NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TECHNICAL MEMORANDUM X-280

TRANSONIC WIND-TUNNEL INVESTIGATION OF THE EFFECT OF CONTROL SPAN AND LARGE WING-TIP NACELLES ON EFFECTIVENESS OF SPOILER-SLOT-DEFLECTOR CONTROLS ON AN UNSWEPT-WING FIGHTER-TYPE AIRPLANE*

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SUMMARY

An investigation was conducted in the Langley 8-foot transonic pressure tunnel to determine the effect of control span and large wing-tip nacelles on spoiler-slot-deflector effectiveness. Effect of control span on control characteristics was obtained by testing the outboard one-third, outboard two-thirds, and the complete control. The complete control extended from 29 to 86 percent of the wing semispan and was located between the 80- and 94-percent-chord lines. The unswept wing of the fighter-type airplane had an aspect ratio of 2.42, a taper ratio of 0.433, and a modified NACA 65A005 airfoil section. Six-component force and moment data were obtained through an angle-of-attack range of approximately -6° to 16° for Mach numbers from 0.60 to 1.20. The test Reynolds number varied from 1.42×10^6 to 1.90×10^6.

Increasing the control span from the outboard one-third to the outboard two-thirds generally produced greater rolling-moment-coefficient increment than further increasing the control span to the complete control. Furthermore, at low angles of attack, the outboard two-thirds control span was nearly as effective as the complete control. However, at high angles of attack and below a Mach number of 0.95 all control spans lost effectiveness with a small degree of control reversal noted for the shorter spans. Wing-tip nacelles increased the rolling-moment coefficient except at angles of attack above approximately 7° for Mach numbers of 0.90 and below. This increase in rolling-moment coefficient may not result in greater lateral maneuverability due to the damping-in-roll contribution of the nacelles.

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INTRODUCTION

Previous transonic investigations of lateral-control devices have shown the usefulness of spoiler-slot-deflector controls in maintaining control effectiveness at high angles of attack for high-speed airplanes. (For example, see ref. 1.) Furthermore, these controls require only small wing thickness, produce small torsional loads, and need less control force than flap-type spoiler ailerons. As a result of these favorable control characteristics further investigations, such as those of references 2 to 4, were made to determine the effect of wing geometry, control surface deflection ratio, and control location on the effectiveness of these controls.

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The present investigation provides transonic data on the effect of control span and large wing-tip nacelles on the spoiler-slot-deflector effectiveness of an unswept-wing fighter-type airplane. Control span was changed by projecting either the outboard two-thirds span or outboard one-third span of the complete control. The complete control extended from approximately 29 to 86 percent of the wing semispan. The large wing-tip nacelles were of a size to house two small jet engines one above the other.

Force and moment data were obtained through an angle-of-attack range from approximately -6° to 16° for Mach numbers from 0.60 to 1.20. The test Reynolds number varied from 1.42×10^{6} to 1.90×10^{6}. Results of the six-component data are presented herein.

SYMBOLS

Presentation of the data is with respect to the stability system of axes. Forces and moments are referred to an assumed center of gravity located in the plane of symmetry and corresponding to the one-third-chord point of the wing mean aerodynamic chord.

b wing span, measured to center line of wing-tip nacelles, in.

c local wing chord, in.

$\bar{c}$ wing mean aerodynamic chord, in.

C_D drag coefficient, Drag/qS

C_L lift coefficient, Lift/qS

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C_l rolling-moment coefficient, Rolling moment/qSb

C_m pitching-moment coefficient, Pitching moment/$qS\bar{c}$

C_n yawing-moment coefficient, Yawing moment/qSb

C_Y side-force coefficient, Side force/qS

M free-stream Mach number

q free-stream dynamic pressure, lb/sq ft

S wing area between center line of wing-tip nacelles, sq ft

t_{max} maximum thickness of airfoil, percent local wing chord

α wing-chord-line angle of attack, deg

δ_s projection of spoiler into airstream, measured perpendicular to wing chord line (negative when projected above surface of wing), fraction of c

δ_d projection of deflector into airstream, measured perpendicular to wing chord line (negative when projected below surface of wing), fraction of c

APPARATUS AND MODEL

The investigation was conducted in the Langley 8-foot transonic pressure tunnel which is a single-return tunnel with a rectangular slotted test section permitting continuous operation through the transonic speed range. Stagnation temperature and dewpoint controls precluded the formation of condensation shocks.

A three-view drawing of the all-metal model of the fighter-type airplane is presented in figure 1. Also shown in figure 1 is a cross-sectional detail of the spoiler-slot-deflector control. Photographs of the sting-mounted model with the spoiler-slot-deflector controls projected are shown in figure 2.

The steel wing, unswept along the 50-percent-chord line, was mounted high on the fuselage. The wing had an aspect ratio of 2.42, a taper ratio of 0.433, and a modified NACA 65A005 airfoil section over the entire span. The basic airfoil section was modified to provide a

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blunt trailing edge with a thickness equal to 30 percent of the maximum thickness of the local airfoil section. This modification was made by straight-line elements from the thick trailing edge to a point of tangency with the basic section forward of the trailing edge. The wing had no twist, camber, or dihedral.

The fuselage and wing-tip nacelles were ducted for internal flow.

The complete spoiler-slot-deflector control (fig. 1) extended from approximately 29 to 86 percent of the wing semispan and had a chord of approximately 14 percent of the wing local chord. The spoiler was hinged at the 0.800c line and the deflector was hinged at the 0.941c line. The outboard two-thirds span of the complete control extended from approximately 48 to 86 percent of the wing semispan. The outboard one-third span of the complete control extended from approximately 67 to 86 percent of the wing semispan. The steel spoiler was hinged to the upper wing surface at the leading edge of the slot. The steel deflector was hinged to the lower wing surface at the trailing edge of the slot. One-sixteenth-inch-diameter braces were used to support the spoiler and deflector in the projected positions.

CORRECTIONS AND ACCURACIES

Boundary interference at subsonic velocities has been minimized by the slotted test section and no corrections have been applied. Supersonic boundary reflected shocks were downstream of the tail of the model at a test Mach number of 1.13 and higher. No corrections have been applied for sting interference effects. All drag data have been corrected for internal flow and base drag.

Through consideration of the static calibrations of the electrical strain-gage balance and repeatability of data, the estimated accuracy of the coefficients is within the following limits:

C_L	±0.05
C_D	±0.0035
C_m	±0.015
C_l	±0.002
C_n	±0.003
C_Y	±0.010

The angle of attack was determined within ±0.15°.

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TESTS

The model was tested at Mach numbers from 0.60 to 1.20 for an angle-of-attack range from approximately -6° to 16°. The test Reynolds number varied from 1.42×10^{6} to 1.90×10^{6} over the Mach number range.

The spoiler slot deflector, mounted on the right wing panel only, was tested at different projections. The complete control was tested at a spoiler projection of 10 percent of the wing local chord with and without wing-tip nacelles. The outboard two-thirds span of the complete control was tested at spoiler projections of 2, 5, 10, 12.2, and 13.3 percent of the wing local chord. The outboard one-third span of the complete control was tested at spoiler projections of 10 and 13.3 percent of the local wing chord. The projection of the deflector was always three-fourths of the spoiler projection.

Transition strips, consisting of grains of carborundum (approximately 0.005 inch in diameter), were placed on the model for all tests. On the fuselage and wing-tip nacelles the strips were 0.15 inch wide and located at 10 percent of their length. On the wing, tail surfaces, and ventral fins the strips were 0.10 inch wide and located at the 10-percent chord.

RESULTS AND DISCUSSION

Presentation of Data

Basic six-component force and moment data for all control conditions tested are presented in tables I and II. Analysis plots showing the principal effects of control span, control deflection, and wing-tip nacelles are presented in figures 3 to 6.

Effect of Control Span

Variation of rolling-moment coefficient with angle of attack ($\delta_s = -0.10c$) for the three control spans is shown in figure 3(d) Increasing the control span from the outboard one-third to the outboard two-thirds generally produced a greater rolling-moment-coefficient increment than further increasing the control span to the complete control. Furthermore, at low angles of attack, the outboard two-thirds span of the complete control was nearly as effective as the complete control. This is probably attributable to the spanwise location of this control as compared to the complete control. However, at the high angles of attack and below a Mach number of 0.95 all control spans lost effectiveness with a small degree of control reversal noted for the shorter spans.

The effects of the three control spans on the remaining forces and moments are shown in figures 3(a), (b), (c), (e), and (f). The effects on the forces were essentially proportional to the control span but for the moments the effects were not consistent. Adverse yawing moments are shown in figure 3(e) for all control spans. In general, the angle of attack at which the yawing moment becomes adverse decreases with L
increases in Mach number. A detrimental inconsistency of the outboard 7
two-thirds control span, when compared to the complete control, is the 8
more adverse yawing moment above $\alpha = 6^{\circ}$ and 12° at $M = 1.00$ and 0.95, 8
respectively. For Mach numbers of 1.13 and 1.20 the complete-control adverse yawing-moment coefficient reached a value of -0.03 at the highest test angles of attack. The degree of adversity, at these supersonic speeds, increased as the control is extended closer to the fuselage. This seems to indicate a strong interference between the control and adjacent side of the fuselage.

Overall, the outboard two-thirds control span appears to be the most effective comparatively. The remainder of the discussion is concerned with this control span except for the effect of wing-tip nacelles on control effectiveness.

Characteristics of the Outboard Two-Thirds Control Span

Effect of angle of attack.- Below a Mach number of 0.95 the rolling-moment coefficient for the outboard two-thirds control span ($\delta_s = -0.10c$) was relatively constant up to an angle of attack of approximately 5°. (See fig. 3(d).) At higher angles of attack, the rolling-moment coefficient decreased rapidly and, as previously noted, became zero or negative. Above a Mach number of 0.95 the rolling moment for the outboard two-thirds control span was essentially constant over the angle-of-attack range tested.

Effect of Mach number.- The variation of rolling-moment coefficient with Mach number for the outboard two-thirds control span is shown in figure 4. Below an angle of attack of 4°, the variation of rolling-moment coefficient with Mach number was small for the three control projections presented. Above 4° the rolling-moment coefficient peaked around a Mach number of 0.95 with the subsonic level being less than the supersonic level. Control reversal is noted at the angle of attack of 12° around a Mach number of 0.75 for control projection up to -0.10c.

Effect of control projection.- Variation of rolling-moment coefficient with control projection for the outboard two-thirds span of the complete control is given in figure 5. Loss of control effectiveness is noted at 14° angle of attack for the test Mach numbers up to 0.90. For the remaining test conditions plotted, control effectiveness was approximately proportional to control projection up to projections of at least -0.10c. Furthermore, at Mach numbers above unity, control effectiveness was not affected by angle of attack.

Effect of Wing-Tip Nacelles

For the complete control at $\delta_s = -0.10c$, wing-tip nacelles increased the rolling-moment coefficient over the test angle of attack and Mach number range except above approximately 7° angle of attack at Mach numbers from 0.60 to 0.90. (See fig. 6.) The maximum increase occurred at a Mach number of 1.00 from approximately 0° to 6° angle of attack where the addition of wing-tip nacelles almost doubled the rolling-moment coefficient. Although the wing-tip nacelles resulted in greater rolling-moment coefficient, the overall lateral maneuverability of such a configuration may not be increased. Reference 5 indicates that the damping in roll due to the wing-tip nacelles may be greater than the increase in rolling moment thus resulting in a decrease in lateral maneuverability.

CONCLUSIONS

A transonic wind-tunnel investigation was made to determine the effects of spanwise control length and large wing-tip nacelles on spoiler-slot-deflector effectiveness of an unswept-wing fighter-type airplane. Results of the investigation indicate the following conclusions:

1. Increasing the control span from the outboard one-third to the outboard two-thirds generally produced greater rolling-moment-coefficient increment than further increasing the control span to the complete control. Furthermore, at low angles of attack, the outboard two-thirds control span was nearly as effective as the complete control.

2. At high angles of attack and below a Mach number of 0.95 all control spans lost effectiveness with a small degree of control reversal noted for the shorter spans.

3. Wing-tip nacelles increased the rolling-moment coefficient except above approximately 7° angle of attack for Mach numbers of 0.90 and below. However, the increased rolling-moment coefficient may not result in greater lateral maneuverability due to the damping-in-roll contribution of the nacelles.

Langley Research Center,
National Aeronautics and Space Administration,
Langley Field, Va., January 21, 1960.

