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LIFT AND DRAG CHARACTERISTICS OF A CABIN MONOPLANE DETERMINED IN FLIGHT

By F. L. Thompson and P. H. Keister
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Summary

The results of flight tests conducted by the National Advisory Committee for Aeronautics to determine the lift and drag characteristics of a full-scale airplane are given herein. A Fairchild FC-2W2 cabin monoplane having a Göttingen 387 wing section was used for the tests.

The maximum lift coefficient for the airplane is compared with that obtained for the Göttingen 387 airfoil in recent tests in the Variable Density Tunnel. The maximum lift coefficient for the airplane was found to be 1.50 and that for the airfoil 1.56. Although the flight tests were confined chiefly to glides with the propeller locked horizontally, data obtained with the propeller operating at zero thrust for a few angles of attack are also included. The most important feature of a comparison between the results obtained with the propeller locked and propeller rotating is that the difference in overall drag agrees very well with that found for the locked propeller in tests with the airplane mounted in the Propeller Research Tunnel.

Introduction

Measurements of the lift and drag characteristics of a full scale cabin monoplane have been completed recently at the Langley Memorial Aeronautical Laboratory of the National Advisory Committee for Aeronautics, Langley Field, Va. An airfoil of the section used on the airplane has been tested recently in the Variable Density Wind Tunnel, and it is possible to compare the maximum lift coefficient obtained for the airfoil with that obtained in flight for the complete airplane.

Lift, drag, and angle of attack were determined by direct measurements of the gliding angle, dynamic pressure, and attitude of the airplane in steady glides (Reference 1). The lift and drag characteristics were established for angles of attack between -2° and $+21^\circ$ with the propeller locked in a horizontal position. The data obtained are tabulated, and are also shown by means of the usual polar diagram and curves of lift and drag coefficients versus angle of attack.

In addition to tests with the propeller locked, glides at angles of attack of -1°, 5°, and 11° were made with the propeller operating at approximately zero thrust. The reason for making these additional tests was that, in connection with the use of this latter method in previous tests, some doubt has been expressed regarding the exactness with which the effect of the propeller is eliminated by this method. An essential phase of this part of the program was a determination of the drag of the locked propeller and the propeller thrust characteristics by means of tests with the complete airplane mounted in the Propeller Research Tunnel. Although the results obtained with the propeller rotating are strictly secondary in importance, they are believed to be sufficiently important to warrant inclusion herein.

Apparatus and Method

The airplane used for these tests (the Fairchild FC-2W2) is shown in Figures 1, 2, and 3. It is a closed-cabin high-wing monoplane having a gross weight of approximately 4700 lb. as flown in these tests. It has a Göttingen 387 wing section with tips rounded and slightly tapered, as shown in Figures 2 and 3. The wing span is 50 feet; chord, 7 feet; area, 336 square feet; and aspect ratio $(\frac{span^2}{area})$, 7.4. The area includes the area between the wing roots that is assumed by the fuselage. The angle of incidence of the wings is +2.6° with respect to the thrust axis.

Propeller locked.- Dynamic pressure and gliding angle were recorded with the N.A.C.A. flight-path-angle and air-speed recorder (Reference 2), which was suspended about 90 feet below the airplane. The angle of the wing chord was recorded with an N.A.C.A. recording pendulum inclinometer. The positions of the three control surfaces were recorded with an N.A.C.A. control position recorder (Reference 3).

Glides, with the propeller locked in a horizontal position, were made at altitudes between 10,000 and 4,000 feet. Records of 30 seconds duration were obtained at various indicated air speeds from the stalling speed of 60 m.p.h. to 140 m.p.h. The glides were made with the horizontal stabilizer in one position (angle of incidence with respect to thrust axis = +.9°). Control at and beyond maximum lift was obtained by installing a large fin and rudder, shown in comparison with the standard surfaces in Figure 4. Tests were made that established the fact that no appreciable increase in drag accompanied the installation of this additional tail structure. The drag of the suspended recording instrument was established by direct measurements in glides with the suspension cable attached to a spring balance and angle indicator.

The lift and drag coefficients for the airplane were found by use of the expressions

$$C_L = \frac{W \cos \gamma}{q S}$$

and

$$C_D = \frac{W \sin \gamma - d}{q S}$$

where W is the total weight of the airplane during a glide,

γ the recorded gliding angle,

q the recorded dynamic pressure,

S the total wing area of 336 square feet,

and d the drag of the suspended instrument.

The angle of attack, α, is given by

$$\alpha = \lambda - \gamma$$

where λ is the recorded attitude angle of the wing measured from the horizontal.

<u>Propeller operating at zero thrust</u>.- Before any flight tests were made, the drag of the propeller locked horizontally and a portion of the thrust curve for the propeller were determined with the complete airplane mounted in the Propeller Research Tunnel. The propeller drag was determined by the difference in over-all drag with and without the propeller in place. The thrust curve was established for values of V/nD near that for zero thrust. The tunnel tests were made with the thrust axis parallel to the air stream; thus the angle of attack of the wings was 2.6°.

The procedure followed in gliding was essentially the same as that employed with the propeller locked except that it was necessary to adjust the propeller speed to approximately the proper value for zero thrust for each gliding speed and to obtain additional data from which the actual V/nD attained could be calculated. The actual thrust developed in flight was calculated from the known dynamic pressure, V/nD, and thrust characteristics. It was added algebraically to the apparent drag of the airplane calculated from the weight and gliding angle.

In addition to the dynamic pressure, the data required for a determination of V/nD and thrust were air temperature, static pressure, and propeller r.p.s. The air temperature was measured with a stem thermometer attached to a wing strut. The static air pressure was determined with an N.A.C.A. recording altimeter, which is a recording aneroid unit, or by means of visual observations of the indicating altimeter with which the airplane was regularly equipped. The propeller r.p.s. was determined from visual observations of the engine tachometer. All of these instruments were calibrated.

Accuracy

The accuracy of the flight-path-angle and air-speed recorder was investigated in flight. The alignment of this instrument with respect to the relative wind, which establishes a reference for the inclinometer element, was determined within limits of $\pm .1^{\circ}$ by means of level flight runs. The accuracy of the air-speed element was checked by means of timed flights over a measured course. The accuracy with which true dynamic pressure was established in these flights was within about ± 1 per cent. The air-speed element was found to be accurate within these limits. The above values refer only to the consistent errors in the instrument, however, and not to the accidental errors which are indicated by a dispersion of experimental points. The other important instrument, the inclinometer used to record the attitude of the airplane, is believed to be subject only to accidental errors.

It should be mentioned that the effect of downwash on the alignment of the flight-path-angle and air-speed recorder was investigated. Calculations show that at the probable position of that instrument when the airplane was developing maximum lift, the downwash angle was about 0.2°. Further calculations show, however, that variations in downwash angle with lift coefficient were nearly compensated by variations of instrument position with air speed. Therefore, since the actual alignment of the instrument was established for the conditions covered in level flight trials (lift coefficients of approximately .62 and .47), and since there appeared to be no appreciable difference in the alignment for those conditions, it is concluded that errors caused by downwash angles at all angles of attack can be neglected.

In addition to the above mentioned sources of error, the weight and, with the propeller rotating, the calculated thrust should also be considered. The weight for each glide (the initial weight minus an estimated weight of fuel consumed) is probably in error by less than ±1 per cent. The total thrust corrections were so small that the effect of errors in calculated thrust can be neglected.

Accidental errors in dynamic pressure and angles are probably the chief cause of the dispersion of points on the curves. It is evident from the manner in which the lift and drag coefficients are calculated that errors in dynamic pressure affect both coefficients equally, but that errors in gliding angle affect only the drag coefficient appreciably. Angles of attack are subject to the sum, in degrees, of errors in flight path and attitude angles. Although the dispersion of points indicates that the accidental errors are fairly large, their effect on the faired curves is believed to be nearly eliminated by reason of the large number of experimental points obtained. The probable limits of accuracy of the faired curves are believed to be as follows: lift coefficient, ±2 per cent; drag coefficient, ±3 per cent; angles of attack, $\pm .3^\circ$.

Elevator angles, values for which are tabulated herein, are probably accurate within $\pm 1^\circ$.

Results

Propeller locked.- The data obtained with the propeller locked are given in Table I. Lift and drag coefficients versus angle of attack are shown in Figure 5. The curve of L/D shown in the same figure was obtained from the faired C_L and C_D curves. The polar diagram is shown in Figure 6.

Figure 5 shows a maximum lift coefficient of 1.50 at an angle of attack of approximately 16°. The slope of the lift curve varies slightly throughout. The data of Table I show that the increase in angle of attack beyond that for maximum lift was accompanied by a sharp increase in flight-path angle without an appreciable change in attitude. An example of the manner in which the airplane responds to a step-by-step increase in elevator deflection at maximum lift is shown by runs 251a, b, and c at the end of Table I. It is worthy of note that all the experimental points for angles of attack greater than approximately 13° were obtained with the aid of the large fin and rudder.

