NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE

No. 1272

INTERFERENCE OF WING AND FUSELAGE FROM TESTS OF 30 COMBINATIONS WITH TRIANGULAR AND ELLIPTICAL FUSELAGES IN THE NACA VARIABLE-DENSITY TUNNEL

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SUMMARY

Tests of 12 wing-fuselage combinations employing triangular and 18 employing elliptical fuselages were made in the NACA variable-density tunnel as a part of a program to investigate at large values of Reynolds number the aerodynamic effects of wing-fuselage interference. This program is outlined in NACA Report No. 540, which contains the test results for 209 combinations, 202 with round and 7 with rectangular fuselages, comprising the basic part of the wing-fuselage interference investigation.

The parameters of combination for the triangular and elliptical fuselages covered in the investigation were: vertical position of the wing with respect to the fuselage axis; wing shape; and wing-fuselage juncture shape. The results bear out the general conclusions advanced in the discussion in NACA Report No. 540 and provide data concerning the wing-fuselage interference of fuselages of triangular and elliptical cross sections.

INTRODUCTION

An extensive program of investigation of the interference between wing and fuselage was undertaken at the Langley Memorial Aeronautical Laboratory as part of a general investigation designed to cover the problem of aerodynamic interference. This program is outlined in reference 1, which presents the initial and basic part of the wing-fuselage interference investigation and contains test results for 209 combinations, 202 with round and 7 with rectangular fuselages. The discussion therein is fundamental in nature and may be used in the general interpretation of the interference effects of wing-fuselage combinations.

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[1]This report is a revised version of a paper that was originally issued in confidential form in June 1937.

A continuation of the investigation is treated in reference 2 comprising combinations numbered 210 to 237, of which 20 have rectangular fuselages and 8 have round. The tests of reference 2 practically completed the study of combinations with a rectangular fuselage and continued the study of combinations with a round fuselage.

The principal object of this report is to present the test results for combinations numbered 238 to 267: 12 combinations with triangular fuselages and 18 with elliptical. The various combinations were chosen to cover generally the interference between wing and fuselage for triangular and elliptical fuselages as affected by the more important of the parameters of combination.

MODELS AND TESTS

The models were formed of the triangular and elliptical fuselages shown in figure 1 and the wing models described in reference 1, namely, the rectangular 5- by 30-inch NACA 0012 and 4412 airfoils and the NACA 0018-09 airfoil of 2:1 taper ratio. The two fuselages had the same nose shape, length, maximum cross-sectional area, and longitudinal distribution of cross-sectional area as the round fuselage of reference 1.

The models were of duralumin, except for the brass cowled engine (described in reference 1) and for the junctures and fillets, which were carefully formed of plaster of paris as required. They differed from the combination models described in references 1 and 2 in that the fuselages, junctures, and fillets were in each instance finished with a rubbed and polished varnished surface. Comparison tests of combinations both with the old smooth plaster surfaces and subsequently with the new polished varnished surfaces indicated that the effects upon the measured aerodynamic characteristics are well within the experimental accuracy <u>except</u> when flow conditions are critical. That is to say, the early flow breakdown at the junctures associated with critical combinations could be somewhat delayed by the improved finish. Comparisons, therefore, between combinations in this report and those in references 1 and 2 (such as shown in figs. 7 to 9) should be made with this fact in mind.

The tests comprised the following: 12 combinations of the triangular fuselage with the rectangular NACA 0012 airfoil, both without and with fillets, in various vertical positions for both the fuselage erect (apex up) and inverted conditions, and 18 combinations of the elliptical fuselage with different wings, both without and with fillets, for the major axis of the section both erect and horizontal, for various vertical positions of the wing, and with a cowled engine at the fuselage nose. (See table III and figs. 11 to 16.) The only wing fore-and-aft position considered was with the wing quarter-chord point at the fuselage "quarter" point. Zero wing incidence only was employed.

These tests were performed in the NACA variable-density tunnel (reference 3) at a test Reynolds number of approximately 3,100,000 (effective R = 8,200,000). (See reference 1.) In addition, values of maximum lift were obtained at a test Reynolds number of approximately 1,400,000 (effective R = 3,700,000). The testing procedure and test precision, which are very much the same as for an airfoil, are fully described in reference 1. As mentioned in reference 2, however, since the tests of reference 1 were made, a small additional correction of less than -1 percent has been applied to the measurement of the dynamic pressure q to improve the precision of the results.

RESULTS

The test data are given in the same manner as those of reference 1, in which the methods of analysis and of presentation of the results are fully discussed. As in the preceding reports of this series, the test results are given in tables supplemented by figures. Table I, taken from reference 1, contains the characteristics of the wings alone. Table II, which is a continuation of table III in reference 2, presents the sums of the fuselage characteristics and the interferences at various angles of attack for each of the combinations tested. The characteristics of the combinations can be determined by adding corresponding items in tables I and II.

Table II of reference 1, which presents the aerodynamic characteristics of the fuselages alone, is not continued herein because such data for the triangular and elliptical fuselages were not obtained. Table IV of reference 1, which presents data for disconnected combinations, is likewise not continued since no additional combinations of this type were investigated.

Table III, which is a continuation of table V in reference 2, contains the profile diagrams, the combination descriptions, and the principal aerodynamic characteristics of the combinations. The values d/c and k/c represent the longitudinal and vertical displacements, respectively, of the wing quarter-chord axis measured (in mean wing-chord lengths) positive ahead of and above the quarter-chord point of the fuselage. The last nine columns of table III present important characteristics as standard nondimensional coefficients based on the original wing areas of 150 square inches. Symbols used in the tables are defined as follows:

A aspect ratio

a lift-curve slope (in degree measure) as determined in low-coefficient range for an effective aspect ratio of 6.86 (This value of the aspect ratio differs from the actual value of the models because the lift results are not otherwise corrected for tunnel-wall interference.)

e Oswald's airplane or span efficiency factor (see reference 1)

$C_{D_{e_{min}}}$ minimum effective profile-drag coefficient

$$\left(C_D - \frac{C_L^2}{\pi A}\right)_{min}$$

$C_{L_{opt}}$ optimum lift coefficient, that is, lift coefficient corresponding to $C_{D_{e_{min}}}$

n_o aerodynamic-center position indicating approximate location of aerodynamic center ahead of wing quarter-chord axis as fraction of mean wing chord (Numerically, n_o equals $dC_{m_{c/4}}/dC_L$ at zero lift)

C_{m_o} pitching-moment coefficient at zero lift about wing quarter-chord axis

$C_{L_{ib}}$ lift coefficient at interference burble, that is, value of lift coefficient beyond which air flow has a tendency to break down as indicated by abnormal increase in drag

$C_{L_{max}}$ maximum lift coefficient given for two different values of effective Reynolds number (see reference 1)

α angle of attack, degrees

The turbulence factor employed in this report to obtain the effective Reynolds number from the test Reynolds number is 2.64. As in reference 2, the values of the effective Reynolds number differ somewhat from those given in reference 1 because of a more accurate determination of the turbulence factor for the tunnel. The values of the effective Reynolds numbers given in reference 1 are, therefore, subject to correction by a factor of 1.1.

Figures 2 to 10 present the polar characteristics of practically all of the combinations investigated. In some instances, those of several combinations taken from references 1 and 2 are also shown for comparison. These figures show the effects of the various parameters of combination: vertical wing position, fillets, wing shape, and fuselage shape.

Many of the combinations tested showed more than one lift-curve peak. Although the C_{D_e} polars cannot show these interesting portions because of the very high values of the associated drags, the character of these lift peaks can be interpreted from the pitching-moment curves.

DISCUSSION

The mechanism of the interference of a fuselage when in combination with a wing is discussed in reference 1, and all the test results of the present investigation are in accord with the generalizations given therein.

Combinations with erect triangular fuselage.- The triangular fuselage was combined only with the rectangular NACA 0012 airfoil, a wing whose sensitivity to flow conditions renders it eminently suitable to indicate aerodynamic interference. In figure 2 are shown the polars for the erect triangular-fuselage combinations, with the wing in different typical vertical positions, both without and with ordinary tapered fillets. Changing the vertical position has a marked effect, both the minimum drag and the maximum lift increasing as the wing is moved upward with respect to the fuselage. (See table III.) Adding fillets causes a small decrease in the minimum drag of only the midwing combination and has also a small effect on the maximum lift, decreasingly beneficial as the wing position is raised.

Combinations with inverted triangular fuselage.- When the fuselage is inverted (fig. 3), the minimum drag and maximum lift both increase as the wing is moved downward with respect to the fuselage. (See table III.) The effect on the maximum lift of adding fillets is of the same nature as for the combinations with the erect fuselage but, with respect to the maximum lift, is greater in magnitude.

In all these instances, for either the erect or inverted triangular fuselages, it appears that the maximum lift is affected more by the amount of wing leading edge exposed than by whether the combination is high wing or low wing. This conclusion is not to be considered general. Were the tapered NACA 0018-09 wing used instead, it is quite possible that the effect of vertical position upon the maximum lift would be opposite to that for the rectangular NACA 0012 airfoil. (See reference 1.)

Combinations with erect elliptical fuselage.- The effects of changing the vertical position of the wing relative to the elliptical fuselage axis as shown in figure 4 are easily predictable from the results of reference 1. The interference burble occurs earlier as the wing position is moved downward. The midwing combination (with the rectangular NACA 0012 airfoil) has the lowest drag and maximum lift. The high-wing combination has the highest maximum lift.