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TABLE I.- AERODYNAMIC CHARACTERISTICS OF THE COMPLETE MODEL

(a) Plain wing

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
M = 0.60						
-4.47	-.332	.0558	.0588	-.0007	-.0012	-.0066
-2.17	-.135	.0409	.0673	-.0007	-.0021	-.0076
-1.03	-.039	.0391	.0665	-.0010	-.0022	-.0069
0.13	.064	.0397	.0642	-.0009	-.0020	-.0081
1.30	.164	.0415	.0583	-.0011	-.0011	-.0069
2.46	.269	.0468	.0457	-.0007	-.0011	-.0078
3.61	.373	.0557	.0317	-.0005	-.0002	-.0107
4.76	.480	.0693	.0126	-.0001	.0000	-.0092
7.05	.686	.1148	-.0447	.0005	.0005	-.0070
9.28	.851	.1752	-.1294	.0036	.0009	-.0073
11.36	.950	.2341	-.2254	.0012	.0010	-.0032
13.52	1.068	.3021	-.3061	.0002	.0008	-.0052
M = 0.80						
-4.89	-.402	.0634	.0427	-.0005	-.0018	-.0040
-2.29	-.160	.0402	.0680	-.0007	-.0030	-.0052
-1.03	-.039	.0370	.0754	-.0008	-.0033	-.0045
0.30	.100	.0377	.0785	-.0007	-.0032	-.0048
1.59	.222	.0415	.0755	-.0011	-.0023	-.0064
2.89	.353	.0508	.0651	-.0007	-.0019	-.0078
4.19	.490	.0672	.0490	-.0007	-.0007	-.0089
5.47	.623	.0912	.0162	-.0001	-.0004	-.0069
7.88	.810	.1471	-.0683	.0008	-.0006	-.0050
10.00	.919	.2090	-.1825	.0005	-.0007	-.0035
12.19	1.032	.2742	-.2825	-.0009	.0002	-.0052
14.34	1.118	.3419	-.3795	.0040	-.0049	.0048
M = 0.90						
-5.13	-.444	.0774	.0516	-.0003	-.0025	-.0037
-2.39	-.175	.0437	.0669	-.0003	-.0036	-.0040
-0.94	-.019	.0388	.0913	-.0004	-.0036	-.0040
0.55	.167	.0426	.0938	-.0007	-.0033	-.0055
1.96	.317	.0522	.0891	-.0009	-.0024	-.0065
3.42	.493	.0718	.0729	-.0007	-.0021	-.0071
4.81	.655	.0996	.0465	-.0004	-.0016	-.0059
5.99	.735	.1254	.0021	.0007	-.0010	-.0052
8.42	.928	.1878	-.0837	-.0004	-.0012	-.0047
M = 0.95						
-5.52	-.558	.1001	.0316	-.0009	-.0022	-.0024
-2.59	-.236	.0592	.0596	-.0001	-.0038	-.0034
-1.05	-.054	.0517	.0731	-.0004	-.0037	-.0041
0.63	.180	.0561	.0723	-.0003	-.0032	-.0047
2.05	.340	.0676	.0624	-.0004	-.0030	-.0055
3.50	.511	.0884	.0439	-.0007	-.0023	-.0061
4.95	.681	.1181	.0105	-.0009	-.0018	-.0060
6.31	.836	.1536	-.0313	-.0006	-.0016	-.0061
9.05	1.121	.2462	-.1512	.0004	-.0015	-.0042
11.54	1.322	.3441	-.2560	.0000	-.0015	-.0053
13.96	1.504	.4526	-.3560	.0027	-.0020	-.0036
16.10	1.581	.5414	-.4766	-.0006	-.0016	-.0073

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
M = 1.00						
-5.62	-.574	.1266	.0646	.0001	-.0028	-.0011
-2.67	-.253	.0806	.0660	-.0001	-.0048	-.0018
-1.15	-.086	.0729	.0743	.0000	-.0051	-.0024
0.45	.131	.0766	.0676	-.0003	-.0056	-.0021
1.98	.306	.0882	.0513	-.0001	-.0044	-.0034
3.48	.480	.1104	.0300	-.0004	-.0034	-.0048
4.90	.648	.1399	-.0080	-.0003	-.0031	-.0034
6.31	.811	.1782	-.0654	-.0001	-.0022	-.0041
9.00	1.092	.2686	-.2016	.0004	-.0016	-.0045
11.47	1.304	.3659	-.3366	.0038	-.0011	-.0004
14.04	1.508	.4815	-.4939	.0012	.0005	-.0058
16.39	1.685	.6038	-.6525	.0009	.0024	-.0079
M = 1.13						
-5.64	-.559	.1334	.1232	-.0004	-.0012	-.0021
-2.75	-.285	.0944	.1122	-.0015	-.0020	-.0057
-1.27	-.130	.0855	.1034	-.0011	-.0025	-.0061
0.28	.045	.0857	.0844	-.0014	-.0027	-.0062
1.71	.197	.0936	.0567	-.0013	-.0022	-.0069
3.23	.365	.1105	.0155	-.0011	-.0013	-.0076
4.69	.533	.1351	-.0361	-.0013	-.0016	-.0063
6.12	.694	.1679	-.0941	-.0012	-.0019	-.0059
8.88	.966	.2486	-.2079	-.0010	-.0020	-.0055
11.48	1.173	.3393	-.3080	-.0007	-.0016	-.0057
13.87	1.321	.4297	-.3999	-.0007	-.0013	-.0057
16.33	1.486	.5391	-.5150	-.0005	-.0025	-.0083
M = 1.20						
-5.58	-.550	.1401	.1520	-.0002	.0010	-.0059
-2.69	-.290	.1011	.1265	-.0006	.0004	-.0072
-1.25	-.139	.0935	.1063	-.0006	.0001	-.0074
0.28	.035	.0926	.0736	-.0007	.0015	-.0102
1.74	.182	.1003	.0438	-.0008	.0001	-.0089
3.21	.341	.1161	-.0022	-.0008	.0007	-.0085
4.59	.494	.1384	-.0582	-.0005	.0008	-.0073
6.03	.644	.1680	-.1201	-.0002	.0013	-.0088
8.75	.926	.2460	-.2450	.0010	.0012	-.0075
11.43	1.138	.3360	-.3473	.0022	.0001	-.0047
13.87	1.287	.4242	-.4339	.0011	.0004	-.0068
16.33	1.444	.5310	-.5376	.0013	-.0012	-.0067

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TABLE I.- AERODYNAMIC CHARACTERISTICS OF THE COMPLETE MODEL - Continued

(b) Complete control; δ_s = -0.10c; δ_d = -0.075c

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
M = 0.60						
-4.77	-.509	.1245	-.0053	.0263	.0122	.0383
-2.44	-.313	.1000	.0238	.0231	.0113	.0389
-1.30	-.216	.0953	.0253	.0231	.0104	.0375
-0.14	-.114	.0932	.0256	.0240	.0101	.0365
1.02	-.020	.0925	.0213	.0247	.0099	.0377
2.17	.078	.0941	.0129	.0256	.0074	.0385
3.33	.177	.0976	.0047	.0259	.0067	.0395
4.47	.286	.1049	-.0109	.0251	.0054	.0383
6.87	.550	.1391	-.0552	.0187	.0030	.0268
9.18	.764	.1912	-.1217	.0150	.0018	.0225
11.38	.922	.2549	-.2174	.0064	-.0003	.0187
13.54	1.041	.3204	-.2971	.0027	-.0034	.0175
M = 0.80						
-5.45	-.605	.1413	-.0344	.0266	.0106	.0454
-2.82	-.363	.1052	.0072	.0231	.0095	.0430
-1.50	-.243	.0967	.0223	.0223	.0089	.0408
-0.20	-.113	.0935	.0327	.0228	.0090	.0390
1.05	-.010	.0916	.0369	.0233	.0088	.0400
2.33	.115	.0939	.0321	.0237	.0079	.0397
3.84	.263	.1026	.0181	.0228	.0060	.0393
4.96	.403	.1173	.0000	.0224	.0035	.0403
7.65	.699	.1644	-.0621	.0177	.0024	.0258
9.98	.878	.2272	-.1678	.0063	.0005	.0190
12.17	1.001	.2917	-.2722	.0032	-.0034	.0189
14.36	1.105	.3624	-.3682	.0009	-.0065	.0161
M = 0.90						
-5.98	-.716	.1663	-.0612	.0336	.0078	.0535
-3.17	-.444	.1154	-.0078	.0236	.0073	.0425
-1.69	-.279	.1003	.0221	.0213	.0072	.0405
-0.27	-.121	.0946	.0403	.0211	.0075	.0391
1.09	-.001	.0935	.0505	.0220	.0079	.0392
2.56	.182	.1002	.0486	.0206	.0064	.0378
4.03	.364	.1158	.0369	.0207	.0050	.0356
5.43	.520	.1383	.0059	.0178	.0014	.0348
8.04	.774	.1935	-.0646	.0121	-.0009	.0291
10.54	1.003	.2678	-.1681	.0071	-.0027	.0278
M = 0.95						
-6.32	-.788	.1884	-.0848	.0234	.0047	.0449
-3.45	-.516	.1303	-.0201	.0208	.0056	.0413
-1.88	-.327	.1112	.0140	.0212	.0065	.0381
-0.27	-.124	.1026	.0497	.0216	.0074	.0361
1.27	.055	.1032	.0616	.0228	.0080	.0344
2.85	.273	.1154	.0488	.0250	.0053	.0377
4.33	.456	.1364	.0273	.0261	.0001	.0448
5.79	.625	.1652	-.0049	.0271	-.0055	.0518
8.52	.910	.2397	-.0921	.0310	-.0134	.0624
10.99	1.113	.3221	-.1998	.0250	-.0139	.0568
13.52	1.334	.4270	-.3087	.0251	-.0111	.0512
15.63	1.408	.5027	-.4224	.0190	-.0053	.0289

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
M = 1.00						
-6.40	-.794	.2164	-.0214	.0200	.0102	.0410
-3.52	-.522	.1565	.0253	.0192	.0094	.0390
-1.96	-.345	.1350	.0458	.0200	.0097	.0361
-0.26	-.125	.1240	.0701	.0223	.0093	.0350
1.34	.069	.1255	.0713	.0237	.0100	.0359
2.91	.269	.1397	.0563	.0247	.0079	.0400
4.40	.444	.1620	.0313	.0250	.0030	.0456
5.84	.607	.1908	-.0111	.0251	-.0012	.0514
8.59	.905	.2687	-.1348	.0257	-.0051	.0581
11.20	1.148	.3629	-.2775	.0238	-.0086	.0621
13.65	1.340	.4651	-.3908	.0256	-.0064	.0547
16.07	1.523	.5749	-.5374	.0280	.0004	.0378
M = 1.13						
-6.27	-.722	.2125	.0406	.0198	-.0045	.0515
-3.37	-.466	.1602	.0796	.0193	-.0043	.0517
-1.85	-.306	.1416	.0847	.0182	-.0051	.0513
-0.29	-.137	.1330	.0802	.0171	-.0058	.0502
1.21	.022	.1320	.0647	.0165	-.0071	.0501
2.74	.202	.1413	.0339	.0158	-.0081	.0509
4.21	.371	.1603	-.0072	.0169	-.0111	.0549
5.68	.531	.1863	-.0548	.0179	-.0134	.0591
8.49	.811	.2560	-.1525	.0197	-.0189	.0661
11.11	1.029	.3384	-.2495	.0186	-.0257	.0705
13.57	1.194	.4278	-.3402	.0173	-.0286	.0723
16.03	1.359	.5265	-.4379	.0174	-.0253	.0601
M = 1.20						
-6.22	-.712	.2152	.1010	.0205	-.0014	.0507
-3.31	-.454	.1641	.1174	.0194	-.0039	.0516
-1.82	-.306	.1467	.1102	.0186	-.0050	.0505
-0.26	-.133	.1368	.0954	.0181	-.0070	.0501
1.16	.008	.1359	.0749	.0178	-.0093	.0513
2.67	.183	.1443	.0360	.0172	-.0123	.0528
4.13	.349	.1615	-.0138	.0173	-.0156	.0557
5.60	.496	.1860	-.0660	.0176	-.0180	.0587
8.38	.774	.2529	-.1755	.0194	-.0242	.0668
11.07	.997	.3341	-.2752	.0190	-.0274	.0695
13.53	1.159	.4206	–-.3673	.0169	-.0318	.0739
15.97	1.323	.5178	-.4614	.0166	-.0316	.0717

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TABLE I.- AERODYNAMIC CHARACTERISTICS OF THE COMPLETE MODEL - Continued

