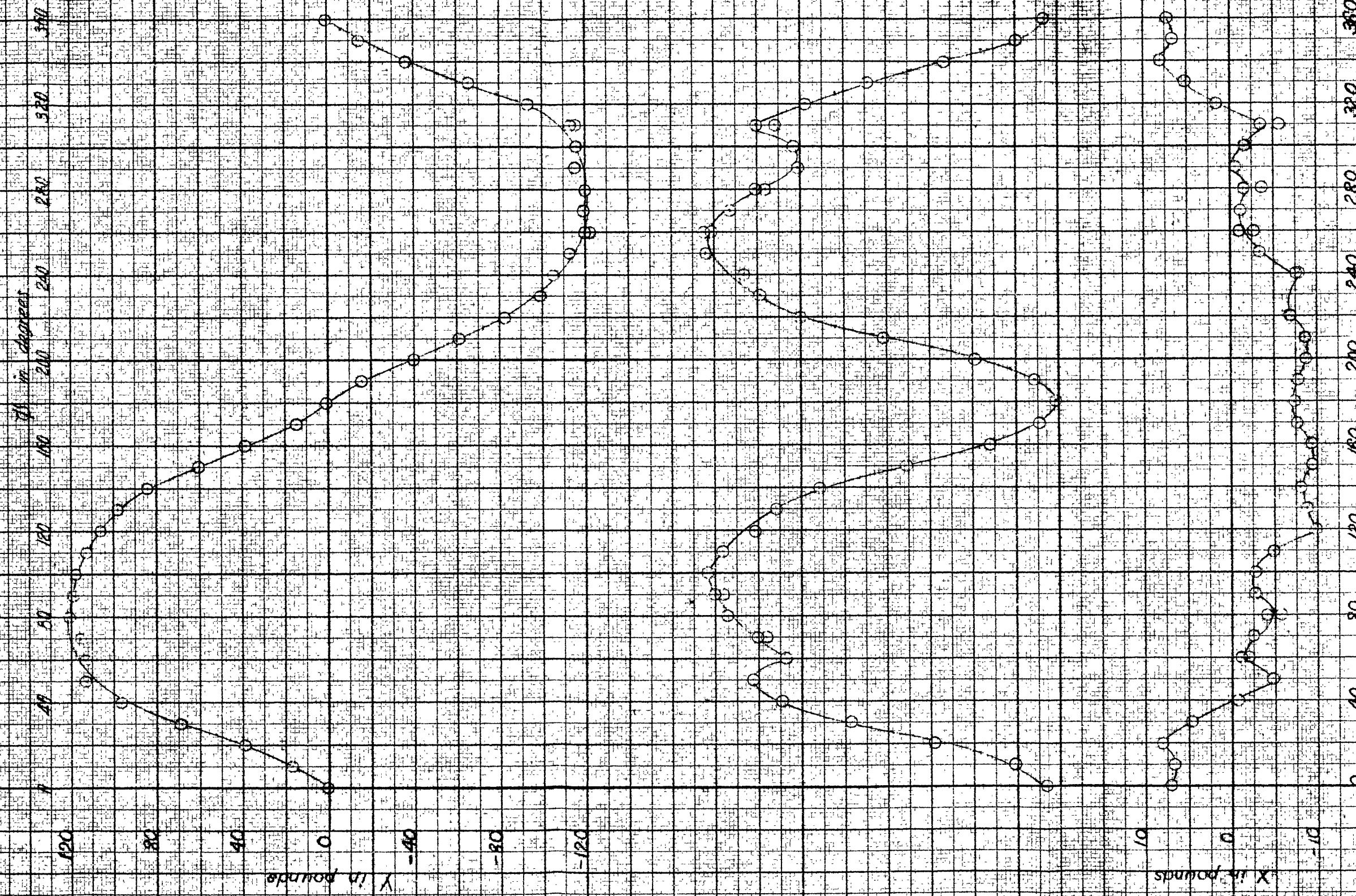


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FIGURE 15 (contd)

α in degrees

Figure 15 (concluded)

