REPORT C-1073, AERO REPORT 955

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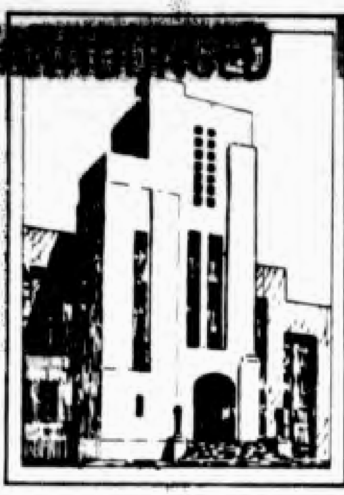

DEPARTMENT OF THE NAVY

DAVID TAYLOR MODEL BASIN

HYDROMECHANICS

AERODYNAMICS

STRUCTURAL MECHANICS

APPLIED MATHEMATICS

WIND-TUNNEL TESTS TO DETERMINE THE AIR-FLOW CHARACTERISTICS IN THE WAKES OF THREE AIRCRAFT CARRIER MODELS

PART II – TESTS OF THE ATTACK CARRIER CVA 62

by

Herbert E. White

AERODYNAMICS LABORATORY

RESEARCH AND DEVELOPMENT REPORT

June 1959

Report C-1073
Aero Report 955

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NSRDC ltr, 7 Oct 80.

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June 1959

Report C-1073
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NS 715-103

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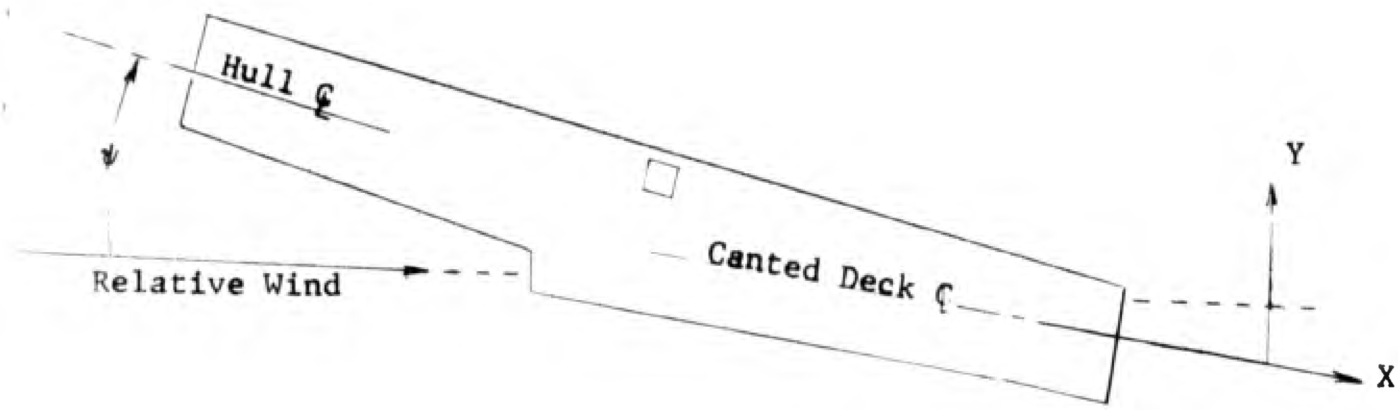
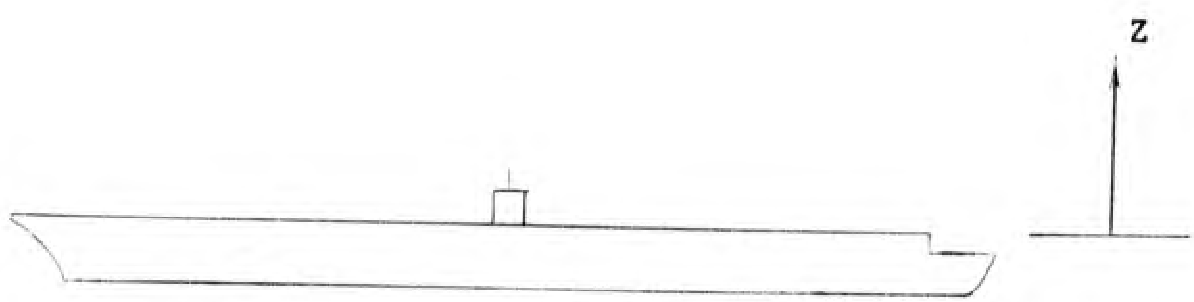
NOTATION

Arrows indicate positive directions of coordinates
and yaw angle





Axis	Positive Direction –	Along –	From --
X	Aft	℄ of canted deck	T.E. of canted deck
Y	Starboard	Perpendicular to relative wind	℄ of canted deck
Z	Up	Vertical line	Deck level

[redacted]

[redacted]

Symbols

q/q_r	dynamic pressure ratio
q	local dynamic pressure ($\rho V^2/2$) in pounds per square foot
q_r	reference (free stream) dynamic pressure ($\rho {V_r}^2/2$) in pounds per square foot
q_a	local dynamic pressure referred to airplane
q_o	initial airplane dynamic pressure at approach airspeed
V	local airspeed at any point in feet per second
V_r	reference (free stream) airspeed in feet per second
ρ	mass density of air in slugs per cubic foot
R	Reynolds number ($\rho V_r \ell/\mu$)
ℓ	length of flight deck in feet
μ	absolute coefficient of viscosity in pound-second per square foot
ψ	angle of yaw in degrees (angle between relative wind vector and the hull axial center line)

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AERODYNAMICS LABORATORY
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WASHINGTON, D. C.

WIND-TUNNEL TESTS TO DETERMINE THE AIR-FLOW CHARACTERISTICS IN THE WAKES OF THREE AIRCRAFT CARRIER MODELS

PART II - TESTS OF THE ATTACK CARRIER CVA 62

by

Herbert E. White

SUMMARY

Tests of a 1/144-scale model CVA 62 aircraft carrier were conducted in the wind tunnel to determine the local dynamic pressures in the area downwind of the carrier.

Surveys were made with a pitot-static rake for three directions of relative wind. Plots are presented showing the ratio of local to free-stream dynamic pressure at various locations. Also, a representative plot is presented which shows the dynamic pressure profiles encountered along a typical approach path for an assumed set of conditions.

The data show that, from the dynamic pressure viewpoint, wind over the bow at 0° is the most favorable condition. With wind at 10° to port (nearly aligned with the center line of the canted deck), and at 20° the conditions are considerably less favorable.

INTRODUCTION

Variations of air flow downwind of a carrier are responsible for a considerable part of the difficulty encountered

[redacted]

reference. The rake of tubes was mounted on a three-axis system of tracks. Pins and numbered pinholes facilitated repetition of position for the more frequently changed positions. This setup is shown in Figures 4 and 5. Pressures on the rake were applied to the tubes of two multiple manometer boards. The tube heights were then recorded on film.

TEST CONDITIONS AND PROCEDURES

The tests were conducted in Wind Tunnel 1, an 8- by 10-Foot Atmospheric Tunnel. The model was installed with the "image" model erect and the real model inverted. The support strut was attached to the ceiling and to the image model. The image model method is preferred because it simulates the water surface without requiring a large ground board in the tunnel. This facilitates adjustments of the model and survey equipment.

As mentioned before, the survey mattress was provided with a system of tracks permitting accurate and rapid positioning.

With the model fixed at a certain yaw angle, a dynamic pressure of six inches of alcohol, corresponding to a velocity of 84 knots, was generated in the tunnel. The pressures on these various tubes of the rake were then recorded by photographing a manometer board. By repeating this procedure for predetermined rake positions, with model both in and out, it was possible to record the dynamic pressures throughout the wake of the model. Using this method cancels out the effects of pitot-tube calibration errors and local variations of dynamic pressure in the tunnel.

The model was tested at yaw angles of 0°, 10°, and 20°. These angles correspond to relative-wind angles on the angled deck of 10 1/2° starboard, 1/2° starboard, and 9 1/2° port. The average Reynolds number, based on standard conditions and a model hull length of 6.81 feet, was 5.87×10^6.

Yes, but q on the airplane is result of net velocity of the airplane, so these reported q changes are not significant

RESULTS

The basic results of the test are presented as ratios of local dynamic pressure in the wake to free-stream dynamic pressure (Figure 6). The ratio of dynamic pressures was chosen instead of the ratio of velocities because the aerodynamic forces vary directly with dynamic pressure. For one set of approach conditions the environment encountered by an approaching airplane has been derived and is presented in Figure 7.

Symbols, notation, and axes are shown in the "Notation" sheet. No corrections for wind-tunnel effects were necessary. Certain areas of the plots show excessive scatter. This is probably due to errors in film readings. Because of the large volume of data involved, only those areas considered significant were checked.

DISCUSSION

In analyzing the dynamic pressure ratios referred to the carrier (as presented in Figure 6) in terms of the effect on an airplane approaching to land, it is important to remember that the airspeed of the airplane is much greater than that of the carrier.

Suppose, for example, that the carrier is moving at an airspeed of 30 knots and that at some point in the approach path the local airspeed is 15 knots. This will be a loss in airspeed of 50 percent. (The loss in q/q_r will be 75 percent.) Now suppose that an airplane approaches the carrier at an airspeed of 130 knots. As the airplane enters that portion of the wake where the local airspeed is 15 knots lower, it will experience a loss of airspeed of 15 knots, but this will be a loss of only 12 percent. The corresponding loss in q_a/q_o will be 23 percent. It will be seen that a given decrease, in either airspeed or dynamic pressure, is much less, in percentage, for the airplane than for the carrier. The factor that makes this relatively small decrease in airspeed so important is, of course, the fact that the airplane is already at a speed not very far above the stall.

A simple formula has been developed by which one may go from the form of dynamic pressure ratio q/q_r in which the data are presented to the more significant dynamic pressure ratio q_a/q_o. The results of this equation (shown below) are presented for a set of assumed approach conditions in Figure 7. For airplane airspeeds greater than the carrier airspeed:

$$\frac{q_a}{q_o} = \left[1 - \frac{V_r}{V_a}\left(1 - \sqrt{\frac{q}{q_r}}\right)\right]^2$$

Studying Figure 7, and comparing it with Figure 6b, from which it is derived, may help the reader to understand the effect of the difference between airplane and carrier airspeed.

At 0° yaw angle, the wake of the island is in evidence. It produces a sharp depression in a region that might be traversed by the right wing of an airplane on some approaches. Effects of the hull and the flight-deck overhang do not appear significant at this wind angle.

At a yaw angle of 10° (W.O.D. approximately aligned with the canted deck), there is a rise in q/q_o just to starboard of the approach center line, and a decrease to port, giving left roll (port wing down) for the close-in stations. However, if the airplane gets off the center line of approach about 50 feet to starboard it will encounter a strong right roll and a decline in q/q_o.

In general the wake at 10° is much rougher than at zero. The effects of the hull, which is now inclined to the wind, are quite prominent. At 1537 feet aft, the disturbance is seen as high as 79 feet above the deck. At this station, the farthest aft surveyed, the disturbance is to port of the approach center line. If the disturbance extends far enough aft, it will be traversed by an airplane on its crosswind leg.

The wake at a yaw angle of 20° is extremely rough out to about 500 feet aft of the trailing edge of the carrier. From 500 feet out to 1580 feet, there is a wide area of depressed q/q_o across the approach path.

The wakes at yaw angles of 10° and 20° are both considerably less desirable than that at a yaw angle of 0°. It appears from analysis of the data that the best distribution of q/q_o might occur at a yaw angle between 0° and 10°. If this is the case, some crosswind (relative to canted deck) would have to be tolerated to achieve the best q/q_o distribution. It might be that the improvement in q/q_o distribution would be worth the sacrifice in wind alignment. Further wind-tunnel tests could determine the best yaw angle from the standpoint of dynamic pressure ratios, but only flight experience can determine the effects of crosswind on the ease of approach.

