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RESEARCH MEMORANDUM

for the

U. S. Air Force

INVESTIGATION OF THE HYDRODYNAMIC CHARACTERISTICS OF THE PANTO-BASE CHASE C-123 AIRPLANE

By William C. Thompson and Lloyd J. Fisher

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Langley Field, Va.

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

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SUMMARY

An investigation of a 1/14-scale dynamically similar model of a panto-base version of the Chase C-123 airplane was conducted to evaluate the hydrodynamic characteristics of the airplane. The resistance, longitudinal stability, and spray patterns during take-off and general behavior in calm- and rough-water landings were determined. Brief calm-water tests were made to compare the initial vertical impact accelerations of the model with and without hydro-skis.

Take-off stability was satisfactory for calm-water operation. A ratio of gross load to maximum resistance of 3.6 was obtained. Heavy spray reached the propellers only during ski emergence. The landing behavior in calm water and in waves 3 feet by 150 feet (full scale) was satisfactory for a normal range of trim angles. Initial impacts in calm-water landings resulted in vertical accelerations of about $2\frac{1}{2}$g with the hydro-skis installed and about 4g with the hydro-skis removed.

INTRODUCTION

A tank investigation of a proposed panto-base version of the Chase C-123 airplane was requested by the U. S. Air Force in order to evaluate the water take-off and landing characteristics. Necessary data and design information were furnished by the manufacturer, Chase Aircraft Co., Inc.

The investigation included the determination of resistance, longitudinal stability, and spray patterns during take-off and general behavior in calm- and rough-water landings. Brief calm-water tests were made to compare the initial vertical impact accelerations of the model with and without hydro-skis. Several hydro-ski locations and afterbody step configurations were investigated to obtain the best landing performance and the minimum take-off resistance. From the results of these preliminary tests the manufacturer selected a final hydro-ski location which would give reasonably good take-off and landing performance and also facilitate conversion of the airplane. The remainder of the model investigation was conducted with this configuration and only the data obtained for this configuration are presented.

SYMBOLS

b	maximum beam of hydro-ski, ft
C_{Δ_o}	hydro-ski gross load coefficient, $\frac{1}{2}\frac{\Delta_o}{wb^3}$
$\bar{c}$	mean aerodynamic chord, ft
D_c	air drag of the model with propellers removed, lb
g	acceleration due to gravity, 32.2 ft/sec/sec
R	total resistance, water and air, lb
R_H	resultant horizontal aerodynamic force with full power, lb
r	rise of center of gravity, ft
T	static thrust, lb
T_e	effective thrust, lb
T_x	resultant horizontal force with full power and the model in the water, lb
V	horizontal speed, knots
w	specific weight of water, 64 lb/cu ft arbitrarily used in these tests
Δ_o	initial load on the water, gross load, lb
δ_e	elevator deflection, deg
τ	trim measured as angle between hull forebody keel and horizontal, deg

DESCRIPTION OF MODEL

The 1/14-scale powered dynamic model was constructed at the Langley Aeronautical Laboratory by modifying an existing ditching model of the Chase XC-123 airplane. The general arrangement of the airplane with the final hydro-ski configuration is shown in figure 1. The airplane has one step located at the termination of the dead-rise portion of the hull and a second step located farther aft on the flat portion of the hull. The twin hydro-skis were located so that their trailing edges were just forward of the first step. Pertinent dimensions of the airplane and the tank model are listed in table I.

Photographs of the model are shown in figure 2. The major portion of the model was of balsa wood construction with hardwood spars and reinforcements. The hull bottom was made of laminated fiber glass and plastic. Internal ballast was used to obtain scale weight and weight distribution. The model weight corresponded to 50,000 pounds (full scale) except where noted. The moments of inertia are given in table I.

Scale diameter two-blade propellers driven by direct-current electric motors were installed and operated so that scale thrust was simulated. The movable elevators and flaps installed on the model were of scale dimension and were adjustable to various positions.

The lines of the hydro-skis are shown in figure 3. The two skis were each attached rigidly to the model by 1/2-inch-diameter struts.

APPARATUS AND PROCEDURE

Take-Off Tests

General.- The take-off tests were conducted from the main towing carriage in the Langley tank no. 2 by using the towing gear shown in figure 4. This gear normally provides fore-and-aft freedom but for the take-off tests the roller cage was fixed so the model had freedom only in trim and rise.

A flap deflection of 20° and full power (18,800 pounds thrust full-scale static) were used for all take-off tests. The elevators were varied over a range of deflection from -25° to 20°.

Resistance, trim, and rise.- Resistance, trim, and rise of the center of gravity were determined with the model towed from the normal center of gravity ($0.27\bar{c}$). The resistance was measured by use of an electrical strain gage installed in the towing staff inside the model. Trim and rise were obtained by visual observation. The resistance as determined in these tests is defined by the equation $R = T_e - T_x$. The effective thrust T_e is defined by the equation $T_e = D_c + R_H$. The values of D_c and R_H were determined at various constant speeds with the model just clear of the water at 0° trim with 0° elevators. The values of D_c were obtained with propellers removed; the values of R_H were obtained with full power. The values of T_x were determined at various constant speeds with full power and the model in the water at various trim and elevator conditions.

Longitudinal stability.- In order to find the trim limits of stability, the model was towed from the normal center of gravity ($0.27\bar{c}$) at constant speeds. The trim was increased or decreased by elevator control until porpoising began or maximum elevator deflection was reached.

The center-of-gravity limits of stability were determined during runs at an acceleration of 3 feet per second per second. The tests were made at various elevator positions and the following center-of-gravity positions: $0.20\bar{c}$, $0.235\bar{c}$, $0.27\bar{c}$, $0.305\bar{c}$, and $0.34\bar{c}$. The range of available center-of-gravity and elevator positions which would permit take-off without porpoising was determined from these runs.

Spray characteristics.- The calm-water spray characteristics with full power were determined from photographs and visual observation during constant speed and accelerated runs.

Landing Tests

General.- Freebody landing tests were made from the monorail in the Langley tank no. 2 (fig. 5) for calm-water landings and from the catapult in the Langley tank no. 2 (fig. 6) for rough-water landings. Calm-water landings were also made using the towing carriage in the Langley tank no. 2 with the fore-and-aft freedom gear (fig. 4). Data pertaining to general behavior were obtained in the free-body landing tests from motion pictures and from visual observations. Vertical accelerations were measured in the landing tests made from the towing carriage. The landing tests were made with the model balanced about the normal center of gravity ($0.27\bar{c}$) with power off and with flaps down 45° at trims of 9°, 12°, and 14°.

Calm water.- In the calm-water tests made from the monorail the model was landed by catapulting it into the air to permit a free glide onto the water. The model left the launching gear at scale speed and the desired landing attitude with the control surfaces set so that the attitude did not change appreciably in flight.

In the calm-water landings from the towing carriage the model had about 4 feet of fore-and-aft freedom with respect to the towing carriage and was free to trim and to rise but was restrained in roll and yaw. Because of the added weight of the test equipment the model was about 10 percent overweight in these tests. During these landings an electrically actuated trim brake, attached to the towing staff, fixed the trim of the model in the air during the initial approach. The trim brake was automatically released when a contact at the trailing edge of the ski touched the water. Vertical speeds varying from 4 to 7.3 feet per second (full scale) were used for these landings which were made to compare the initial vertical accelerations of the model with and without hydro-skis. A strain-gage-type accelerometer mounted on the towing staff of the model measured the vertical accelerations. The frequency response of the accelerometer and recording galvanometer was flat to about 200 cycles per second.

Rough water.- For the rough-water landings the model was launched as a free body from the catapult into oncoming waves 3 feet high and 150 feet long (full scale) generated by the wave maker in the Langley tank no. 2. The launching method was similar to that described for the monorail.

RESULTS AND DISCUSSION

Take-Off Tests

Resistance, trim, and rise.- Plots of total resistance, trim, and rise for various elevator settings are shown in figure 7. The total resistance includes both the water resistance and the air drag of the model. The plots show that reasonable resistance and stability are obtained with full-down elevators up to the hump speed (about 22 knots, full scale). Above this speed, up elevators are necessary to obtain stability. Figure 8 shows curves of total resistance, trim, and rise for a best compromise run consistent with stability. A ratio of gross load to maximum resistance of 3.6 was obtained in this case. Minimum resistance was not utilized throughout the run of figure 8 because of instability at certain speed and trim combinations as shown in figure 7. For speeds up to 22 knots (full scale), a δ_e of 20° was used; between 22 and 30 knots, δ_e was considered to be changed gradually to -10°; between 30 and 55 knots, a δ_e of -10° was used; and above 55 knots, a δ_e of -3° was used. The air drag of the model for the same range of trims is also shown in figure 8. Because of a Reynolds number difference and a possible stall condition of the wing near take-off, the model air drag is high compared with full-scale air-drag data supplied by the manufacturer.

Longitudinal stability.- The trim limits of stability for a center-of-gravity location of $0.27\bar{c}$ are shown in figure 9. No instability was observed at ski emergence and no upper-limit instability was encountered. The full range of elevator deflection (-25° to 20°) gave a variation in trim from 14° to 11° at emergence. Lower-limit porpoising was encountered at a speed of about 28 knots (full scale) for trim angles of 9° or less. Between the speeds of 30 and 45 knots (full scale), a stable trim range of from 1° to 3° was obtained between lower-limit porpoising and the maximum trim. No instability was encountered between the speeds of 37 and 41 knots or at speeds above 55 knots (full scale).

The variation of trim with speed is shown in figure 10 for the center-of-gravity location of $0.27\bar{c}$ and an acceleration of 3 feet per second per second. Lower-limit porpoising was encountered shortly after ski emergence with elevator settings of 0°, 10°, and 20° but stable take-offs were obtained with elevator settings of -10° and -25°.

