Copy No. 6
RM No. L9C18

NACA RM No. L9C18

RESEARCH MEMORANDUM

PRESSURE-DISTRIBUTION DATA FOR THE NACA 64_1-012 AND 64_1A012 AIRFOILS AT HIGH SUBSONIC MACH NUMBERS

By

Milton D. Humphreys

Langley Aeronautical Laboratory
Langley Air Force Base, Va.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

May 6, 1949

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

PRESSURE-DISTRIBUTION DATA FOR THE NACA 64_1-012 AND 64_1A012 AIRFOILS AT HIGH SUBSONIC MACH NUMBERS

By Milton D. Humphreys

SUMMARY

Pressure-distribution data of the NACA 64_1-012 and 64_1A012 airfoils have been analyzed to determine the effects of increasing the trailing-edge angle from 9° to 14°.

The primary effect of increasing the trailing-edge angle was to decrease the loading over the rear portion of the airfoil under lifting conditions. The differences in trailing-edge load increased with Mach number and lift coefficient.

INTRODUCTION

A derivation of the NACA 64_1-012 airfoil having a trailing-edge cusp and the NACA 64_1A012 airfoil having the trailing edge formed by straight lines is presented in reference 1. The trailing-edge modification resulted in a change in trailing-edge angle from 9° to 14°

The effect of the change in trailing-edge angle upon the aerodynamic characteristics encountered at high subsonic Mach numbers by the two 12-percent-thick airfoils was discussed in reference 2. Additional data in the form of pressure distributions are needed for loading analysis and design work. The present paper presents pressure-distribution data for the NACA 64_1-012 and 64_1A012 airfoils and is supplementary to the force data presented in reference 2. Schlieren photographs of the flow field were made for the two airfoils to determine whether any significant flow changes had occurred.

APPARATUS AND TESTS

The Langley rectangular high-speed tunnel and the test procedure used in obtaining the present data are described in reference 2. The tunnel has a 4- by 18-inch test section and the model spanned the 4-inch

dimension. The NACA 64_1-012 and 64_1A012 airfoils investigated had 42 static-pressure orifices located near the center line on the upper and lower surfaces of the $2\frac{1}{2}$-inch-chord models, as shown in figure 1. The orifice locations are given in table I. A comparison of the airfoil profiles tested is shown in figure 2. The ordinates for the NACA 64_1-012 airfoil were changed over the rear 50 percent of the model chord in such a manner that they formed a straight line from approximately the 80-percent-chord station to the trailing edge (reference 1). The ordinates for the airfoils tested are presented in table II. Pressure-distribution measurements and schlieren photographs were made at Mach numbers between 0.30 and 0.89 for angles of attack of 0°, 4°, and 8°. The Reynolds number range was from 4 to 9×10^5.

CORRECTIONS

The pressure-distribution data and the Mach numbers have been corrected for tunnel-wall constriction effects by the method of reference 3. No correction has been applied to the angles of attack since their correction due to constriction is very small. No choking effects are included in the data as test results within 0.03 of the choking Mach number are not presented.

RESULTS

A direct comparison between the pressure-distribution diagrams obtained at various Mach numbers for each airfoil is presented in figures 3, 4, and 5 for angles of attack of 0°, 4°, and 8°, respectively. The pressure-distribution data over the Mach number range are given in tabular form for the NACA 64_1-012 airfoil in tables III, IV, and V for angles of attack of 0°, 4°, and 8°, respectively, and for the NACA 64_1A012 airfoil in tables VI, VII, and VIII for angles of attack of 0°, 4°, and 8°, respectively. Schlieren photographs are shown in figure 6 to illustrate the flow conditions about the two airfoils.

DISCUSSION

The experimental pressure-distribution diagrams for the NACA 64_1-012 and 64_1A012 airfoils at 0° incidence and at Mach numbers of 0.30 and 0.65 (figs. 3(a) and 3(b)) show a slightly higher maximum negative pressure coefficient and, at the trailing edge, a larger pressure recovery for the normal section than for the 64_1A012 airfoil. The same general trends are indicated by the theoretical pressure distributions for these airfoils (reference 1).

[redacted]

The pressure recovery on the two airfoils was the same at M = 0.81 (fig. 3(c)). The maximum negative pressure coefficients were approximately the same at M = 0.85 (fig. 3(d)). The larger pressure recovery shown for the NACA 64_1A012 airfoil at this Mach number, in contrast to that for the low-speed conditions, can be attributed to the less extensive separation and narrower wake for this airfoil as shown in the schlieren photographs (fig. 6(a), M = 0.85). These favorable effects produced a drag coefficient for this airfoil approximately 20 percent lower than that shown for the NACA 64_1-012 airfoil at this speed (reference 2).

It was pointed out in reference 2 that the NACA 64_1-012 airfoil produced a higher lift-curve slope and, under lifting conditions, a greater variation of moment coefficient with Mach number than the straight-trailing-edge airfoil. The experimental pressure-distribution data for the airfoils at moderate and high angles of attack (figs. 4 and 5) indicate that the larger loading near the trailing edge, and in some cases near the leading edge of the cusped airfoil, produced the higher lift-curve slope shown in reference 2 throughout the Mach number range for the NACA 64_1-012 airfoil.

The difference in loading near the trailing edge increased with speed up to the highest Mach number of this investigation, and, in general, the differences in trailing-edge load of the airfoils became greater as the angle-of-attack was increased (figs. 4 and 5). The reduced loading over the rear part of the NACA 64_1A012 airfoil was the important factor in causing the smaller variation in moment coefficient with Mach number shown for this airfoil in reference 2. The lower loading at the trailing edge and the more uniform pressure recovery over the rear surfaces of the modified airfoil could contribute the lower drag coefficients that were observed for the NACA 64_1A012 airfoil (reference 2). The persistence of the large trailing-edge load on the NACA 64_1-012 airfoil could contribute to structural problems in the use of trailing-edge flaps in the Mach number range investigated.

CONCLUSIONS

Pressure-distribution tests conducted in the NACA rectangular high-speed tunnel to determine the effect of increasing the trailing-edge angle from 9° to 14° on the NACA 64_1-012 airfoil at high subsonic Mach numbers indicate that:

1. The primary effect of increasing the trailing-edge angle was to decrease the loading over the rear portion of the airfoil operating

[redacted]

under lifting conditions. The differences in loading near the trailing edge for the two airfoils increased with Mach number and lift coefficient.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Air Force Base, Va.

REFERENCES

1. Loftin, Laurence K., Jr.: Theoretical and Experimental Data for a Number of NACA 6A-Series Airfoil Sections. NACA TN No. 1368, 1947.

2. Lindsey, W. F., and Humphreys, Milton D.: Tests of the NACA 64_1-012 and 64_1A012 Airfoils at High Subsonic Mach Numbers. NACA RM No. L8D23, 1948.

3. Allen, H. Julian, and Vincenti, Walter G.: The Wall Interference in a Two-Dimensional-Flow Wind Tunnel with Consideration of the Effect of Compressibility. NACA Rep. No. 782, 1944.

TABLE I

AIRFOIL ORIFICE LOCATIONS

(Stations in percent of wing chord)

NACA 64_1-012 airfoil		NACA 64_1A012 airfoil	
Upper-surface orifice locations	Lower-surface orifice locations	Upper-surface orifice locations	Lower-surface orifice locations
1.4	1.9	1.6	1.6
4.5	4.4	4.3	4.4
7.6	7.4	7.3	7.7
11.0	10.9	10.7	10.1
14.8	15.5	15.4	15.5
20.1	20.7	20.2	20.0
24.8	25.6	25.2	24.6
30.0	30.5	30.3	29.5
35.3	35.7	35.4	34.5
40.3	40.9	40.4	39.8
45.2	45.8	45.5	45.0
50.5	50.6	50.4	49.8
55.4	55.7	55.4	55.2
60.1	60.5	60.2	59.7
65.3	65.7	65.6	65.3
70.4	70.5	70.3	70.4
75.6	75.5	75.2	75.5
80.5	80.4	80.2	80.6
86.0	85.8	85.2	85.2
90.3	90.3	90.1	90.1
93.6	93.1	93.5	93.3

[redacted]

TABLE II

ORDINATES OF AIRFOILS

(Stations and ordinates in percent of wing chord)

NACA 64_1-012	
Station	Upper-or lower-surface ordinates
0	0
.5	.978
.75	1.179
1.25	1.490
2.5	2.035
5.0	2.810
7.5	3.394
10.0	3.871
15.0	4.620
20.0	5.173
25.0	5.576
30.0	5.844
35.0	5.978
40.0	5.981
45.0	5.798
50.0	5.480
55.0	5.056
60.0	4.548
65.0	3.974
70.0	3.350
75.0	2.695
80.0	2.029
85.0	1.382
90.0	.786
95.0	.288
100.0	0
L.E. radius: 1.040	

NACA 64_1A012	
Station	Upper-or lower-surface ordinates
0	0
.5	.961
.75	1.158
1.25	1.464
2.5	2.018
5.0	2.788
7.5	3.364
10.0	3.839
15.0	4.580
20.0	5.132
25.0	5.534
30.0	5.809
35.0	5.965
40.0	5.993
45.0	5.863
50.0	5.605
55.0	5.244
60.0	4.801
65.0	4.289
70.0	3.721
75.0	3.118
80.0	2.500
85.0	1.882
90.0	1.263
95.0	.644
100.0	.025
L.E. radius: 0.994 T.E. radius: 0.028	

TABLE III

CORRECTED PRESSURE COEFFICIENTS FOR THE

NACA 64_1-012 AIRFOIL AT $\alpha = 0°$

Station (percent c)	M = 0.293		M = 0.409		M = 0.454		M = 0.515	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5	0.162	0.162	0.079	0.089	0.157	0.276	0.021	0.081
2.5	-.105	-.071	-.131	-.086	-.098	-.028	-.123	-.076
5.0	-.222	-.195	-.236	-.199	-.233	-.199	-.234	-.191
7.5	-.281	-.264	-.296	-.261	-.296	-.272	-.303	-.253
10	-.322	-.302	-.337	-.299	-.327	-.308	-.344	-.292
15	-.352	-.358	-.363	-.344	-.368	-.368	-.372	-.342
20	-.361	-.382	-.370	-.376	-.377	-.397	-.379	-.377
25	-.371	-.401	-.377	-.395	-.397	-.419	-.382	-.396
30	-.391	-.416	-.394	-.412	-.417	-.439	-.402	-.424
35	-.410	-.424	-.415	-.425	-.432	-.451	-.424	-.438
40	-.395	-.421	-.395	-.421	-.415	-.443	-.407	-.435
45	-.372	-.396	-.376	-.396	-.388	-.416	-.379	-.403
50	-.334	-.361	-.339	-.360	-.356	-.317	-.344	-.364
55	-.294	-.320	-.291	-.312	-.317	-.332	-.298	-.313
60	-.250	-.274	-.246	-.258	-.268	-.282	-.233	-.254
65	-.190	-.218	-.181	-.196	-.186	-.210	-.169	-.179
70	-.122	-.158	-.112	-.140	-.109	-.137	-.098	-.124
75	-.062	-.089	-.057	-.081	-.052	-.068	-.026	-.066
80	-.007	-.022	.013	-.006	.020	-.001	.031	.011
85	.058	.038	.082	.062	.081	.053	.096	.076
90	.101	.054	.114	.078	.115	.071	.134	.096
95	.094	.074	.111	.097	.111	.093	.130	.111