In Figure 7, the lift curve for the airplane is shown in comparison with that obtained for the Göttingen 387 airfoil at full-scale Reynolds Number. The airfoil tests were made recently in the new Variable Density Wind Tunnel with a polished airfoil of rectangular form and aspect ratio 6 (Reference 4). The maximum coefficient for the airfoil is about 4 per cent higher than that for the complete airplane. Calculations show that at maximum lift there is probably a down load on the tail of the airplane equal to about 1 per cent of the total weight. It is possible, therefore, that the maximum lift coefficient for the airplane wing is slightly greater than that for the complete airplane, and that the actual difference between the maximum lift coefficients for the airfoil and actual airplane wing is less than 4 per cent.

Propeller rotating.- The results obtained with the propeller rotating are shown in Table II and Figures 8 and 9. Curves obtained with the propeller locked are included in these figures for comparison. Figure 8 shows that in addition to the difference in drag for the two conditions, there is also an appreciable difference in lift. It is possible that the difference shown is at least partially due to experimental inaccuracy, particularly at 4.5° angle of attack. However, it should be noted that the difference shown at 10.5° angle of attack was verified by check runs that were made for both conditions after the difference in results was first observed. Since lift and drag are both affected, the difference in drag shown by the polar diagrams appears to be greater than that shown by the curves of drag coefficient versus angle of attack, except at low angles of attack.

In the wind tunnel, with the wing at an angle of attack of 2.6°, the drag of the propeller was found to be equivalent to a drag coefficient of .0124, whereas the difference between the two drag curves determined in flight is .0105 at this angle of attack. The discrepancy is small compared with the total drag coefficient (about 2.5 per cent), and can probably be attributed to experimental inaccuracies. It is concluded, therefore, that the effect of the propeller was practically eliminated in the tests conducted with the propeller rotating.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., January 13, 1931.

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Table I (continued on next page)

TABLE I

FAIRCHILD GLIDE TESTS

(propeller locked)

Run No.	Attitude angle λ	Gliding angle γ	Angle of attack α	Cos γ	Sin γ	Weight before flight	Fuel used till run	Weight during run W	Lift L	Dynamic press. q	Apparent drag	Drag of suspended instrument, d	True drag D	Lift coef. C_L	Drag coef. C_D	Elevator position δ_e	Remarks
	deg.	deg.	deg.			lb.	lb.	lb.	lb.	lb./sq.ft	lb.	lb.	lb.			deg. from stab.	
35	+ 0.8	- 6.6	+ 7.4	.9934	.1149	4742	46	4696	4660	13.3	534	17	517	1.042	.1158	+ 7	
37	- 2.0	- 6.7	+ 4.7	.9932	.1167	4742	46	4696	4660	16.6	548	19	529	.835	.0944	+ 3	
38	- 4.0	- 7.1	+ 3.1	.9923	.1236	4742	46	4696	4660	19.9	581	20	561	.696	.0838	+ 2	
40	- 7.6	- 8.4	+ .8	.9893	.1461	4742	92	4650	4600	26.5	680	21	659	.517	.0739	0	
42	+12.9	-11.7	- 1.2	.9792	.2028	4742	132	4610	4515	38.8	935	22	913	.346	.0700	- 2	
53	-15.9	-13.9	- 2.0	.9707	.2402	4732	200	4532	4400	46.9	1090	22	1068	.280	.0679	- 4	
54	+ 2.6	- 6.9	+ 9.5	.9928	.1201	4732	68	4664	4631	12.2	560	17	543	1.130	.1323	+ 9	
55	+ 2.8	- 7.0	+ 9.8	.9925	.1219	4732	68	4664	4629	12.3	566	17	549	1.120	.1327	+ 8	
56	+ 1.1	- 6.7	+ 7.8	.9932	.1167	4732	68	4664	4632	13.5	544	18	526	1.020	.1158	+ 5	
57	- .1	- 6.7	+ 6.6	.9932	.1167	4732	68	4664	4632	14.7	544	19	525	.938	.1062	+ 5	
58	- 1.9	- 6.7	+ 4.8	.9932	.1167	4732	68	4664	4632	16.6	541	19	522	.830	.0935	+ 4	
59	- 3.0	- 6.9	+ 3.9	.9928	.1201	4732	68	4664	4630	18.2	560	20	540	.757	.0882	+ 2	
61	-12.8	-11.7	- 1.1	.9792	.2028	4732	113	4619	4522	39.8	936	22	914	.338	.0683	- 1	
73	+ 5.4	- 7.7	+13.1	.9910	.1340	4728	89	4639	4595	9.9	621	15	606	1.381	.1820	+14	
75	+ 3.1	- 7.0	+10.1	.9925	.1219	4728	89	4639	4605	11.8	565	16	549	1.162	.1385	+10	
78	+ .5	- 6.7	+ 7.2	.9932	.1167	4728	89	4639	4605	13.6	542	17	525	1.007	.1149	+ 6	
79	- .1	- 6.6	+ 6.5	.9934	.1149	4728	130	4598	4565	14.6	530	18	512	.930	.1043	+ 6	
83	+ 5.4	- 7.4	+12.8	.9917	.1288	4749	74	4675	4630	10.4	602	16	586	1.325	.1675	+14	
86	+ 2.5	- 6.9	+ 9.4	.9928	.1201	4749	74	4675	4640	12.6	562	17	545	1.096	.1286	+ 9	
89	- 1.7	- 6.7	+ 5.0	.9932	.1167	4749	74	4675	4645	16.6	545	19	526	.832	.0942	+ 3	
103	+ 4.7	- 6.9	+11.6	.9928	.1201	4731	57	4674	4640	10.6	562	15	547	1.303	.1535	+12	
104	+ 4.1	- 6.9	+11.0	.9928	.1201	4731	57	4674	4640	10.9	562	15	547	1.267	.1494	+11	
106	+ 2.2	- 7.0	+ 9.2	.9925	.1219	4731	57	4674	4640	12.5	570	16	554	1.105	.1319	+ 7	
108	- 1.4	- 6.7	+ 5.3	.9932	.1167	4731	57	4674	4645	16.1	546	19	527	.857	.0976	+ 3	
109	- 5.0	- 7.5	+ 2.5	.9914	.1305	4731	85	4646	4605	21.5	606	20	586	.637	.0810	+ 2	
112	+ 5.5	- 7.7	+13.2	.9910	.1340	4739	68	4671	4630	9.8	626	15	611	1.420	.1875	+14	
113	+ 4.9	- 7.4	+12.3	.9917	.1288	4739	68	4671	4630	10.1	602	15	587	1.365	.1730	+12	
114	+ 4.0	- 7.0	+11.0	.9925	.1219	4739	68	4671	4635	11.2	569	16	553	1.232	.1470	+11	
116	+ 5.3	- 7.4	+12.7	.9917	.1288	4739	102	4637	4595	10.1	597	15	582	1.354	.1715	+14	
117	+ 4.7	- 7.3	+12.0	.9919	.1271	4739	102	4637	4595	10.6	589	15	574	1.290	.1612	+12	
118	+ 3.6	- 6.9	+10.5	.9928	.1201	4739	102	4337	4605	10.9	557	16	541	1.257	.1475	+10	
120	+ 2.4	- 6.9	+ 9.3	.9928	.1201	4739	139	4600	4565	12.2	552	16	536	1.113	.1307	+ 8	
122	-12.3	-11.4	- .9	.9803	.1977	4742	90	4652	4560	38.4	920	22	898	.353	.0696	- 3	
123	-15.6	-13.8	- 1.8	.9711	.2385	4742	90	4652	4520	47.7	1110	22	1088	.282	.0678	- 5	
124	-12.8	-11.6	- 1.2	.9796	.2011	4742	141	4601	4510	39.1	925	22	903	.343	.0687	- 3	
125	-16.3	-14.1	- 2.2	.9699	.2436	4742	141	4601	4460	48.0	1120	22	1098	.277	.0680	- 5	
126	-12.9	-11.7	- 1.2	.9792	.2028	4742	200	4542	4450	39.7	921	22	899	.334	.0673	- 3	
128	+ 5.5	- 7.5	+13.0	.9914	.1305	4739	69	4670	4630	10.4	609	15	594	1.330	.1699	+14	
129	+ 5.9	- 7.7	+13.6	.9910	.1340	4739	69	4670	4630	10.1	626	15	611	1.365	.1800	+15	
132	+ 5.3	- 7.3	+12.6	.9919	.1271	4739	69	4670	4630	10.5	594	15	579	1.312	.1642	+13	
135	+ 5.5	- 7.6	+13.1	.9912	.1323	4739	112	4627	4585	10.2	612	15	597	1.338	.1740	+14	
136	+ 5.9	- 7.6	+13.5	.9912	.1323	4739	112	4627	4585	9.9	612	15	597	1.378	.1795	+14	
139	+ 5.5	- 7.6	+13.1	.9912	.1323	4739	73	4666	4625	10.3	617	15	602	1.335	.1735	+14	
140	+ 3.9	- 7.1	+11.0	.9923	.1236	4739	73	4666	4630	11.0	577	16	561	1.253	.1518	+11	
141	+ 2.9	- 6.9	+ 9.8	.9928	.1201	4739	73	4666	4630	11.8	560	16	544	1.168	.1372	+ 9	
146	- 6.4	- 8.3	+ 1.9	.9895	.1444	4739	116	4623	4575	25.2	668	21	647	.541	.0764	0	
149	+ 5.1	- 7.4	+12.5	.9917	.1288	4737	82	4655	4615	10.5	599	15	584	1.308	.1655	+13	
150	+ 4.2	- 7.3	+11.5	.9919	.1271	4737	82	4655	4615	11.1	592	15	577	1.237	.1547	+11	
152	+ .6	- 6.7	+ 7.3	.9932	.1167	4737	134	4603	4570	13.6	537	17	520	1.000	.1138	+ 5	
153	- .1	- 6.6	+ 6.5	.9934	.1149	4737	134	4603	4570	15.1	529	18	511	.900	.1006	+ 4	
154	- 2.0	- 6.8	+ 4.8	.9930	.1184	4737	134	4603	4570	16.3	545	19	526	.834	.0960	+ 2	
155	- 3.1	- 6.9	+ 3.8	.9928	.1201	4737	134	4603	4570	18.2	553	19	534	.749	.0872	+ 2	
158	- 9.2	- 9.6	+ .4	.9858	.1668	4737	173	4564	4500	30.2	751	21	730	.445	.0718	- 1	
159	-15.9	-14.3	- 1.6	.9692	.2485	4737	205	4532	4395	48.2	1126	22	1104	.272	.0682	- 5	
187	+ 1.8	- 6.7	+ 8.5	.9932	.1167	4738	113	4625	4595	13.0	540	17	523	1.050	.1196	+ 7	
188	- 3.9	- 7.2	+ 3.3	.9921	.1253	4738	113	4625	4590	19.7	579	20	559	.693	.0844	+ 2	
189	- 7.6	- 8.7	+ 1.1	.9885	.1513	4738	113	4625	4575	27.5	700	21	679	.496	.0735	0	
190	+ 1.6	- 6.6	+ 8.2	.9934	.1149	4738	152	4586	4555	13.0	525	17	508	1.042	.1163	+ 6	
191	- 4.1	- 7.2	+ 3.1	.9921	.1253	4738	152	4586	4550	19.7	574	20	554	.687	.0837	+ 2	
192	- 7.7	- 8.8	+ 1.1	.9882	.1530	4738	152	4586	4535	27.5	702	21	681	.492	.0737	0	