The center-of-gravity limits of stability are shown in figure 11 as a plot of elevator position against center-of-gravity location. The stable range of elevator deflection was about 7° at a center-of-gravity location of $0.20\bar{c}$ and increased rapidly from about 9° at a center-of-gravity location of $0.235\bar{c}$ to 27° at a center-of-gravity location of $0.34\bar{c}$. This wide range of possible elevator deflections may be attributed to the fact that no upper-limit porpoising was encountered.

Spray characteristics.- Spray patterns for various speeds may be seen in the sequence photographs of figure 12 which show typical behavior at various constant speeds. Heavy spray reached the propellers just at ski emergence but only for a very narrow speed range. The flaps and horizontal tail were clear except for occasional very light spray just at ski emergence.

Landing Tests

Calm water.- Free model landings in calm water resulted in fairly smooth runs except for some porpoising when landings were made at a 14° trim. The results of vertical accelerations measured in calm-water landings are shown in table II. With the hydro-skis installed a vertical acceleration of about $2\frac{1}{2}g$ was obtained on initial impact. With the hydro-skis removed a vertical acceleration of about 4g was obtained on initial impact.

Rough water.- In the rough-water landings, the skis penetrated the first three or four wave crests with no noticeable change in the trim of the model. The skis then submerged and the model followed the wave contours for the remainder of the run. For the size waves investigated (3 feet by 150 feet, full scale) the landing behavior of the model was relatively good.

CONCLUSIONS

The results of the investigation of the hydrodynamic characteristics of a 1/14-scale dynamic model of the panto-base Chase C-123 airplane led to the following conclusions:

1. The take-off stability was satisfactory for calm-water operation.

2. A ratio of gross load to maximum resistance of 3.6 was obtained.

3. Heavy spray reached the propellers only during ski emergence.

4. The landing behavior in calm water and in waves 3 feet by 150 feet (full scale) was satisfactory for a normal range of landing trims.

5. Initial impacts in calm-water landings resulted in vertical accelerations of about $2\frac{1}{2}g$ with the hydro-skis installed and about 4g with the hydro-skis removed.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., January 21, 1954.

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TABLE I

PERTINENT DIMENSIONS OF THE PANTO-BASE CHASE C-123 AIRPLANE

AND THE 1/14-SCALE DYNAMIC MODEL

	Full scale	Model
General:		
Design gross load, lb	50,000	18.20
Moments of inertia		
Roll, slug-ft^2	320,000	0.60
Pitch, slug-ft^2	367,000	0.68
Yaw, slug-ft^2	633,000	1.18
Static thrust, lb	18,800	6.85
Over-all length, ft	75.74	5.41
Over-all height, ft	33.32	2.38
Center-of-gravity location		
Percent mean aerodynamic chord	27.0	27.0
Height above keel, ft	7.98	0.57
Hull:		
Length, ft	75.74	5.41
Maximum beam, ft	14.0	1.0
Height, ft	12.6	0.9
Angle of dead rise, deg	9	9
Forebody step from bow, ft	33.18	2.37
Afterbody step from bow, ft	41.25	2.95
Wing:		
Area, sq ft	1223.22	6.24
Span, ft	110.0	7.86
Mean aerodynamic chord, ft	11.69	0.84
Root chord, ft	14.96	1.07
Tip chord, ft	7.50	0.54
Aspect ratio	9.89	9.89
Flaps		
Take-off position, deg	20	20
Landing position, deg	45	45
Horizontal tail:		
Total area, sq ft	309.20	1.58
Span, ft	36.33	2.60
Vertical tail:		
Total area, sq ft	179.53	0.92

TABLE I. - Concluded

PERTINENT DIMENSIONS OF THE PANTO-BASE CHASE C-123 AIRPLANE

AND THE 1/14-SCALE DYNAMIC MODEL

	Full scale	Model
Hydro-ski:		
Length, ft	14	1
Beam, ft	3.50	0.25
Length-beam ratio	4	4
Total area of one ski (including hydrovanes), sq ft	51.7	0.264
Gross loading, lb/ft^2	483.35	34.47
Gross load coefficient, C_{Δ_0}	9.25	9.25
Tip floats:		
Length, ft	12.04	0.86
Beam, ft	3.08	0.22
Height, ft	3.09	0.2208

TABLE II

PANTO-BASE CHASE C-123 CALM-WATER LANDINGS

[All values are full scale; the accelerometer indicates 1g static]

Contact trim, deg	Contact speed		Initial contact acceleration (vertical) g
	Horizontal, knots	Vertical, fps	
Hydro-skis removed			
9	79	7.3	4.6
9	79	6.0	3.7
12	74	6.9	3.9
12	73	6.9	4.0
12	74	7.3	4.3
12	74	6.7	4.0
12	81	6.7	3.7
14	79	6.0	4.0
14	79	6.3	3.7
14	81	4.9	3.5
Hydro-skis installed			
9	81	4.7	2.2
9	85	4.7	2.4
9	85	4.5	2.0
9	89	4.5	2.1
9	86	4.0	1.9
12	82	4.5	2.2
12	75	6.0	2.3
12	79	6.0	2.3
14	75	6.0	2.6
14	76	5.6	2.3
14	74	4.2	2.1

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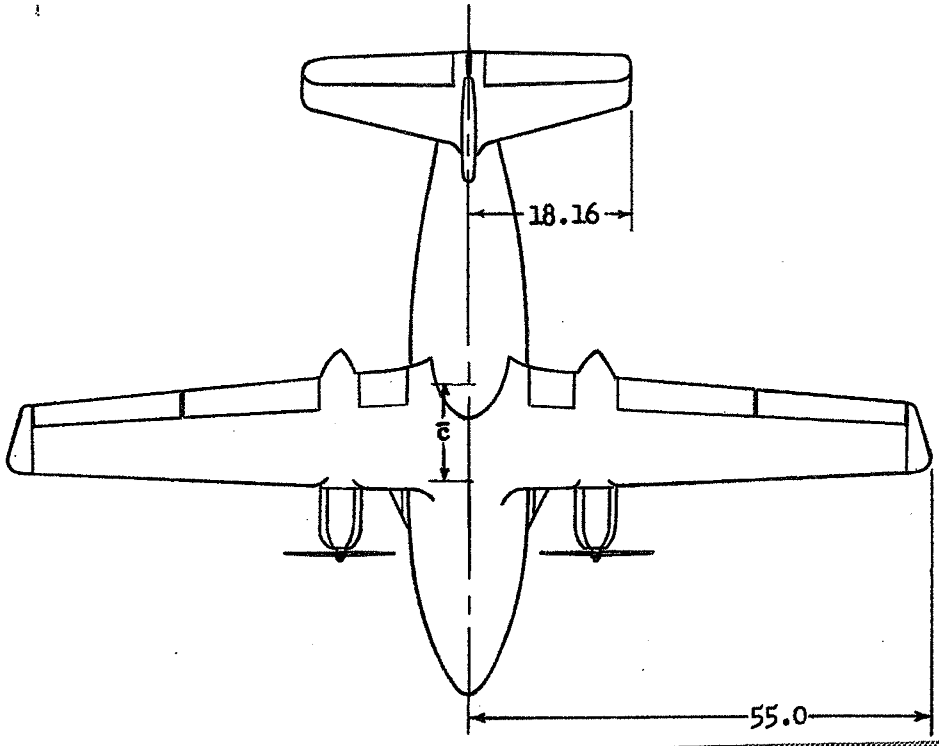

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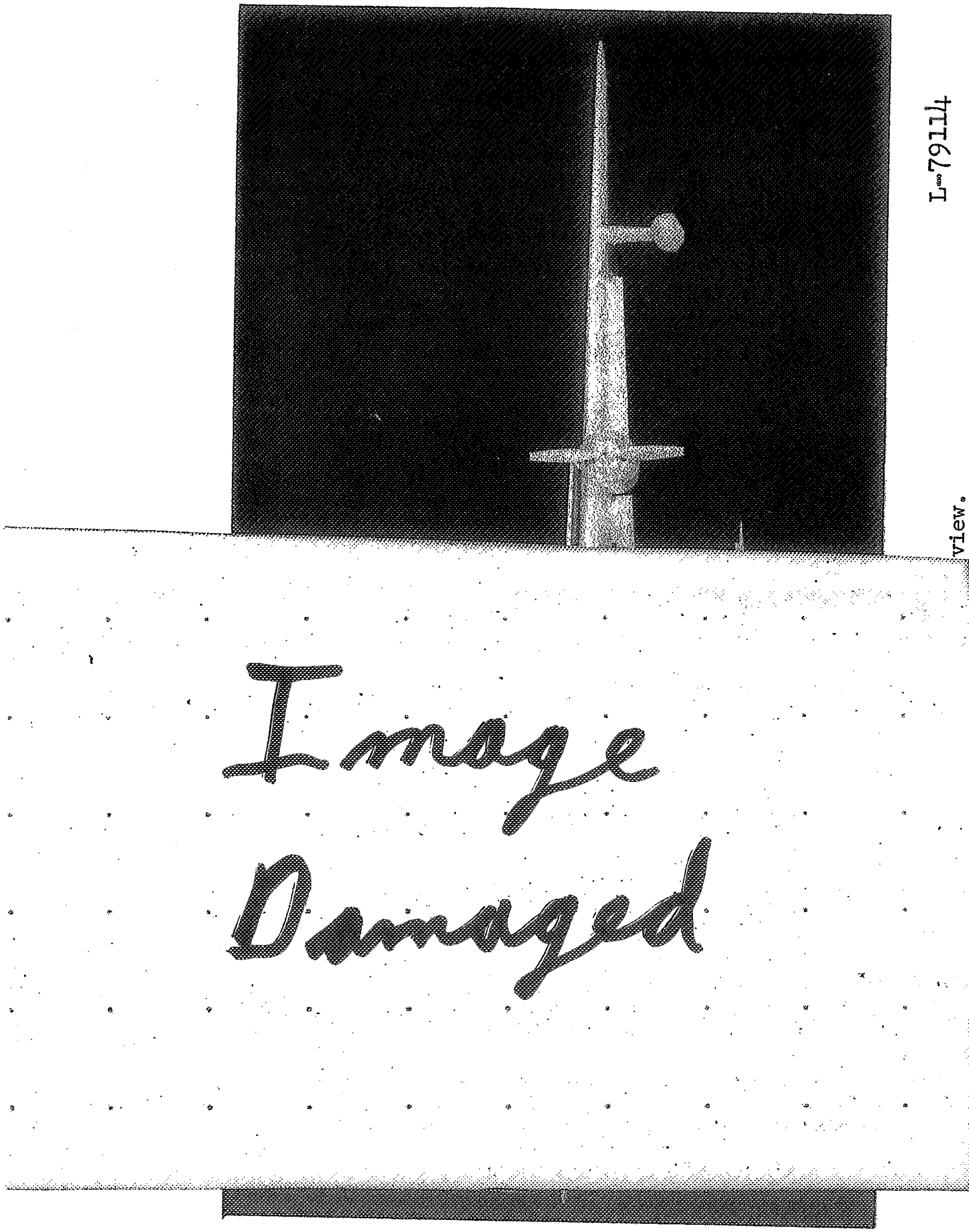
Figure 1.- Three-view drawing of the panto-base Chase C-123 airplane. All dimensions are in feet (full scale).