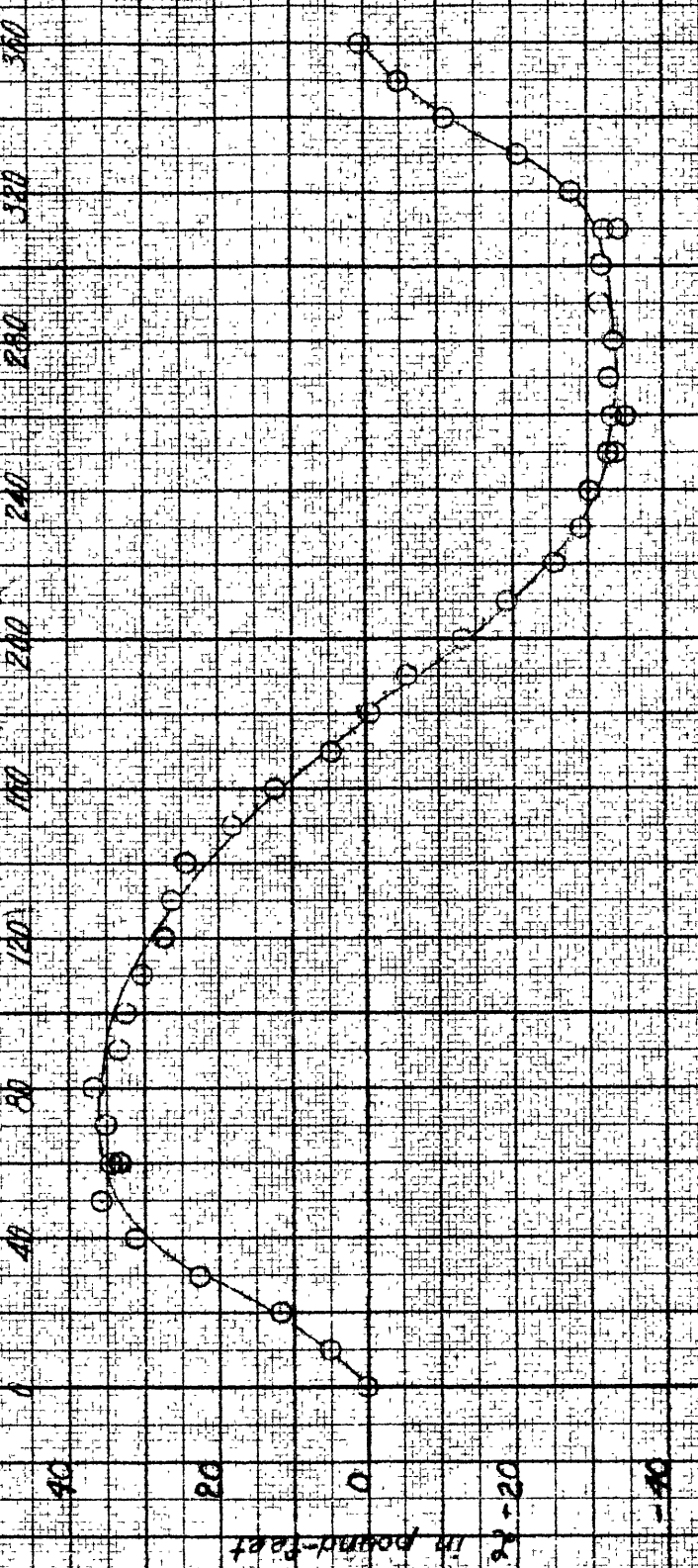


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FIGURE 16

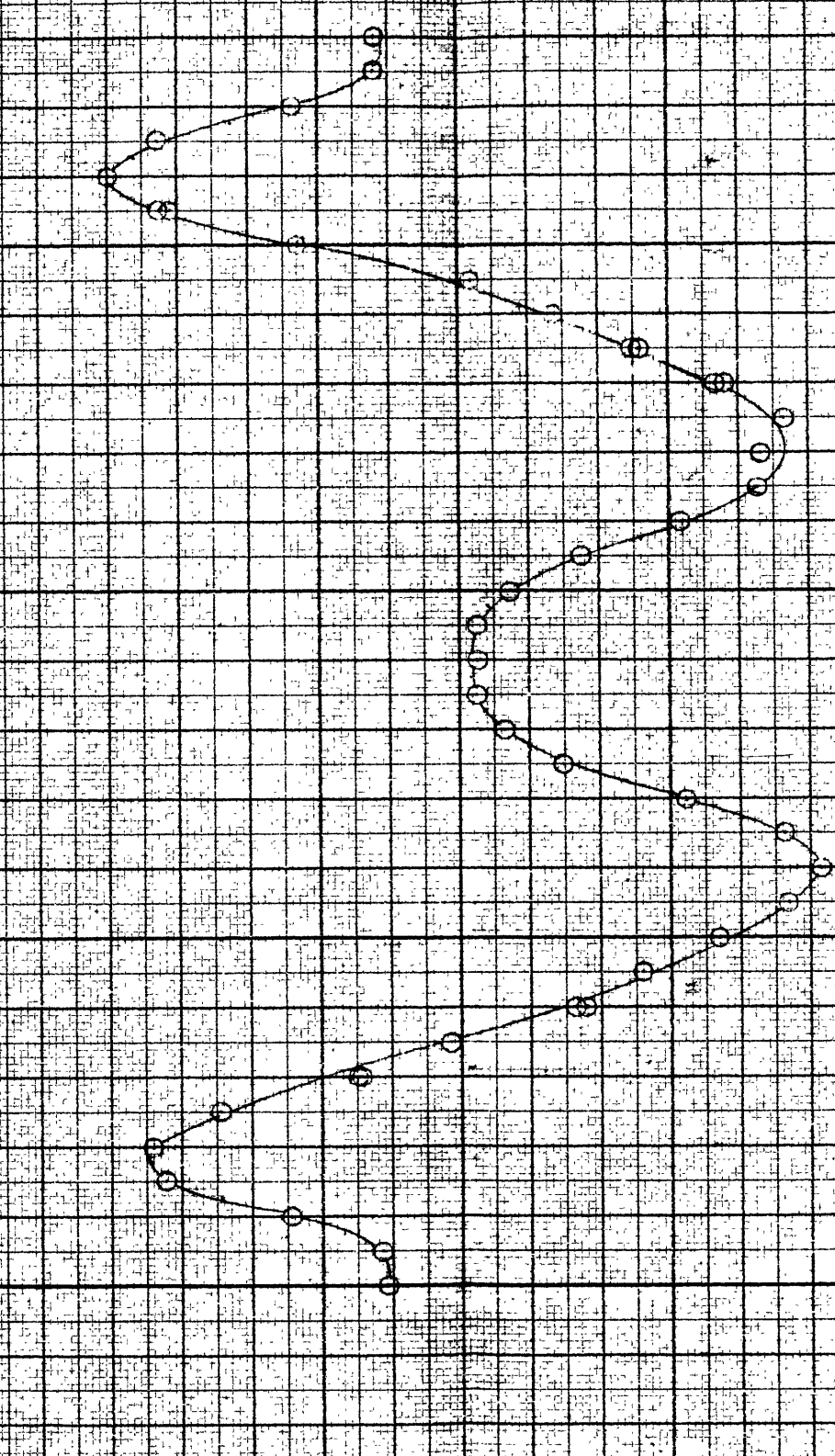
Figure 16 - Aerodynamic Forces and Moments on a 1/50 Scale Model SS, UNITED STATES
 $q = 400 \text{ lb/ft}^2$

