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No. 433

THE PRESSURE DISTRIBUTION OVER A STANDARD AND A MODIFIED NAVY ELLIPTICAL WING TIP ON A BIPLANE IN FLIGHT

By Richard V. Rhode
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THE PRESSURE DISTRIBUTION OVER A STANDARD AND A MODIFIED NAVY ELLIPTICAL WING TIP ON A BIPLANE IN FLIGHT

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 in turn with a standard Navy elliptical tip and a tip having the same plan form but modified in its front elevation from the "swept-up" aspect of the standard tip to a symmetrical aspect.

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. The results indicate that the modification in front elevation of the tip had no appreciable effect on the load distribution.

INTRODUCTION

This note presents the results obtained in pressure-distribution tests in flight of a standard Navy elliptical tip and a modified Navy elliptical tip. These tips constitute the sixth and seventh tips of a series under investigation. Results of tests on five tips have already been reported: the "Douglas" tip in reference 1; the square tip, both with and without faired end, in reference 2; the semicircular tip in reference 3; and a modified elliptical tip in reference 4.

During the tests herein reported, a rounded tip of the Douglas form (see reference 1) was used on the right lower panel below the tips under investigation. However, as was shown by previous tests (reference 2), the results obtained on the upper wing may be considered to be unaffected by the shape of the lower tip.

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 shapes of the two wing tips are given in Figure 1 and the ordinates of the profiles in Tables II and III. The Clark Y section was maintained throughout the span.

In the case of the standard Navy elliptical tip, the shape is such that the locus of points on the upper surface of the wing at the 50 per cent chord location is a straight line out to the extreme tip. It will be noted in Figure 1 that this feature of the design results in a swept-up appearance of the tip in elevation. In the case of the modified tip, the plan form and other features of the design remain the same as those of the standard tip with the exception that the projection on a spanwise plane normal to the lower surface of the wing of the locus of the maximum mean camber points is a straight line. This modification results in a symmetrical appearance of the tip in front elevation, and thus conforms the tip in that respect to the tips previously tested, except the Douglas tip.

The wings were rigged with a washin of about 0.2°. Deflection measurements previously made (reference 1) indicated that this amount would be sufficient to approximately cancel the torsional deflection at the low angles of attack. However, at high angles of attack the torsional deflection is practically zero (reference 1), and the rigged washin therefore resulted in an "effective twist." This twist was such a small percentage of the angle of attack in this condition that it had a negligible effect on the results, and consequently they can be considered to represent closely the conditions for zero wing twist throughout the range of angle of attack investigated.

The same procedure was followed in these tests as was used in the previous tests. (References 1, 2, 3, and 4.) As in the case of the square tip, the extra pressure rib X (fig. 1) was connected in place of rib C in approximately one-half the runs. Although it was not possible to measure simultaneously the pressures at ribs X and C, sufficient information was obtained on both ribs to establish the span load and the moment curves at stations X and C.

A few ribs, particularly on the standard Navy tip, were inadvertently built in to have about 1/2° incidence with respect to adjacent ribs. This peculiarity in the construction resulted in slightly unfair span-load curves, but corrections were applied to the results by shifting the affected individual rib C_N curves a slight amount so that all rib C_N curves passed simultaneously through zero lift.

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 are given in Figures 2, 3, and 4, and in Tables VI to X, inclusive. Tables VI and VII do not include all of the data obtained but contain only a number of representative sets of pressure data through the range of the tests. The coefficients referred to in these tables are defined as follows:

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

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

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

The curves of Figures 2, 3, and 4 were established by a large number of points as in Figures 6 and 7 of reference 1, but the points were omitted to avoid confusion. Since no differences outside of the experimental error were ob-

served between the corrected span-load curves for the standard and modified tips, both of these tips are represented by Figure 2. The curves for the root section were obtained by extrapolating span C_N curves 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.

Tables VIII, IX, and X give coordinates of the curves of Figures 2, 3, and 4 to allow their construction on a larger and more accurate scale, if so desired. To use Figures 2, 3, and 4: For any wing C_N (or, practically speaking, for any wing lift coefficient), the span C_N distribution may be obtained from Figure 2 by plotting the corresponding values of rib C_N at their proper locations on the span base line as determined from Figure 1. The values of rib C_m corresponding to these values of rib C_N may be determined from Figures 4 or 5, and the center of pressure locus can be drawn from the relation $C_p = C_m/C_N$. To obtain the span load distribution, the ordinates of the span C_N curve must be reduced at the tip in the same ratio as the reduction in chord length.

DISCUSSION

No differences outside the limits of experimental errors were observed between the curves of rib C_N against wing C_N for the two tips other than the slight shifts previously mentioned, which could be accounted for by slight variations in individual pressure-rib incidence. It may therefore be concluded that moderate changes in front elevation at the tip do not introduce appreciable aerodynamic effects in unyawed conditions.

The differences between the moment curves for the two tips were sufficiently pronounced to require presentation as two separate sets of data. A considerable part of these differences may, however, be attributed to experimental error and it is probable also that another considerable part of these differences may properly be attributed to unintended differences in wing shape such as those indicated in Tables II and III. In any case, allowing for all sources of error, the moment curves for the two tips are in suffi-

ciently good agreement to justify the assertion that, for practical purposes of design, moderate changes in front elevation at the tip result only in inappreciable differences in the load distribution in unyawed conditions.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., September 27, 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.