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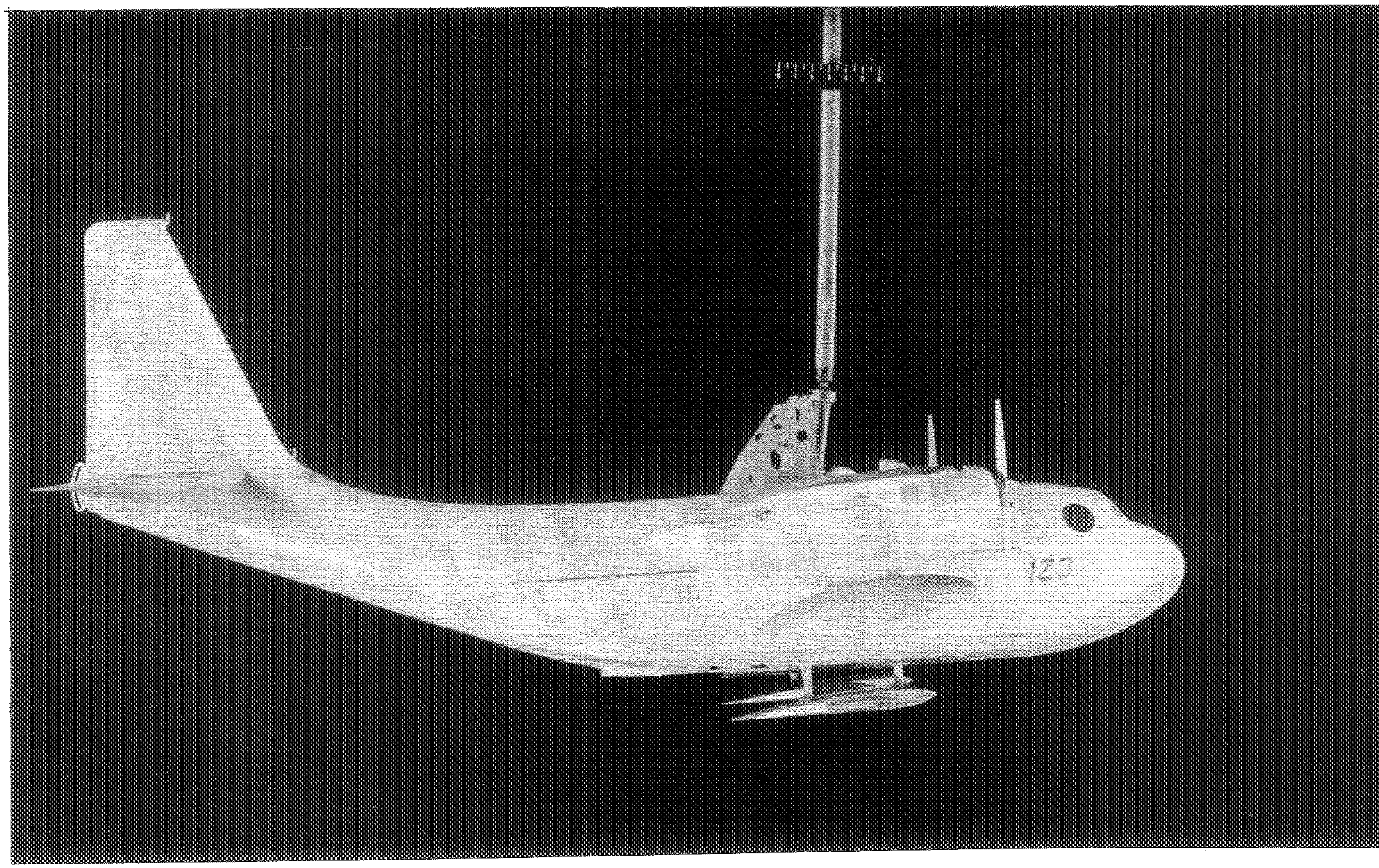
view.

Figure 2.- The panto-base Chase C-123 model.



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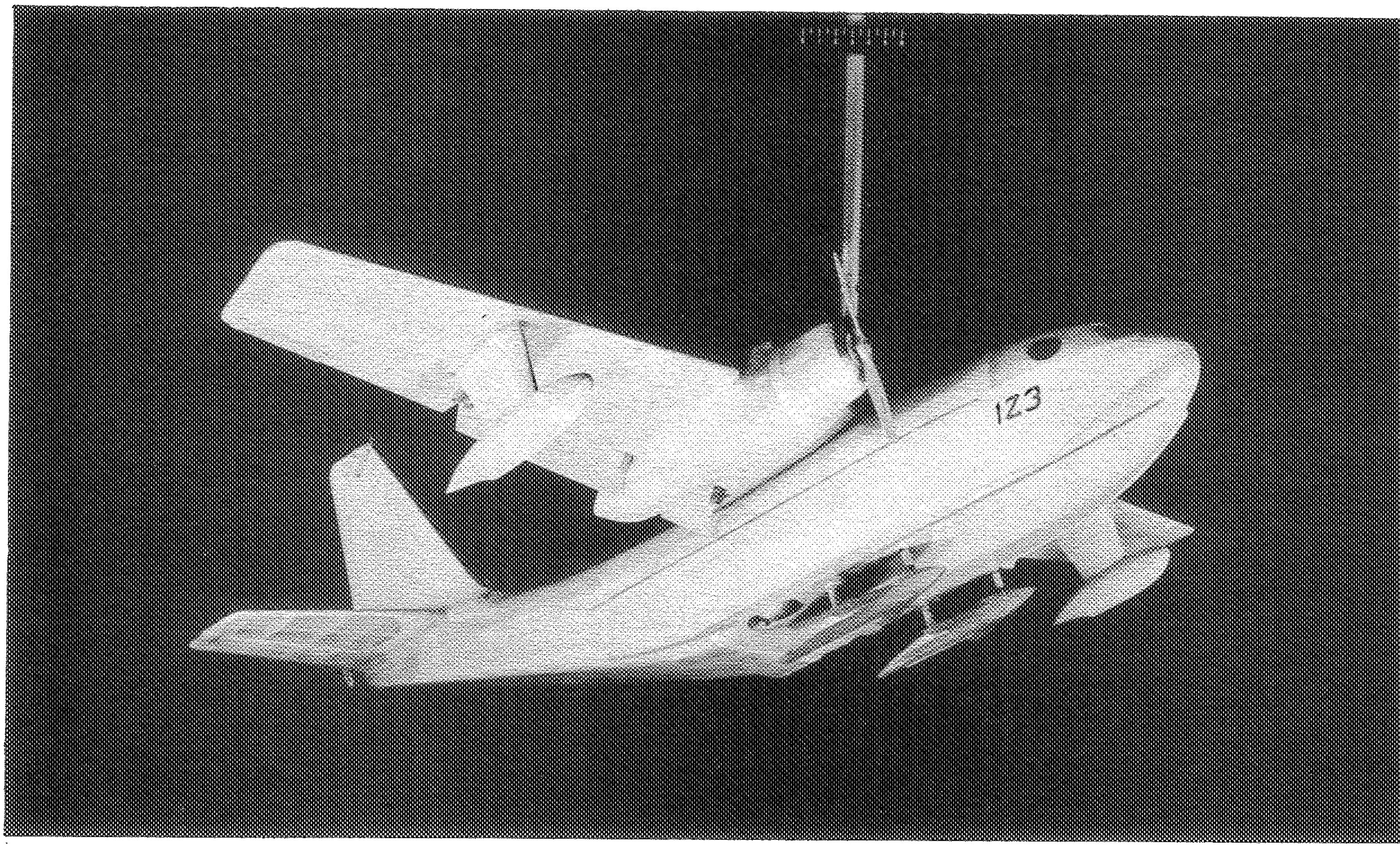
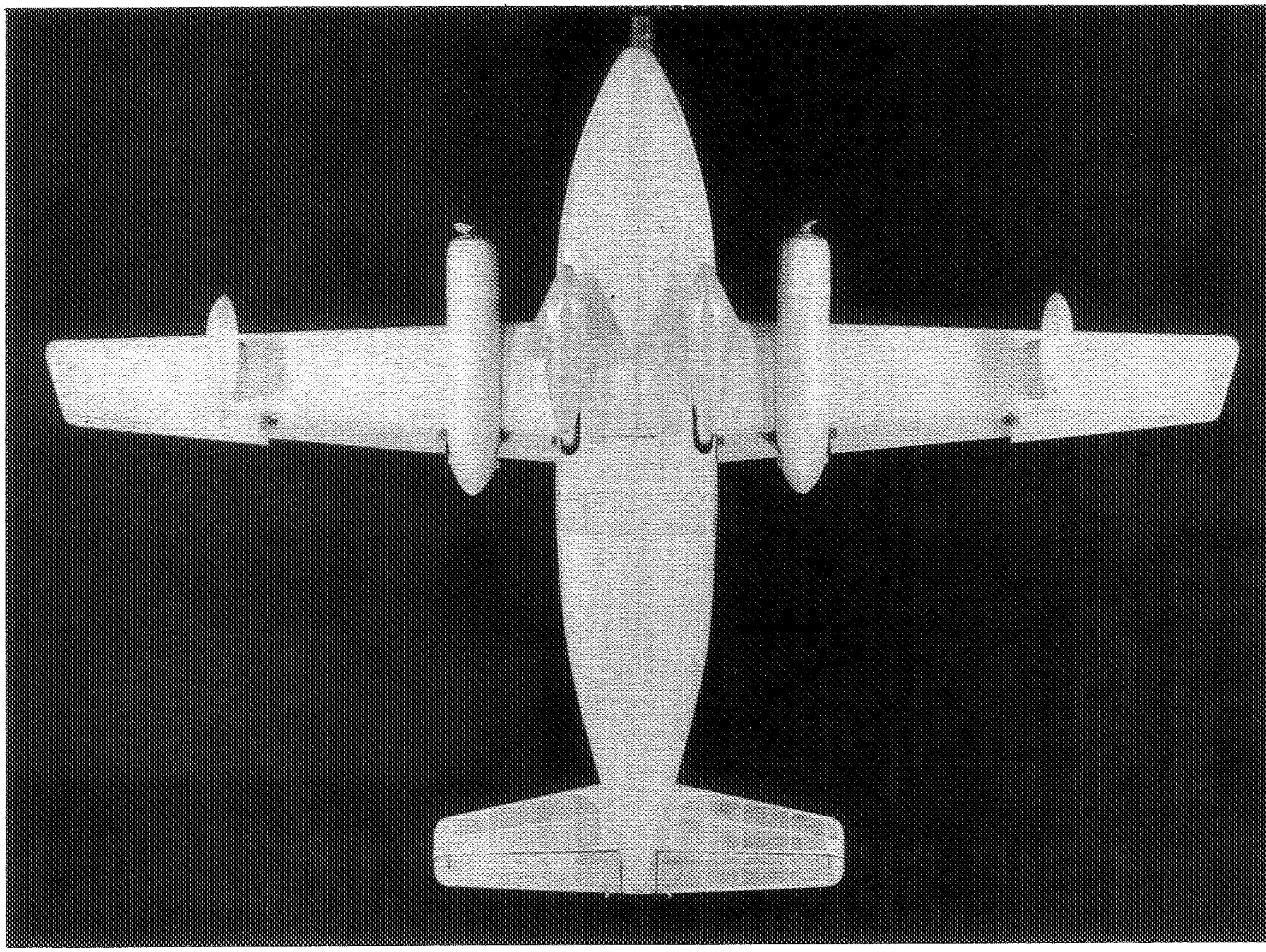
(b) Side view.