(c) Outboard two-thirds span of complete control; δ_s = -0.02c; δ_d = -0.015c

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
M = 0.60						
0.12	.032	.0401	.0657	.0044	-.0016	-.0047
2.44	.232	.0460	.0486	.0040	-.0012	-.0048
4.76	.450	.0680	.0176	.0036	-.0003	-.0044
7.05	.664	.1137	-.0379	.0027	.0007	-.0046
10.30	.879	.2020	-.1709	.0040	-.0013	-.0024
13.49	1.044	.2997	-.3048	.0026	-.0025	-.0012
M = 0.80						
-4.97	-.439	.0699	.0369	.0057	-.0003	-.0002
-2.36	-.203	.0442	.0670	.0054	-.0020	-.0008
0.27	.059	.0411	.0799	.0047	-.0027	-.0008
2.86	.328	.0532	.0674	.0039	-.0018	-.0026
5.47	.597	.0912	.0216	.0024	-.0006	-.0039
7.84	.791	.1449	-.0555	.0023	-.0006	-.0022
11.08	.954	.2386	-.2251	.0034	-.0027	-.0007
14.30	1.097	.3385	-.3712	.0069	-.0071	.0076
M = 0.90						
-5.26	-.493	.0855	.0432	.0073	-.0016	.0017
-2.54	-.232	.0494	.0643	.0070	-.0027	.0015
0.45	.114	.0460	.1001	.0056	-.0032	-.0007
3.32	.446	.0707	.0841	.0041	-.0023	-.0028
6.01	.728	.1270	.0196	.0099	-.0029	.0047
8.35	.883	.1836	-.0672	.0051	-.0026	.0018
11.70	1.080	.2846	-.2530	.0078	-.0055	.0045
15.02	1.251	.4062	-.4284	.0116	-.0107	.0106
M = 0.95						
-5.63	-.599	.1081	.0250	.0080	-.0009	.0009
-2.69	-.282	.0635	.0627	.0063	-.0032	.0018
0.51	.140	.0592	.0849	.0063	-.0038	-.0002
3.46	.482	.0907	.0586	.0052	-.0041	.0004
6.31	.814	.1558	-.0202	.0044	-.0045	.0012
9.04	1.109	.2472	-.1362	.0054	-.0038	.0006
12.70	1.386	.3918	-.2954	.0065	-.0025	-.0003
16.02	1.550	.5328	-.4699	.0098	-.0057	.0011
M = 1.00						
-5.73	-.611	.1321	.0566	.0056	-.0027	.0046
-2.73	-.293	.0821	.0696	.0051	-.0051	.0035
0.37	.086	.0748	.0802	.0050	-.0054	.0020
3.43	.452	.1093	.0472	.0045	-.0044	.0013
6.32	.788	.1763	-.0499	.0039	-.0038	.0018
9.04	1.082	.2699	-.1953	.0042	-.0040	.0015
12.74	1.381	.4177	-.4103	.0054	-.0005	-.0009
16.39	1.661	.5980	-.6287	.0096	-.0013	-.0056
M = 1.13						
-5.67	-.573	.1396	.1244	.0023	-.0013	.0015
-2.76	-.304	.0978	.1188	.0014	-.0038	.0004
0.24	.020	.0888	.0950	.0013	-.0046	-.0003
3.19	.347	.1118	.0273	.0014	-.0040	-.0007
6.17	.686	.1707	-.0846	.0018	-.0039	-.0007
8.95	.965	.2535	-.1997	.0018	-.0040	-.0022
12.63	1.219	.3792	-.3366	.0029	-.0038	-.0001
16.31	1.475	.5386	-.5146	.0036	-.0062	-.0060
M = 1.20						
-5.63	-.573	.1442	.1585	.0010	.0030	-.0003
-2.75	-.307	.1033	.1372	.0014	.0015	-.0027
0.24	.020	.0941	.0922	.0016	.0000	-.0025
3.16	.330	.1149	.0134	.0012	-.0004	-.0037
6.08	.645	.1686	-.1077	.0016	.0004	-.0045
8.85	.922	.2472	-.2330	.0021	.0013	-.0064
12.61	1.200	.3748	-.3757	.0050	.0000	-.0017
16.25	1.425	.5236	-.5250	.0048	-.0027	-.0004

TABLE I.- AERODYNAMIC CHARACTERISTICS OF THE COMPLETE MODEL - Continued

(d) Outboard two-thirds span of complete control; δ_s = -0.05c; δ_d = -0.0375c

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
M = 0.60						
0.00	-.016	.0514	.0600	.0113	.0017	.0020
2.31	.190	.0546	.0415	.0118	.0007	.0040
4.66	.421	.0757	.0078	.0093	.0015	.0025
7.00	.658	.1185	-.0443	.0049	.0014	-.0017
10.33	.889	.2083	-.1737	.0043	-.0010	-.0001
13.47	1.044	.3035	-.3068	.0022	-.0029	-.0015
M = 0.80						
-5.13	-.499	.0853	.0231	.0154	.0028	.0104
-2.48	-.234	.0556	.0598	.0107	.0012	.0057
0.12	.020	.0502	.0804	.0104	.0005	.0041
2.72	.279	.0588	.0664	.0090	.0005	.0033
5.36	.574	.0946	.0206	.0056	.0005	.0011
7.86	.804	.1512	-.0561	.0003	.0001	-.0010
10.03	.927	.2153	-.1742	-.0023	-.0012	-.0030
12.16	1.028	.2784	-.2770	-.0034	-.0018	-.0051
14.32	1.104	.3457	-.3701	.0024	-.0036	-.0001
M = 0.90						
-5.49	-.568	.1038	.0221	.0194	.0012	.0168
-2.73	-.301	.0657	.0538	.0163	.0000	.0121
0.26	.061	.0548	.0963	.0113	-.0002	.0063
3.22	.414	.0763	.0829	.0078	-.0001	.0045
5.99	.733	.1312	.0190	.0078	-.0017	.0071
8.37	.901	.1916	-.0715	.0026	-.0019	.0041
12.73	1.133	.3261	-.3155	.0007	-.0050	.0018
14.98	1.249	.4096	-.4223	.0090	-.0094	.0100
M = 0.95						
-5.89	-.666	.1275	.0044	.0159	.0011	.0134
-2.88	-.338	.0773	.0555	.0154	.0000	.0121
0.37	.090	.0670	.0891	.0151	-.0012	.0119
3.31	.433	.0947	.0677	.0134	-.0029	.0125
6.19	.774	.1569	-.0115	.0114	-.0057	.0138
8.89	1.056	.2428	-.1266	.0146	-.0085	.0211
11.35	1.256	.3336	-.2289	.0099	-.0045	.0082
13.83	1.460	.4442	-.3447	.0112	-.0049	.0078
15.91	1.528	.5266	-.4689	.0086	-.0067	.0026

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
M = 1.00						
-5.92	-.662	.1506	.0465	.0142	.0001	.0155
-2.91	-.341	.0957	.0720	.0126	-.0019	.0144
0.20	.033	.0836	.0890	.0126	-.0035	.0130
3.28	.408	.1142	.0543	.0118	-.0048	.0147
6.18	.749	.1771	-.0433	.0095	-.0064	.0155
8.88	1.033	.2651	-.1814	.0116	-.0068	.0189
11.40	1.242	.3592	-.3158	.0081	-.0022	.0078
13.86	1.466	.4729	-.4830	.0099	-.0037	.0074
16.34	1.644	.5935	-.6175	.0129	-.0015	-.0027
M = 1.13						
-5.82	-.613	.1556	.1288	.0091	-.0021	.0169
-2.91	-.339	.1118	.1299	.0071	-.0042	.0125
0.08	-.021	.1001	.1081	.0069	-.0067	.0160
3.10	.314	.1178	.0389	.0065	-.0074	.0117
6.03	.654	.1725	-.0755	.0063	-.0079	.0124
8.85	.937	.2534	-.1943	.0063	-.0070	.0113
11.35	1.137	.3386	-.2938	.0090	-.0079	.0124
13.78	1.286	.4254	-.3834	.0065	-.0066	.0070
16.25	1.459	.5355	-.5021	.0063	-.0075	.0013
M = 1.20						
-5.81	-.614	.1589	.1642	.0078	.0039	.0110
-2.90	-.350	.1153	.1461	.0070	.0019	.0082
0.10	-.030	.1011	.1082	.0073	.0000	.0073
3.04	.291	.1189	.0283	.0061	-.0032	.0090
5.92	.612	.1688	-.0908	.0057	-.0033	.0070
8.77	.893	.2459	-.2165	.0062	-.0024	.0042
11.37	1.111	.3328	-.3237	.0057	-.0020	.0023
13.79	1.258	.4179	-.4104	.0065	-.0028	.0034
16.24	1.415	.5221	-.5156	.0072	-.0045	.0058

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TABLE I.- AERODYNAMIC CHARACTERISTICS OF THE COMPLETE MODEL - Continued

(e) Outboard two-thirds span of complete control; δ_s = -0.10c; δ_d = -0.075c

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
M = 0.60						
-0.07	-.064	.0689	.0470	.0205	.0065	.0203
2.23	.128	.0705	.0357	.0217	.0065	.0206
4.59	.356	.0854	.0023	.0204	.0073	.0170
6.94	.612	.1253	-.0440	.0124	.0039	.0088
10.32	.906	.2150	-.1696	.0035	.0007	.0022
13.54	1.064	.3133	-.3033	-.0002	-.0026	.0022
M = 0.80						
-5.26	-.552	.1106	.0041	.0238	.0083	.0256
-2.66	-.306	.0780	.0410	.0204	.0064	.0246
-1.35	-.181	.0707	.0555	.0196	.0059	.0252
-0.04	-.054	.0687	.0620	.0199	.0056	.0235
1.22	.055	.0686	.0625	.0207	.0057	.0233
2.52	.193	.0733	.0541	.0199	.0045	.0229
3.82	.330	.0836	.0413	.0190	.0043	.0213
5.17	.487	.1018	.0182	.0175	.0045	.0171
7.71	.747	.1526	-.0514	.0123	.0023	.0104
9.99	.917	.2185	-.1685	.0005	-.0009	.0032
12.18	1.035	.2855	-.2746	-.0030	-.0025	.0019
14.31	1.113	.3530	-.3712	.0008	-.0027	.0039
M = 0.90						
-5.71	-.649	.1341	-.0118	.0319	.0049	.0359
-2.88	-.350	.0871	.0332	.0214	.0053	.0254
-1.43	-.191	.0757	.0576	.0197	.0047	.0234
0.03	-.035	.0731	.0779	.0200	.0045	.0233
1.41	.114	.0748	.0826	.0193	.0045	.0207
2.90	.301	.0857	.0751	.0179	.0039	.0196
4.35	.483	.1056	.0570	.0180	.0036	.0191
5.76	.649	.1338	.0272	.0183	.0021	.0196
8.23	.855	.1925	-.0635	.0070	-.0008	.0136
12.81	1.156	.3359	-.3167	-.0008	-.0057	.0077
15.02	1.270	.4215	-.4239	.0033	-.0061	.0092
M = 0.95						
-6.05	-.726	.1571	-.0273	.0222	.0065	.0246
-3.12	-.425	.1022	.0249	.0206	.0051	.0222
-1.51	-.218	.0862	.0558	.0213	.0049	.0213
0.16	.013	.0833	.0796	.0228	.0048	.0210
1.70	.198	.0888	.0806	.0225	.0026	.0221
3.11	.362	.1052	.0673	.0221	.0009	.0246
4.54	.530	.1294	.0422	.0222	-.0015	.0285
5.97	.693	.1605	.0030	.0231	-.0048	.0325
8.69	.983	.2431	-.1002	.0257	-.0120	.0423
11.16	1.192	.3324	-.2114	.0200	-.0131	.0377
13.69	1.408	.4426	-.3294	.0192	-.0137	.0347
15.84	1.506	.5270	-.4631	.0145	-.0099	.0175
M = 1.00						
-6.06	-.725	.1836	.0196	.0202	.0045	.0284
-3.13	-.425	.1257	.0540	.0205	.0056	.0234
-1.55	-.234	.1083	.0678	.0210	.0049	.0236
0.06	-.018	.1039	.0770	.0208	.0036	.0239
1.59	.169	.1094	.0731	.0202	.0022	.0243
3.08	.344	.1270	.0537	.0204	.0011	.0273
4.51	.511	.1524	.0200	.0203	-.0004	.0304
5.90	.669	.1833	-.0321	.0202	-.0037	.0356
8.73	.973	.2689	-.1712	.0206	-.0103	.0426
11.23	1.191	.3607	-.3029	.0159	-.0127	.0387
13.75	1.419	.4737	-.4615	.0163	-.0141	.0369
16.17	1.599	.5896	-.5819	.0196	-.0085	.0225
M = 1.13						
-5.97	-.663	.1807	.0951	.0188	.0015	.0298
-3.07	-.397	.1327	.1115	.0169	-.0028	.0309
-1.56	-.238	.1180	.1107	.0154	-.0050	.0302
-0.03	-.071	.1129	.0997	.0144	-.0062	.0290
1.42	.086	.1159	.0761	.0140	-.0073	.0293
2.89	.255	.1284	.0389	.0142	-.0082	.0305
4.36	.426	.1484	-.0063	.0145	-.0102	.0326
5.87	.592	.1793	-.0623	.0154	-.0119	.0361
8.60	.863	.2517	-.1667	.0169	-.0139	.0386
11.18	1.075	.3352	-.2685	.0159	-.0153	.0358
13.60	1.234	.4230	-.3643	.0138	-.0165	.0332
16.08	1.412	.5289	-.4759	.0128	-.0130	.0219
M = 1.20						
-5.88	-.656	.1825	.1474	.0163	.0068	.0267
-3.03	-.396	.1361	.1413	.0158	.0032	.0245
-1.55	-.244	.1214	.1300	.0156	.0009	.0243
-0.05	-.074	.1167	.1082	.0152	-.0018	.0262
1.33	.065	.1198	.0802	.0153	-.0037	.0275
2.87	.241	.1314	.0356	.0146	-.0065	.0291
4.36	.394	.1499	-.0142	.0146	-.0085	.0300
5.73	.550	.1756	-.0723	.0149	-.0098	.0303
8.53	.827	.2467	-.1916	.0165	-.0112	.0312
11.13	1.044	.3281	-.2967	.0159	-.0109	.0282
13.58	1.205	.4141	-.3908	.0145	-.0136	.0287
16.04	1.371	.5165	-.4883	.0131	-.0128	.0260

