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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

COMPARISON OF WATER-LOAD DISTRIBUTIONS OBTAINED DURING SEAPLANE LANDINGS WITH BUREAU OF AERONAUTICS SPECIFICATIONS

TED NO. NACA 2413

By

Robert F. Smiley and Gilbert A. Haines

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

Bureau of Aeronautics Design Specifications SS-IC-2 for water loads in sheltered water are compared with experimental water loads obtained during a full-scale landing investigation. This investigation was conducted with a JRS-1 flying boat which has a 20° dead-rise V-bottom with a partial chine flare.

The range of landing conditions included airspeeds between 88 and 126 feet per second, sinking speeds between 1.6 and 9.1 feet per second, flight angles less than 6°, and trims between 2° and 12°. Landings were moderate and were made in calm water. Measurements were obtained of maximum over-all loads, maximum pitching moments, and pressure distributions. Maximum experimental loads include over-all load factors of 2g, moments of 128,000 pound-feet, and maximum local pressures greater than 40 pounds per square inch. Experimental over-all loads are approximately one-half the design values, while local pressures are of the same order as or larger than pressures calculated from specifications for plating, stringer, floor, and frame design. The value of this comparison is limited, to some extent, by the necessary simplifying assumptions used in comparing the specifications with the experimental loads.

INTRODUCTION

A full-scale landing investigation was conducted for the purpose of determining the applicability of hydrodynamic impact theory and model tests to actual seaplane landings. A series of landings were made in smooth water with a JRS-1 flying boat having a 20° dead-rise V-bottom with a partial chine flare. Measurements were obtained of over-all loads, pitching moments, and pressure distributions. The over-all load measurements have been partially reported in reference 2 where they have been compared with hydrodynamic impact theory.

At the request of the Bureau of Aeronautics, the load-distribution measurements obtained from this investigation have been compared with the specifications provided in reference 1. The following comparisons have been made: (1) Experimental over-all loads have been compared with over-all forebody loads calculated from design specifications; (2) average pressures have been compared with pressures calculated from specifications for floor, frame, plating, and stringer design; and (3) peak pressures have been compared with pressures calculated from specifications for plating and stringer design.

Landing conditions encountered covered a fairly wide range of airspeed, sinking speed, and trim angle. Impacts were moderate and were made in smooth water. During several of the impacts, the afterbody of the hull was clear of the water; but in the majority of cases, both forebody and afterbody were involved. During all landings the extremely warped region of the bow was either clear of the water or it was not involved until so late in the impacts that the loads in that vicinity were small.

SYMBOLS

V_s stalling speed, miles per hour

γ flight-path angle, degrees

τ trim, degrees

ω pitching velocity, degrees per second

α angular acceleration, radians per second^2

W gross weight of seaplane, pounds

i_y pitching radius of gyration of the airplane, feet

β angle of dead rise at any section under consideration, degrees

β_k angle of dead rise at keel, degrees

β_c angle of dead rise at chine, degrees

β_{c_1} angle of dead rise at chine measured in the section containing the center of pressure, degrees

x longitudinal distance between the center of gravity and the center of pressure, feet $\left(\frac{\text{Pitching moment}}{\text{Normal load}}\right)$

L_f length of the forebody, feet

n_{i_k} acceleration normal to keel in g units

g acceleration due to gravity, 32.2 feet per second per second

P water load, pounds

p pressure, pounds per inch^2

p_f floor and frame design pressure, pounds per inch^2

p_k bottom plating and stringer design pressure at the keel, pounds per inch^2

p_c bottom plating and stringer design pressure at the chines, pounds per inch^2

K_1 constant in specifications used in computing pressure

K_2 constant in specifications used in computing loads

Subscript:

o parameters at time of water contact

INSTRUMENTATION

The airplane used in this investigation was a conventional amphibian-type flying boat. (See fig. 1.) Pertinent geometric properties are given in figures 2 and 3 and in table I.

The principal quantities used in comparing experimental and design loads are trim, bottom pressure, acceleration of the center of gravity normal to the keel, and the pitching angular acceleration of the airplane about the center of gravity. Additional measured quantities include vertical displacement of the forebody step, airspeed, water speed, and time of initial water contact.

The relative locations of the instruments involved are shown in figure 4, and specific locations are given in tables II and III. A time history of the trim was obtained from a Sperry gyroscope mounted on the floor of the cabin. Pressure indicators were 1-inch-diameter flush-mounted electrical induction-type gages. Their locations are given in figure 5 and in table III. A typical oscillograph record is presented in figure 6. On this record are shown traces of pressure gages, normal acceleration, and angular acceleration. Also shown on this record are strain-gage measurements and wing-tip accelerations which are discussed in other papers.

The acceleration of the center of gravity normal to the keel and the wing lift at time of contact were obtained with a standard NACA accelerometer having a natural frequency of approximately 19 cycles per second. The acceleration due to water load was obtained from the difference between the total acceleration and the acceleration due to initial wing lift. The pitching angular acceleration of the airplane was measured with a Trimount angular accelerometer having a natural frequency of about 22 cycles per second. These measured values were multiplied by the moment of inertia to obtain the pitching moment about the center of gravity. Typical linear and angular acceleration records are presented in figure 7.

The time of water contact was obtained through the completion of an electrical circuit by the water when the forebody step contacted the water surface. Vertical displacements of the forebody step before water contact were obtained by the use of a small rod extending from the step, together with a 16-millimeter motion camera mounted on the wing and focused on the region of the step. The point of intersection of the rod with the water surface was indicated by a line of spray. Vertical distances from this point to the step were scaled from the photographs to obtain vertical displacements. Vertical displacements after water contact were obtained by using the wetted keel lengths and the associated instantaneous trim angles. The wetted keel lengths were obtained from the immersion of the pressure gages located near the keel. A detailed description of this determination is given in reference 2.

The vertical velocity used to determine the initial flight angle was obtained by graphically differentiating the vertical displacement time history at the time of water contact. Airspeed was obtained with a standard NACA airspeed head mounted above the pilot's compartment. Water speed was obtained from the dynamic pressure on an inductive-type pressure gage mounted at the same level as the keel near the forebody step.

A more complete discussion of this instrumentation may be found in reference 2.

PRECISION OF MEASUREMENTS

The following figures are estimates of the maximum errors in the data presented, based on both instrument and reading errors:

Airspeed, feet per second	±4
Water speed, feet per second	±4
Sinking speed, feet per second	±1
Trim, degrees	$\pm\frac{1}{4}$
n_{i_k}, g units	±0.3
p, percent of reading	±10
α, radians per second^2	$\pm\frac{1}{4}$
Wing lift, g units	±0.05

RESULTS AND DISCUSSION

The experimental loads obtained from this landing investigation have been compared with loads calculated from Bureau of Aeronautics Specification SS-1C-2. The following formulas taken from this reference cover the smooth-water landing requirements and have been used for these comparisons:

Component of the water load on the float forebody normal to hull reference line. (For this investigation the hull reference line was taken as the keel which is straight for the portion of the forebody involved during the impacts.)

$$P = 0.0085K_2\left(\frac{W}{1 + \frac{x^2}{i_y^2}}\right)^{2/3} V_s^2 \cot^{2/3}\beta_{c_1} + \frac{W}{3}$$

Floor and frame design pressures:

$$p_f = 0.00070K_1V_s^2\cot\beta_c$$

Bottom plating and stringer design pressures at the keel:

$$p_k = 0.00160K_1V_s^2\cot\beta_k$$

Bottom plating and stringer design pressures at the chines:

$$p_c = 0.00120K_1V_s^2\cot\beta_c$$

Specified design distributions and constants are shown in figure 8.

The scope of the landing investigation is indicated in table IV where the flight parameters for the time of initial water contact are tabulated for all impacts.

Over-All Loads

The values of the maximum experimental loads, the corresponding pitching moments about the center of gravity, and the associated center-of-pressure locations are presented in table V. In the same table are presented the maximum pitching moments about the center of gravity, the corresponding loads, and the center-of-pressure locations. Maximum loads vary between loads of approximately 8,000 and 40,000 pounds with an average load of 20,000 pounds, corresponding to load factors of 0.4g, 2g, and 1 g, respectively. Maximum moments vary from -105,000 to 128,000 pound-feet, corresponding to angular accelerations of -2.2 to 2.7 radians per second^2. In figure 9, maximum experimental forebody loads and a combination of forebody and afterbody loads are plotted against center-of-pressure location and are compared with forebody design loads. These forebody loads are separated into two groups: chines immersed at time of maximum load and chines not immersed. The combined forebody and afterbody loads could not be separated accurately, so the combination is compared with forebody design loads. The plots show that the maximum experimental forebody loads and combination of forebody and afterbody loads are of the same order of magnitude and are approximately one-half the value of the design loads.

Table VI presents maximum loads, corresponding pitching moments, and center-of-pressure locations for afterbody impacts. These impacts are the early portions of a few combination forebody and afterbody impacts in which the afterbody contacted the water prior to the forebody. The values are presented as a matter of interest. Because they are so small, no comparison with afterbody design loads was attempted.

Pressure Distribution

As a basis for the comparison of experimental pressure data with the specifications, maximum lateral experimental pressure distributions at a given cross section of the hull have been considered comparable to the equivalent lateral load calculated from the specifications for the same section. This involves two assumptions: (1) Over longitudinal distances on the order of stringer and frame spacing, the pressure distribution is constant and (2) hull frequency response is negligible and instantaneous experimental distributions may be compared to design specifications.

Experimental pressure data have been divided into three classes of (1) peak pressure, (2) average pressure over the wetted beam, and (3) average pressure over the total beam. These classes are illustrated in figure 10. Peak pressures represent the maximum pressure obtained on a 1-inch-diameter area. Average pressures over the wetted beam were obtained by averaging the instantaneous pressure distributions at each of two well-instrumented cross sections of the hull over the wetted beam. Average pressures over the total beam were similarly obtained for the two cross sections. These two cross sections, A-A and B-B, are located 31.1 inches and 92.5 inches, respectively, forward of the forebody step and are shown in figure 5.

In table VII peak pressures have been tabulated for all landings, together with the pertinent flight parameters. This table includes only forebody gages whose readings varied from 0 to over 40 pounds per inch^2. Small pressures were usually observed on several of the afterbody gages, but these same gages were unreliable due to various instrument difficulties and the magnitude of their readings was questionable. The same forebody peak-pressure data are plotted in figure 11 and are compared with values calculated from specifications for plating and stringer design for sheltered-water landings. These data for sections A-A and B-B are also presented in figure 12. Although the experimental peak pressures are larger than pressures calculated from these specifications, this fact is not too significant since the peak pressure acts on a smaller area than that area relevant to plating and stringer loading. Stringer-loading areas on the subject hull are about 5 inches wide while the width of several of the larger pressure peaks is on the order of an inch or two. Largely for this reason, values of average pressures over the wetted beam were calculated for several of the hardest impacts and are presented in figure 13 as a comparison with values calculated from specifications for plating and stringer design and for floor and frame design. The points in this figure were determined as illustrated in figure 9. These values of average pressure are considered to be a low estimate of effective stringer loads.

Figure 14 shows comparisons of average pressures over the total beam at sections A-A and B-B with values calculated from specifications for floor and frame design. For both sections these average pressures are less than 9 pounds per inch^2. These comparisons indicate that average pressures are of the same order as specified values at section A-A and are smaller at section B-B. It should be realized that these were moderate landings made at positive trim to the water surface; consequently, section B-B encountered the water later with a lower load. Because section A-A is fairly close to the step, it is improbable that any other sections of the hull experienced more severe loading. However, under normal operating conditions pressures of the magnitude of those at section A-A or larger might be expected at section B-B or at any other section of the hull.

Figures 15 and 16, respectively, give the actual instantaneous pressure distributions at sections A-A and B-B for several of the more severe landings, together with pressure distributions calculated from design specifications. These figures clearly demonstrate the differences between the experimental and design distributions.

Figures 17 and 18 show several instantaneous distributions for two runs. The foregoing comparisons of experimental and design loads were limited by the moderate conditions of the landings. However, the lateral shape of the pressure distribution on a V-bottom hull is approximately the same regardless of the trim, velocity, and flight angle. Consequently, these figures can be considered to describe the shape of the pressure distribution for all practical landing conditions of this seaplane.

SUMMARY OF RESULTS

The measured loads and pressures are considered typical of moderate landings of a conventional-type seaplane in calm water. Landing conditions include airspeeds from 88 to 126 feet per second, sinking speeds from 1.6 to 9.1 feet per second, flight angles up to 6°, and trims from 2° to 12°.