Aerodynamics Laboratory
David Taylor Model Basin
Washington, D. C.
June 1959

REFERENCE

1. BUSHIPS CONF ltr C-A11/NS-715-103 Ser 420-0179 of 30 Jul 1956

Table 1

Altitudes at the Fore and Aft Stations for a Typical Approach Path

Carrier Yaw Angle in degrees	Survey Station	Distance Aft of T.E. of Deck, feet	Distance Aft of Touchdown, feet	Altitude Above Deck, feet
0	1	-16	134	15
	2	20	170	18
	3	130	280	26
	4	240	390	33
	5	533	683	54
	6	1045	1195	90
	7	1558	1708	125
10	1	-11	139	16
	2	25	175	18
	3	133	283	26
	4	241	391	33
	5	529	679	53
	6	1033	1183	89
	7	1537	1687	124
20	1	10	160	17
	2	47	197	20
	3	156	306	27
	4	266	416	35
	5	558	708	55
	6	1069	1219	91
	7	1580	1730	127

Conditions:

Approach angle, 4°

Touchdown, 150 feet forward of flight deck trailing edge

Wing plane 6 feet above deck at touchdown

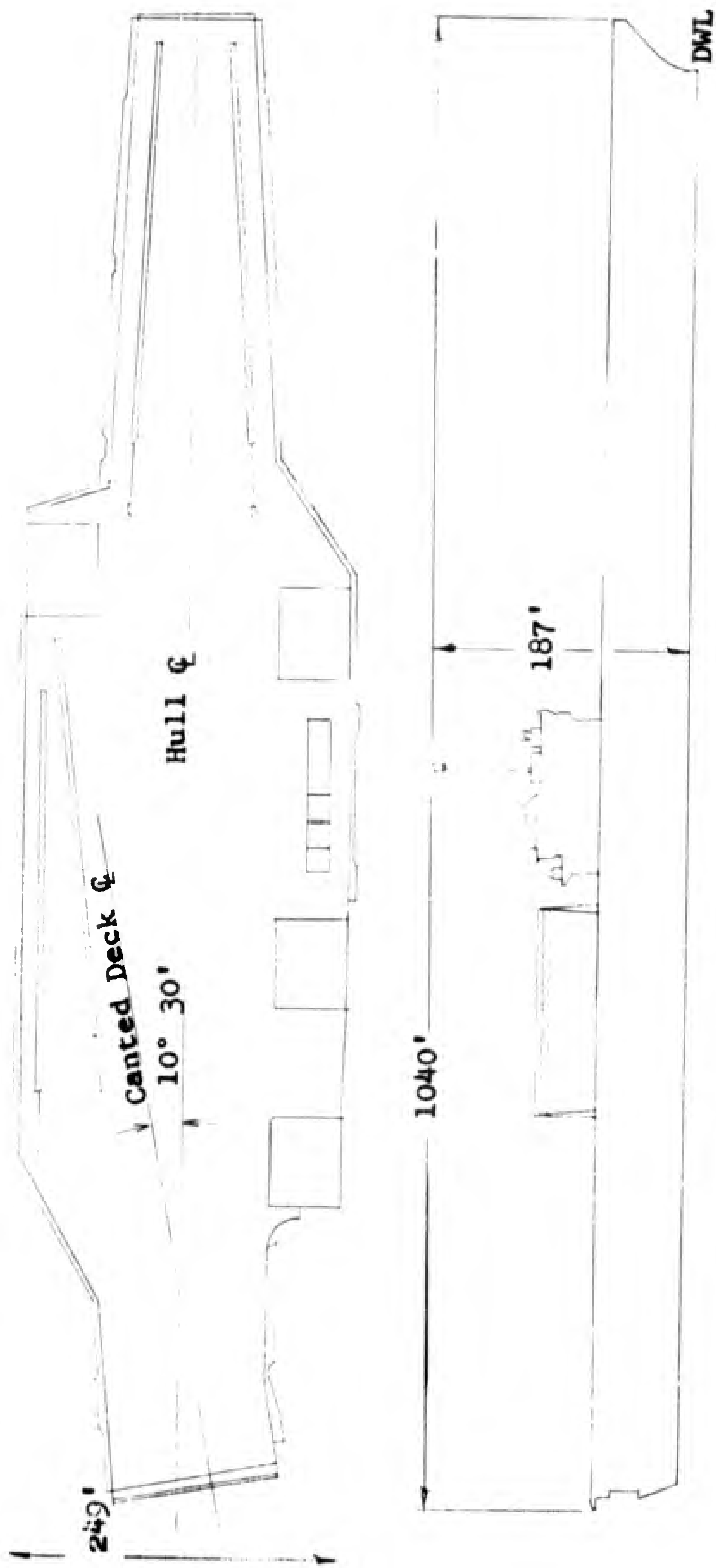

Figure 1 - General Arrangement of the CVA 62 Aircraft Carrier

Figure 2 - Three- Quarter Front View of the "Real" Model CVA 62

Figure 3 - Three-Quarter Rear View of the "Real" Model CVA 62

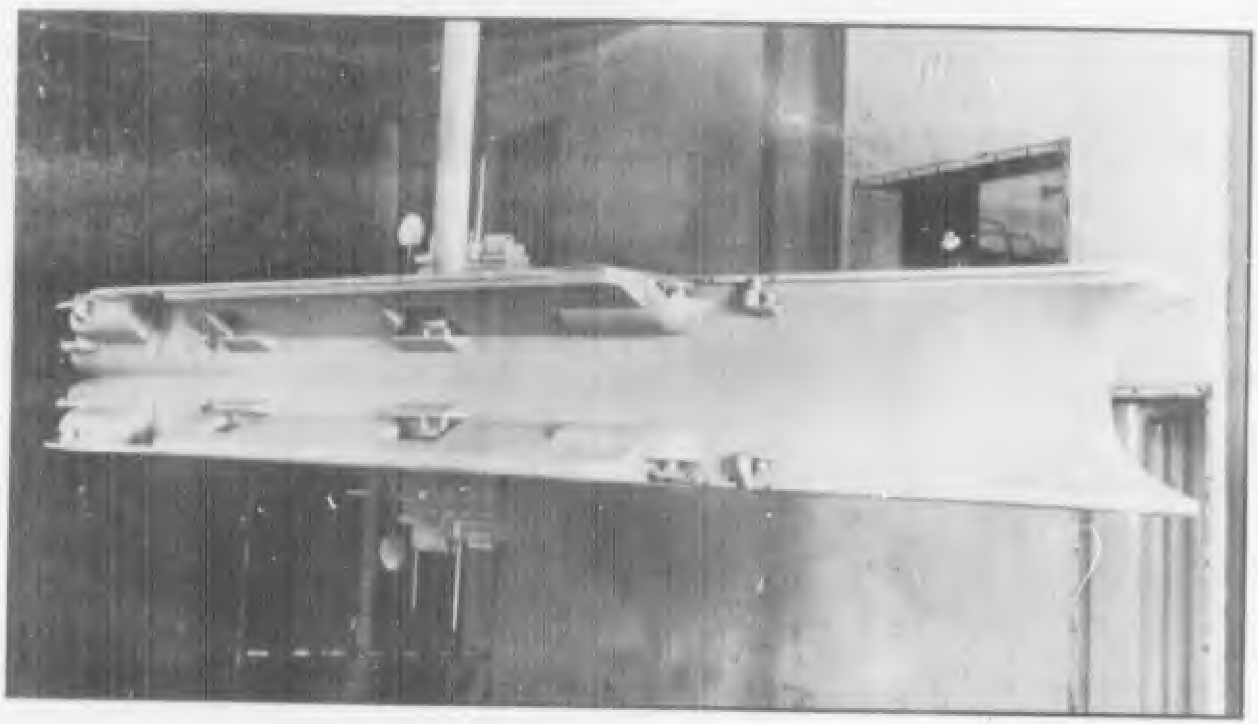

Figure 4 - Three-Quarter Front View of the Survey Rake Installed in the Wind Tunnel With the Model CVA 64

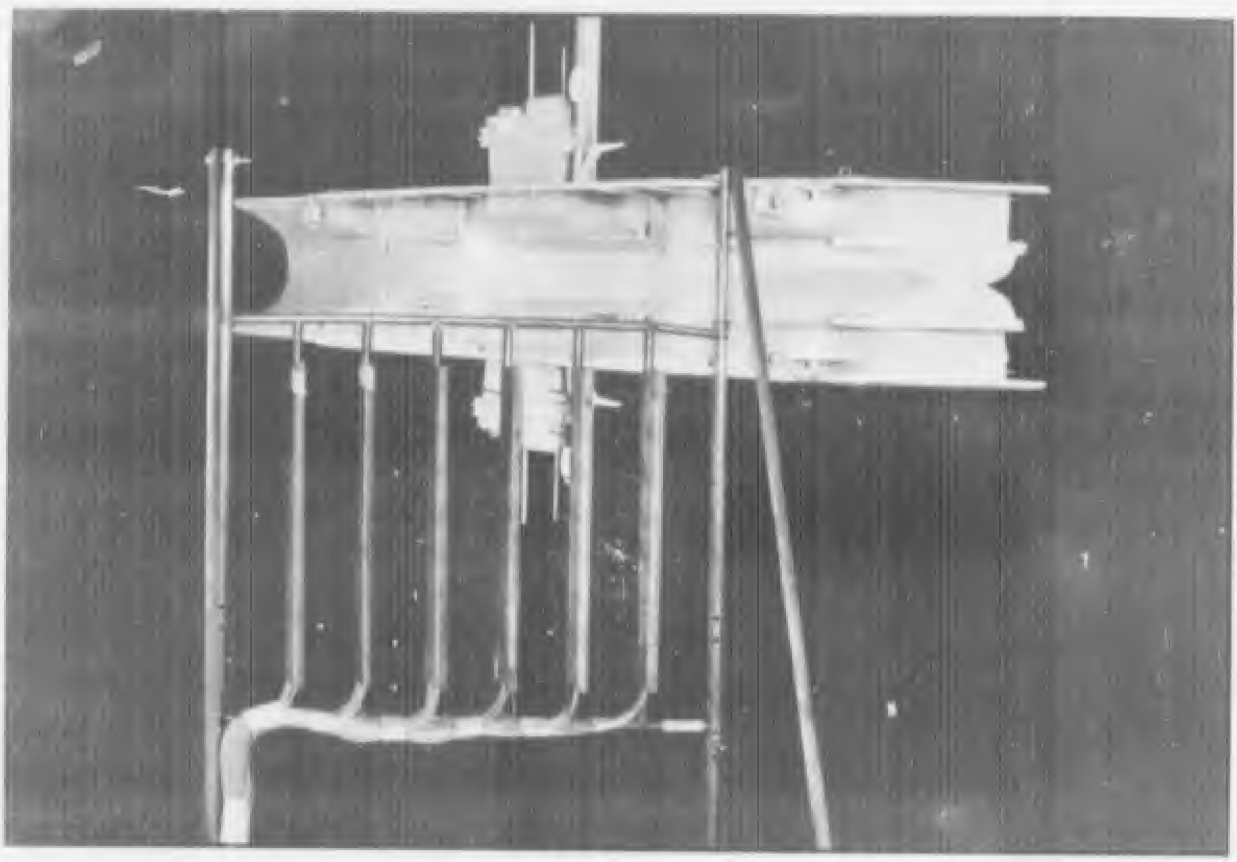

Figure 5 - Three-Quarter Rear View of the Survey Rake Installed in the Wind Tunnel With the Model CVA 64

