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No. 437

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By Richard V. Rhode

SUMMARY

This note presents the results of flight pressure-distribution tests on the right upper wing panel of a Douglas M-3 airplane equipped with an elliptical tip of length equal to the wing chord.

The results are given in such form that the load distribution for any normal-force coefficient within the usual range encountered in flight may easily be determined.

INTRODUCTION

This note presents the results obtained in pressure-distribution tests in flight on an elliptical wing tip whose length equals the wing chord. This tip is the eighth and last of a series under investigation. Results of the previous seven tips have been reported as follows: the "Douglas" tip in reference 1; the square tip, both with and without faired end, in reference 2; the semicircular tip in reference 3; a modified elliptical tip in reference 4; a standard Navy elliptical tip in reference 5; and a modified Navy elliptical tip also in reference 5.

As in previous tests, a rounded tip of the Douglas form was used on the right lower panel below the tip under investigation, which procedure did not, as shown by previous tests (reference 2), introduce any effect in the results.

The tests were made at Langley Field, Va., by the National Advisory Committee for Aeronautics, late in 1931.

METHODS AND APPARATUS

The M-3 airplane that was used in these tests is a normal biplane having, however, an aspect ratio somewhat higher than usual. The characteristics of this airplane are given in Table I. The shape of the wing tip is shown in Figure 1, and the ordinates of the rib profiles in Table II. The Clark Y section was maintained as closely as practicable throughout the span.

The wings were rigged with a slight washin, sufficient approximately to cancel the torsional deflection at the low angles of attack. At the higher angles of attack, this rigged washin was not canceled by the negligible torsional deflection, so that a slight twist in the wing was present. However, this twist has no noticeable effect at high angles of attack, and the results may therefore be considered to represent conditions for no twist throughout the angle-of-attack range investigated.

A portion of the tests was made with the tip covered with fabric. The tip was later covered with plywood to provide a more nearly perfect shape, because the true profile could not be maintained near the tip between ribs by the use of fabric.

In other respects the same procedure was used in these tests as was used in the previous tests. (References 1, 2, 3, 4, and 5.)

All measurements were made in unyawed conditions of flight.

PRECISION

As mentioned in references 1 and 2, the accuracy of these tests was maintained at a relatively high level, largely because of the installation of all instruments in an insulated compartment, which was kept at a constant temperature. The discussion of precision given in reference 1 applies to all measurements given, as no changes were made in apparatus, methods, or procedure.

RESULTS

The results of the tests made with plywood covering showed slight differences from the results obtained with the fabric covering. These differences, however, were within the experimental error except, possibly, for rib F for which a somewhat greater difference was apparent near zero lift. It is not believed that the slight differences observed are in any case good evidence of true variations in the results as caused by the type of covering. For this reason, the results for both types of covering have been averaged and are thus presented in Figures 2 and 3, and in Tables III and IV.

The coefficients referred to in the results are defined as follows:

$$\text{Wing} \quad C_N = \frac{\text{wing normal force}}{q \times \text{wing area}}$$

$$\text{Rib} \quad C_N = \frac{\text{rib normal force (per unit span)}}{q \times \text{rib chord}}$$

$$\text{Rib} \quad C_m = \frac{\text{moment of rib normal force about L.E.}}{q \times (\text{rib chord})^2}$$

The curves of Figures 2 and 3 were established by a large number of points as in Figures 6 and 7 of reference 1, but the points have been omitted to avoid confusion. Curves for the root section were obtained by extrapolating span C_N and span C_m curves from considerable data. Owing to the extrapolation, the curves do not represent the true conditions near the fuselage and in the slipstream, but represent more nearly the ideal conditions in which there is no effect from fuselage and propeller.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., November 18, 1932.

REFERENCES

1. Rhode, Richard V., and Lundquist, Eugene E.: The Pressure Distribution over a Douglas Wing Tip on a Biplane in Flight. T.N. No. 347, N.A.C.A., 1930.

2. Rhode, Richard V., and Lundquist, Eugene E.: The Pressure Distribution over a Square Wing Tip on a Biplane in Flight. T.N. No. 360, N.A.C.A., 1931.

3. Rhode, Richard V., and Lundquist, Eugene E.: The Pressure Distribution over a Semicircular Wing Tip on a Biplane in Flight. T.N. No. 379, N.A.C.A., 1931.

4. Rhode, Richard V., and Lundquist, Eugene E.: The Pressure Distribution over a Modified Elliptical Wing Tip on a Biplane in Flight. T.N. No. 387, N.A.C.A., 1931.