Figure 2.- Continued.



(c) Three-quarter bottom view. L-79115

Figure 2.- Continued.



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(d) Bottom view.

Figure 2.- Concluded.

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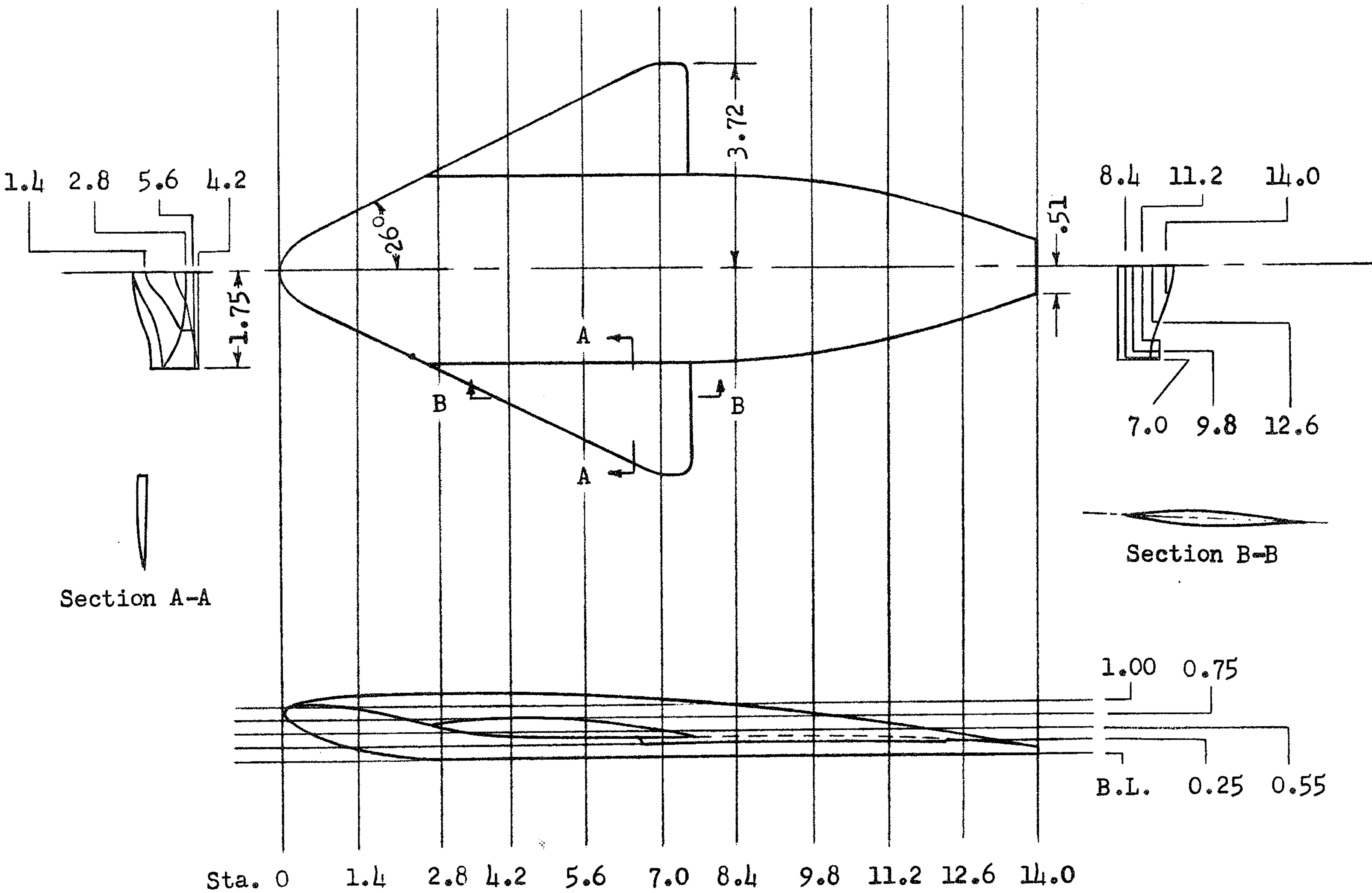

Figure 3.- Hydro-ski lines of the panto-base C-123 model. All dimensions are in feet (full scale).