Results obtained in connection with the program of investigation of wing-fuselage interference have proved that the use of special fillets may entirely eliminate the interference burble. Hence, any discussion of this flow breakdown is to be considered only for what light it sheds upon the mechanism of aerodynamic interference. In the evaluation, therefore, of the relative desirability of the various combinations, too much consideration should not be given to the interference burble and its effect on the maximum lift.

Ordinary tapered fillets on the midwing combination are known to be ineffective from the results of reference 1 and hence were not investigated. When added to the high-wing combination, the fillets have very little effect but, for the low-wing combination, they delay the onset of the interference burble to maximum lift and considerably increase the maximum lift (fig. 5, table III). The same combinations with the tapered NACA 0018-09 wing substituted for the rectangular NACA 0012 airfoil display interference effects (table III) identical with those for the corresponding combinations with the round fuselage (combinations 185, 186, 187, 230, 231, 234 of references 1 and 2): Fillets have little effect on the midwing or high-wing combinations for which values of maximum lift are high and nearly equal, but for the low-wing combination they delay the early interference burble and raise the maximum lift to the neighborhood of the others.

Different wing shapes combined with the elliptical fuselage in the midwing position show the interference effects that would be predicted (fig. 6). The cambered section and the thick symmetrical sections of the tapered wing are less sensitive to the presence of the fuselage than the moderately thick symmetrical NACA 0012 airfoil section.

A cowled radial engine at the nose has similar effects on the aerodynamic characteristics of both the elliptical-fuselage combination and the corresponding round-fuselage combination (fig. 7). The drag increment due to the cowled engine is, however, decidedly greater for the elliptical-fuselage combination, the added drag probably being caused by the poorer cowling shape produced by the elliptical fuselage.

Results also are given in table III, as a matter of interest, for a midwing elliptical-fuselage combination with the tapered wing having added a 0.20c split flap deflected 60° (combination 259).

Combinations with horizontal elliptical fuselage.- In very large airplanes the required fuselage depth may become a small dimension as compared with the other dimensions. The elliptical fuselage with its sectional major axis horizontal serves to simulate such a condition. When combined with the rectangular NACA 0012 airfoil in the midwing position, the horizontally disposed elliptical fuselage exhibits approximately the same effects as the round fuselage (table III, reference 1). The addition of fillets has a beneficial effect upon the occurrence of the interference burble and the value of maximum lift. (See fig. 10.) The substitution of the tapered NACA 0018-09 wing results in a combination having improved characteristics. Enlarging the fillets to very large sizes slightly increases both the lift and drag, as would be expected.

Effect of fuselage shape.- In figures 8 and 9 are summarized the effects of fuselage shape for the six different fuselages investigated combined with the sensitive rectangular NACA 0012 airfoil. The two types of wing-fuselage combination, midwing and low wing, that show markedly the effects of the presence of the fuselage, are used for illustration.

The midwing combinations have approximately the same values of minimum drag, that for the round-fuselage combination being the lowest by a slight amount. The combinations with the round and the inverted triangular fuselages show the earliest interference burbles, and those with the rectangular and the erect triangular fuselages show the latest. The values of maximum lift, however, are approximately the same for the combinations with the round, elliptical, and inverted triangular fuselages (table III) and are lower than for the erect triangular-fuselage and rectangular-fuselage combinations.

The low-wing combinations (fig. 9) have also approximately the same values of minimum drag, that for the erect triangular-fuselage combination being the lowest by a slight amount. The interference burbles are not so sharply defined as for the midwing combinations and are spread, for the different combinations, over a wider range of lift coefficient. The rectangular fuselage still shows the latest occurrence of the burble.

CONCLUDING REMARKS

The main value of the subject report is in the data it makes available for wing-fuselage combinations with the triangular and elliptical fuselage shapes. Very little in the way of new conclusions of a general nature are deducible. Previous to this investigation, the occurrence of more than one lift-curve peak was not brought out, but since has been studied in greater detail through the use of improved balances. The multiple peaks occur when only a portion of the lifting system definitely stalls at a normally high lift coefficient, the rest of the system stalling some time later. This characteristic shows on the figures in the curves of pitching moment. The drag curves are usually not extended to sufficiently high values to encompass more than one peak. One fairly important conclusion reached during the course of testing in this investigation, although not illustrated in the present results, is the importance of unusually smooth surfaces at the junctures of critical combinations as regards the stalling. This conclusion was to be expected, however, from the results of airfoil tests alone.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va., October 16, 1946

REFERENCES

1. Jacobs, Eastman N., and Ward, Kenneth E.: Interference of Wing and Fuselage from Tests of 209 Combinations in the N.A.C.A. Variable-Density Tunnel. NACA Rep. No. 540, 1935.

2. Sherman, Albert: Interference of Wing and Fuselage from Tests of 28 Combinations in the N.A.C.A. Variable-Density Tunnel. NACA Rep. No. 575, 1936.

3. Jacobs, Eastman N., and Abbott, Ira H.: The N.A.C.A. Variable-Density Wind Tunnel. NACA Rep. No. 416, 1932.

TABLE I.- AIRFOIL CHARACTERISTICS

[Taken from reference 1]

Airfoil	C_L	C_{D_e}	$C_{m_{c/4}}$	C_L	C_{D_e}	$C_{m_{c/4}}$	C_L	C_{D_e}	$C_{m_{c/4}}$
	$\alpha = 0^\circ$			$\alpha = 4^\circ$			$\alpha = 12^\circ$		
Rectangular NACA 0012	0.000	0.0080	0.000	0.307	0.0087	0.003	0.920	0.0150	0.004
Tapered NACA 0018-09	.000	.0093	.000	.305	.0099	.006	.910	.0146	.013
	$\alpha = -4^\circ$			$\alpha = 0^\circ$			$\alpha = 8^\circ$		
Rectangular NACA 4412	-0.006	0.0097	-0.089	0.298	0.0095	-0.087	0.899	0.0136	-0.084

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TABLE II

LIFT AND INTERFERENCE, DRAG AND INTERFERENCE, AND PITCHING MOMENT AND INTERFERENCE OF FUSELAGE IN WING-FUSELAGE COMBINATIONS

[Continuation of table III in reference 2]

Combi-nation	ΔC_L	ΔC_{D_e}	$\Delta C_{m_{c/4}}$	ΔC_L	ΔC_{D_e}	$\Delta C_{m_{c/4}}$	ΔC_L	ΔC_{D_e}	$\Delta C_{m_{c/4}}$
	$\alpha = 0^\circ$			$\alpha = 4^\circ$			$\alpha = 12^\circ$		
238	0.005	0.0047	0.004	0.019	0.0054	0.012	0.028	0.0075	0.024
239	.030	.0044	.001	.053	.0048	.006	.068	.0076	.012
240	.008	.0041	.002	.029	.0048	.010	.067	.0065	.018
241	.004	.0036	.000	.029	.0042	.007	.071	.0053	.018
242	.008	.0038	-.002	.029	.0041	.008	.054	.0059	.017
243	-.003	.0037	.001	.021	.0042	.006	.066	.0052	.012
244	-.008	.0038	.002	.013	.0041	.012	.036	.0047	.027
245	.003	.0037	-.001	.021	.0041	.008	.056	.0051	.019
246	-.008	.0041	-.002	.009	.0045	.006	.026	.0059	.021
247	-.004	.0036	.000	.010	.0041	.007	.045	.0049	.019
248	-.005	.0047	-.004	-.005	.0052	.002	-.042	.0129	.010
249	-.030	.0044	-.001	-.018	.0049	.004	-.009	.0064	.005
250	-.015	.0043	.005	-.010	.0050	.009	.003	.0060	.018
251	.020	.0047	.000	.031	.0054	.000	.055	.0066	.002
252	.009	.0038	-.001	.025	.0043	.002	.047	.0048	.006
253	.015	.0043	-.005	.031	.0051	-.001	-.020	.0245	-.007
254	-.020	.0047	.000	.003	.0049	-.003	.023	.0056	-.008
255	-.028	.0037	.009	-.023	.0040	.011	-.018	.0053	.019
256	.001	.0038	-.001	.012	.0043	-.001	.025	.0070	.002
257	.010	.0031	-.002	.023	.0032	.000	.045	.0047	.005
258	.020	.0029	-.001	.034	.0031	-.001	.062	.0044	.002
259	.973	.1264	-.200	.976	.1261	-.211	.965	.1289	-.220
260	.028	.0037	-.009	.035	.0045	-.007	.022	.0079	-.008
261	-.001	.0038	.001	.015	.0042	.003	.015	.0058	-.002
	$\alpha = -4^\circ$			$\alpha = 0^\circ$			$\alpha = 8^\circ$		
262	-0.017	0.0044	-0.011	0.002	0.0041	-0.002	0.031	0.0042	0.000
	$\alpha = 0^\circ$			$\alpha = 4^\circ$			$\alpha = 12^\circ$		
263	0.006	0.0071	-0.001	0.028	0.0082	0.008	0.064	0.0155	0.015
264	.009	.0038	.000	.030	.0038	.009	.067	.0051	.023
265	.004	.0038	.000	.031	.0039	.006	.083	.0047	.015
266	.027	.0019	-.003	.047	.0019	.005	.083	.0038	.019
267	.020	.0027	-.006	.051	.0029	.005	.103	.0053	.020