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TABLE I.- AERODYNAMIC CHARACTERISTICS OF THE COMPLETE MODEL - Continued

(f) Outboard two-thirds span of complete control; $\delta_s = -0.122c$; $\delta_d = -0.0915c$

M = 0.60

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
-0.10	-.076	.0863	.0474	.0202	.0096	.0252
2.21	.114	.0863	.0337	.0219	.0085	.0253
4.53	.336	.1036	.0070	.0209	.0082	.0213
6.91	.603	.1454	-.0372	.0133	.0063	.0094
10.29	.889	.2243	-.1638	.0041	.0010	.0065
13.47	1.040	.3189	-.3047	.0046	-.0038	.0117

M = 0.80

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
-5.32	-.561	.1256	.0022	.0240	.0100	.0317
-2.72	-.323	.0928	.0365	.0208	.0087	.0309
-0.11	-.076	.0836	.0583	.0207	.0082	.0299
2.42	.162	.0873	.0527	.0215	.0080	.0281
5.08	.454	.1114	.0210	.0202	.0067	.0237
7.66	.728	.1603	-.0488	.0158	.0043	.0144
9.94	.897	.2246	-.1649	.0041	.0002	.0099
12.14	1.011	.2917	-.2746	.0024	-.0024	.0104
14.30	1.100	.3594	-.3634	.0046	-.0037	.0118

M = 0.90

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
-5.72	-.650	.1471	-.0111	.0300	.0079	.0374
-2.97	-.379	.1042	.0244	.0232	.0076	.0300
-0.10	-.064	.0890	.0671	.0212	.0072	.0292
2.74	.248	.0968	.0736	.0207	.0072	.0256
5.51	.559	.1378	.0249	.0182	.0060	.0223
8.10	.803	.1961	-.0550	.0132	.0024	.0202
12.74	1.132	.3399	-.3123	.0047	-.0036	.0144
14.96	1.243	.4227	-.4234	.0126	-.0116	.0256

M = 0.95

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
-6.12	-.740	.1715	-.0411	.0226	.0080	.0311
-3.23	-.446	.1162	.0133	.0211	.0068	.0287
-0.03	-.042	.0950	.0735	.0226	.0066	.0270
3.03	.327	.1137	.0686	.0258	.0035	.0316
5.88	.660	.1656	.0103	.0285	-.0020	.0400
8.59	.938	.2430	-.0882	.0332	-.0121	.0540
11.10	1.155	.3311	-.2072	.0251	-.0133	.0468
13.53	1.363	.4318	-.3306	.0218	-.0141	.0420
15.54	1.406	.5003	-.4595	.0251	-.0137	.0318

M = 1.00

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
-6.15	-.738	.1988	.0096	.0200	.0085	.0319
-3.24	-.446	.1432	.0418	.0197	.0089	.0273
-0.04	-.043	.1172	.0735	.0227	.0081	.0276
3.04	.328	.1406	.0577	.0237	.0054	.0320
5.92	.652	.1935	-.0183	.0250	.0003	.0401
8.64	.941	.2740	-.1568	.0264	-.0087	.0540
11.15	1.170	.3662	-.3082	.0193	-.0148	.0526
13.69	1.393	.4762	-.4458	.0219	-.0175	.0497
16.07	1.573	.5873	-.5981	.0225	-.0087	.0268

M = 1.13

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
-6.09	-.683	.1972	.0820	.0195	.0020	.0365
-3.21	-.419	.1486	.1018	.0193	-.0028	.0398
-0.19	-.099	.1280	.0916	.0171	-.0062	.0390
2.85	.240	.1414	.0323	.0165	-.0081	.0393
5.79	.576	.1885	-.0627	.0185	-.0124	.0437
8.54	.845	.2601	-.1715	.0202	-.0187	.0516
11.18	1.066	.3466	-.2785	.0184	-.0235	.0545
13.57	1.223	.4328	-.3712	.0152	-.0253	.0527
16.05	1.413	.5407	-.4825	.0148	-.0216	.0398

M = 1.20

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
-6.01	-.674	.1993	.1346	.0183	.0074	.0335
-3.18	-.419	.1513	.1344	.0185	.0022	.0342
-0.19	-.104	.1321	.1030	.0184	-.0030	.0359
2.77	.217	.1435	.0334	.0178	-.0076	.0377
5.67	.533	.1862	-.0745	.0182	-.0121	.0405
8.47	.813	.2559	-.1920	.0198	-.0159	.0440
11.06	1.034	.3362	-.2990	.0186	-.0184	.0433
13.54	1.192	.4228	-.3875	.0171	-.0217	.0448
16.03	1.368	.5271	-.4912	.0155	-.0218	.0422

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TABLE I.- AERODYNAMIC CHARACTERISTICS OF THE COMPLETE MODEL - Continued

(g) Outboard two-thirds span of complete control; δ_s = -0.133c; δ_d = -0.10c

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
M = 0.60						
-0.11	-.079	.0868	.0394	.0201	.0107	.0317
2.21	.115	.0890	.0281	.0220	.0107	.0322
4.52	.327	.1021	-.0015	.0216	.0090	.0301
6.95	.598	.1373	-.0420	.0153	.0081	.0168
10.34	.900	.2231	-.1651	.0043	.0018	.0091
13.51	1.054	.3213	-.3076	.0043	-.0029	.0142
M = 0.80						
-5.34	-.567	.1297	-.0078	.0247	.0123	.0352
-2.73	-.324	.0976	.0247	.0210	.0102	.0370
-0.12	-.076	.0881	.0469	.0207	.0106	.0348
2.41	.156	.0913	.0451	.0218	.0104	.0330
5.07	.445	.1154	.0158	.0215	.0084	.0300
7.67	.716	.1632	-.0503	.0183	.0062	.0197
9.99	.900	.2272	-.1631	.0060	.0012	.0135
12.14	1.007	.2921	-.2768	.0047	-.0007	.0129
14.36	1.117	.3662	-.3665	.0059	-.0027	.0155
M = 0.90						
-5.79	-.649	.1544	-.0211	.0295	.0101	.0414
-3.05	-.393	.1110	.0132	.0236	.0097	.0342
-0.13	-.071	.0938	.0539	.0210	.0098	.0323
2.69	.224	.1014	.0641	.0212	.0098	.0299
5.59	.571	.1437	.0276	.0244	.0080	.0304
12.81	1.138	.3455	-.3116	.0072	-.0015	.0181
15.01	1.257	.4302	-.4272	.0128	-.0097	.0288
M = 0.95						
-6.18	-.746	.1799	-.0557	.0235	.0096	.0353
-3.33	-.469	.1257	-.0013	.0217	.0090	.0328
-0.11	-.068	.1031	.0608	.0226	.0090	.0298
-0.11	-.068	.1028	.0616	.0226	.0090	.0298
2.95	.307	.1186	.0627	.0273	.0063	.0348
5.88	.649	.1687	.0093	.0313	-.0010	.0440
8.58	.923	.2474	-.0872	.0377	-.0090	.0576
11.17	1.177	.3392	-.2081	.0339	-.0145	.0569
13.50	1.337	.4257	-.3472	.0299	-.0124	.0408
15.61	1.403	.5048	-.4592	.0269	-.0120	.0350
M = 1.00						
-6.22	-.744	.2070	-.0056	.0205	.0120	.0352
-3.34	-.467	.1505	.0303	.0194	.0126	.0314
-0.11	-.069	.1243	.0685	.0229	.0123	.0284
3.01	.304	.1434	.0589	.0257	.0086	.0351
5.90	.634	.1951	-.0123	.0281	.0036	.0422
8.63	.917	.2746	-.1375	.0313	-.0031	.0544
11.20	1.174	.3703	-.3050	.0280	-.0109	.0599
13.71	1.387	.4765	-.4488	.0250	-.0119	.0492
16.09	1.559	.5871	-.5977	.0266	.0006	.0264
M = 1.13						
-6.12	-.690	.2055	.0732	.0202	.0027	.0439
-3.28	-.431	.1573	.0974	.0201	-.0013	.0453
-0.21	-.107	.1349	.0851	.0183	-.0050	.0445
2.84	.230	.1475	.0263	.0177	-.0079	.0444
5.80	.568	.1927	-.0691	.0200	-.0132	.0498
8.56	.844	.2660	-.1833	.0227	-.0211	.0608
11.12	1.055	.3518	-.2940	.0218	-.0283	.0676
13.57	1.215	.4374	-.3852	.0175	-.0306	.0655
16.08	1.407	.5409	-.5089	.0124	-.0271	.0424
M = 1.20						
-6.07	-.684	.2068	.1193	.0193	.0088	.0382
-3.22	-.428	.1588	.1237	.0198	.0038	.0397
-0.20	-.115	.1380	.0935	.0196	-.0014	.0398
2.76	.209	.1483	.0254	.0192	-.0062	.0418
5.68	.529	.1898	-.0787	.0198	-.0120	.0456
8.48	.804	.2595	-.1964	.0220	-.0183	.0527
11.07	1.017	.3415	-.3014	.0214	-.0247	.0585
13.57	1.185	.4287	-.3878	.0182	-.0280	.0596
16.08	1.358	.5340	-.4922	.0168	-.0275	.0594

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TABLE I.- AERODYNAMIC CHARACTERISTICS OF THE COMPLETE MODEL - Continued

(h) Outboard one-third span of complete control; δ_s = -0.10c; δ_d = -0.075c

M = 0.60

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y

M = 0.80

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
-5.13	-.495	.0863	.0244	.0184	.0058	.0092
-2.51	-.239	.0575	.0559	.0140	.0036	.0073
0.10	.024	.0508	.0758	.0138	.0032	.0059
2.74	.287	.0596	.0677	.0116	.0033	.0025
5.39	.594	.0967	.0248	.0072	.0036	-.0032
7.86	.822	.1520	-.0514	.0008	.0019	-.0031
10.08	.934	.2167	-.1703	.0004	.0002	-.0034
12.21	1.039	.2815	-.2741	-.0019	.0013	-.0081
14.36	1.126	.3501	-.3686	-.0037	.0052	-.0153

M = 0.90

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
-5.55	-.585	.1068	.0181	.0252	.0041	.0168
-2.70	-.283	.0646	.0523	.0159	.0029	.0078
0.27	.062	.0555	.0955	.0141	.0029	.0054
3.26	.425	.0761	.0823	.0101	.0019	.0019
6.07	.754	.1327	.0217	.0112	-.0003	.0046
8.50	.946	.1964	-.0713	.0009	.0005	-.0027
12.86	1.178	.3370	-.3212	.0013	-.0010	-.0040
15.16	1.301	.4260	-.4296	.0030	-.0016	-.0055

M = 0.95

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
-5.87	-.663	.1270	.0108	.0171	.0049	.0099
-2.85	-.331	.0768	.0541	.0162	.0028	.0084
0.38	.098	.0677	.0882	.0162	.0021	.0072
3.33	.437	.0950	.0682	.0156	.0008	.0081
6.22	.782	.1572	-.0138	.0148	-.0021	.0084
8.96	1.081	.2468	-.1306	.0164	-.0056	.0130
11.48	1.296	.3451	-.2410	.0090	-.0013	-.0013
13.95	1.490	.4553	-.3525	.0096	-.0026	-.0010
16.01	1.547	.5348	-.4706	.0066	-.0034	-.0039

M = 1.00

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
-5.93	-.661	.1509	.0480	.0156	.0033	.0111
-2.93	-.339	.0985	.0694	.0142	.0012	.0088
0.26	.046	.0870	.0821	.0139	.0006	.0079
3.30	.414	.1163	.0531	.0143	.0001	.0087
6.17	.753	.1777	-.0416	.0131	-.0023	.0094
8.98	1.053	.2693	-.1813	.0145	-.0035	.0115
11.55	1.302	.3737	-.3340	.0129	.0003	.0037
13.99	1.501	.4859	-.4890	.0092	.0036	-.0065
16.35	1.657	.6013	-.6207	.0145	-.0010	-.0053

M = 1.13

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
-5.83	-.619	.1543	.1211	.0115	.0027	.0105
-2.94	-.342	.1125	.1219	.0096	-.0003	.0084
0.11	-.020	.0990	.1035	.0097	-.0020	.0077
3.07	.309	.1179	.0412	.0100	-.0029	.0069
6.11	.660	.1733	-.0687	.0104	-.0045	.0079
8.89	.935	.2530	-.1828	.0119	-.0047	.0068
11.49	1.156	.3444	-.2934	.0111	-.0040	.0028
13.92	1.314	.4364	-.3909	.0069	-.0008	-.0075
16.35	1.473	.5432	-.5056	.0075	-.0041	-.0075

