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RESEARCH MEMORANDUM

PRELIMINARY MEASUREMENTS OF STATIC LONGITUDINAL STABILITY AND TRIM FOR THE XF-92A DELTA-WING RESEARCH AIRPLANE IN SUBSONIC AND TRANSONIC FLIGHT

By Thomas R. Sisk and John M. Mooney

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Langley Field, Va.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

Preliminary static-longitudinal-stability and trim results obtained with the XF-92A delta-wing research airplane during power-plant demonstration and U. S. Air Force performance tests are presented for Mach numbers up to 0.97 and altitudes from 11,000 to 40,000 feet.

The data indicate that the airplane had a stable variation of control angle with speed up to some Mach number between 0.75 and 0.87. A nose-down trim change extended from a Mach number of 0.87 to a Mach number of about 0.93 at which point a nose-up trim change was encountered.

The apparent longitudinal stability was constant up to a Mach number of about 0.75. As the Mach number increased above 0.75, the apparent stability increased rapidly to approximately five times the low-speed value at a Mach number of 0.96. Most of this increase was caused by an increase in the static longitudinal stability which increased threefold for the same Mach number range.

INTRODUCTION

The XF-92A airplane was constructed by Consolidated Vultee Aircraft Corporation as a prototype of a proposed fighter to provide information on the flight characteristics of the delta-wing configuration at low speeds.

In the course of the demonstration flight tests of the airplane by Consolidated Vultee, limited stability and control data up to a Mach number of 0.70 in level flight and 0.925 in dives were obtained and reported in reference 1. Reference 2 reported the U. S. Air Force phase II performance and stability flight tests of the airplane.

Because of the increased interest in the delta wing as a possible supersonic configuration, the U. S. Air Force requested that the Allison J-33-A-23 power plant be replaced by a J-33-A-29 engine with afterburner in order to improve the speed capabilities of the airplane. Following an engine demonstration and some performance testing by the U. S. Air Force, the airplane is to be turned over to the National Advisory Committee for Aeronautics for flight research.

The U. S. Air Force performance tests to demonstrate the augmented turbojet have been completed. The NACA High-Speed Flight Research Station at Edwards Air Force Base, Calif. supplied engineering, instrumentation, and operational assistance to the Air Force during these flights. The longitudinal trim and static-longitudinal-stability data obtained in the course of these tests are presented in this paper.

SYMBOLS

C_{m_α}	static stability parameter per deg
C_{N_A}	airplane normal-force coefficient, $\frac{Wn}{qS}$
c.g.	airplane center-of-gravity location, percent M.A.C.
g	acceleration due to gravity
h_p	pressure altitude, ft
M	Mach number
n	normal acceleration, g units
q	dynamic pressure, lb/sq ft
S	wing area, sq ft
c	mean aerodynamic chord, ft
t	time, sec
P	period of oscillation, sec

V_i	indicated airspeed, mph
W	airplane weight, lb
I_Y	moment of inertia in pitch, slug-ft^2
α	angle of attack, deg
δ_e	longitudinal control angle, $\frac{\delta_{e_L} + \delta_{e_R}}{2}$, deg
$d\delta_e/dC_{N_A}$	apparent stability parameter, negative value indicates a stable variation, deg

Subscripts:

L	left
R	right

AIRPLANE

The Convair XF-92A is a semitailless delta-wing research airplane having 60° leading-edge sweepback. The elevons and rudder are full-span constant-chord surfaces and are 100 percent hydraulically boosted. An artificial feel system is provided. Photograph of the airplane is shown in figure 1 and a three-view drawing is shown in figure 2. The airplane physical characteristics are listed in table I.

INSTRUMENTATION

The XF-92A airplane is equipped with standard NACA recording instruments for recording airspeed, altitude, normal acceleration, control positions, sideslip angle, and angle of attack. The angle-of-attack recorder was inoperative during some of the flights due to malfunctioning of the transmitter. All instruments were correlated by a common timer.

A preliminary airspeed calibration has been obtained by radar tracking and radiosonde balloon pressure-survey measurements during one flight. The error in this preliminary calibration is believed to be approximately ±0.02 Mach number.

TESTS, RESULTS, AND DISCUSSION

The longitudinal trim and static longitudinal stability was measured in the clean configuration at Mach numbers varying from 0.20 to 0.97 and at pressure altitudes of 11,000, 15,000, 25,000, and 35,000 feet and in dives from 40,000 to 30,000 feet. The center of gravity for these tests ranged from 26.7 to 28.2 percent mean aerodynamic chord. The Reynolds number range covered in the tests was from 17×10^6 to 75×10^6. The apparent longitudinal stability was derived from the dive recoveries and from cross plots of the longitudinal-trim curves, and the static-stability parameter was determined from oscillatory maneuvers. The results of these tests are presented in figures 3 to 7.

Figure 3 shows the variation of the longitudinal control angle with Mach number for the various test altitudes and the dives. The center of gravity varied from 27.1 to 28.2 percent mean aerodynamic chord with the exception of the flagged points which have a center-of-gravity location of 26.7 percent mean aerodynamic chord. The data indicate that the airplane has a stable variation of control angle with Mach number to some Mach number between 0.75 and 0.87. A nose-down trim change extends from a Mach number of 0.87 to a Mach number of about 0.93. At a Mach number of about 0.93 a nose-up trim change occurs. These trim changes are generally similar to those reported by others (ref. 3) in rocket model and tunnel investigations of triangular-wing configurations. The discontinuity between the nose-down and nose-up trim changes at a Mach number of about 0.93 is caused by the difference in airplane normal-force coefficient of the two dives from which the data were obtained.

The trim points for Mach numbers below 0.75 given in figure 3 are presented in figure 4 as a function of indicated airspeed. The points all fall on one line; this result indicates that the variation with altitude shown in figure 3 is caused by lift coefficient for this Mach number range. These data also indicate the large control deflections required at low speeds.

Figure 5 presents the variation of longitudinal control angle with airplane normal-force coefficient. The data at Mach numbers below 0.75 were obtained by cross-plotting the curves of figure 3 at constant Mach number, whereas the data at Mach numbers greater than 0.84 were obtained from dive recoveries. Time histories of these dive recoveries are presented in figure 6 with the range over which the apparent longitudinal stability was obtained being noted. The oscillations present in these recoveries result from low damping and high control effectiveness. The variation of apparent longitudinal stability with Mach number obtained from figure 5 is presented in figure 7(a). These data show that the apparent stability increases rapidly to approximately five times the low-speed value at a Mach number of 0.96. Figure 7(b) presents the variation of the static-stability parameter C_{m_α} from measurements of the periods of several oscillations encountered during the performance tests with Mach number. The value of C_{m_α} was obtained from the expression $C_{m_\alpha} = -\frac{I_Y}{qSc}\left(\frac{2\pi}{P}\right)^2$. These data show that the static longitudinal stability increases threefold as the Mach number increases from approximately 0.75 to 0.94. This indicates that most of the increase in apparent stability is caused by an increase in static longitudinal stability.