Station (percent c)	M = 0.552		M = 0.614		M = 0.660		M = 0.705	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5	0.056	0.066	0.079	0.153	0.136	0.206	0.119	0.168
2.5	-.174	-.125	-.102	-.050	-.088	-.024	-.091	-.043
5.0	-.288	-.237	-.231	-.186	-.224	-.174	-.249	-.206
7.5	-.342	-.296	-.311	-.266	-.311	-.263	-.341	-.294
10	-.378	-.328	-.355	-.314	-.367	-.312	-.399	-.354
15	-.409	-.387	-.390	-.376	-.415	-.391	-.450	-.434
20	-.413	-.423	-.405	-.415	-.427	-.437	-.474	-.482
25	-.427	-.449	-.416	-.437	-.444	-.471	-.493	-.526
30	-.453	-.468	-.441	-.463	-.473	-.499	-.529	-.569
35	-.468	-.479	-.460	-.476	-.493	-.512	-.561	-.589
40	-.445	-.476	-.444	-.474	-.476	-.510	-.536	-.578
45	-.417	-.447	-.412	-.446	-.442	-.479	-.493	-.536
50	-.378	-.404	-.372	-.398	-.398	-.431	-.447	-.487
55	-.333	-.353	-.321	-.344	-.347	-.373	-.395	-.434
60	-.274	-.292	-.256	-.274	-.267	-.292	-.310	-.320
65	-.177	-.209	-.167	-.184	-.168	-.188	-.165	-.197
70	-.104	-.138	-.096	-.126	-.098	-.129	-.090	-.130
75	-.046	-.069	-.036	-.059	-.037	-.062	-.032	-.054
80	.023	-.001	.037	.012	.038	.014	.040	.020
85	.085	.061	.114	.084	.115	.086	.109	.084
90	.124	.085	.145	.110	.151	.107	.166	.110
95	.119	.098	.143	.122	.151	.127	.148	.130

NACA

[redacted]

TABLE III - Concluded

CORRECTED PRESSURE COEFFICIENTS FOR THE

NACA 64_1-012 AIRFOIL AT $\alpha = 0^\circ$ - Concluded

Station (percent c)	M = 0.770		M = 0.817		M = 0.856		M = 0.890	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5	0.131	0.281	0.264	0.314	0.334	0.403	0.428	0.529
2.5	-.072	-.037	.017	.076	.059	.140	.129	.249
5.0	-.230	-.184	-.161	-.097	-.112	-.037	-.054	.033
7.5	-.331	-.263	-.281	-.211	-.224	-.140	-.160	-.074
10	-.403	-.331	-.368	-.289	-.308	-.215	-.247	-.147
15	-.480	-.437	-.475	-.402	-.422	-.337	-.356	-.275
20	-.511	-.509	-.525	-.469	-.488	-.418	-.424	-.350
25	-.535	-.570	-.546	-.529	-.517	-.479	-.459	-.415
30	-.603	-.639	-.603	-.613	-.573	-.547	-.517	-.483
35	-.680	-.709	-.696	-.702	-.656	-.641	-.596	-.568
40	-.663	-.715	-.735	-.760	-.696	-.723	-.684	-.649
45	-.599	-.667	-.685	-.715	-.664	-.729	-.727	-.727
50	-.553	-.620	-.666	-.686	-.643	-.726	-.753	-.774
55	-.496	-.569	-.666	-.696	-.639	-.721	-.749	-.777
60	-.301	-.350	-.595	-.644	-.627	-.690	-.738	-.763
65	-.161	-.192	-.347	-.425	-.533	-.605	-.728	-.745
70	-.090	-.122	-.184	-.260	-.429	-.518	-.713	-.733
75	-.019	-.050	-.075	-.137	-.350	-.411	-.687	-.720
80	.053	.033	.010	-.035	-.275	-.313	-.635	-.686
85	.133	.101	.087	.049	-.190	-.203	-.563	-.627
90	.169	.127	.134	.098	-.117	-.108	-.455	-.507
95	.159	.140	.154	.133	-.040	-.040	-.381	-.358

[redacted]

TABLE IV

CORRECTED PRESSURE COEFFICIENTS FOR THE

NACA 64_1-012 AIRFOIL AT $\alpha = 4^\circ$

Station (percent c)	M = 0.304		M = 0.433		M = 0.504		M = 0.559	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5								
2.5	-1.319	0.650	-1.371	0.653	-1.493	0.679	-1.435	0.719
5.0	-1.046	.403	-1.121	.403	-1.219	.408	-1.179	.454
7.5	-.944	.259	-1.010	.258	-1.099	.250	-1.066	.300
10	-.880	.160	-.945	.166	-1.037	.149	-1.007	.198
15	-.780	.030	-.827	.035	-.909	.019	-.897	.061
20	-.700	-.042	-.727	-.042	-.800	-.080	-.780	-.028
25	-.650	-.094	-.688	-.102	-.760	-.138	-.740	-.099
30	-.626	-.139	-.674	-.152	-.755	-.187	-.730	-.155
35	-.615	-.177	-.661	-.197	-.737	-.235	-.714	-.204
40	-.612	-.209	-.608	-.222	-.675	-.260	-.652	-.230
45	-.514	-.209	-.552	-.222	-.615	-.258	-.585	-.230
50	-.452	-.193	-.490	-.207	-.543	-.238	-.508	-.210
55	-.395	-.167	-.418	-.176	-.460	-.204	-.427	-.181
60	-.321	-.131	-.343	-.142	-.381	-.171	-.348	-.145
65	-.245	-.107	-.264	-.107	-.294	-.140	-.261	-.111
70	-.173	-.082	-.189	-.082	-.212	-.108	-.187	-.076
75	-.108	-.043	-.115	-.037	-.132	-.050	-.108	-.024
80	-.039	.022	-.044	.033	-.059	.029	-.029	.048
85	.027	.090	.024	.114	0	.092	.035	.120
90	.070	.126	.065	.116	.048	.084	.080	.119
95	.092	.121	.081	.103	.067	.089	.102	.123

Station (percent c)	M = 0.602		M = 0.649		M = 0.707		M = 0.762	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5								
2.5	-1.555	0.630	-1.541	0.692	-1.294	0.702	-0.952	0.608
5.0	-1.291	.430	-1.417	.458	-1.309	.447	-.996	.375
7.5	-1.170	.281	-1.312	.299	-1.309	.298	-1.029	.238
10	-1.115	.190	-1.250	.194	-1.329	.204	-1.063	.148
15	-.992	.046	-1.132	.038	-1.353	.057	-1.130	.009
20	-.847	-.046	-1.004	-.049	-1.348	-.045	-1.081	-.099
25	-.788	-.119	-.823	-.113	-1.297	-.125	-1.071	-.184
30	-.783	-.179	-.827	-.174	-1.236	-.188	-1.052	-.262
35	-.772	-.228	-.827	-.233	-1.162	-.247	-1.065	-.335
40	-.704	-.258	-.743	-.265	-.953	-.281	-.983	-.377
45	-.623	-.257	-.663	-.265	-.642	-.283	-.794	-.375
50	-.543	-.239	-.569	-.246	-.515	-.260	-.652	-.350
55	-.459	-.199	-.468	-.210	-.422	-.220	-.564	-.301
60	-.369	-.165	-.375	-.169	-.334	-.176	-.490	-.254
65	-.277	-.130	-.280	-.135	-.249	-.139	-.410	-.207
70	-.195	-.092	-.192	-.094	-.169	-.091	-.341	-.154
75	-.118	-.028	-.111	-.025	-.088	-.012	-.274	-.069
80	-.045	.042	-.032	.050	-.015	.064	-.213	.016
85	.029	.110	.032	.114	.050	.128	-.110	.077
90	.073	.109	.082	.114	.098	.138	-.035	.075
95	.090	.109	.102	.120	.121	.131	.024	.072

TABLE IV - Concluded

CORRECTED PRESSURE COEFFICIENTS FOR THE

NACA 64_1-012 AIRFOIL AT $\alpha = 4^\circ$ - Concluded

Station (percent c)	M = 0.789		M = 0.799		M = 0.826		M = 0.869	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5								
2.5	-0.740	0.587	-0.666	0.588	-0.502	0.558	-0.305	0.533
5.0	-.812	.347	-.750	.341	-.612	.318	-.427	.336
7.5	-.861	.202	-.811	.193	-.684	.174	-.512	.198
10	-.910	.113	-.862	.094	-.743	.081	-.577	.102
15	-.991	-.038	-.939	-.058	-.840	-.072	-.677	-.046
20	-1.024	-.145	-.971	-.169	-.885	-.183	-.730	-.156
25	-.961	-.238	-.926	-.256	-.852	-.279	-.763	-.236
30	-.938	-.334	-.905	-.345	-.811	-.381	-.804	-.332
35	-.951	-.415	-.915	-.453	-.819	-.494	-.848	-.439
40	-.876	-.483	-.836	-.532	-.801	-.597	-.876	-.539
45	-.723	-.491	-.711	-.561	-.704	-.674	-.896	-.627
50	-.633	-.445	-.619	-.527	-.603	-.688	-.900	-.693
55	-.573	-.389	-.570	-.456	-.555	-.657	-.892	-.738
60	-.524	-.343	-.531	-.409	-.524	-.610	-.868	-.766
65	-.474	-.287	-.490	-.335	-.493	-.576	-.835	-.779
70	-.421	-.192	-.452	-.212	-.460	-.365	-.813	-.771
75	-.380	-.091	-.409	-.108	-.435	-.236	-.781	-.735
80	-.335	-.017	-.368	-.034	-.400	-.122	-.740	-.713
85	-.215	.039	-.271	.030	-.317	-.041	-.689	-.679
90	-.148	.024	-.178	.011	-.246	-.043	-.636	-.679
95	-.084	.007	-.111	-.013	-.204	-.058	-.572	-.644

[redacted]