W in degrees

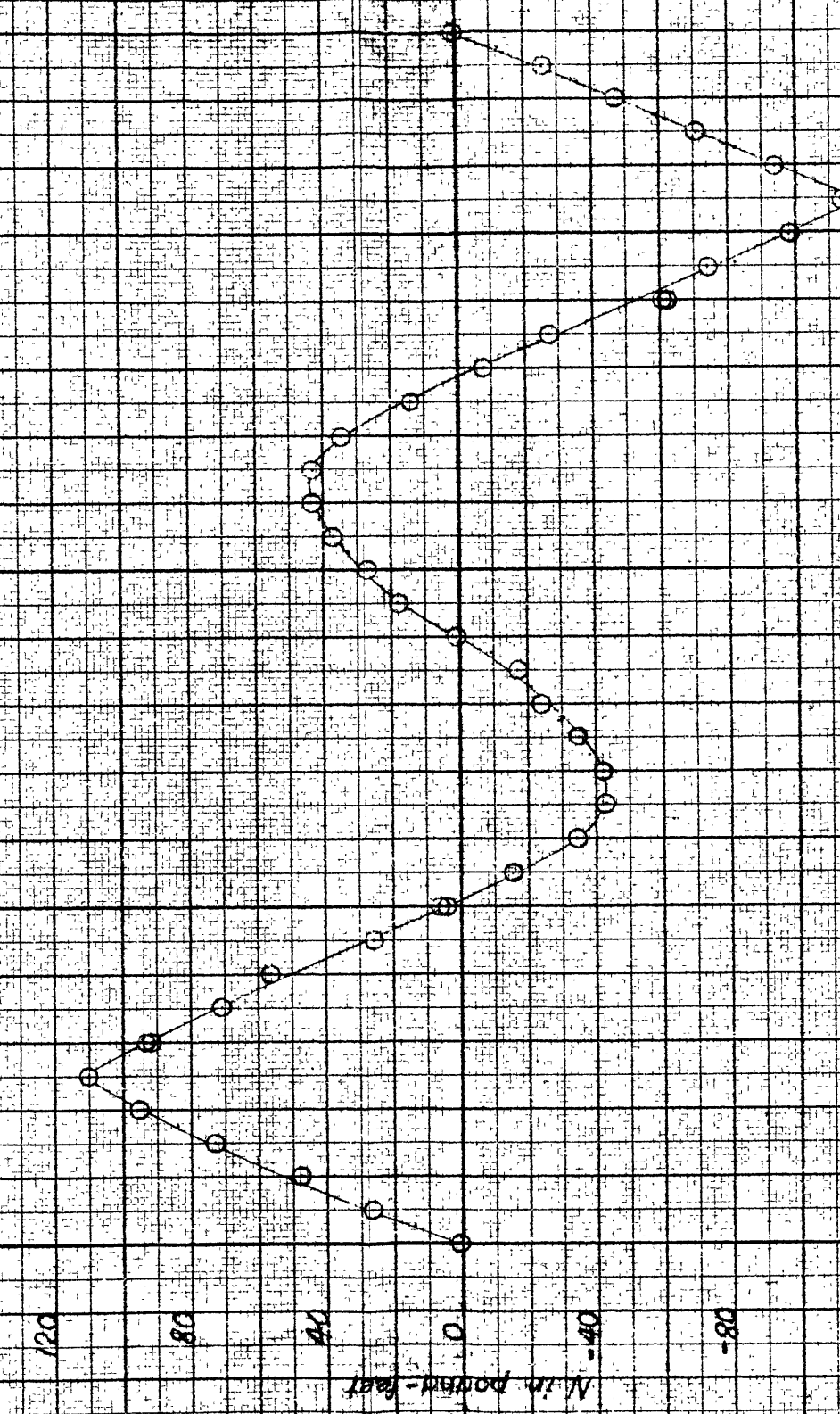


Cl in pound-feet

M in pound-feet



M in pound-feet



alpha in degrees

Figure 16 (continued)

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FIGURE 16 (cont)