Maximum experimental loads included (1) load factors of 2g, with an average of 1 g, (2) pitching moments less than 128,000 pound-feet, corresponding to an angular acceleration of 2.7 radians per second^2, (3) lateral pressure distributions averaged over the total beam less than 9 pounds per square inch, and (4) peak pressures greater than 40 pounds per square inch.

A comparison of the experimental load distribution with loads calculated from Bureau of Aeronautics Specification SS-1C-2 shows that: (1) experimental total loads are approximately one-half the design values, (2) average instantaneous pressures at representative cross sections of the hull are of the same order as or larger than pressures calculated from specifications for bottom plating, stringer, floor and frame design, and (3) peak pressures are considerably larger than pressures calculated from specifications for bottom plating and stringer design.

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1. Anon.: Bureau of Aeronautics Specification – Airplane Strength and Rigidity. NAVAER SS-1C-2, Bur. Aero., June 12, 1947.

2. Steiner, Margaret F.: Comparison of Over-All Impact Loads Obtained during Seaplane Landing Tests with Loads Predicted by Hydrodynamic Theory. NACA TN 1781, 1949.

TABLE I

GENERAL INFORMATION ABOUT FLYING BOAT USED IN LANDING TESTS

Normal gross weight, lb	19,000
Approximate flying weight during tests, lb	20,000
Stalling speed (flap down), mph	65
Wing span, ft	86
Wing root chord, ft	11.5
M.A.C., ft	9.8
Wing area, sq ft	780.6
C.g. position:	
Percent M.A.C.	31.9
Feet from bow	18.6
Beam of hull, ft	8.33
Distance from main step to bow, ft	21.25
Distance from main step to afterbody step, ft	16
Moment of inertia in pitch, slug-ft^2	48,137

TABLE II

SPECIFIC LOCATION OF INSTRUMENTS

Instrument number	Instrument	Location
1	Standard NACA accelerometer	6 in. forward, 3 in. below, 8 in. to starboard of c.g.
2	Trimount angular accelerometer	4 in. forward, 3 in. below, 6 in. to starboard of c.g.
3	Gyro trim recorder	12 in. aft, 60 in. below, 20 in. to port from c.g.
4	Pressure gages	See table III
5	Wing camera	30 in. forward, 146 in. above, 409 in. to starboard of point of step
6	Vertical-displacement indicator	Pivot 13.2 in. aft, 4.4 in. above, 4 in. to port of point of step
7	Water-contact indicator	Point of forebody step
8	NACA airspeed indicator	185 in. forward of step, on top of fuselage on center line
9	Water-speed pressure gage	15 in. forward, axis parallel to keel, 11 in. to starboard of point of step

TABLE III

PRESSURE GAGE LOCATIONS[a]

Number	Longitudinal distance forward from step (in.) (b)	Normal distance from base line (in.)	Transverse distance from keel center line (in.)
1	215.0	6.4	2.5
2	188.0	2.3	2.2
3	162.8	.7	2.2
4	149.8	.5	2.2
5	122.4	.5	2.2
6	92.5	.5	2.4
7	92.5	5.8	17.0
8	92.5	11.7	32.0
9	92.5	13.8	43.5
10	81.5	.5	2.2
11	58.6	.5	2.2
19	31.1	.5	2.5
13	31.1	2.2	7.2
14	31.1	4.0	12.0
15	31.1	5.8	17.0
16	31.1	9.9	28.5
17	31.1	13.8	43.2
18	18.8	.5	2.2
12	–5.5	5.3	2.2
20	–77.8	15.4	2.2
21	–131.0	22.9	2.2
22	–176.0	29.2	2.2

[a]See figure 5. All measurements are made to the centers of the pressure gages.

[b]Step reference is 255 inches from bow. All longitudinal measurements are parallel to the base line shown in figure 2.

TABLE IV

LANDING CONDITIONS

Run	τ_o (deg)	ω_o (deg/sec)	γ_o (deg)	Sinking speed (ft/sec)	Airspeed (ft/sec)	Water speed (ft/sec)	Wing lift at contact (g)	Remarks (water contact)
1	2.8	-6.0	5.3	9.1	112	98	0.8	Forebody only
2	5.2	-3.5	2.3	4.0	103	98	.7	Forebody only
3	5.4	0	2.2	4.0	123	106	1.0	Forebody only
4	5.7	-4.7	2.2	3.5	112	90	.8	Forebody only
5	5.7	-5.0	4.6	7.5	101	94	.8	Forebody only
6	6.0	-4.9	2.8	4.6	98	95	.8	Forebody only
7	6.0	-2.8	3.1	4.5	95	83	.7	Forebody only
8	6.2	-9.2	5.2	7.5	98	83	.8	Forebody only
9	6.2	0	1.7	3.3	126	110	.9	Forebody only
10	6.4	-1.1	2.1	3.3	103	89	.8	Forebody only
11	7.5	-4.4	2.1	3.5	104	96	.8	Forebody only
12	7.5	-2.9	1.8	2.7	101	85	.9	Forebody only
13	7.7	-4.9	1.1	2.0	115	105	.8	Forebody only
14	8.1	-3.0	2.3	3.3	97	82	.7	Forebody only
15	8.5	-10.0	1.1	1.8	107	95	.9	Forebody only
16	8.5	0	2.2	3.5	104	91	.8	Forebody only
17	8.3	-1.2	2.0	3.0	103	88	.8	Forebody contacts first
18	8.4	2.5	1.2	2.1	119	103	1.0	Forebody contacts first
19	9.2	4.3	1.4	2.1	98	84	.8	Afterbody contacts first
20	9.3	3.3	2.0	3.8	116	108	1.0	Afterbody contacts first
21	9.6	0	1.6	2.7	109	97	1.0	Afterbody contacts first
22	9.9	2.5	2.3	3.3	100	83	.7	Afterbody contacts first
23	10.2	-.8	2.1	3.1	98	85	.8	Afterbody contacts first
24	10.3	-1.2	1.5	2.9	115	110	.9	Afterbody contacts first
25	10.4	1.5	1.9	2.9	100	86	.8	Afterbody contacts first
26	10.6	1.0	2.5	4.0	98	90	.8	Afterbody contacts first
27	10.7	-13.0	1.8	2.9	110	93	1.0	Afterbody contacts first
28	7.3	-3.8	3.7	5.1	101	78	.8	Forebody contacts first
29	7.8	-2.6	3.8	6.3	103	94	.9	Forebody contacts first
30	8.1	1.7	1.2	2.3	120	106	1.0	Forebody contacts first
31	8.9	-1.4	3.8	6.3	113	95	1.0	Forebody contacts first
32	9.0	-5.8	1.8	3.0	112	94	.8	Simultaneous contact
33	9.3	-.8	1.7	2.7	106	89	.8	Afterbody contacts first
34	9.4	4.8	.9	1.6	122	104	1.0	Afterbody contacts first
35	9.4	5.5	1.7	2.3	91	78	.7	Afterbody contacts first
36	9.5	4.5	1.2	1.9	100	92	.8	Afterbody contacts first
37	9.5	0	1.8	3.2	116	104	1.0	Afterbody contacts first
38	10.1	1.5	2.0	3.5	112	101	.9	Afterbody contacts first
39	10.3	-2.1	2.6	4.7	112	103	1.0	Afterbody contacts first
40	10.3	2.2	2.1	2.9	97	80	.8	Afterbody contacts first
41	10.5	3.6	2.4	3.3	101	80	.8	Afterbody contacts first
42	10.5	-1.3	2.7	3.9	88	83	.8	Afterbody contacts first
43	10.7	1.9	1.7	2.4	98	80	.8	Afterbody contacts first
44	10.8	5.0	1.8	2.8	100	91	.8	Afterbody contacts first
45	10.8	1.3	1.1	1.9	106	102	1.0	Afterbody contacts first
46	10.9	-11.0	1.9	2.9	103	88	.8	Afterbody contacts first
47	11.2	3.6	1.3	2.2	106	94	.9	Afterbody contacts first
48	11.4	-.3	3.4	4.8	95	82	.8	Afterbody contacts first
49	11.5	4.0	1.3	1.9	98	86	.8	Afterbody contacts first
50	12.1	-1.5	2.6	4.0	101	89	.9	Afterbody contacts first

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TABLE V

OVER-ALL LOADS AND MOMENTS

Run	Max. P	Moment about c.g. corresponding to max. P (lb-ft) (a)	x (ft) (b)	Max. moment about c.g. (lb-ft) (a)	P corresponding to max. moment (lb)	x (ft) (b)
1	36,995	83,000	2.24	128,000	32,400	4.00
2	20,517	12,800	.63	15,950	19,200	.83
3	18,511	-5,000	-.27	15,000	16,000	.94
4	18,545	28,700	1.55	28,700	18,545	1.55
5	32,000	60,600	1.89	60,600	32,000	1.90
6	23,086	27,100	1.17	27,100	23,086	1.17
7	24,067	12,800	.53	25,600	22,800	1.12
8	28,689	9,600	.33	44,600	16,000	2.79
9	18,440	3,190	.17	23,900	13,000	1.84
10	20,400	9,600	.47	-9,600	12,200	-.79
11	21,899	3,190	.15	15,950	14,000	-1.14
12	18,837	-12,760	-.68	-35,090	16,200	-2.16
13	7,904	-3,190	-.41	-15,950	7,000	-2.28
14	17,150	12,000	.70	12,000	17,150	.70
15	23,300	-3,190	-.14	-25,500	13,000	-1.97
16	18,198	0	0	-19,140	16,200	-1.18
17	17,019	-3,190	-.19	-19,140	5,000	-3.84
18	6,727	15,950	2.38	-35,090	5,000	-7.03
19	21,914	14,355	.66	-98,890	7,400	-13.38
20	14,606	6,380	.43	-54,230	3,600	-15.10
21	13,508	4,785	.35	57,420	6,448	8.91
22	21,285	9,570	.45	-73,370	4,400	-16.65
23	12,007	12,760	1.06	-66,990	9,200	-7.28
24	23,790	-15,950	-.67	-28,710	8,540	-3.37
25	14,754	22,330	1.51	-52,635	5,800	-9.10
26	22,616	-11,165	-.49	-105,270	6,800	-15.50
27	19,580	12,750	.65	--------	------	------
28	21,400	7,975	.37	-19,140	3,600	-5.32
29	38,800	-44,660	-1.15	-44,660	38,800	-1.15
30	11,000	-15,950	-1.45	-35,090	5,600	-6.28
31	21,800	-44,660	-2.05	-102,080	13,600	-7.51
32	15,600	15,950	1.02	-82,940	11,000	-7.47
33	------	--------	------	--------	------	------
34	5,600	-70,180	-12.50	-70,180	5,600	-12.50
35	17,800	19,140	1.08	-63,800	7,400	-8.63
36	23,400	-6,380	-.27	-54,230	5,600	-9.69
37	------	--------	------	--------	------	------
38	20,800	15,950	.77	-86,130	9,800	-8.70
39	20,000	-31,900	-1.60	-105,270	8,000	-13.19
40	19,400	19,140	.99	-31,900	2,400	-13.30
41	17,800	22,330	1.25	-41,470	2,800	-14.80
42	21,800	-9,570	-0.45	-51,040	7,400	-6.82
43	17,600	25,520	1.45	-47,850	3,080	-15.55
44	23,400	15,950	.68	-54,230	4,400	-11.78
45	27,000	9,570	.35	-47,850	4,900	-9.77
46	22,800	6,380	.28	-22,300	6,800	-3.28
47	21,200	6,380	.30	-57,420	4,600	-12.48
48	18,800	25,520	1.36	-44,660	2,450	-18.15
49	20,600	-15,950	-.78	-47,850	3,680	-13.00
50	17,800	44,700	2.51	-66,990	4,600	-14.55

[a]Negative moment is pitching down.
[b]Negative x is located aft of the center of gravity.

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TABLE VI

AFTERBODY LOADS AND MOMENTS

Run	P (lb)	Moment about c.g. corresponding to P (lb-ft) (a)	Arm to c.g. (ft) (b)
41	3000	-35,090	-11.70
43	2800	-19,140	-6.85
44	5000	-51,040	-10.20
47	4600	-19,140	-4.17
49	4600	-41,470	-9.01
50	4400	-63,800	-14.50

[a]Negative moment is pitching down.

[b]Negative arm is located aft of the center of gravity.