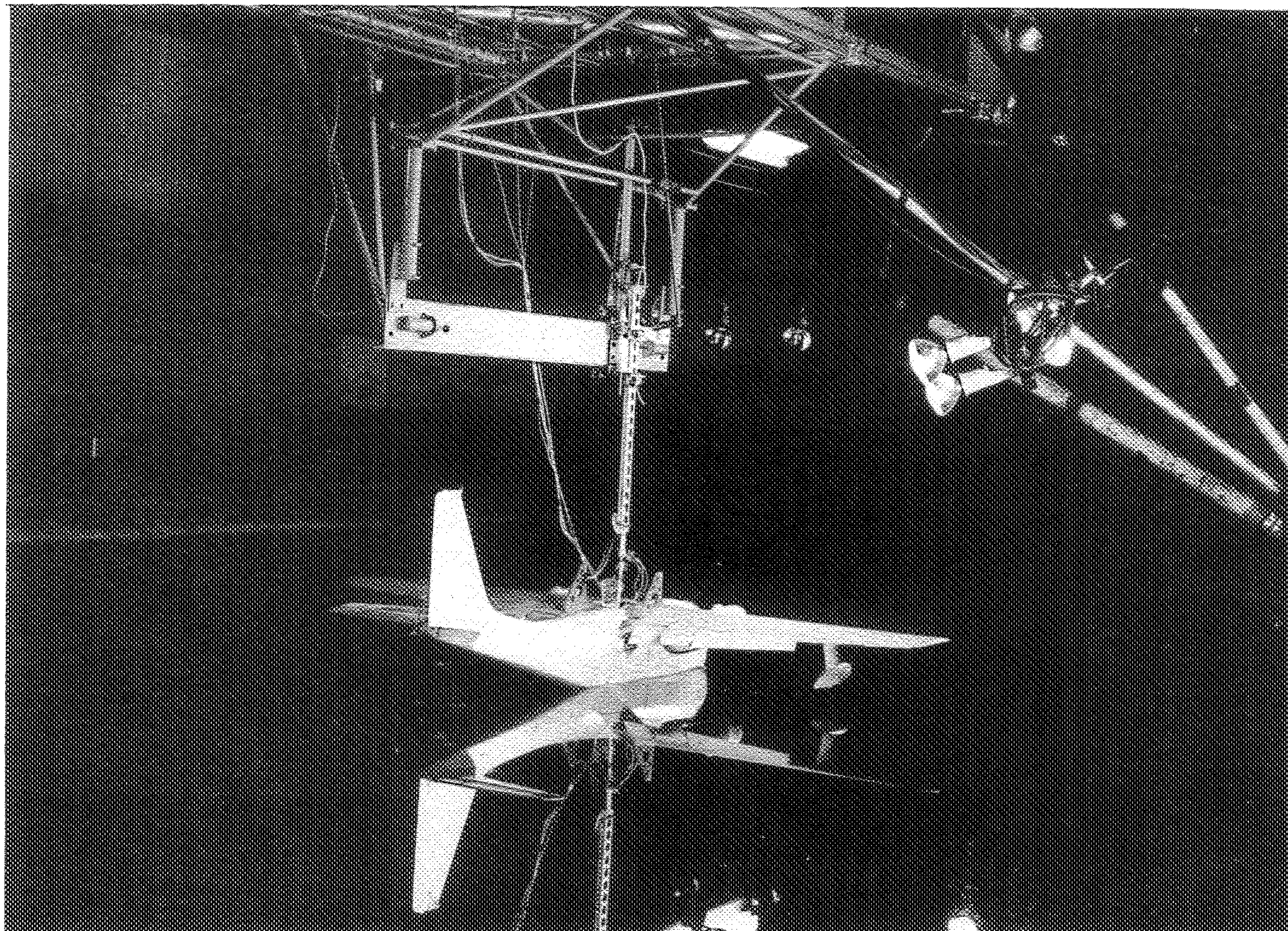

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Figure 4.- The fore-and-aft freedom gear in the Langley tank no. 2 with the panto-base C-123 model attached.

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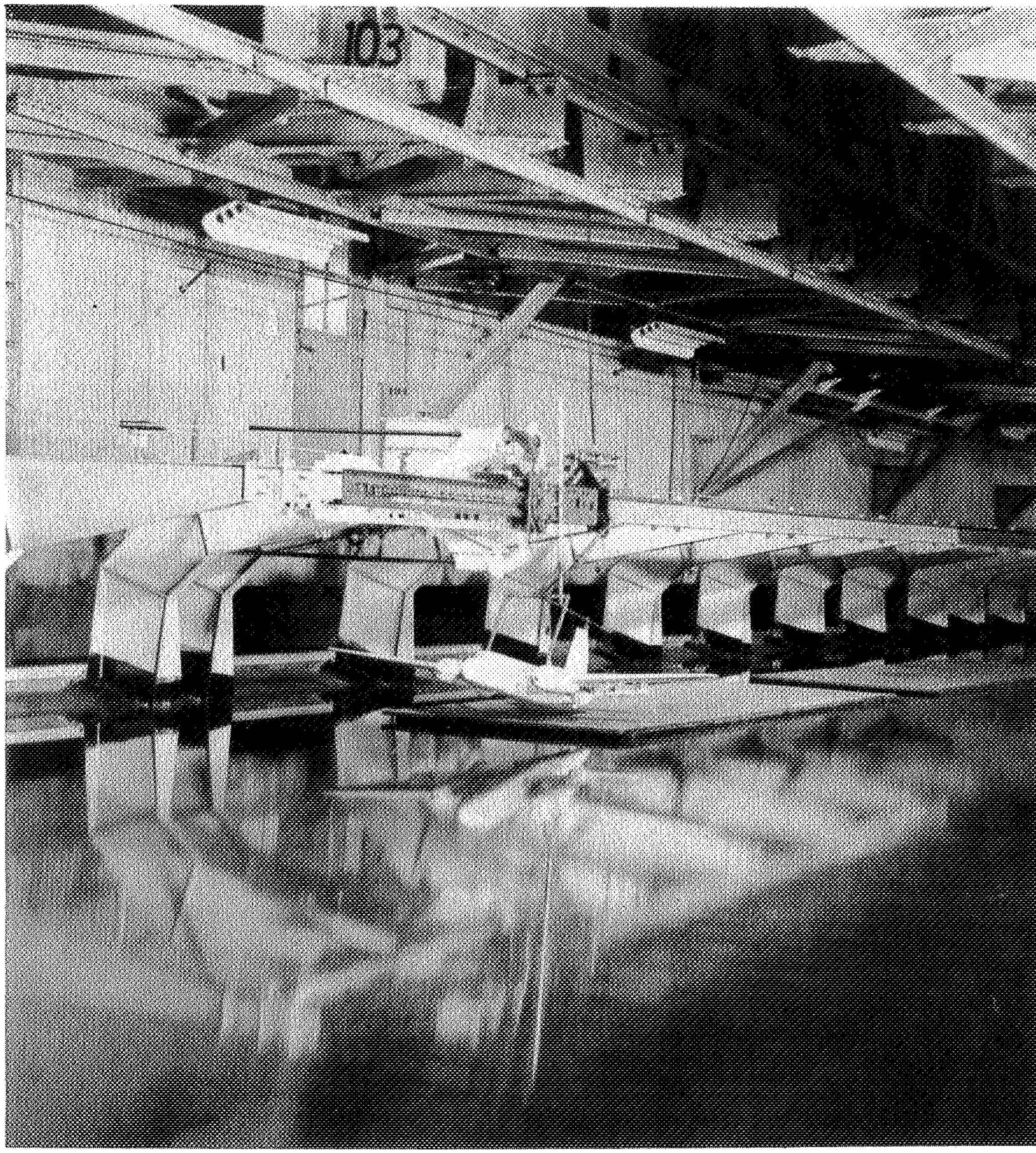

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Figure 5.- The monorail in the Langley tank no. 2 with a model attached.

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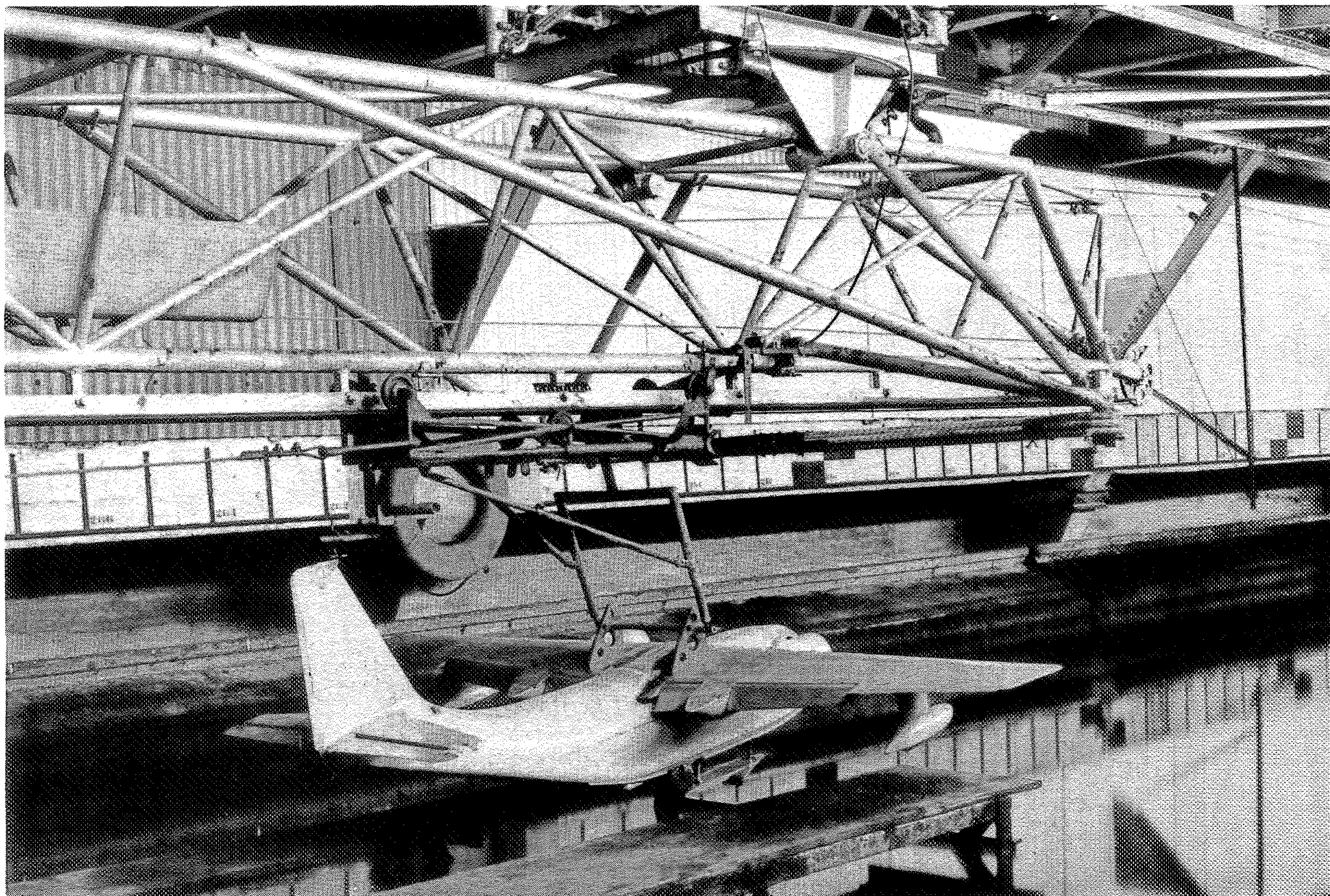

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Figure 6.- The catapult in the Langley tank no. 2 with the panto-base C-123 model attached.