(Continued on next page)

(Continuation of Table I)

F A I R C H I L D G L I D E T E S T S

(propeller locked)

Run No.	Attitude angle λ deg.	Gliding angle γ deg.	Angle of attack α deg.	Cos γ	Sin γ	Weight before flight lb.	Fuel used till run lb.	Weight during run W lb.	Lift L lb.	Dynamic press. q lb/sq.ft.	Apparent drag lb.	Drag of suspended instrument, d lb.	True drag D lb.	Lift coef. C_L	Drag coef. C_D	Elevator position δ_e deg. from stab.	Remarks
217	+ 5.1	- 7.9	+13.0	.9905	.1374	4746	105	4641	4600	10.1	638	15	623	1.355	.1835	+15	Large fin and rudder installed
218	+ 5.9	- 8.7	+14.6	.9885	.1513	4746	105	4641	4590	9.6	702	15	687	1.423	.2130	+18	
220	+ 4.8	- 7.3	+11.5	.9919	.1271	4746	167	4579	4540	10.3	582	15	567	1.310	.1638	+13	
222	+ 6.2	- 8.3	+14.5	.9889	.1444	4746	167	4579	4530	9.9	660	15	645	1.362	.1989	+18	
223	+ 6.2	- 8.8	+15.0	.9879	.1530	4746	167	4579	4520	9.0	692	14	678	1.495	.2242	+19	
227	- 5.0	- 7.7	+ 2.7	.9910	.1340	4746	99	4647	4605	21.3	622	20	602	.643	.0841	-	
228	- 1.6	- 6.9	+ 5.3	.9928	.1201	4746	99	4647	4610	16.6	558	19	539	.825	.0966	-	
229	+ 5.0	- 7.8	+12.8	.9907	.1357	4746	99	4647	4600	10.1	630	15	615	1.356	.1810	-	
231	+ 6.0	- 8.5	+14.5	.9890	.1478	4746	99	4647	4595	9.5	686	14	672	1.440	.2105	-	
232	+ 6.4	- 9.9	+16.3	.9851	.1719	4746	99	4647	4575	9.2	798	14	784	1.485	.2535	-	
233	+ 4.8	- 7.8	+12.6	.9907	.1357	4746	165	4581	4540	10.1	622	15	607	1.338	.1789	-	
235	+ 6.3	- 8.6	+14.9	.9888	.1495	4746	165	4581	4530	9.5	685	14	671	1.420	.2101	-	
236	+ 6.3	- 9.2	+15.5	.9871	.1599	4746	165	4581	4520	9.2	732	14	718	1.468	.2320	-	
237	+ 5.0	- 7.2	+12.2	.9921	.1253	4746	74	4672	4635	10.1	586	11	575	1.370	.1694	+12	
238	+ 6.9	-10.1	+17.0	.9845	.1754	4746	74	4672	4600	9.6	820	11	809	1.425	.2508	+23	
239	+ 7.0	-10.7	+17.7	.9826	.1851	4746	74	4672	4590	9.7	865	11	854	1.415	.2620	+25	
240	+ 6.4	- 7.7	+14.1	.9910	.1340	4746	74	4672	4630	9.4	626	11	615	1.472	.1945	+16	
241	+ 6.6	- 7.4	+14.0	.9917	.1288	4746	74	4672	4635	9.4	602	11	591	1.472	.1870	+15	
242	+ 6.0	- 7.3	+13.3	.9919	.1271	4746	109	4637	4600	9.4	589	11	578	1.462	.1830	+15	
243	+ 6.1	- 7.4	+13.5	.9917	.1288	4746	109	4637	4595	9.4	597	11	586	1.459	.1855	+15	
245	+ 7.3	- 8.6	+15.9	.9888	.1495	4746	109	4637	4585	9.1	693	11	682	1.505	.2230	+17	
246	+ 7.1	- 8.8	+15.9	.9882	.1530	4746	109	4637	4580	9.1	710	11	699	1.504	.2283	+17	
248	+ 5.3	- 7.0	+12.3	.9925	.1219	4750	88	4662	4630	10.1	568	11	577	1.365	.1641	+12	
249	+ 6.7	- 7.7	+14.4	.9910	.1340	4750	88	4662	4620	9.4	625	11	614	1.469	.1934	+16	
252	+ 6.9	-10.8	+17.7	.9823	.1874	4750	88	4662	4580	9.8	873	11	862	1.390	.2620	+21	
253	+ 6.2	- 7.5	+13.7	.9914	.1305	4750	131	4619	4575	9.4	602	11	591	1.448	.1871	+12	
255	+ 7.1	- 8.5	+15.6	.9890	.1478	4750	131	4619	4570	9.1	682	11	671	1.495	.2194	+17	
259	+ 7.1	-11.3	+18.4	.9806	.1959	4750	95	4655	4560	9.4	912	11	901	1.445	.2851	+25	
260	+ 7.1	-11.2	+18.3	.9810	.1942	4750	95	4655	4565	9.4	904	11	893	1.445	.2825	+25	
261	+ 7.2	-11.6	+18.8	.9796	.2011	4750	95	4655	4560	9.8	936	11	925	1.390	.2809	+25	
262	+ 7.3	-12.1	+19.4	.9778	.2096	4750	95	4655	4550	9.8	975	11	964	1.385	.2927	+25	
263	+ 7.2	-13.8	+21.0	.9711	.2385	4750	148	4602	4470	10.1	1098	11	1087	1.317	.3200	+22	Stabilizer full down
264	+ 7.1	-13.8	+20.9	.9711	.2385	4750	148	4602	4470	10.3	1097	11	1086	1.295	.3139	+23	" " "
266	+ 7.3	-13.2	+20.5	.9736	.2248	4750	148	4602	4480	10.1	1034	11	1023	1.320	.3030	+23	" " "
290	+ 4.6	- 6.8	+11.4	.9930	.1184	4748	89	4659	4630	10.4	552	11	541	1.330	.1548	+ 9	
293	- 2.5	- 6.7	+ 4.2	.9932	.1167	4748	89	4659	4630	18.5	544	15	529	.744	.0850	+ 1	
294	-12.6	-11.9	- .7	.9785	.2062	4748	89	4659	4560	40.4	961	17	944	.335	.0695	- 6	
296	-13.6	-12.3	- 1.3	.9770	.2130	4748	144	4604	4500	41.7	981	17	964	.320	.0688	- 5	
297	- 3.0	- 7.0	+ 4.0	.9925	.1219	4748	144	4604	4570	18.5	561	15	546	.734	.0878	0	
336	+ 3.6	- 6.7	+10.3	.9932	.1167	4727	137	4690	4654	10.9	548	15	533	1.270	.1455	+11	Large fin and rudder removed
337	+ 4.1	- 6.7	+10.8	.9932	.1167	4727	137	4690	4654	10.7	548	15	533	1.295	.1473	+13	
338	+ 4.0	- 6.6	+10.6	.9934	.1149	4727	137	4690	4654	10.9	540	15	525	1.270	.1433	+12	
339	- 1.4	- 6.4	+ 5.0	.9938	.1115	4727	137	4690	4660	16.0	523	17	506	.868	.0942	+ 4	
340	- 1.2	- 6.5	+ 5.3	.9936	.1132	4727	137	4690	4660	15.7	531	17	514	.884	.0974	+ 4	
341	- 1.6	- 6.4	+ 4.8	.9938	.1115	4727	137	4690	4660	16.0	523	17	506	.868	.0942	+ 4	
342	-11.7	-10.8	- .9	.9823	.1874	4727	218	4509	4430	36.5	846	20	826	.361	.0673	- 6	
343	-11.9	-10.9	- 1.0	.9820	.1891	4727	218	4509	4430	37.0	854	20	834	.356	.0670	- 6	
344	-11.8	-11.0	- .8	.9816	.1908	4727	218	4509	4425	36.7	861	20	841	.359	.0682	- 6	