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	*Navy elliptical and modified Navy elliptical Right upper
Right upper wing including aileron	126.4	124.5
Right lower wing including aileron	126.4	126.4
Total wing area	505.6	503.7
Horizontal tail surfaces	58.0	
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
(Standard Navy 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
0.00	3.50	3.50	3.40	3.40	3.49	3.49	3.36	3.36	3.49	3.49	3.17	3.12	3.65	3.65	2.83	2.80
1.25	5.45	1.93	5.47	1.84	5.56	1.93	5.34	1.79	5.42	1.84	5.17	1.56	5.53	2.24	5.18	1.11
2.50	6.50	1.466	6.53	1.29	6.52	1.47	6.38	1.33	6.43	1.38	6.25	1.08	5.75	1.54	5.93	.75
5.00	7.90	.933	7.90	.87	8.00	.97	7.90	.83	8.00	.87	7.65	.69	7.99	1.19	7.05	.36
7.50	8.85	.629	8.82	.51	9.05	.65	8.91	.28	8.96	.46	8.69	.44	8.93	.88	8.40	.09
10.00	9.60	.42	9.65	.41	9.74	.46	9.65	.32	9.65	.32	9.53	.30	9.52	-	8.94	-.09
15.00	10.685	.15	10.61	.18	10.76	.28	10.67	.14	10.62	.18	10.60	.11	10.76	.28	10.27	-.30
20.00	11.36	.033	11.21	.05	11.26	.09	11.26	.05	11.26	.05	11.28	-.05	11.40	.00	10.93	-.48
30.00	11.70	.00	11.67	.00	11.73	.00	11.81	.00	11.81	.00	11.62	-.05	11.70	-.11	11.41	-.48
40.00	11.40	.00	11.30	.00	11.36	.00	11.40	.05	11.45	.00	11.41	.00	11.40	-.11	11.41	-.39
50.00	10.515	.00	10.48	.00	10.48	.00	10.58	.03	10.58	.05	10.45	-.05	10.65	-.06	10.84	-.30
60.00	9.148	.00	9.19	.00	9.19	-.05	9.42	.09	9.25	.14	9.06	.00	9.18	.00	9.51	.00
70.00	7.35	.00	7.35	.09	7.36	.00	7.68	.09	7.67	.14	7.23	.00	7.41	.00	7.74	.00
80.00	5.216	.00	5.38	.00	5.33	.00	5.65	.18	5.70	.23	5.00	-.05	5.17	.00	5.96	.09
90.00	2.802	.00	2.90	.00	2.80	-.05	3.31	.23	3.31	.18	2.52	-.09	2.75	.00	3.85	.09
95.00	1.494	.00	1.65	.00	1.52	-.09	2.02	.14	2.02	.09	1.22	-.14	1.43	.00	2.62	.18
100.00	.12	.00	.37	.00	.23	-.23	.74	.00	.65	.00	-.06	-.14	.13	.00	.66	.18

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

TABLE III

COMPARISON OF SPECIFIED AND MEASURED ORDINATES OF PRESSURE RIBS
(Modified Navy 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
0.00	3.50	3.50	3.40	3.40	3.49	3.49	3.36	3.36	3.49	3.49	3.28	3.28	3.42	3.42	3.58	3.58
1.25	5.45	1.93	5.47	1.84	5.56	1.93	5.34	1.79	5.42	1.84	5.34	1.81	5.44	-	-	1.72
2.50	6.50	1.466	6.53	1.29	6.52	1.47	6.38	1.33	6.43	1.38	6.31	1.41	6.44	1.47	6.59	1.32
5.00	7.90	.933	7.90	.87	8.00	.97	7.90	.83	8.00	.87	7.84	.93	7.86	.94	7.92	.93
7.50	8.85	.629	8.82	.51	9.05	.65	8.91	.28	8.96	.46	8.78	.58	8.84	.66	8.79	.57
10.00	9.60	.42	9.65	.41	9.74	.46	9.65	.32	9.65	.32	9.51	.38	9.54	.11	9.54	.39
15.00	10.685	.15	10.61	.18	10.76	.28	10.67	.14	10.62	.18	10.56	.11	10.60	.00	10.65	.18
20.00	11.36	.033	11.21	.05	11.26	.09	11.26	.05	11.26	.05	11.19	.00	11.25	.00	11.22	.00
30.00	11.70	.00	11.67	.00	11.73	.00	11.81	.00	11.81	.00	11.63	.00	11.65	.00	11.35	.00
40.00	11.40	.00	11.30	.00	11.36	.00	11.40	.05	11.45	.00	11.29	.00	11.35	.00	10.99	.00
50.00	10.515	.00	10.48	.00	10.48	.00	10.58	.03	10.58	.05	10.45	-.05	10.46	-.06	10.23	.00
60.00	9.148	.00	9.19	.00	9.19	-.05	9.42	.09	9.25	.14	9.16	-.05	9.22	.00	8.91	.00
65.00	8.30	.00	8.27	.05	8.27	.00	8.54	.09	8.45	.14	8.26	-.05	8.27	.00	8.00	.00
70.00	7.35	.00	7.35	.09	7.36	.00	7.68	.09	7.67	.14	7.31	.00	7.35	.00	7.07	-.09
80.00	5.216	.00	5.38	.00	5.33	.00	5.65	.18	5.70	.23	5.30	.00	5.27	-.06	5.00	.00
90.00	2.802	.00	2.90	.00	2.80	-.05	3.31	.23	3.31	.18	2.83	.00	2.82	.00	2.65	.00
95.00	1.494	.00	1.65	.00	1.52	-.09	2.02	.14	2.02	.09	1.43	-.05	1.59	.00	1.42	.00
100.00	.12	.00	.37	.00	.23	-.23	.74	.00	.65	.00	.19	.00	.25	.00	.18	.00

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

TABLE IV

ORIFICE LOCATIONS IN PER CENT CHORD FROM LEADING EDGE

(STANDARD NAVY ELLIPTICAL TIP)