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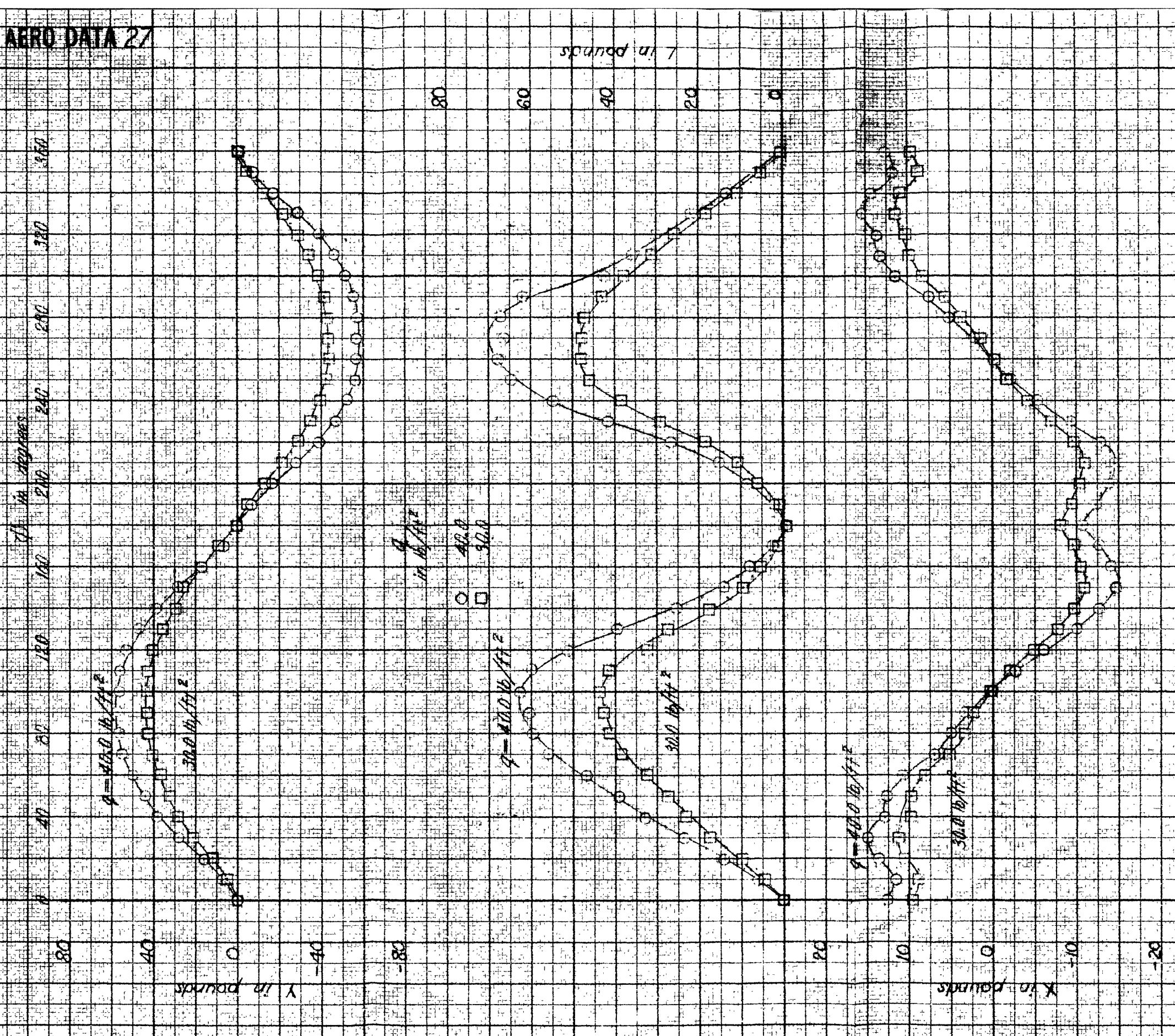
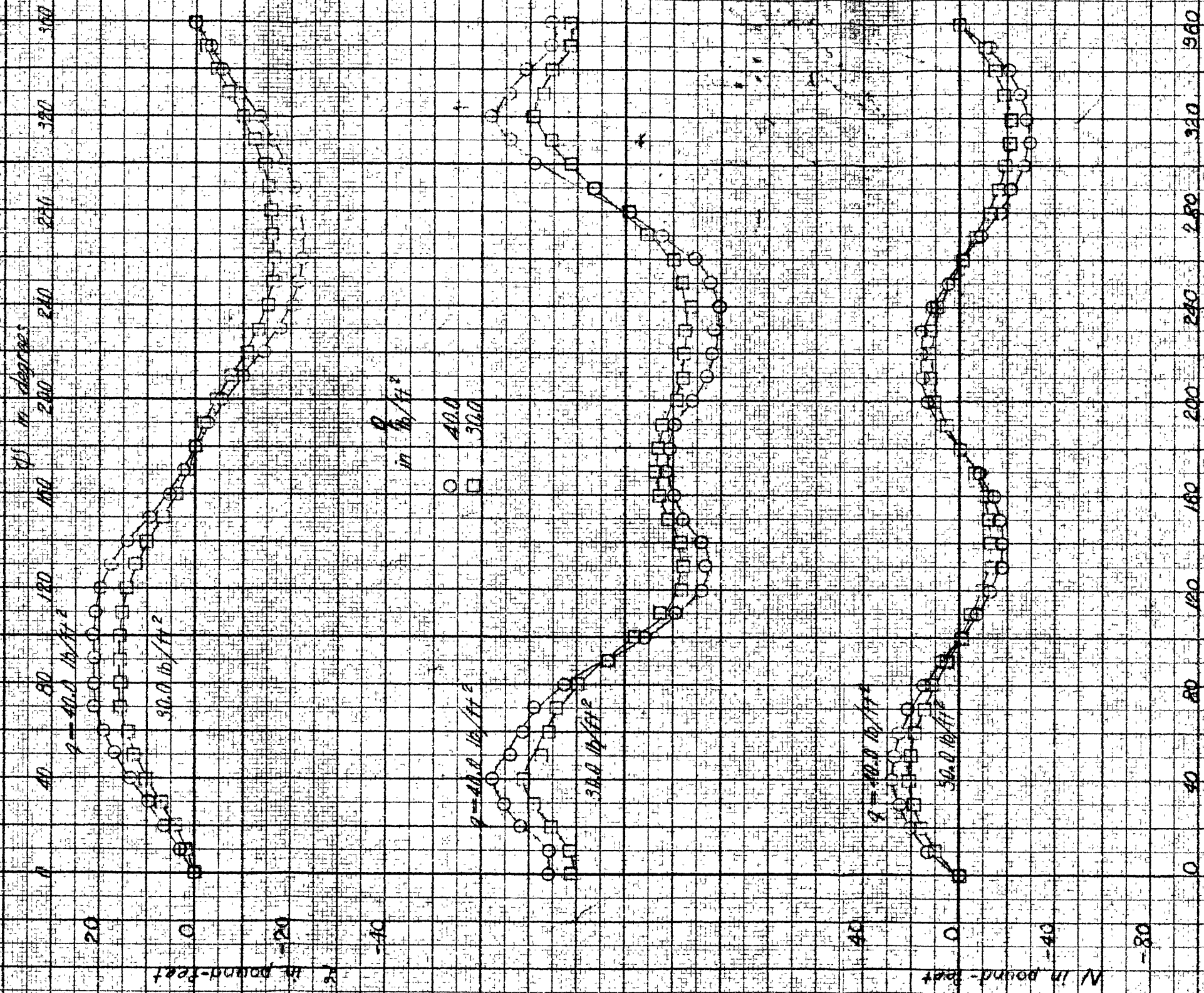