M = 1.20

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
-5.79	-.610	.1591	.1624	.0089	.0071	.0073
-2.95	-.348	.1164	.1446	.0091	.0048	.0059
0.08	-.029	.1032	.1065	.0102	.0028	.0058
3.05	.292	.1212	.0311	.0098	.0004	.0057
5.94	.610	.1713	-.0847	.0104	-.0001	.0038
8.72	.890	.2477	-.2095	.0112	-.0003	.0028
11.39	1.127	.3383	-.3262	.0094	.0007	-.0011
13.84	1.273	.4259	-.4143	.0084	.0018	-.0052
16.22	1.424	.5276	-.5162	.0081	-.0004	-.0044

[redacted]

TABLE I.- AERODYNAMIC CHARACTERISTICS OF THE COMPLETE MODEL - Concluded

(i) Outboard one-third span of complete control; $\delta_s = -0.133c$; $\delta_d = -0.10c$

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
M = 0.60						
0.05	-.021	.0628	.0562	.0142	.0057	.0146
3.50	.294	.0730	.0273	.0144	.0060	.0118
7.02	.658	.1259	-.0377	.0062	.0028	.0031
10.34	.920	.2148	-.1619	-.0001	.0008	.0015
M = 0.80						
0.11	-.005	.0621	.0682	.0147	.0047	.0177
4.00	.399	.0805	.0474	.0132	.0055	.0106
7.84	.790	.1538	-.0507	.0057	.0022	.0050
11.13	.973	.2515	-.2164	-.0005	-.0002	.0046
M = 0.90						
0.21	.023	.0676	.0852	.0154	.0048	.0149
4.62	.564	.1056	.0574	.0145	.0032	.0113
8.42	.914	.1987	-.0715	.0058	.0013	.0058
11.71	1.089	.2970	-.2551	.0055	-.0015	.0075
M = 0.95						
0.32	.066	.0754	.0821	.0179	.0045	.0140
4.72	.577	.1230	.0417	.0183	.0008	.0176
8.84	1.037	.2443	-.1214	.0201	-.0055	.0228
12.64	1.364	.3953	-.2882	.0138	-.0047	.0137
M = 1.00						
0.21	.027	.0963	.0761	.0151	.0039	.0137
4.73	.564	.1488	.0121	.0156	.0007	.0170
8.89	1.024	.2691	-.1812	.0168	-.0043	.0206
12.67	1.361	.4233	-.4016	.0109	-.0023	.0101
M = 1.13						
0.09	-.032	.1075	.0973	.0108	-.0032	.0171
4.59	.469	.1464	-.0106	.0123	-.0060	.0175
8.76	.903	.2518	-.1751	.0137	-.0084	.0193
12.60	1.210	.3869	-.3355	.0092	-.0075	.0131
M = 1.20						
0.05	-.042	.1113	.1032	.0114	.0024	.0131
4.48	.447	.1503	-.0272	.0122	-.0025	.0140
8.66	.858	.2488	-.2014	.0142	-.0051	.0150
12.54	1.181	.3805	-.3659	.0126	-.0061	.0127

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TABLE II.- AERODYNAMIC CHARACTERISTICS OF THE MODEL WITHOUT WING-TIP NACELLES

[Complete control; $\delta_s = -0.10c$; $\delta_d = -0.075c$]

α, deg	C_L	C_D	C_m	C_l	C_n	C_Y
M = 0.60						
-0.13	-.092	.0795	.0294	.0176	.0040	.0336
2.07	.044	.0791	-.0062	.0175	.0016	.0350
4.25	.184	.0862	-.0496	.0177	.0003	.0349
6.49	.356	.1046	-.1026	.0176	.0006	.0334
9.88	.640	.1643	-.1968	.0148	.0002	.0222
13.26	.918	.2638	-.3229	.0121	-.0003	.0200
M = 0.80						
-4.88	-.373	.1027	.0362	.0175	.0053	.0396
-2.50	-.235	.0853	.0519	.0163	.0042	.0373
-0.20	-.088	.0790	.0362	.0156	.0032	.0358
2.13	.057	.0787	.0018	.0157	.0012	.0360
4.47	.229	.0886	-.0440	.0163	.0001	.0356
6.94	.451	.1130	-.1057	.0156	.0018	.0264
9.44	.687	.1655	-.1932	.0128	.0012	.0180
11.84	.885	.2359	-.2914	.0117	-.0013	.0180
14.12	1.041	.3123	-.3790	.0104	-.0009	.0194
M = 0.90						
-5.07	-.404	.1109	.0238	.0165	.0043	.0393
-2.64	-.251	.0902	.0556	.0156	.0032	.0373
-0.19	-.087	.0820	.0462	.0146	.0029	.0338
2.18	.072	.0831	.0115	.0148	.0016	.0345
4.70	.276	.0986	-.0382	.0158	.0018	.0340
7.35	.541	.1349	-.1113	.0160	.0039	.0235
9.97	.814	.2002	-.2156	.0177	-.0020	.0221
12.45	1.031	.2834	-.3237	.0211	-.0081	.0270
14.81	1.196	.3737	-.4252	.0240	-.0122	.0332
M = 0.95						
-5.22	-.430	.1205	.0133	.0166	.0047	.0397
-2.65	-.255	.0965	.0617	.0151	.0033	.0376
-0.21	-.087	.0885	.0523	.0146	.0030	.0356
2.23	.080	.0899	.0207	.0146	.0019	.0352
4.88	.324	.1103	-.0412	.0145	.0044	.0287
7.59	.607	.1577	-.1243	.0189	.0005	.0307
10.16	.845	.2277	-.2358	.0221	-.0016	.0354
12.67	1.060	.3145	-.3483	.0242	-.0039	.0363
15.08	1.244	.4129	-.4504	.0242	-.0095	.0402
M = 1.00						
-5.32	-.448	.1391	.0262	.0145	.0045	.0441
-2.67	-.258	.1136	.0761	.0126	.0062	.0381
-0.18	-.085	.1056	.0617	.0128	.0063	.0368
2.30	.091	.1072	.0194	.0127	.0042	.0376
4.96	.338	.1275	-.0402	.0131	.0036	.0342
7.65	.601	.1765	-.1327	.0153	-.0003	.0380
10.22	.843	.2489	-.2781	.0153	-.0063	.0484
12.72	1.056	.3361	-.4073	.0217	-.0102	.0494
15.16	1.244	.4349	-.5268	.0241	-.0152	.0545
M = 1.13						
-5.46	-.472	.1572	.0628	.0147	-.0062	.0477
-2.84	-.288	.1251	.0929	.0125	-.0054	.0441
-0.17	-.082	.1115	.0702	.0109	-.0055	.0428
2.44	.122	.1171	.0155	.0098	-.0069	.0430
5.03	.343	.1431	-.0677	.0097	-.0108	.0477
7.64	.563	.1875	-.1608	.0106	-.0160	.0538
10.19	.761	.2487	-.2540	.0125	-.0236	.0636
12.69	.948	.3237	-.3486	.0143	-.0300	.0718
15.07	1.103	.4004	-.4567	.0151	-.0390	.0752
M = 1.20						
-5.50	-.478	.1602	.0925	.0156	-.0033	.0445
-2.84	-.293	.1270	.1075	.0135	-.0048	.0417
-0.21	-.089	.1139	.0739	.0117	-.0070	.0412
2.41	.115	.1189	.0149	.0106	-.0109	.0439
5.02	.328	.1448	-.0690	.0103	-.0151	.0484
7.63	.549	.1898	-.1685	.0117	-.0189	.0539
10.17	.749	.2512	-.2683	.0134	-.0237	.0604
12.70	.934	.3257	-.3731	.0149	-.0284	.0658
15.11	1.081	.4033	-.4613	.0134	-.0351	.0736

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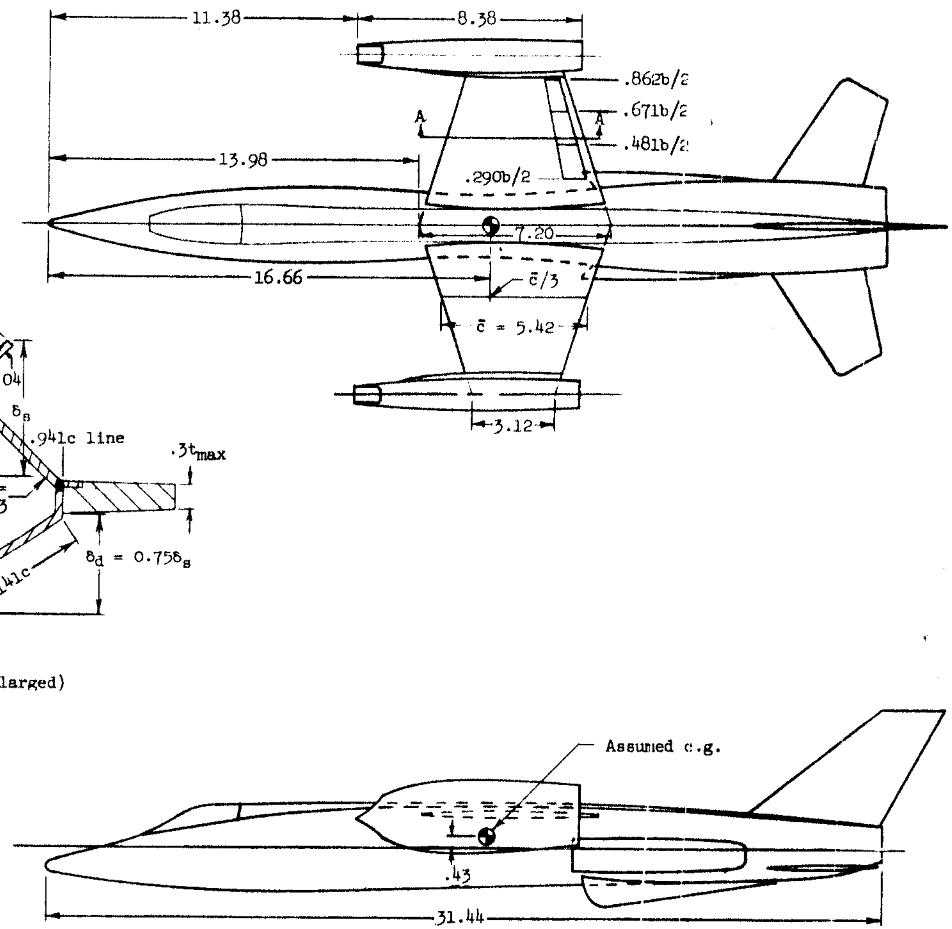
Wing data

Taper ratio	0.433
Aspect ratio	2.42
Wing area, sq ft	0.447
Airfoil section	NACA 65A005(modified)
Sweep of 0.5c, deg	0