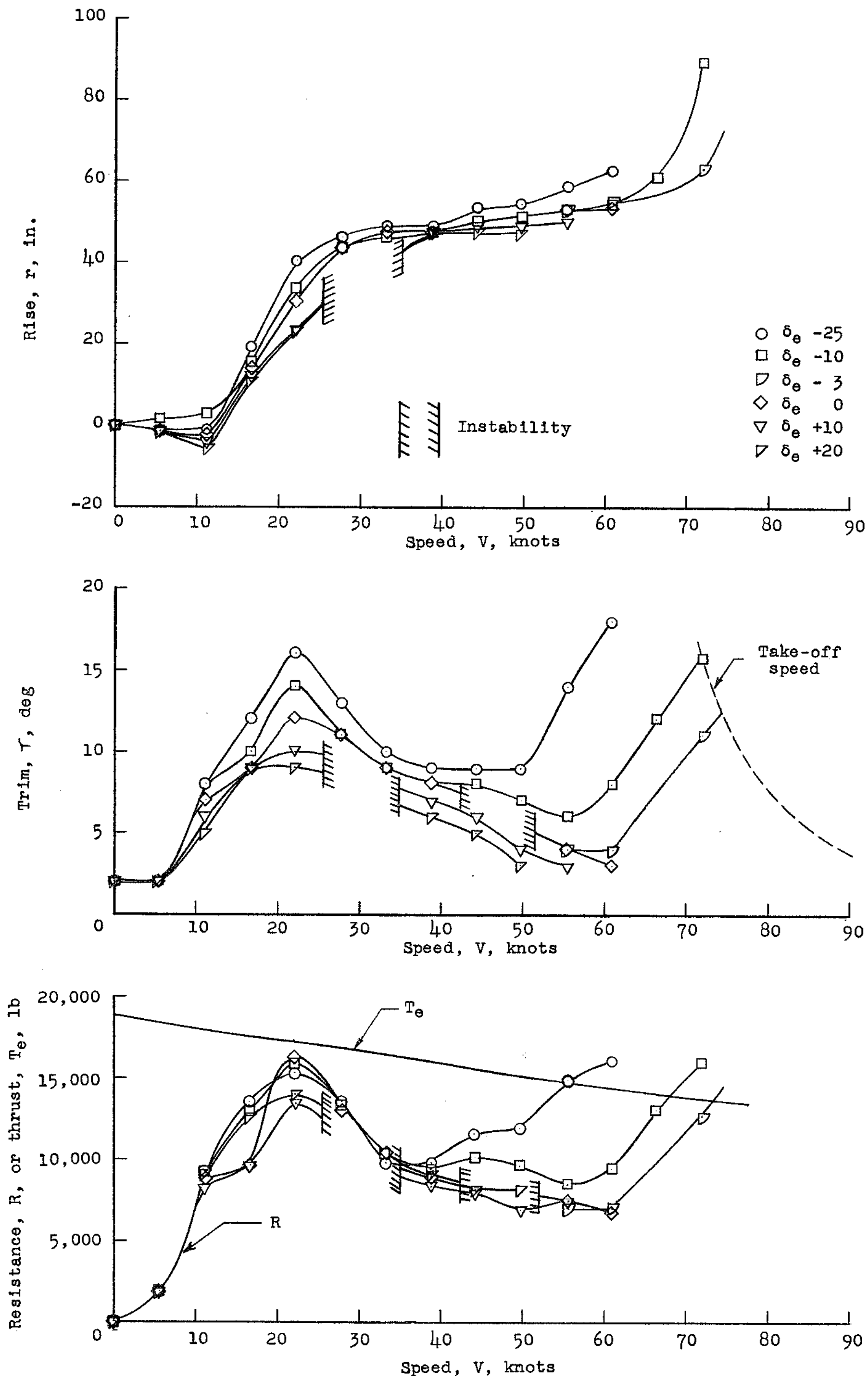

Figure 7.- Resistance, trim, and rise at constant speeds for the panto-base C-123 model. All values are full scale.

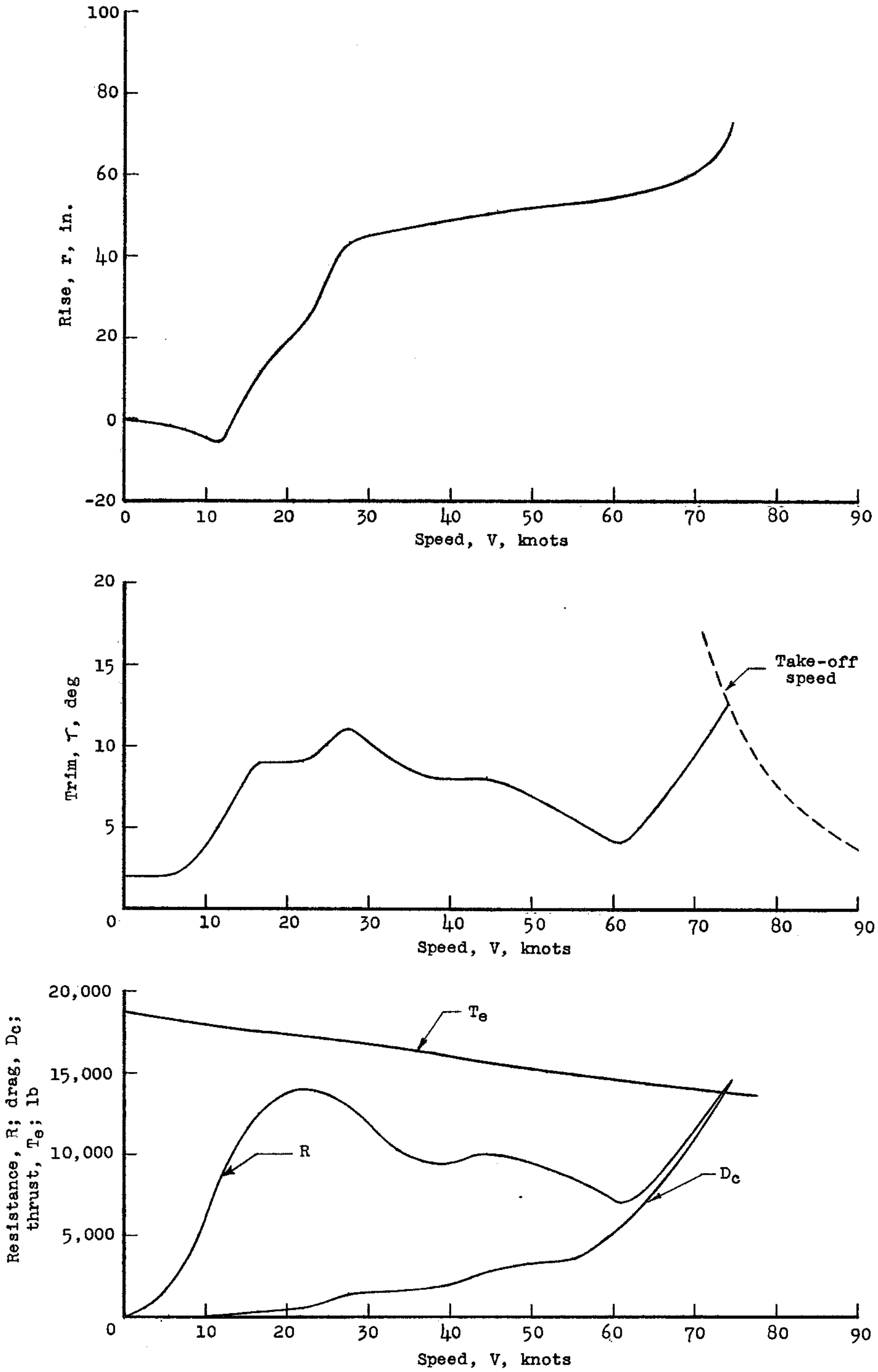

Figure 8.- Total resistance, air drag, trim, and rise for best take-off performance for the panto-base C-123 model. All values are full scale.