Figure 17 - Aerodynamic Forces and Moments on a 1/105 Scale Model SS-100 Colony Masses

FIGURE 17



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FIGURE 17 (cont.)

ψ in degrees
Figure 17 (concluded)

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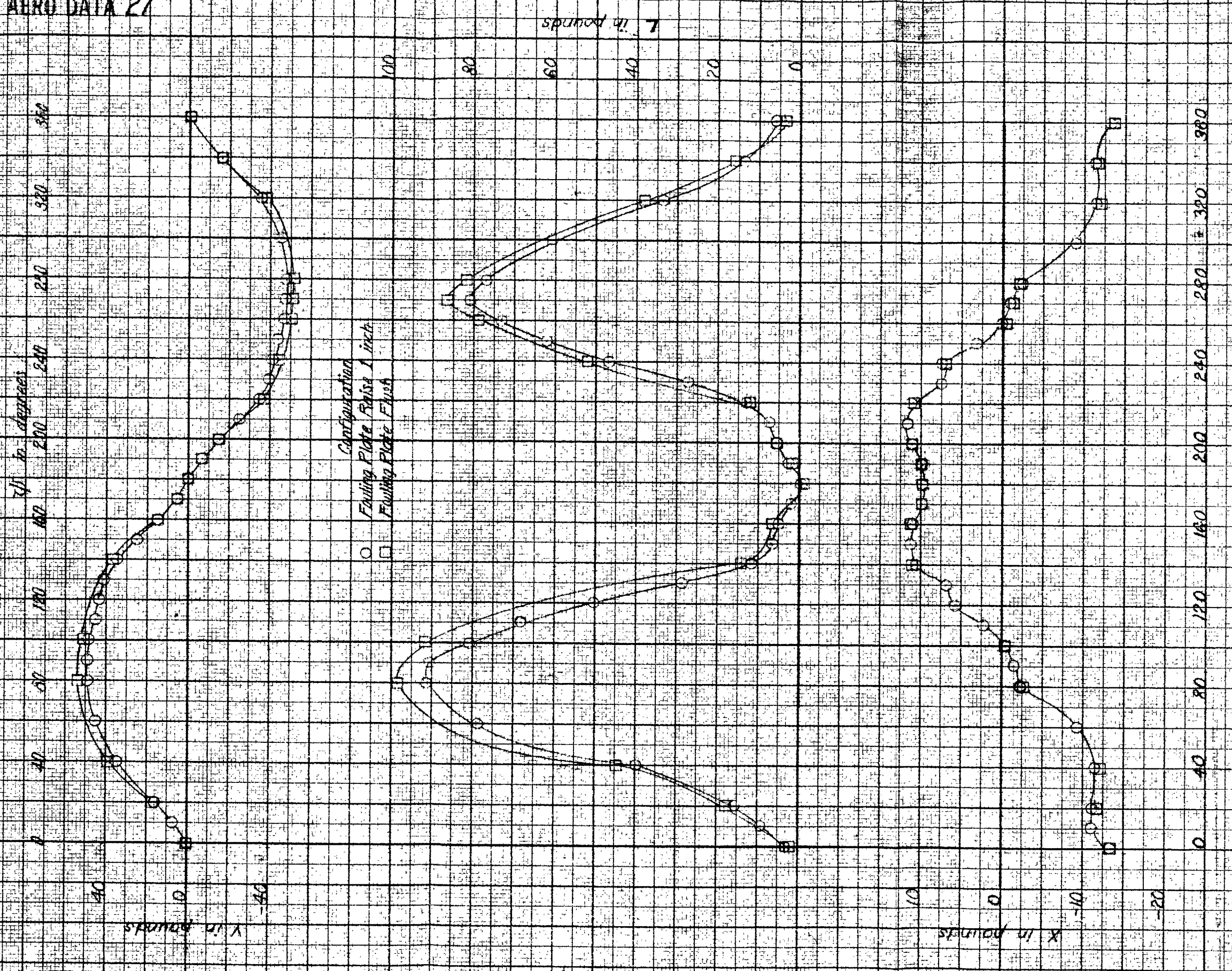


Figure 18 - Aerodynamic Forces and Moments on a 1/100 Scale Model SS Pennsylvania
 $q = 60 \text{ lb/ft}^2$