PSD-68247

May 7, 1957

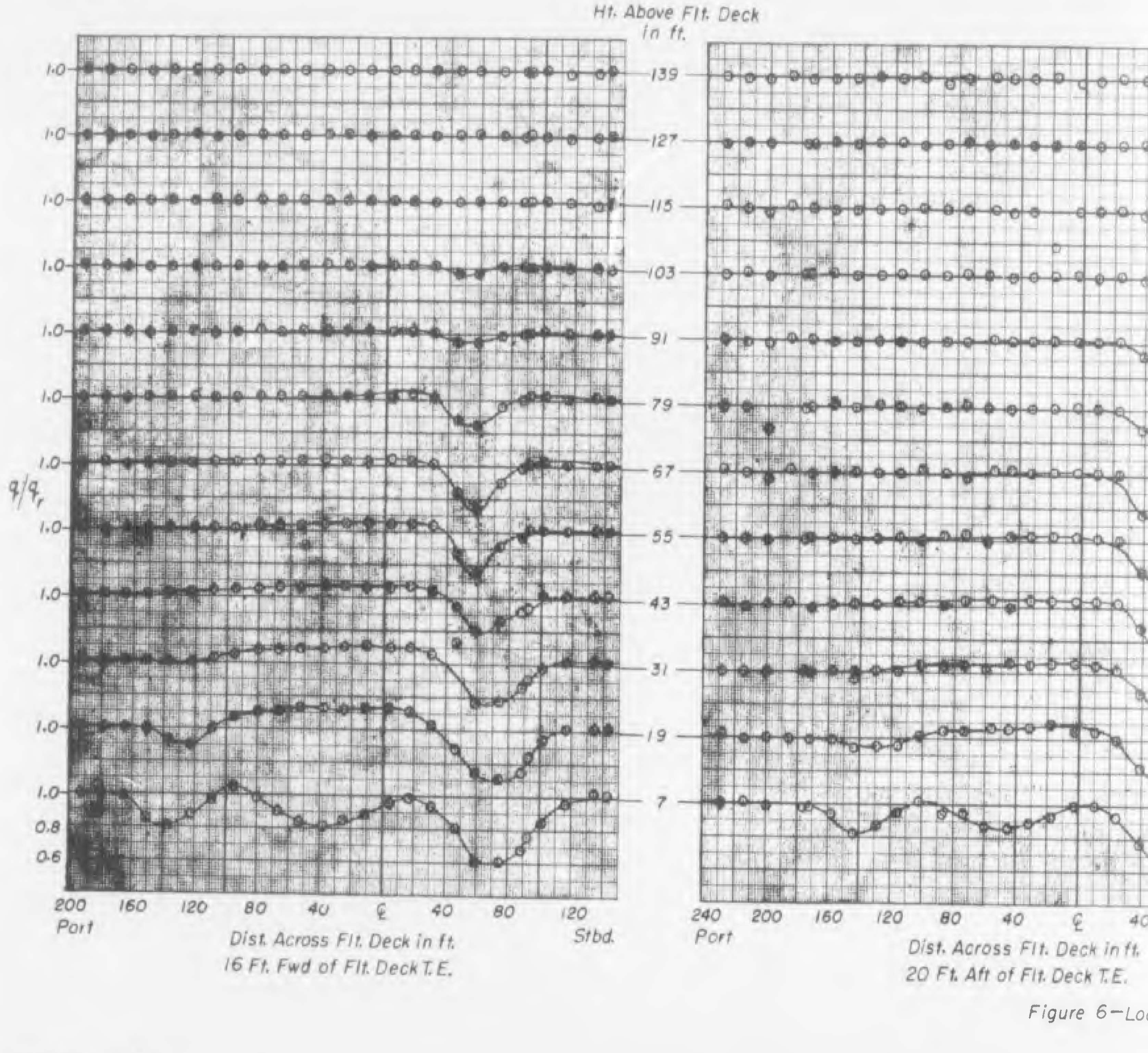

Figure 6—Lo

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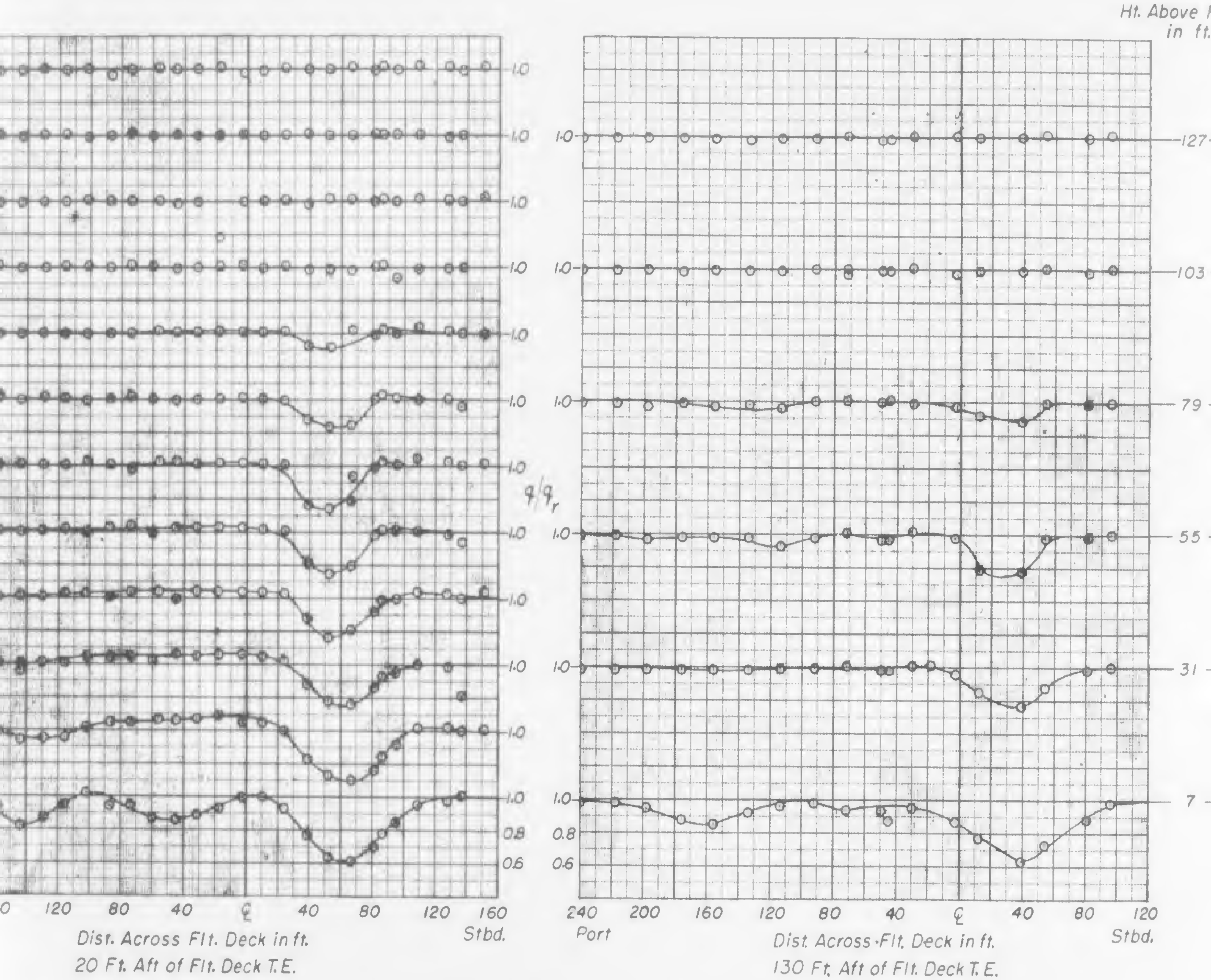

Figure 6—Local Dynamic Pressure Ratios in the Wake of the CVA62 Model

(a) $\psi = 0°$

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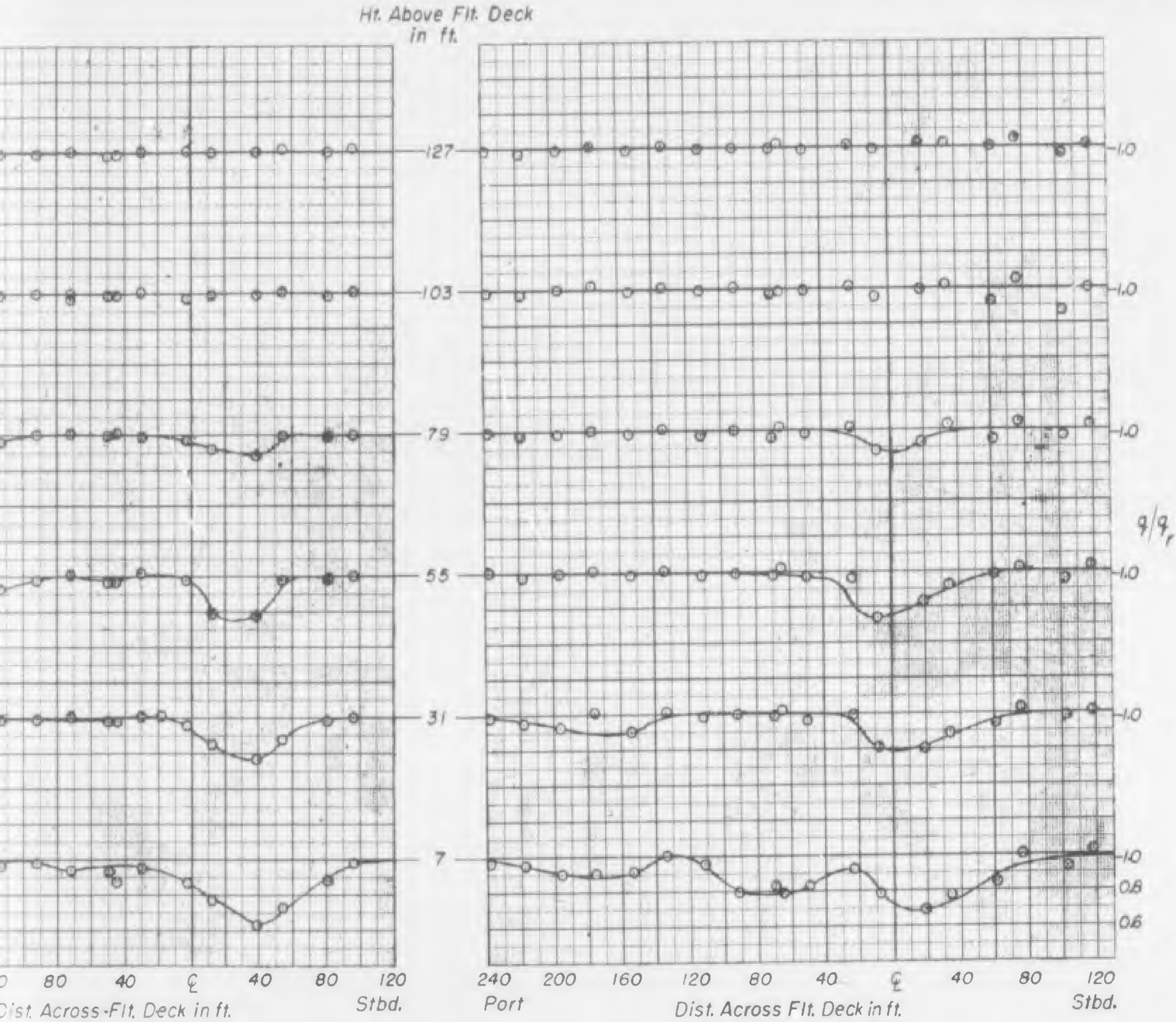

Dist. Across-Flt. Deck in ft.
130 Ft. Aft of Flt. Deck T.E.

Dist. Across Flt. Deck in ft.
240 Ft. Aft of Flt. Deck T.E.