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TABLE VII

MAXIMUM BOTTOM PRESSURES AND CORRESPONDING APPROACH CONDITIONS

Gage number				3	4	5	6	7	8	9	10	11	13	14	15	16	17	18
Run	Airspeed ft/sec	τ_o (deg)	γ_o (deg)	Pressure (lb/sq in.)														
1	112	2.8	5.3	9	13	12	9	12	5	2	11	11	(b)	13	14	(b)	4	15
2	103	5.2	2.3	0	0	8	9	6	0	0	8	9	(b)	13	11	(b)	0	(a)
3	123	5.4	2.2	0	0	0	11	0	0	0	14	14	(b)	22	22	(b)	0	26
4	112	5.7	2.2	6	11	10	11	13	0	0	13	13	(b)	16	18	(b)	12	13
5	101	5.7	4.6	4	12	14	13	17	3	0	17	15	(b)	22	21	(b)	19	26
6	98	6.0	2.8	0	0	13	17	18	0	0	16	16	(b)	32	30	(b)	28	16
7	95	6.0	3.1	0	0	8	10	7	0	0	9	10	(b)	14	13	(b)	3	10
8	98	6.2	5.2	5	7	8	10	5	0	0	9	13	(b)	9	11	(b)	1	15
9	126	6.2	1.7	0	0	0	8	0	0	0	15	15	(b)	24	26	(b)	2	19
10	103	6.4	2.1	0	0	0	12	0	0	0	12	15	(b)	22	24	(b)	6	17
11	104	7.5	2.1	0	0	0	13	0	0	0	15	12	(b)	29	26	(b)	5	19
12	101	7.5	1.8	0	0	0	7	0	0	0	12	14	(b)	17	19	(b)	3	21
13	115	7.7	1.1	0	0	0	0	0	0	0	(a)	(a)	(a)	20	2	0	0	23
14	97	8.1	2.3	0	0	0	12	0	0	0	18	21	(b)	26	25	(b)	3	24
15	107	8.5	1.1	0	0	0	0	0	0	0	11	13	(b)	22	21	(b)	5	19
16	104	8.5	2.2	0	0	0	7	0	0	0	13	26	(b)	18	27	(b)	7	24
17	103	8.3	2.0	0	0	0	0	0	0	0	15	20	(b)	29	23	(b)	4	23
18	119	8.4	1.2	0	0	0	0	0	0	0	0	0	(b)	2	2	(b)	0	26
19	98	9.2	1.4	0	0	0	0	0	0	0	10	14	(b)	17	14	(b)	2	27
20	116	9.3	2.0	0	0	0	0	0	0	0	0	21	(b)	28	37	(b)	2	35
21	109	9.6	1.6	0	0	0	0	0	0	0	10	29	(b)	26	27	(b)	3	30
22	100	9.9	2.3	0	0	0	13	0	0	0	15	11	(b)	16	16	(b)	3	19
23	98	10.2	2.1	0	0	0	15	0	0	0	20	26	(b)	33	27	(b)	32	28
24	115	10.3	1.5	0	0	0	15	0	0	0	15	18	(b)	32	23	(b)	4	25
25	100	10.4	1.9	0	0	0	16	0	0	0	20	26	(b)	32	26	(b)	3	27
26	98	10.6	2.5	0	0	0	11	0	0	0	13	17	(b)	17	15	(b)	1	20
27	110	10.7	1.8	0	0	0	12	0	0	0	20	19	(b)	20	19	(b)	4	28
28	101	7.3	3.7	0	0	0	11	0	0	0	13	13	(b)	16	24	(b)	3	18
29	103	7.8	3.8	0	0	0	16	0	0	0	22	23	(b)	31	28	(b)	22	28
30	120	8.1	1.2	0	0	0	0	0	0	0	0	0	(b)	25	2	(b)	0	22
31	113	8.9	3.8	0	0	0	17	0	0	0	15	24	(b)	41	30	(b)	4	34
32	112	9.0	1.8	0	0	0	11	0	0	0	19	23	(b)	28	28	(b)	4	26
33	106	9.3	1.7	0	0	0	0	0	0	0	(a)	(a)	(a)	24	28	(b)	3	27
34	122	9.4	.9	0	0	0	0	0	0	0	0	0	(b)	0	0	0	0	27
35	91	9.4	1.7	0	0	0	8	0	0	0	13	14	(b)	18	14	(b)	3	21
36	100	9.5	1.2	0	0	0	0	0	0	0	0	18	(b)	18	17	(b)	2	20
37	116	9.5	1.8	0	0	0	0	0	0	0	0	21	(b)	32	23	(b)	0	27
38	112	10.1	2.0	0	0	0	0	0	0	0	13	20	(b)	25	20	(b)	2	27
39	112	10.3	2.6	0	0	0	16	0	0	0	17	26	(b)	30	27	(b)	4	33
40	97	10.3	2.1	0	0	0	13	0	0	0	15	16	(b)	18	16	(b)	3	20
41	101	10.5	2.4	0	0	0	14	0	0	0	12	13	(b)	18	14	(b)	4	19
42	88	10.5	2.7	0	0	0	14	0	0	0	17	17	(b)	17	18	(b)	3	19
43	98	10.7	1.7	0	0	7	12	5	0	0	16	20	(b)	20	18	(b)	18	20
44	100	10.8	1.8	0	0	0	0	0	0	0	14	15	(b)	24	20	(b)	3	21
45	106	10.8	1.1	0	0	0	0	0	0	0	0	20	(b)	27	29	(b)	0	27
46	103	10.9	1.9	0	0	0	16	0	0	0	16	19	(b)	25	19	(b)	5	22
47	106	11.2	1.3	0	0	0	0	0	0	0	(a)	(a)	(a)	18	17	(b)	2	19
48	95	11.4	3.4	0	0	10	13	8	0	0	16	17	(b)	20	24	(b)	13	21
49	98	11.5	1.3	0	0	0	0	0	0	0	(a)	(a)	(a)	19	18	(b)	3	16
50	101	12.1	2.6	0	0	12	19	20	0	0	19	20	(b)	47	32	(b)	26	41

[a]No pressure record obtained.

[b]Gage 13 oscillates appreciably at time of peak but is readable at other times. The calibration on gage 16 is unreliable, but the gage is useful in determining the wetted beam.

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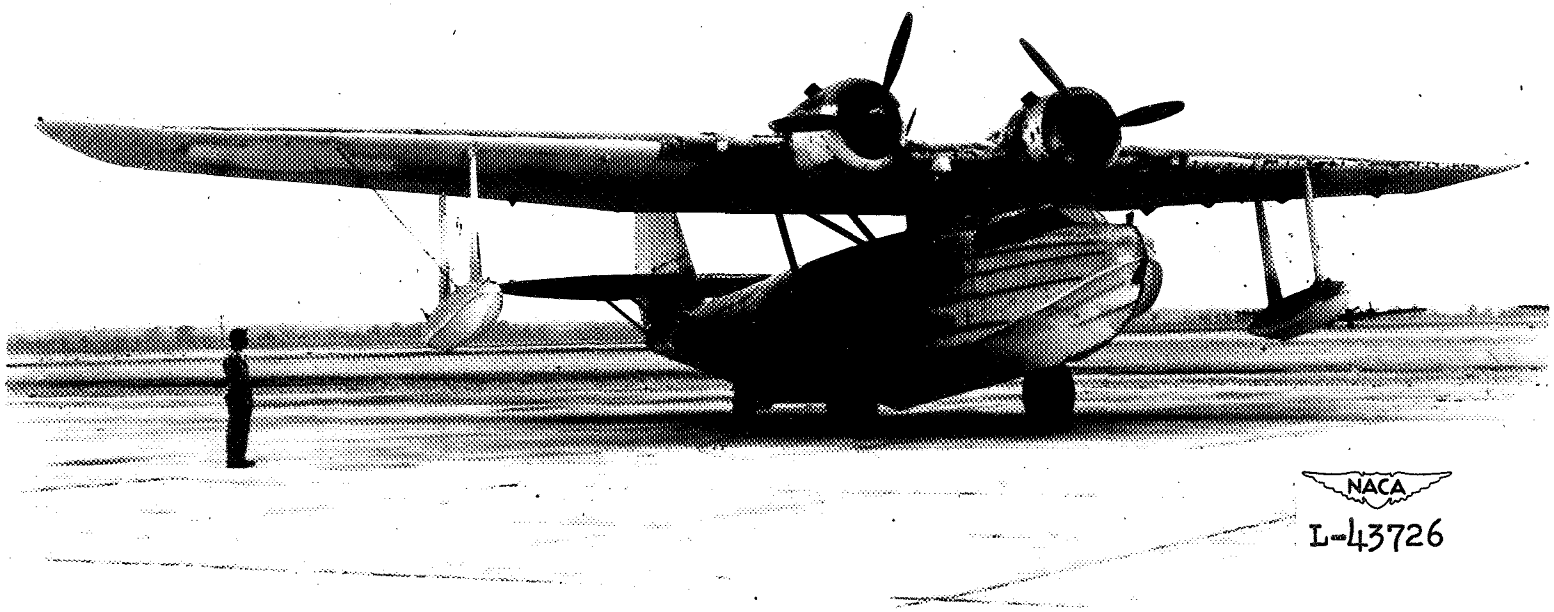
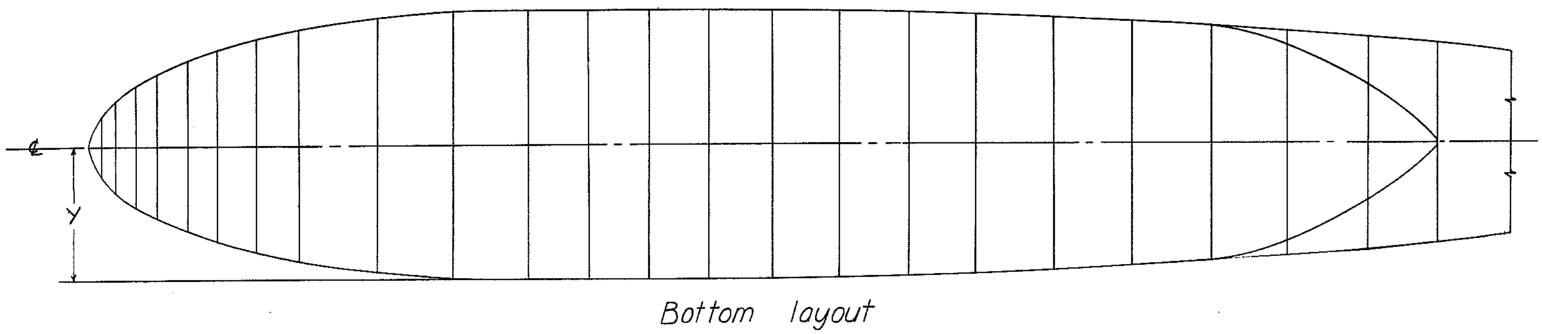
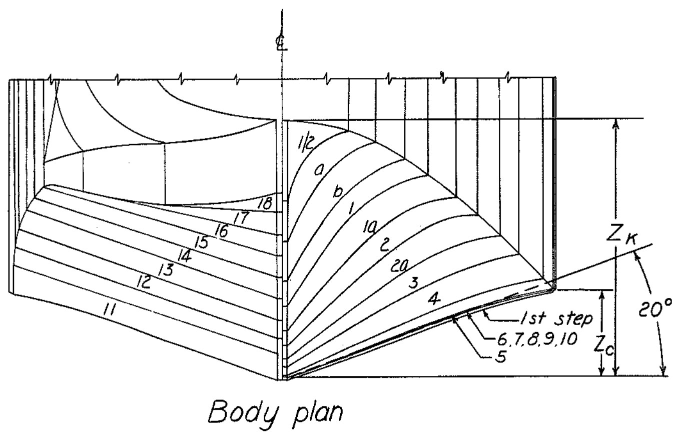


Figure 1.- Flying boat used in landing investigation.