Orifice No.	Rib						
	X	A	B	C	D	E	F
1	1.47	1.54	1.47	1.47	1.64	1.79	3.52
2	2.94	3.06	2.94	3.02	3.20	3.57	5.87
3	4.41	4.45	4.41	4.49	8.02	5.98	7.92
4	6.62	6.69	6.70	6.69	13.13	9.78	13.04
5	13.24	13.31	13.30	13.30	19.37	15.62	19.28
6	25.00	25.00	25.00	25.00	29.40	26.95	34.10
7	41.18	41.30	41.40	41.30	42.90	40.35	51.95
8	58.95	59.50	59.10	58.80	59.45	57.90	66.95
9	72.30	73.70	72.00	72.30	81.65	75.30	83.95
10	94.20	94.40	94.50	94.40	90.80	89.80	---

TABLE V

ORIFICE LOCATIONS IN PER CENT CHORD FROM LEADING EDGE

(MODIFIED NAVY ELLIPTICAL TIP)

Orifice No.	Rib						
	X	A	B	C	D	E	F
1	1.47	1.54	1.47	1.47	1.68	1.83	3.31
2	2.94	3.06	2.94	3.02	3.30	3.78	6.32
3	4.41	4.45	4.41	4.49	8.25	5.95	9.63
4	6.62	6.69	6.70	6.69	13.44	9.73	13.18
5	13.24	13.31	13.30	13.30	19.75	15.62	19.50
6	25.00	25.00	25.00	25.00	29.54	26.91	34.40
7	41.18	41.30	41.40	41.30	43.20	40.51	52.20
8	58.95	59.50	59.10	58.80	59.80	58.05	67.30
9	72.30	73.70	72.00	72.30	82.35	75.40	87.10
10	94.20	94.40	94.50	94.40	91.65	90.20	---

TABLE VI

RECORDED PRESSURES IN MULTIPLES OF q

(STANDARD NAVY ELLIPTICAL TIP)

Wing C_N = 0.000						
Orifice No.	Rib					
	A	B	C	D	E	F
1	-2.37	-2.30	-2.37	-1.88	-1.94	-1.10
2	-1.61	-1.42	-1.38	-1.28	-1.29	-.58
3	-1.15	-1.04	-1.08	-.45	-.77	-.39
4	-.79	-.70	-.69	-.22	-.30	-.13
5	-.26	-.26	-.25	-.06	-.08	.18
6	.15	.10	.11	.17	.14	.17
7	.29	.22	.17	.25	.23	.23
8	.19	.24	.21	.24	.26	.13
9	.19	.15	.20	.15	.19	---
10	.06	.08	.04	.07	.07	---

TABLE VI - CONTINUED

RECORDED PRESSURES IN MULTIPLES OF q

(STANDARD NAVY ELLIPTICAL TIP)

Wing C_N = 0.213						
Orifice No.	Rib					
	X	A	B	D	E	F
1	-0.91	-0.94	-1.10	-1.07	-1.00	-0.56
2	-.51	-.54	-.54	-.64	-.63	-.06
3	-.15	-.20	-.27	.07	-.24	.06
4	.11	-.07	.00	.17	.12	.19
5	.23	.28	.21	.30	.31	.26
6	.57	.33	.36	.36	.33	.32
7	.38	.53	.41	.36	.38	.32
8	.33	.28	.33	.30	.34	.14
9	.08	.23	.19	.17	.21	.07
10	.07	.07	.04	.09	.08	---

TABLE VI - CONTINUED

RECORDED PRESSURES IN MULTIPLES OF q

(STANDARD NAVY ELLIPTICAL TIP)

Wing C_N = 0.344						
Orifice No.	Rib					
	X	A	B	D	E	F
1	0.04	0.00	-0.28	-0.35	-0.33	0.00
2	.12	.13	.08	.00	-.08	.36
3	.44	.34	.34	.44	.15	.36
4	.60	.55	.35	.42	.41	.44
5	.71	.59	.44	.47	.51	.52
6	.73	.49	.54	.52	.46	.36
7	.42	.58	.46	.43	.51	.37
8	.34	.23	.36	.36	.41	.19
9	.25	.22	.15	.14	.19	.18
10	.06	.09	.04	.06	.08	---

TABLE VI - CONTINUED

RECORDED PRESSURES IN MULTIPLES OF q

(STANDARD NAVY ELLIPTICAL TIP)

Wing C_N = 0.580						
Orifice No.	Rib					
	A	B	C	D	E	F
1	1.10	0.72	0.69	0.67	0.62	0.69
2	1.12	1.10	.84	.79	.60	.85
3	1.20	1.10	.94	.95	.76	.88
4	1.38	1.14	1.09	.83	.92	.83
5	1.14	.90	.90	.82	.87	.76
6	.83	.79	.81	.72	.73	.58
7	.79	.59	.55	.59	.55	.55
8	.37	.39	.40	.37	.45	.37
9	.33	.21	.28	.18	.26	.14
10	.07	.10	.02	.08	.08	---

TABLE VI - CONTINUED

RECORDED PRESSURES IN MULTIPLES OF q

(STANDARD NAVY ELLIPTICAL TIP)

Wing C_N = 0.908						
Orifice No.	Rib					
	X	A	B	D	E	F
1	3.30	2.63	1.85	1.67	1.69	1.62
2	2.90	2.42	2.08	1.84	1.55	1.57
3	2.70	2.35	2.06	1.61	1.54	1.45
4	2.61	2.36	1.93	1.33	1.54	1.30
5	1.96	1.79	1.50	1.18	1.27	1.21
6	1.60	1.22	1.18	1.02	1.04	.80
7	.99	1.06	.82	.78	.82	.78
8	.68	.50	.52	.55	.61	.53
9	.44	.39	.26	.26	.35	.30
10	.17	.13	.07	.11	.14	---