2 Model

FIGURE 6 a

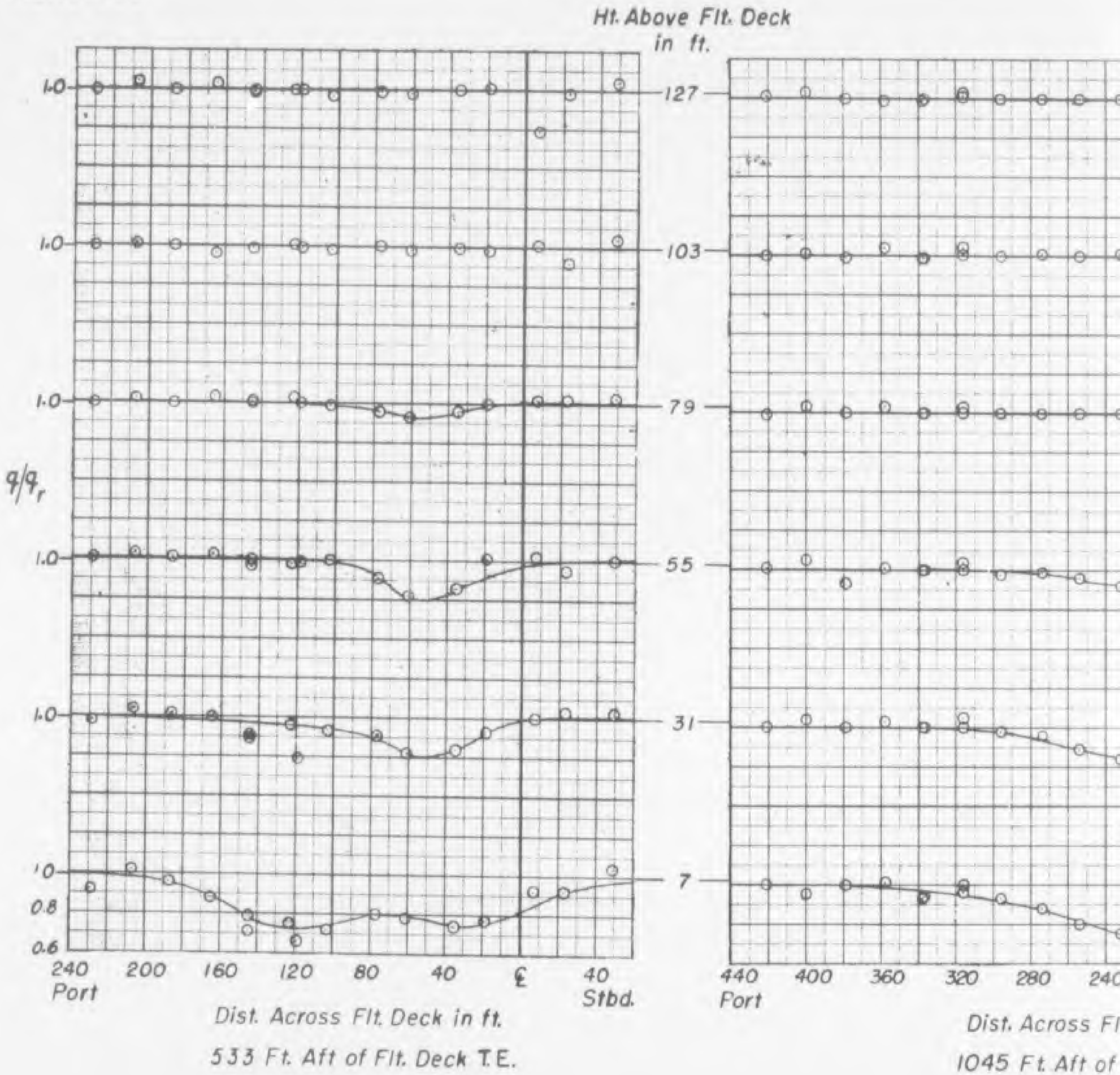

Figure 6 (
(a) Cond

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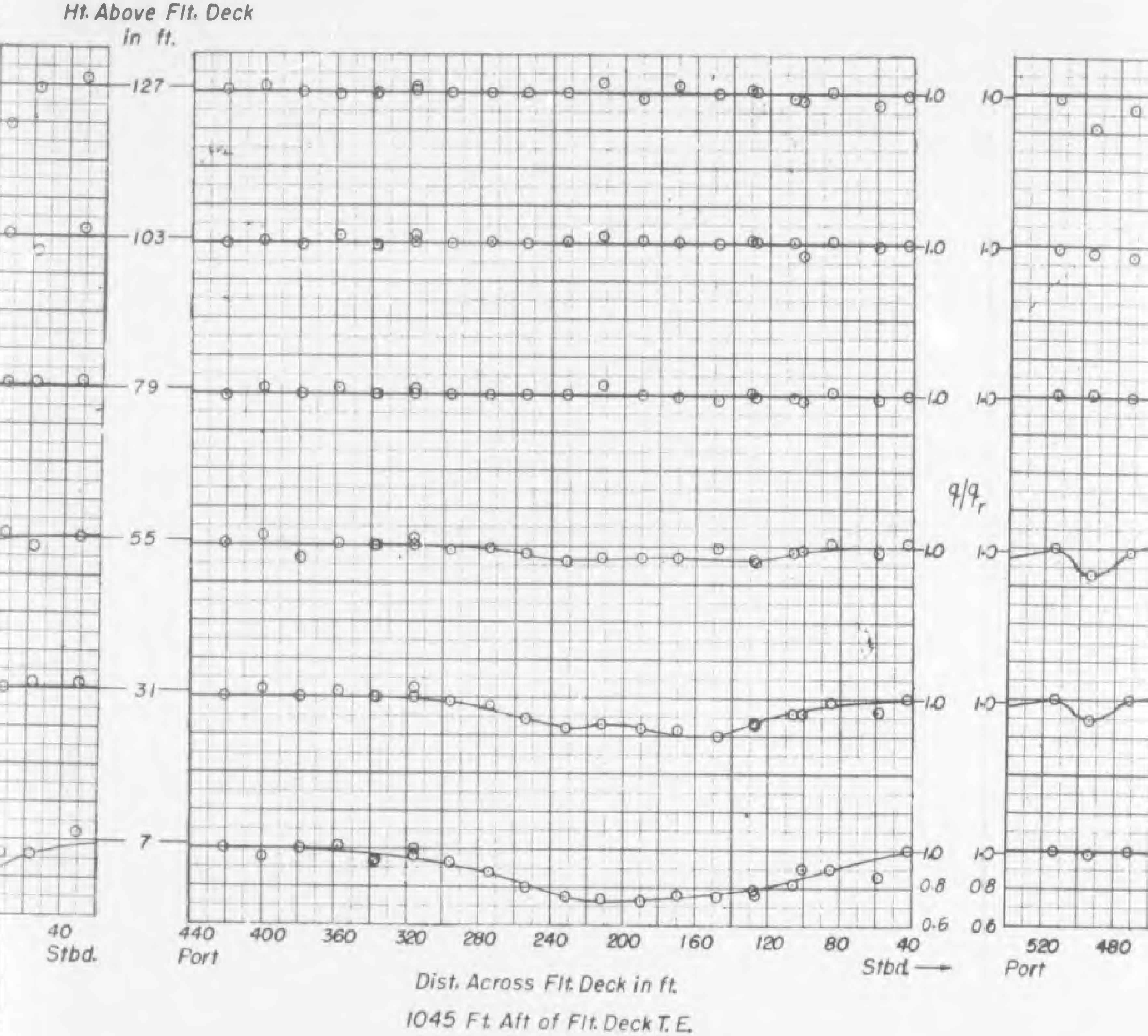

Figure 6 (Continued)

(a) Concluded

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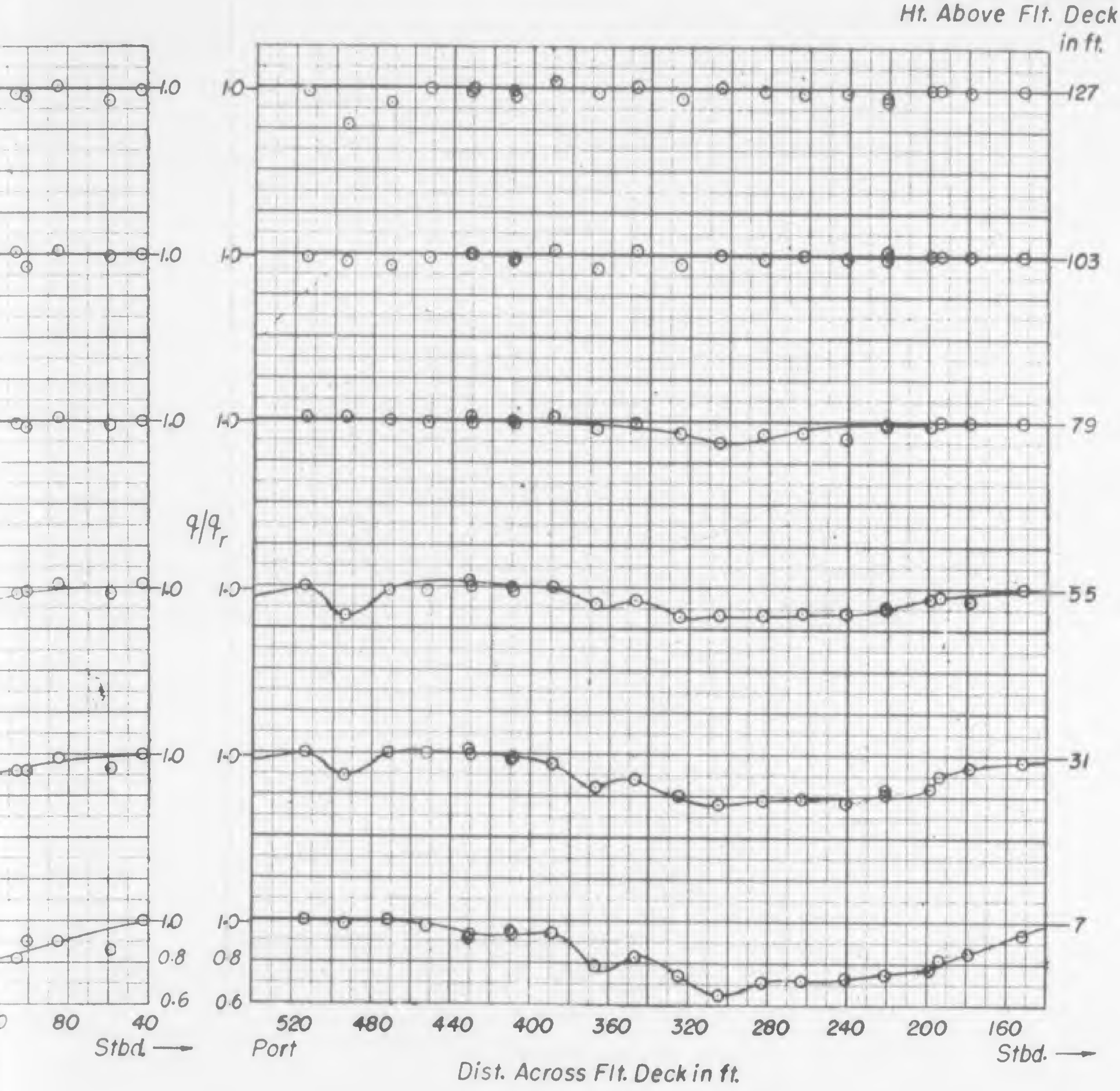
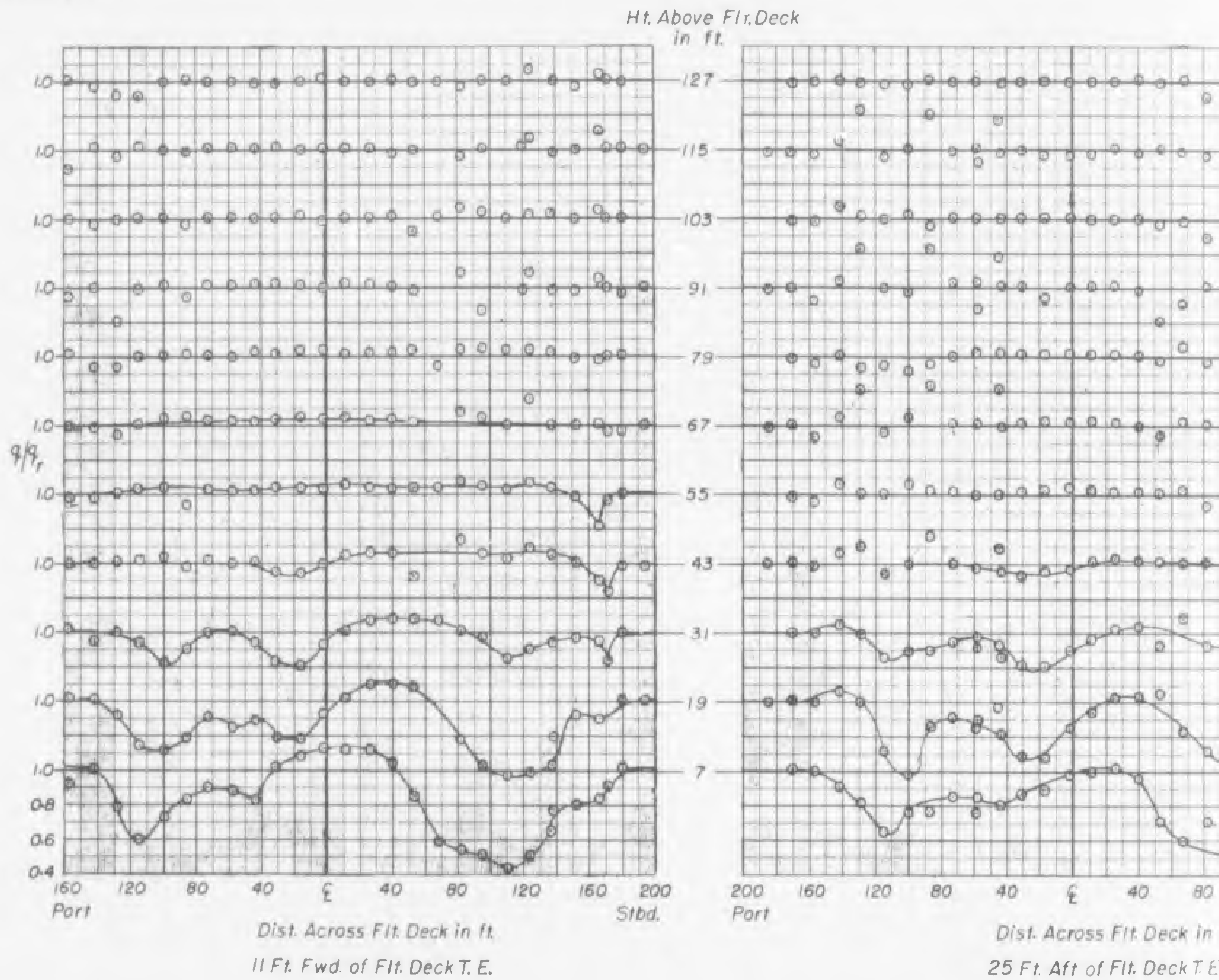


1558 Ft. Aft of Flt. Deck T.E.

FIGURE 6 a (concl)


Ht. Above Flt. Deck
in ft.
127
115
103
91
79
67
55
43
31
19
7
q/q_r
1.0
0.8
0.6
0.4
160
120
80
40
℄
40
80
120
160
200
Port
Stbd.
Dist. Across Flt. Deck in ft.
11 Ft. Fwd. of Flt. Deck T. E.
200
160
120
80
40
℄
40
80
Port
Dist. Across Flt. Deck in
25 Ft. Aft of Flt. Deck T. E.