Station	X (in.)	Z_K (in.)	Z_C (in.)	Y (in.)
0	0	43.0	43.0	0.0
1/2	4.5	29.6	41.3	11.0
a	9	22.7	39.4	15.3
b	16	16.1	36.6	20.1
1	23	11.8	33.9	24.0
1a	33	7.8	30.3	28.5
2	43	5.2	27.1	32.1
2a	56	3.1	23.6	35.8
3	70	1.7	20.5	38.9
4	96	0.3	16.5	42.8
5	121	0.0	14.5	44.8
6	146	0.0	14.0	45.0
7	166	0.0	14.0	45.0
8	186	0.0	14.0	45.0

Station	X (in.)	Z_K (in.)	Z_C (in.)	Y (in.)
9	206	0.0	14.0	45.0
10	227	0.0	14.0	44.8
11	249	-0.2	13.9	44.5
1st step	255	-0.5	13.9	44.4
1st step	255	4.0	19.8	44.4
12	272	6.4	22.1	44.0
13	294	9.5	24.9	43.3
14	320	13.2	28.2	42.2
15	346	16.8	30.4	40.9
16	372	20.5	32.1	39.3
17	397	24.0	31.2	32.8
18	424	27.8	29.0	19.2
19	447	31.0	31.0	1.0

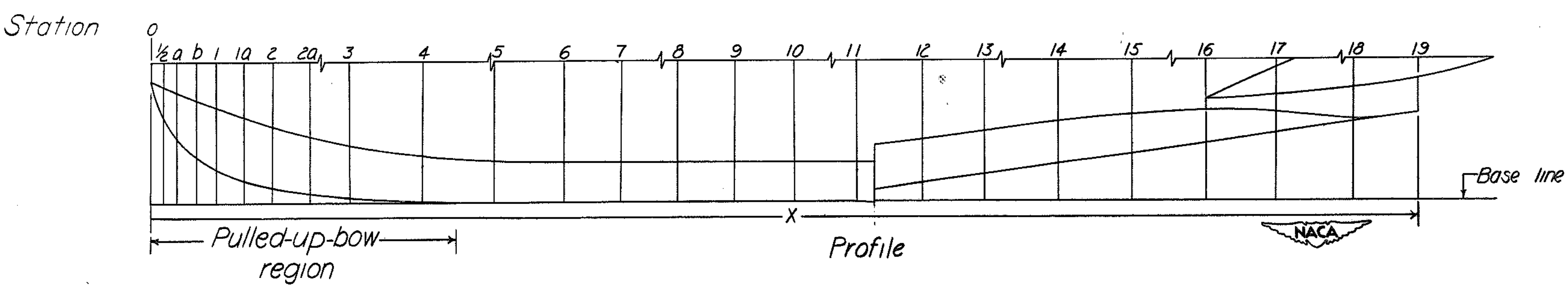


Figure 2.– Hull lines of flying boat used in landing investigation.

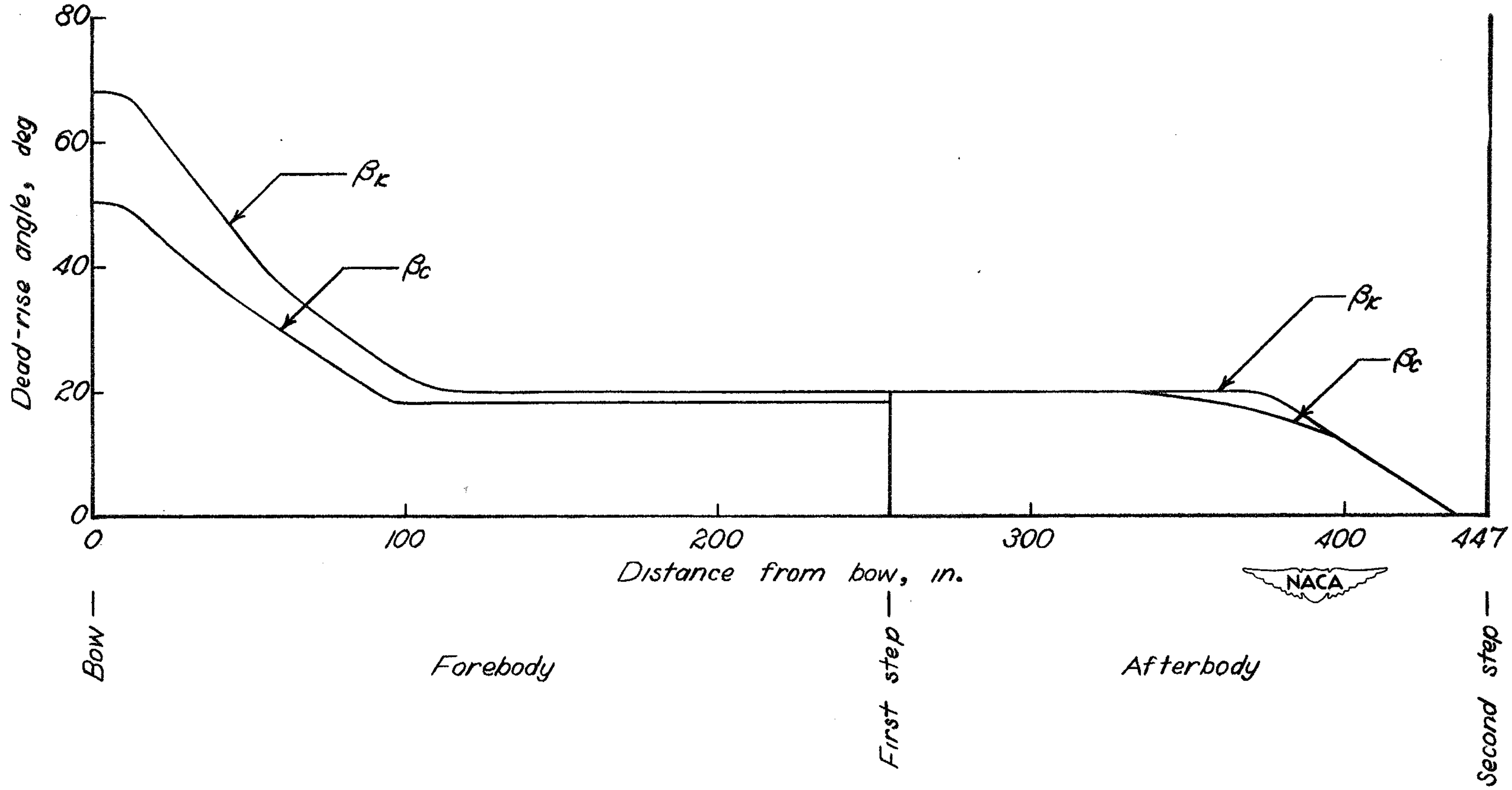
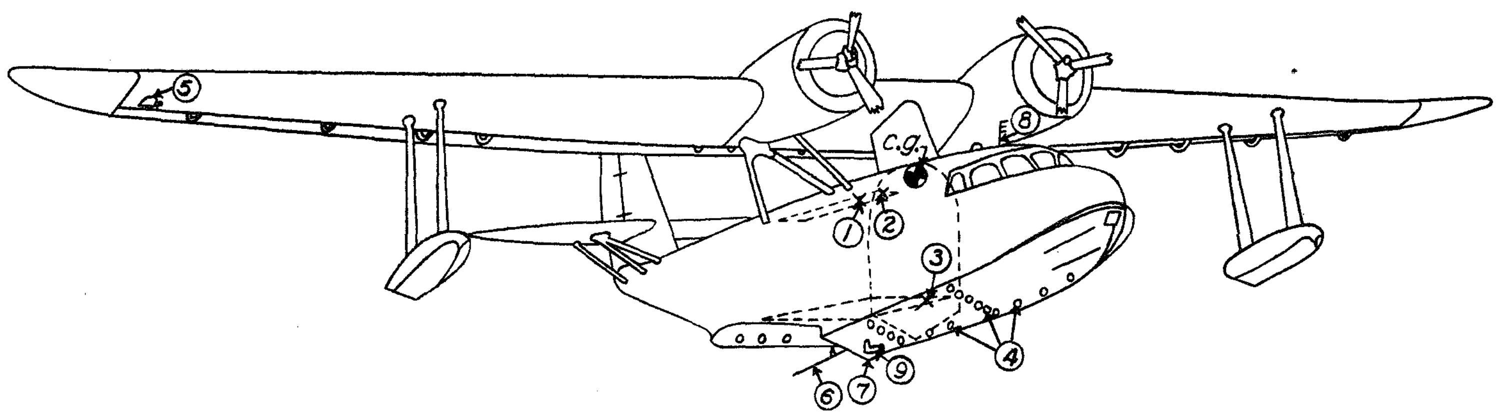


Figure 3.– Variation of dead rise with longitudinal position.



① Standard NACA accelerometer
② Trimount angular accelerometer
③ Gyro trim recorder
④ Pressure gages
⑤ Wing camera
⑥ Vertical displacement indicator
⑦ Water contact indicator
⑧ NACA airspeed indicator
⑨ Water-speed pressure gage

Figure 4.– Location of instruments in flying boat.

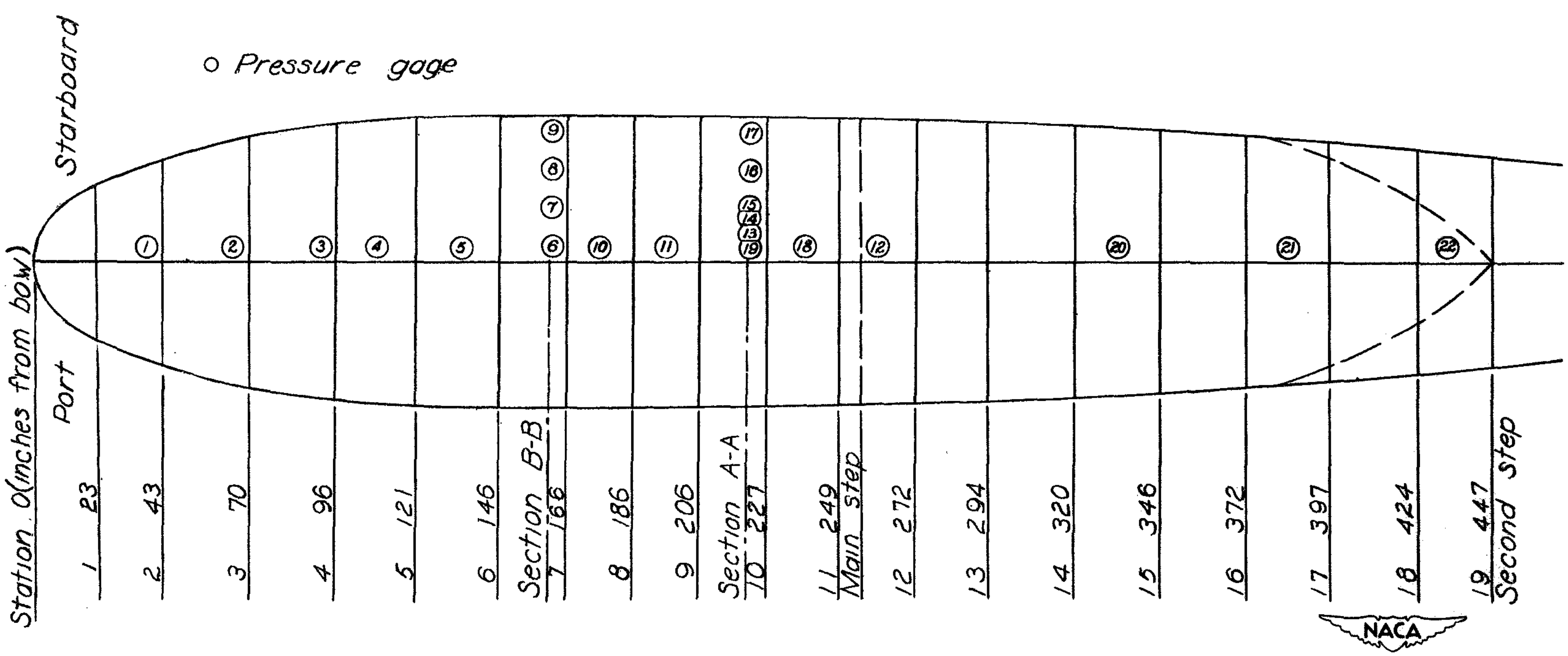


Figure 5.— Location of pressure gages in hull bottom.