5. Rhode, Richard V.: The Pressure Distribution over a Standard and a Modified Navy Elliptical Wing Tip on a Biplane in Flight. T.N. No. 433, N.A.C.A., 1932.

TABLE I

CHARACTERISTICS OF DOUGLAS M-3 AIRPLANE

Type	Biplane
Airfoil	Clark Y
Span (upper and lower)	45 ft. 10 in.
Chord (upper and lower)	5 ft. 8 in.
Gap	6 ft. 0 in.
Stagger	None
c.g. in per cent of chord	29

Areas (sq.ft.)	Original	Long elliptical*
Right upper wing, including aileron	126.4	123
Right lower wing, including aileron	126.4	126.4
Total wing area	505.6	502.2
Horizontal tail surfaces	58	
Vertical tail surfaces	17.7	
Weight during tests	4,840 lb.	
Engine	Liberty	
Rated hp at 1,750 r.p.m.	420	
Power loading	11.52 lb./hp	
Wing loading	9.57 lb./sq.ft.	

*Left wing panels remained unchanged.

TABLE II

COMPARISON OF SPECIFIED AND MEASURED ORDINATES OF PRESSURE RIBS
(Long Elliptical Tip)

Station in % chord	Clark Y		Rib X		Rib A		Rib B		Rib C		Rib D		Rib E		Rib F	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
.00	3.50	3.50	3.40	3.40	3.49	3.49	3.36	3.36	3.44	3.44	3.58	3.58	3.65	3.65	3.52	3.52
1.25	5.45	1.93	5.47	1.84	5.56	1.93	5.34	1.79	5.47	1.85	5.67	1.87	5.30	2.01	5.69	1.83
2.50	6.50	1.466	6.53	1.29	6.52	1.47	6.38	1.33	6.43	1.42	6.49	1.41	6.28	1.51	6.48	1.31
5.00	7.90	.933	7.90	.87	8.00	.97	7.90	.83	7.80	.92	7.78	.93	7.72	.95	7.79	1.00
7.50	8.85	.629	8.82	.51	9.05	.65	8.91	.28	8.74	.64	8.77	.65	8.70	.53	8.76	.69
10.00	9.60	.42	9.65	.41	9.74	.46	9.65	.32	9.54	.44	9.51	.43	9.46	.32	9.48	.48
15.00	10.685	.15	10.61	.18	10.76	.28	10.67	.14	10.60	.15	10.50	.17	10.48	.15	10.62	.21
20.00	11.36	.033	11.21	.05	11.26	.09	11.26	.05	11.29	.02	11.17	.00	11.16	.06	11.24	.10
30.00	11.70	.00	11.67	.00	11.73	.00	11.81	.00	11.58	.00	11.53	.00	11.73	.00	11.58	.00
40.00	11.40	.00	11.30	.00	11.36	.00	11.40	.05	11.23	.02	11.27	.00	11.28	.00	11.27	.00
50.00	10.515	.00	10.48	.00	10.48	.00	10.58	.03	10.35	.05	10.45	.05	10.37	.00	10.34	.00
60.00	9.148	.00	9.19	.00	9.19	-.05	9.42	.09	9.07	.05	9.06	.05	9.01	.02	9.00	.00
70.00	7.35	.00	7.35	.09	7.36	.00	7.68	.09	7.31	.06	7.26	.05	7.06	.00	7.28	.00
80.00	5.216	.00	5.38	.00	5.33	.00	5.65	.18	5.12	.06	5.19	.09	4.92	.00	5.17	.03
90.00	2.802	.00	2.90	.00	2.80	-.05	3.31	.23	2.72	.00	2.79	.12	2.50	.00	2.55	.00
95.00	1.494	.00	1.65	.00	1.52	-.09	2.02	.14	1.45	.00	1.54	.12	1.23	.00	1.38	.00
100.00	.12	.00	.37	.00	.23	-.23	.74	.00	.15	.00	.26	.07	.15	-.04	.14	.00

Note: All ordinates given are in per cent of chord.