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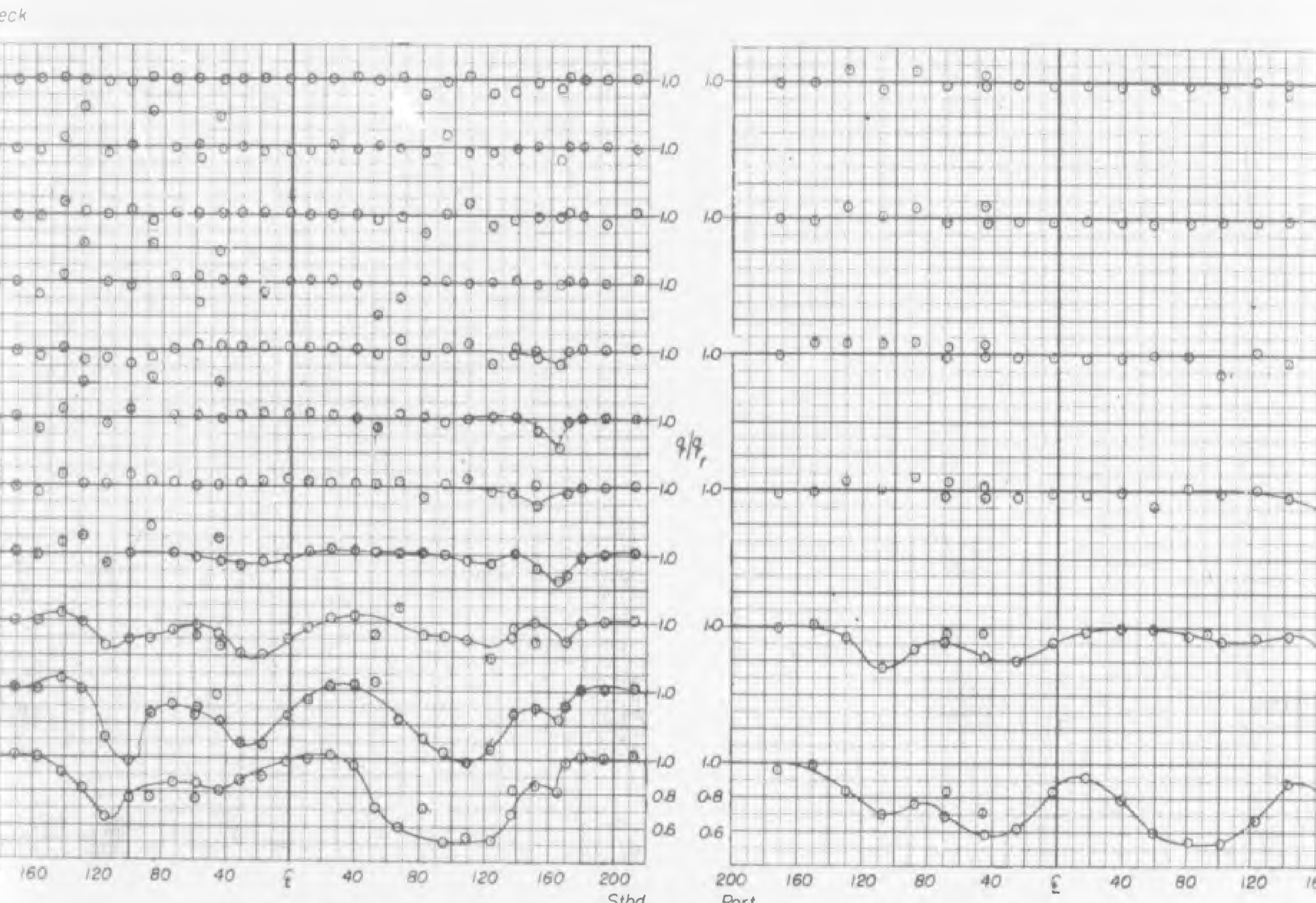

Dist. Across Flt. Deck in ft.
25 Ft. Aft of Flt. Deck T. E.

Dist. Across Flt. Deck in ft.
133 Ft. Aft of Flt. Deck T. E.

Figure 6 (Continued)

(b) $\psi = 10^\circ$

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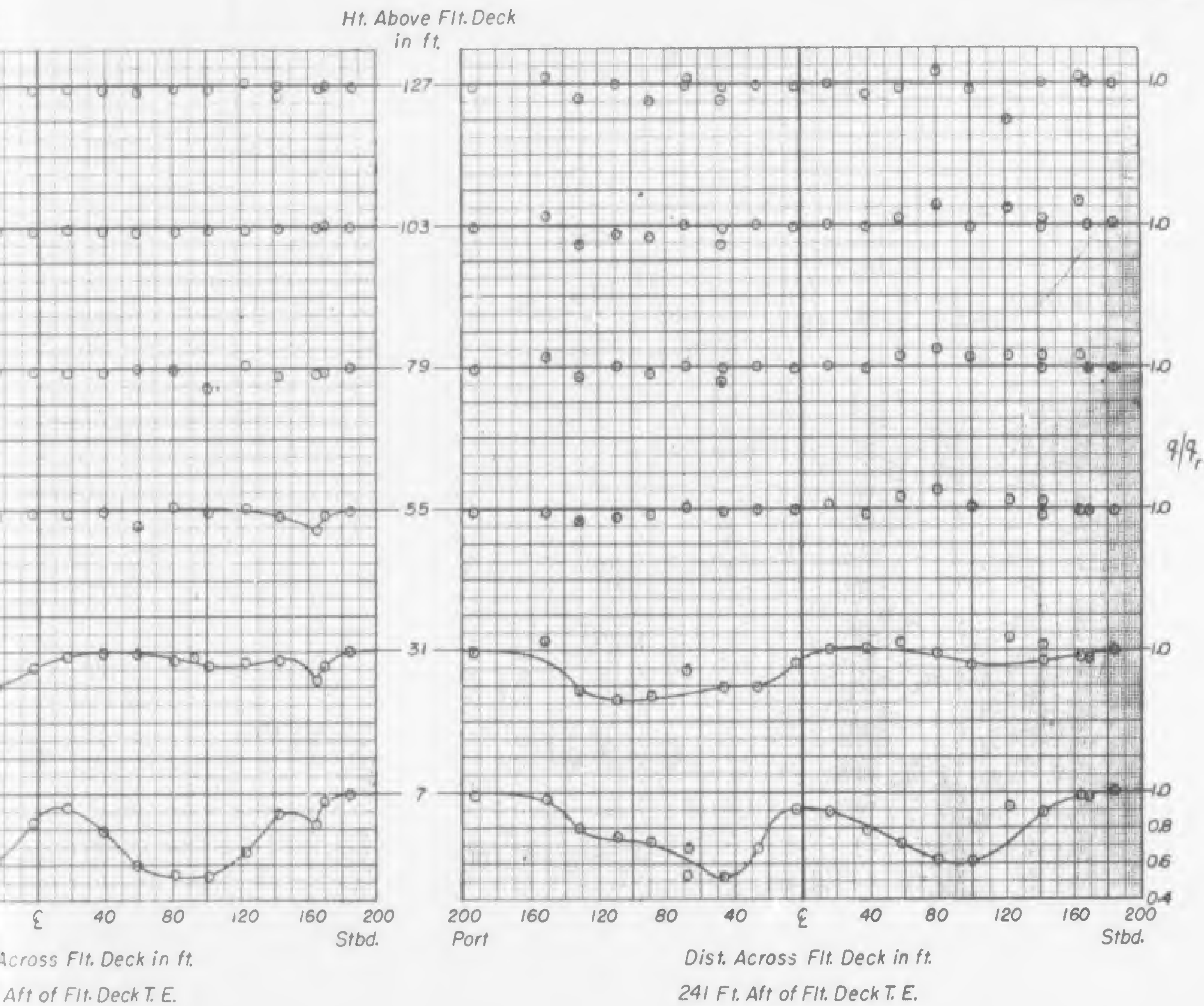
Ht. Above Flt. Deck
in ft.
127
103
79
55
31
7
1.0
0.8
0.6
0.4
q/q_r
40
80
120
160
200
Stbd.
Across Flt. Deck in ft.
Aft of Flt. Deck T. E.
200
Port
160
120
80
40
Dist. Across Flt. Deck in ft.
241 Ft. Aft of Flt. Deck T. E.

FIGURE 6 b

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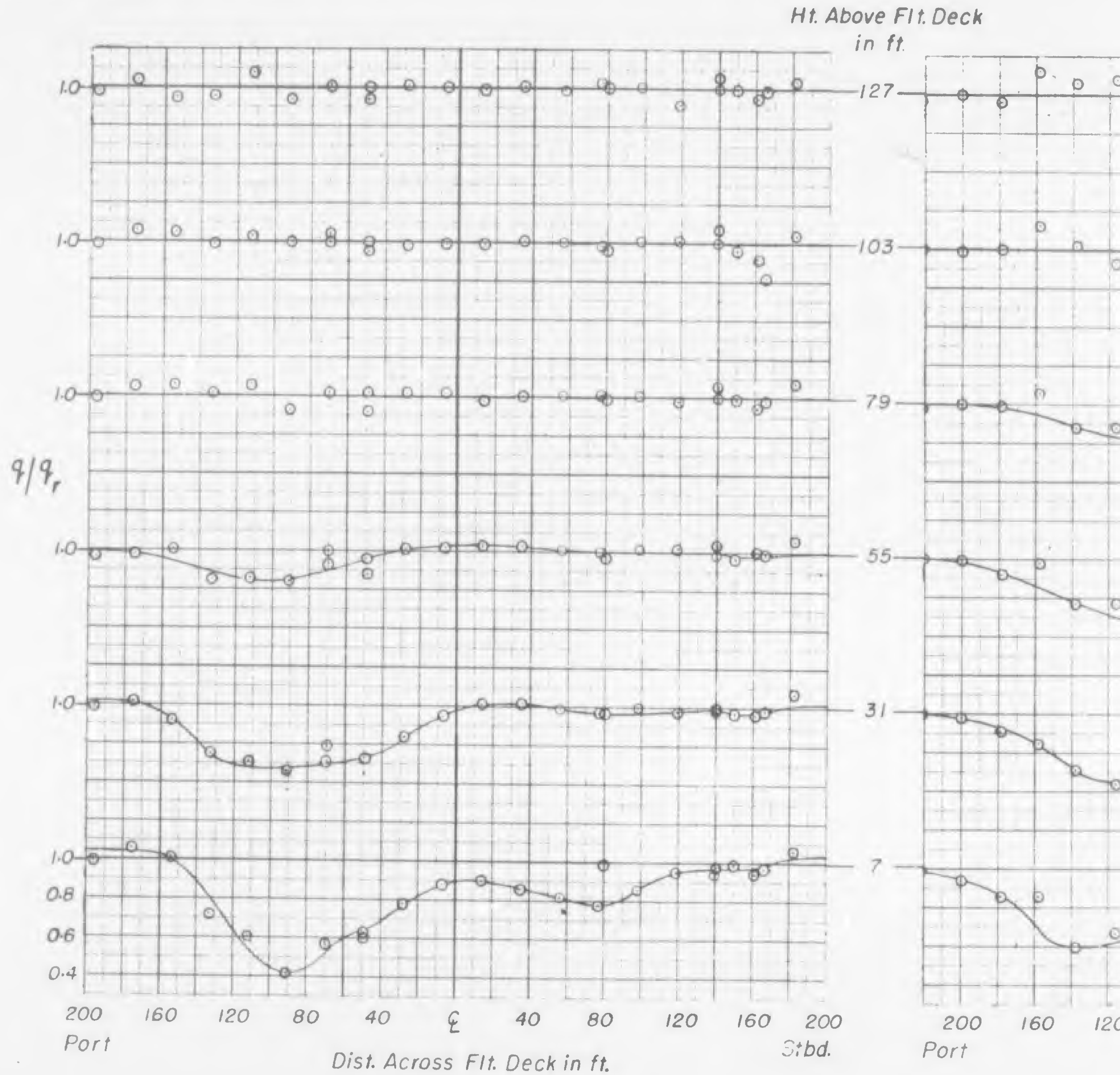