TABLE V

CORRECTED PRESSURE COEFFICIENTS FOR THE

NACA 64_1-012 AIRFOIL AT $\alpha = 8^\circ$

Station (percent c)	M = 0.327		M = 0.431		M = 0.554		M = 0.609	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5								
2.5	-2.376	0.970	-2.572	0.955	-2.432	0.964	-2.120	0.905
5.0	-1.744	.751	-2.328	.731	-2.432	.723	-2.159	.686
7.5	-1.474	.596	-1.895	.578	-2:140	.560	-1.921	.538
10	-1.330	.481	-1.581	.464	-1.856	.445	-1.732	.423
15	-1.120	.307	-1.214	.303	-1.372	.282	-1.419	.273
20	-.986	.207	-1.038	.191	-1.145	.178	-1.186	.156
25	-.881	.132	-.921	.103	-.978	.101	-1.019	.049
30	-.821	.062	-.839	.034	-.872	.017	-.875	-.016
35	-.761	.007	-.774	-.019	-.790	-.047	-.764	-.079
40	-.677	-.043	-.697	-.075	-.697	-.092	-.669	-.120
45	-.597	-.073	-.612	-.092	-.610	-.112	-.585	-.138
50	-.512	-.068	-.521	-.091	-.527	-.113	-.506	-.143
55	-.427	-.058	-.442	-.082	-.439	-.101	-.439	-.128
60	-.343	-.048	-.363	-.066	-.355	-.081	-.385	-.102
65	-.263	-.028	-.282	-.047	-.277	-.063	-.339	-.077
70	-.194	-.008	-.214	-.032	-.221	-.043	-.287	-.059
75	-.129	.012	-.152	-.004	-.171	-.018	-.249	-.045
80	-.084	.042	-.108	.026	-.127	.019	-.218	-.002
85	-.039	.067	-.075	.048	-.097	.035	-.189	.064
90	-.020	.082	-.052	.064	-.073	.073	-.174	.091
95	0	.058	-.033	.063	-.053	.043	-.145	.062

Station (percent c)	M = 0.656		M = 0.691		M = 0.742		M = 0.764	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5								
2.5	-1.933	0.905	-1.776	0.887	-1.586	0.809	-1.452	0.826
5.0	-1.992	.672	-1.810	.654	-1.524	.626	-1.425	.585
7.5	-1.940	.523	-1.759	.508	-1.456	.489	-1.381	.433
10	-1.876	.419	-1.710	.397	-1.413	.379	-1.341	.340
15	-1.677	.260	-1.640	.238	-1.351	.217	-1.290	.191
20	-1.305	.151	-1.531	.128	-1.293	.095	-1.262	.077
25	-1.032	.061	-1.256	.032	-1.150	-.009	-1.187	-.028
30	-.864	-.021	-1.015	-.050	-.953	-.096	-1.004	-.119
35	-.761	-.070	-.841	-.123	-.830	-.172	-.854	-.208
40	-.667	-.133	-.726	-.181	-.752	-.222	-.760	-.267
45	-.597	-.161	-.643	-.202	-.688	-.250	-.702	-.304
50	-.527	-.158	-.577	-.199	-.636	-.250	-.663	-.300
55	-.459	-.142	-.527	-.179	-.594	-.226	-.629	-.272
60	-.416	-.120	-.486	-.155	-.556	-.199	-.601	-.246
65	-.377	-.098	-.444	-.129	-.519	-.172	-.575	-.216
70	-.329	-.077	-.411	-.114	-.481	-.152	-.546	-.192
75	-.289	-.049	-.378	-.077	-.446	-.122	-.519	-.165
80	-.260	-.001	-.345	-.034	-.414	-.083	-.492	-.110
85	-.254	.034	-.341	.014	-.382	-.040	-.464	-.058
90	-.236	.081	-.321	.065	-.347	.008	-.440	-.009
95	-.209	.043	-.288	.016	-.302	-.032	-.371	-.072

TABLE V - Concluded

CORRECTED PRESSURE COEFFICIENTS FOR THE

NACA 64_1-012 AIRFOIL AT $\alpha = 8^\circ$ - Concluded

Station (percent c)	M = 0.785		M = 0.819		M = 0.840		M = 0.867	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5								
2.5	-1.306	0.836	-1.123	0.817	-1.015	0.798	-0.864	0.789
5.0	-1.305	.596	-1.139	.569	-1.034	.556	-.906	.548
7.5	-1.287	.439	-1.130	.424	-1.033	.417	-.901	.407
10	-1.274	.331	-1.140	.319	-1.042	.317	-.916	.315
15	-1.211	.170	-1.124	.161	-1.057	.157	-.938	.149
20	-1.185	.061	-1.079	.041	-1.036	.041	-.961	.039
25	-1.152	-.046	-1.051	-.063	-1.004	-.068	-.965	-.061
30	-1.046	-.140	-1.034	-.165	-.989	-.167	-.956	-.167
35	-.877	-.233	-.952	-.268	-.974	-.272	-.944	-.281
40	-.768	-.303	-.824	-.364	-.913	-.378	-.940	-.381
45	-.709	-.341	-.736	-.422	-.811	-.456	-.935	-.473
50	-.674	-.342	-.691	-.427	-.746	-.489	-.907	-.537
55	-.645	-.316	-.659	-.392	-.708	-.463	-.861	-.577
60	-.624	-.277	-.642	-.344	-.681	-.402	-.812	-.591
65	-.605	-.245	-.626	-.303	-.662	-.350	-.779	-.576
70	-.583	-.223	-.615	-.274	-.648	-.325	-.759	-.576
75	-.557	-.193	-.597	-.246	-.637	-.287	-.741	-.546
80	-.532	-.140	-.582	-.181	-.626	-.171	-.728	-.488
85	-.514	-.057	-.562	-.028	-.595	-.002	-.686	-.418
90	-.487	-.038	-.520	-.042	-.547	-.045	-.634	-.379
95	-.422	-.087	-.462	-.130	-.477	-.136	-.576	-.339

[redacted]

TABLE VI

CORRECTED PRESSURE COEFFICIENTS FOR THE

NACA 64_1A012 AIRFOIL AT $\alpha = 0°$

Station (percent c)	M = 0.299		M = 0.416		M = 0.530		M = 0.569	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5	0.731	0.731	0.182	0.182	0.873	0.873	0.869	0.869
2.5	-.165	-.126	-.107	-.087	-.153	-.138	-.158	-.158
5.0	-.252	-.202	-.242	-.216	-.249	-.213	-.255	-.227
7.5	-.292	-.247	-.287	-.263	-.294	-.259	-.301	-.275
10	-.314	-.268	-.318	-.291	-.324	-.291	-.333	-.306
15	-.337	-.318	-.348	-.331	-.360	-.336	-.366	-.357
20	-.355	-.345	-.370	-.361	-.381	-.368	-.398	-.392
25	-.377	-.368	-.386	-.383	-.398	-.398	-.412	-.412
30	-.387	-.368	-.395	-.404	-.418	-.413	-.428	-.428
35	-.397	-.377	-.400	-.406	-.427	-.427	-.437	-.447
40	-.387	-.367	-.397	-.397	-.410	-.410	-.430	-.430
45	-.373	-.351	-.380	-.371	-.398	-.383	-.409	-.401
50	-.345	-.325	-.351	-.341	-.367	-.346	-.375	-.368
55	-.313	-.287	-.311	-.302	-.326	-.308	-.341	-.328
60	-.262	-.255	-.261	-.261	-.263	-.263	-.277	-.277
65	-.205	-.192	-.202	-.204	-.179	-.194	-.190	-.201
70	-.137	-.147	-.129	-.139	-.104	-.119	-.118	-.133
75	-.078	-.084	-.069	-.085	-.058	-.069	-.068	-.073
80	-.036	-.036	-.022	-.037	-.010	-.028	-.011	-.043
85	.015	-.032	.028	.003	.034	.020	.041	.027
90	.052	.020	.073	.042	.080	.055	.090	.061
95	.048	.037	.082	.073	.093	.085	.101	.088

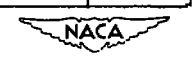
Station (percent c)	M = 0.612		M = 0.647		M = 0.719		M = 0.756	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5	0.851	0.851	0.852	0.852	0.857	0.857	0.726	0.726
2.5	-.110	-.085	-.173	-.159	-.134	-.089	-.077	-.022
5.0	-.240	-.210	-.259	-.239	-.253	-.223	-.226	-.201
7.5	-.291	-.264	-.314	-.291	-.318	-.292	-.317	-.285
10	-.333	-.295	-.350	-.332	-.360	-.337	-.376	-.335
15	-.366	-.343	-.396	-.374	-.415	-.406	-.447	-.419
20	-.396	-.393	-.423	-.423	-.462	-.462	-.496	-.496
25	-.416	-.416	-.444	-.444	-.497	-.497	-.554	-.554
30	-.432	-.434	-.463	-.478	-.522	-.534	-.599	-.603
35	-.449	-.454	-.478	-.491	-.544	-.558	-.634	-.654
40	-.438	-.438	-.471	-.471	-.530	-.544	-.619	-.639
45	-.415	-.407	-.448	-.441	-.496	-.502	-.578	-.580
50	-.381	-.369	-.411	-.397	-.446	-.448	-.517	-.534
55	-.340	-.326	-.366	-.353	-.412	-.398	-.475	-.479
60	-.275	-.270	-.297	-.297	-.338	-.338	-.385	-.373
65	-.186	-.194	-.197	-.219	-.183	-.207	-.188	-.188
70	-.115	-.125	-.119	-.134	-.104	-.130	-.096	-.125
75	-.057	-.075	-.065	-.084	-.053	-.068	-.054	-.067
80	-.005	-.022	-.013	-.031	.006	-.014	0	-.017
85	.049	.035	.054	.026	.066	.041	.063	.039
90	.095	.072	.097	.073	.115	.074	.117	.077
95	.108	.098	.106	.095	.120	.110	.121	.111

TABLE VI - Concluded

CORRECTED PRESSURE COEFFICIENTS FOR THE

NACA 64_1A012 AIRFOIL AT $\alpha = 0^\circ$ - Concluded

Station (percent c)	M = 0.785		M = 0.807		M = 0.844		M = 0.893	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5	0.505	0.505	0.659	0.659	0.664	0.664	0.633	0.633
2.5	-.041	-.041	-.073	-.014	.098	.098	.183	.183
5.0	-.236	-.234	-.213	-.181	-.146	-.092	-.035	.009
7.5	-.328	-.299	-.300	-.264	-.245	-.198	-.142	-.086
10	-.390	-.349	-.356	-.325	-.309	-.259	-.214	-.159
15	-.451	-.423	-.451	-.410	-.399	-.343	-.315	-.253
20	-.517	-.517	-.510	-.510	-.466	-.444	-.378	-.349
25	-.573	-.573	-.572	-.567	-.527	-.516	-.442	-.417
30	-.630	-.630	-.639	-.624	-.591	-.579	-.510	-.483
35	-.697	-.711	-.713	-.713	-.661	-.655	-.580	-.567
40	-.708	-.730	-.754	-.777	-.589	-.725	-.653	-.653
45	-.650	-.690	-.698	-.719	-.660	-.692	-.712	-.706
50	-.611	-.632	-.666	-.693	-.642	-.673	-.745	-.746
55	-.585	-.603	-.659	-.679	-.635	-.661	-.758	-.748
60	-.399	-.399	-.612	-.642	-.624	-.651	-.763	-.742
65	-.173	-.187	-.338	-.338	-.536	-.562	-.755	-.741
70	-.091	-.115	-.139	-.164	-.387	-.414	-.723	-.738
75	-.042	-.052	-.049	-.066	-.285	-.296	-.682	-.706
80	.012	.001	.014	-.003	-.187	-.197	-.659	-.669
85	.069	.048	.064	.045	-.102	-.108	-.598	-.621
90	.111	.088	.106	.084	-.029	-.029	-.496	-.507
95	.137	.122	.133	.117	.045	.045	-.378	-.385