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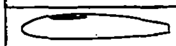
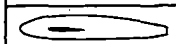
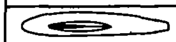
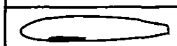
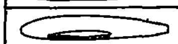
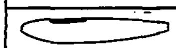
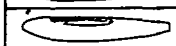
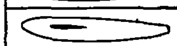
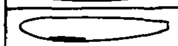
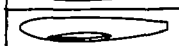
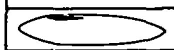
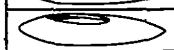
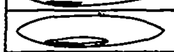
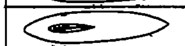
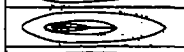
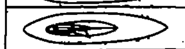
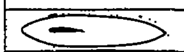
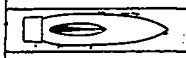
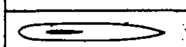
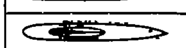
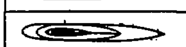
TABLE III.- PRINCIPAL AERODYNAMIC CHARACTERISTICS OF WING-FUSELAGE COMBINATIONS

[Continuation of table V in reference 2]

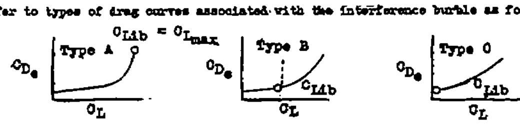
Diagrams representing combinations	Combination	Remarks	Longitudinal position, d/c	Vertical position, k/c	Angle of wing setting, i_w (deg)	Lift-curve slope (per degree), a (A=6.86)	Span efficiency factor, e	$C_{D_{e_{min}}}$	$C_{L_{opt}}$	Aerodynamic-center position, n_o	C_{m_o}	Lift coefficient at interference burble, $C_{L_{ib}}$ (1)	$C_{L_{max}}$ (2) Effective R=8.2x10⁶	
													Effective R=8.2×10^6	Effective R=3.7×10^6
Rectangular NACA 0012 airfoil with erect triangular fuselage														
	- - -	Wing alone - - - -	- - - -	- - - -	- - -	0.077	0.85	0.0080	0.00	0.010	0.000	[A]1.5	[c]1.54	[c]1.39
	238	- - - - - - - - - - -	0	0.35	0	.080	4.80	.0125	-.05	.030	.004	[A]1.5	[c]1.56	[c]1.40
	239	With tapered fillets	0	.35	0	.081	5.85	.0124	.04	.023	.000	[B]1.2	[c]1.57	[c]1.50
	240	- - - - - - - - - - -	0	0	0	.082	5.85	.0121	.00	.033	.001	[B]1.3	[c]1.35	[c]1.35
	241	With tapered fillets	0	0	0	.082	5.85	.0117	.02	.027	.000	[A]1.4	[c]1.40	[b]1.34
	242	- - - - - - - - - - -	0	-.22	0	.081	5.85	.0117	-.01	.037	-.002	[B]1.0	[a]1.25	[a]1.24
	243	With tapered fillets	0	-.22	0	.082	.85	.0117	.00	.031	.001	[A]1.3	[b]1.34	[a]1.26
Rectangular NACA 0012 airfoil with inverted triangular fuselage														
	244	- - - - - - - - - - -	0	0.22	0	0.080	0.85	0.0117	0.01	0.040	0.002	[B]0.9	[a]1.27	[a]1.21
	245	With tapered fillets	0	.22	0	.081	.85	.0117	.00	.030	-.001	[B].9	[a]1.30	[a]1.25
	246	- - - - - - - - - - -	0	0	0	.081	.85	.0121	.00	.032	-.001	[B].9	[a]1.23	[b]1.20
	247	With tapered fillets	0	0	0	.080	5.85	.0117	-.02	.029	.000	[A]1.3	[b]1.38	[c]1.34
	248	- - - - - - - - - - -	0	-.35	0	.077	5.80	.0125	.05	.027	-.004	[6A]1.1	[c]1.41	[c]1.33
	249	With tapered fillets	0	-.35	0	.079	4.85	.0124	-.04	.023	.000	[B]1.1	[c]1.61	[b]1.44
Rectangular NACA 0012 airfoil with erect elliptical fuselage														
	250	- - - - - - - - - - -	0	0.38	0	0.078	5.85	0.0123	-0.03	0.020	0.005	[A]1.5	[c]1.54	[b]1.34
	251	With tapered fillets	0	.38	0	.080	5.85	.0128	.02	.005	.000	[6A]1.5	[c]1.52	[c]1.45
	252	- - - - - - - - - - -	0	0	0	.081	4.85	.0118	.00	.019	-.001	[B]1.2	[c]1.22	[c]1.22
	253	- - - - - - - - - - -	0	-.38	0	.079	5.85	.0123	.03	.022	-.005	[B].7	[b]1.38	[c]1.34
	254	With tapered fillets	0	-.38	0	.081	5.85	.0128	-.02	.000	.000	[6A]1.6	[c]1.62	[c]1.51

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

TABLE III. - PRINCIPAL AERODYNAMIC CHARACTERISTICS OF WING-FUSELAGE COMBINATIONS - CONCLUDED

Diagrams representing combinations	Combination	Remarks	Longitudinal position, a/c	Vertical position, k/c	Angle of wing setting, i_w (deg)	Lift-curve slope (per degree), a (A=6.86)	Span efficiency factor, e	$C_{D_{e_{min}}}$	$C_{L_{opt}}$	Aerodynamic-center position, n_o	C_{m_o}	Lift coefficient at interference burble, $C_{L_{lb}}$ (1)	$C_{L_{max}}$ (2) Effective R=8.4×10⁶	$C_{L_{max}}$ (2) Effective R=3.7×10⁶
Tapered NACA 0018-09 airfoil with erect elliptical fuselage														
	- -	Wing alone - - - -	- - - -	- - - -	- - - -	0.077	0.90	0.0093	0.00	0.020	0.000	A1.4	[c]1.48	[c]1.23
	255	- - - - - - - - - -	0	0.32	0	.078	5.85	.0130	-.02	.026	.009	[6]A1.5	[c]1.53	[a]1.29
	256	With tapered fillets	0	.32	0	.078	5.85	.0131	-.01	.021	-.001	[6]A1.5	[b]1.60	[c]1.32
	257	- - - - - - - - - -	0	0	0	.079	4.85	.0123	.00	.024	-.002	[6]A1.5	[c]1.53	[b]1.27
	258	With tapered fillets	0	0	0	.080	4.85	.0121	-.01	.020	-.002	[6]A1.5	[a]1.55	[c]1.28
	259	With fillets and 0.20c split flap deflected 60°	0	0	0	.079	- - -	[7].14	- -	[3]-.007	-.181	- - -	[a]2.22	[a]2.03
	260	- - - - - - - - - -	0	-.32	0	.078	4.85	.0130	.02	.025	-.009	B.9	[c]1.28	[a]1.11
	261	With tapered fillets	0	-.32	0	.079	4.85	.0131	.01	.018	.001	A1.5	[b]1.54	[a]1.22
Rectangular NACA 4412 airfoil with erect elliptical fuselage														
	- -	Wing alone	- -	- - -	- - - -	0.076	0.90	0.0094	0.22	0.006	-0.089	A1.6	[a]1.64	[a]1.51
	262	- - - - - - - - - -	0	0	0	.080	4.90	.0135	.23	.022	-.097	[6]A1.5	[b]1.59	[a]1.49
Rectangular NACA 0012 airfoil with erect elliptical fuselage														
	263	With fillets and cowled engine	0	0	0	0.082	5.80	0.0150	0.00	0.031	-0.001	[6]A1.4	[b]1.48	[b]1.32
Rectangular NACA 0012 airfoil with horizontal elliptical fuselage														
	264	- - - - - - - - - -	0	0	0	0.082	[4]0.85	0.0118	0.00	0.034	-0.001	B1.2	[c]1.28	[c]1.26
	265	With tapered fillets	0	0	0	.084	[5].90	.0118	.00	.028	.000	A1.3	[b]1.37	[b]1.32
Tapered NACA 0018-09 airfoil with horizontal elliptical fuselage														
	266	With tapered fillets	0	0	0	0.080	[5]0.90	0.0113	0.02	0.040	-0.004	[6]A1.5	[c]1.59	[a]1.30
	267	With very large fillets	0	0	0	.083	.90	.0120	.00	.047	-.008	A1.6	[c]1.66	[a]1.34

[1] Letters refer to types of drag curves associated with the interference burble as follows:



[2] Letters refer to condition at maximum lift as follows: a, reasonably steady at $C_{L_{max}}$; b, small loss of lift beyond $C_{L_{max}}$; c, large loss of lift beyond $C_{L_{max}}$ and uncertain value of $C_{L_{max}}$.

[3] Poor agreement in high-speed range.

[4] Poor agreement over whole range.

[5] Poor agreement in high-lift range.

[6] Rapid increase in drag preceding definite breakdown.