TABLE III

COORDINATES OF CURVES OF FIGURE 2

Wing C_N	Rib C_N							
	Root	X	A	B	C	D	E	F
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
.1	.120	.115	.100	.083	.083	.081	.076	.050
.2	.239	.228	.200	.166	.168	.162	.154	.104
.3	.358	.340	.300	.248	.251	.243	.233	.165
.4	.476	.452	.400	.330	.335	.325	.315	.230
.5	.595	.566	.500	.412	.420	.405	.396	.308
.6	.713	.679	.600	.495	.503	.487	.478	.392
.7	.833	.794	.700	.578	.588	.569	.560	.484
.8	.951	.908	.800	.661	.672	.651	.645	.581
.9	1.070	1.020	.900	.744	.756	.731	.729	.684
1.0	1.187	1.134	1.000	.827	.842	.813	.815	.796
1.1	1.306	1.247	1.100	.910	.926	.896	.902	.911
1.2	1.421	1.360	1.200	.994	1.010	.980	.995	1.035
1.3	1.532	1.472	1.300	1.076	1.094	1.065	0.092	1.164
1.4	1.640	1.583	1.400	1.158	1.178	1.155	1.195	1.300
1.5	1.740	1.690	1.500	1.240	1.261	1.250	1.305	1.440
1.6	1.836	1.795	1.600	1.321	1.345	1.351	1.425	1.582

TABLE IV

COORDINATES OF CURVES OF FIGURE 3

Rib C_N	Rib C_m							
	Root	X	A	B	C	D	E	F
0	-0.071	-0.068	-0.074	-0.073	-0.068	-0.068	-0.057	-0.048
.1	-.094	-.090	-.096	-.092	-.089	-.087	-.077	-.068
.2	-.118	-.113	-.118	-.112	-.110	-.106	-.098	-.091
.3	-.142	-.137	-.141	-.132	-.131	-.125	-.120	-.117
.4	-.165	-.160	-.164	-.153	-.154	-.147	-.144	-.147
.5	-.188	-.184	-.187	-.174	-.176	-.171	-.169	-.179
.6	-.212	-.208	-.209	-.196	-.199	-.194	-.195	-.213
.7	-.236	-.232	-.232	-.217	-.222	-.219	-.222	-.249
.8	-.259	-.256	-.254	-.238	-.246	-.244	-.250	-.286
.9	-.283	-.279	-.277	-.260	-.270	-.268	-.279	-.324
1.0	-.306	-.302	-.299	-.281	-.293	-.293	-.308	-.363
1.1	-.329	-.326	-.321	-.302	-.315	-.318	-.337	-.403
1.2	-.353	-.349	-.343	-.323	-.337	-.344	-.367	-.444
1.3	-.376	-.372	-.363	-.344	-.357	-.369	-.398	-.485
1.4	-.400	-.395	-.384	-	-	-.394	-.428	-.526
1.5	-.424	-.418	-.404	-	-	-	-	-.568
1.6	-.447	-.441	-.423	-	-	-	-	-.610
1.7	-.471	-.463	-	-	-	-	-	-
1.8	-.494	-.485	-	-	-	-	-	-