20
0
-20
N in pound-feet

20
0
-20
M in pound-feet

40
0
-40
N in pound-feet

Calculation
 ○ Failing Plate Raised 1 inch
 □ Failing Plate Flush

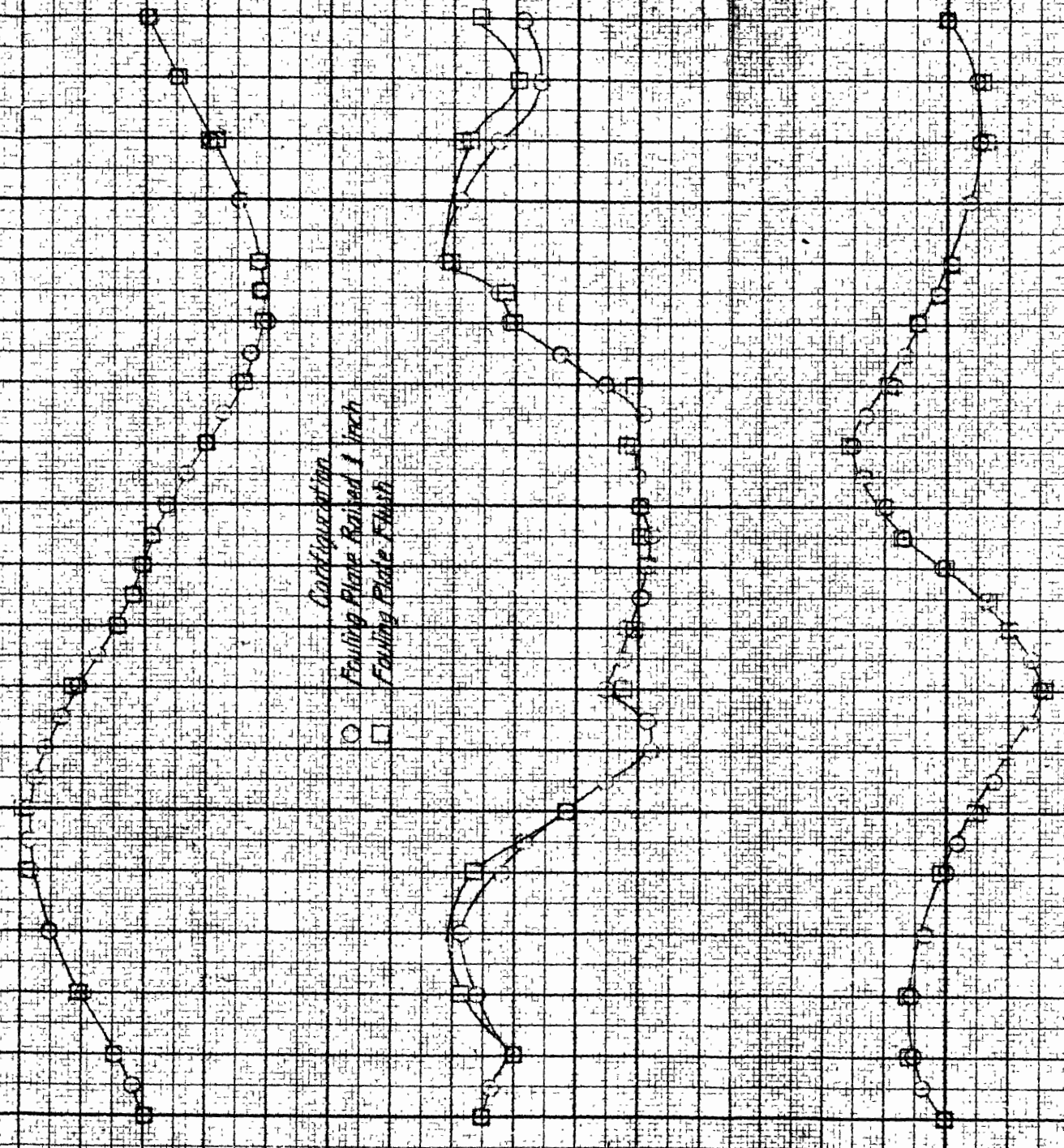
0 40 80 120 160 200 240 280 320 360

ψ in degrees

FIGURE 18 (concluded)

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FIGURE 18 (conclD)



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Sharon A. Little