TABLE VI - CONTINUED

RECORDED PRESSURES IN MULTIPLES OF q

(STANDARD NAVY ELLIPTICAL TIP)

Wing $C_N = 1.116$						
Orifice No.	Rib					
	X	A	B	D	E	F
1	4.52	3.86	2.72	2.72	2.55	2.29
2	3.86	3.39	3.17	2.67	2.16	2.13
3	3.54	3.31	2.06	2.15	2.09	1.86
4	3.31	3.20	2.82	1.69	2.02	1.61
5	2.42	2.38	1.95	1.47	1.59	1.50
6	1.84	1.55	1.44	1.21	1.19	.95
7	1.11	1.20	.95	.93	.96	.94
8	.77	.57	.54	.59	.73	.71
9	.48	.38	.27	.27	.38	.40
10	.16	.11	.10	.14	.18	---

TABLE VI - CONTINUED

RECORDED PRESSURES IN MULTIPLES OF q

(STANDARD NAVY ELLIPTICAL TIP)

Wing C_N = 1.242						
Orifice No.	Rib					
	X	A	B	D	E	F
1	4.98	4.26	3.07	3.04	2.64	2.53
2	4.29	4.15	3.44	2.85	2.28	2.36
3	4.27	3.94	3.27	2.45	2.23	2.18
4	3.64	3.55	3.09	1.93	2.00	2.01
5	2.58	2.59	2.21	1.72	1.84	1.63
6	2.05	1.71	1.54	1.33	1.38	1.20
7	1.26	1.26	1.05	1.00	1.05	1.02
8	.81	.65	.63	.65	.78	.82
9	.54	.45	.28	.33	.47	.51
10	.20	.15	.12	.18	.20	---

TABLE VI - CONTINUED

RECORDED PRESSURES IN MULTIPLES OF q

(STANDARD NAVY ELLIPTICAL TIP)

Wing C_N = 1.493						
Orifice No.	Rib					
	X	A	B	D	E	F
1	6.22	5.72	4.15	4.26	3.87	3.76
2	5.82	5.54	4.50	3.75	3.29	3.25
3	5.42	4.99	4.15	3.10	3.08	2.97
4	4.76	4.54	4.01	2.40	2.70	2.56
5	3.32	3.15	2.75	2.03	2.31	2.18
6	2.40	2.08	1.90	1.59	1.76	1.58
7	1.49	1.48	1.19	1.20	1.33	1.47
8	.83	.73	.66	.73	.96	1.24
9	.55	.48	.36	.38	.65	.72
10	.24	.17	.13	.19	.28	---

TABLE VII

RECORDED PRESSURES IN MULTIPLES OF q

(MODIFIED NAVY ELLIPTICAL TIP)

Wing C_N = -0.030						
Orifice No.	Rib					
	X	A	B	D	E	F
1	-2.39	-2.39	-2.54	-2.26	-2.25	-1.12
2	-2.03	-1.71	-1.82	-1.11	-1.38	-.86
3	-1.23	-1.12	-1.11	-.56	-.77	-.49
4	-.83	-.79	-.79	-.40	-.55	-.27
5	-.22	-.34	-.27	.04	-.18	.05
6	.16	.06	.22	.22	.10	.14
7	.13	.20	.17	.28	.20	.24
8	.21	.22	.28	.21	.19	.06
9	.15	.13	.18	.19	.13	.08
10	.06	.06	.05	.08	.03	---

TABLE VII - CONTINUED

RECORDED PRESSURES IN MULTIPLES OF q

(MODIFIED NAVY ELLIPTICAL TIP)

Wing C_N = 0.218						
Orifice No.	Rib					
	A	B	C	D	E	F
1	-1.20	-1.35	-1.20	-1.24	-1.18	-0.45
2	-.68	-.76	-.73	-.33	-.64	-.34
3	-.19	-.34	-.36	-.09	-.17	-.17
4	-.09	.00	-.09	.00	.04	.19
5	.16	.24	.17	.27	.17	.26
6	.37	.43	.39	.49	.31	.34
7	.45	.38	.39	.39	.38	.30
8	.30	.39	.38	.37	.22	.10
9	.21	.21	.27	.21	.16	.13
10	.09	.09	.09	.08	.03	---

TABLE VII - CONTINUED

RECORDED PRESSURES IN MULTIPLES OF q

(MODIFIED NAVY ELLIPTICAL TIP)

Wing C_N = 0.322						
Orifice No.	Rib					
	A	B	C	D	E	F
1	-0.46	-0.54	-0.61	-0.69	-0.79	-0.14
2	-.09	-.30	-.37	-.11	-.35	-.08
3	.22	.07	-.06	.08	.00	.17
4	.38	.20	.10	.19	.28	.33
5	.42	.38	.28	.40	.33	.38
6	.44	.46	.52	.55	.46	.43
7	.56	.44	.45	.46	.42	.31
8	.34	.38	.37	.29	.32	.20
9	.26	.21	.29	.20	.17	.07
10	.11	.08	.05	.08	.02	---

TABLE VII - CONTINUED

RECORDED PRESSURES IN MULTIPLES OF q

(MODIFIED NAVY ELLIPTICAL TIP)

Wing C_N = 0.527						
Orifice No.	Rib					
	A	B	C	D	E	F
1	0.58	0.37	0.15	0.14	0.03	0.36
2	.86	.51	.38	.59	.25	.42
3	1.08	.75	.58	.60	.49	.54
4	1.07	.80	.68	.55	.64	.69
5	.89	.82	.64	.69	.64	.63
6	.71	.73	.76	.72	.65	.59
7	.69	.57	.58	.56	.52	.39
8	.44	.45	.44	.36	.37	.29
9	.31	.24	.32	.22	.22	.17
10	.11	.09	.05	.10	.05	---

