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THE EFFECT ON PERFORMANCE OF CARRYING A CANOE ON AN AEROPLANE

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(Aeronautics)

The Effect on Performance of Carrying a Canoe on an Aeroplane.

By J. J. Green

Approved by J.H. Parkin

Summary

Introduction - Reasons for Investigation

Aircraft operators in the north country are frequently requested to carry canoes for the purpose of delivering them to some remote lake or river. This form of transportation offers so many advantages that it has become common practice to use aircraft for this purpose. The doubt expressed by a number of operators concerning the effect of the canoe on the all-round performance of the aircraft made it very desirable to investigate this question in the wind tunnel. It was intended that the tests should also reveal the best way in which to carry the canoe.

Range of Tests

A 1/8th scale model of the Bellanca "Pacemaker" with Edo "X" floats and a 1/8th scale model of the 16 ft. Chestnut "Labrador" canoe were used for the tests which covered the measurement of lift, drag and pitching moment. In addition to a test of the aeroplane without the canoe, eleven different arrangements with the canoe were investigated. A standard wind speed of 100 ft./sec. was used in all tests and, for each arrangement, the lift, drag and pitching moment were measured at incidences ranging from the no-lift incidence up to and beyond the stalling angle. The canoe model was provided with detachable ends and in four of the eleven arrangements, the ends were removed and the canoe was covered in.

Results of Tests

In the worst position for the conventional canoe, a decrease of 9 m.p.h. (7.3%) in maximum level speed, and 120 ft./min. (21%) in initial rate of climb were revealed. In the best position, maximum speed was decreased by 5.5% and rate of climb by 15.5%. With the canoe ends detached and the canoe covered in, these figures are reduced materially and, in the case of the canoe, fitted snugly to the side of the fuselage, the performance is practically the same as for the aircraft without the canoe (drop in maximum speed being 2 m.p.h. and in the rate of climb, 4 ft./min.). The longitudinal stability of the aeroplane with canoe attached was either unaltered or slightly improved with the exception of two of the poorer arrangements in which cases it was slightly impaired.

Conclusions

With poor arrangements of a canoe on an aeroplane, the performance, especially the rate of climb, is impaired. The tests show very clearly how the provision of canoes with detachable ends allows them to be carried on aircraft with negligible effect on performance.

Introduction - Reasons for Investigation

It is frequently necessary in the Canadian north country to transport canoes to and from remote districts. The aeroplane offers the most rapid and direct transportation with the result that it has become common practice to use aircraft for this purpose, the canoe being lashed to the float chassis or to the fuselage. The doubt expressed by a number of operators concerning the effect of the canoe on the all-round performance of the aircraft made it very desirable to investigate this question by wind tunnel tests. By examining the effect produced by the canoe in a variety of locations, on the aeroplane, it was hoped to arrive at some conclusion as regards the best way in which to carry the canoe. Resulting from requests from operators, the canoe constructors have produced a canoe with detachable ends which enables it to be lashed up snugly under the fuselage. It was decided to investigate this arrangement to see if the effect on performance warrants the extra complication of removable ends.

Range of Tests

A 1/8th scale model of the Bellanca "Pacemaker" with Edo "X" floats was used for the tests and a 1/8th scale model of the 16 ft. Chestnut "Labrador" canoe was constructed for use in the investigation. This model had detachable ends and was provided with a wooden covering to duplicate in the tests the canvas cover that could be used in practice once the ends were removed. No cover was used in the tests with the complete canoe, in view of the fact that it might be difficult to apply satisfactorily in actual practice and further, the shape of a canoe is such that without the ends detached, it is doubtful if covering it in would make any material improvement.

In addition to a test of the aeroplane without the canoe, eleven different arrangements of the canoe on the aeroplane were investigated. A three-view drawing, giving the canoe lines, is included in the report and two-view sketches are included which show the various arrangements tested. Arrangements 8 to 11 refer to the canoe with ends detached and of these, 9, 10 and 11 were with the canoe covered in. It will be seen that in arrangements 8, 9 and 10, with the ends detached, the canoe occupied the same position as in arrangements 7, 1 and 3, in which the ends were not detached. The canoe model was lashed in place with string.

A standard wind speed of 100 ft./sec. was used in all the tests and for each arrangement the lift, drag and pitching moments on the combination were measured at incidences (wing chord) ranging from the no-lift incidence up to and beyond the stalling angle, at intervals of 2° or 3°. The propeller was not present during the tests. The use of slipstream would have greatly complicated the test procedure without materially affecting the results and the comparisons made from the tests without slipstream.

Results of Tests

The measurements made on the various arrangements are given in tables 1 to 4. The aeroplane with no canoe is designated as arrangement 0 and the other arrangements, with canoe, are numbered from 1 to 11 and correspond with the drawings.

The forces and moments are given in the form of coefficients in the usual way, viz.:-

$$K_L = \frac{L}{\rho SV^2} \qquad K_D = \frac{D}{\rho SV^2} \qquad K_M = \frac{M}{\rho SCV^2}$$

where K_L, K_D and K_M are the lift coefficient, the drag coefficient and the pitching moment coefficient respectively and

L = lift in lbs. as measured in the tests
D = drag in lbs. as measured in the tests
M = pitching moment in ft. lbs. as measured in the tests
ρ = air density (0.002378 slugs /c. ft.)
S = wing area (4.32 s.ft.)
V = wind speed (100 ft./sec.)
C = chord of wing (0.823 ft.)
whence ρSV^2 = 102.73; ρSCV^2 = 84.65

It will be observed that the lift is not appreciably affected by the addition of a canoe. With the exception of arrangement 1, the maximum lift is in all cases increased due to the presence of the canoe and by varying amounts. The stalling angle or maximum lift angle also varies between 13° and 15° incidence.

The drag coefficients are considerably increased by the presence of the canoe, especially is this shown by the minimum drag coefficients at -3° incidence. It is possible to arrange the various combinations in order of merit from these minimum drag coefficients and it can be seen that arrangements 8, 11, 9 and 10 are superior to the rest, of which 7 is the best and 2 is the worst.

The lift/drag ratios are reduced by the presence of the canoe. Of main interest is the reduction in maximum lift/drag ratio which occurs around +4° incidence.

The slope of the curve of pitching moment coefficient plotted against incidence is an indication of the static longitudinal stability. If the slope is negative, the aeroplane is stable and if positive, it is unstable. The curves for the various arrangements are very similar to that for the aeroplane with no canoe. The neutral stability range which is present at small negative incidences, extends up to -1°. In most of the arrangements, this is unaltered, but in arrangements 2, 6 and 11, the neutral range is slightly reduced, giving improved stability and in arrangements 3 and 5, the neutral stability range is extended giving slightly impaired characteristics. On the whole, the differences from the aeroplane with no canoe are so small as to be of no practical significance and it may be safely assumed that adding a canoe to an aeroplane in any of the positions tried will have no noticeable effect on longitudinal stability.

Performance Estimates

The stalling speeds and best gliding angles for the various arrangements can be obtained directly from the maximum lift coefficients of table 1 and the maximum lift/drag ratios of table 3 respectively.

If V_S is the stalling speed corresponding to the maximum lift coefficient K_L max.

Then $W = K_L \text{ max. } \rho S . V_S^2$

$$\text{or } V_S = \sqrt{\frac{W}{K_L \text{ max. } \rho . S}} \qquad \text{------------------- (1)}$$

W = all up weight (4835 lbs.)
S = wing area = 276.5 s.ft.
ρ = 0.002378

Substituting the values of K_L max. for the various arrangements in the above equation gives V_S the stalling speed in ft./sec. When gliding, the angle of glide (θ) is given by the equation -

$$\cot.\ \theta = \frac{L}{D}$$

hence the best gliding angle is given by

$$\cot.\ \theta = \left(\frac{L}{D}\right)_{max.}$$

Values of stalling speed and best gliding angle for the various arrangements are given in table 8. It will be seen that the stalling speed is not materially affected by the presence of a canoe. The gliding angle is steepened appreciably by carrying a canoe, except in the case of the better arrangements 8, 9, 10 and 11. The only significance in this fact is that, in the event of engine failure, the horizontal distance that can be covered by a glide is slightly reduced when a canoe is carried in an unfavourable location.