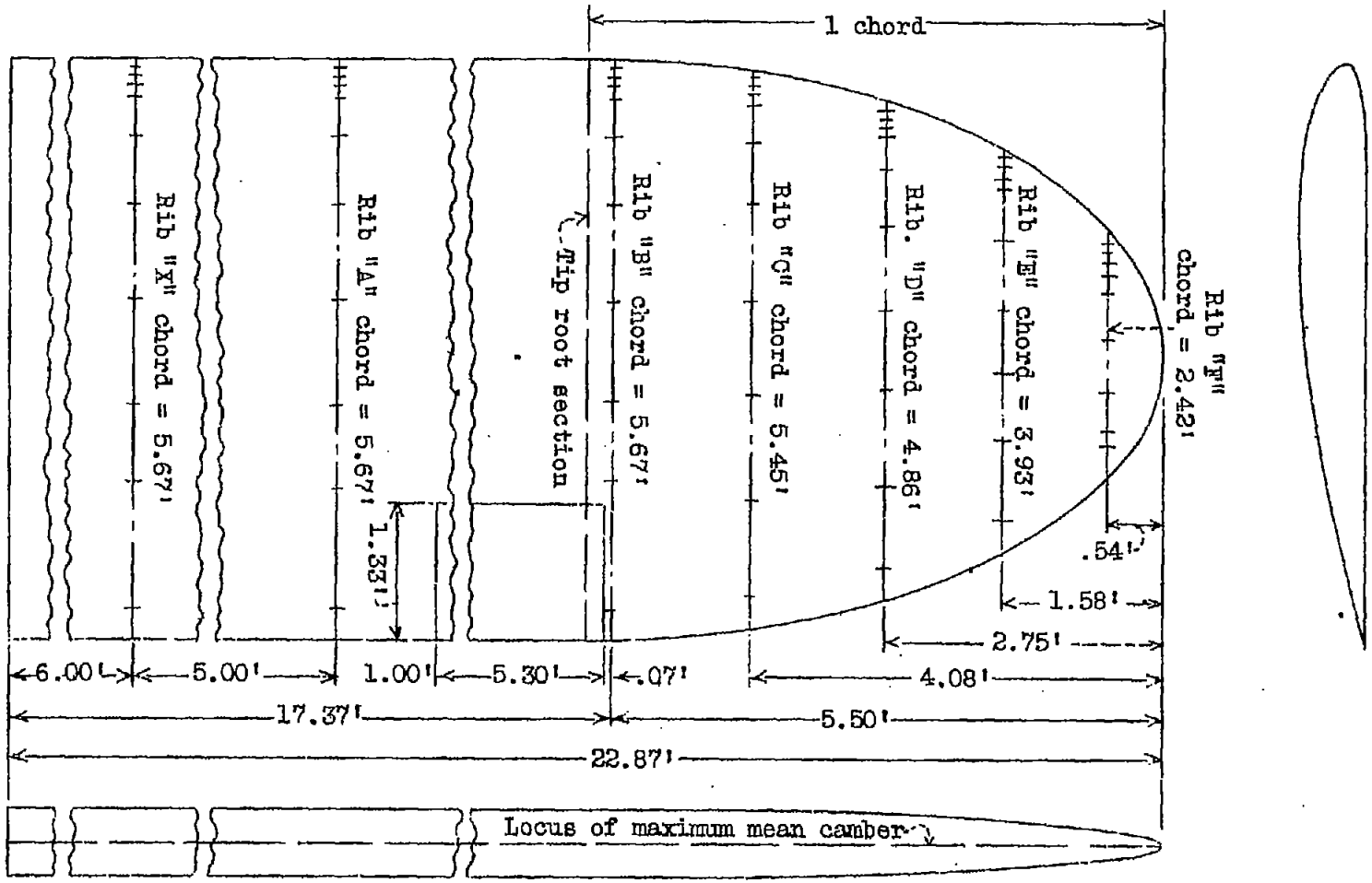

Fig.1 M-3 wing with pressure ribs and orifice locations.(Long elliptical tip)