[redacted]

TABLE VII

CORRECTED PRESSURE COEFFICIENTS FOR THE

NACA 64_1A012 AIRFOIL AT $\alpha = 4^\circ$

Station (percent c)	M = 0.304		M = 0.408		M = 0.509		M = 0.556	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5								
2.5	-1.220	0.594	-1.312	0.596	-1.297	0.630	-1.392	0.584
5.0	-1.006	.364	-1.094	.361	-1.094	.392	-1.165	.365
7.5	-.894	.239	-.963	.232	-.988	.251	-1.058	.248
10	-.824	.145	-.888	.152	-.917	.163	-.985	.171
15	-.734	.030	-.782	.034	-.811	.053	-.871	.045
20	-.675	-.045	-.713	-.053	-.734	-.029	-.785	-.045
25	-.635	-.096	-.672	-.121	-.679	-.093	-.728	-.118
30	-.609	-.140	-.646	-.167	-.644	-.148	-.695	-.171
35	-.583	-.173	-.615	-.197	-.624	-.183	-.674	-.204
40	-.549	-.199	-.575	-.208	-.594	-.203	-.640	-.221
45	-.508	-.200	-.533	-.210	-.547	-.207	-.586	-.224
50	-.461	-.189	-.479	-.203	-.484	-.190	-.521	-.214
55	-.398	-.168	-.413	-.179	-.412	-.169	-.438	-.190
60	-.316	-.139	-.340	-.152	-.334	-.144	-.347	-.158
65	-.245	-.115	-.263	-.120	-.254	-.110	-.258	-.127
70	-.182	-.084	-.190	-.089	-.177	-.073	-.186	-.090
75	-.124	-.055	-.126	-.057	-.111	-.036	-.117	-.046
80	-.068	-.022	-.072	-.019	-.046	.006	-.056	-.002
85	-.017	.010	-.017	-.016	.012	.042	.002	.045
90	.025	.041	.035	.055	.061	.082	.053	.070
95	.066	.079	.064	.074	.103	.092	.101	.085

Station (percent c)	M = 0.607		M = 0.659		M = 0.709		M = 0.759	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5								
2.5	-1.398	0.651	-1.388	0.640	-1.187	0.668	-0.913	0.591
5.0	-1.212	.412	-1.364	.407	-1.250	.412	-1.010	.474
7.5	-1.109	.278	-1.286	.275	-1.283	.277	-1.061	.249
10	-1.031	.180	-1.175	.182	-1.299	.185	-1.088	.149
15	-.898	.058	-1.037	.052	-1.291	.038	-1.109	.014
20	-.812	-.027	-.931	-.045	-1.261	-.054	-1.148	-.079
25	-.740	-.098	-.852	-.118	-1.215	-.136	-1.124	-.160
30	-.709	-.156	-.787	-.169	-1.142	-.195	-1.055	-.224
35	-.692	-.197	-.756	-.221	-1.039	-.243	-1.048	-.307
40	-.658	-.222	-.708	-.244	-.883	-.270	-1.067	-.332
45	-.600	-.227	-.642	-.246	-.671	-.270	-.926	-.323
50	-.527	-.214	-.560	-.234	-.535	-.254	-.702	-.302
55	-.437	-.185	-.469	-.214	-.444	-.231	-.539	-.272
60	-.341	-.147	-.367	-.183	-.361	-.196	-.416	-.238
65	-.255	-.115	-.268	-.143	-.258	-.161	-.309	-.194
70	-.183	-.078	-.188	-.095	-.168	-.112	-.225	-.146
75	-.108	-.036	-.111	-.046	-.099	-.054	-.148	-.094
80	-.039	.014	-.043	.002	-.038	.004	-.080	-.033
85	.024	.058	.002	.038	.021	.056	-.020	.036
90	.074	.084	.068	.068	.075	.068	.039	.044
95	.106	.086	.110	.106	.100	.079	.088	.045

TABLE VII - Concluded

CORRECTED PRESSURE COEFFICIENTS FOR THE

NACA 64_1A012 AIRFOIL AT $\alpha = 4^\circ$ - Concluded

Station (percent c)	M = 0.798		M = 0.813		M = 0.851		M = 0.882	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5								
2.5	-0.636	0.569	-0.533	0.580	-0.380	0.501	-0.266	0.543
5.0	-.759	.333	-.655	.340	-.515	.262	-.422	.309
7.5	-.834	.208	-.732	.190	-.599	.158	-.507	.191
10	-.881	.119	-.787	.084	-.656	.075	-.561	.104
15	-.940	-.028	-.859	-.055	-.729	-.063	-.636	-.018
20	-.960	-.129	-.897	-.152	-.769	-.175	-.686	-.113
25	-.941	-.216	-.883	-.252	-.783	-.254	-.728	-.210
30	-.898	-.323	-.836	-.340	-.743	-.343	-.760	-.304
35	-.896	-.413	-.834	-.439	-.730	-.455	-.783	-.400
40	-.885	-.442	-.819	-.523	-.726	-.556	-.797	-.490
45	-.769	-.436	-.734	-.547	-.681	-.623	-.801	-.565
50	-.640	-.422	-.612	-.522	-.579	-.666	-.792	-.627
55	-.556	-.386	-.543	-.481	-.509	-.686	-.768	-.675
60	-.485	-.346	-.501	-.435	-.469	-.685	-.743	-.705
65	-.421	-.295	-.455	-.377	-.445	-.670	-.705	-.724
70	-.368	-.235	-.413	-.300	-.422	-.634	-.659	-.692
75	-.312	-.136	-.364	-.165	-.386	-.576	-.610	-.662
80	-.251	-.062	-.299	-.093	-.342	-.492	-.560	-.651
85	-.176	-.028	-.223	-.067	-.277	-.370	-.507	-.637
90	-.089	-.028	-.137	-.074	-.191	-.258	-.453	-.613
95	.006	-.033	-.048	-.094	-.132	-.165	-.392	-.556

TABLE VIII

CORRECTED PRESSURE COEFFICIENTS FOR THE

NACA 64_1A012 AIRFOIL AT $\alpha = 8°$

Station (percent c)	M = 0.415		M = 0.505		M = 0.558		M = 0.620	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5								
2.5	-3.013	0.950	-2.865	0.955	-2.687	0.942	-2.360	0.944
5.0	-2.107	.724	-2.631	.738	-2.582	.709	-2.289	.711
7.5	-1.571	.557	-1.930	.569	-2.234	.557	-2.232	.547
10	-1.363	.445	-1.492	.446	-1.778	.450	-2.129	.431
15	-1.109	.300	-1.156	.296	-1.225	.302	-1.618	.286
20	-.969	.203	-1.004	.195	-1.031	.197	-1.230	.183
25	-.875	.124	-.920	.113	-.922	.111	-1.020	.098
30	-.800	.054	-.845	.039	-.836	.035	-.873	.023
35	-.732	-.008	-.774	-.022	-.775	-.032	-.766	-.041
40	-.617	-.048	-.698	-.061	-.704	-.074	-.673	-.083
45	-.593	-.067	-.620	-.084	-.624	-.095	-.592	-.102
50	-.515	-.077	-.536	-.090	-.531	-.098	-.507	-.111
55	-.433	-.075	-.453	-.089	-.441	-.096	-.424	-.105
60	-.349	-.064	-.364	-.078	-.361	-.082	-.346	-.090
65	-.268	-.047	-.288	-.060	-.284	-.064	-.270	-.069
70	-.200	-.025	-.222	-.037	-.220	-.045	-.210	-.045
75	-.134	-.008	-.161	-.017	-.160	-.025	-.159	-.020
80	-.085	.011	-.101	-.002	-.104	-.005	-.117	-.004
85	-.046	.030	-.055	.005	-.061	-.004	-.081	0
90	-.013	.041	-.026	.012	-.026	.011	-.055	-.004
95	.007	.035	-.002	.014	-.006	-.005	-.033	-.015

Station (percent c)	M = 0.661		M = 0.715		M = 0.773		M = 0.796	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
0.5								
2.5	-2.072	0.927	-1.698	0.882	-1.272	0.855	-1.136	0.837
5.0	-1.975	.690	-1.672	.639	-1.312	.608	-1.185	.578
7.5	-1.926	.523	-1.615	.477	-1.309	.435	-1.197	.412
10	-1.893	.408	-1.556	.370	-1.256	.325	-1.174	.302
15	-1.729	.263	-1.457	.234	-1.168	.187	-1.103	.164
20	-1.411	.161	-1.224	.130	-1.062	.068	-1.058	.054
25	-1.151	.073	-1.054	.041	-.918	-.025	-.956	-.043
30	-.976	-.003	-.934	-.039	-.798	-.112	-.813	-.140
35	-.853	-.078	-.845	-.116	-.726	-.203	-.719	-.240
40	-.718	-.116	-.769	-.161	-.685	-.254	-.671	-.301
45	-.620	-.136	-.702	-.186	-.653	-.284	-.641	-.336
50	-.535	-.141	-.638	-.194	-.626	-.300	-.621	-.354
55	-.457	-.139	-.581	-.188	-.605	-.293	-.599	-.350
60	-.387	-.127	-.529	-.174	-.584	-.274	-.584	-.328
65	-.323	-.108	-.477	-.151	-.563	-.244	-.573	-.291
70	-.269	-.084	-.428	-.126	-.544	-.213	-.557	-.257
75	-.228	-.059	-.382	-.103	-.521	-.190	-.540	-.230
80	-.190	-.039	-.334	-.087	-.488	-.172	-.517	-.210
85	-.156	-.027	-.278	-.081	-.442	-.171	-.483	-.203
90	-.127	-.019	-.204	-.084	-.371	-.180	-.424	-.207
95	-.094	-.017	-.130	-.093	-.269	-.203	-.321	-.230

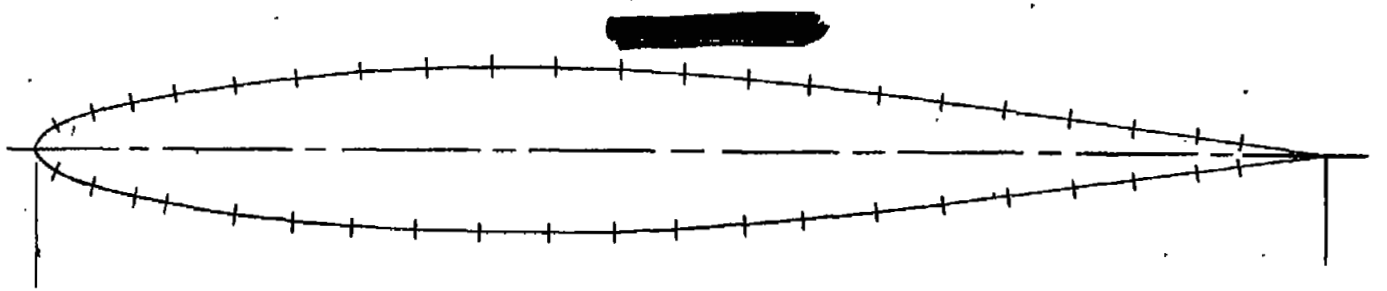
[redacted]