For the calculation of maximum level speeds, it is necessary to make some assumptions as regards power from the propeller. For the evaluation of maximum level speed at sea level of the aeroplane with no canoe, it was assumed that the Wright J-6 engine delivers 320 h.p. at 2100 r.p.m. at maximum speed and that the airscrew efficiency has its maximum value of 0.80 at this speed.

From the plotted curves of K_L and K_D for the aeroplane without canoe, it was necessary to find the wing incidence for maximum level speed such that the K_L and K_D values for that incidence satisfy the two equations -

$$L = W = K_L \rho S V^2 \text{max.} \quad \text{------------------------} \quad (2)$$

$$\frac{D.V\text{max.}}{550} = \eta\,\text{max.}\ (\text{H.P.})\ \text{max.} \quad \text{----------------} \quad (3)$$

Equation (2) covers the requirement that the weight to be supported shall be equalled by the lift developed at maximum speed ($V_{max.}$)

Equation (3) expresses the fact that the power delivered by the airscrew at maximum speed shall be equal to the power required to overcome drag.

D = drag of aeroplane at maximum speed

η max. = maximum airscrew efficiency

(H.P.) max. = maximum H.P. delivered by engine

Equation (3) can be written -

$$\frac{K_D \rho S V^3\text{max.}}{550} = 0.8(320) \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (4)$$

Equations (2) and (4) are satisfied at a wing incidence of -1° and the K_L and K_D values corresponding to this incidence lead to a maximum level speed of 122.5 m.p.h. Actual flight tests give a maximum speed of 127 m.p.h. which is sufficiently close to justify the assumptions of power and propeller efficiency.

For the calculation of the climbing qualities of each arrangement, it is necessary to evaluate firstly, the power available at various forward speeds and secondly, the power required to overcome the drag at various forward speeds.

In table 5, the various steps are given in the calculation of power available. The arbitrary values of air speed in columns 1 and 2 are expressed as percentages of the maximum speed (122.5 m.p.h.) in column 3. On curve sheet #1 is given the approximate drop in propeller r.p.m. with decrease in air speed (from "Simple Aerodynamics" by Carter, p.290). From this curve, the figures in column 4 are obtained and hence the values of r.p.m. in column 5 are deduced from the maximum r.p.m. (2100). Column 7 is obtained from the power curve of the engine (N.R.C. Report No. PAE-4). Columns 8 and 9 follow from the values of V, n and propeller diameter D (9 ft.) and the value of V/nD at maximum V and n. Curve sheet #2 gives the approximate drop in a propeller's efficiency with decreased speed (decreased V/nD) ("Handbook of Aeronautics", vol. 1, p.157) and hence columns 10 and 11 follow directly. Finally, the power available given in column 12, is calculated from the product of propeller efficiency in column 11 and power from the engine in column 7.

Curve sheet #3 gives a plot of the power available.

The calculations for power required in level flight for each of the arrangements are given in tables 6 and 7. In column 3 of table 6, the appropriate lift coefficient ($K_L = \frac{W}{\rho S V^2}$) has been evaluated for level flight at each of the arbitrarily chosen wind speeds given in columns 1 and 2. From the plotted K_L and K_D curves for each arrangement, the value of K_D at the same incidence at which these K_L values are obtained has been read off. These values are given in the remaining columns of table 6. The h.p. required for level flight for each of the arrangements at the various speeds chosen then follows directly from the K_D values. Thus:-

$$H.P. = \frac{\text{Drag (lbs.)} \times \text{Speed (ft./sec.)}}{550}$$

$$= \frac{K_D \rho S V^2 \times V}{550}$$

$$= \frac{K_D \rho S V^3}{550}$$

The curves of H.P. required for level flight against air speed were then plotted on the same sheet as the H.P. available curve. The excess of H.P. available over H.P. required then gave the H.P. available for climbing. The air speed at which this excess was a maximum for each arrangement represented the best climbing speed. The best climbing speed for each arrangement has been given in column 5 of table 8.

The rate of climb V_c them followed from the excess H.P. (E.H.P.) available for climbing, thus:-

$$\frac{W \times V_c \text{ (ft./sec.)}}{550} = \text{E.H.P. therefore } V_c = \frac{550 \times \text{E.H.P.}}{W}$$

where W = weight of aircraft in lbs. (all up = 4835 lbs.)

The rates of climb for the various arrangements are givem in column 6 of table 8.

The angle of climb or best climbing angle is given in column 7 and follows from the relationship between climbing speed and rate of climb.

If V = best climbing speed in ft./sec.
V_c = rate of climb in ft./sec.
Then θ (climbing angle) is given by the equation

$$\sin \theta = \frac{V_c}{V}$$

The air speed at which the curves of H.P. required for level flight and H.P. available intersect at their upper ends gives the maximum level flight speed for each arrangement. This is tabulated in column 2 of table 8, along with the other performance figures. It will be seen from table 8 that maximum speed is decreased by 9 m.p.h. in the worst case (arrangements 2 and 3) but that in the case of good arrangements (8, 9, 10 and 11) the maximum speed is affected very slightly. The initial rate of climb and the climbing angle are probably the most important factors affected by the addition of a canoe. With the worst arrangements, the rate of climb is decreased by 120 ft./min. from an original 564 ft./min. and an already small climbing angle of 4°21' is reduced to 3°29'. This has an important bearing on the ability of the aeroplane carrying a canoe to climb out of small lakes where the trees bordering the lakes may act as obstructions.

With the best arrangements (8, 11) the climbing ability of the aeroplane is only very slightly impaired.

If we place the arrangements in order of merit as regards the various items of performance, we get slight variations in order of merit, but assuming that climbing qualities are paramount, we find that the order of merit is as follows:-

<u>Arrangement No.</u>

8
11
10
9
7
2
6
5
4
3)
1)

The advantages of using canoes specially adapted for carrying on aircraft is obvious, since the first four arrangements (8,11, 10 and 9) are with the canoe ends detached.

Arrangement No. 8 is with the canoe fitted snugly to the side of the fuselage. Its effect on all the items of performance is practically negligible and it therefore represents the ideal way of carrying a canoe. The second in order of merit is arrangement No. 11, which is only slightly inferior to the first. In general, it is felt that this arrangement would be in every way as good as arrangement No. 8.

In the particular case of these tests, the aeroplane model was the photographic "Pacemaker", on the under side of which was a streamlined cowling for the camera, which interfered in arrangement 11, making it impossible to fit the canoe snugly under the fuselage. In most cases, it would be possible to secure a good snug fit and it can be inferred from the tests that this would result in as good an arrangement as No. 8.

The next two positions in the order of merit are 10 and 9. Except for the fact that the canoe had its ends removed and was covered in, these positions are the same as in arrangements 1 and 3 which happen to be the worst arrangements. This shows clearly the merit of a specially adapted canoe which can change a bad arrangement into one of the best. It can be assumed safely that detaching the ends and covering-in the canoe will considerably improve any of the arrangements.

Of the remaining arrangements, in which the conventional canoe is used, arrangement No. 7 is the best. It is still far short of the ideal arrangements, but is superior enough to the worst arrangements to warrant its adoption when the canoe is not equipped with detachable ends. The only argument against this arrangement is that it prevemts the use of the door on one side of the cabin. It has one other advantage besides merit as regards performance, viz., that it is well away from the spray from the floats.