345	+ 4.3	- 7.0	+11.3	.9925	.1219	4750	96	4654	4620	10.6	566	15	551	1.295	.1547	-	
346	+ 4.6	- 6.9	+11.5	.9928	.1201	4750	96	4654	4625	10.6	559	15	544	1.298	.1527	-	
347	+ 4.6	- 6.8	+11.4	.9930	.1184	4750	96	4654	4625	10.6	551	15	536	1.298	.1506	-	
348	- 1.5	- 6.2	+ 4.7	.9942	.1080	4750	96	4654	4625	16.6	502	17	485	.828	.0866	-	
349	- 1.3	- 6.2	+ 4.9	.9942	.1080	4750	96	4654	4630	15.6	502	17	485	.882	.0925	-	
350	- 1.4	- 6.3	+ 4.9	.9940	.1097	4750	96	4654	4630	15.9	510	17	493	.864	.0922	-	
351	-11.7	-10.4	- 1.3	.9836	.1805	4750	96	4654	4575	37.3	840	20	820	.365	.0654	-	
352	-11.0	-10.4	- .6	.9836	.1805	4750	96	4654	4575	35.5	840	20	820	.384	.0687	-	
353	-11.6	-10.6	- 1.0	.9829	.1840	4750	141	4609	4540	36.8	849	20	829	.367	.0670	-	
354	-11.8	-10.8	- 1.0	.9823	.1874	4750	141	4609	4530	37.3	865	20	845	.361	.0675	-	
355	-11.7	-10.7	- 1.0	.9826	.1857	4750	141	4609	4540	37.3	855	20	835	.362	.0666	-	
356	+ 4.5	- 6.9	+11.4	.9928	.1201	4750	87	4663	4630	10.6	560	15	545	1.300	.1530	-	
357	+ 4.6	- 6.9	+11.5	.9928	.1201	4750	87	4663	4630	10.6	560	15	545	1.300	.1530	-	
358	+ 4.6	- 6.9	+11.5	.9928	.1201	4750	87	4663	4630	10.6	560	15	545	1.300	.1530	-	
359	- 1.3	- 6.2	+ 4.9	.9942	.1080	4750	87	4663	4640	15.6	504	17	487	.884	.0928	-	
360	- 1.2	- 6.2	+ 5.0	.9942	.1080	4750	87	4663	4640	15.6	504	17	487	.884	.0928	-	
361	- 1.3	- 6.3	+ 5.0	.9940	.1097	4750	87	4663	4635	15.6	511	17	494	.884	.0941	-	
362	-11.8	-10.4	- 1.4	.9836	.1805	4750	135	4615	4540	36.4	832	20	812	.371	.0664	-	
363	-11.8	-10.8	- 1.0	.9823	.1874	4750	135	4615	4535	37.1	864	20	844	.364	.0677	-	
364	-11.9	-10.8	- 1.1	.9823	.1874	4750	135	4615	4535	37.1	864	20	844	.364	.0677	-	
365	-12.0	-10.8	- 1.2	.9823	.1874	4750	135	4615	4535	37.6	864	20	844	.359	.0668	-	
376	- 1.1	- 6.4	+ 5.3	.9938	.1115	4725	63	4662	4630	15.4	520	17	503	.894	.0972	-	
378	- 1.3	- 6.5	+ 5.2	.9936	.1132	4725	63	4662	4630	15.6	528	17	511	.883	.0975	-	
251a	+ 7.2	- 7.7	+14.9	.9910	.1340	4750	88	4662	4620	9.1	625	11	614	1.518	.2010	+17	
251b	+ 7.2	- 8.3	+15.5	.9895	.1444	4750	88	4662	4610	9.1	673	11	662	1.515	.2163	+20	
251c	+ 6.9	-10.8	+17.7	.9823	.1874	4750	88	4662	4580	9.8	874	11	863	1.391	.2620	+22	

TABLE II

FAIRCHILD GLIDE TESTS

(propeller operating at zero thrust)

Run No.	Attitude angle λ (deg.)	Gliding angle γ (deg.)	Angle of attack α (deg.)	Cos γ	Sin γ	Weight before flight (lb.)	Fuel used till run (lb.)	Weight during run W (lb.)	Lift L (lb.)	Apparent drag (lb.)	Dynamic press. q (lb/sq.ft)	Drag of suspended instrument, d (lb.)
309	+ 4.3	-6.1	+ 10.4	.9943	.1063	4733	98	4641	4615	493	10.9	15
310	+ 4.3	-6.1	+ 10.4	.9943	.1063	4733	113	4620	4595	491	10.7	15
311	+ 4.2	-6.1	+ 10.3	.9943	.1063	4733	113	4620	4595	491	10.7	15
312	- .8	-5.5	+ 4.7	.9954	.0958	4733	142	4591	4570	440	15.8	17
313	- .8	-5.4	+ 4.6	.9956	.0941	4733	158	4575	4555	431	15.8	17
314	- .8	-5.5	+ 4.7	.9954	.0958	4733	158	4575	4555	438	15.7	17
315	-10.2	-9.5	- .7	.9863	.1650	4733	189	4544	4485	750	37.8	20
316	- 9.6	-9.1	- .5	.9874	.1582	4733	208	4525	4465	716	37.7	20
317	-10.0	-9.3	- .7	.9869	.1616	4733	234	4499	4440	727	37.3	20
318	+ 4.4	-6.2	+ 10.6	.9942	.1080	4733	97	4636	4610	501	10.7	15
319	+ 4.2	-6.2	+ 10.4	.9942	.1080	4733	120	4613	4590	498	10.7	15
320	+ 4.1	-6.1	+ 10.2	.9943	.1063	4733	120	4613	4590	490	10.8	15
321	- 1.2	-5.5	+ 4.3	.9954	.0958	4733	143	4590	4570	440	16.0	17
322	- .9	-5.5	+ 4.6	.9954	.0958	4733	170	4563	4540	437	15.8	17
323	- .9	-5.5	+ 4.6	.9954	.0958	4733	170	4563	4540	437	15.7	17
324	-10.1	-9.1	- 1.0	.9874	.1582	4733	205	4528	4470	716	37.2	20
325	-10.3	-9.2	- 1.1	.9871	.1599	4733	228	4505	4445	720	38.0	20
326	- 9.9	-9.0	- .9	.9877	.1564	4733	228	4505	4450	704	37.7	20
328	+ 4.3	-6.0	+ 10.3	.9945	.1045	4733	112	4621	4595	483	10.9	15
329	+ 4.2	-6.0	+ 10.2	.9945	.1045	4733	112	4621	4595	483	10.9	15
330	+ 4.6	-5.9	+ 10.5	.9947	.1028	4733	143	4590	4565	472	10.7	15
331	- .8	-5.6	+ 4.8	.9952	.0976	4733	143	4590	4570	448	15.8	17
333	- .8	-5.4	+ 4.6	.9956	.0941	4733	168	4565	4545	430	15.8	17
334	- 9.8	-8.8	- 1.0	.9882	.1530	4733	198	4535	4480	694	37.2	20
335	- 9.8	-8.9	- .9	.9880	.1547	4733	198	4535	4480	702	36.9	20
379	- 1.1	-5.7	+ 4.6	.9951	.0993	4725	111	4614	4590	458	15.6	17
380	- .9	-5.7	+ 4.8	.9951	.0993	4725	111	4614	4590	458	15.6	17
381	- .9	-5.7	+ 4.8	.9951	.0993	4725	111	4614	4590	458	15.6	17
382	+ 4.3	-6.1	+ 10.4	.9943	.1063	4725	114	4611	4585	490	10.6	14
383	+ 4.5	-6.1	+ 10.6	.9943	.1063	4725	114	4611	4585	490	10.6	14
384	+ 4.3	-6.2	+ 10.5	.9942	.1080	4725	114	4611	4585	498	10.6	14
385	+ 4.3	-6.1	+ 10.4	.9943	.1063	4725	114	4611	4585	490	10.6	14