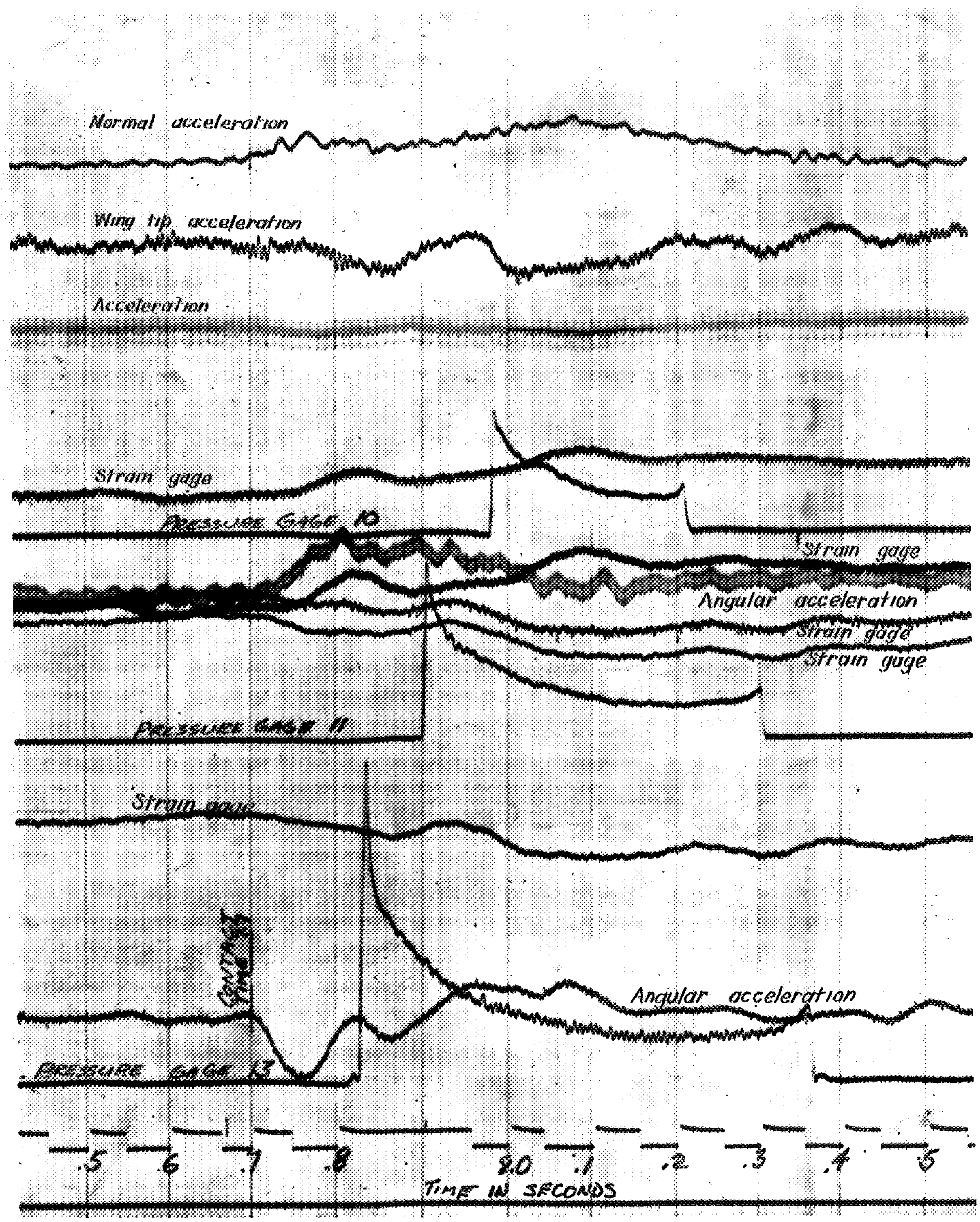
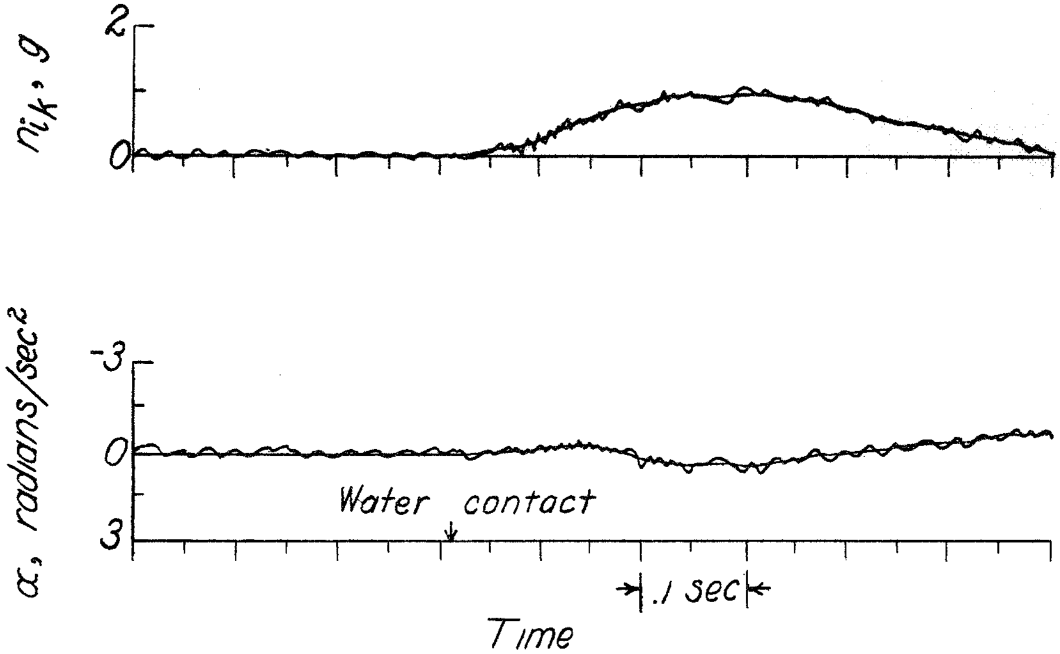
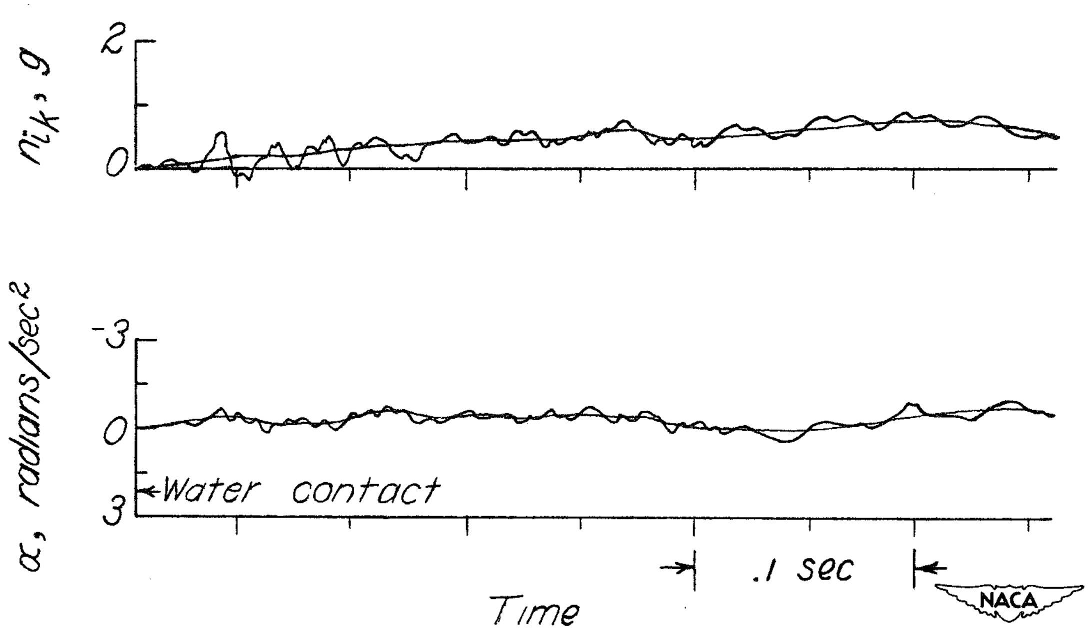


Figure 6.- Typical oscillograph record.

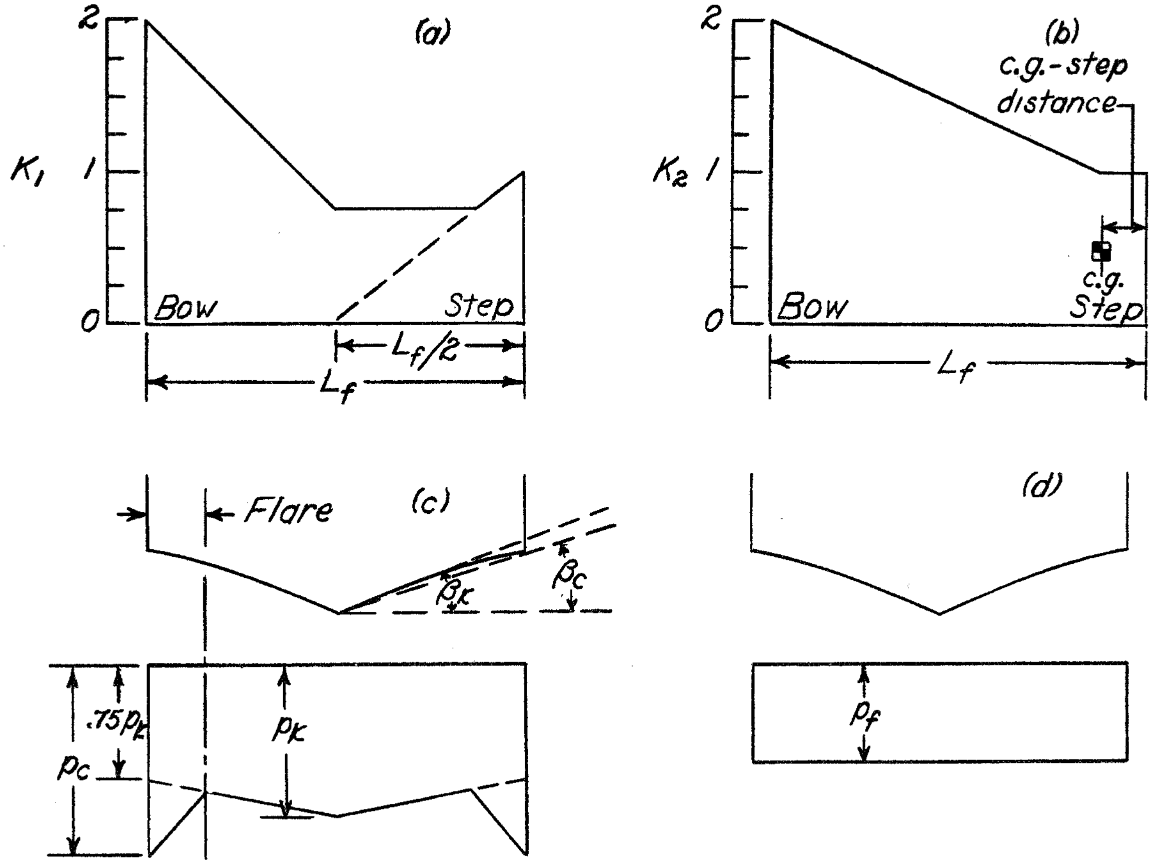


(a) Normal and angular acceleration for Run 6.



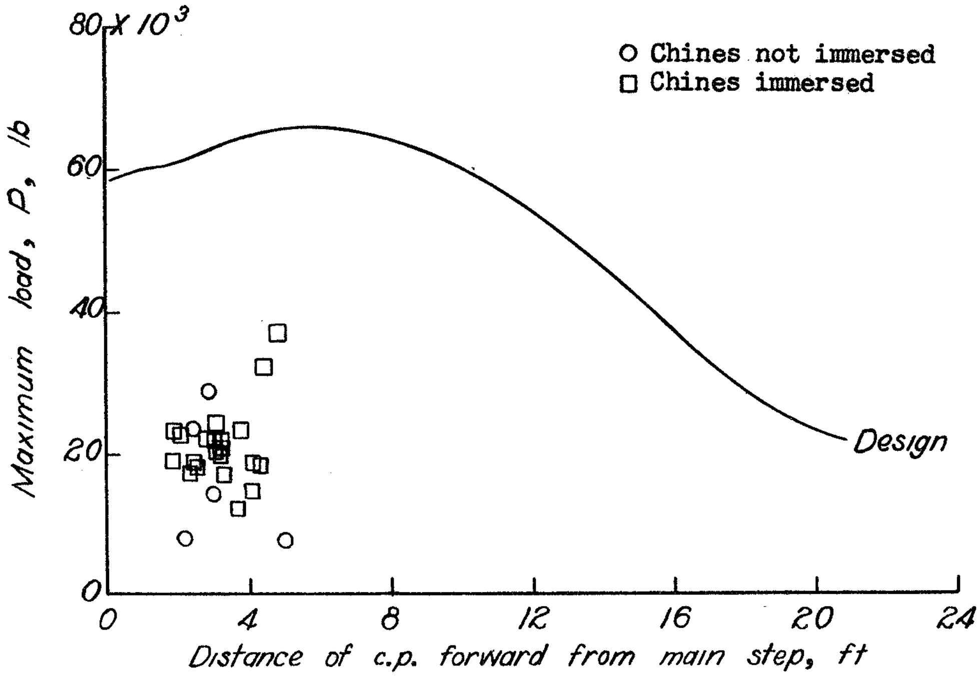
(b) Normal and angular acceleration for Run 3.