Arrangements 1 and 3 are the worst as regards performance. This is interesting in view of the fact that position 1 is apparently a popular one with the operators. It has another disadvantage in its proximity to the spray from the floats, there being a risk of shipping water during the take-off run. Arrangement 3 would probably be prohibited since the rear of the canoe would be submerged during the take-off run and apart from rendering the take-off difficult, might even prevent it.

Conclusions

The trouble taken in providing canoes, to be carried on aircraft, with detachable ends, is well repaid by the unimpaired performance of the aeroplane. The best location for such a canoe is fitted snugly, either to the side or bottom of the fuselage. If for any reason, these positions are prohibitive, the canoe with detached ends and covered in will still provide a very considerably superior arrangement to that of the conventional canoe, in any other position chosen. If the canoe to be carried has not detachable ends, a position alongside the fuselage with the open top of the canoe facing inwards to the fuselage is the best. A position for the canoe on top of the float spreader tubes, which appears to be favoured by the operators, has the most serious effect on the performance of the aircraft.

Acknowledgments

The author is indebted to the Chestnut Canoe Company for their co-operation in supplying the lines of their 16 ft. "Labrador" canoe and to Mr. Douglas Baker for his assistance in the tests and in the preparation of the drawings for this report.

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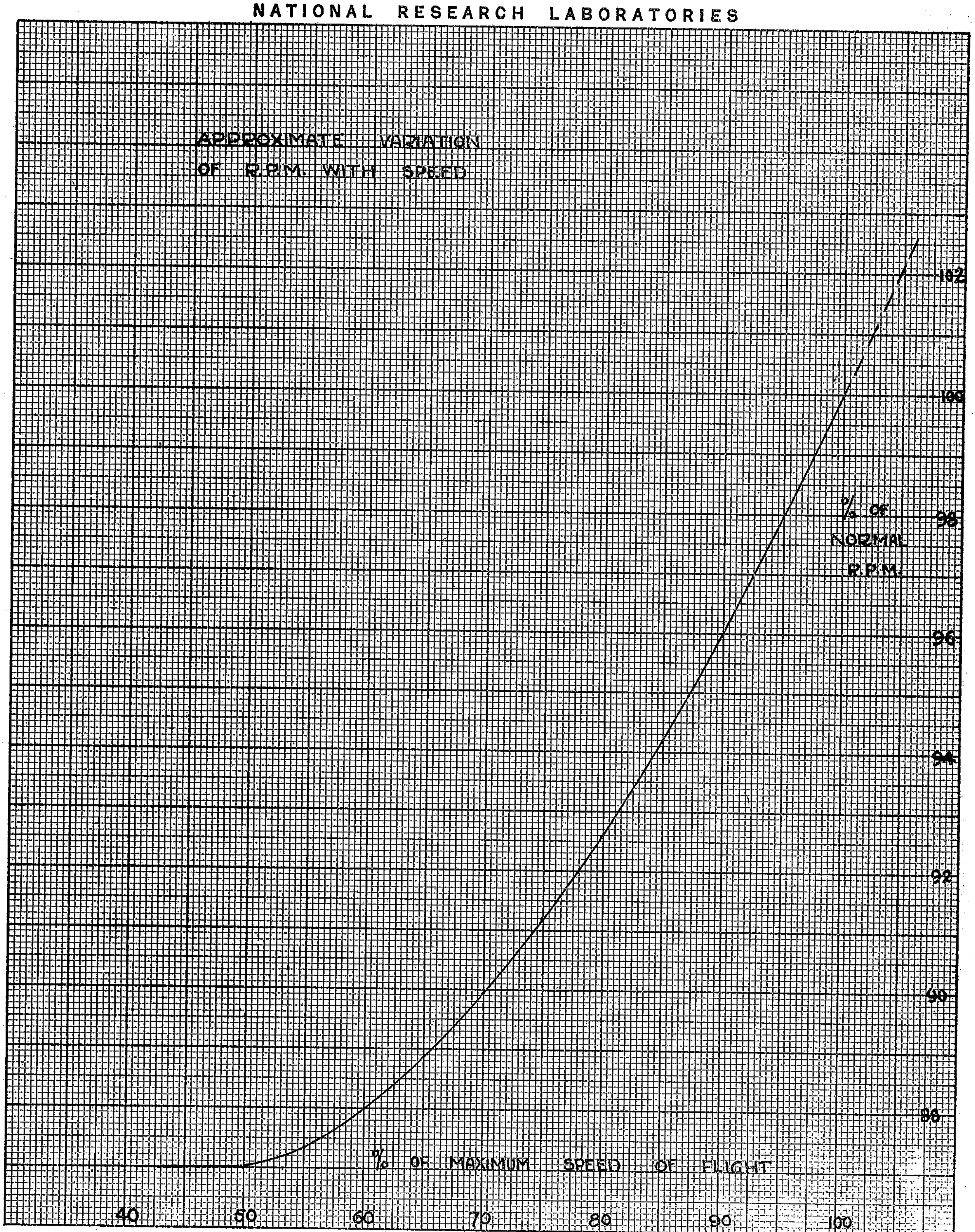

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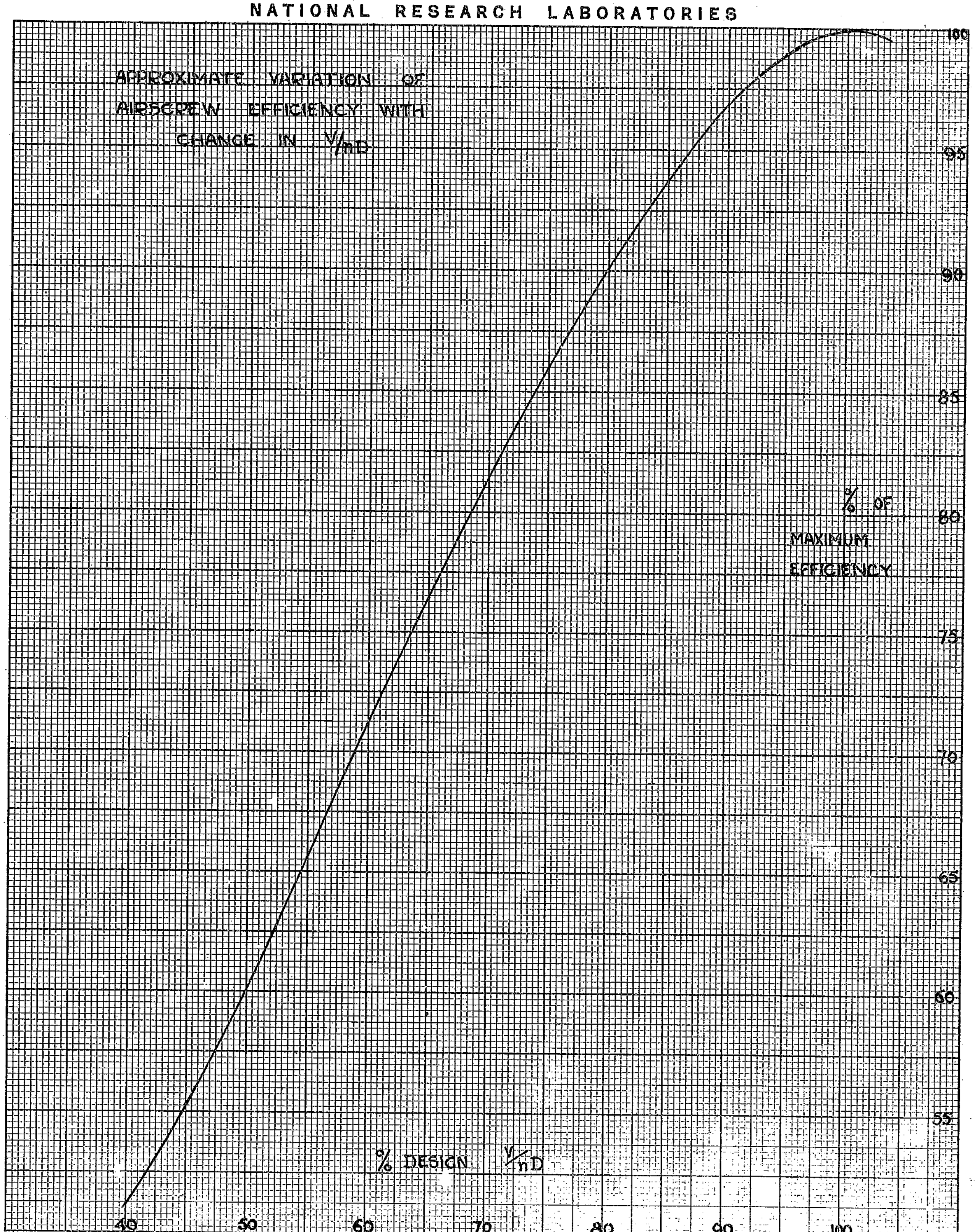