CONCLUSIONS

From the results obtained during the power-plant demonstration and U. S. Air Force performance tests of the XF-92A research airplane the following conclusions were drawn:

1. The airplane had a stable variation of control angle with speed up to some Mach number between 0.75 and 0.87. A nose-down trim change extended from a Mach number of 0.87 to a Mach number of about 0.93, at which point a nose-up trim change was encountered.

2. The apparent longitudinal stability was constant up to a Mach number of about 0.75. As the Mach number increased above 0.75 the apparent stability increased rapidly to approximately five times the low-speed value at a Mach number of 0.96. The static longitudinal stability increased threefold as the Mach number increased from approximately 0.75 to 0.94; this result indicates that most of the increase in apparent stability was caused by an increase in static longitudinal stability.

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REFERENCES

1. Anon.: Flight Test Memorandum XF-92 (Model-7002) Airplane. Rep. Nos. F-7002-1, F-7002-2, F-7002-3, F-7002-4, F-7002-5, F-7002-6, Consolidated Vultee Aircraft Corp., 1949.

2. Mapp, Robert, Yeager, Charles E., and Everest, Frank K., Jr.: Phase II Flight Tests of the XF-92A Airplane USAF No. 46-682. MR No. MCRFT-2262, Flight Test Div., Air Materiel Command, U. S. Air Force, Dec. 20, 1949.

3. Mitcham, Grady L., Stevens, Joseph E., and Norris, Harry P.: Aerodynamic Characteristics and Flying Qualities of a Tailless Triangular-Wing Airplane Configuration As Obtained From Flights of Rocket-Propelled Models at Transonic and Low Supersonic Speeds. NACA RM L9L07, 1950.

TABLE I

PHYSICAL CHARACTERISTICS OF THE XF-92A AIRPLANE

Wing:	
Area, sq ft	425
Span, ft	31.33
Airfoil section	NACA $65_{(06)}$-006.5
Mean aerodynamic chord, ft	18.09
Aspect ratio	2.31
Root chord, ft	27.13
Tip chord	0
Taper ratio	0
Sweepback (leading edge), deg	60
Incidence, deg	0
Dihedral (chord plane), deg	0
Elevons:	
Area (both), sq ft	78.22
Span (1 elevon), ft	13.65
Chord, ft	3.04
Movement, deg	
Elevator:	
Up	15
Down	5
Aileron, total	10
Operation	Hydraulic
Vertical tail:	
Area, sq ft	75.35
Height, above fuselage center line, ft	11.50
Rudder:	
Area, sq ft	15.53
Span, ft	9.22
Travel, deg	±8.5
Operation	Hydraulic
Fuselage:	
Length, ft	42.80
Power plant:	
Engine	Allison J-33-A-29 with afterburner
Rating:	
Static thrust at sea level, lb	5600
Static thrust at sea level with afterburner, lb	7500

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TABLE I.- Concluded.

PHYSICAL CHARACTERISTICS OF THE XF-92A AIRPLANE

Weight:	
Gross weight (560 gal fuel), lb	15,560
Empty weight, lb	11,808
Center-of-gravity locations:	
Gross weight (560 gal fuel), percent M.A.C.	25.5
Empty weight, percent M.A.C.	29.2
Moment of inertia in pitch, slug-ft^2	35,000