Run No.	Barometric press. (in.Hg.)	Air temperature (deg.F)	Specific weight of air (lb./cu.ft.)	True velocity V (ft./sec.)	Propeller speed n (rev./sec.)	Pitch diameter ratio (V/nD)	Thrust coefficient C_T	Thrust T (lb.)	True drag D (lb.)	Lift coefficient C_L	Drag coefficient C_D
309	21.5	59	.0550	113	11.6	1.030	+.0020	+ 4	482	1.260	.1316
310	21.5	59	.0550	112	11.3	1.050	-.0010	- 2	474	1.278	.1318
311	21.6	62	.0550	112	11.2	1.060	-.0025	- 4	472	1.278	.1313
312	21.5	61	.0548	136	14.0	1.030	+.0020	+ 5	428	.860	.0806
313	21.5	60	.0549	136	13.9	1.035	+.0010	+ 3	417	.858	.0785
314	22.2	64	.0563	134	13.8	1.025	+.0025	+ 7	428	.863	.0811
315	22.1	57	.0568	207	21.0	1.045	-.0005	- 3	727	.353	.0572
316	23.0	62	.0586	203	21.3	1.010	+.0050	+ 31	727	.352	.0574
317	23.0	64	.0584	202	20.8	1.025	+.0025	+ 16	723	.354	.0577
318	21.4	60	.0547	112	11.5	1.030	+.0020	+ 4	490	1.281	.1363
319	21.3	59	.0545	112	11.3	1.050	-.0010	- 2	481	1.276	.1338
320	21.7	61	.0553	112	11.2	1.060	-.0025	- 5	470	1.265	.1295
321	21.1	60	.0539	138	14.3	1.020	+.0035	+ 10	433	.850	.0805
322	21.0	60	.0536	137	14.2	1.020	+.0035	+ 10	430	.855	.0810
323	22.1	64	.0561	134	13.8	1.030	+.0020	+ 6	426	.860	.0808
324	21.5	60	.0549	209	21.3	1.040	.0000	0	696	.358	.0556
325	21.7	59	.0555	209	21.7	1.020	+.0035	+ 22	722	.348	.0566
326	22.7	64	.0576	203	21.5	1.000	+.0060	+ 38	722	.351	.0570
328	21.4	59	.0548	114	11.8	1.020	+.0035	+ 7	475	1.255	.1296
329	21.8	60	.0557	112	11.6	1.020	+.0035	+ 5	473	1.255	.1292
330	21.2	58	.0543	113	12.0	.995	+.0065	+ 12	469	1.270	.1304
331	21.9	62	.0558	135	14.0	1.020	+.0035	+ 9	440	.861	.0827
333	21.9	64	.0555	135	13.7	1.045	-.0005	- 1	412	.856	.0776
334	21.5	62	.0547	208	21.7	1.015	+.0040	+ 25	699	.358	.0559
335	22.5	65	.0570	204	21.4	1.010	+.0050	+ 32	714	.361	.0576
379	22.7	36	.0608	128	13.0	1.040	.0000	0	441	.876	.0841
380	23.1	37	.0618	127	13.0	1.035	+.0010	+ 3	444	.876	.0846
381	23.5	38	.0636	126	13.0	1.025	+.0025	+ 7	448	.876	.0854
382	24.9	41	.0660	102	10.4	1.040	.0000	0	476	1.288	.1335
383	25.3	42	.0670	101	10.4	1.025	+.0025	+ 4	480	1.288	.1346
384	25.7	44	.0678	101	10.4	1.025	+.0025	+ 4	488	1.288	.1370
385	26.1	47	.0684	100	10.4	1.020	+.0035	+ 6	482	1.288	.1352

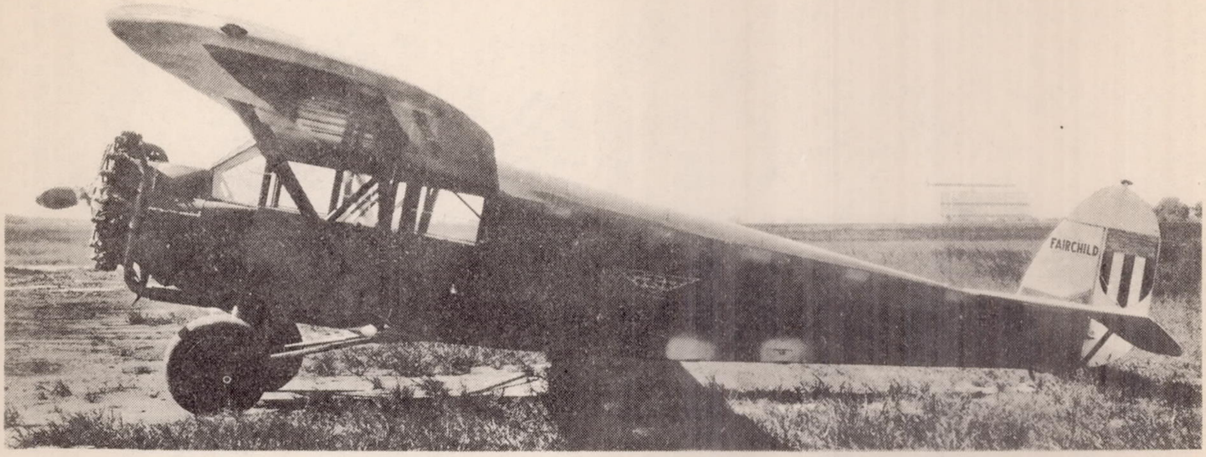

Fig.1 Side view of the Fairchild cabin airplane, FC-2W2.

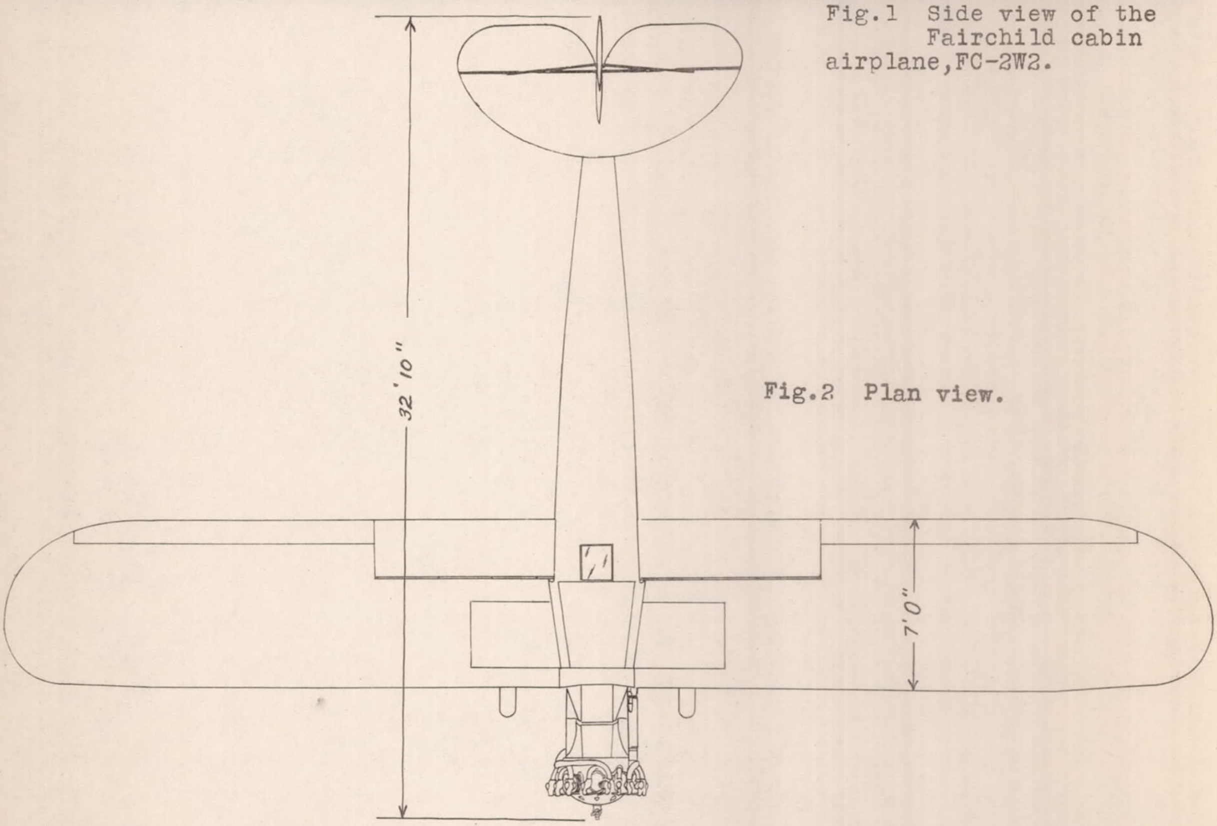

Fig.2 Plan view.