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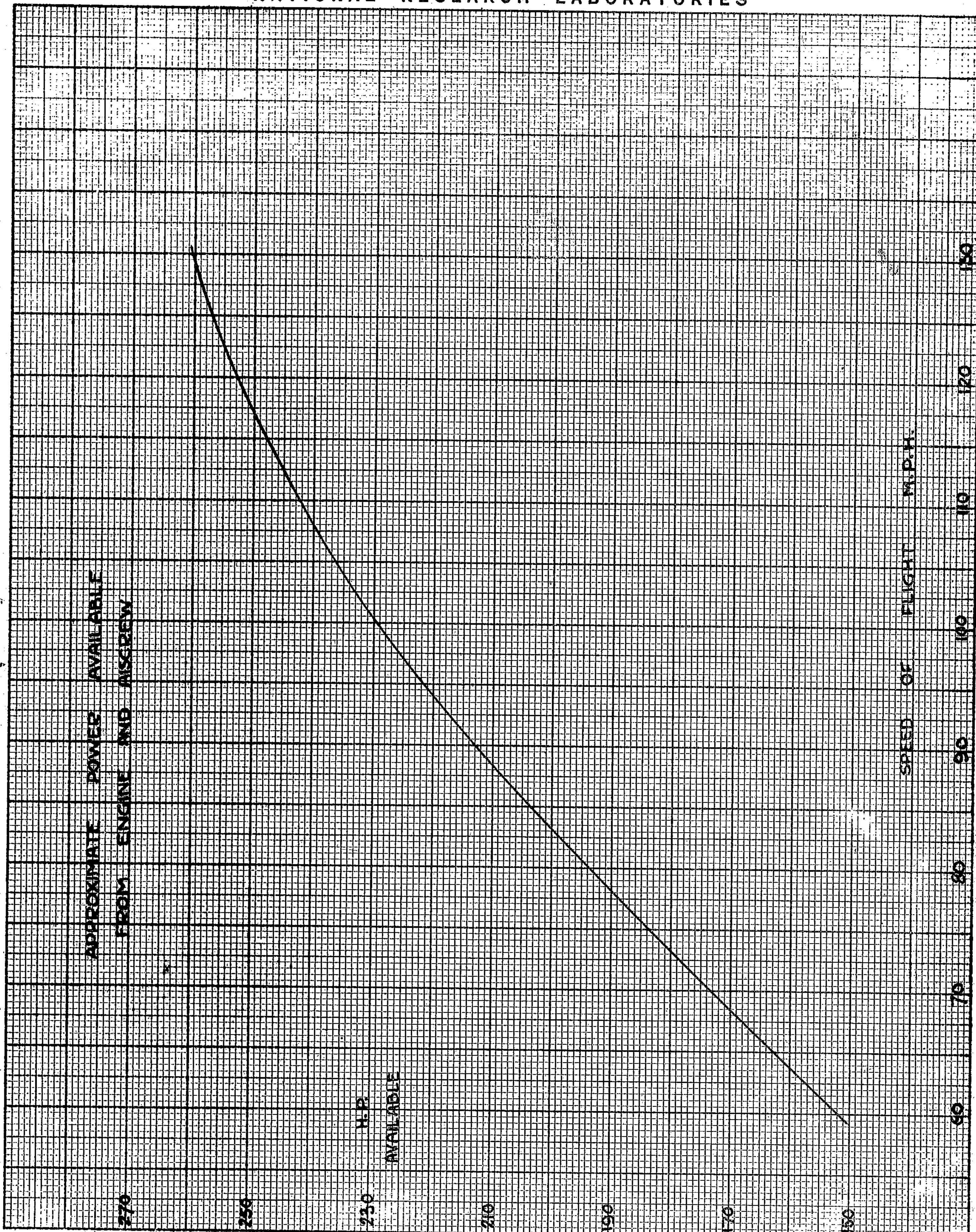

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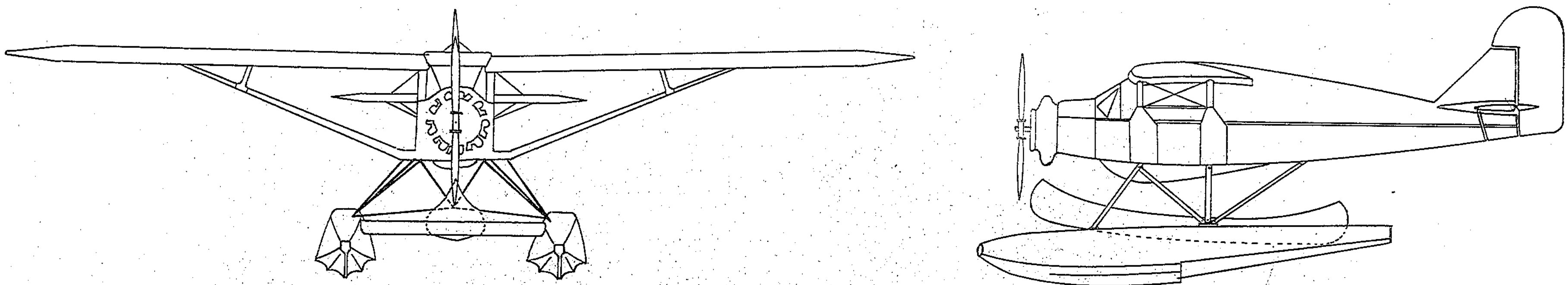

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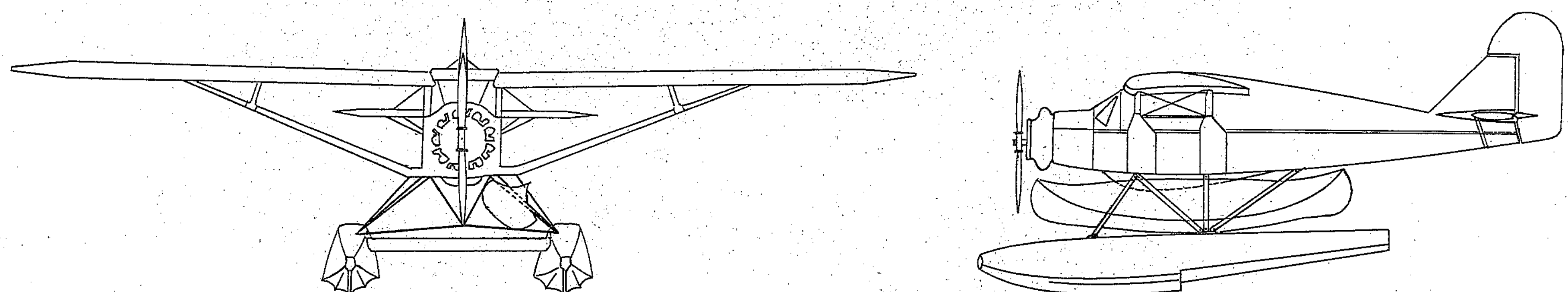