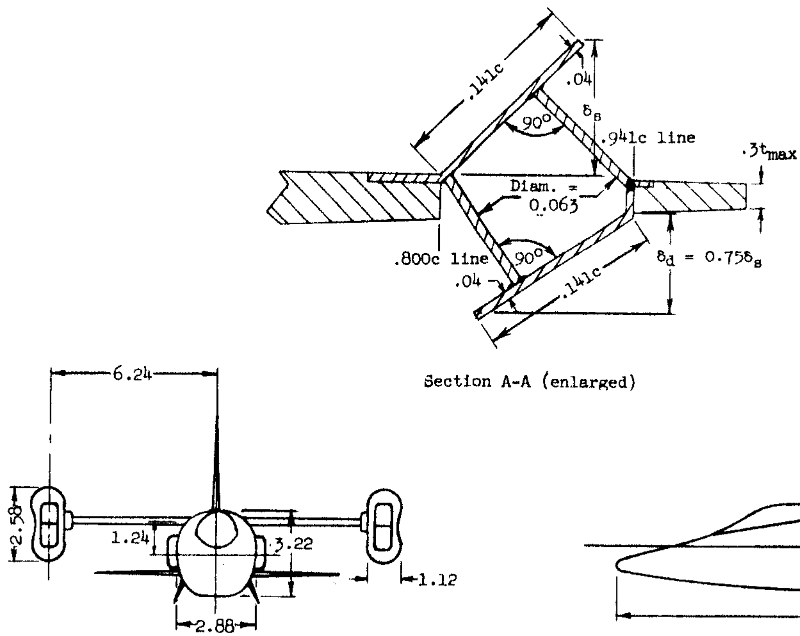
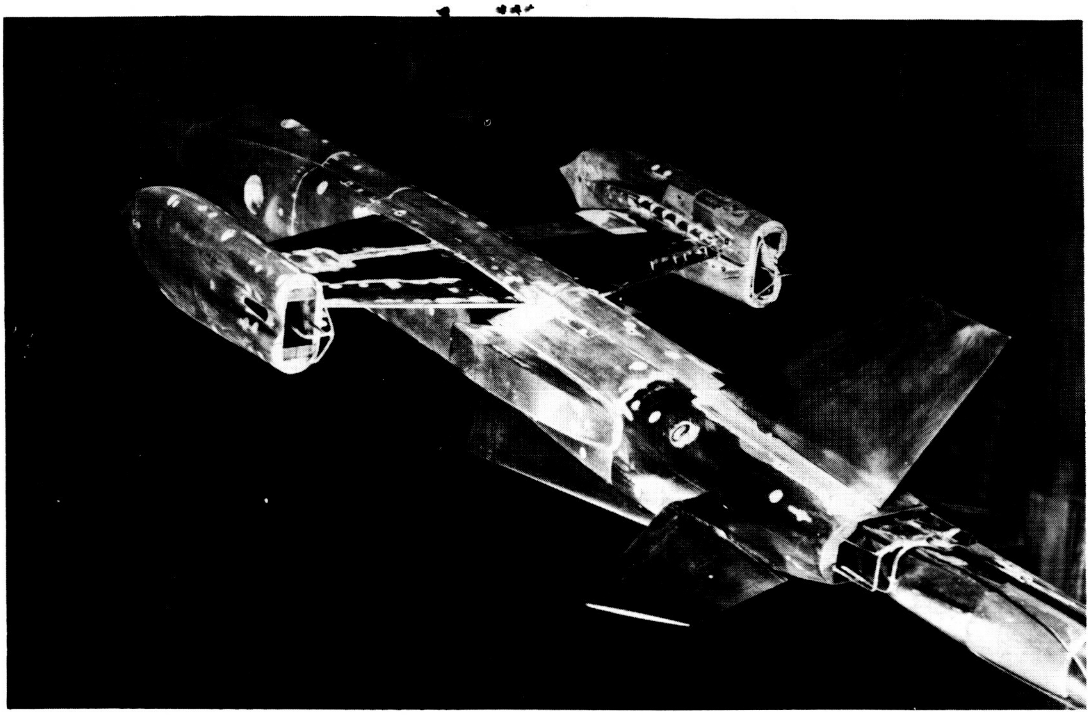
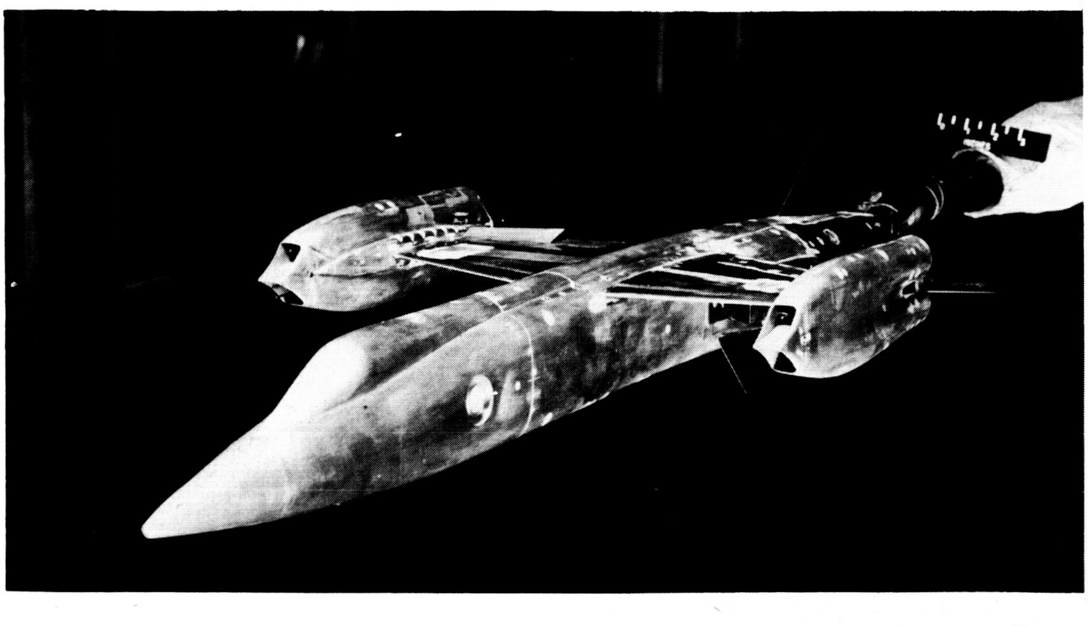


Figure 1.- A three-view drawing of the model including details of the spoiler-slot-deflector control. All dimensions are in inches unless otherwise noted.



L-59-1812



L-59-1811

Figure 2.- Model installed in the Langley 8-foot transonic pressure tunnel. Outboard two-thirds span of complete control with $\delta_s = -0.05c$; $\delta_d = -0.0375c$.

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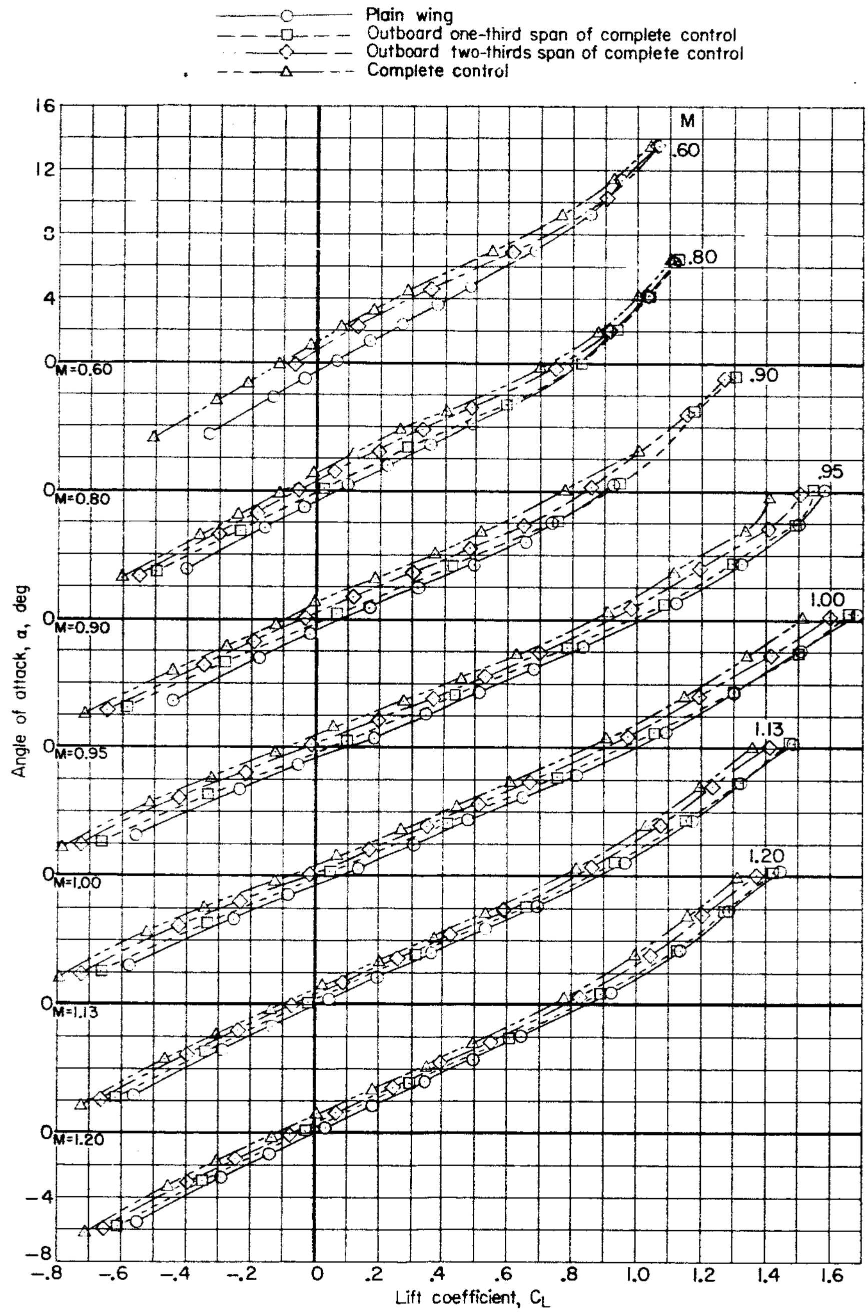
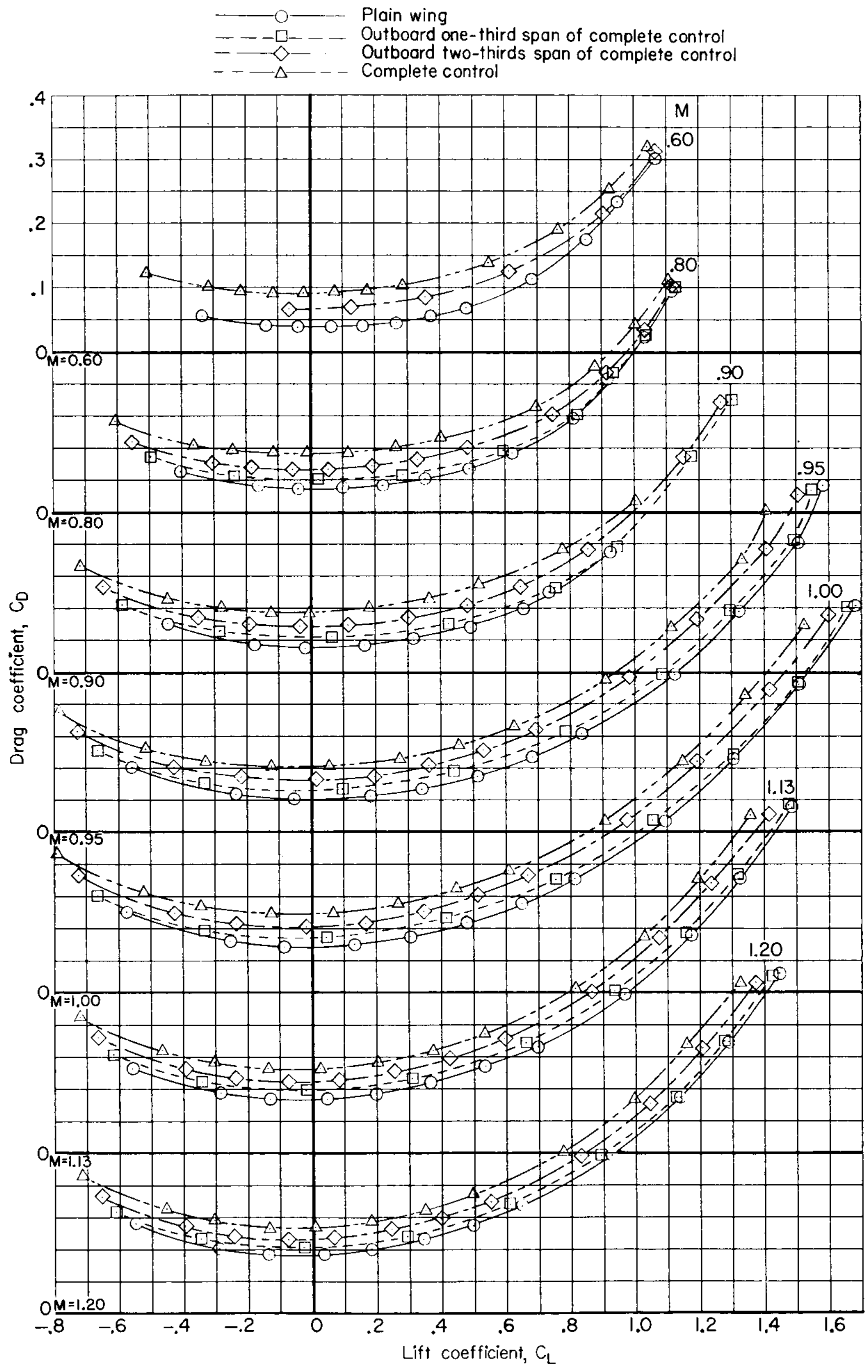
L-788



(a) Lift coefficient.