529 Ft. Aft of Flt. Deck T. E.

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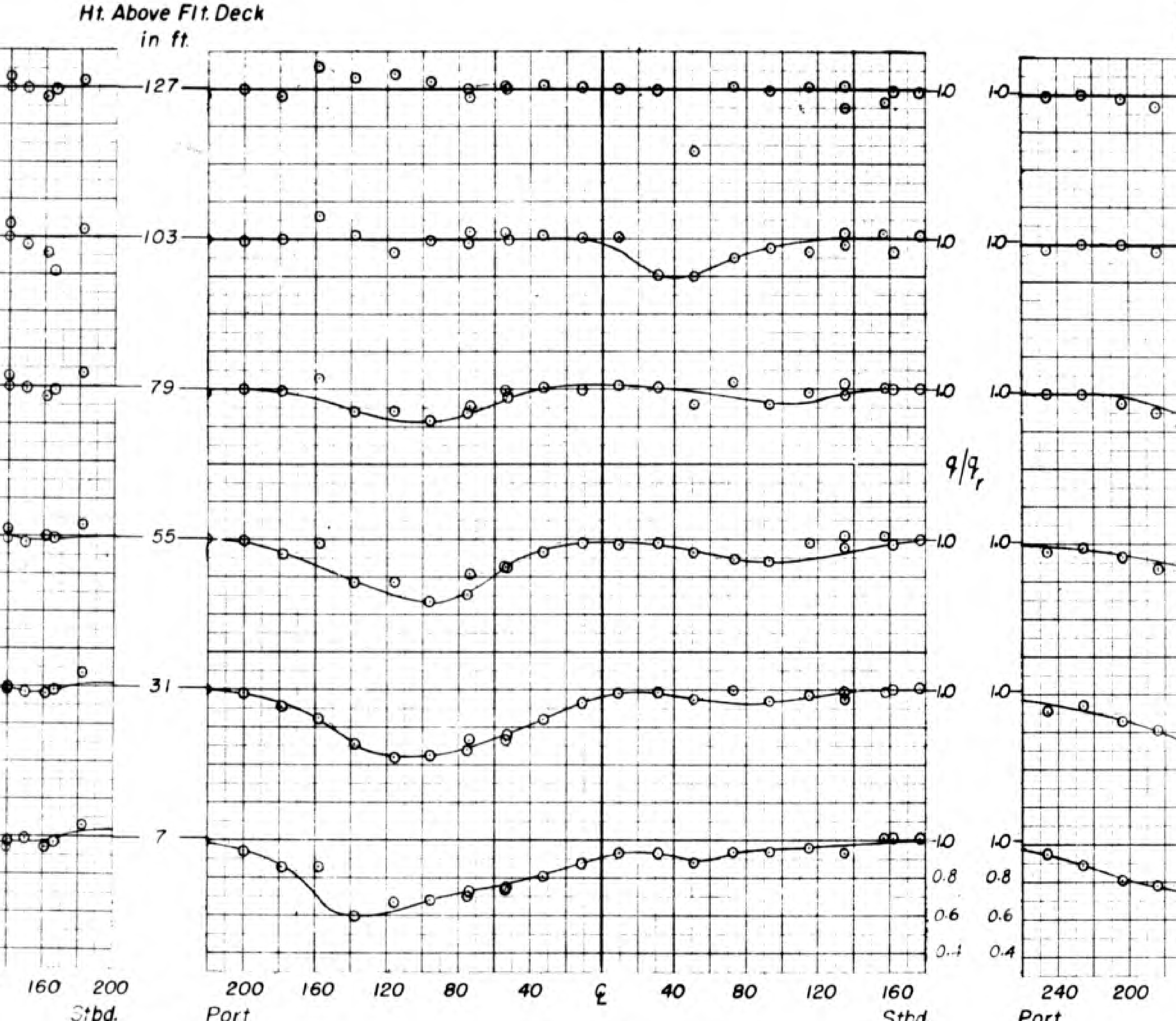

Dist. Across Flt. Deck in ft.

1033 Ft. Aft of Flt. Deck T. E.

Figure 6 (Continued)

(b) Concluded

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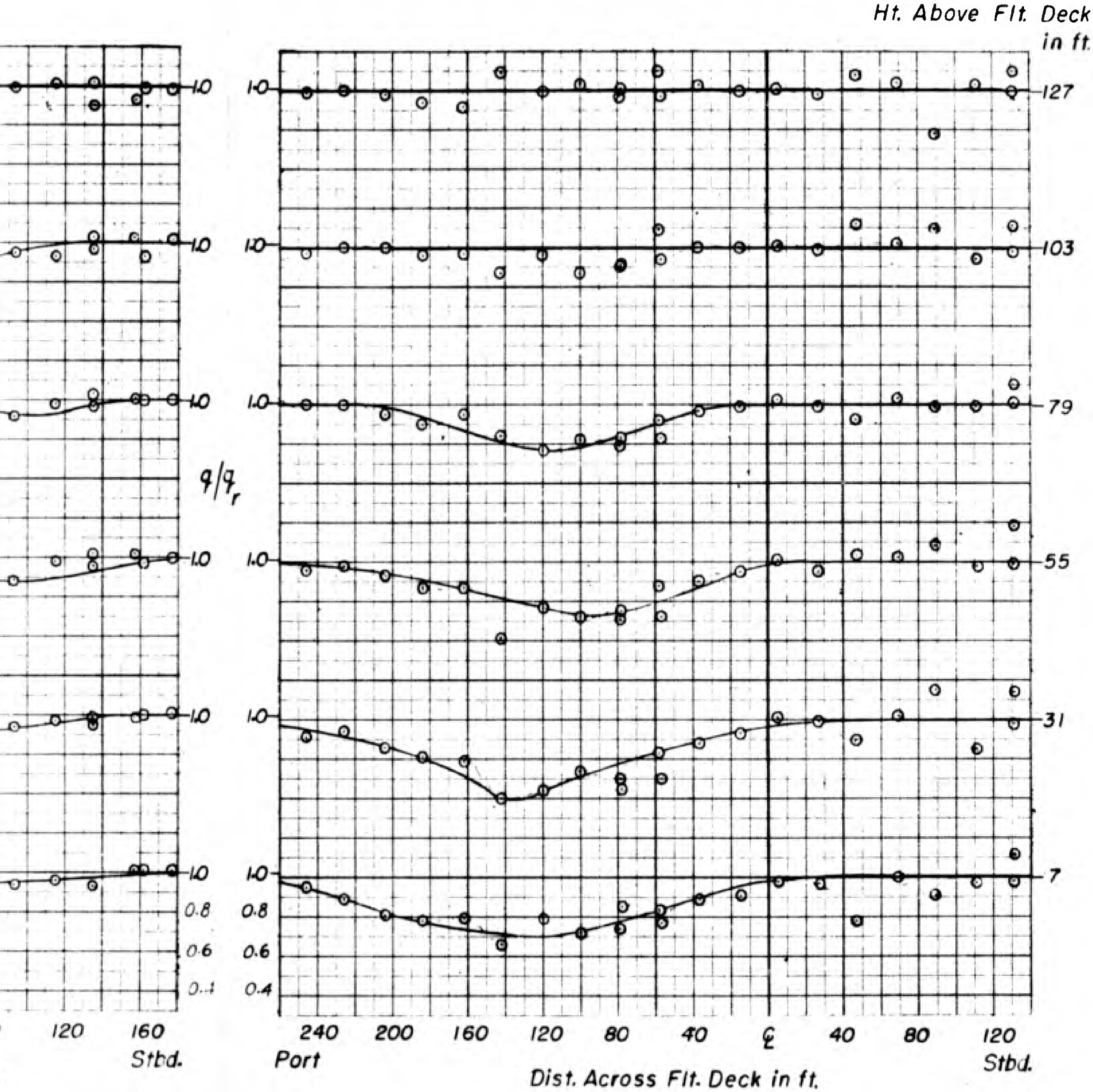
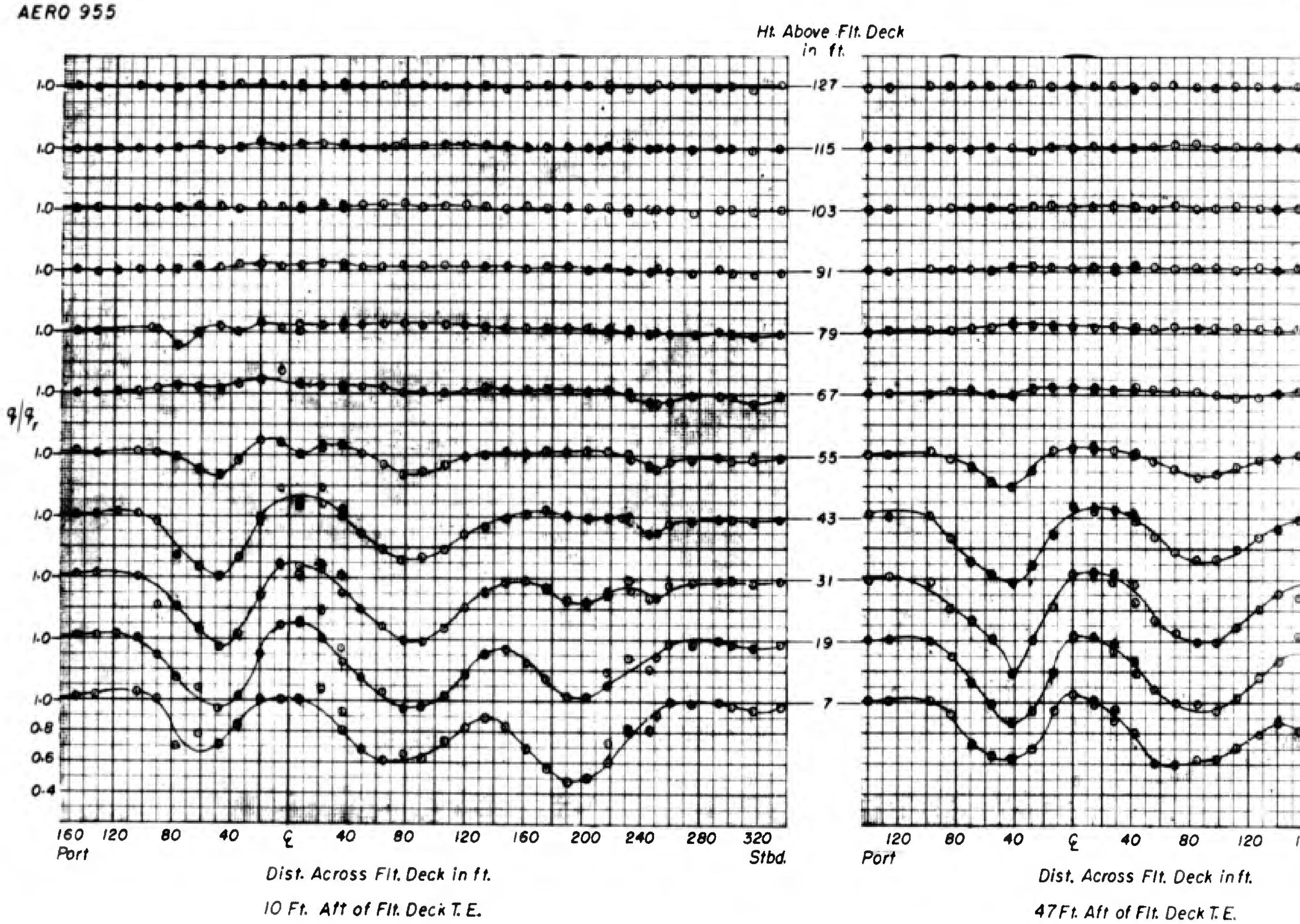