TABLE VII - CONTINUED

RECORDED PRESSURES IN MULTIPLES OF q

(MODIFIED NAVY ELLIPTICAL TIP)

Wing C_N = 0.738						
Orifice No.	Rib					
	X	A	B	D	E	F
1	2.03	1.63	1.13	0.86	0.82	0.79
2	1.67	1.82	1.29	1.26	.88	.94
3	1.88	2.01	1.38	1.10	1.05	1.01
4	1.91	1.86	1.42	.96	.98	1.05
5	1.50	1.32	1.23	.95	.94	.95
6	1.37	.99	1.03	.93	.87	.68
7	.89	.85	.70	.73	.65	.53
8	.60	.51	.50	.42	.43	.30
9	.40	.36	.28	.27	.25	.30
10	.14	.11	.07	.11	.05	---

TABLE VII - CONTINUED

RECORDED PRESSURES IN MULTIPLES OF q

(MODIFIED NAVY ELLIPTICAL TIP)

Wing C_N = 0.967						
Orifice No.	Rib					
	A	B	C	D	E	F
1	2.72	2.13	1.86	1.80	1.57	1.35
2	2.81	2.22	1.86	1.92	1.55	1.39
3	2.83	2.15	1.95	1.54	1.55	1.44
4	2.50	2.00	1.77	1.34	1.48	1.42
5	1.84	1.64	1.37	1.25	1.29	1.15
6	1.27	1.31	1.23	1.05	1.09	.91
7	1.02	.85	.86	.83	.84	.62
8	.63	.58	.58	.50	.58	.60
9	.45	.32	.35	.27	.35	.44
10	.12	.10	.06	.10	.08	---

TABLE VII - CONTINUED

RECORDED PRESSURES IN MULTIPLES OF q

(MODIFIED NAVY ELLIPTICAL TIP)

Wing C_N = 1.175						
Orifice No.	Rib					
	X	A	B	D	E	F
1	4.37	3.73	2.79	2.61	2.34	1.76
2	3.53	3.86	2.97	2.67	2.08	1.94
3	3.52	3.78	2.81	2.03	2.14	1.85
4	3.31	3.34	2.63	1.73	1.80	1.87
5	2.49	2.30	2.09	1.55	1.63	1.52
6	1.98	1.57	1.52	1.27	1.31	1.10
7	1.27	1.16	.99	.98	.97	.81
8	.81	.70	.65	.58	.71	.70
9	.55	.50	.36	.31	.40	.70
10	.20	.13	.17	.14	.12	---

TABLE VII - CONTINUED

RECORDED PRESSURES IN MULTIPLES OF q

(MODIFIED NAVY ELLIPTICAL TIP)

Wing C_N = 1.397						
Orifice No.	Rib					
	A	B	C	D	E	F
1	4.98	3.56	3.71	3.23	3.28	2.57
2	4.79	3.86	3.23	3.25	2.76	2.65
3	4.76	3.56	3.28	2.61	2.70	2.58
4	4.06	3.44	3.04	2.04	2.49	2.38
5	2.87	2.58	2.21	1.78	1.95	1.87
6	1.89	1.71	1.70	1.50	1.59	1.39
7	1.35	1.12	1.14	1.11	1.14	1.12
8	.73	.71	.75	.70	.79	.93
9	.49	.39	.47	.40	.54	.97
10	.17	.18	.09	.20	.23	---

TABLE VIII

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	.116	.111	.101	.086	.079	.077	.073	.068
.2	.232	.225	.202	.171	.159	.154	.149	.139
.3	.347	.336	.302	.256	.238	.232	.224	.211
.4	.463	.449	.403	.341	.318	.309	.301	.285
.5	.579	.561	.504	.427	.398	.387	.377	.333
.6	.694	.674	.605	.512	.478	.466	.456	.446
.7	.812	.788	.706	.596	.558	.544	.535	.531
.8	.928	.899	.807	.681	.639	.623	.615	.620
.9	1.045	1.010	.908	.767	.719	.702	.695	.716
1.0	1.160	1.122	1.009	.852	.800	.783	.779	.817
1.1	1.274	1.233	1.111	.938	.881	.864	.867	.927
1.2	1.390	1.345	1.212	1.023	.963	.945	.958	1.044
1.3	1.506	1.455	1.313	1.109	1.044	1.027	1.051	1.174
1.4	1.619	1.564	1.413	1.194	1.126	1.110	1.147	1.314
1.5	1.726	1.669	1.512	1.279	1.208	1.194	1.248	1.469
1.6	1.829	1.771	1.611	1.366	1.289	1.280	1.353	1.650

TABLE IX

COORDINATES OF CURVES OF FIGURE 3

Rib C_N	Rib C_m						
	X	A	B	C	D	E	F
0	-0.057	-0.065	-0.064	-0.060	-0.065	-0.071	-0.042
.1	-.078	-.088	-.084	-.078	-.084	-.087	-.064
.2	-.100	-.110	-.104	-.097	-.103	-.106	-.088
.3	-.122	-.129	-.121	-.117	-.123	-.126	-.116
.4	-.145	-.147	-.140	-.140	-.145	-.148	-.147
.5	-.168	-.170	-.161	-.165	-.169	-.174	-.181
.6	-.193	-.192	-.184	-.189	-.195	-.200	-.216
.7	-.219	-.216	-.206	-.212	-.220	-.226	-.251
.8	-.245	-.240	-.228	-.232	-.245	-.251	-.286
.9	-.270	-.264	-.250	-.250	-.268	-.279	-.322
1.0	-.294	-.285	-.271	-.272	-.291	-.309	-.356
1.1	-.315	-.304	-.292	-.296	-.314	-.339	-.391
1.2	-.336	-.323	-.312	-.324	-.339	-.370	-.428
1.3	-.358	-.343	-.333	-.353	-.365	-.401	-.466
1.4	-.381	-.366	-.354	-.383	-.392	-.432	-.505
1.5	-.406	-.389	-.375	-.414	-.419	-.462	-.543
1.6	-.432	-.412	-.396	-	-	-.493	-.582
1.7	-.458	-.432	-	-	-	-	-.621
1.8	-.485	-	-	-	-	-	-.661