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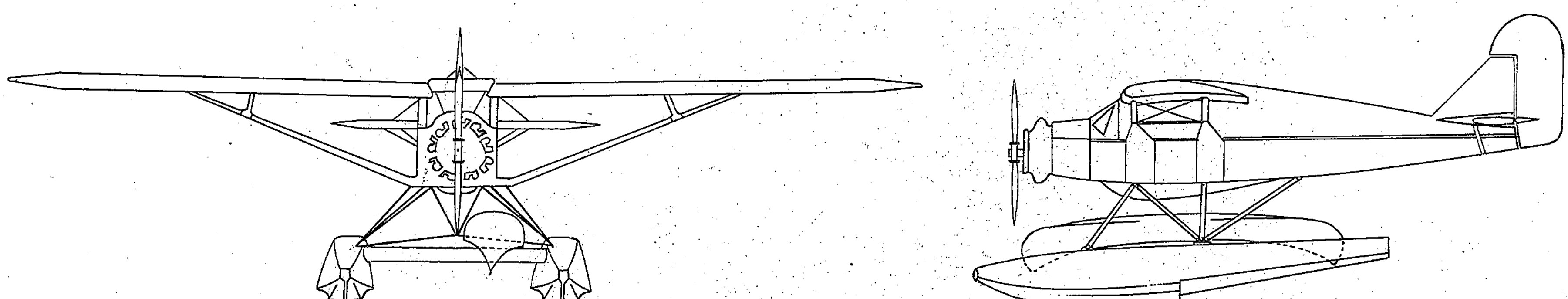

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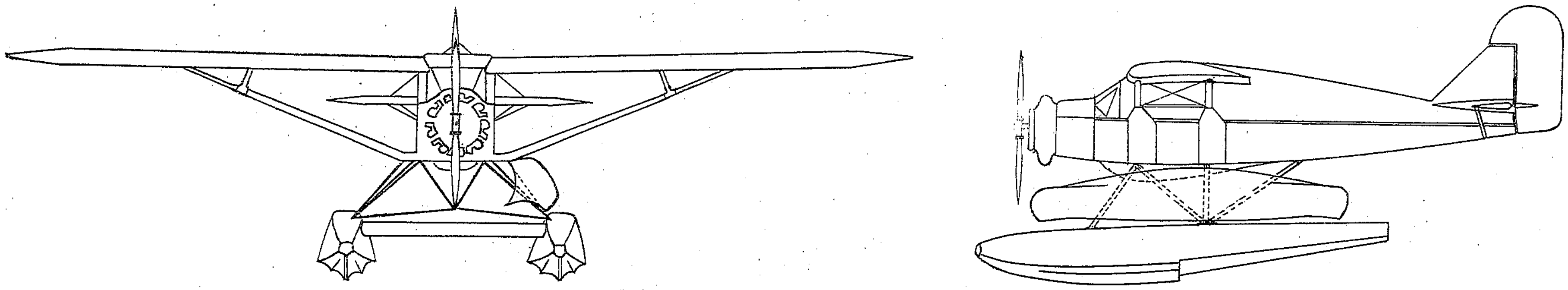

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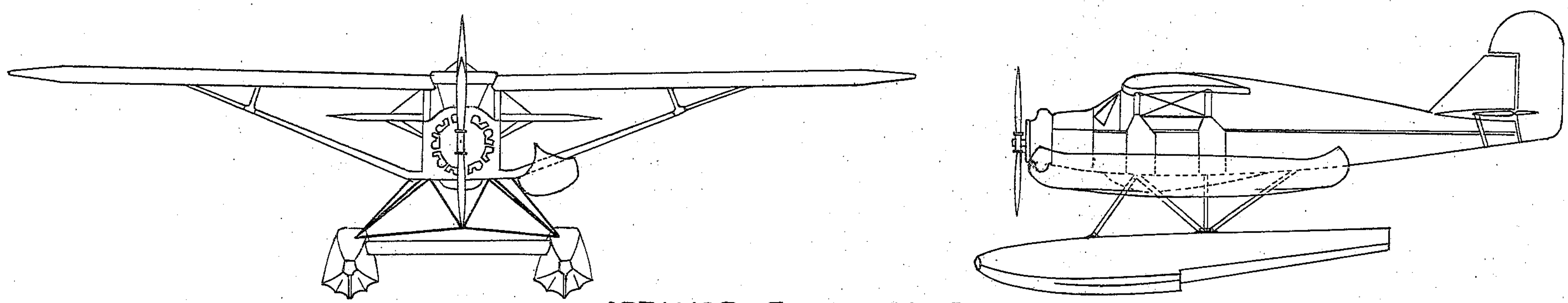

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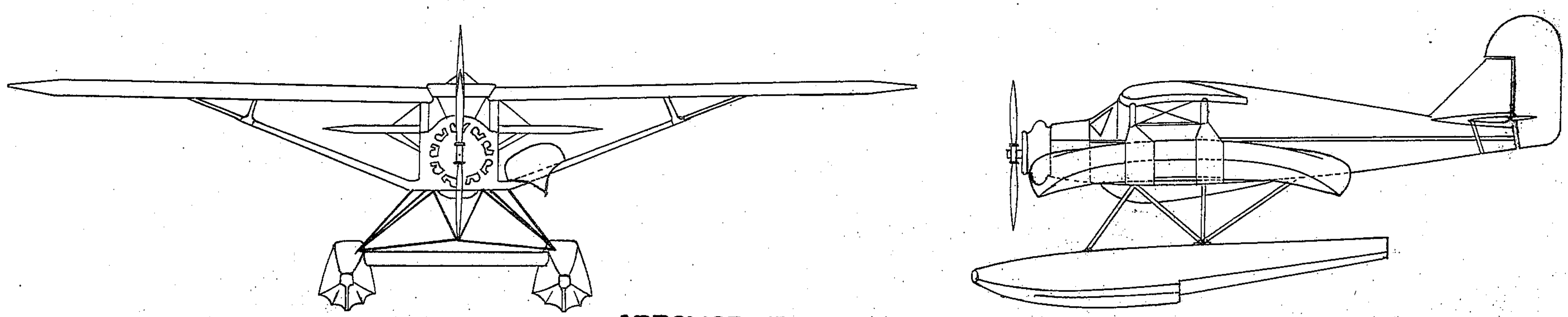

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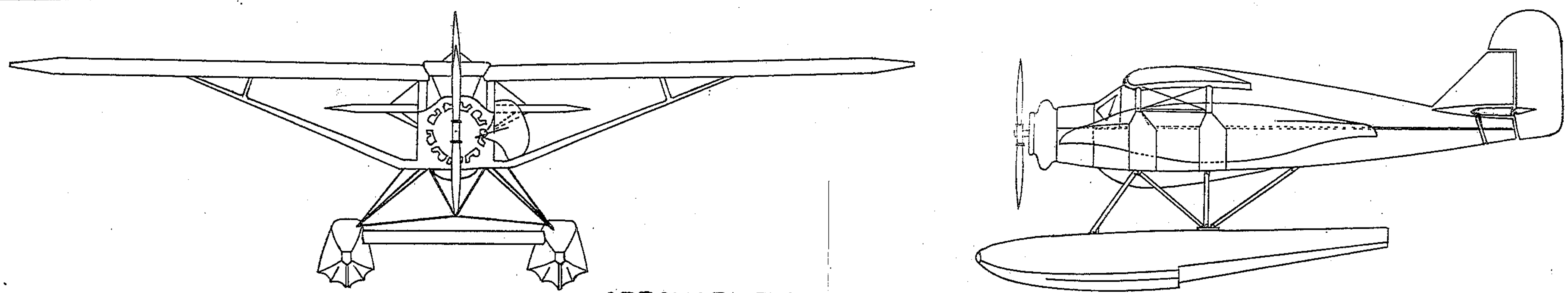