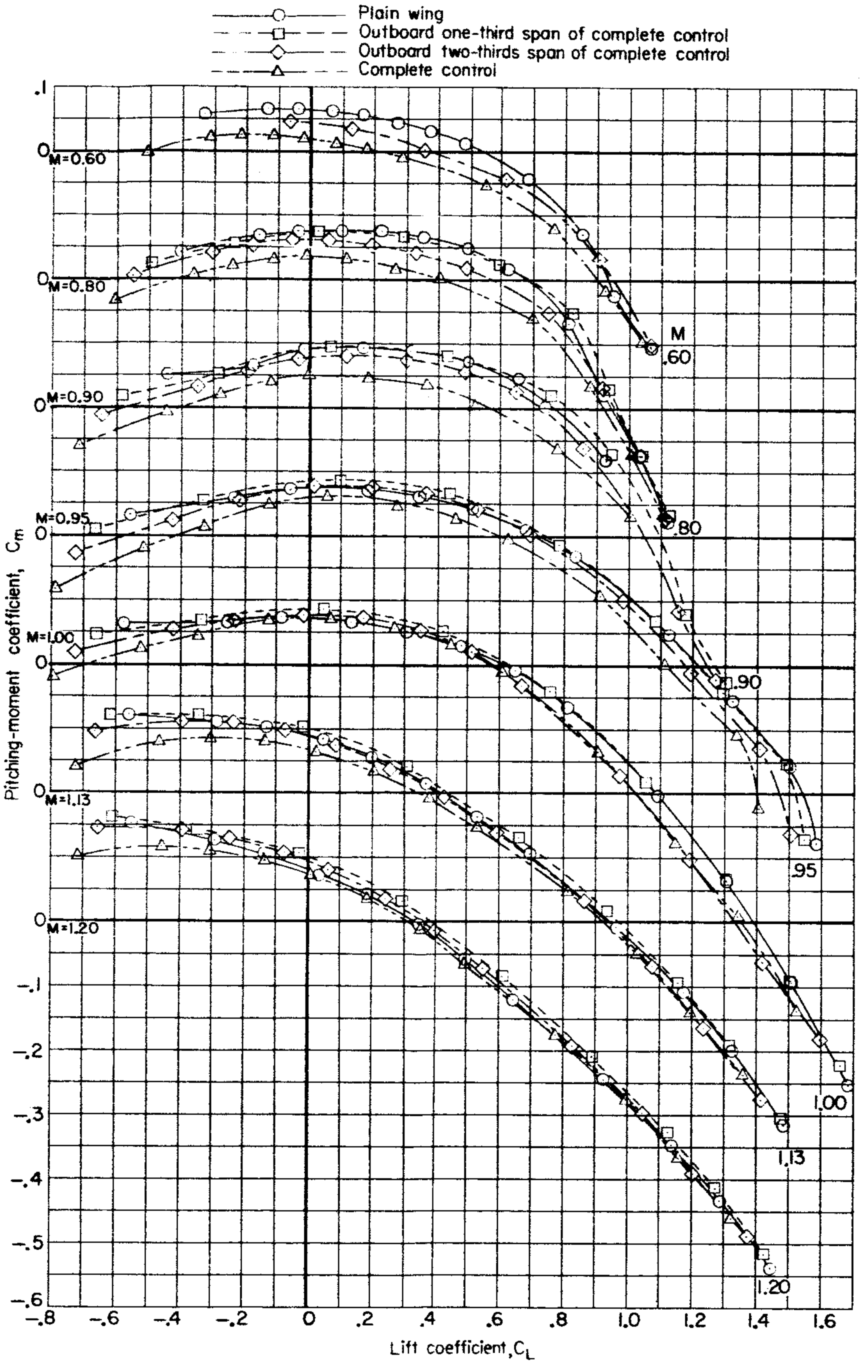
Figure 3.- Effect of complete and partial control span spoiler slot deflector on the aerodynamic characteristics of the model. $\delta_s = -0.10c$; $\delta_d = -0.075c$.

[redacted]



(b) Drag coefficient.

Figure 3.- Continued.

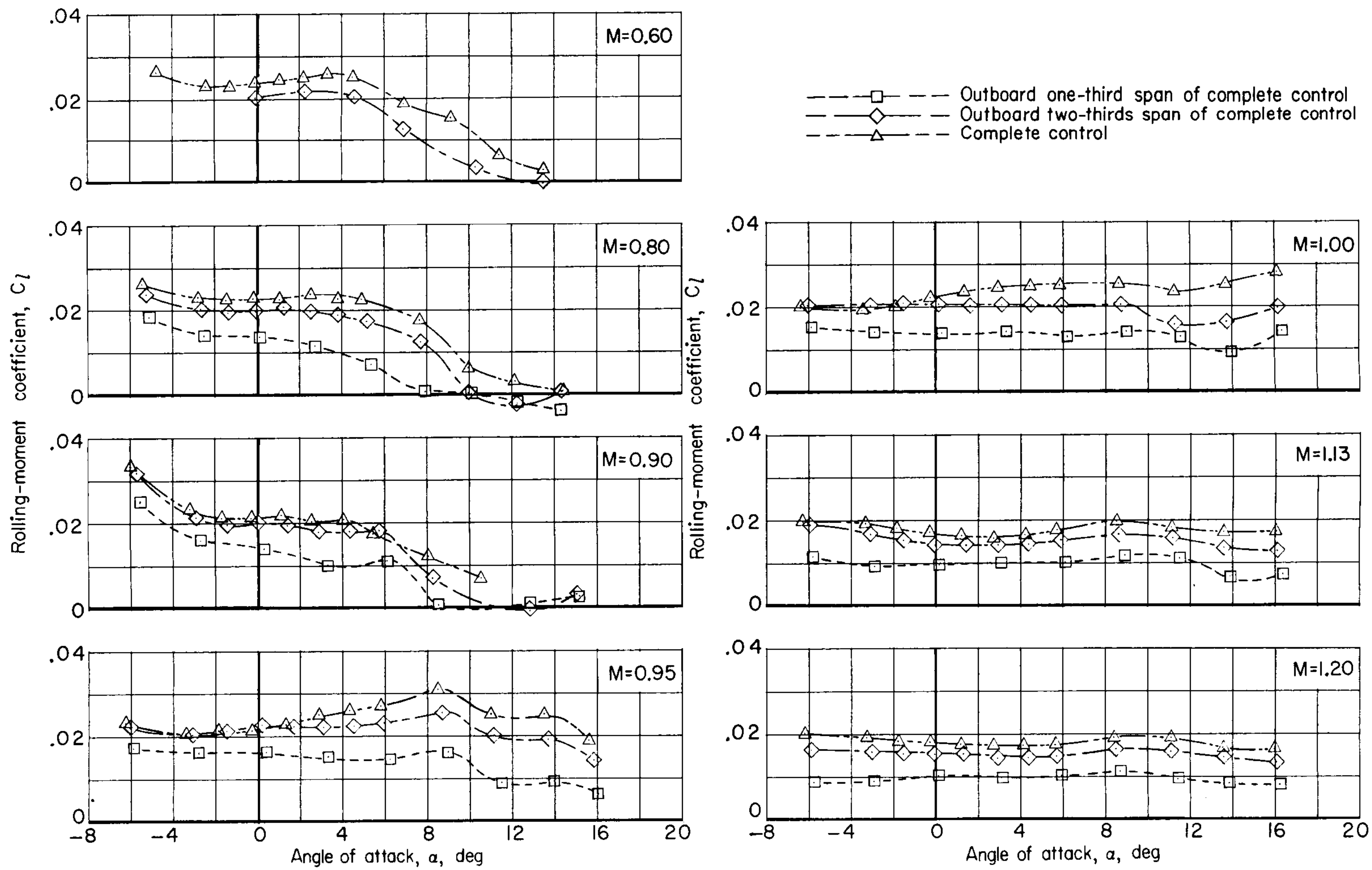


(c) Pitching-moment coefficient.

Figure 3.- Continued.

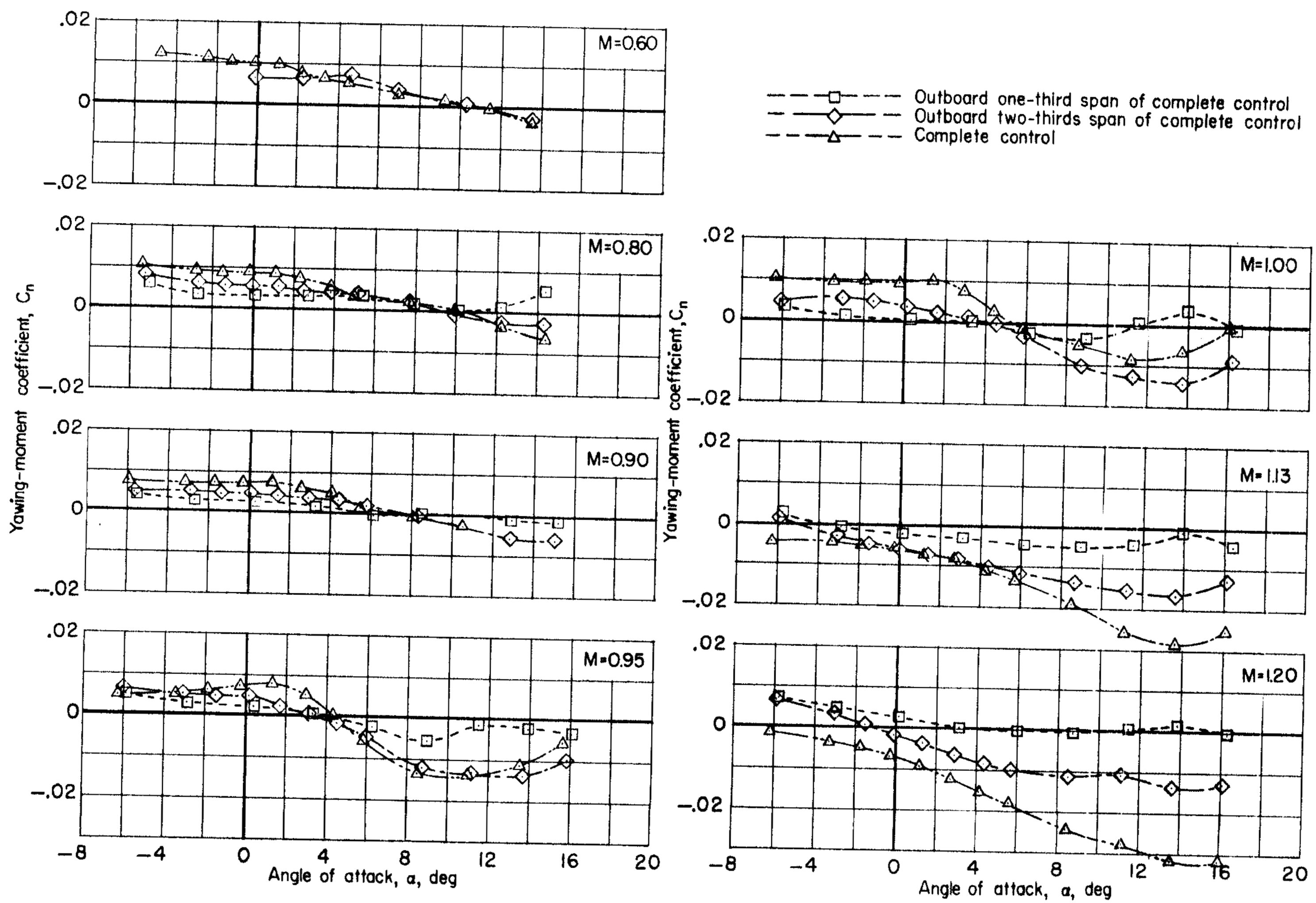
[redacted]

[redacted]



(d) Rolling-moment coefficient.

Figure 3.- Continued.



(e) Yawing-moment coefficient.

Figure 3.- Continued.

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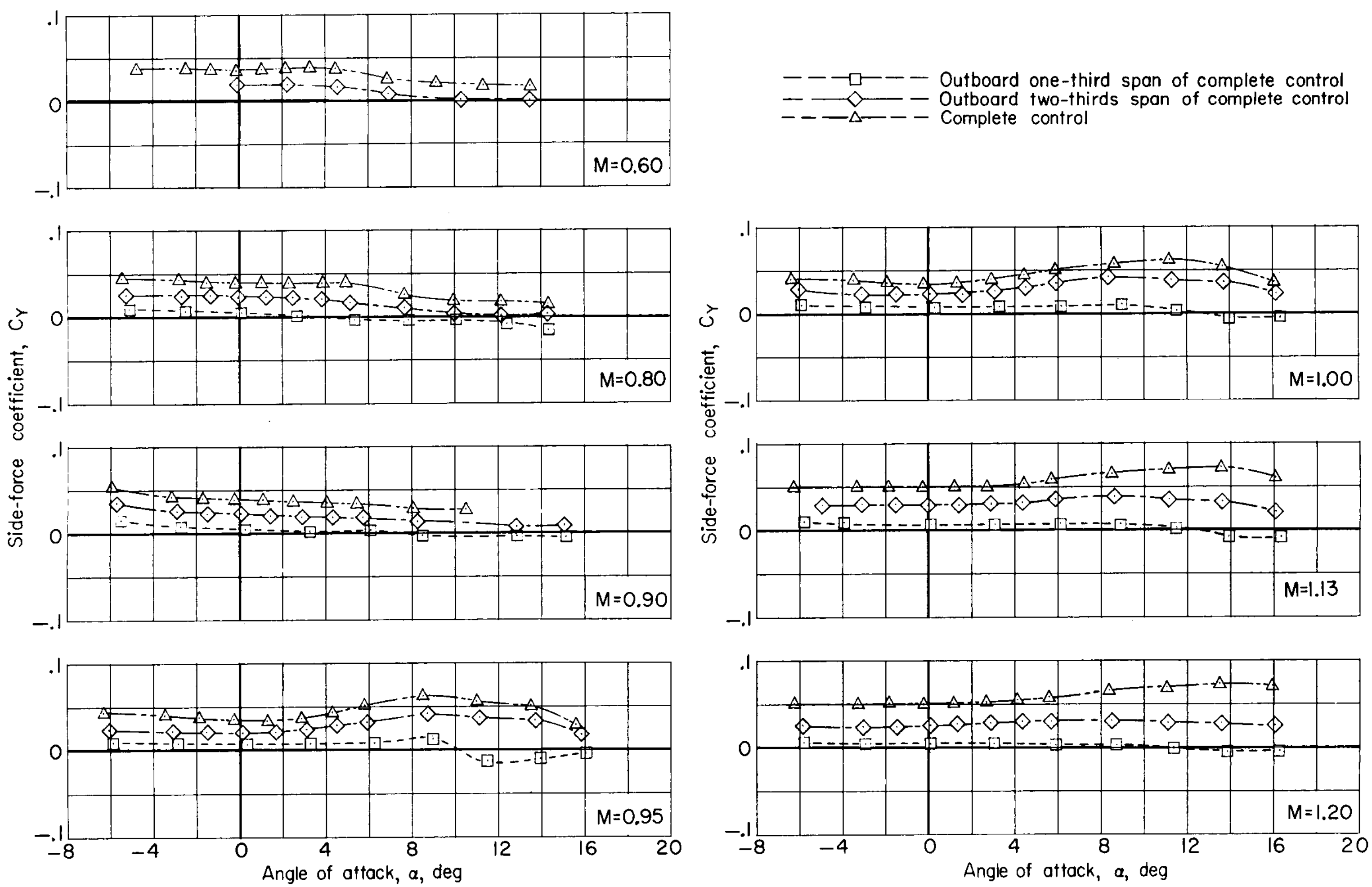

(f) Side-force coefficient.