TABLE X

COORDINATES OF CURVES OF FIGURE 4

Rib C_N	Rib C_m						
	X	A	B	C	D	E	F
0	-0.064	-0.066	-0.072	-0.071	-0.083	-0.062	-0.046
.1	-.091	-.091	-.094	-.093	-.102	-.081	-.070
.2	-.117	-.115	-.115	-.115	-.122	-.102	-.095
.3	-.142	-.139	-.137	-.136	-.142	-.123	-.124
.4	-.167	-.163	-.159	-.158	-.162	-.145	-.155
.5	-.191	-.186	-.180	-.179	-.184	-.169	-.189
.6	-.215	-.209	-.201	-.201	-.206	-.195	-.224
.7	-.239	-.231	-.222	-.222	-.229	-.222	-.261
.8	-.263	-.252	-.243	-.244	-.253	-.251	-.299
.9	-.286	-.274	-.264	-.265	-.277	-.280	-.339
1.0	-.309	-.295	-.285	-.287	-.302	-.310	-.379
1.1	-.333	-.316	-.305	-.308	-.328	-.340	-.420
1.2	-.356	-.336	-.326	-.330	-.354	-.371	-.461
1.3	-.379	-.357	-.347	-.351	-.381	-.402	-.503
1.4	-.402	-.378	-.367	-.373	-.409	-.434	-.545
1.5	-.425	-.398	-.388	-.395	-.437	-.466	-.587
1.6	-.448	-.419	-.407	-.416	-.467	-.498	-.630
1.7	-.471	-.439	-	-	-	-	-.672
1.8	-.495	-	-	-	-	-	-.716

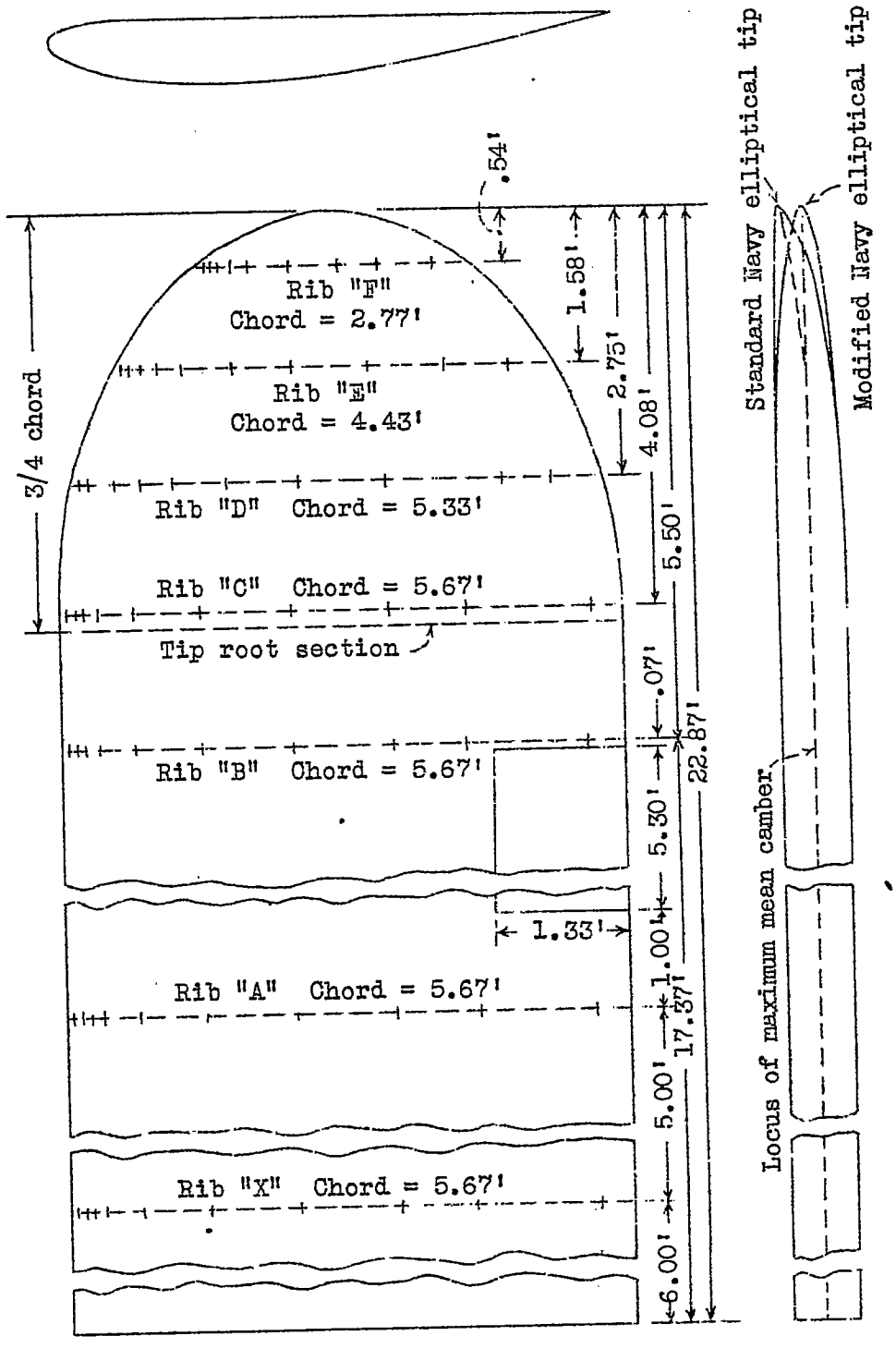

Fig. 1 M-3 wing with pressure ribs and orifice locations.