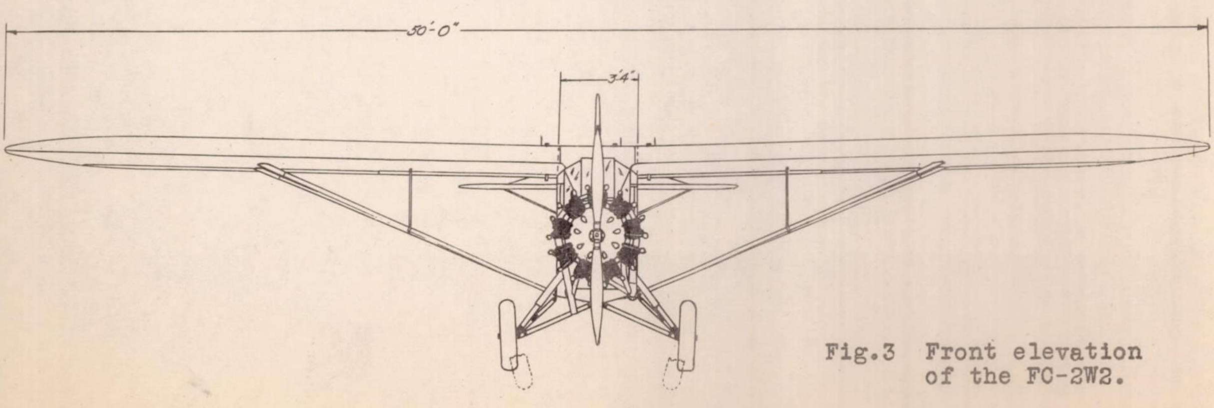

Fig.3 Front elevation of the FC-2W2.

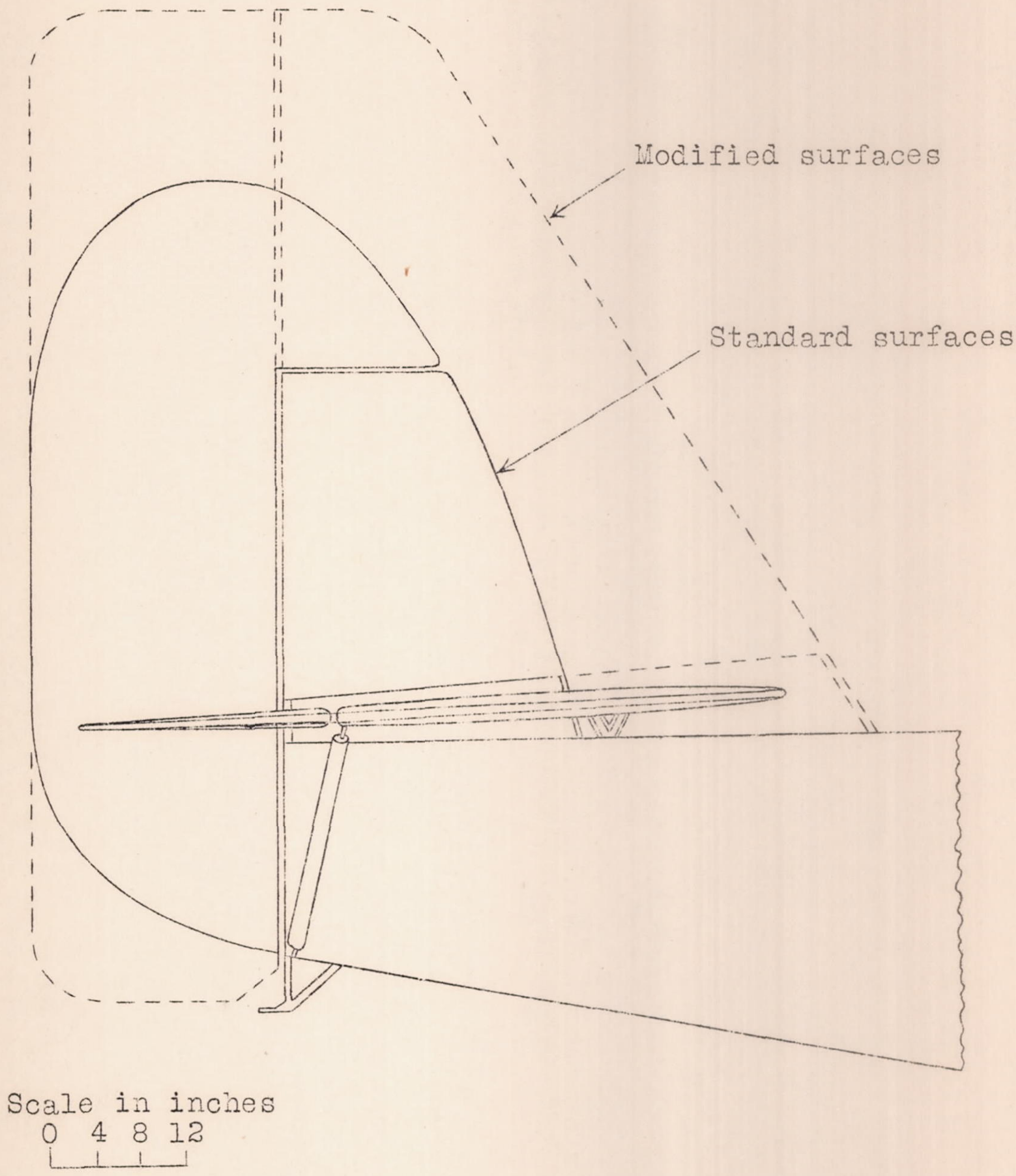

Fig.4 Vertical tail surfaces used on Fairchild (FC-2W2) airplane.