TABLE VIII - Concluded

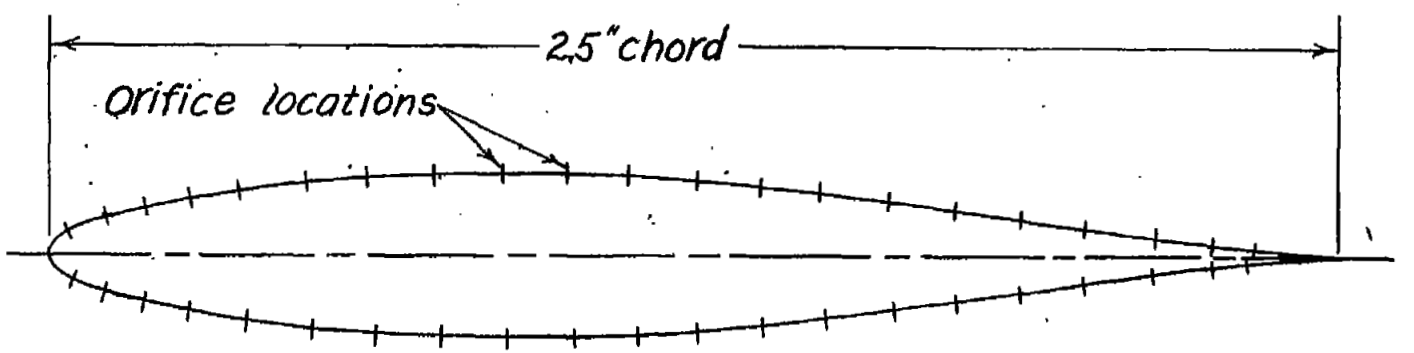
CORRECTED PRESSURE COEFFICIENTS FOR THE

NACA 64_1A012 AIRFOIL AT $\alpha = 8^\circ$ - Concluded

Station (percent c)	M = 0.818		M = 0.835		M = 0.868	
	Upper	Lower	Upper	Lower	Upper	Lower
0.5						
2.5	-1.011	0.814	-0.903	0.811	-0.690	0.794
5.0	-1.068	.570	-.969	.556	-.764	.545
7.5	-1.086	.402	-1.006	.389	-.832	.389
10	-1.105	.290	-1.038	.283	-.878	.291
15	-1.057	.159	-1.025	.139	-.926	.152
20	-1.035	.044	-.988	.027	-.950	.036
25	-1.003	-.061	-.979	-.075	-.958	-.062
30	-.907	-.160	-.937	-.172	-.956	-.162
35	-.776	-.269	-.833	-.290	-.955	-.275
40	-.702	-.347	-.731	-.376	-.955	-.363
45	-.653	-.384	-.673	-.434	-.954	-.434
50	-.622	-.411	-.639	-.480	-.930	-.489
55	-.600	-.411	-.618	-.499	-.890	-.540
60	-.586	-.384	-.605	-.480	-.856	-.576
65	-.573	-.340	-.596	-.435	-.832	-.593
70	-.560	-.301	-.589	-.393	-.816	-.597
75	-.549	-.272	-.581	-.358	-.800	-.589
80	-.531	-.247	-.567	-.318	-.780	-.577
85	-.505	-.232	-.544	-.271	-.746	-.537
90	-.461	-.215	-.509	-.230	-.699	-.518
95	-.394	-.238	-.441	-.237	-.630	-.499



NACA 64$_1$A012 airfoil



NACA 64$_1$-012 airfoil

Figure 1.—Airfoil profiles and static-pressure-orifice locations. (Orifice locations are given in Table I)

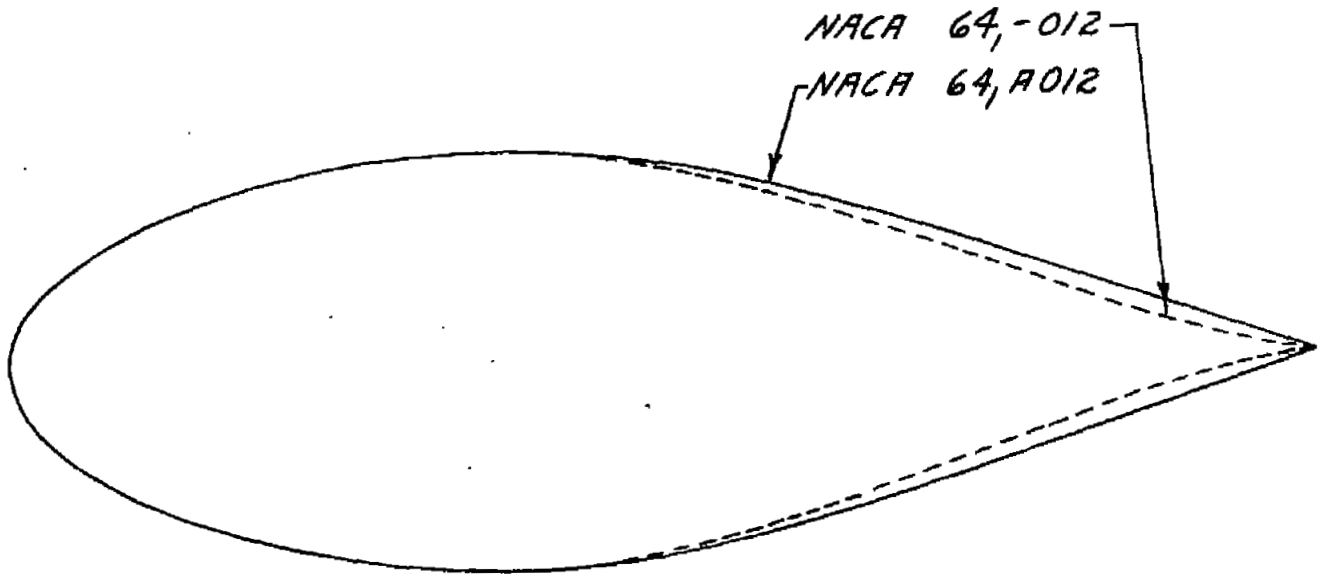


Figure 2.- A comparison of airfoil profiles showing the effect of removing the cusp from the NACA 64_1-012 airfoil. (Ordinates expanded.)

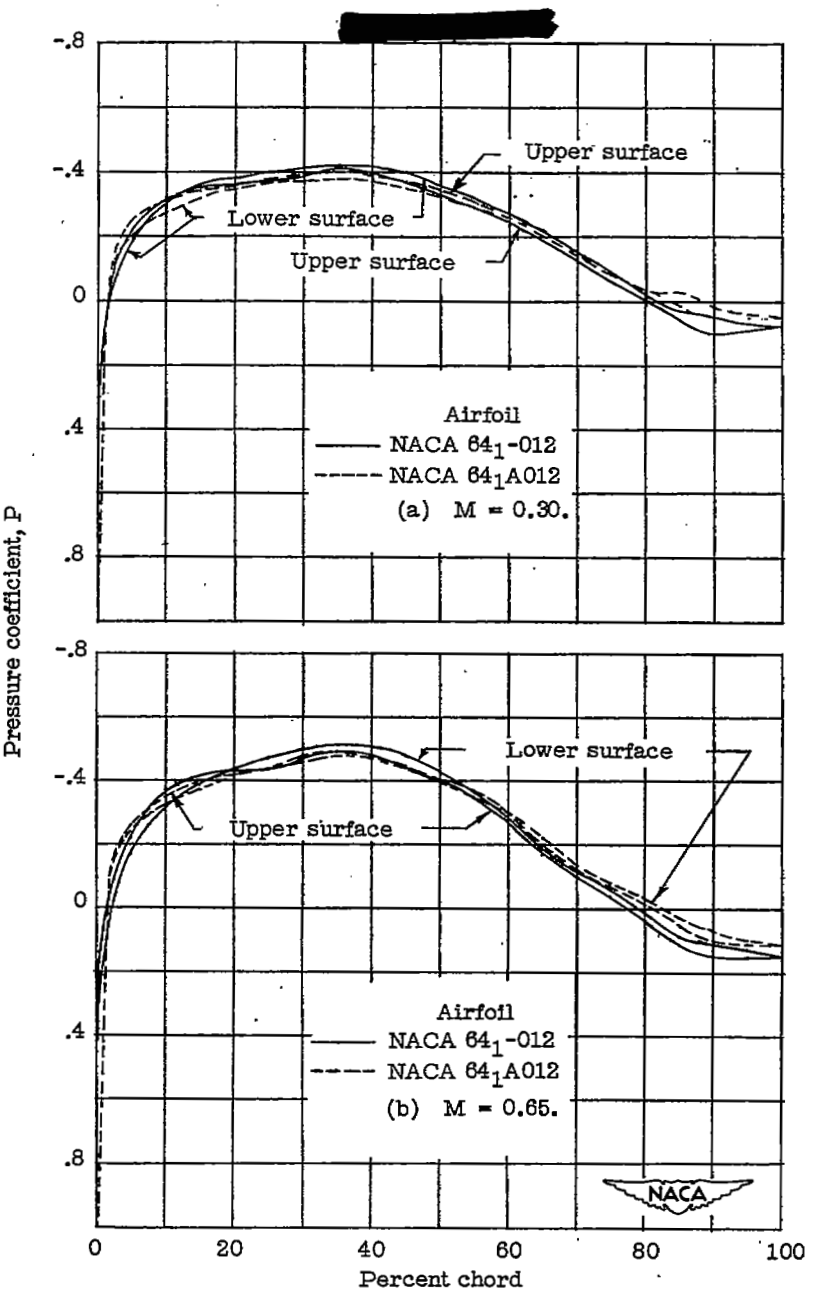


Figure 3.- A comparison of pressure-distribution diagrams for the NACA 64$_1$-012 and 64$_1$A012 airfoils. $\alpha = 0^{\circ}$.