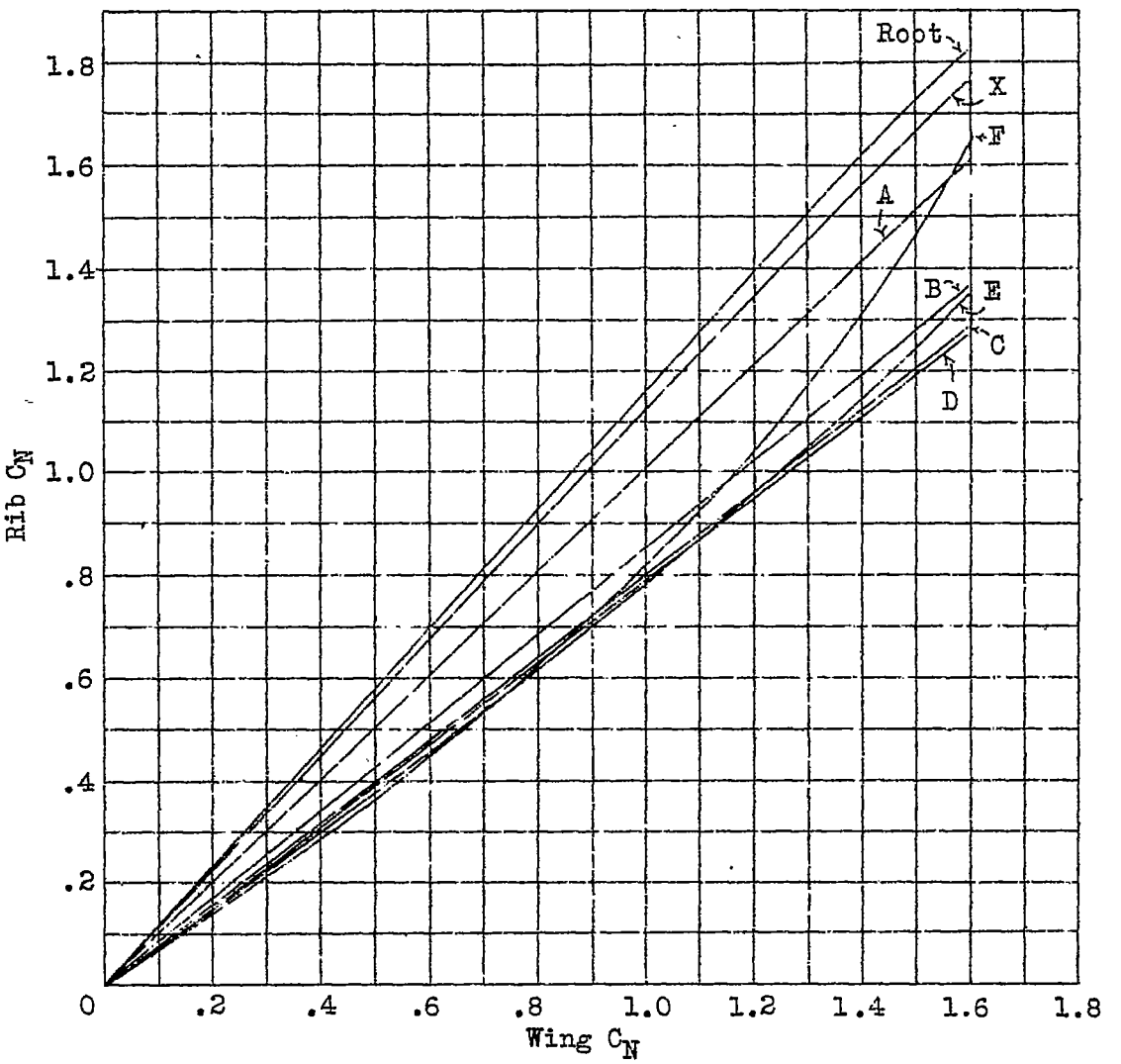

Fig. 2 Rib C_N against wing C_N for Standard Navy elliptical tip and modified tip.