[7] Value that holds approximately constant over useful range.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

FUSELAGE ORDINATES

[All dimensions in inches]

	Triangular fuselage					Elliptical fuselage	
Station x	y_u	y_l	w	r_o	r_s	h	d
-0.156		0.000				0.000	
0		.772				.772	
.250		1.242	Diameter			1.242	
.500		1.572				1.572	
.719		1.795				1.795	
1.500	- - -	- - -	- - -	- - -	- - -	2.490	2.140
1.719	1.383	1.188	2.644	0.891	5.650	- - -	- - -
2.312	- - -	- - -	- - -	- - -	- - -	3.310	2.320
2.719	1.760	1.296	3.203	.634	6.640	- - -	- - -
3.000	- - -	- - -	- - -	- - -	- - -	3.625	2.390
4.000	2.025	1.358	3.609	.405	7.286	4.170	2.475
5.000	- - -	- - -	- - -	- - -	- - -	4.431	2.532
6.000	2.136	1.436	3.814	.426	7.673	4.512	2.578
8.000	2.153	1.449	3.845	.430	7.740	4.550	2.600
10.000	2.132	1.434	3.805	.426	7.664	4.505	2.574
12.000	2.046	1.394	3.635	.409	7.353	4.323	2.470
14.000	1.871	1.318	3.264	.374	6.728	3.955	2.260
16.000	1.576	1.175	2.643	.315	5.661	3.329	1.902
17.000	1.362	1.077	2.182	.272	4.894	2.870	1.640
18.000	- - -	- - -	- - -	- - -	- - -	2.247	1.284
19.000	.849	.746	.828	.092	6.615	1.323	.756
19.500	- - -	- - -	- - -	- - -	- - -	.725	.414
20.000	.562	.562	0	0		0	0

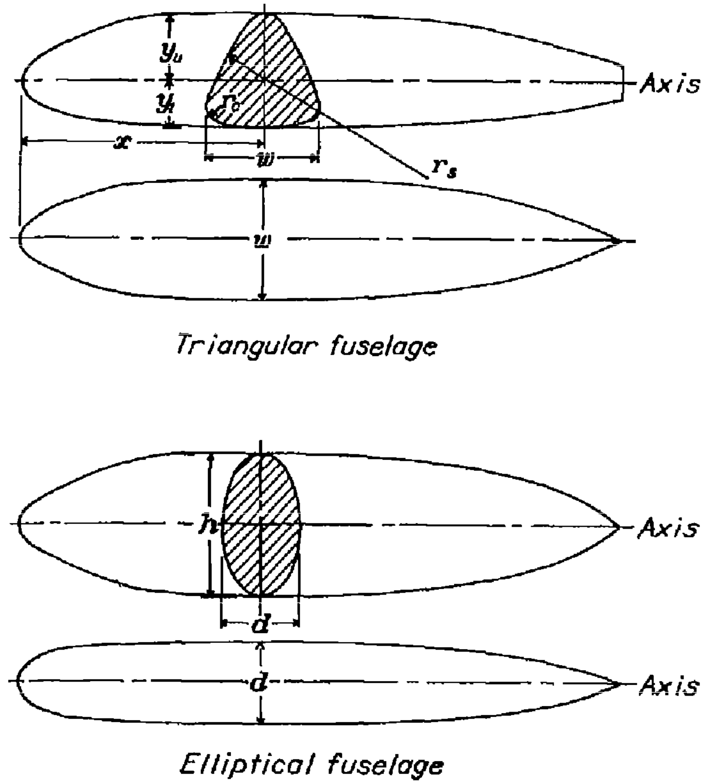


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Figure 1.- Fuselage models.

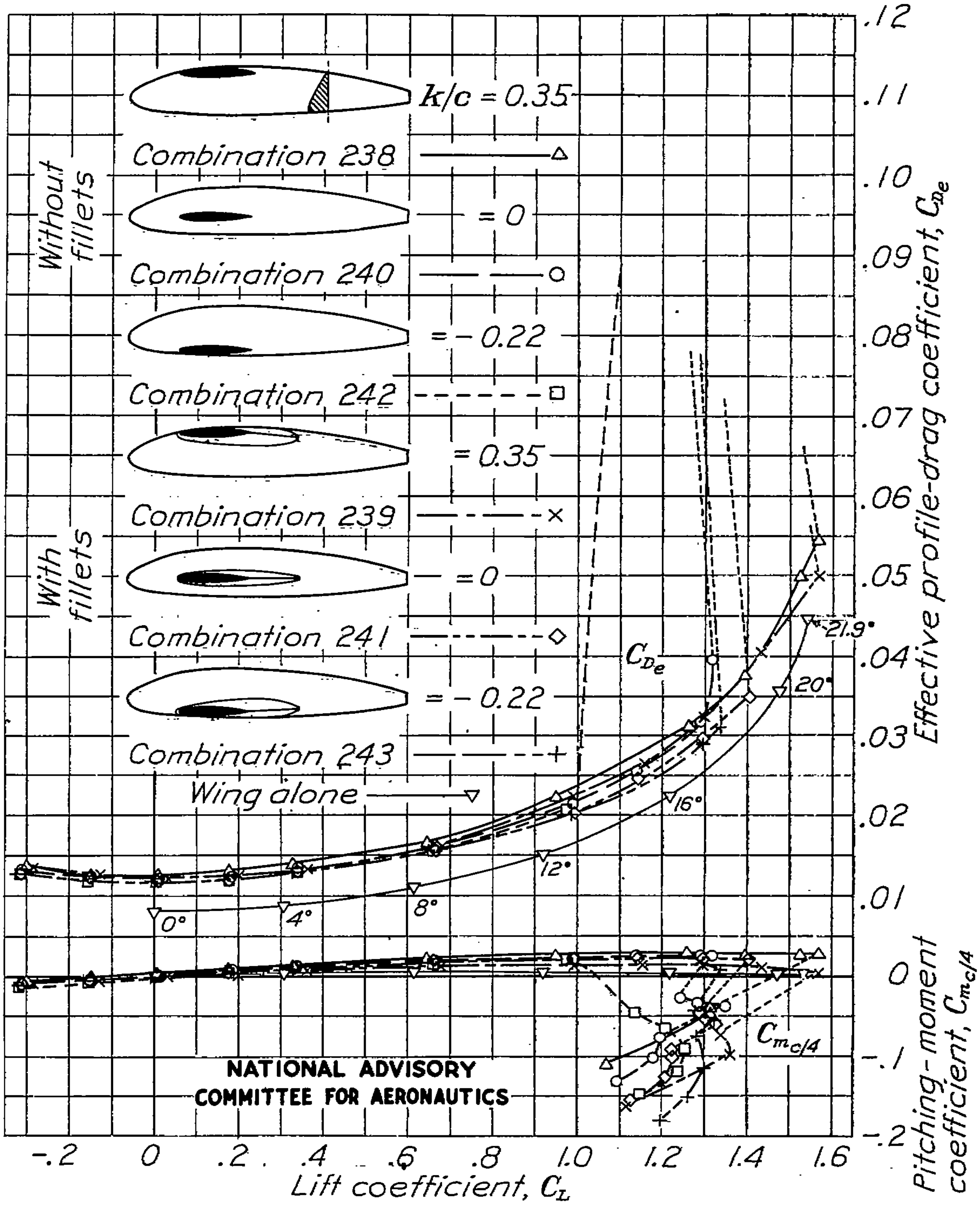

Figure 2.- Characteristics for various vertical wing positions. Rectangular NACA 0012 airfoil and erect triangular fuselage, both without and with fillets.

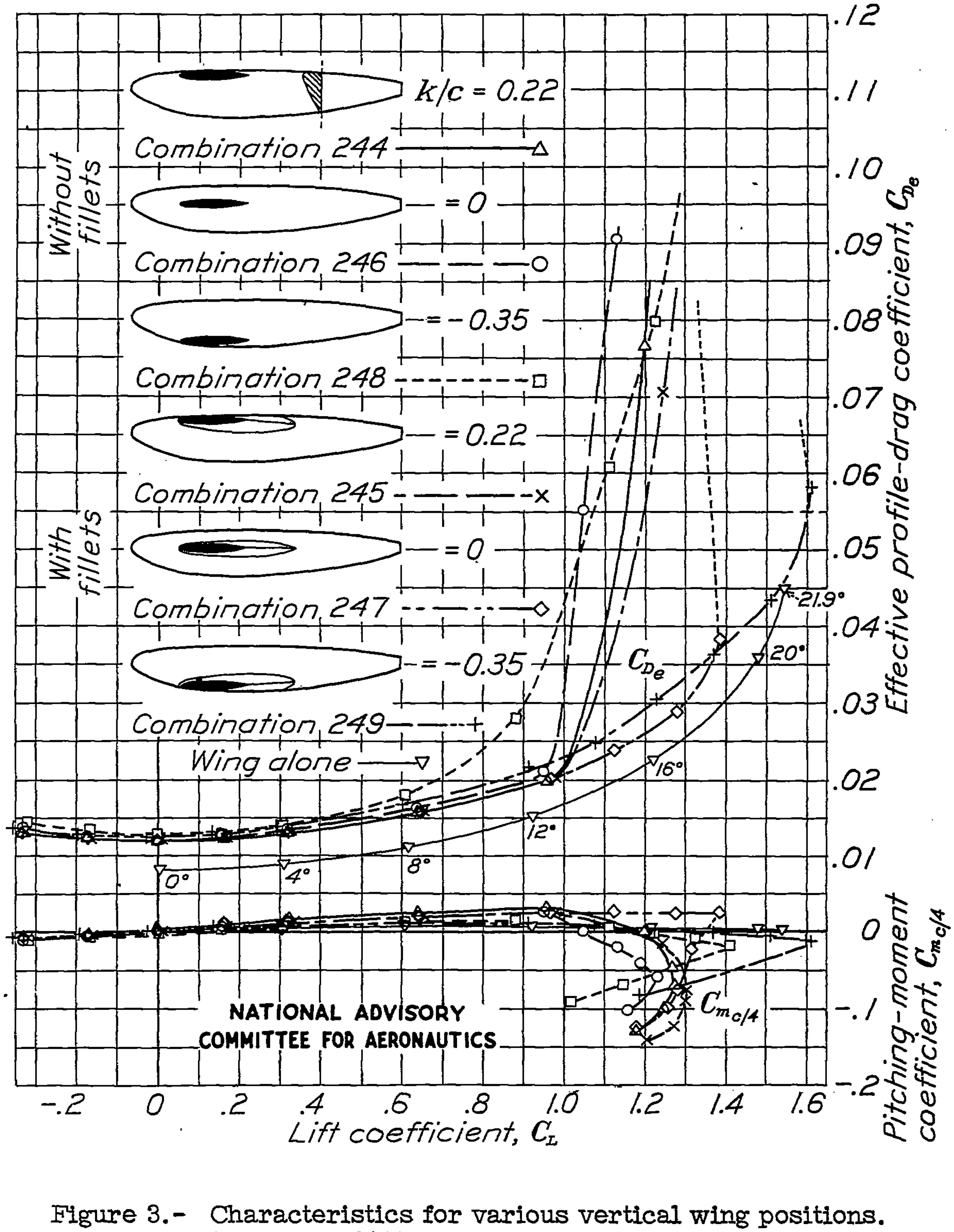

Figure 3.- Characteristics for various vertical wing positions. Rectangular NACA 0012 airfoil and inverted triangular fuselage, both without and with fillets.