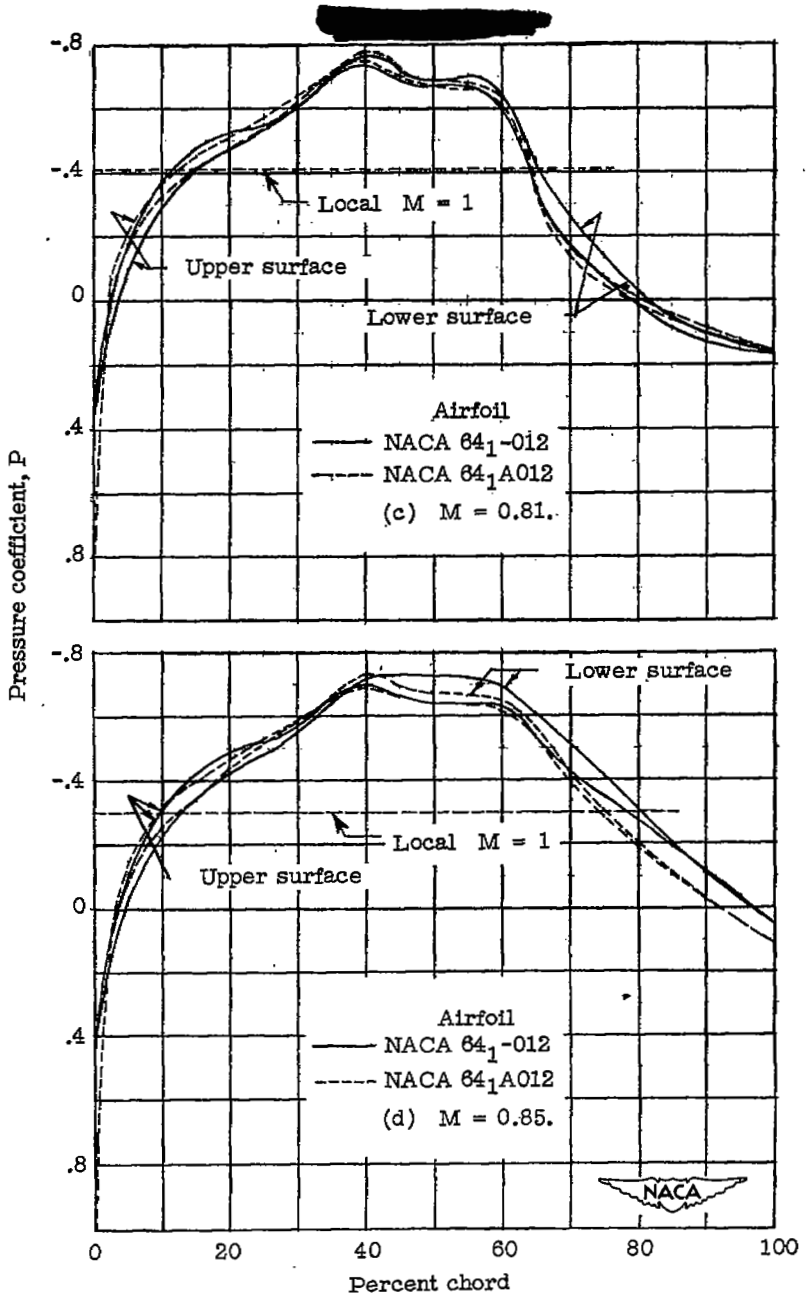
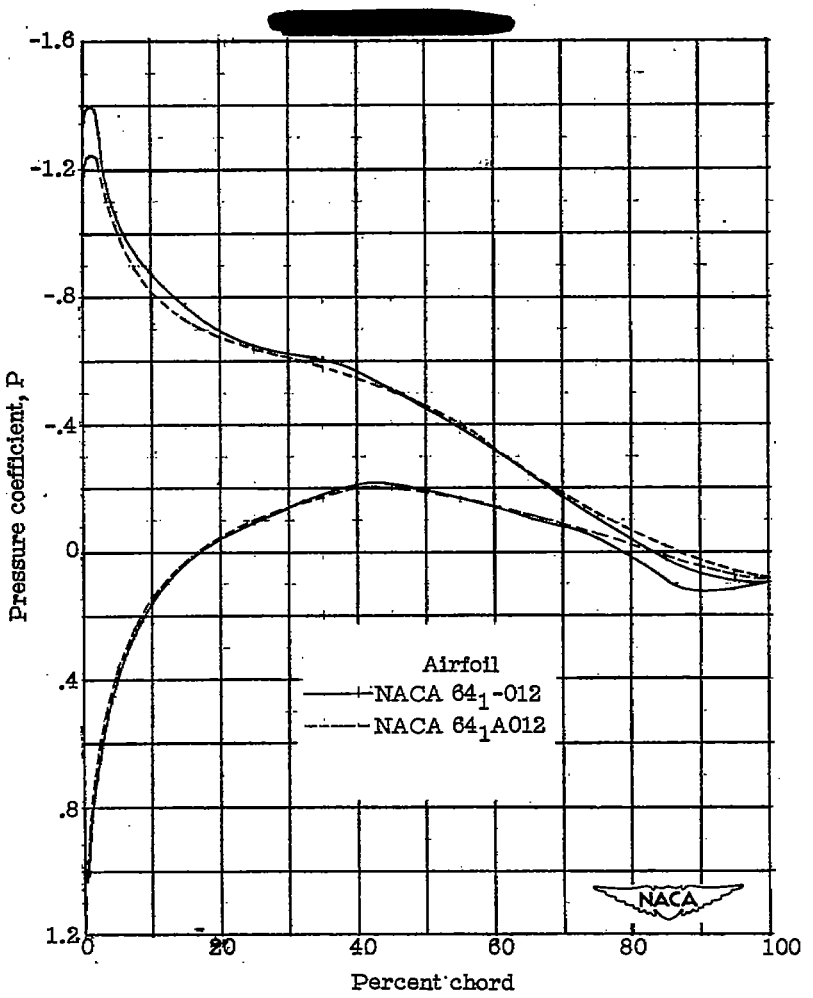
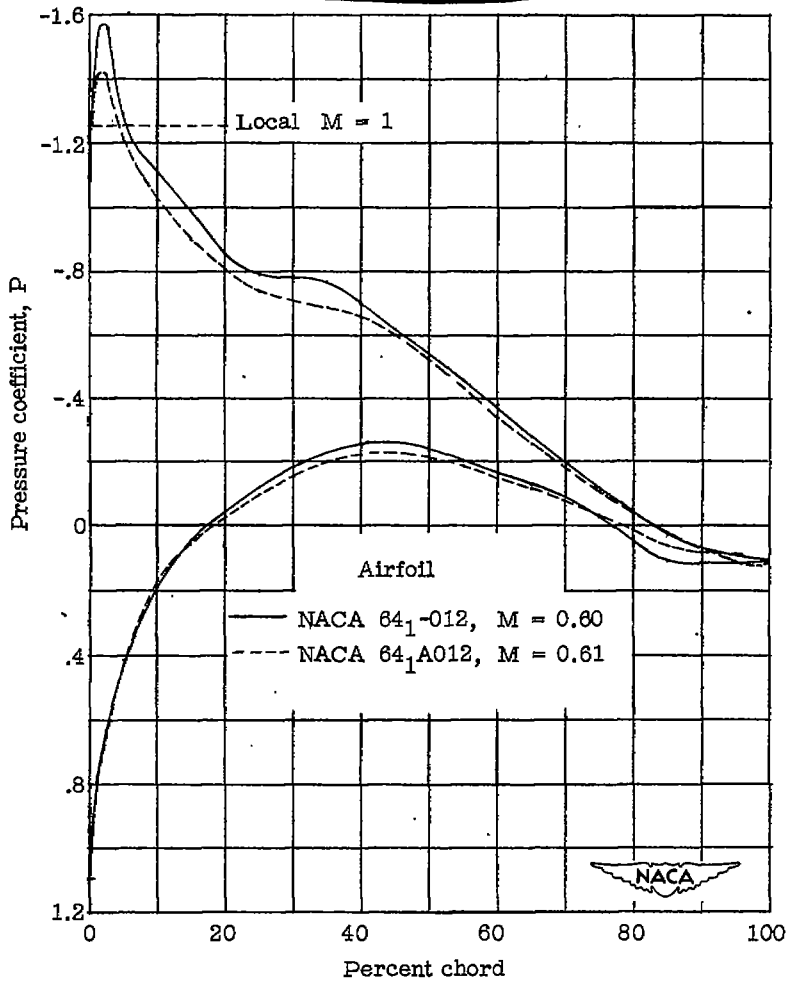


Figure 3.- Concluded.



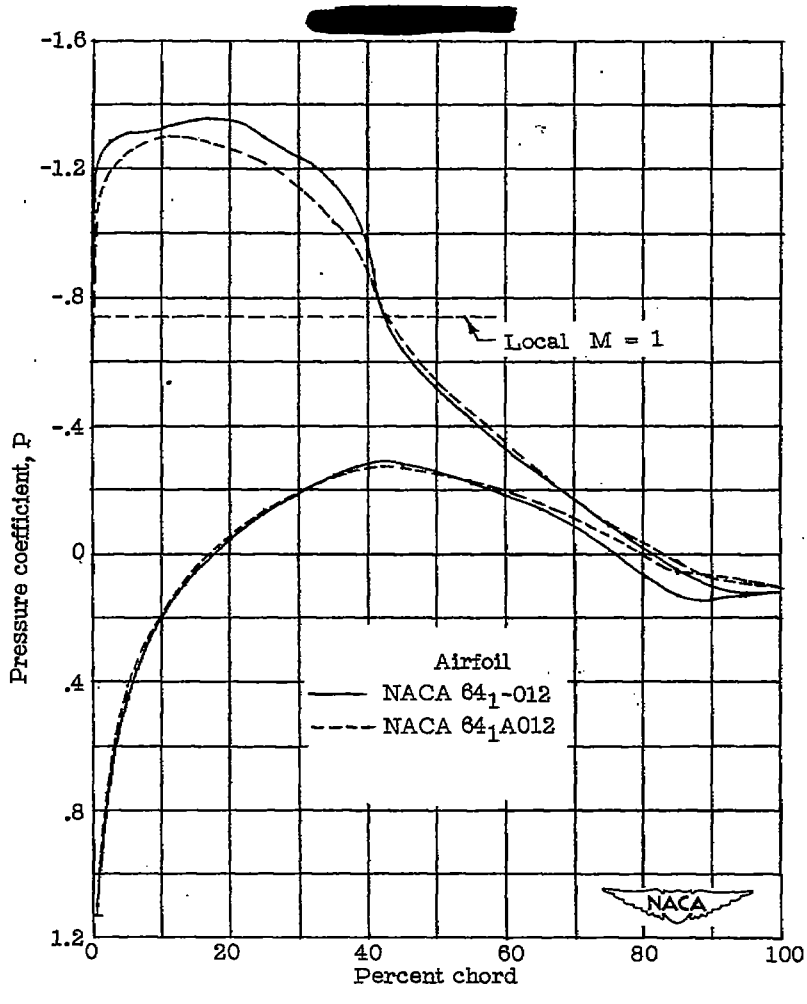
(a) M = 0.30.

Figure 4.- A comparison of pressure-distribution diagrams for the NACA 64$_1$-012 and 64$_1$A012 airfoils. $\alpha = 4^\circ$.