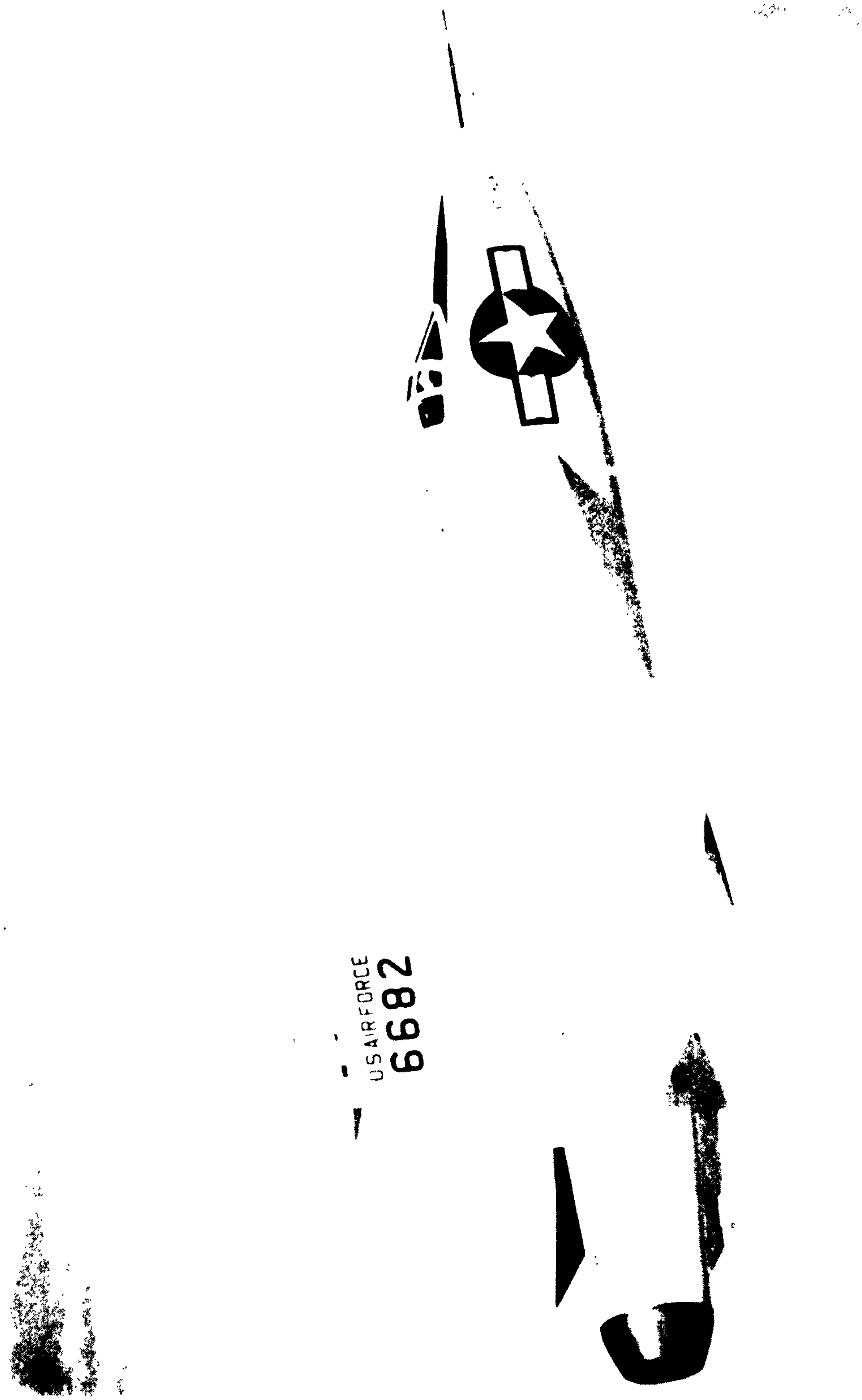


Figure 1.- Photograph of the XF-92A research airplane. L-77934

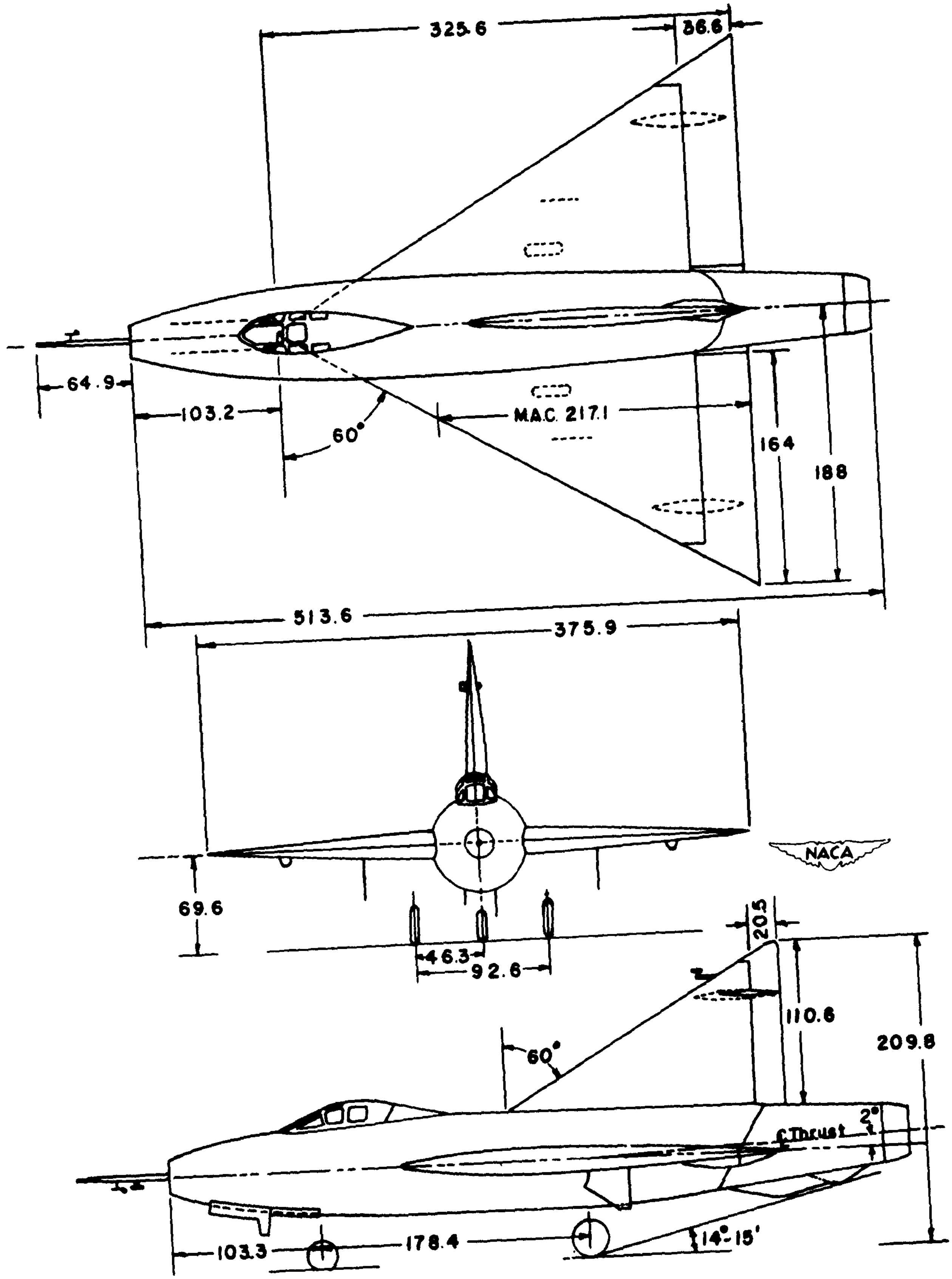


Figure 2.- Three-view drawing of XF-92A airplane. All dimensions are in inches.