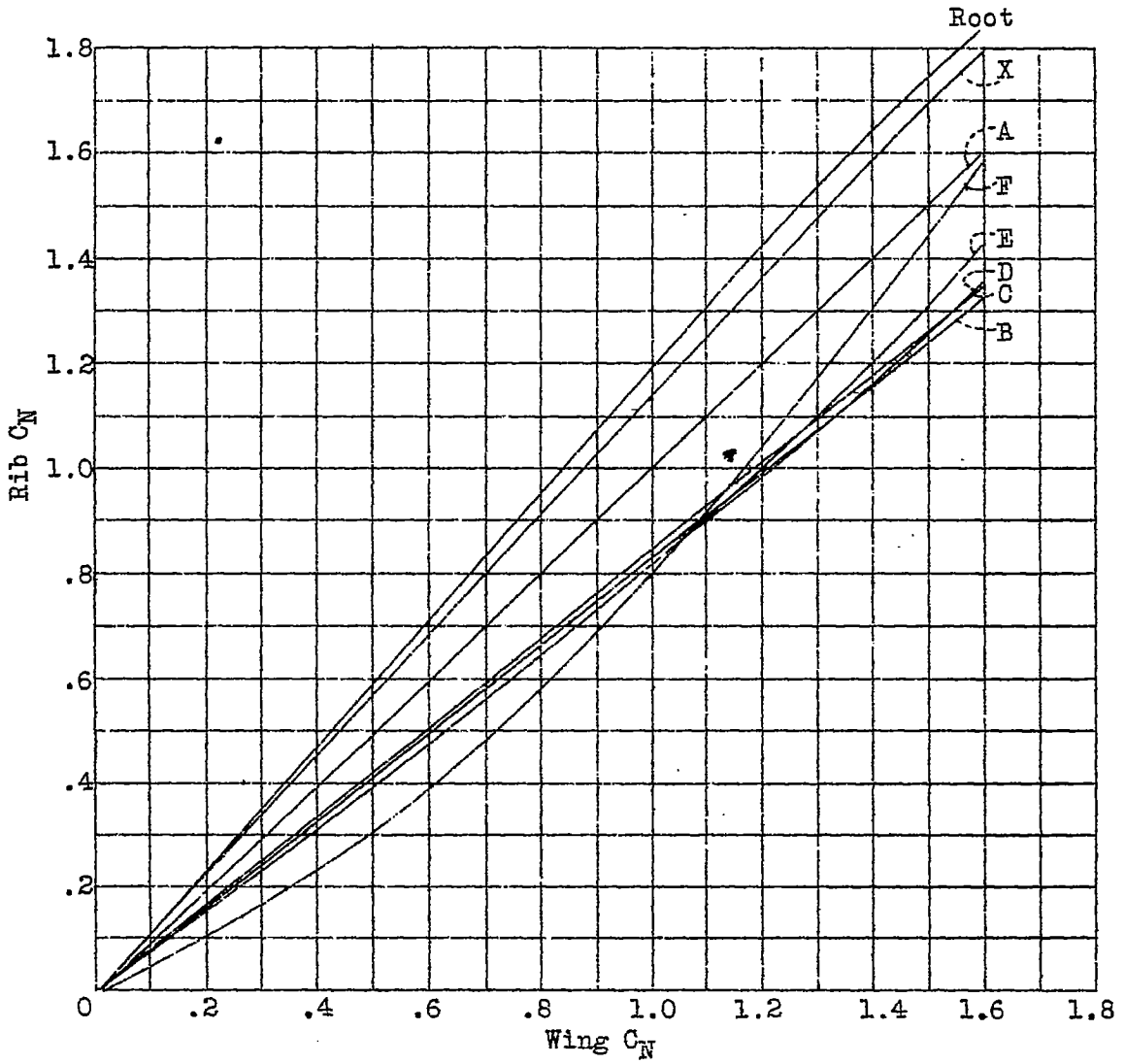

Fig.2 Rib C_N against wing C_N

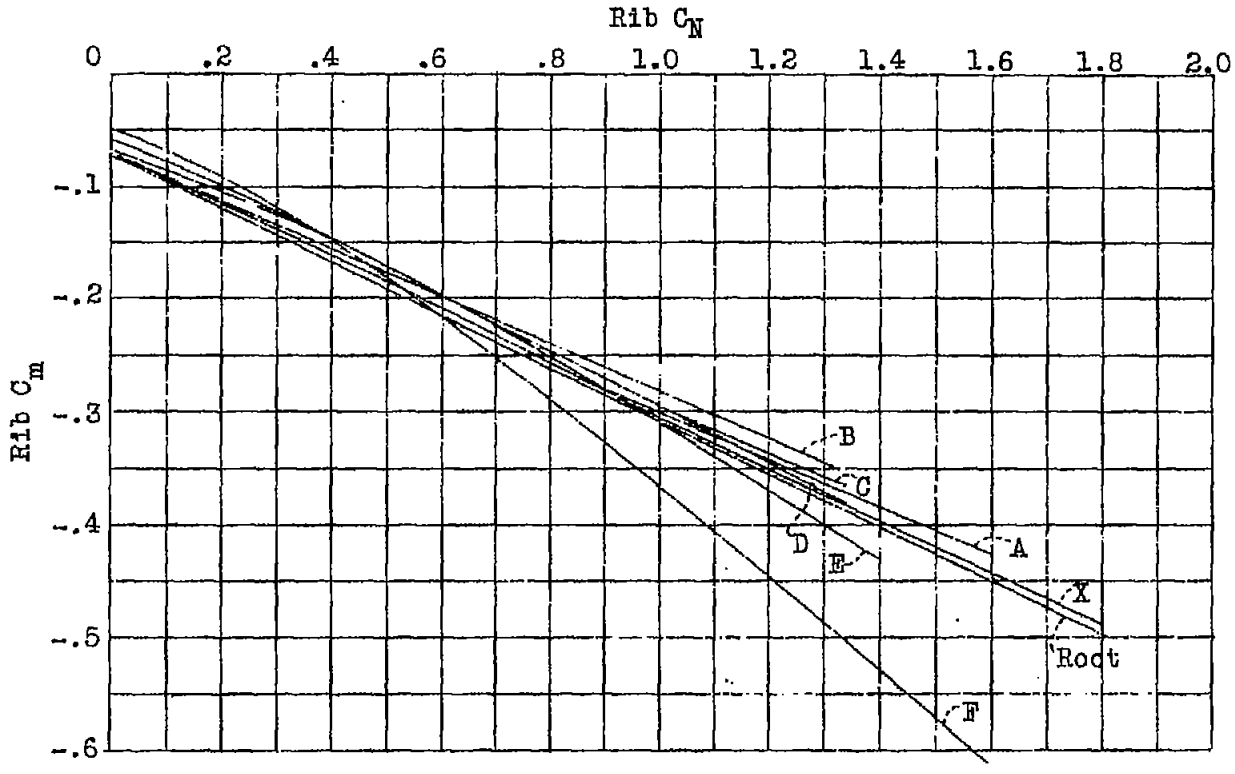

Fig.3 Rib C_m against rib C_N