1537 Ft. Aft of Flt. Deck T.E.

Figure 6 (Continued)
(b) Concluded

FIGURE 6 b (concl)

AERO 955



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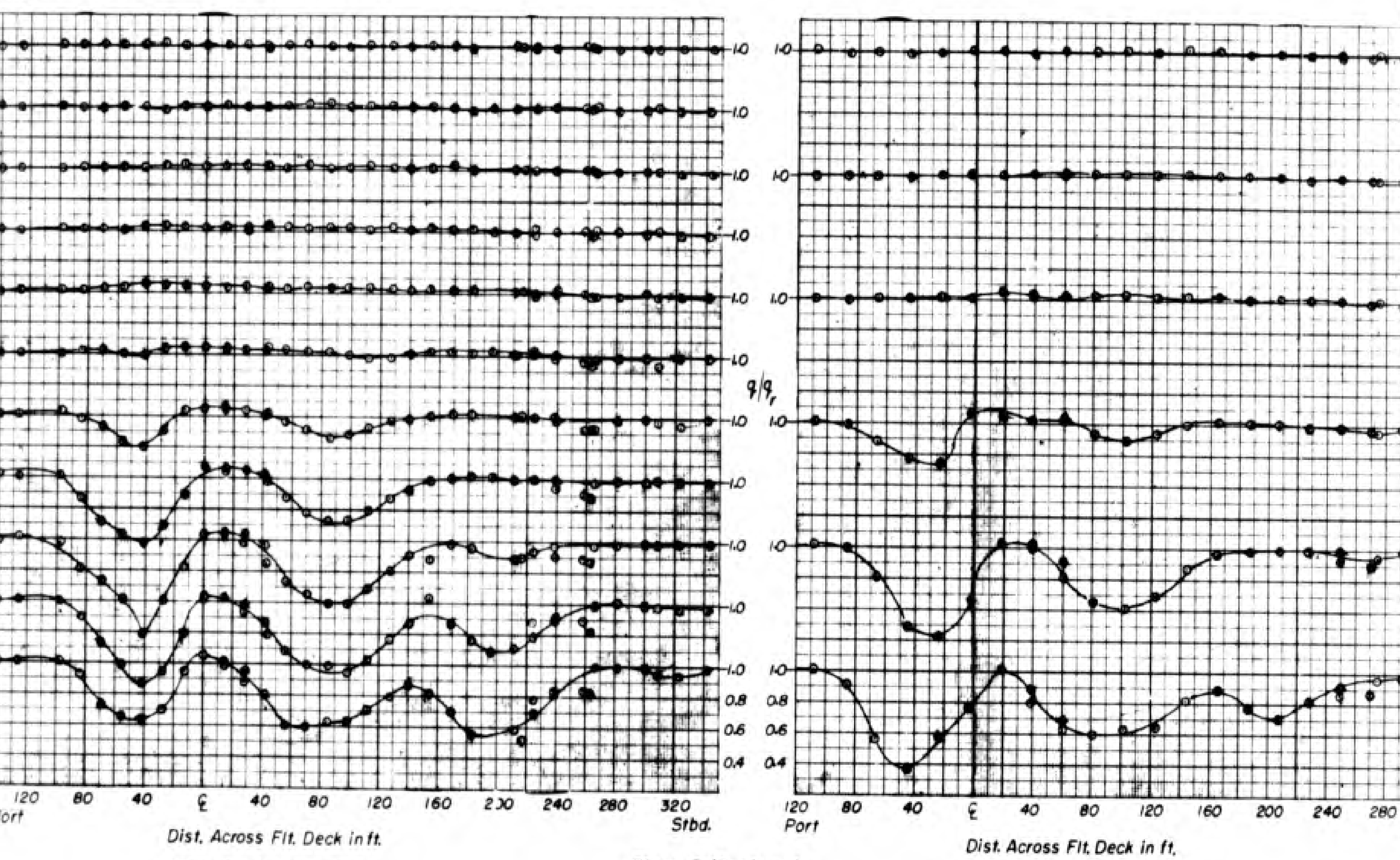
Deck



47 Ft. Aft of Flt. Deck T.E.

Dist. Across Flt. Deck in ft.

156 Ft. Aft of Flt. Deck T.E.

Figure 6 (Continued)
(c) $\psi = 20°$

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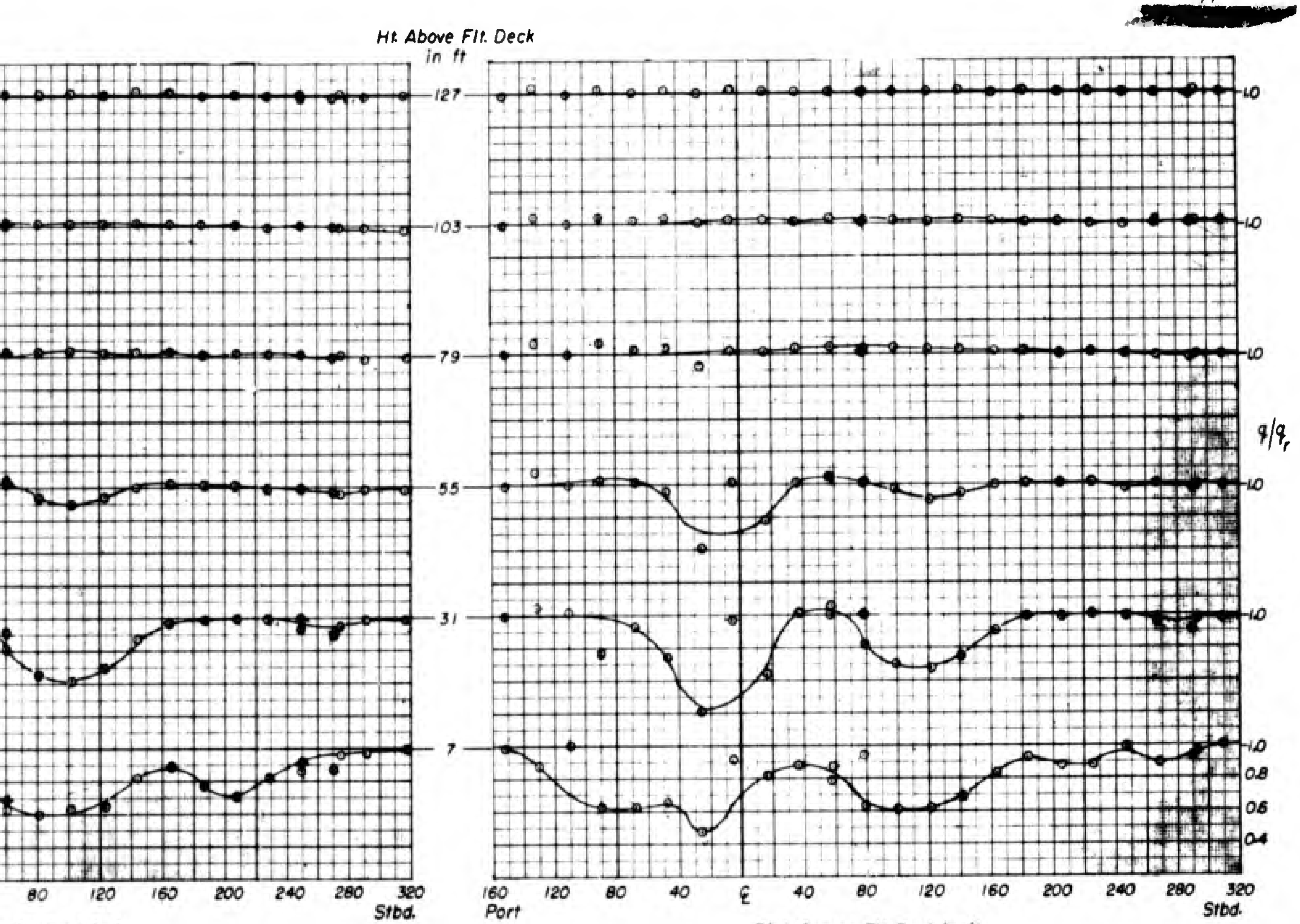


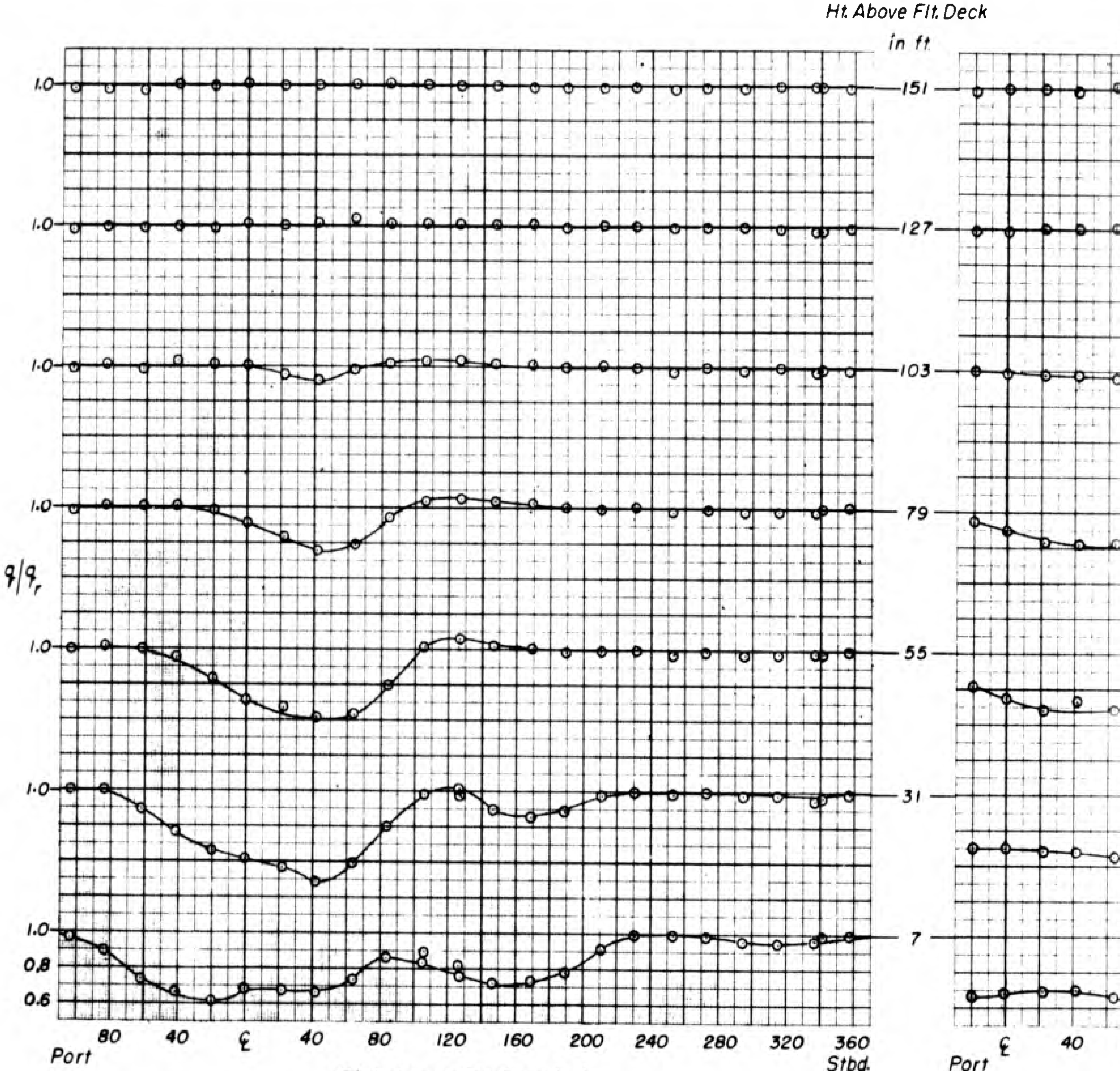
s Flt. Deck in ft.

of Flt. Deck T. E.