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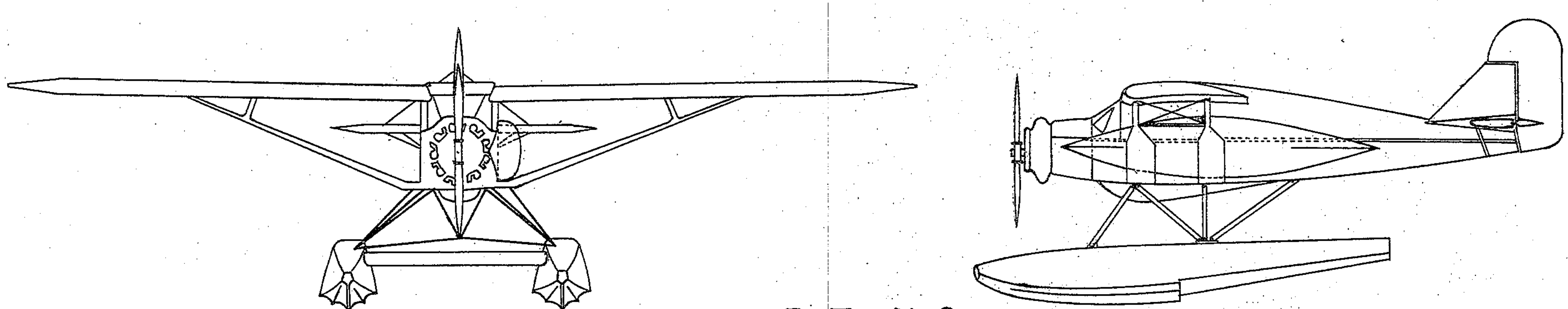

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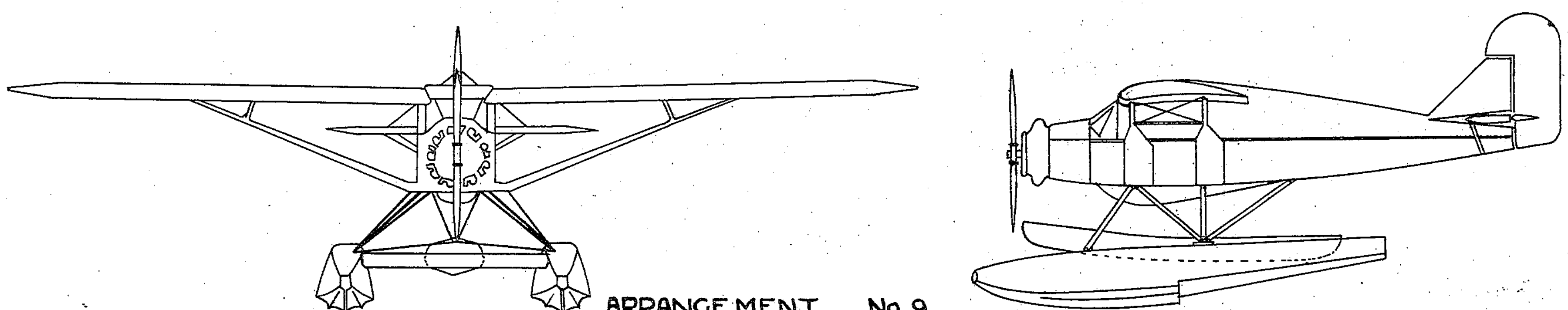

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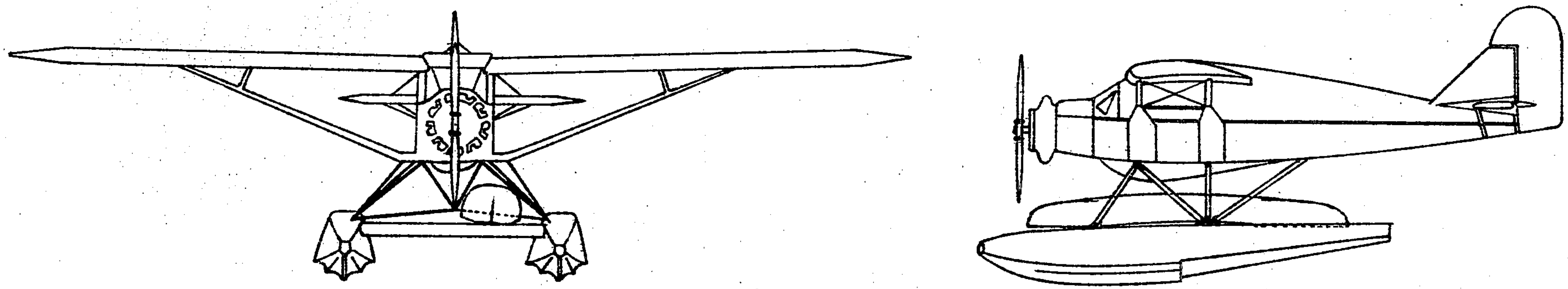

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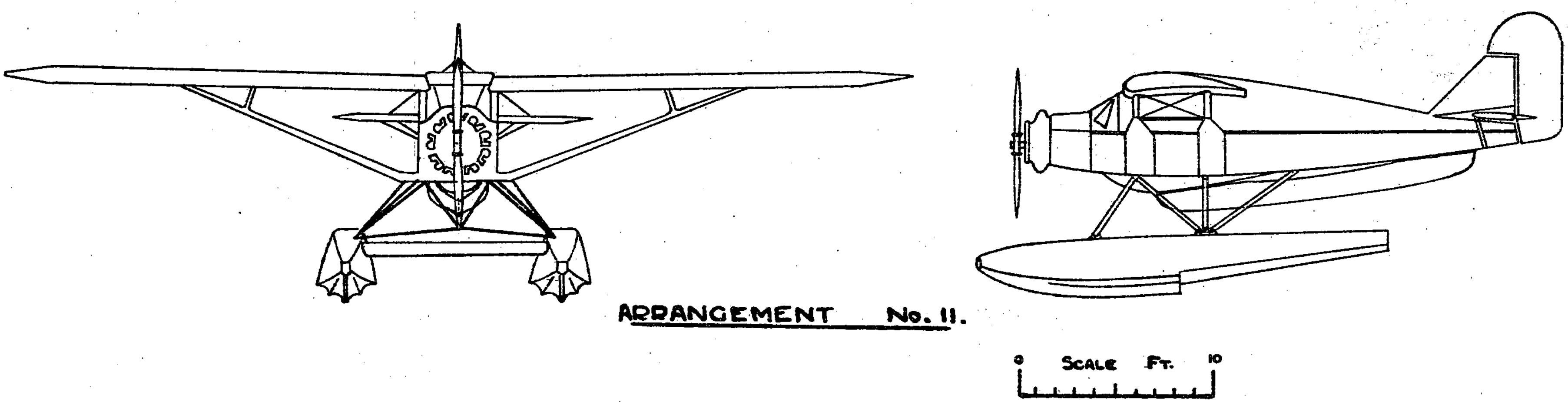