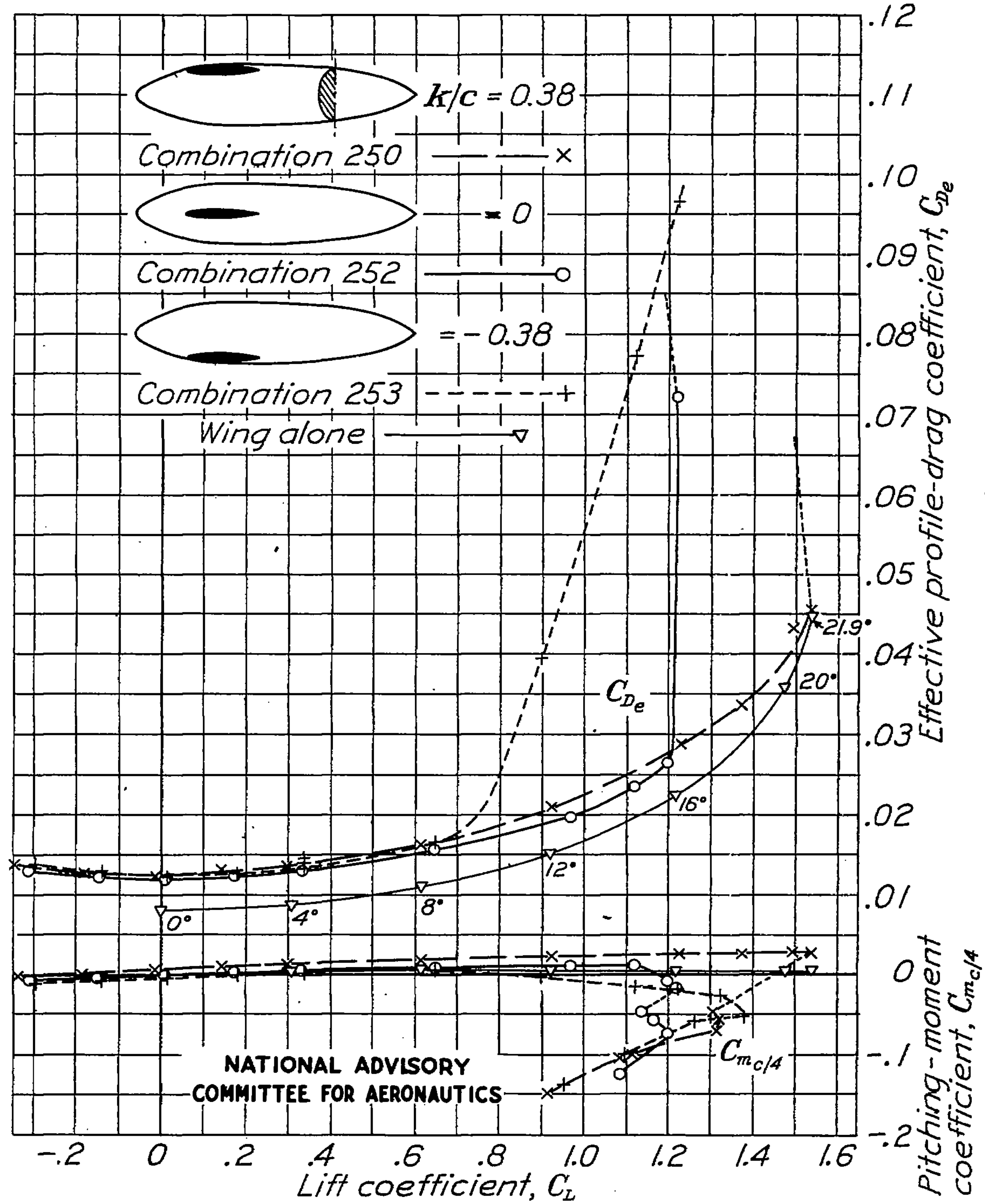

Figure 4.- Characteristics for various vertical wing positions. Rectangular NACA 0012 airfoil and erect elliptical fuselage.

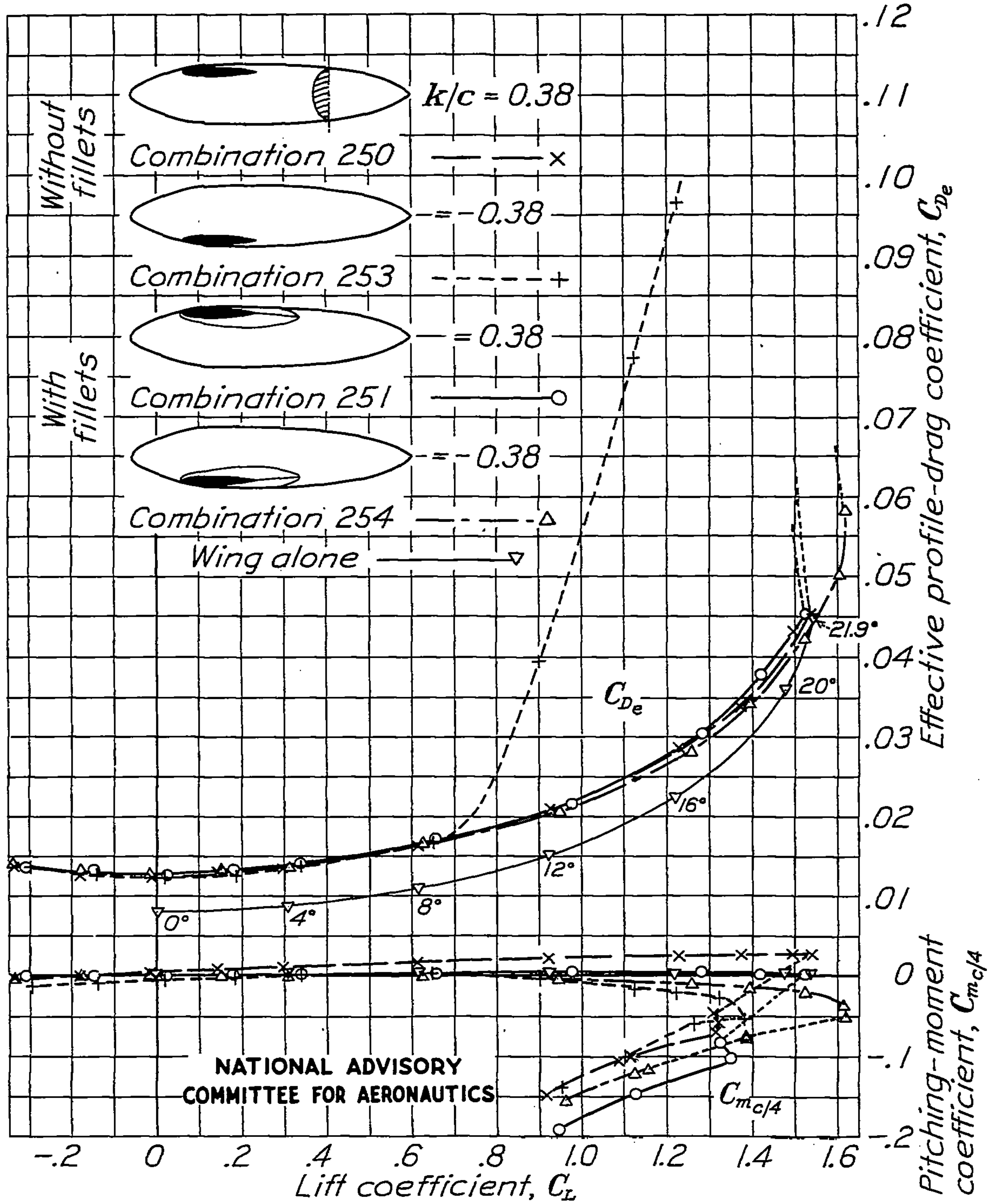

Figure 5.- Effect of normal tapered fillets on the characteristics of combinations with the erect elliptical fuselage. Rectangular NACA 0012 airfoil.