Figure 3.- Concluded.

[redacted]

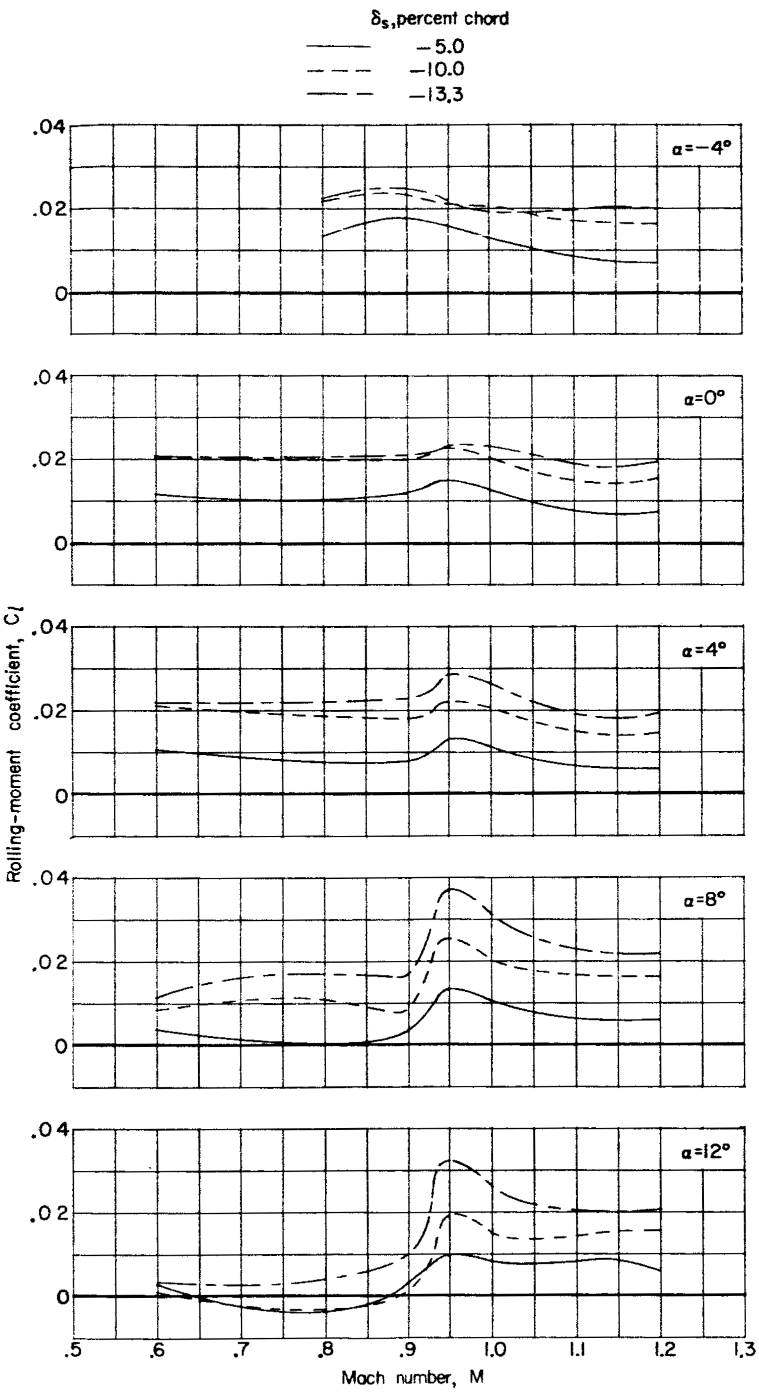

Figure 4.- Variation of rolling-moment coefficient with Mach number at various angles of attack for the outboard two-thirds span of the complete controls. $\delta_d = 0.75\delta_s$.

[redacted]

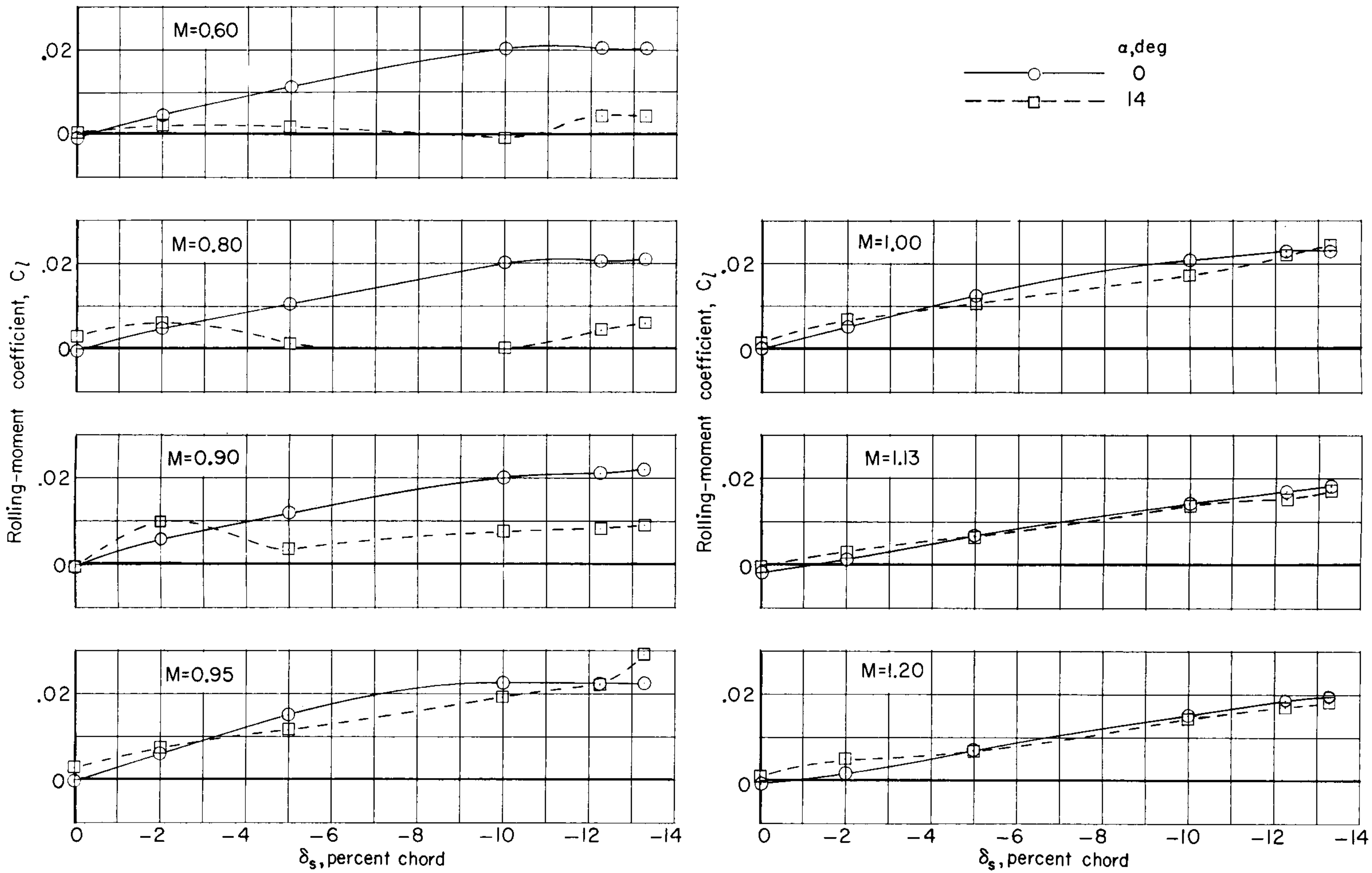

Figure 5.- Variation of rolling-moment coefficient with control projection for the outboard two-thirds span of the complete control.

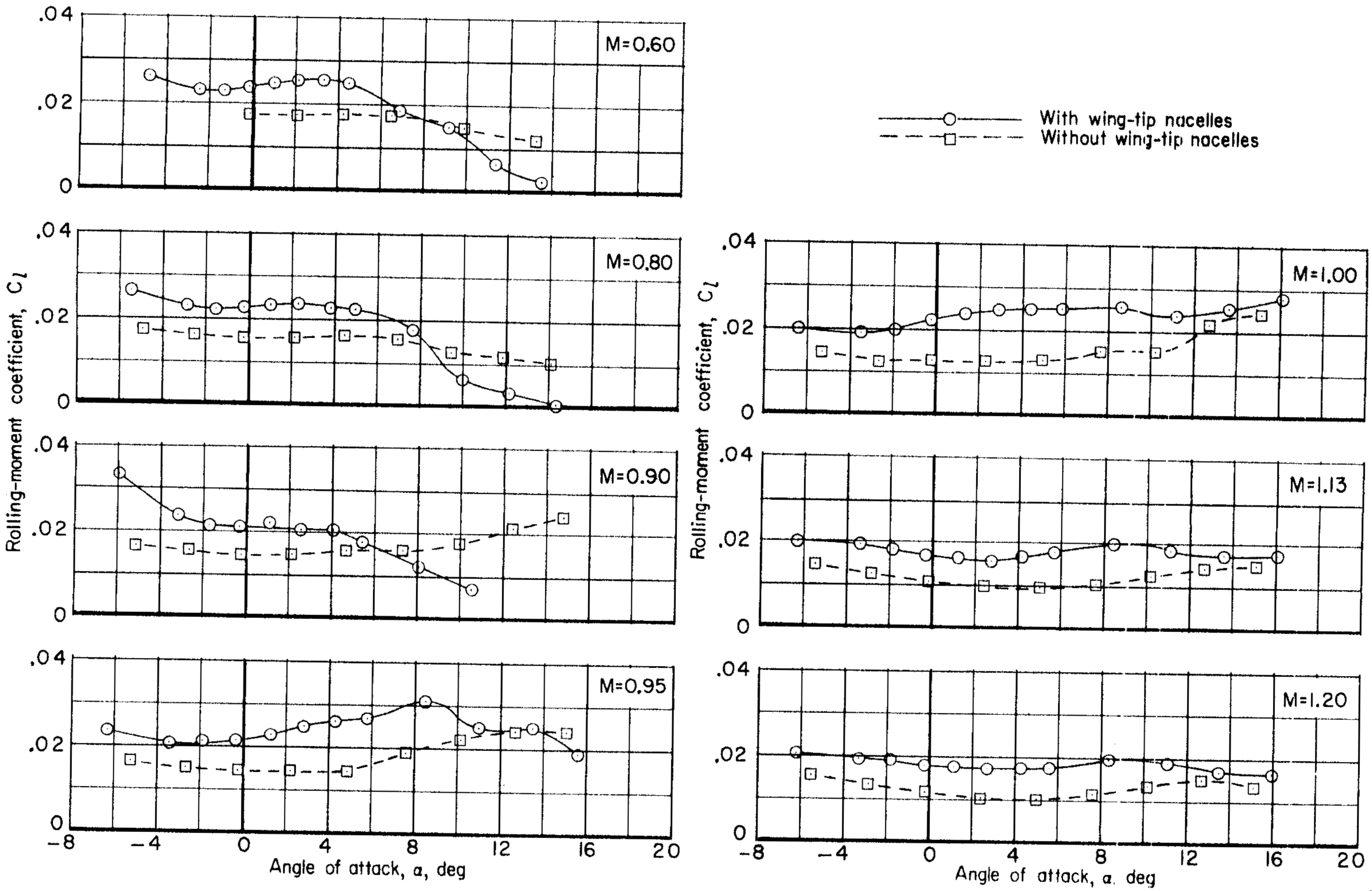

Figure 6.- Effect of wing-tip nacelles on the complete control. $\delta_s = -0.10c$; $\delta_d = -0.075c$.

[redacted]