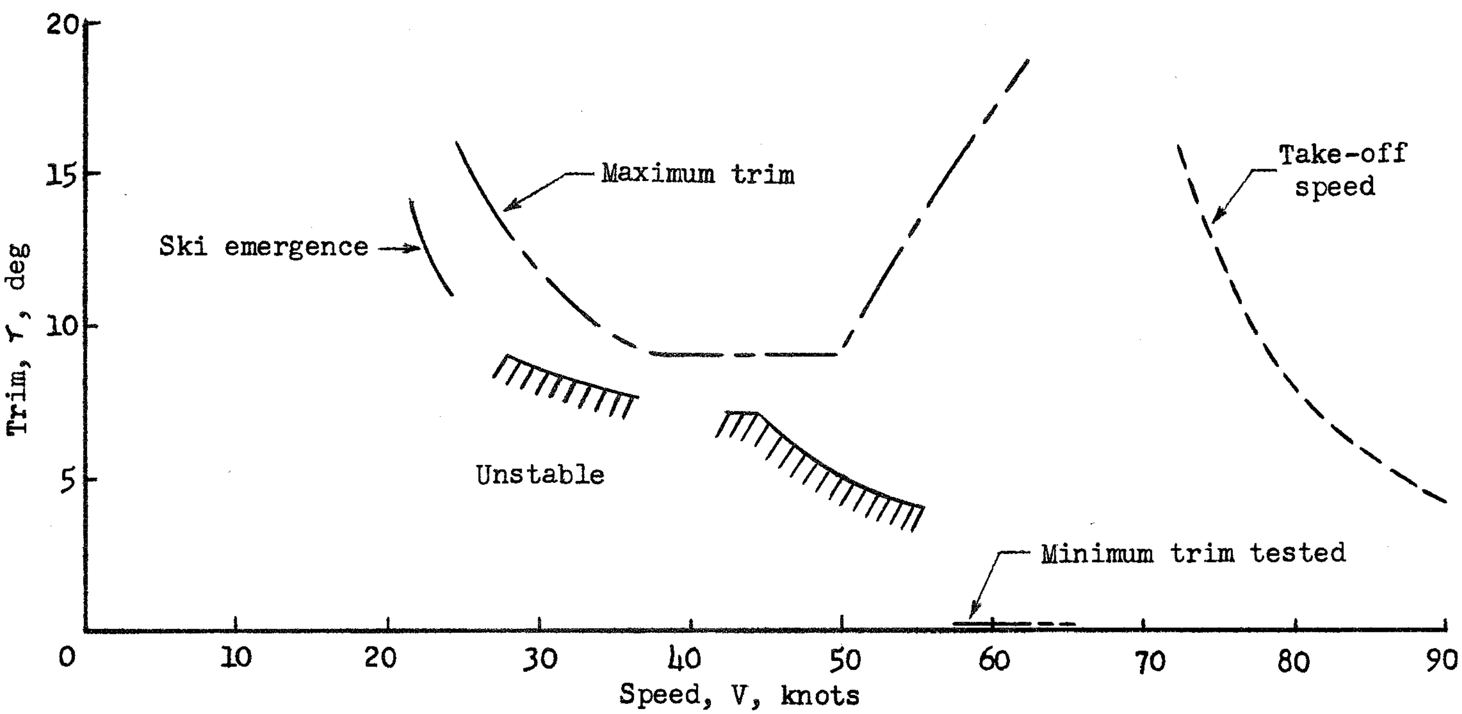

Figure 9.- Trim limits of stability for the panto-base C-123 model. All values are full scale.

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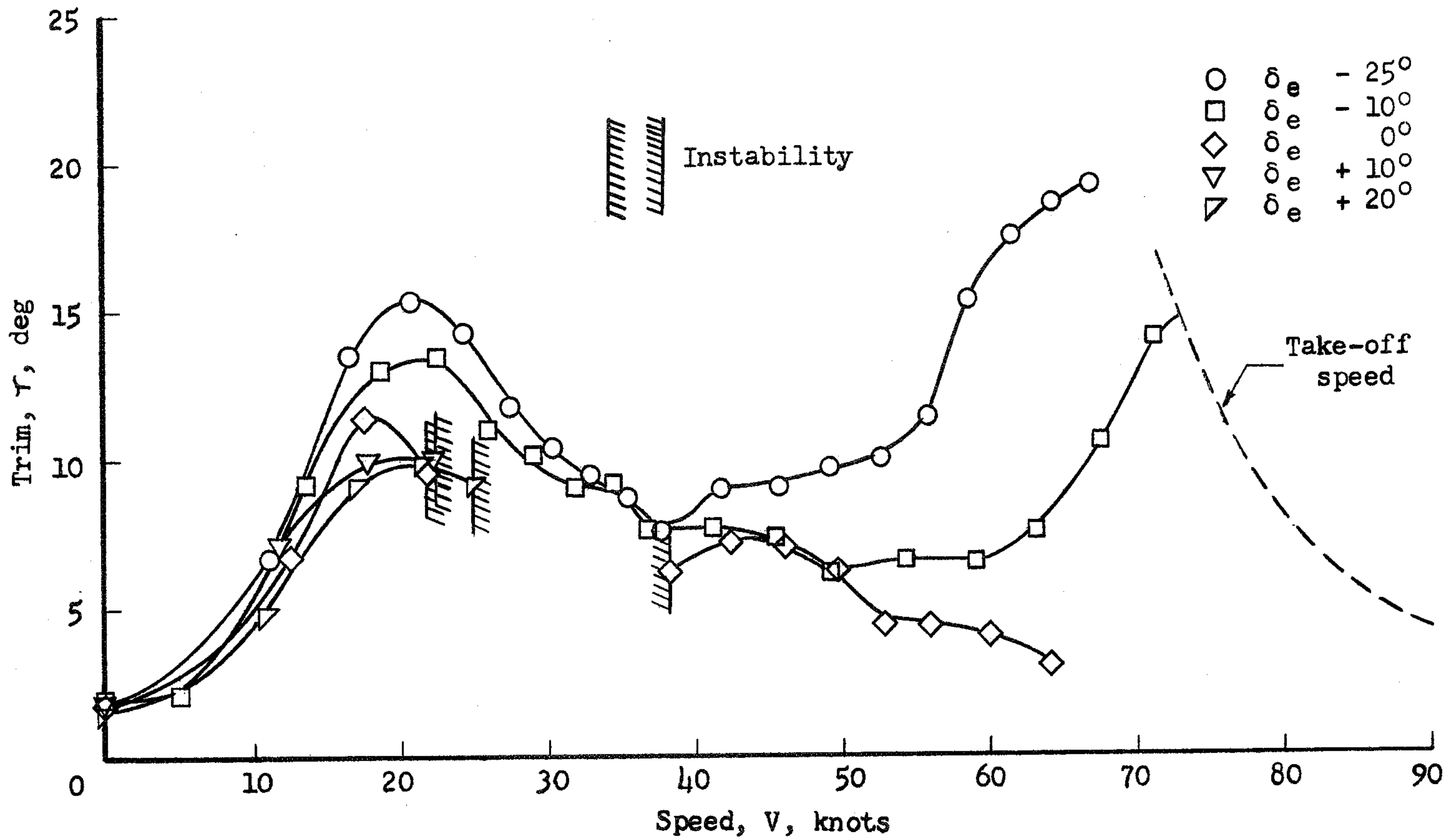

Figure 10.- Variation of trim with speed at an acceleration of 3 feet per second per second for the panto-base C-123 model. All values are full scale.

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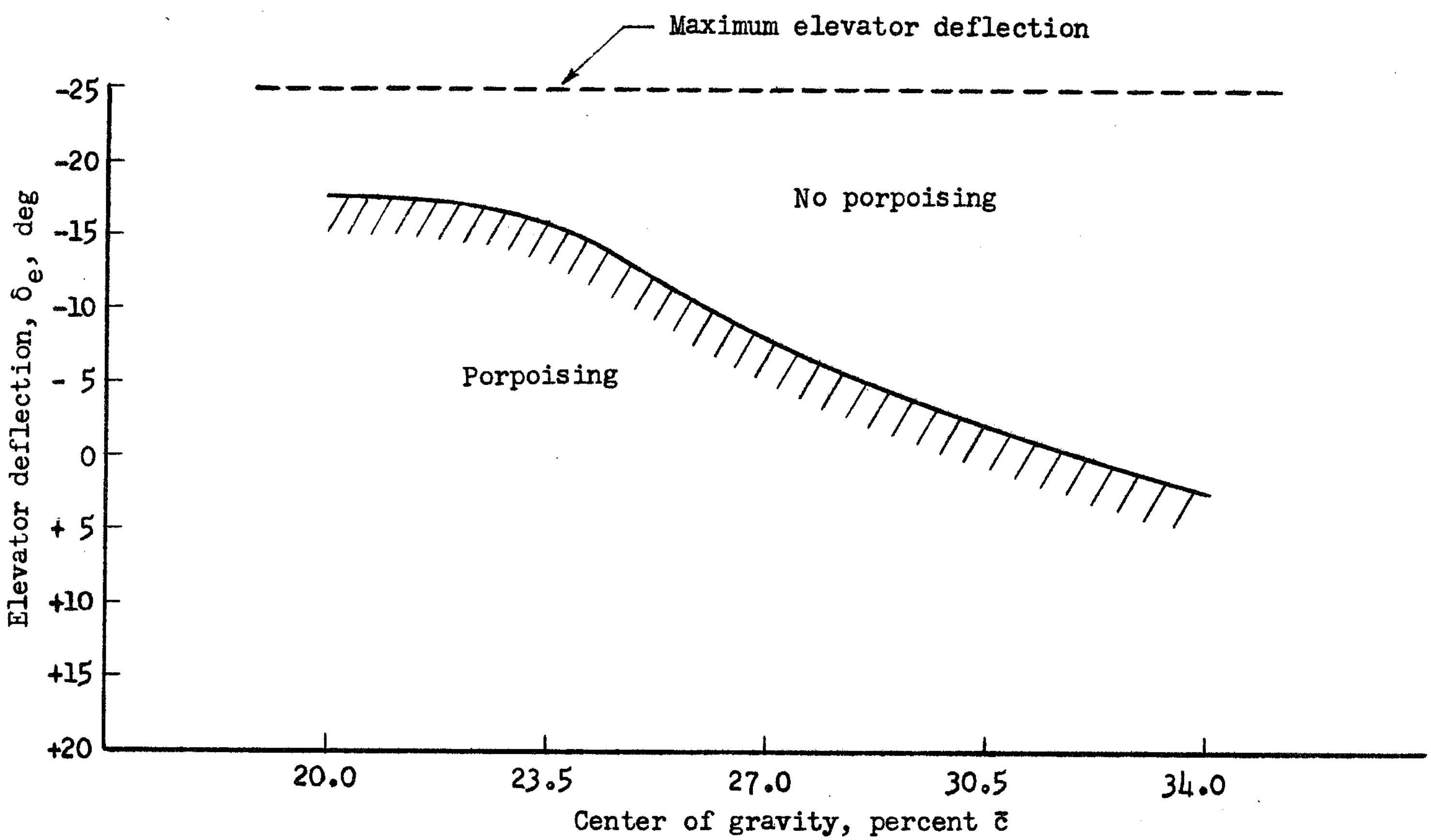

Figure 11.- Center-of-gravity limits of stability for the panto-base C-123 model.