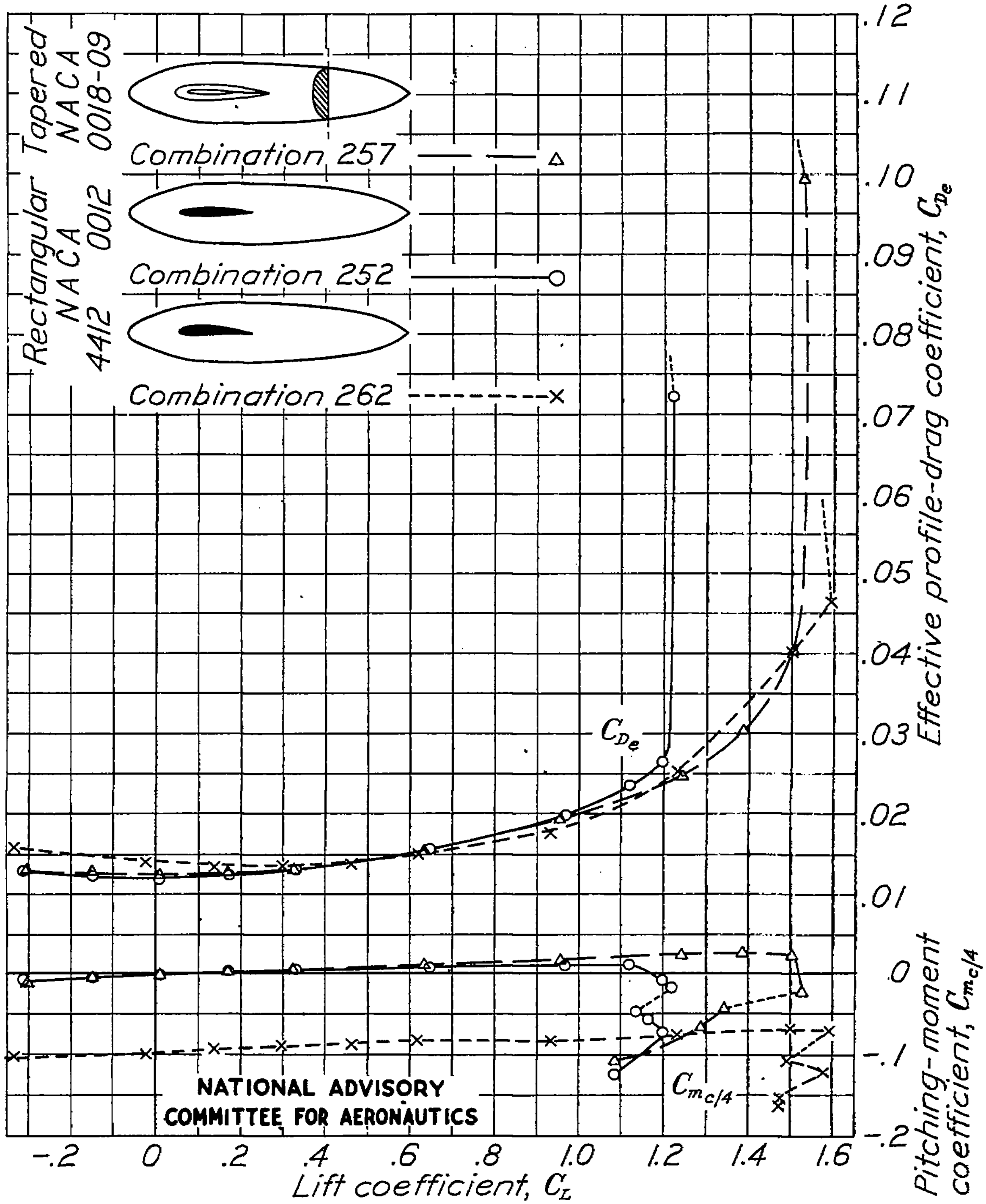

Figure 6.- Characteristics for various wing shapes. Erect elliptical fuselage, midwing position.

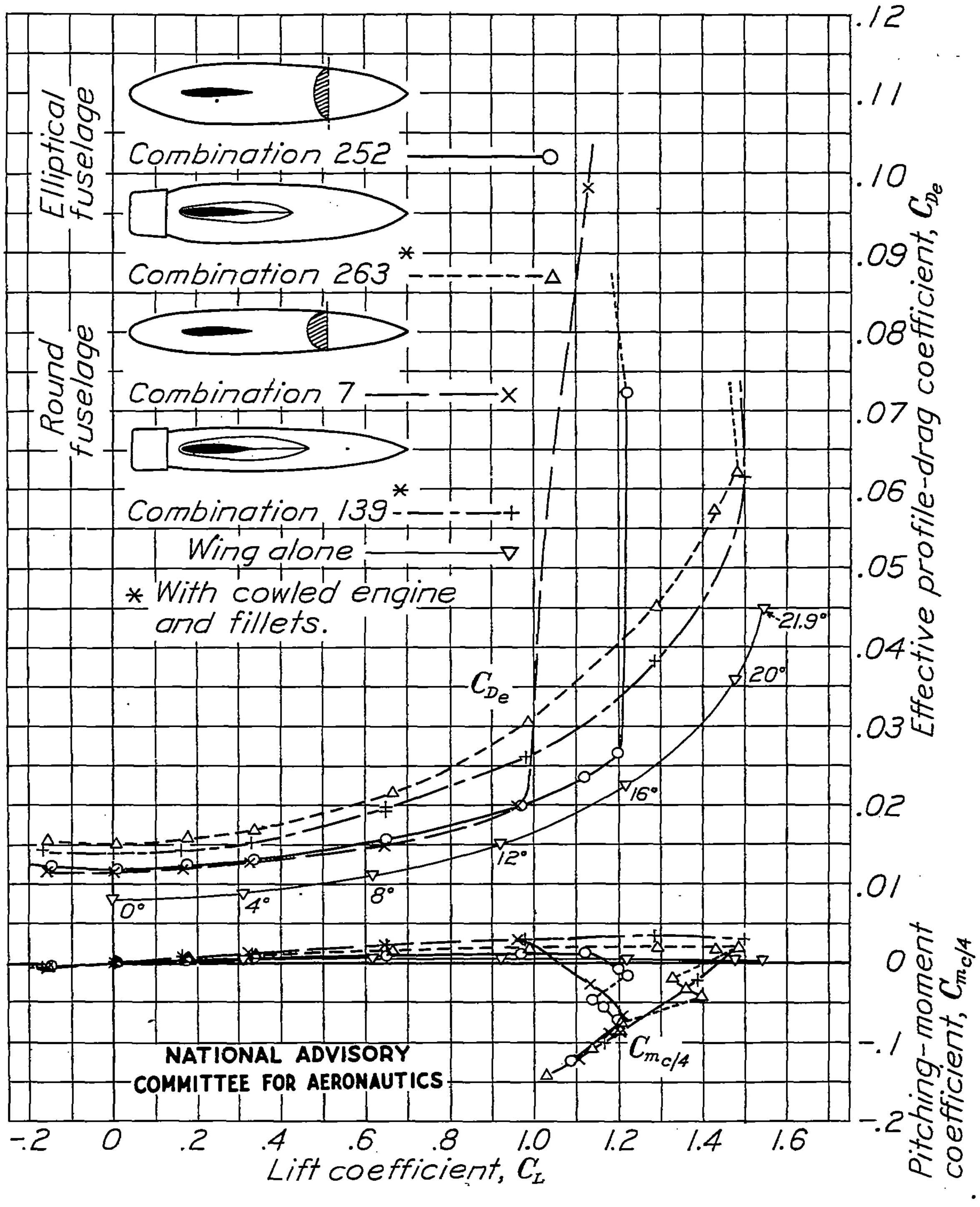

Figure 7.- Effects of adding a cowled engine and fillets upon the characteristics of a combination with the erect elliptical fuselage. Midwing position.

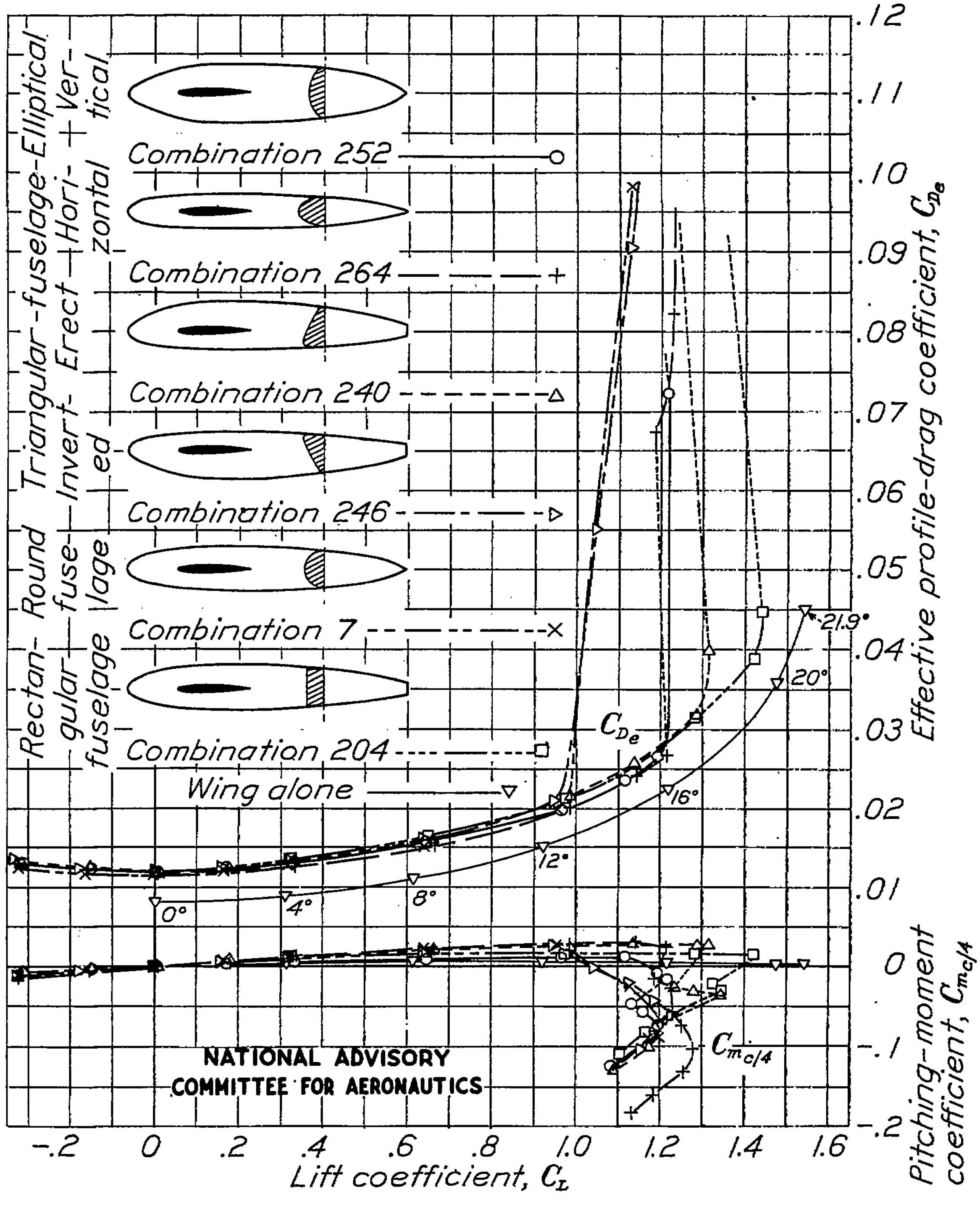

Figure 8.- Characteristics for various fuselage shapes. Rectangular NACA 0012 airfoil. Midwing position.