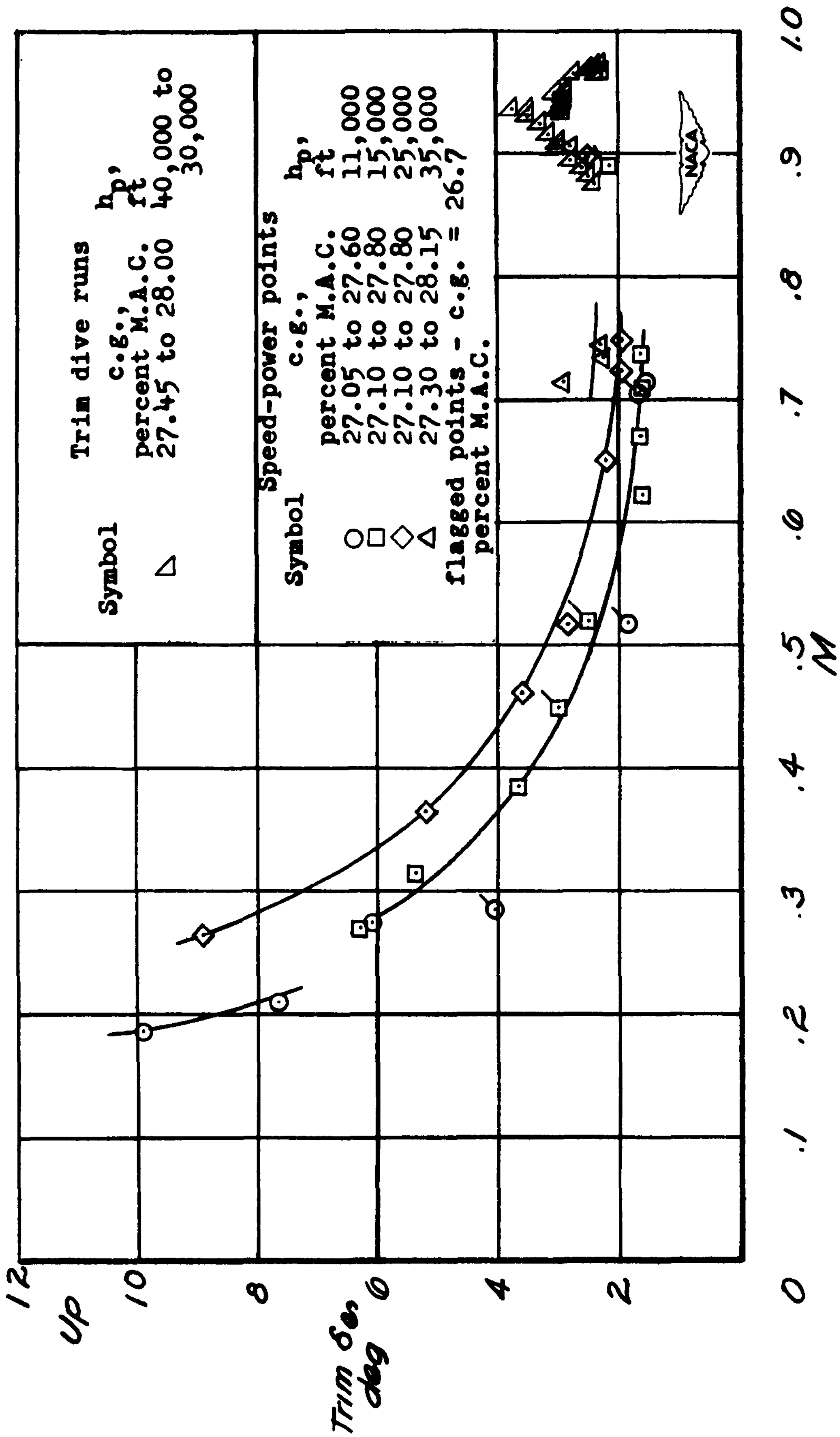


Figure 3.- Variation of longitudinal control angle with Mach number for center-of-gravity variation of 26.7 to 28.2 percent M.A.C.