Figure 7.– Typical acceleration records showing fairing through oscillation.

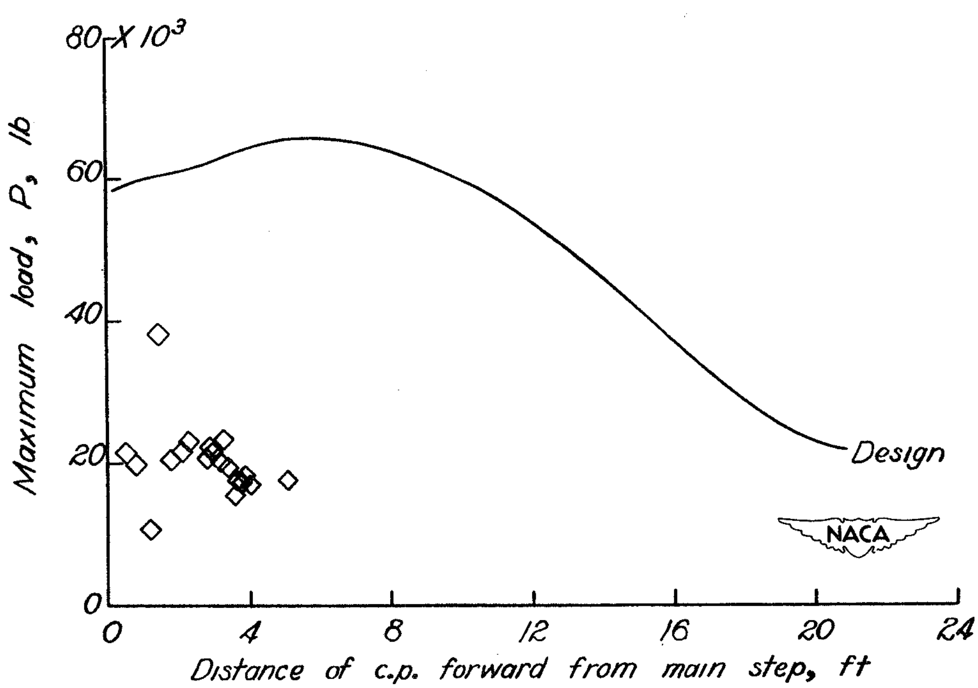


(a) Variation of K_1 with forebody length.
(b) Variation of K_2 with forebody length.
(c) Transverse variation of bottom pressure for skin and stringer design for a float with a partial flare.
(d) Transverse variation of bottom pressure for floor and frame design.

Figure 8.– Load distribution for sheltered water forebody design taken from reference 1.



(a) Experimental forebody loads.



(b) Combination of experimental forebody and afterbody loads.

Figure 9.- Comparison of maximum experimental loads with design specifications.

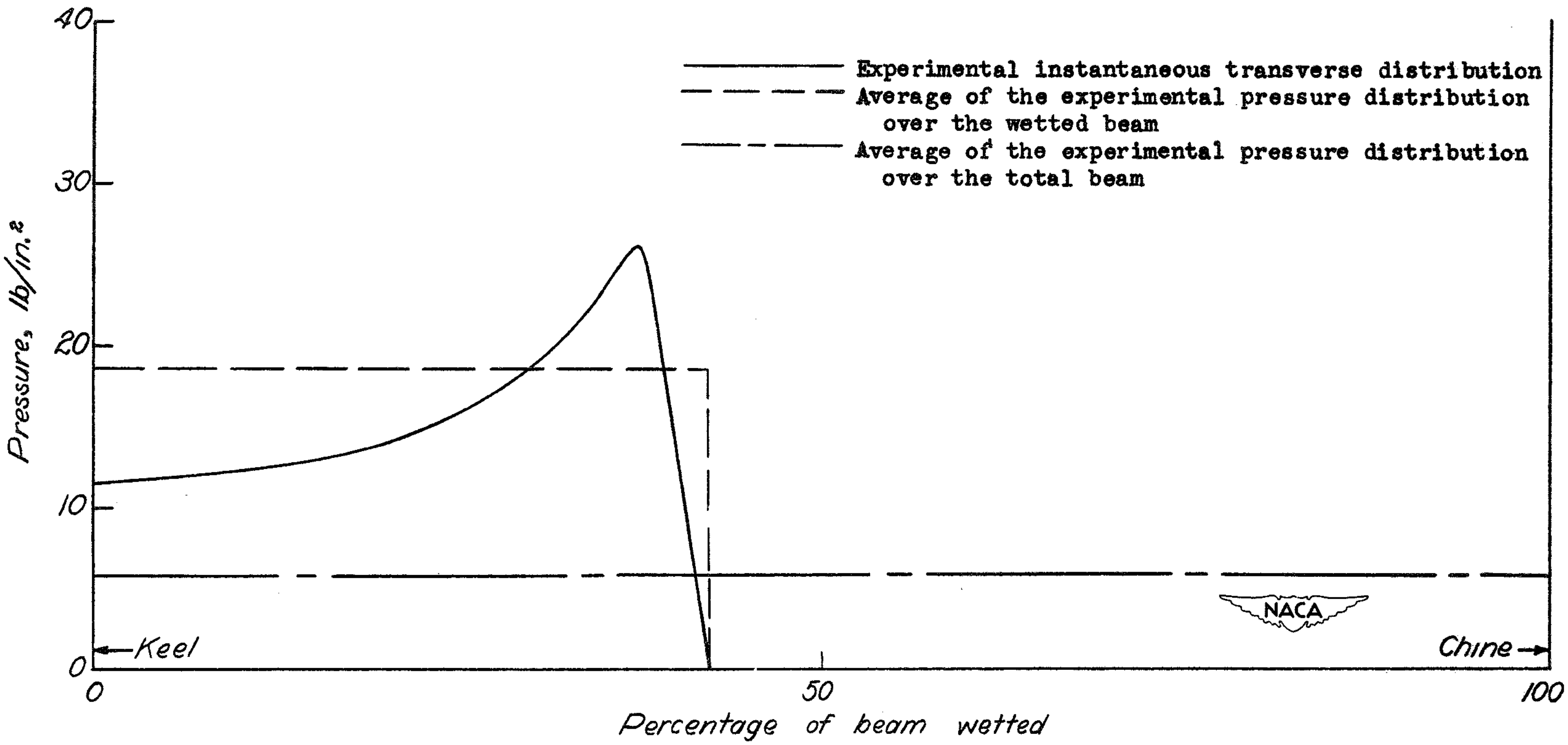


Figure 10.– Graphical indication of the reduction of experimental pressure data.

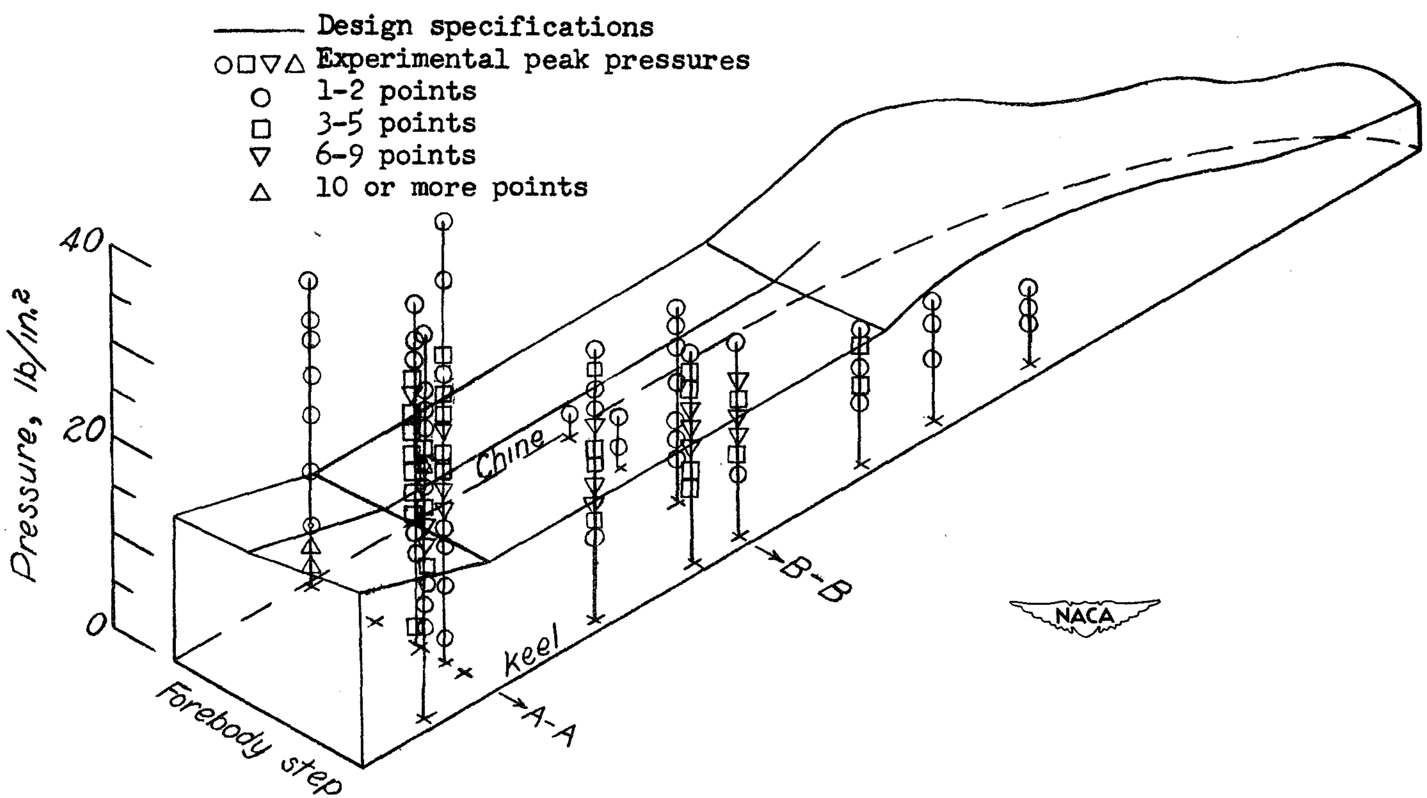


Figure 11.- Comparison of experimental peak pressures with distributed loads calculated from specifications for plating and stringer design.

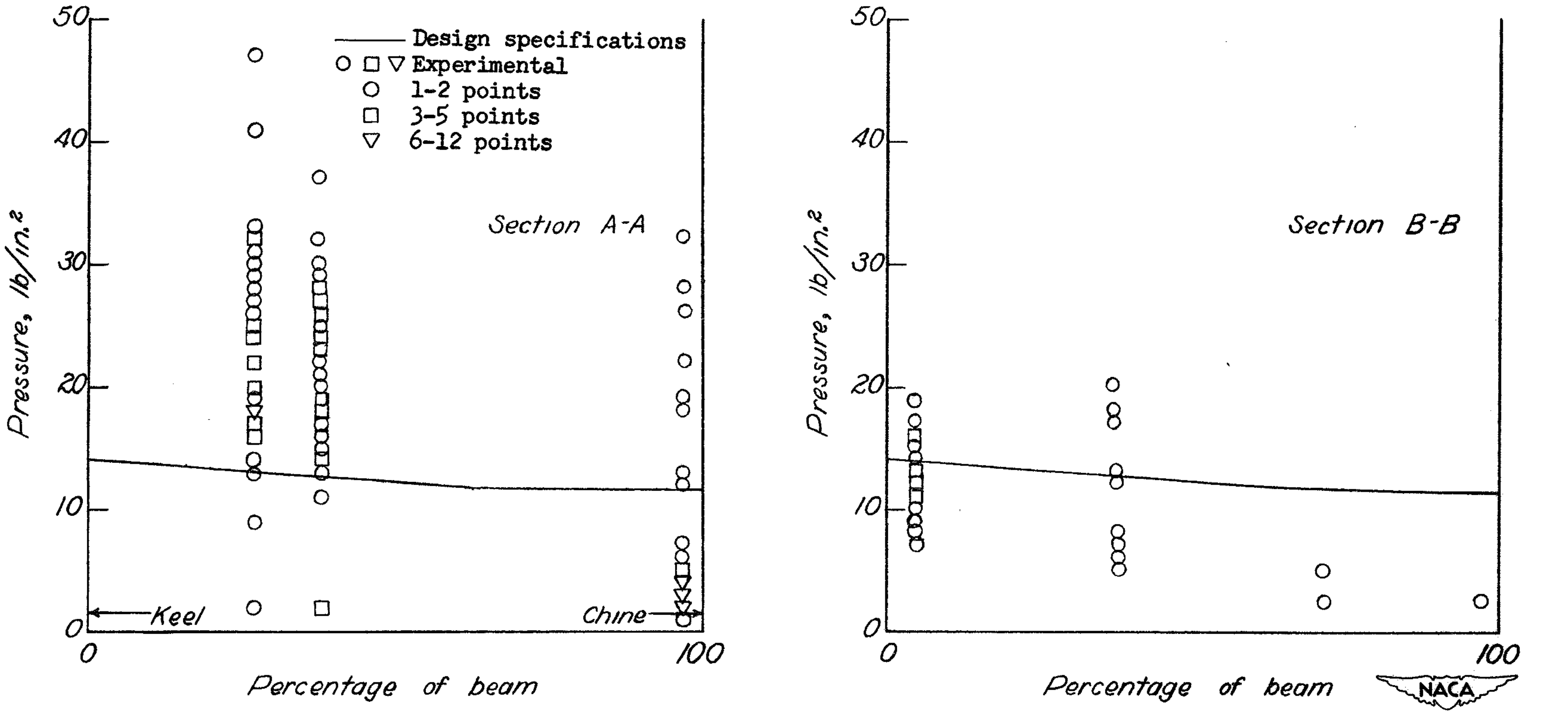


Figure 12.— Comparison of experimental peak pressures at sections A–A and B–B with distributed loads calculated from specifications for plating and stringer design.