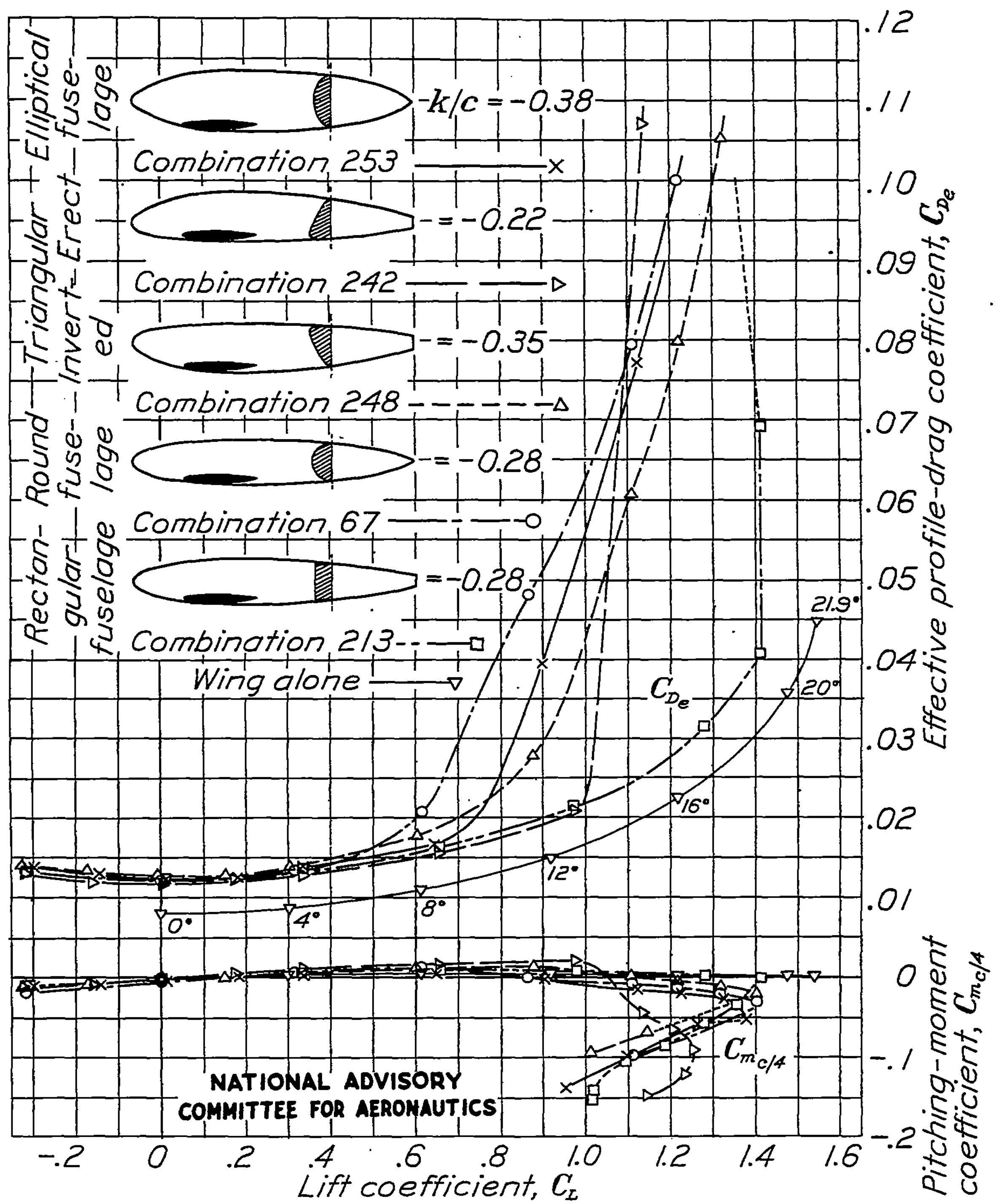

Figure 9.- Characteristics for various fuselage shapes. Rectangular NACA 0012 airfoil. Low-wing position.

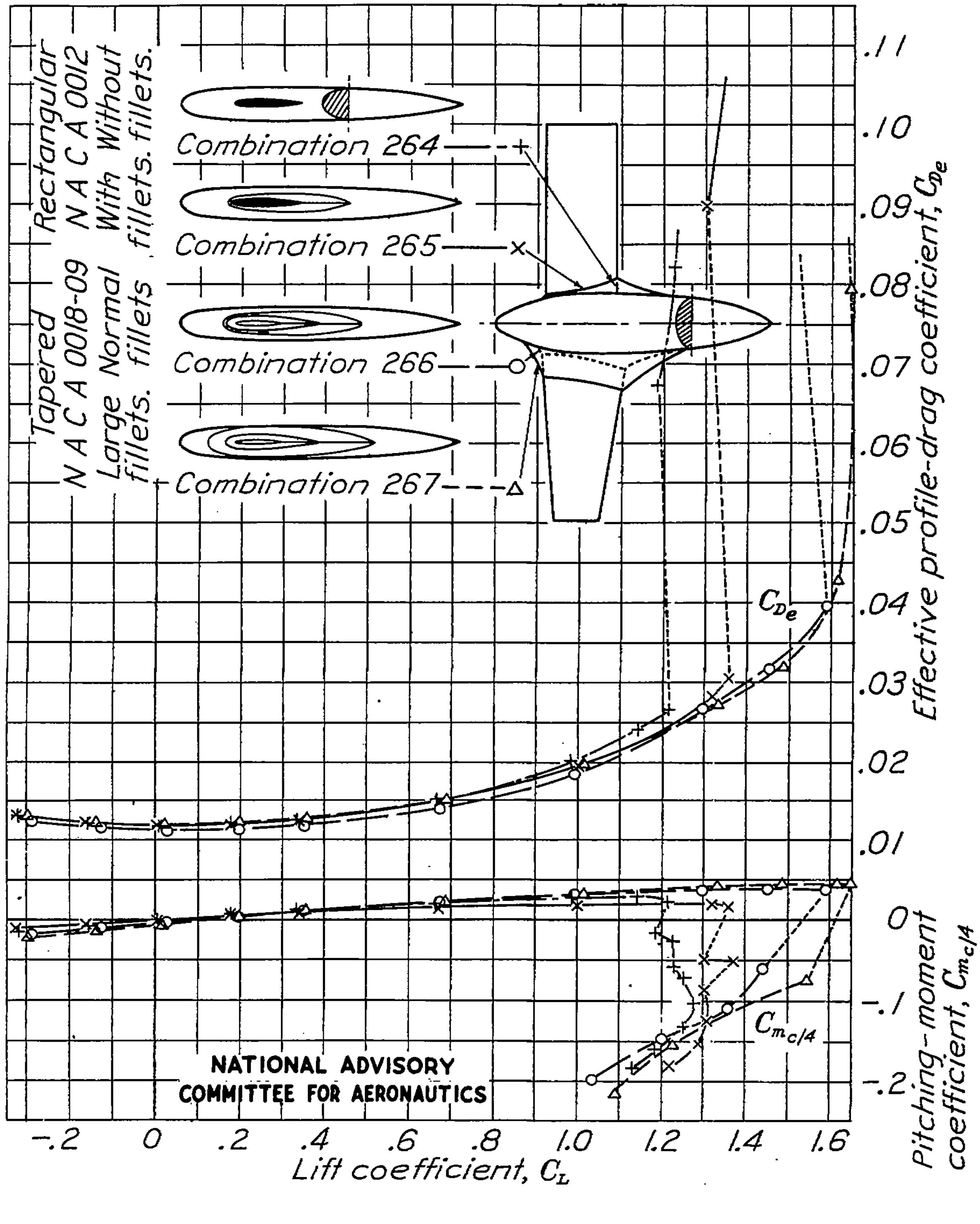

Figure 10.- Characteristics for various combinations with the horizontal elliptical fuselage.