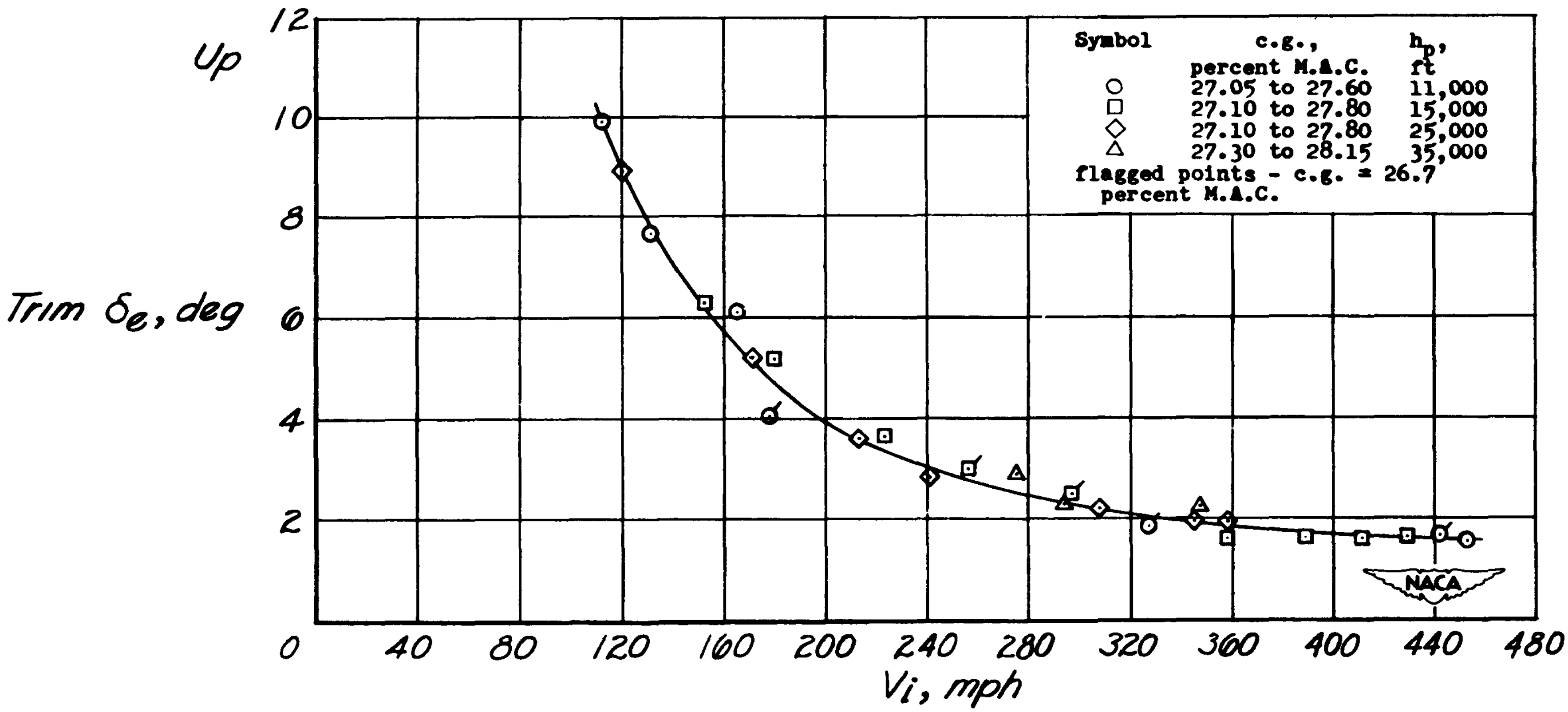
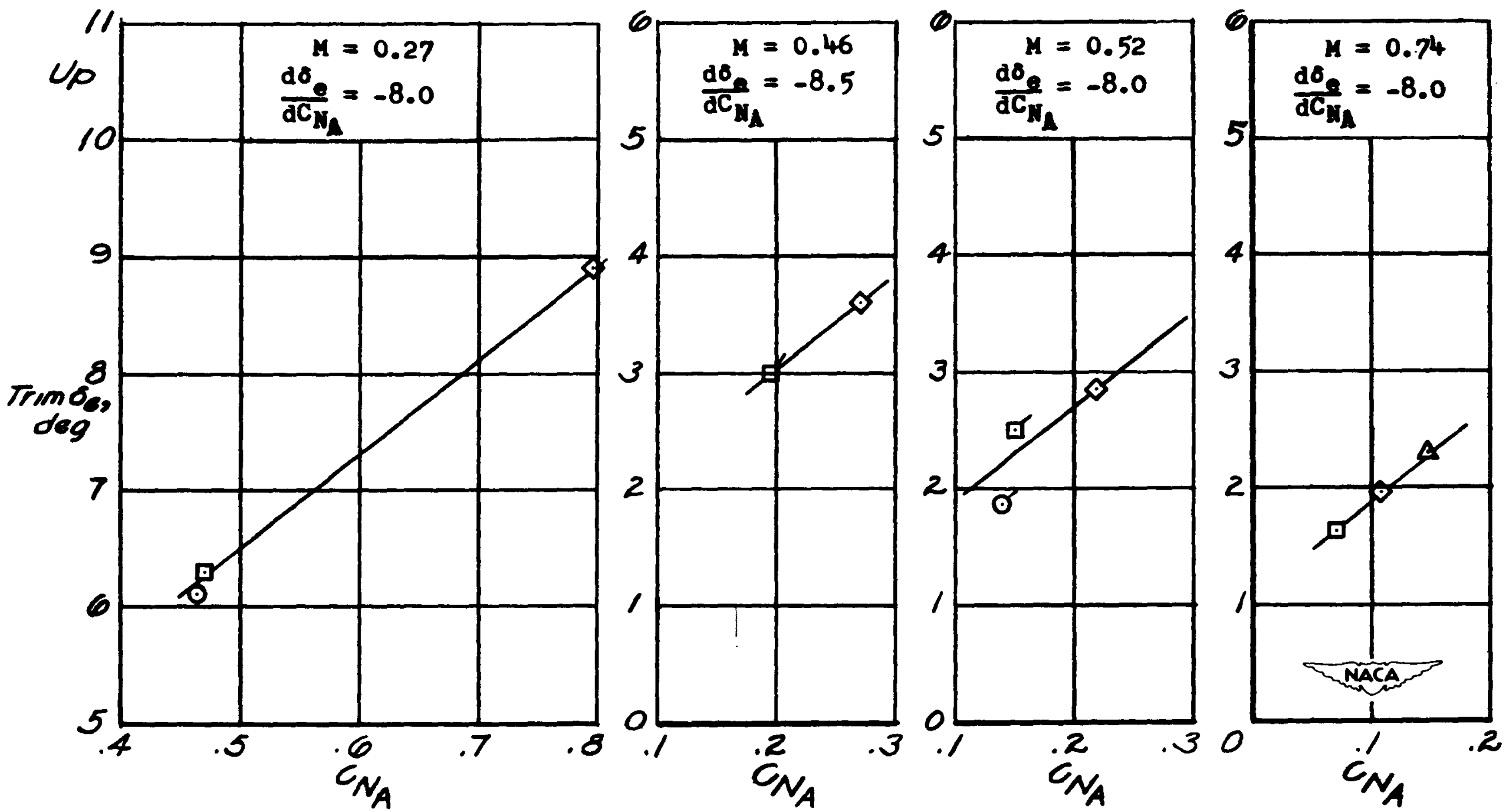
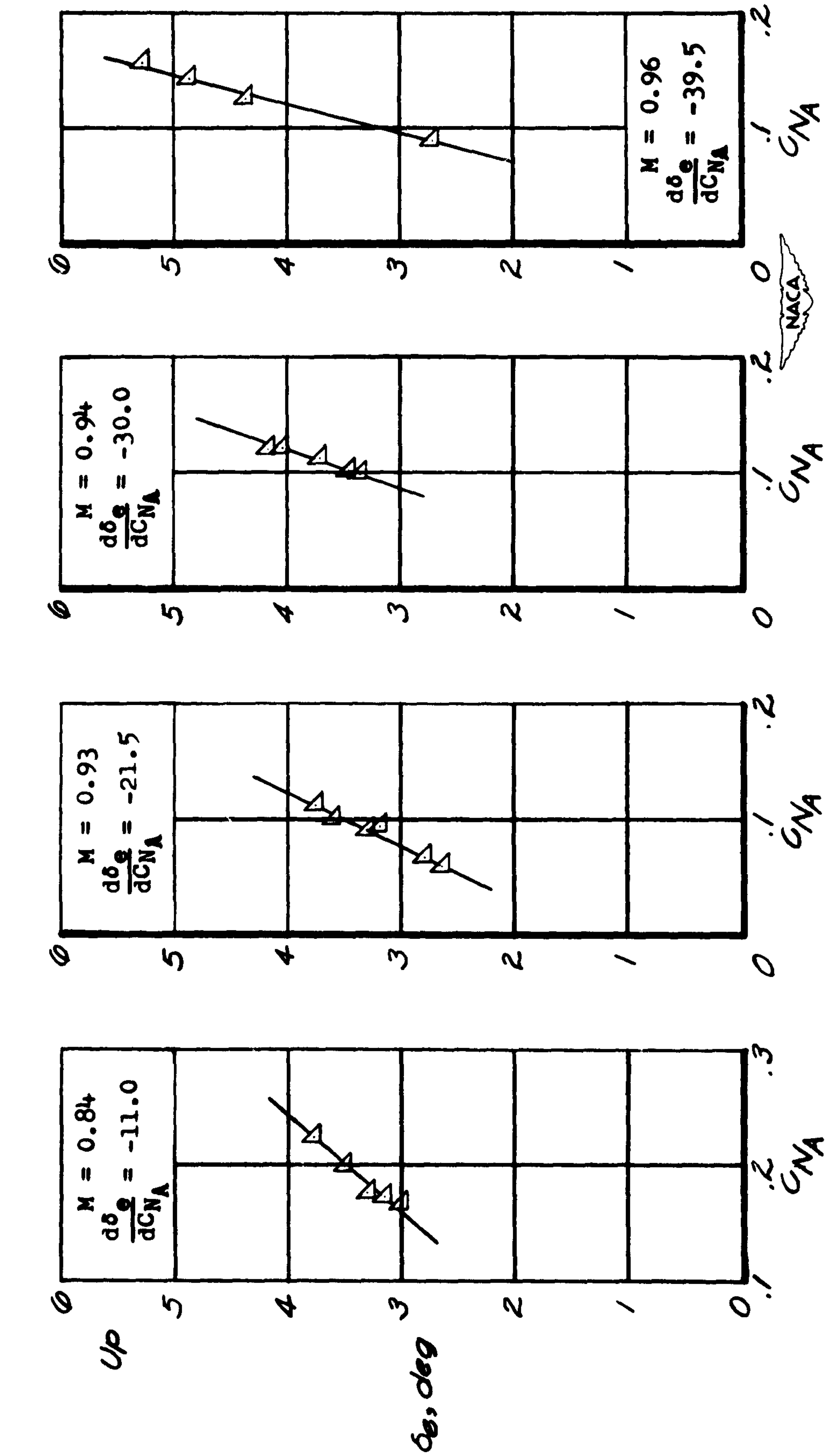


Figure 4.- Variation of longitudinal control angle for trim with indicated airspeed for Mach numbers less than 0.75.