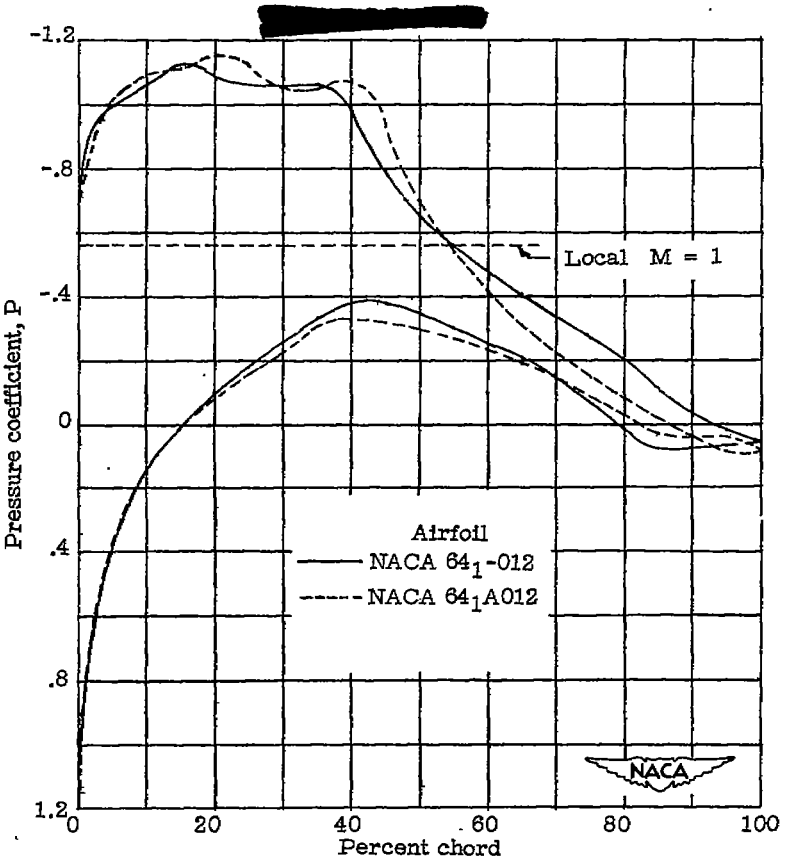
(b) M ≈ 0.6.

Figure 4.- Continued.



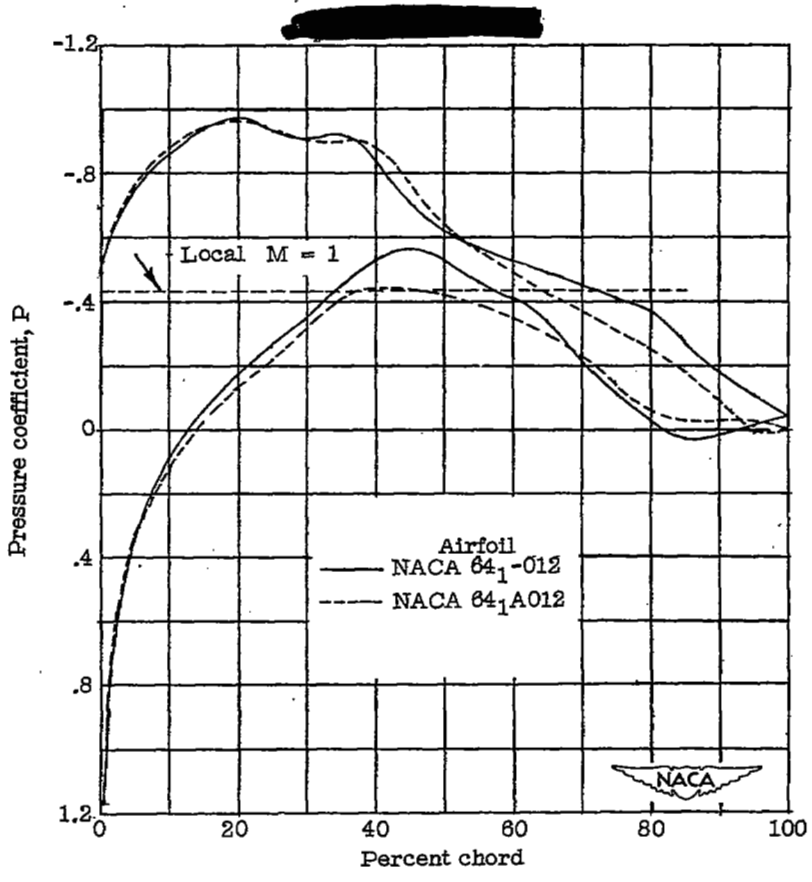
(c) M = 0.71.

Figure 4.- Continued.



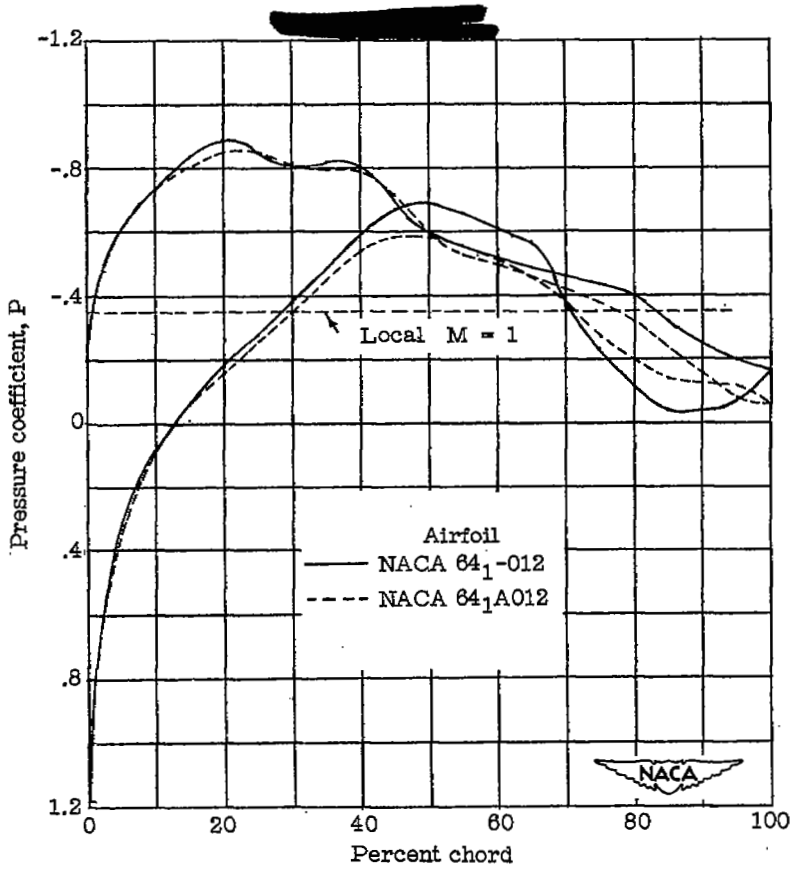
(d) M = 0.76.

Figure 4.- Continued.



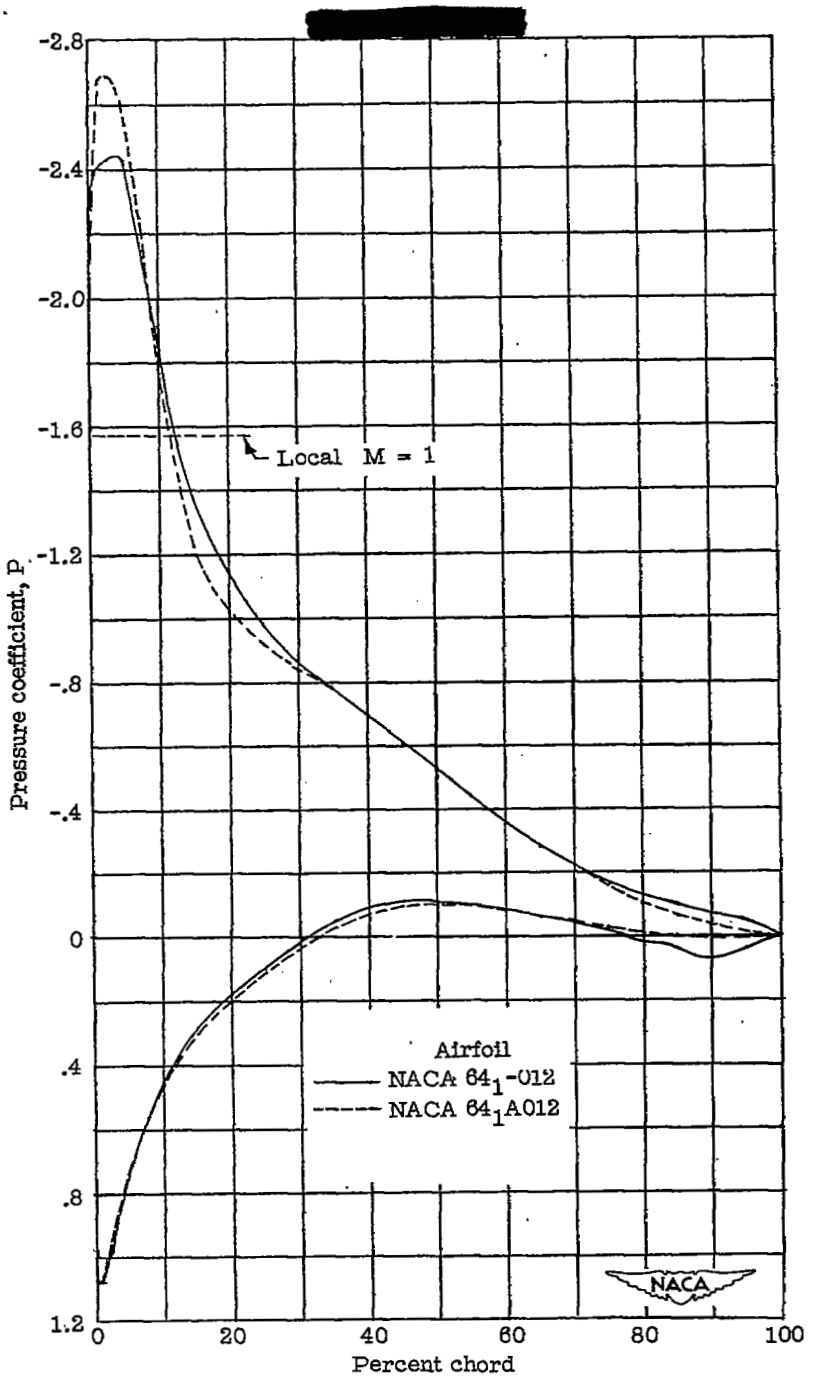
(e) M = 0.80.

Figure 4.- Continued.