Dist. Across Flt. Deck in ft.

266 Ft. Aft of Flt. Deck T. E.

FIGURE 6 c



Dist. Across Flt. Deck in ft.
558 Ft. Aft of Flt. Deck T.E.

Figure 6

(c) C

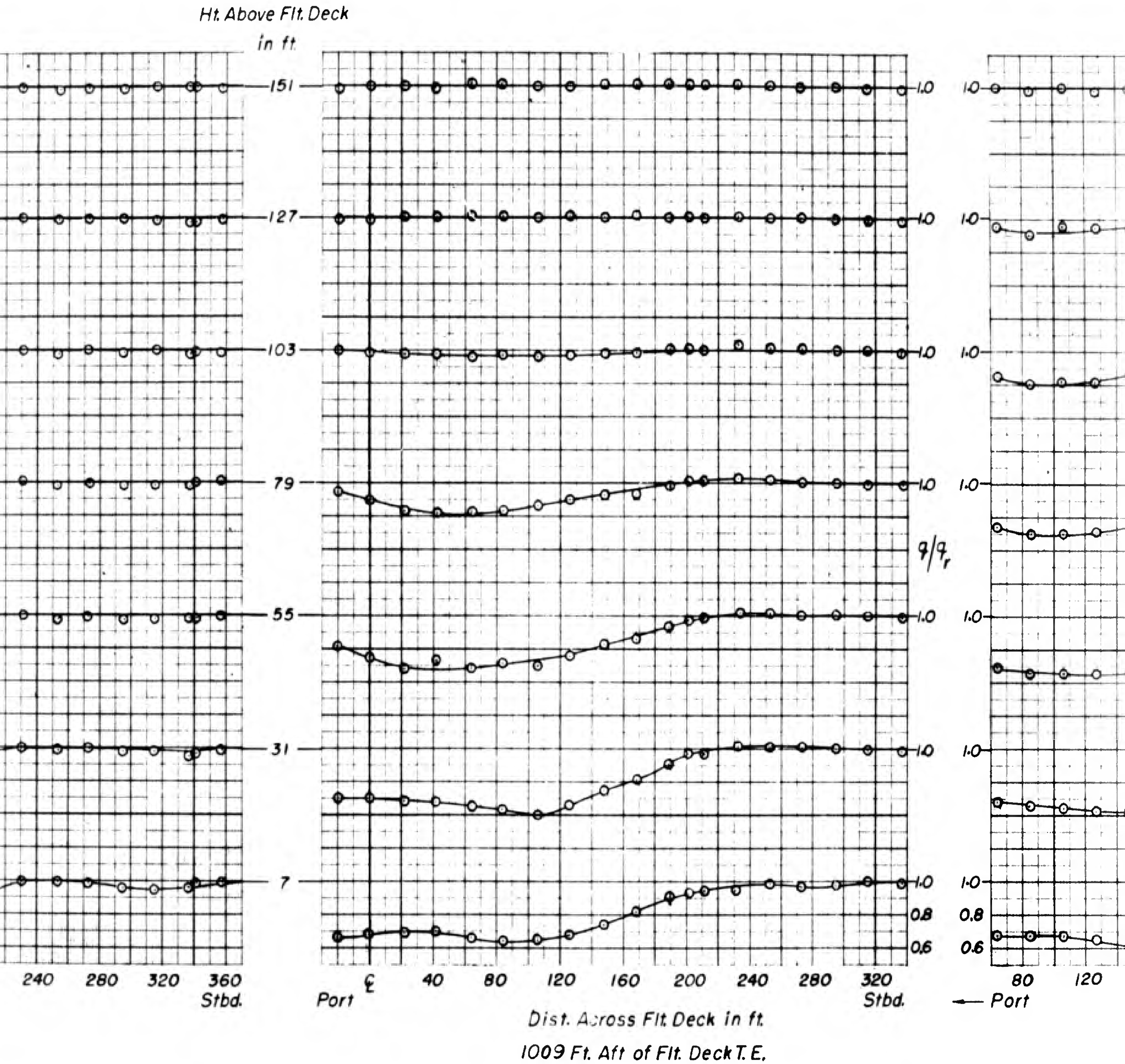


Figure 6 (Concluded)

(c) Concluded

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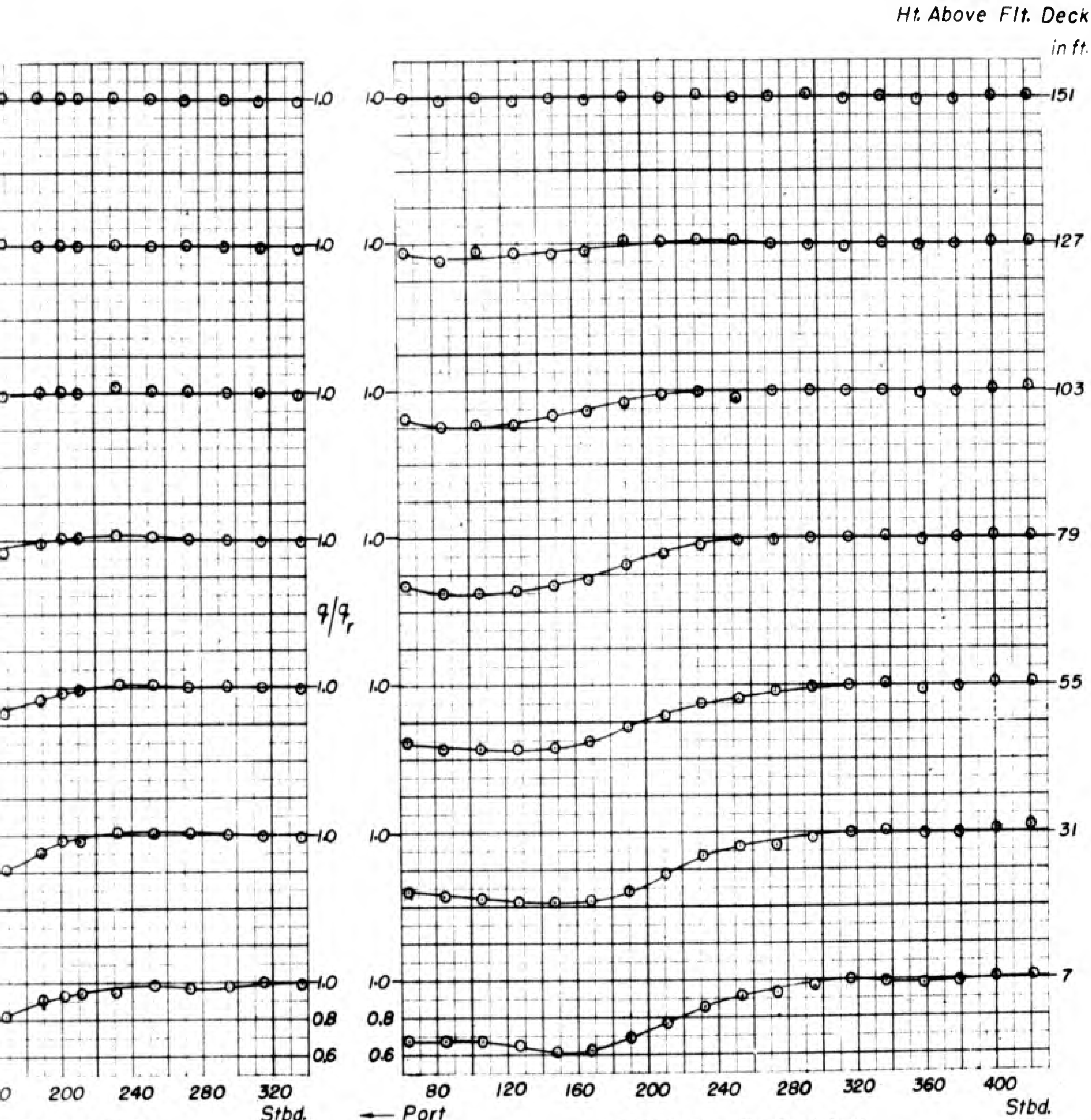

s Flt. Deck in ft.
of Flt. Deck T. E.

Dist. Across Flt. Deck in ft.
1580 Ft. Aft of Flt. Deck T.E.

[redacted]

FIGURE 6 c (concl)

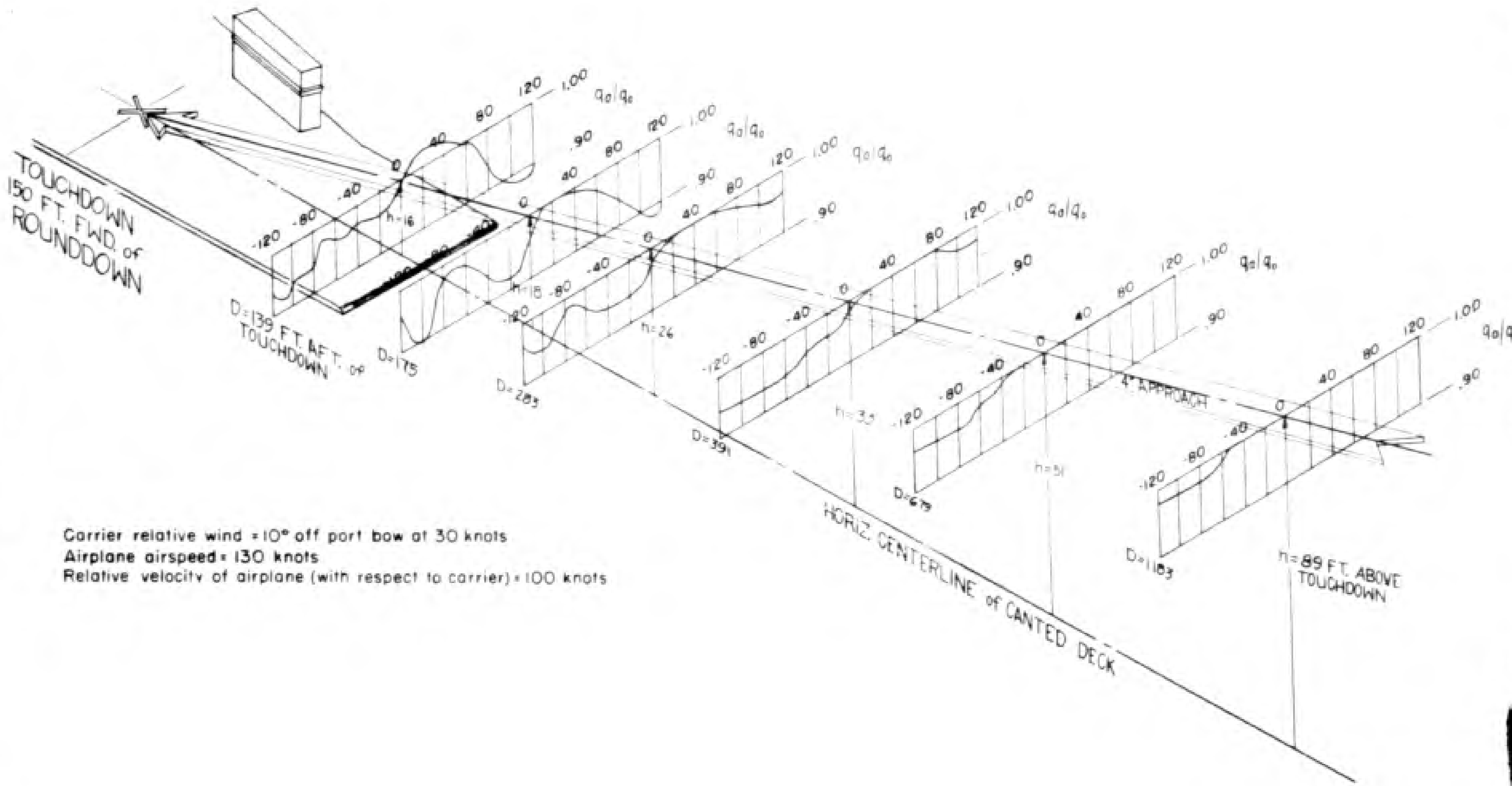

Figure 7 - Local Dynamic Pressure Ratios Encountered by an Airplane Approaching for a Landing Aboard the CVA 62

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