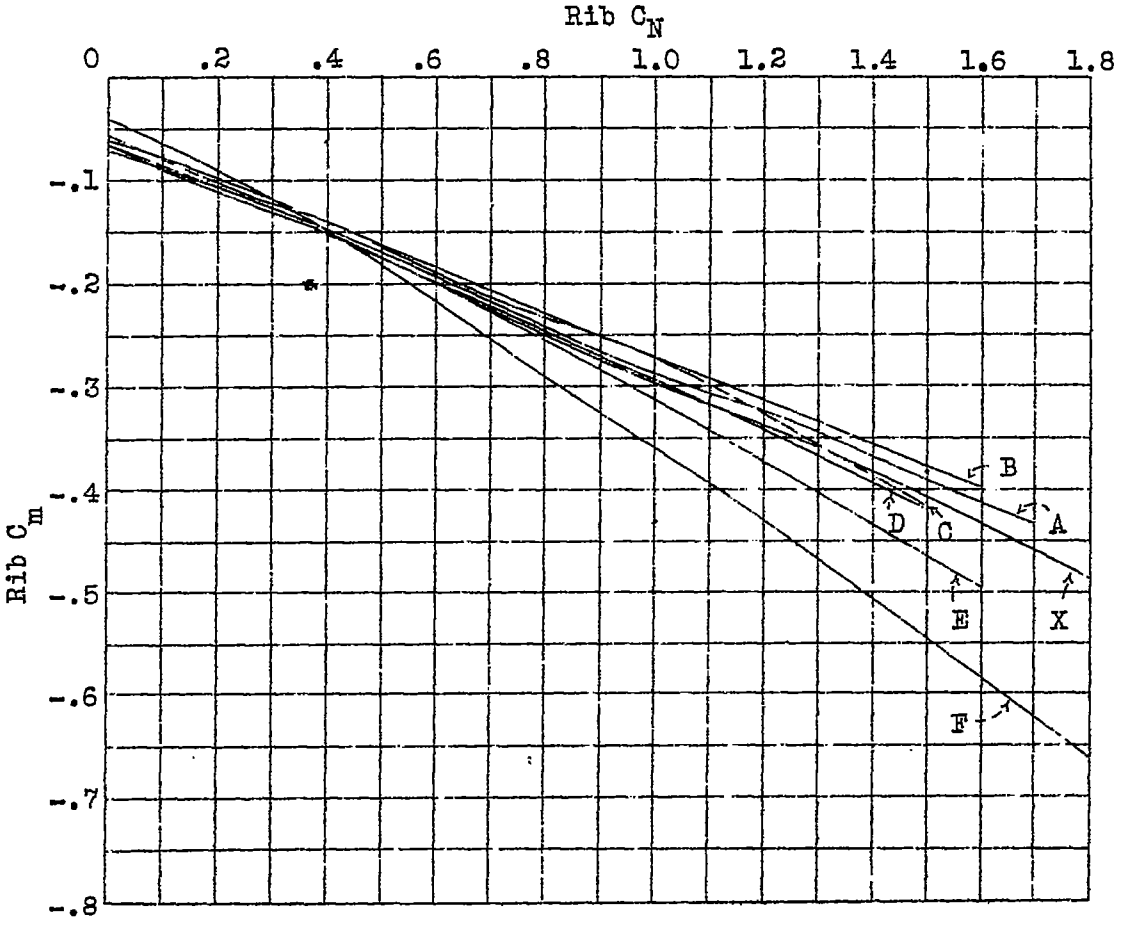

Fig. 3 Rib C_m against rib C_N (Standard Navy elliptical tip)

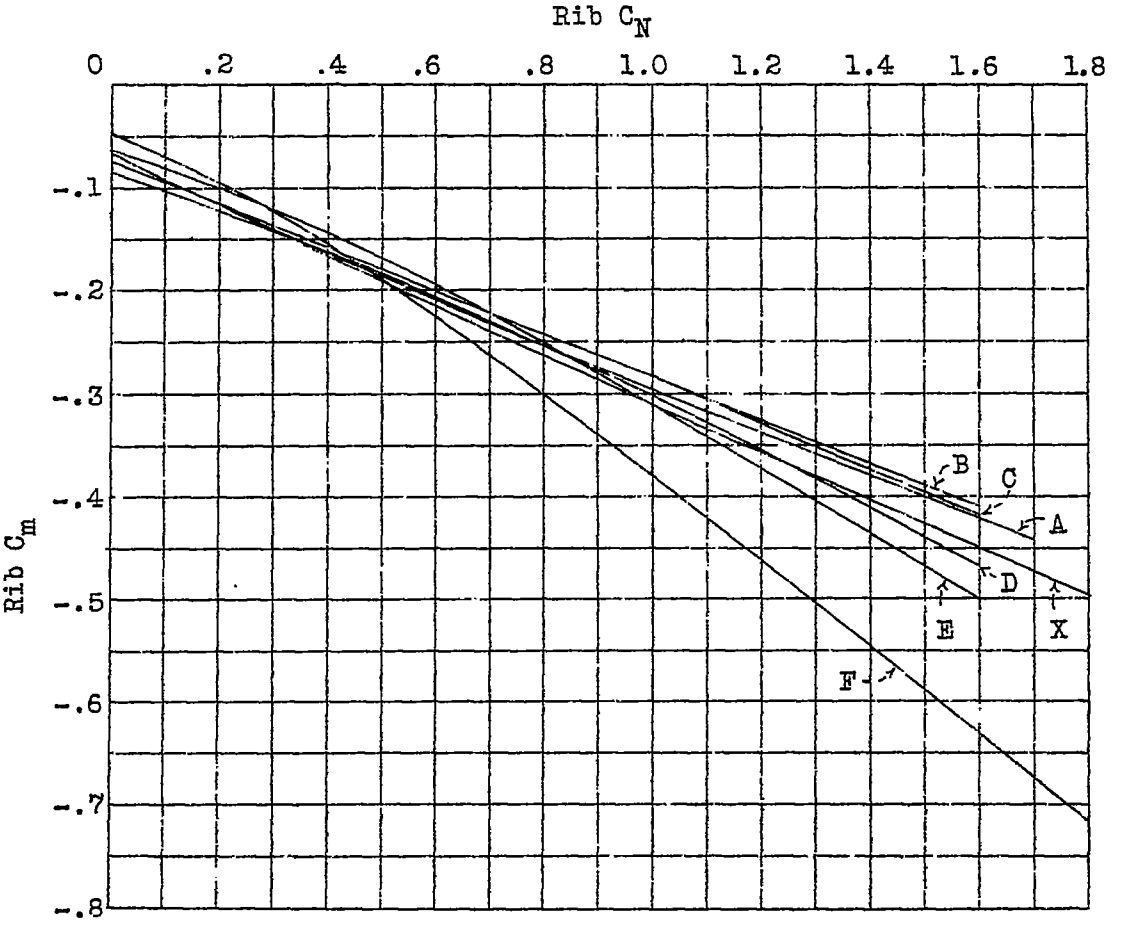

Fig. 4 Rib C_m against rib C_N (Modified Navy elliptical tip)