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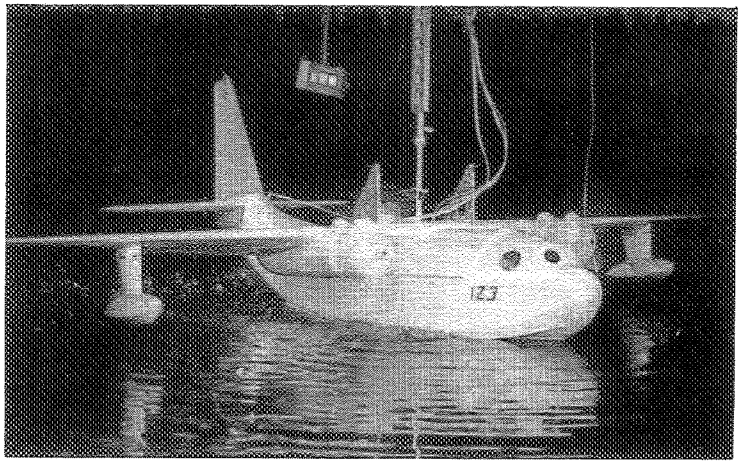
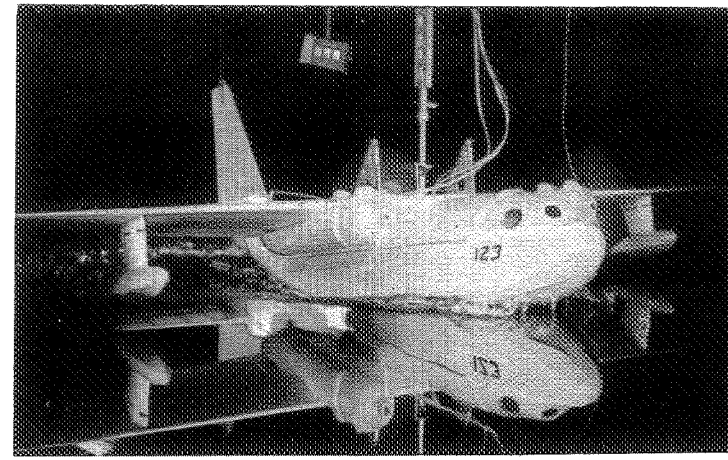
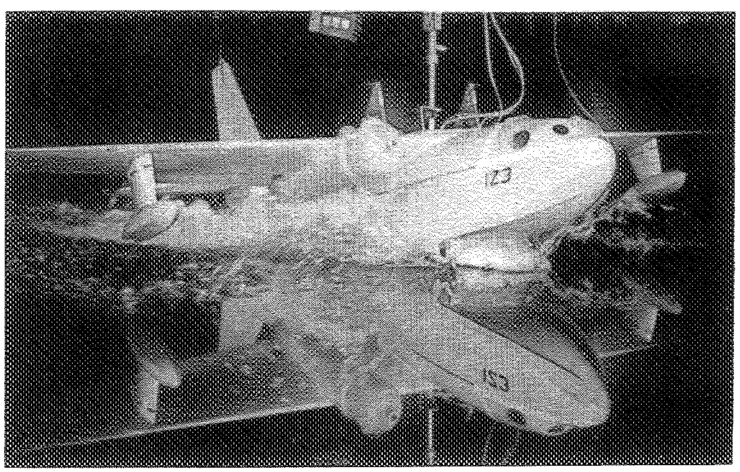


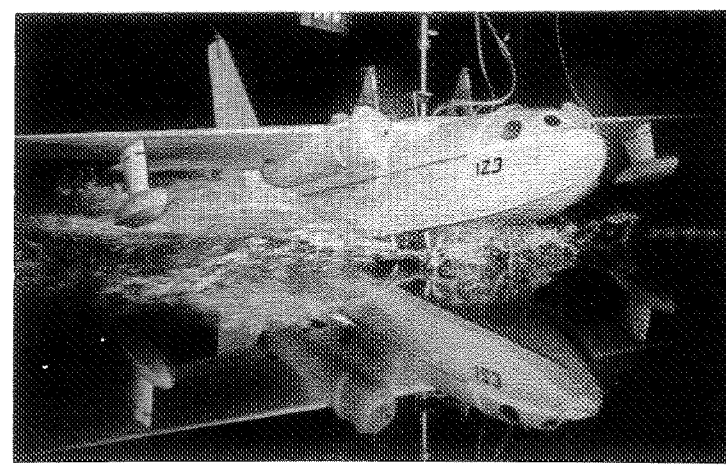
V = 0 knots, τ = 2°



V = 11.1 knots, τ = 7°



V = 22.1 knots, τ = 13°



V = 27.7 knots, τ = 11°

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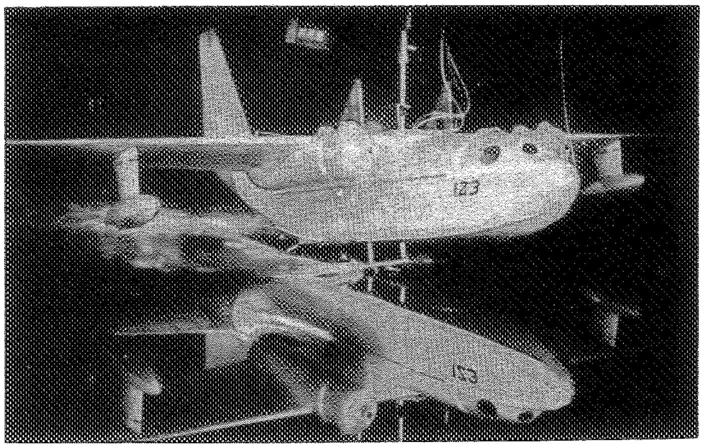
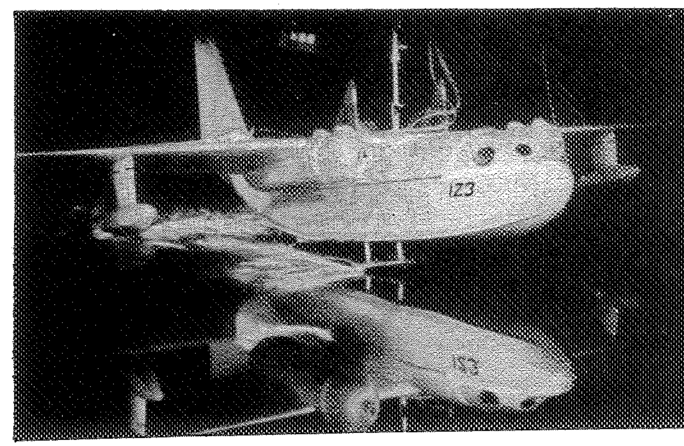
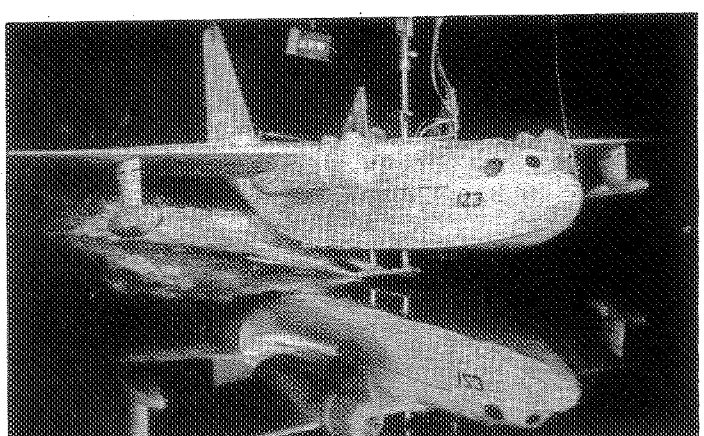
Figure 12.- Sequence photographs showing model spray patterns at various speeds during a take-off run. All values are full scale; δ_e, -3°.



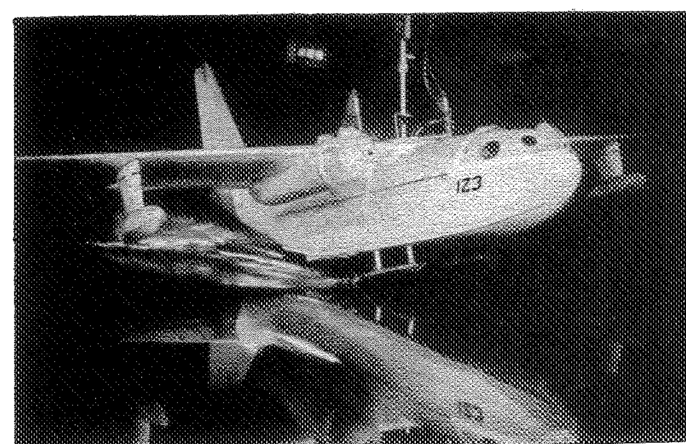
V = 33.2 knots, $\tau = 9^{\circ}$



V = 44.3 knots, $\tau = 7^{\circ}$



V = 55.4 knots, $\tau = 5^{\circ}$



V = 72.0 knots, $\tau = 11^{\circ}$

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Figure 12.- Concluded.

Restriction/Classification Cancelled