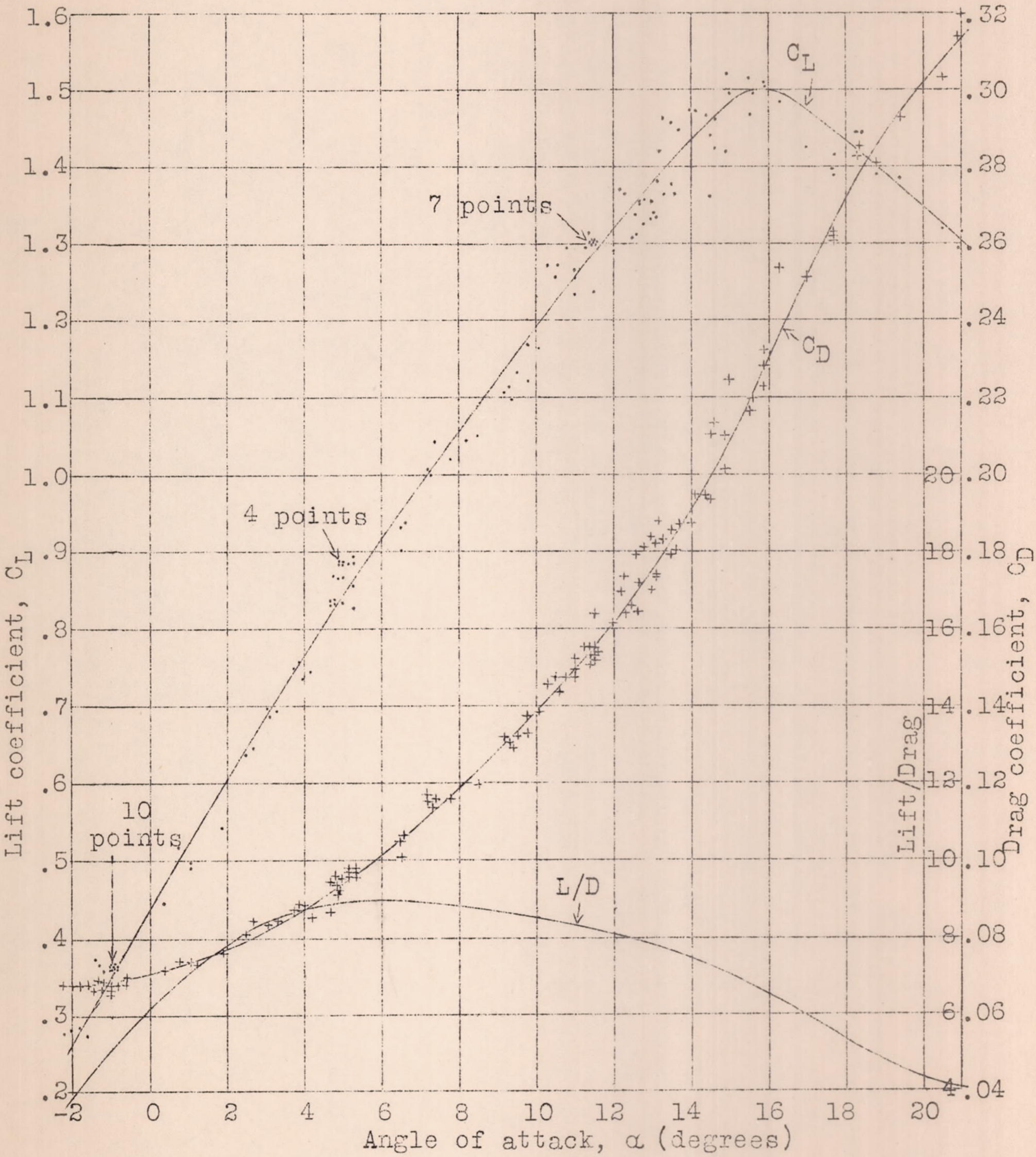

Fig.5 Lift and drag characteristics of Fairchild (FC-2W2) airplane with propeller locked.

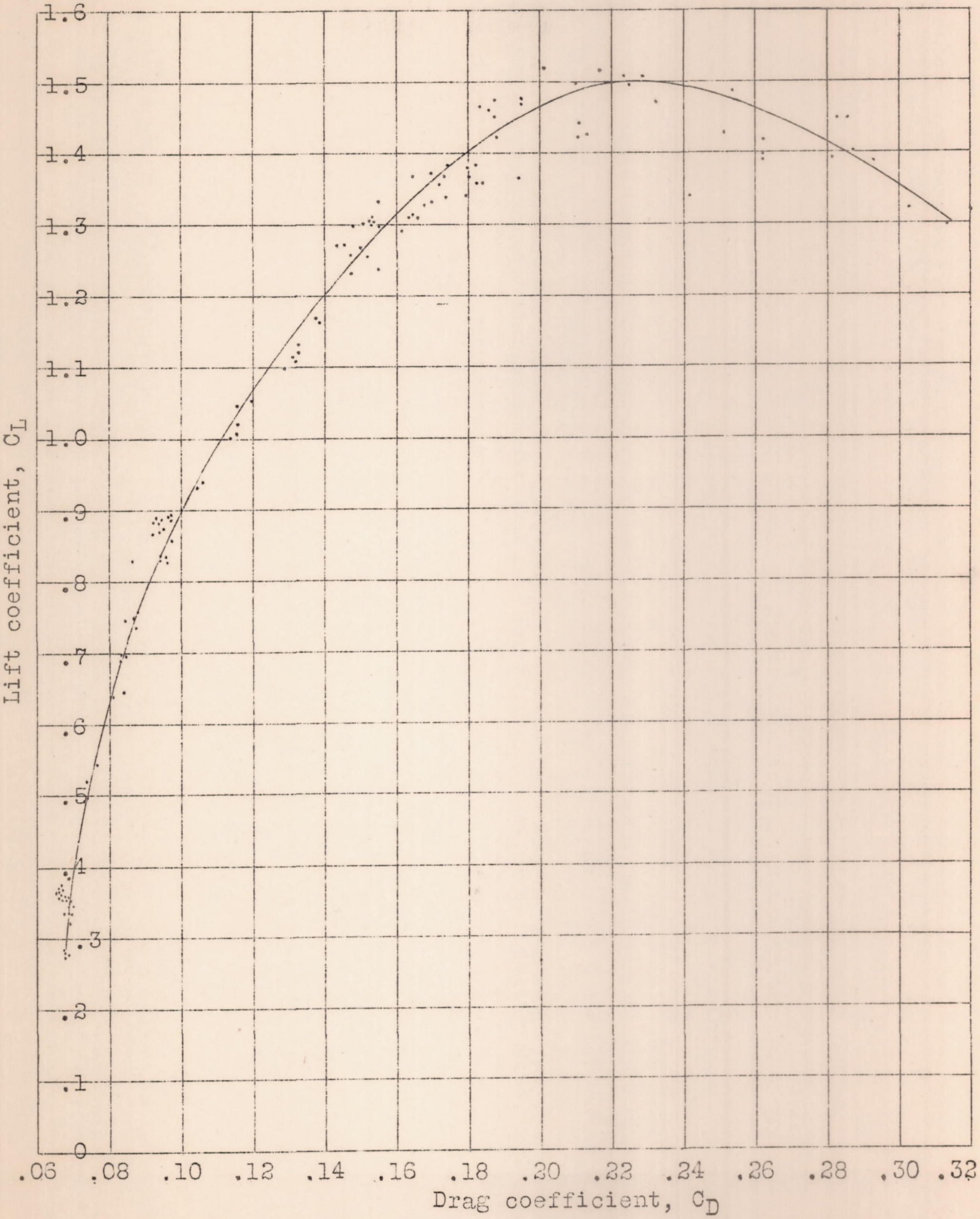

Fig.6 Polar diagram of Fairchild (FC-2W2) airplane with propeller locked.

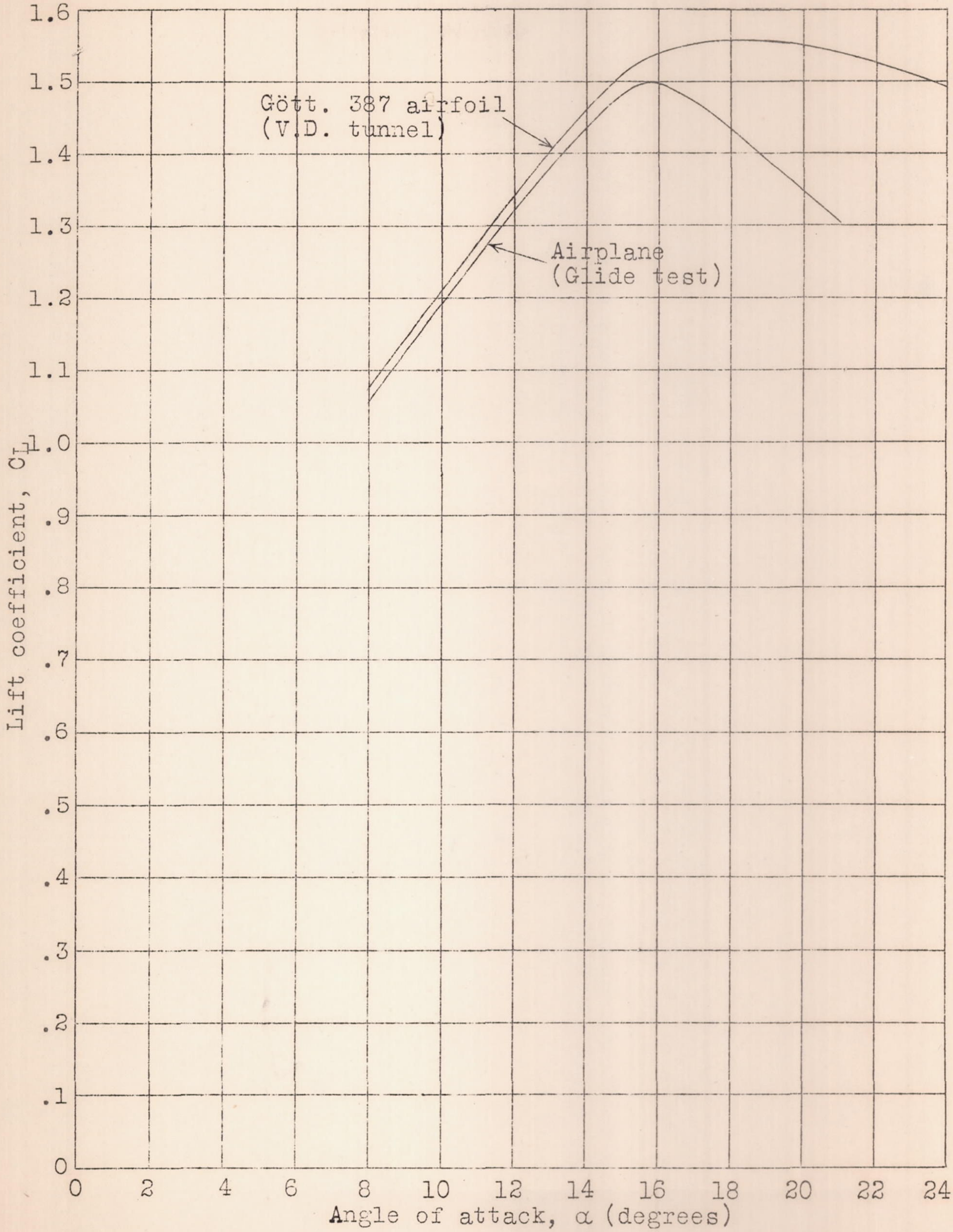

Fig.7 Comparison between lift coefficients for the Fairchild airplane and Göttingen 387 airfoil.