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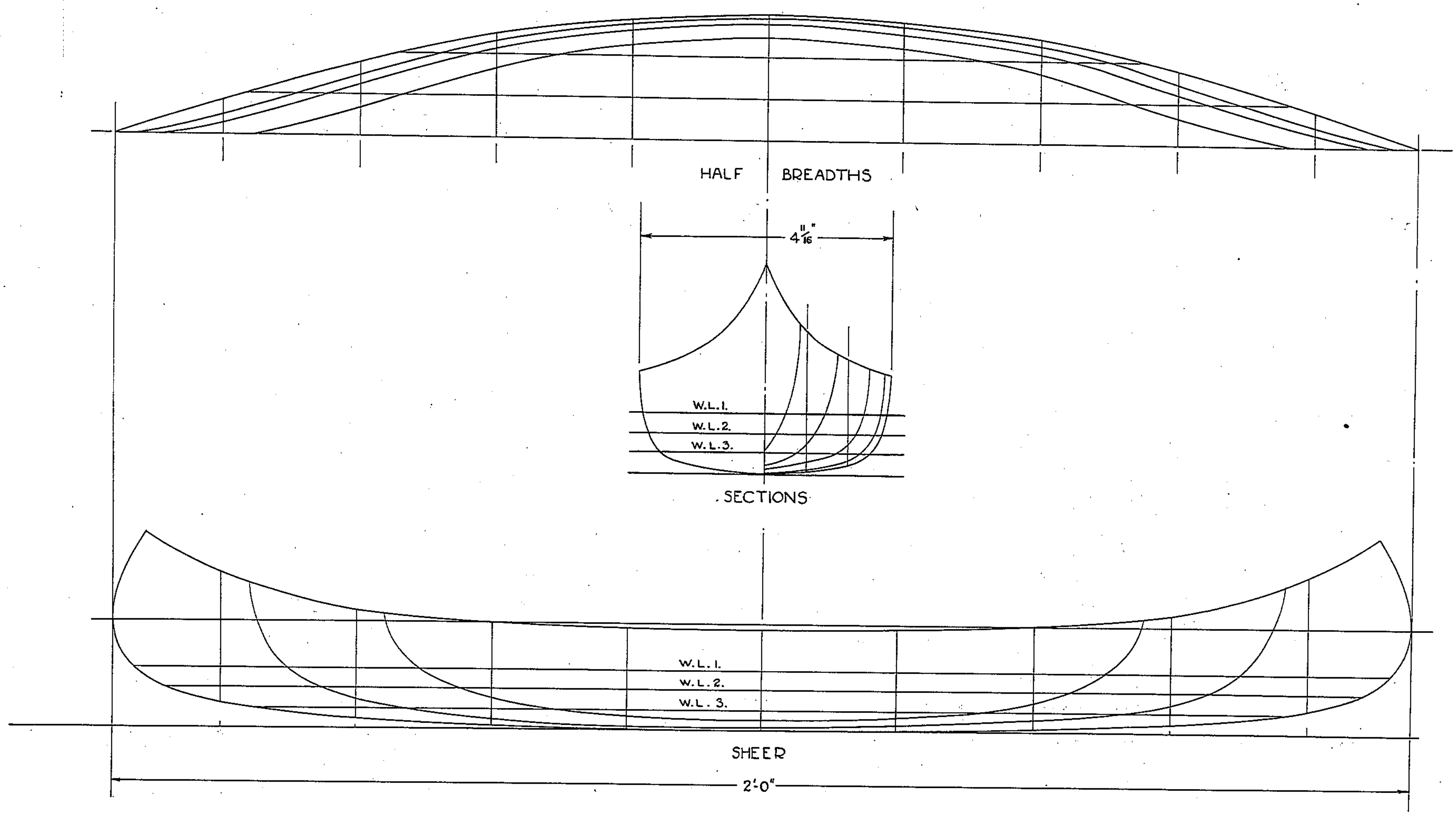

MODEL LINES OF 16 FT.
CHESTNUT "LABRADOR"
CANOE

0 1" 2" 3"

TABLE 1.

LIFT COEFFICIENTS FOR THE VARIOUS ARRANGEMENTS

ANGLE OF INCIDENCE	K_L												
	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
−6°	−·013	−·016	−·018	−·012	+·001	−·014	−·006	−·005	−·009	−·012	−·015	−·001	
−3°	·128	·128	·122	·133	·140	·129	·139	·140	·136	·130	·130	·140	
−1°	·225	·222	·222	·226	·239	·227	·237	·236	·230	·226	·228	·238	
1°	·329	·329	·326	·330	·344	·328	·336	·339	·340	·332	·330	·339	
4°	·475	·471	·470	·475	·485	·470	·480	·485	·483	·474	·473	·479	
7°	·601	·608	·611	·615	·627	·605	·624	·626	·628	·618	·620	·622	
10°	·731	·715	·720	·722	·740	·716	·733	·735	·731	·730	·729	·731	
13°	·793	·796	·806	·809	·812	·800	·815	·808	·806	·814	·810	·816	
15°	·800	·795	·805	·811	·820	·803	·817	·802	·802	·818	·812	·814	
17°	·779	·772	·786	·791	·797	·781	·796	·780	·783	·796	·790	·788	

TABLE 2.

DRAG COEFFICIENTS FOR THE VARIOUS ARRANGEMENTS

ANGLE OF INCIDENCE	K_D												
	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
−6°	·0381	·0454	·0476	·0486	·0458	·0472	·0457	·0436	·0399	·0413	·0451	·0392	
−3°	·0352	·0423	·0442	·0440	·0433	·0431	·0430	·0414	·0369	·0383	·0409	·0372	
−1°	·0367	·0439	·0452	·0450	·0445	·0441	·0442	·0431	·0384	·0398	·0417	·0390	
1°	·0416	·0485	·0492	·0483	·0497	·0482	·0479	·0478	·0430	·0446	·0454	·0432	
4°	·0525	·0594	·0582	·0675?	·0605	·0589	·0591	·0595	·0544	·0555	·0555	·0545	
7°	·0690	·0772	·0769	·0774	·0790	·0758	·0778	·0776	·0732	·0747	·0740	·0734	
10°	·0932	·0975	·0970	·0984	·1013	·0968	·0992	·0985	·0958	·0966	·0952	·0951	
13°	·1220	·1284	·1277	·1280	·1324	·1271	·1304	·1293	·1260	·1274	·1252	·1269	
15°	·1508	·1560	·1558	·1571	·1614	·1550	·1595	·1594	·1557	·1563	·1535	·1555	
17°	·1856	·1884	·1912	·1920	·1960	·1895	·1993	·1918	·1892	·1920	·1914	·1915	

TABLE 3.

RATIO OF LIFT TO DRAG

ANGLE OF INCIDENCE	L/D											
	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10	11.	12.
−6°	−0·33	−0·35	−0·38	−0·26	+0·02	−0·30	−0·0	−0·12	−0·23	−0·03	−0·33	−0·04	
−3°	3·64	3·03	2·76	3·03	3·23	3·00	3·25	3·38	3·69	3·41	3·17	3·76	
−1°	6·15	5·06	4·93	5·03	5·37	5·15	5·36	5·48	5·99	5·69	5·47	6·11	
1°	7·92	6·80	6·63	6·82	6·93	6·80	7·02	7·09	7·91	7·45	7·27	7·85	
4°	9·06	7·94	8·08	7·04?	8·02	7·98	8·12	8·15	8·88	8·54	8·52	8·79	
7°	8·71	7·88	7·95	7·95	7·94	7·98	8·02	8·07	8·58	8·28	8·38	8·48	
10°	7·85	7·33	7·42	7·34	7·31	7·40	7·39	7·46	7·63	7·56	7·66	7·69	
13°	6·50	6·20	6·31	6·32	6·13	6·30	6·25	6·25	6·40	6·39	6·47	6·43	
15°	5·30	5·10	5·17	5·16	5·08	5·18	5·12	5·03	5·15	5·23	5·29	5·24	
17°	4·19	4·10	4·11	4·12	4·06	4·12	3·99	4·06	4·14	4·14	4·13	4·11	

TABLE 4.