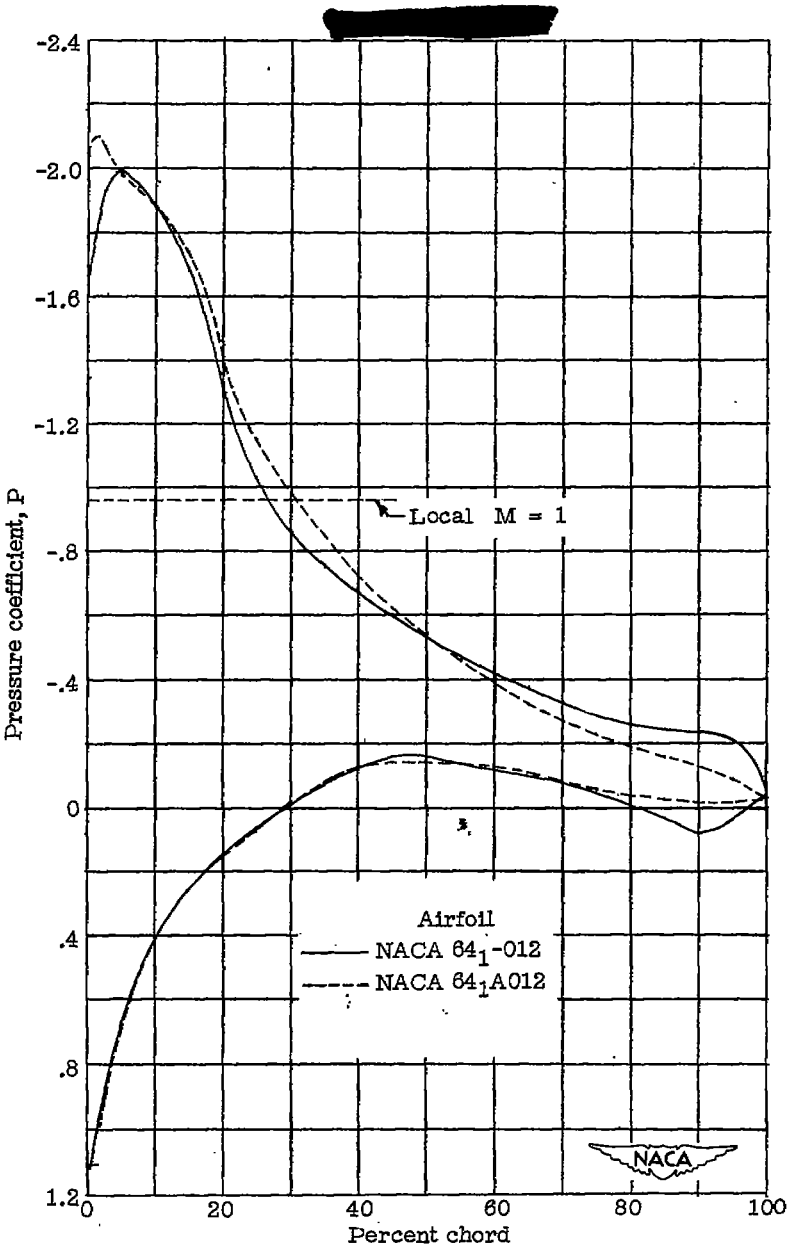
(f) M = 0.83.

Figure 4.- Concluded.



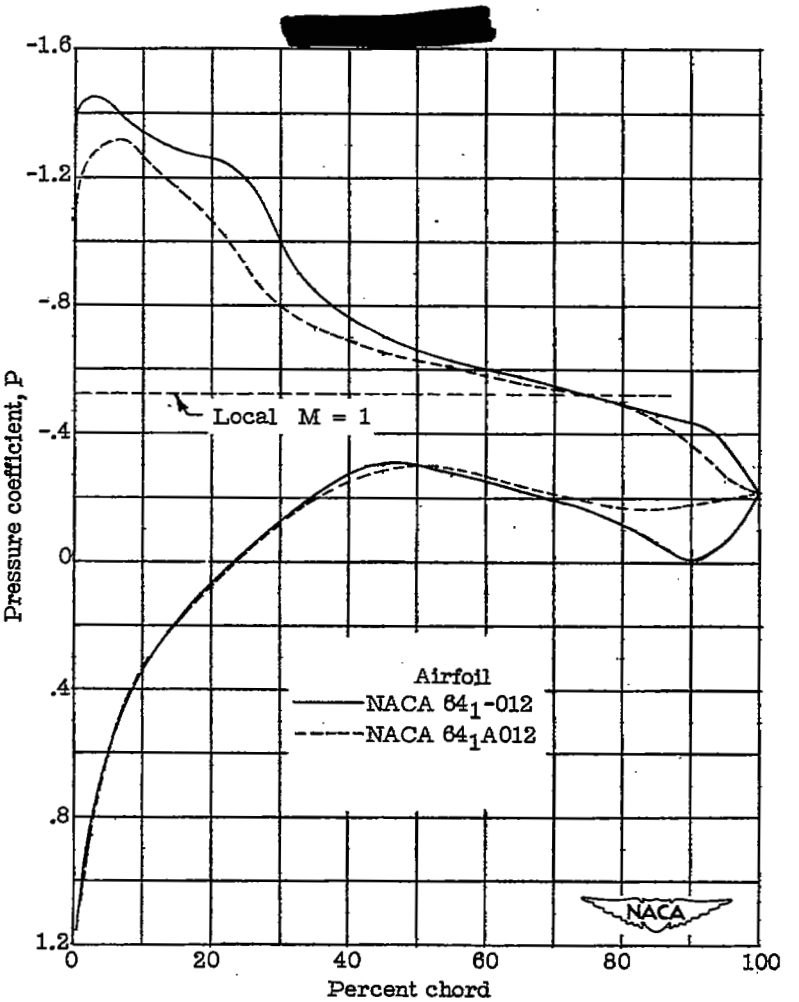
(a) M = 0.56.

Figure 5.- A comparison of pressure-distribution diagrams for the NACA 64$_1$-012 and 64$_1$A012 airfoils. $\alpha = 8^{\circ}$.



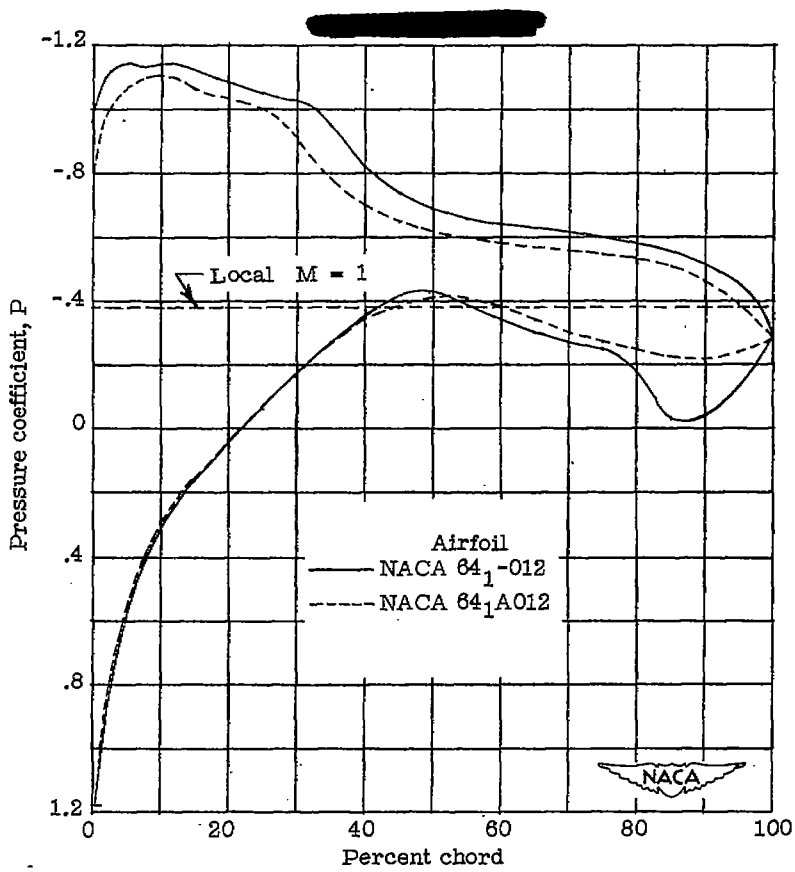
(b) M = 0.86.

Figure 5.- Continued.



(c) M = 0.77.

Figure 5.- Continued.

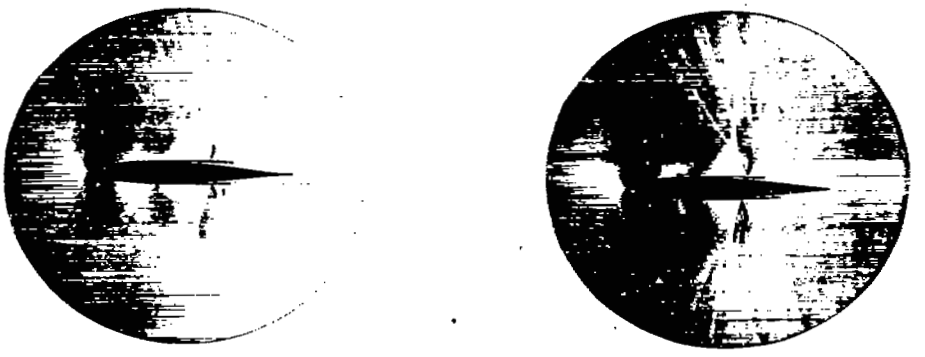


(d) M = 0.82.

Figure 5.- Concluded.

M = 0.61 M = 0.61

M = 0.75 M = 0.74



M = 0.84 M = 0.85

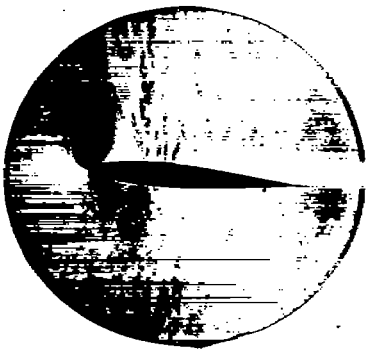
NACA 64_1-012 airfoil NACA 64_1A012 airfoil

(a) $\alpha = 0^\circ$.

NACA L-59835

Figure 6.— Schlieren photographs of the flow about the NACA 64_1-012 and 64_1A012 airfoils.

M = 0.70



M = 0.70

M = 0.75

M = 0.75

M = 0.81

NACA 64_1-012 airfoil

M = 0.81

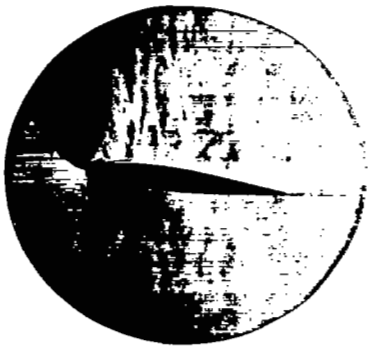
NACA 64_1A012 airfoil

(b) $\alpha = 4^\circ$.

Figure 6.- Continued.

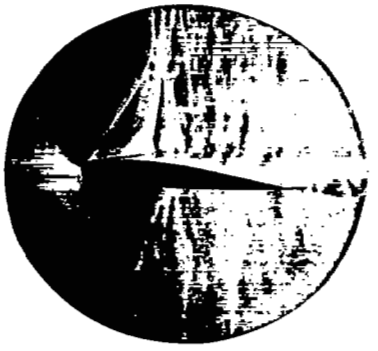
NACA L-59836

M = 0.65

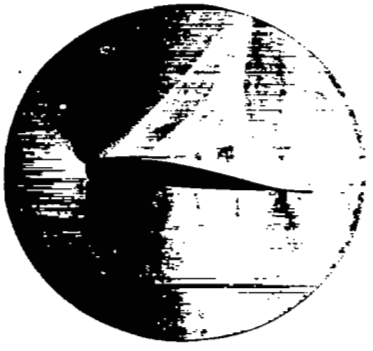


M = 0.65

M = 0.78



M = 0.79



M = 0.82

NACA 64_1-012 airfoil

M = 0.82

NACA 64_1A012 airfoil

(c) $\alpha = 8^\circ$.

Figure 6.– Concluded.

NACA L-59837