(a) Speed-power points from figure 3.

Figure 5.- Variation of longitudinal control angle with airplane normal-force coefficient at various Mach numbers.



(b) Dive recoveries of figure 6.

Figure 5.- Concluded.

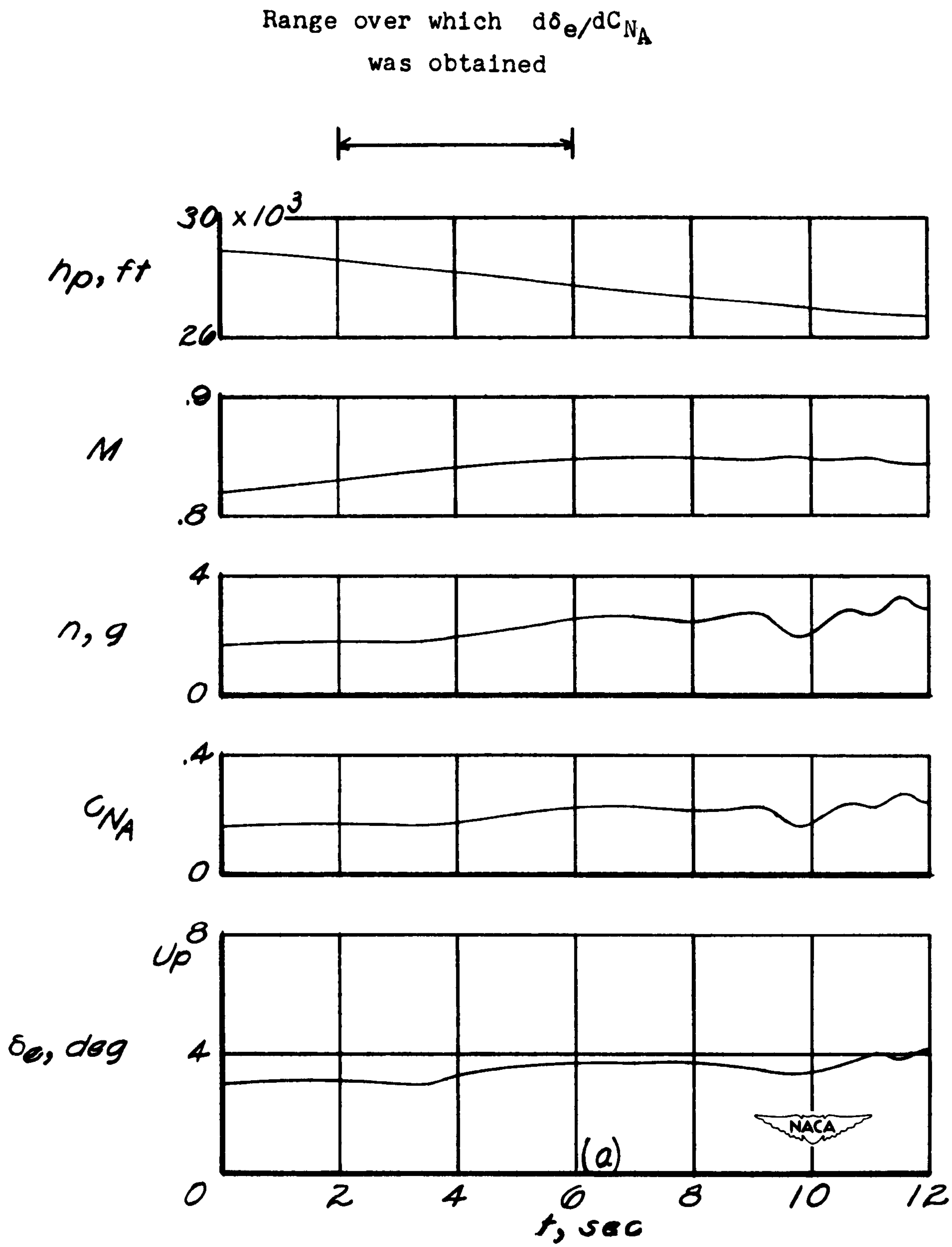


Figure 6.- Time histories of dive recoveries from which $d\delta_e/dC_{N_A}$ variation was obtained; c.g. = 28.0 percent M.A.C.