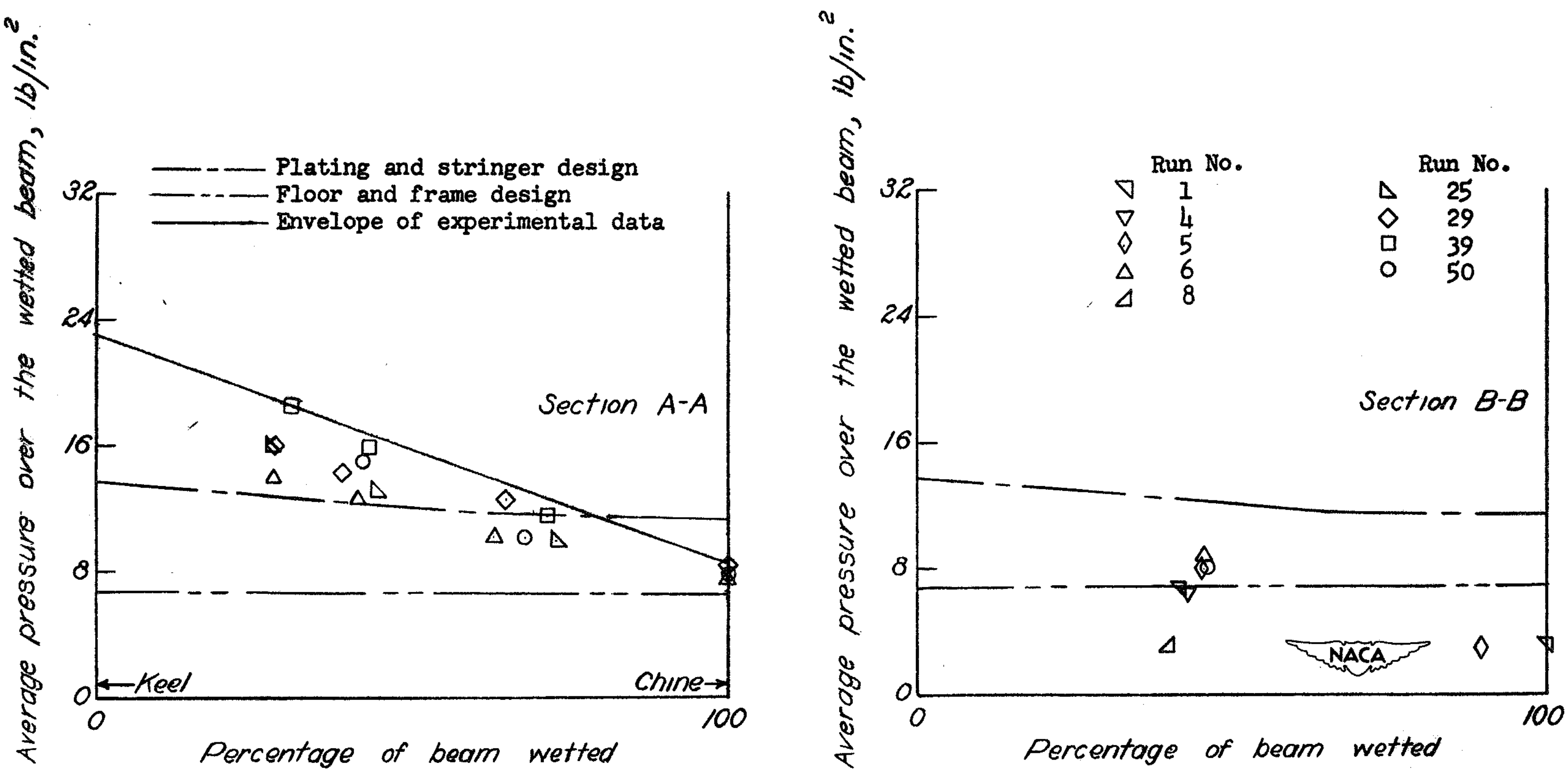


Figure 13.– Variation of average pressure with wetted beam and a comparison with distributed load calculated from specifications.

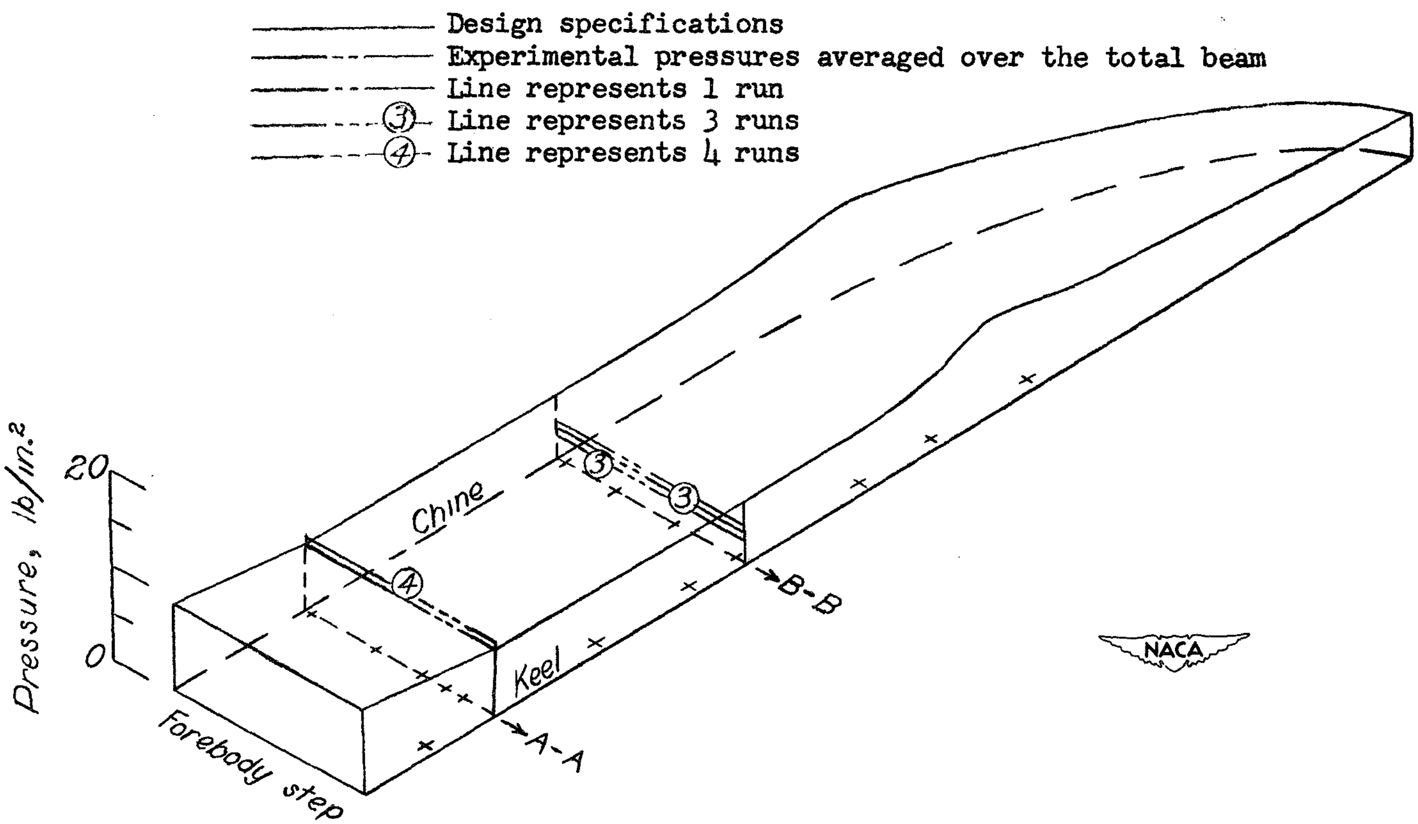


Figure 14.– Comparison of experimental average pressures for the heaviest impacts with distributed loads calculated from specifications for floors and frames at sections A–A and B–B.

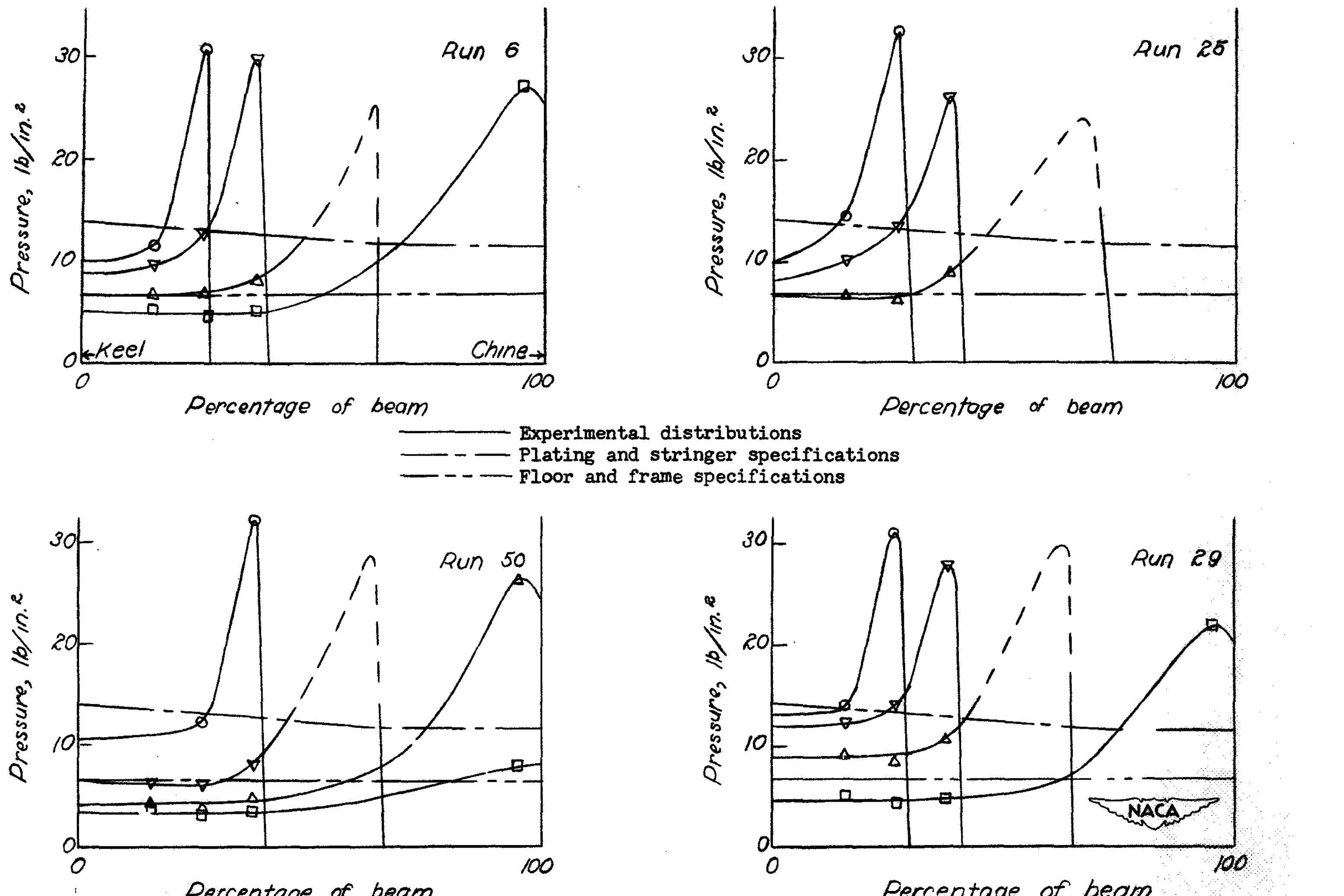


Figure 15.- Experimental instantaneous pressure distributions at section A-A and a comparison with distributed loads calculated from design specifications.