PITCHING MOMENT COEFFICIENTS FOR THE VARIOUS ARRANGEMENTS

ANGLE OF INCIDENCE	K_M											
	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
−6°	−·0078	−·0115	−·0063	−·0188	−·0115	−·0146	−·0124	−·0086	−·0125	−·0144	−·0190	−·0041	
−3°	−·0074	−·0101	−·0035	−·0167	−·0088	−·0094	−·0083	−·0072	−·0064	−·0103	−·0154	+·0011	
−1°	−·0057	−·0114	−·0046	−·0163	−·0083	−·0090	−·0091	−·0069	−·0063	−·0105	−·0161	+·0003	
1°	−·0076	−·0147	−·0081	−·0188	−·0100	−·0111	−·0125	−·0080	−·0096	−·0139	−·0179	−·0023	
4°	−·0126	−·0021	−·0154	−·0210?	−·0135	−·0133	−·0162	−·0127	−·0145	−·0205	−·0240	−·0072	
7°	−·0222	−·0309	−·0228	−·0368	−·0236	−·0219	−·0247	−·0217	−·0239	−·0310	−·0333	−·0166	
10°	−·0442	−·0512	−·0431	−·0559	−·0446	−·0385	−·0408	−·0406	−·0337	−·0503	−·0547	−·0389	
13°	−·0892	−·0877	−·0783	−·0909	−·0891	−·0739	−·0821	−·0843	−·0837	−·0881	−·0897	−·0876	
15°	−·1169	−·1106	−·1041	−·1140	−·1158	−·1036	−·1103	−·1225	−·1102	−·1155	−·1152	−·1153	
17°	−·1409	−·1302	−·1290	−·1392	−·1367	−·1232	−·1271	−·1262	−·1319	−·1361	−·1400	−·1360	

TABLE 5.

CALCULATION OF H.P AVAILABLE

AIR SPEED M.P.H.	AIR SPEED FT./SEC. V.	% MAXIM^M SPEED	% MAXIM^M R.P.M.	R.P.M.	n. REVS. PER. SEC.	H.P. FROM ENGINE	$\frac{V}{nD}$	% OF DESIGN $\frac{V}{nD}$	% OF MAXIM^M EFFIC^NCY	PROP^LR EFFIC^NCY η	H.P. AVAIL-ABLE
130	190·6	106	102·8	2160	36	327	0·588	103·1	99·6	0·796	260
125	183·4	102	101	2120	35·3	322	·577	101·1	100	·80	257
120	176	97·9	99·2	2080	34·7	316	·564	98·8	99·7	·797	252
110	161·3	89·8	96	2015	33·6	307	·533	93·4	98·5	·788	242
100	146·6	81·6	93·1	1954	32·6	300	·501	87·7	95·5	·764	229
90	132	73·4	90·8	1906	31·8	293	·461	80·9	90·7	·726	213
80	117·3	65·3	89	1868	31·1	287	·419	73·3	84·5	·676	194
70	102·6	57·1	87·6	1839	30·6	283	·372	65·2	76·6	·612	173
60	88	49	87	1826	30·4	281	·321	56·2	67	·536	152

TABLE 6.

DRAG COEFFICIENTS AT VARIOUS SPEEDS OF FLIGHT

AIR SPEED M.P.H.	V. FT./SEC.	K_L $\left(\frac{W}{\rho S V^2}\right)$	K_D APPROPRIATE TO K_L VALUES FOR EACH ARRANGEMENT											
			0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
130	190·6	·202	0·0361	·0431	·0450	·0443	·0439	·0438	·0435	·0422	·0375	·0392	·0410	·0379
125	183·4	·218	·0365	·0436	·0453	·0445	·0441	·0440	·0439	·0427	·0380	·0397	·0413	·0382
120	176	·237	·0372	·0443	·0458	·0448	·0446	·0446	·0443	·0431	·0387	·0402	·0418	·0389
110	161·3	·282	·0392	·0462	·0472	·0463	·0463	·0460	·0454	·0446	·0401	·0421	·0431	·0405
100	146·6	·342	·0424	·0495	·0500	·0498	·0496	·0492	·0480	·0480	·0430	·0452	·0459	·0436
90	132	·423	·0481	·0552	·0548	·0550	·0550	·0549	·0536	·0537	·0480	·0510	·0510	·0489
80	117·3	·534	·0588	·0671	·0653	·0670	·0660	·0660	·0651	·0647	·0599	·0630	·0621	·0614
70	102·6	·699	·0867	·0940	·0925	·0930	·0916	·0933	·0910	·0909	·0872	·0891	·0886	·0864
60	88	·950	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 7.

H.P. REQUIRED FOR LEVEL FLIGHT AT EACH SPEED

AIR SPEED M.P.H.	V. FT./SEC.	H.P. REQUIRED FOR LEVEL FLIGHT, FOR EACH ARRANGEMENT.											
		0.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
130	190·6	298·8	356·8	372·5	366·7	363·4	362·6	360·1	349·3	310·4	324·5	339·4	313·7
125	183·4	269·2	321·5	334·1	328·2	325·2	324·5	323·7	314·9	280·2	292·8	304·6	281·7
120	176	242·5	288·7	298·5	292·0	290·7	290·7	288·7	280·9	252·2	262·0	272·4	253·5
110	161·3	196·7	231·8	236·8	232·3	232·3	230·8	227·8	223·8	201·2	211·2	216·2	203·2
100	146·6	159·7	186·4	188·3	187·6	186·8	185·3	180·8	180·8	162·0	170·2	172·9	164·2
90	132	132·0	151·4	150·3	150·9	150·9	150·6	147·0	147·3	131·7	139·9	139·9	134·1
80	117·3	113·5	129·5	126·0	129·3	127·3	127·3	125·6	124·8	115·6	121·6	119·8	118·5
70	102·6	111·9	121·4	119·4	120·1	118·3	120·5	117·5	117·4	112·6	115·0	114·4	111·6
60	88	–	–	–	–	–	–	–	–	–	–	–	–

TABLE 8.

PERFORMANCE FIGURES FOR THE VARIOUS ARRANGEMENTS.

ARRANGEMENT No.	MAXIMUM LEVEL FLIGHT SPEED (SEA-LEVEL) M.P.H.	STALLING SPEED (W=4835 lb.) M.P.H.	BEST GLIDING ANGLE	BEST CLIMBING SPEED M.P.H.	INITIAL RATE OF CLIMB FT./MIN.	ANGLE OF FLIGHT PATH TO HORIZONTAL IN CLIMB	LONGITUDINAL STABILITY CHANGE DUE TO PRESENCE OF CANOE.
0.	122·5	65·3	6° 18′	84·5	564	4° 21′	STABLE AT INCIDENCES IN EXCESS OF −1°, NEUTRAL BELOW −1°
1.	114·2	65·5	7° 11′	83	444	3° 29′	NO CHANGE
2.	113·5	65·1	7° 3′	82·5	471	3° 43′	IMPROVED
3.	113·5	64·9	8° 5′	83	444	3° 29′	SLIGHTLY IMPAIRED
4.	114·2	64·6	7° 6′	82	454	3° 37′	NO CHANGE
5.	114·2	65·3	7° 9′	82	458	3° 38′	SLIGHTLY IMPAIRED
6.	114·8	64·7	7° 1′	83	471	3° 42′	SLIGHTLY IMPROVED
7.	115·7	65	7° 0′	82	478	3° 48′	NO CHANGE
8.	120·7	65·1	6° 25′	86	560	4° 15′	NO CHANGE
9.	119	64·6	6° 40′	85	505	3° 53′	NO CHANGE
10.	117·3	64·9	6° 42′	84	516	4° 0′	NO CHANGE
11.	120·3	64·7	6° 29′	87·5	540	4° 2′	SLIGHTLY IMPROVED