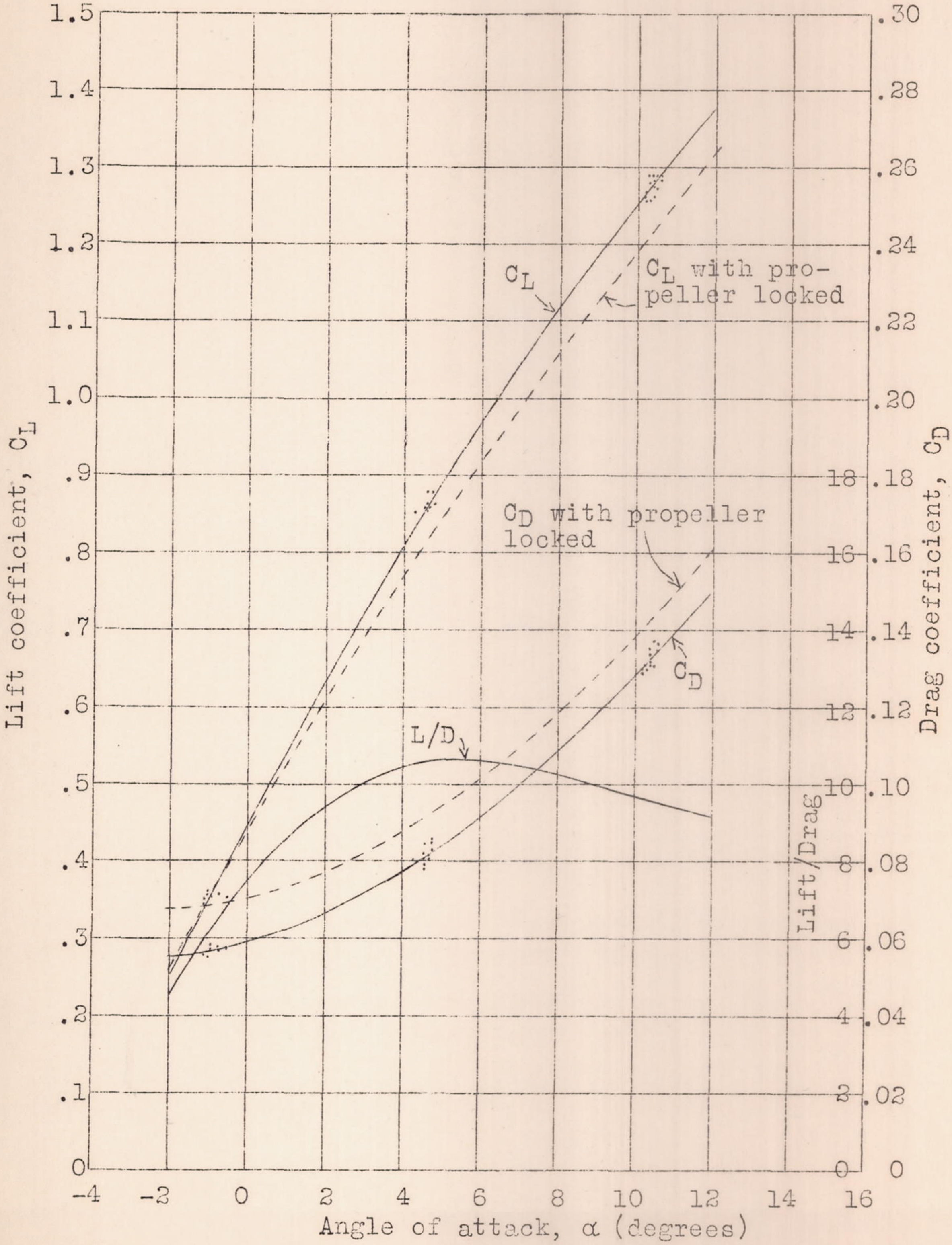

Fig.8 Lift and drag characteristics of Fairchild (FC-2W2) airplane with propeller operating at zero thrust.

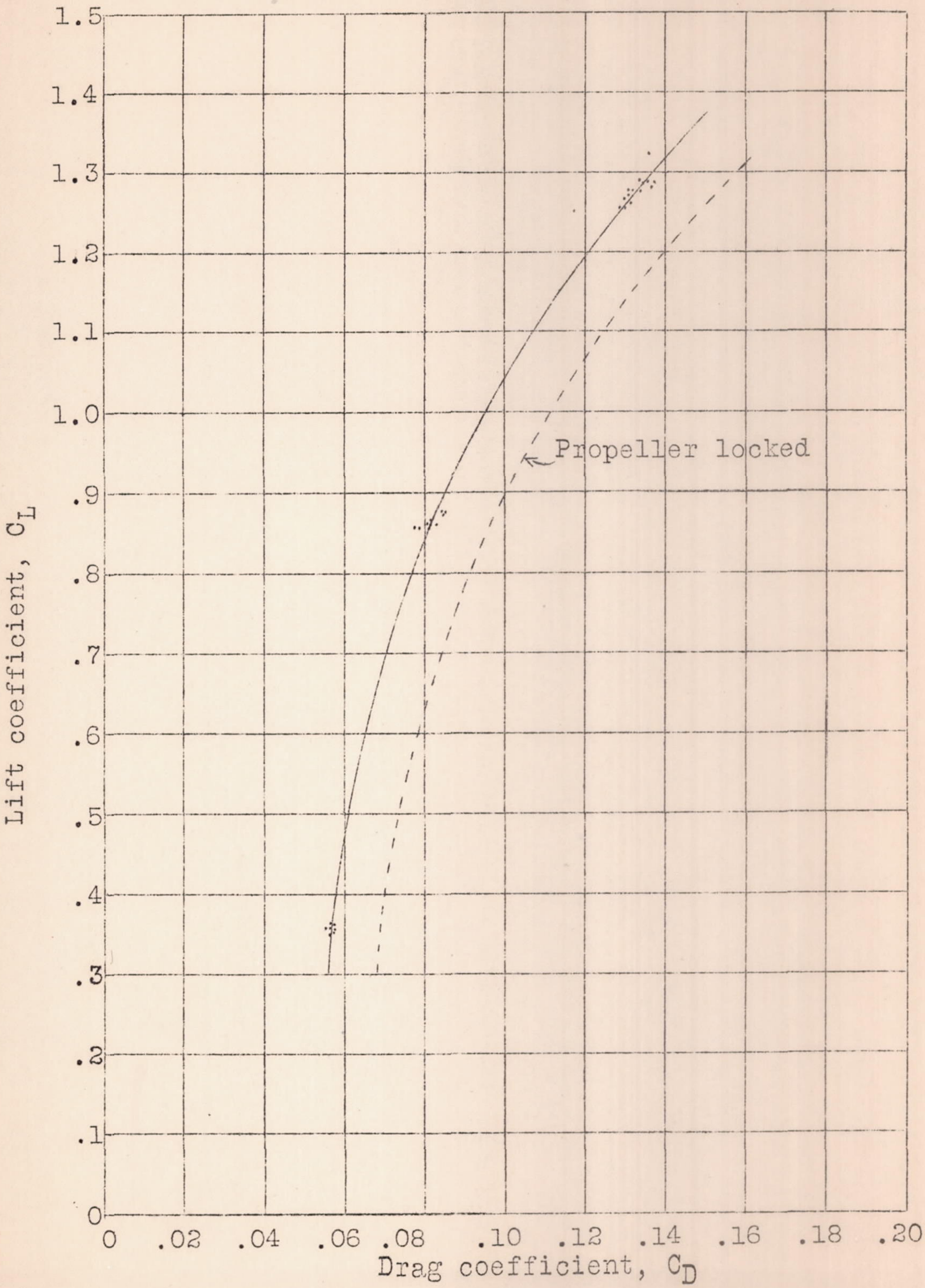

Fig.9 Polar diagram of Fairchild (FC-2W2) airplane with propeller operating at zero thrust.