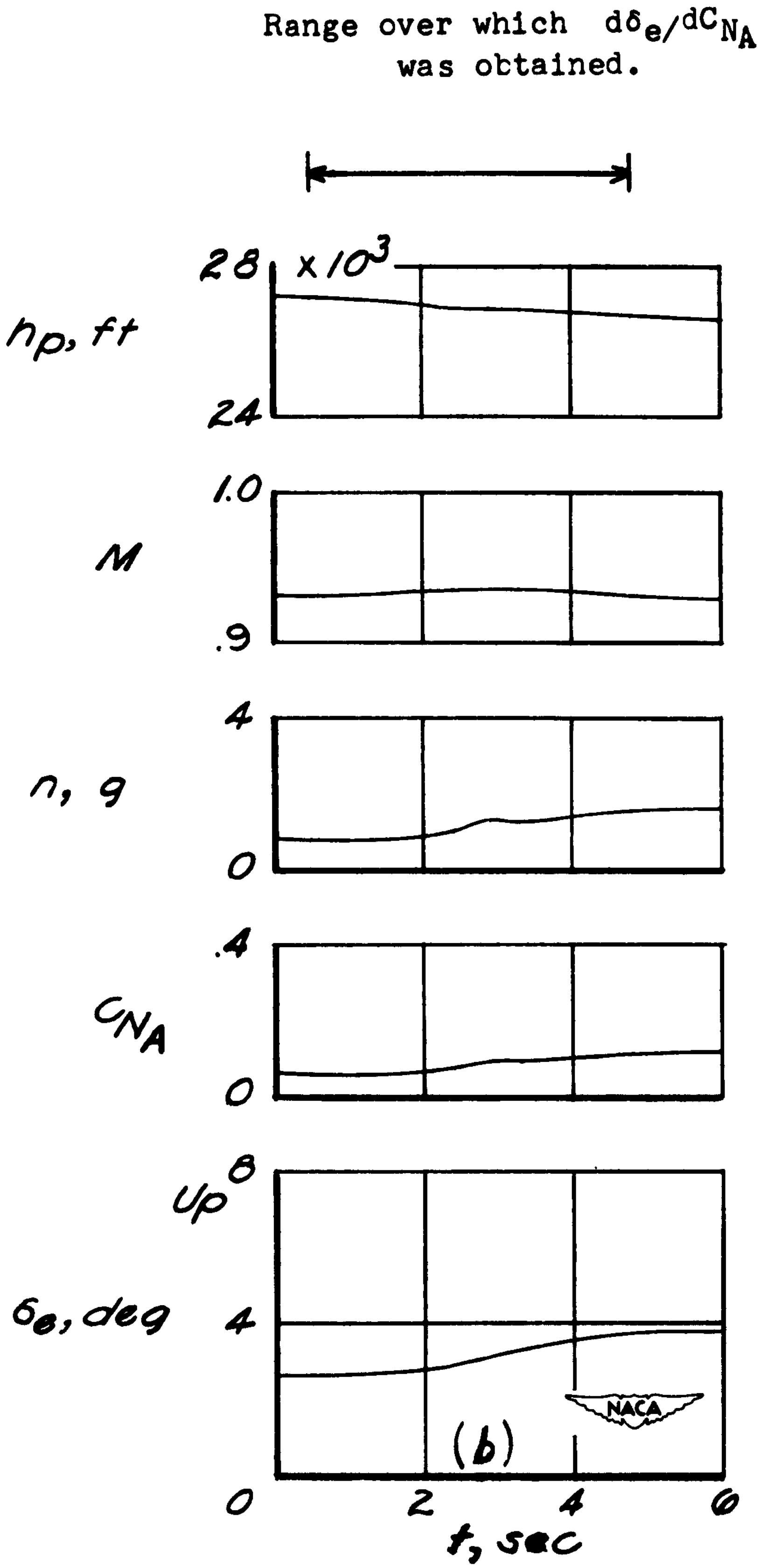


Figure 6.- Continued.

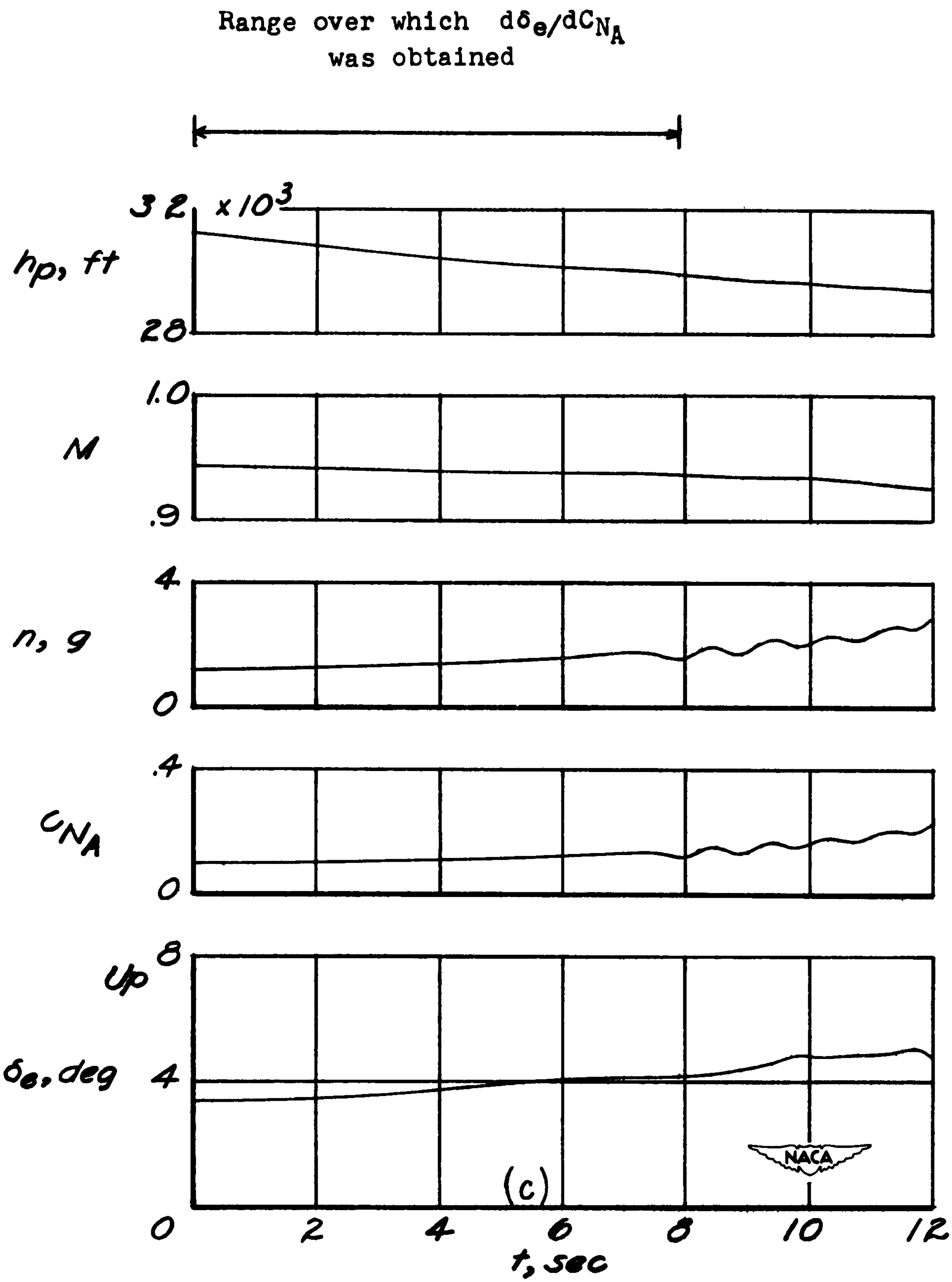


Figure 6.- Continued.