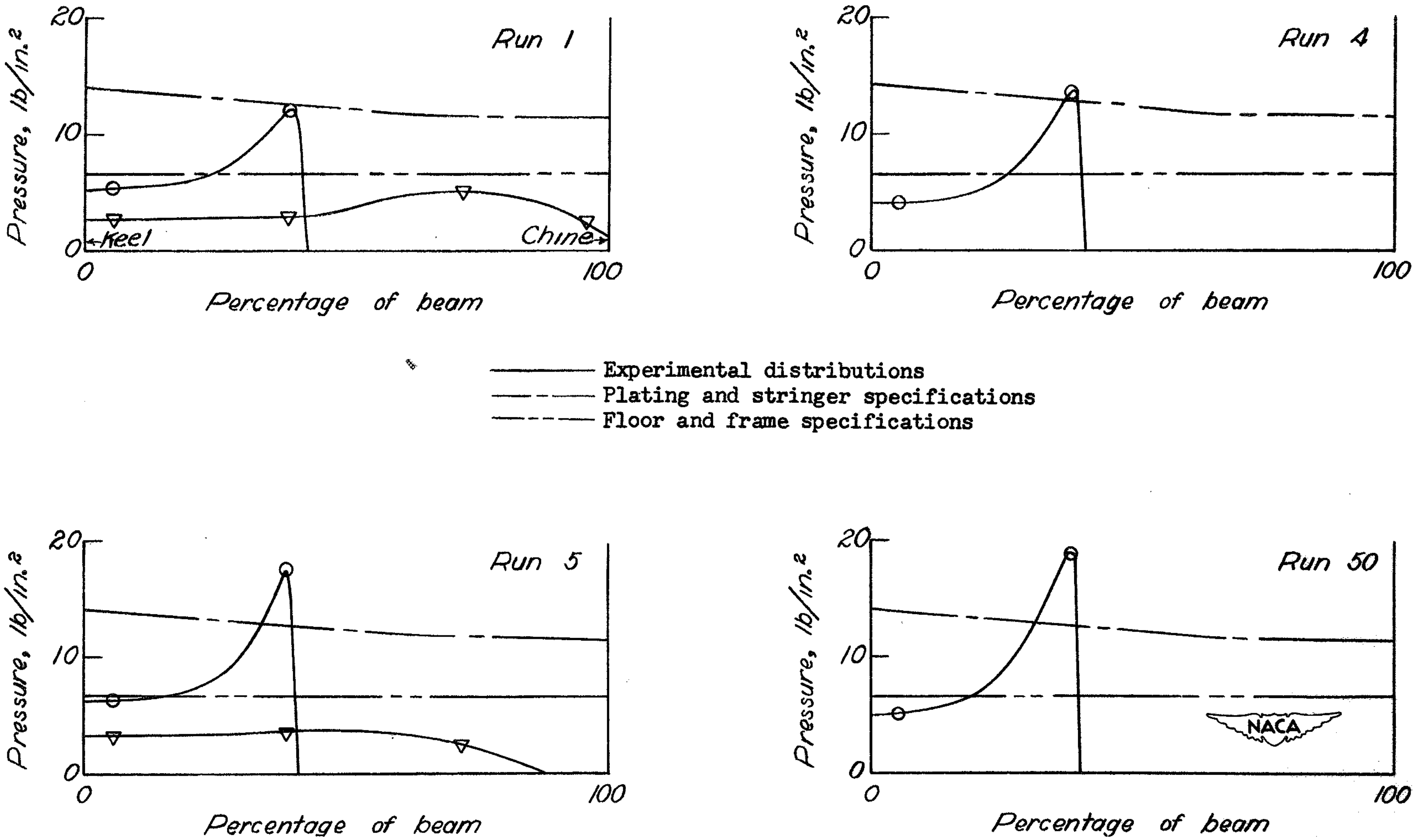


Figure 16.– Experimental instantaneous pressure distributions at section B–B and a comparison with distributed loads calculated from design specifications.

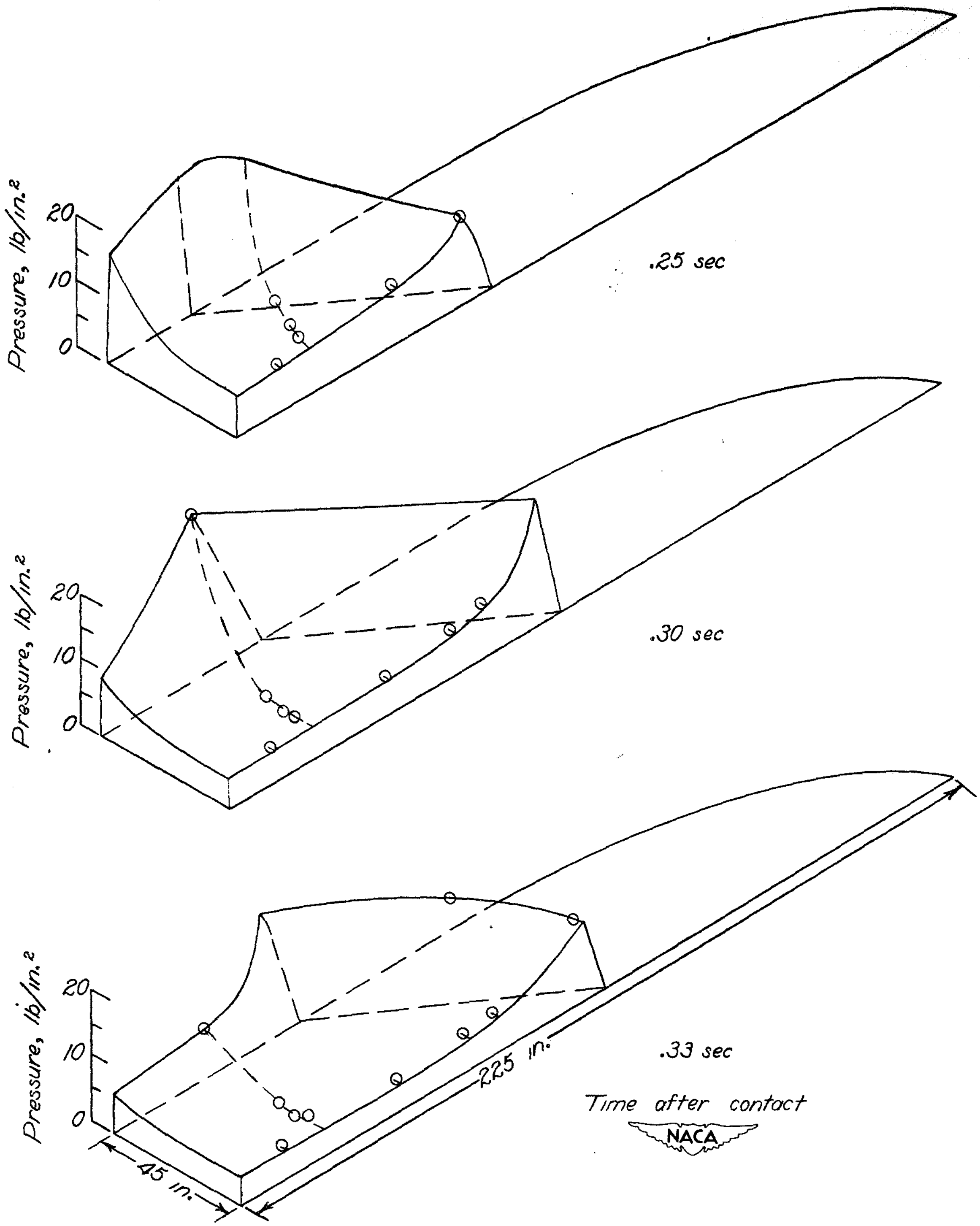


Figure 17.- Pressure distribution on hull bottom during run 50.

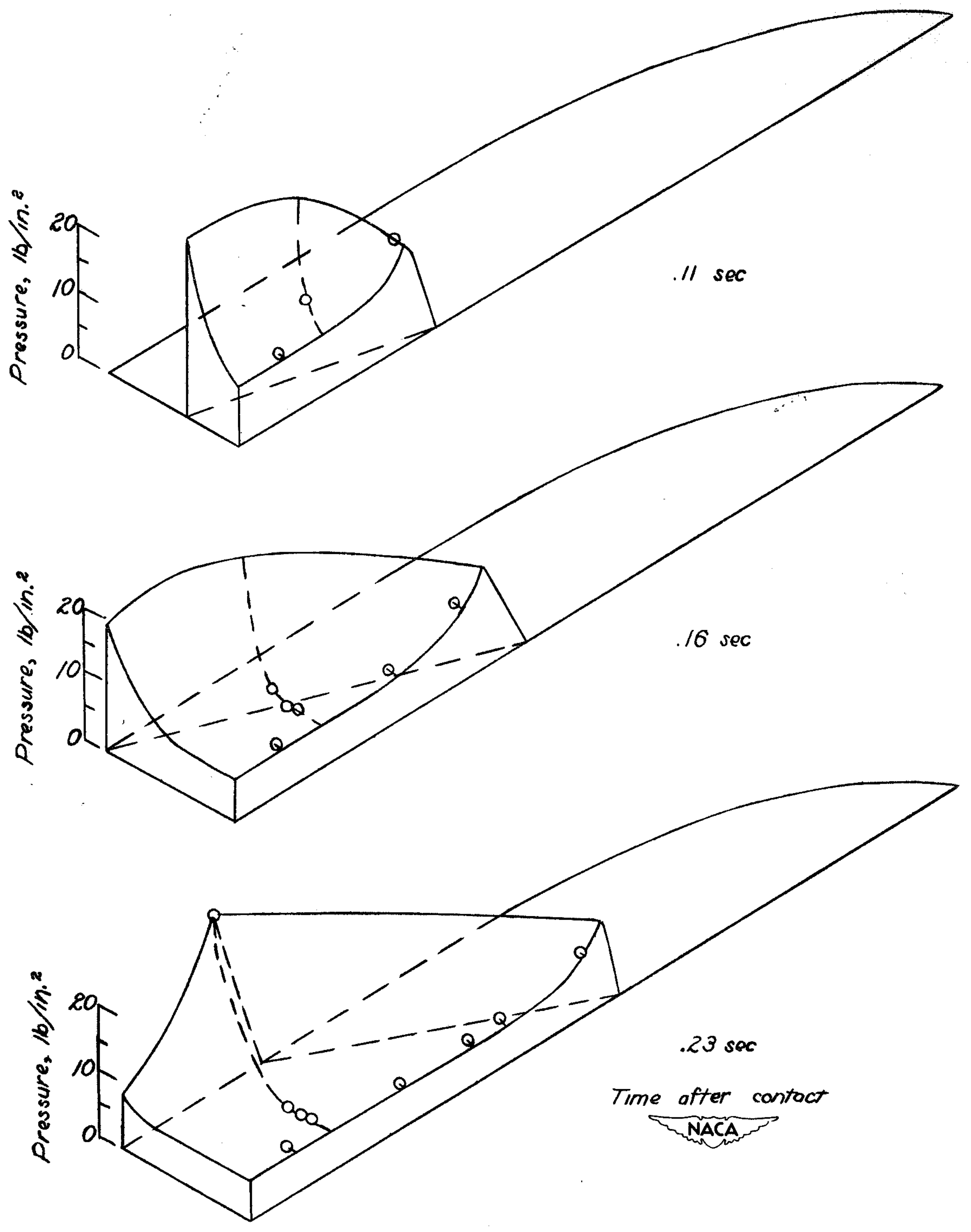


Figure 18.- Pressure distribution on hull during run 6.