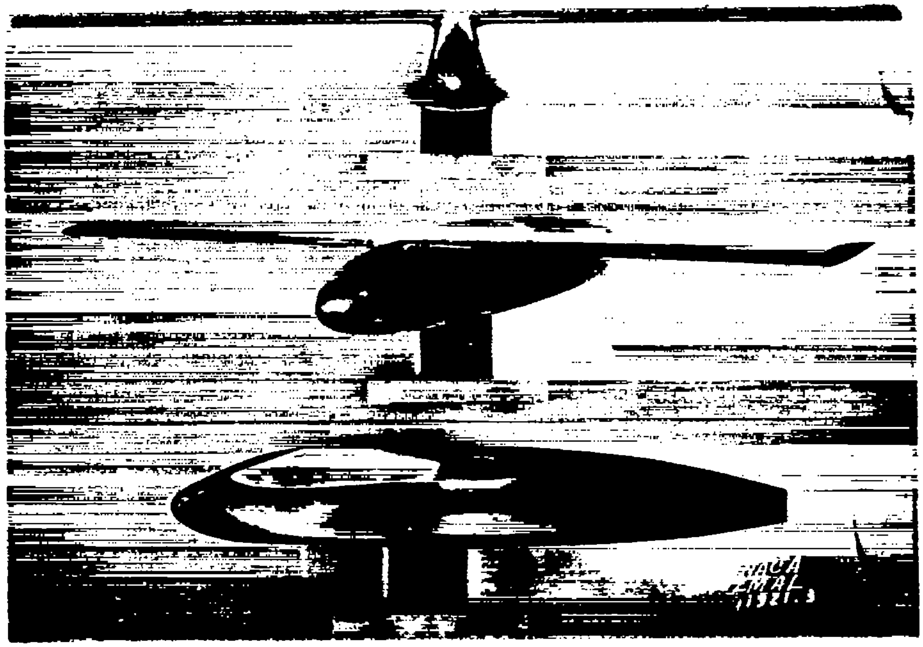

Figure 11.- Combination 239 (combination 249 inverted).

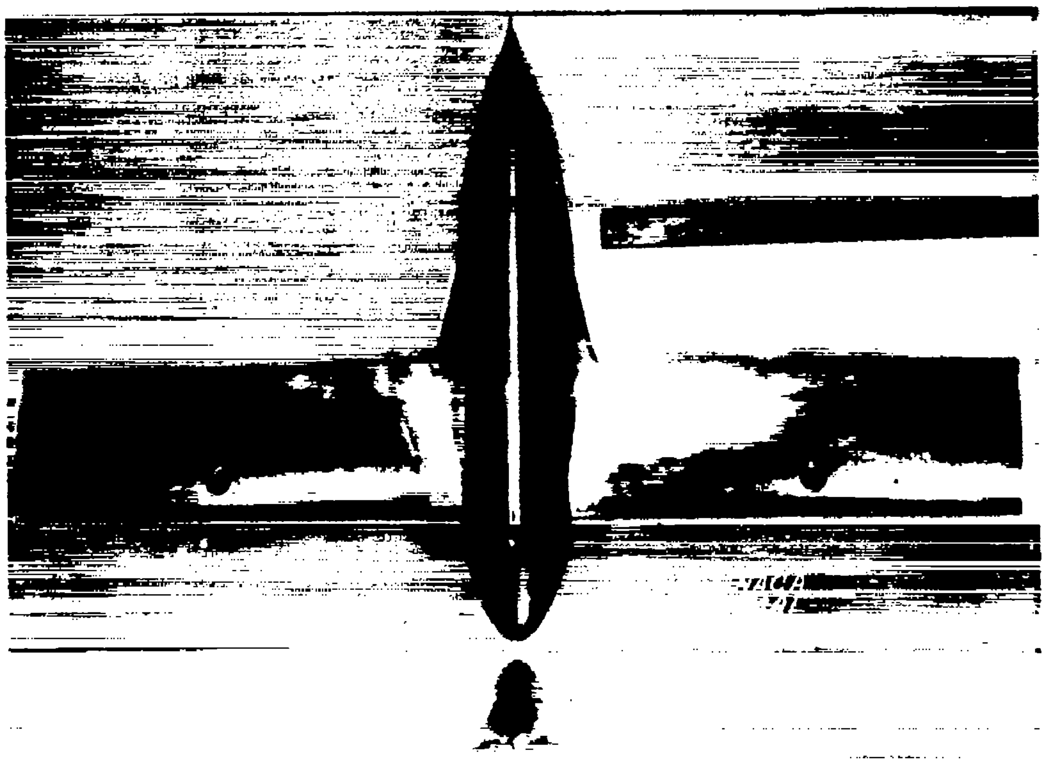

Figure 12.- Combination 243 (combination 245 inverted).

Figure 13.- Combination 254 (combination 251 inverted).

Figure 14.- Combination 261 (combination 256 inverted).

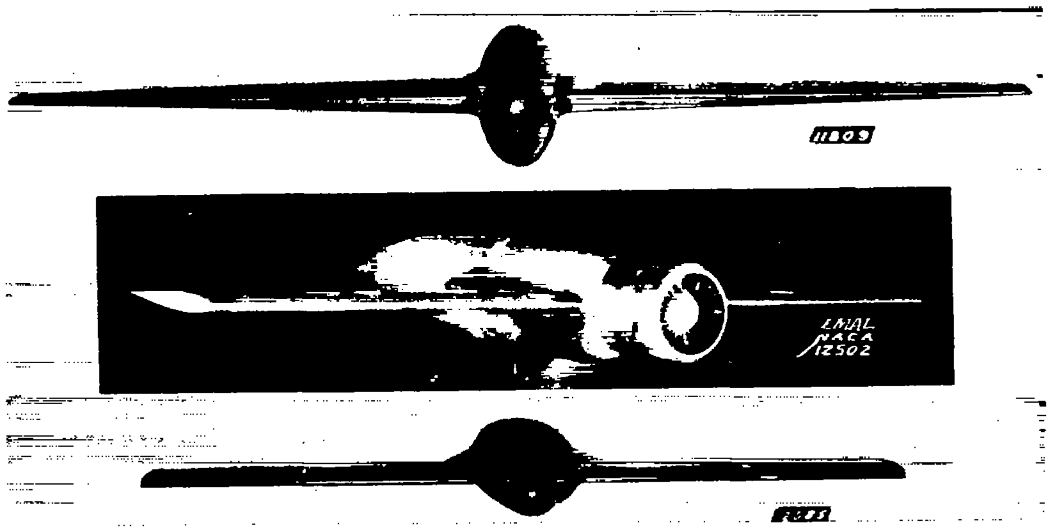

Figure 15.- Combinations 258, 263, 265.

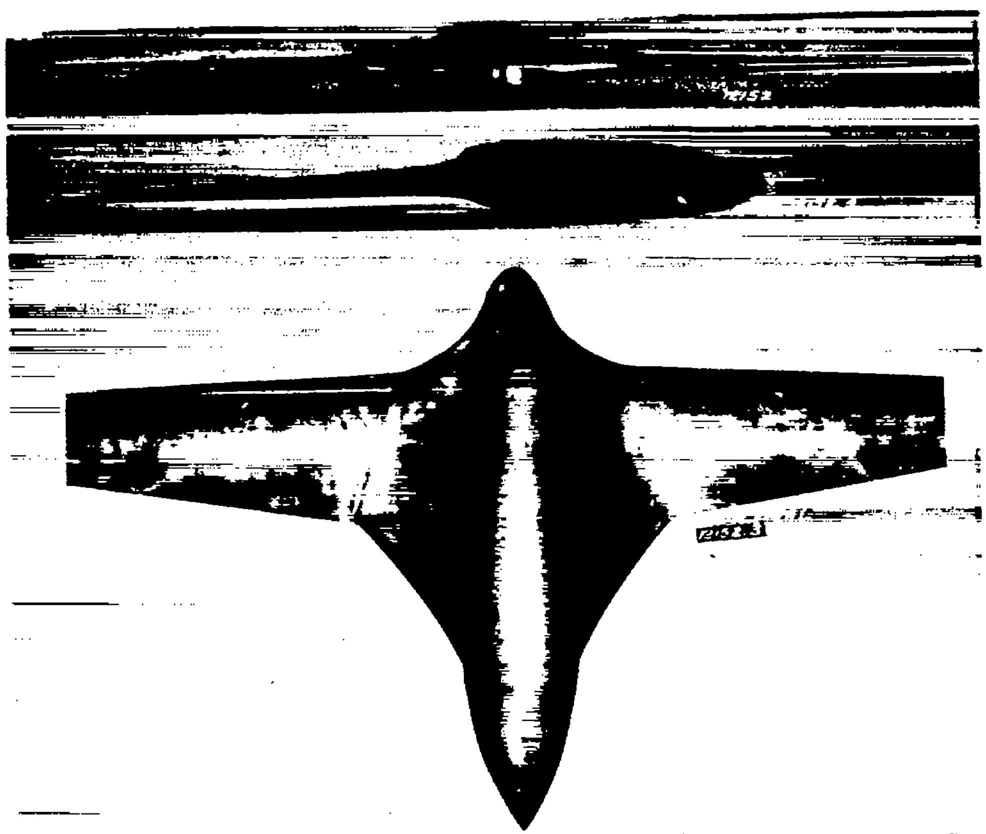

Figure 16.- Combination 267.

TITLE: Interference of Wing and Fuselage from Tests of 30 Combinations with Triangular and Elliptical Fuselages in the NACA Variable-Density Tunnel

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ABSTRACT:

Data and results are presented for 12 wing-fuselage combinations with triangular fuselages and 18 with elliptical. Parameters of the combinations for the two types of fuselages concerned vertical position of the wing with respect to fuselage axis, wing shape, and wing-fuselage juncture shape. Tables are presented containing profile diagrams, combination descriptions, and principal aerodynamic charactertstics of the combinations. Two other tables are included covering characteristics of the wings alone and sums of the fuselage charactertstics.

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