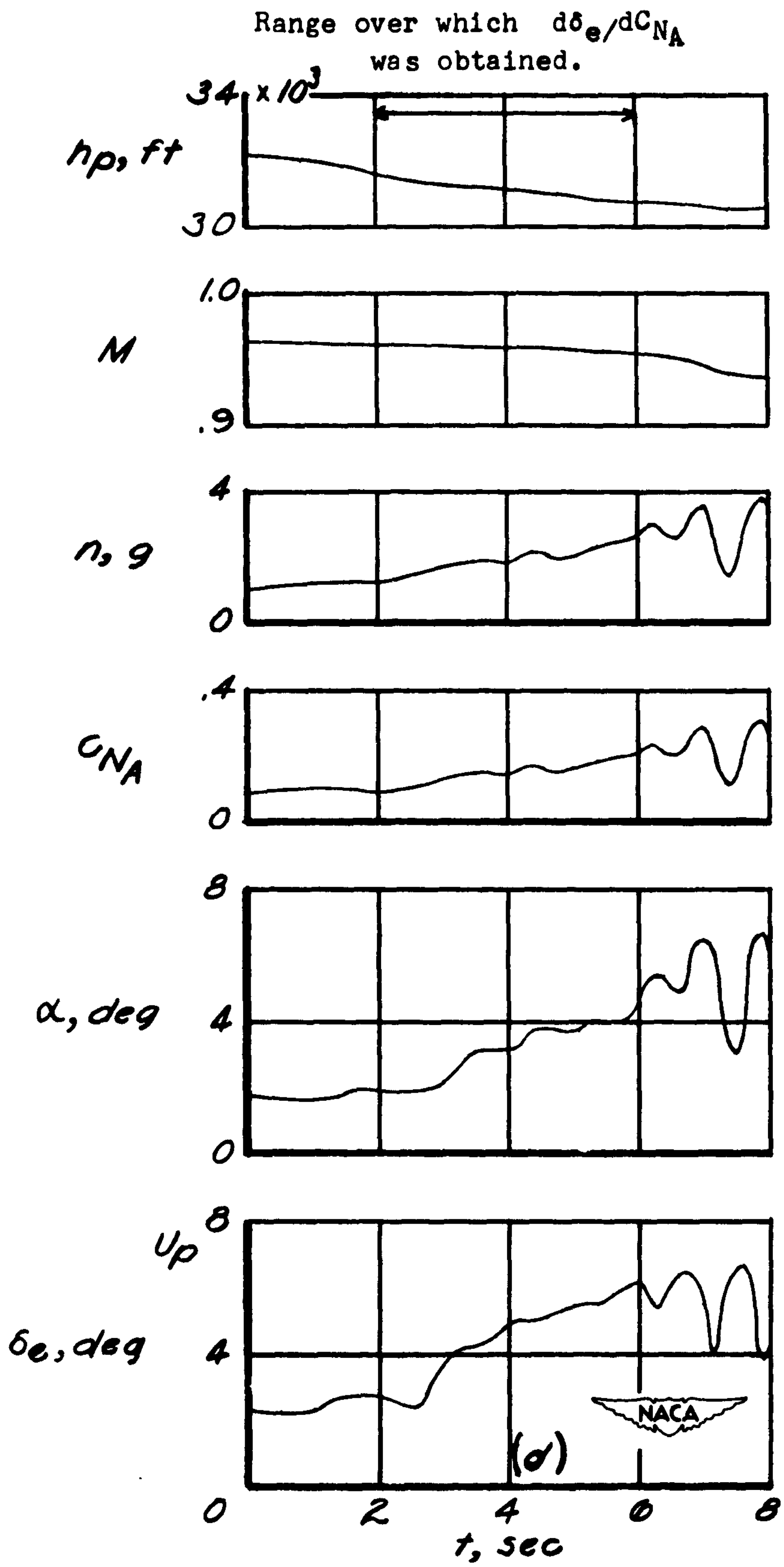
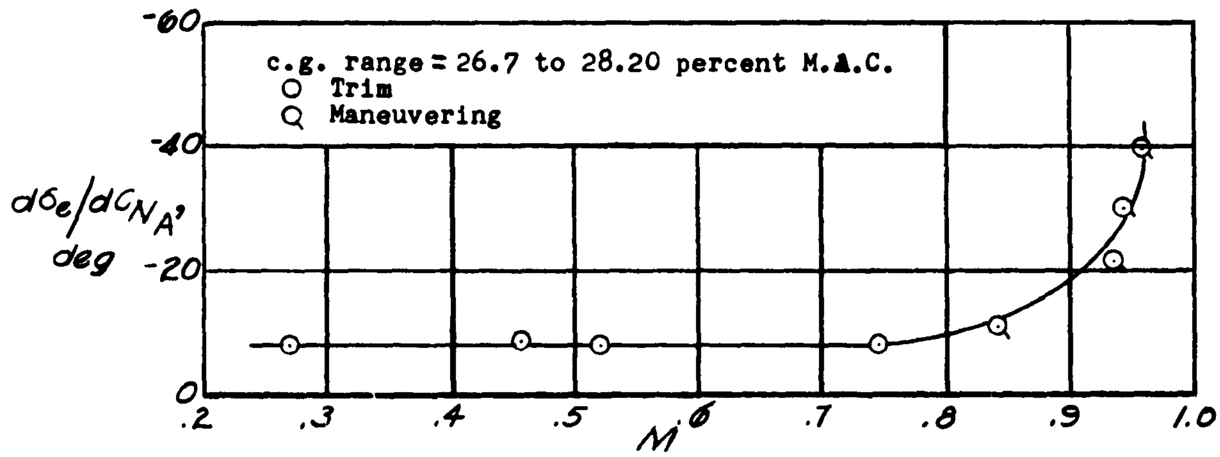
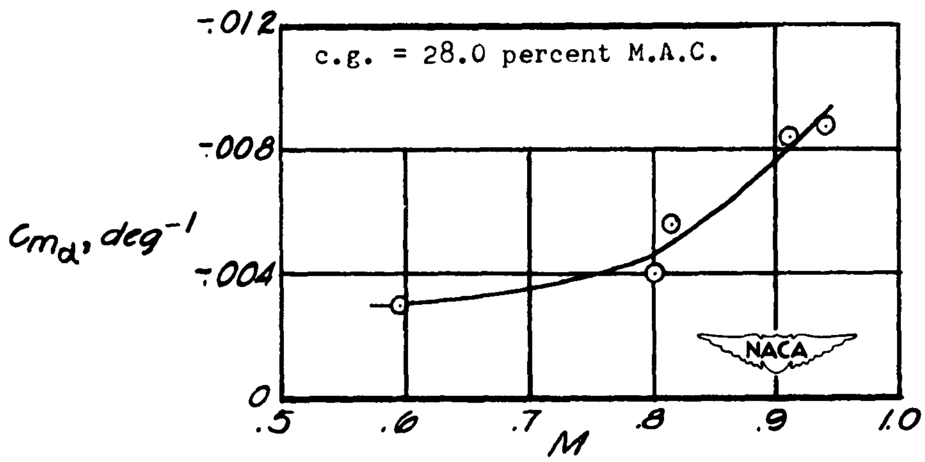


Figure 6.- Concluded.



(a) Apparent longitudinal stability.



(b) Static stability parameter.

Figure 7.- Variation of apparent longitudinal stability and static-stability parameter with Mach number.

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Preliminary longitudinal-trim and static longitudinal stability measurements were made on the XF-92A delta-wing research airplane from Mach number of 0.18 to 0.97 at altitudes from 11,000 to 40,000 feet.

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1. Airplanes - Specific Types (1.7.1.2)
2. Stability, Longitudinal - Static (1.8.1.1.1)
3. Control, Longitudinal (1.8.2.1)
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