# NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE 2103

## MAXIMUM PITCHING ANGULAR ACCELERATIONS OF AIRPLANES MEASURED IN FLIGHT

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## SUMMARY

Existing flight-test data on pitching angular accelerations have been compiled. The sources from which the data were taken were manufacturer's reports, NACA papers, and unpublished tests which were conducted at the Langley Aeronautical Laboratory. The compilation has been made for conventional airplanes that had moments of inertia which ranged from 535 to 572,000 slug-feet$^2$. All the data available are for Mach numbers below 0.80.

In addition to the compilation, an analysis was made of the data to establish methods for determining maximum pitching accelerations. The methods presented follow several elementary approaches and include variables which are usually available at the design stage.

## INTRODUCTION

Knowledge of the maximum values of pitching angular accelerations to which an airplane may be subjected is necessary in the structural design of various airplane components. For example, critical loads occur on the horizontal tail either when maximum negative angular accelerations are combined with maximum positive load factors or when maximum positive angular accelerations are combined with maximum negative load factors.

Analytical methods such as those given in references 1 to 4 are available which may be used to obtain maximum values of pitching accelerations. These methods are based on either (1) a prescribed load-factor variation, (2) a maximum constant rate of force application, or (3) a maximum constant rate of elevator motion. At the design stage, however, any of these methods are complicated by the problem of determining several aerodynamic quantities to a high degree of refinement for use in the equations of motion.

The purpose of this paper is to present existing flight-test data on maximum pitching accelerations that have been collected during the past 19 years and to analyze these data by elementary concepts in which consideration is given to the possible effects of airplane geometry, weight, load factor, and rapidity of maneuver. The results may be used in the preliminary design of an airplane.

## SYMBOLS

| | |
|---|---|
| $\ddot{\theta}$ | angular acceleration in pitch, radians per second per second |
| $\dot{\theta}$ | angular velocity in pitch, radians per second |
| $I_Y$ | airplane moment of inertia in pitch, slug-feet$^2$ |
| $W$ | airplane weight, pounds |
| $\lambda$ | time from start of maneuver to peak normal load factor, seconds |
| $\delta$ | elevator deflection, radians |
| $b$ | horizontal surface span, feet |
| $h_p$ | pressure altitude, feet |
| $n$ | load factor |
| $\Delta n$ | increment in load factor $(n - 1)$ |
| $S$ | gross area including area within fuselage, square feet |
| $V_e$ | equivalent airspeed, miles per hour |
| $t$ | time, seconds |

Subscripts:

| | |
|---|---|
| max | maximum value |
| min | minimum value |
| t | horizontal tail |
| meas | measured value |

## SCOPE OF DATA

The pitching-angular-acceleration data available for analysis were compiled from various NACA papers (references 5 to 9), from unpublished tests which were conducted at the Langley Aeronautical Laboratory, as well as from material furnished by several airplane manufacturers.

Table I presents the geometric characteristics of the airplanes considered in this analysis, which have moments of inertia that range from 535 to 572,000 slug-feet$^2$. The center-of-gravity position, the weight, and the moment of inertia listed therein apply at the time of the tests and are not necessarily the values used in design. Of the airplanes comprising this investigation, all are of conventional configuration and had conventional cable or rod control systems except airplane 20, which had hydraulic boost.

From the data available, only the more severe maneuvers were used. All these maneuvers were made at Mach numbers below 0.80. The following quantities for the airplanes of table I are tabulated in table II:

(1) The equivalent airspeed $V_e$

(2) The maximum positive increment in load factor $\Delta n$ obtained in each maneuver

(3) The increment in time $\lambda$ from the start of the maneuver to the maximum positive load factor

(4) The maximum rate of elevator movement $d\delta/dt$

(5) The maximum positive and negative angular acceleration $\ddot{\theta}$ obtained in the maneuver (These values do not necessarily coincide with the maximum load factor.)

(6) The maximum positive angular velocity $\dot{\theta}$ attained in the maneuver (This value occurs near the time of maximum load factor.)

(7) The pressure altitude $h_p$ of the maneuver

(8) Remarks as to type of maneuver, degree of abruptness, and so forth

Figure 1 is illustrative of the method used in obtaining the slopes and shows a graphical representation of some of the quantities listed.

## ANALYSIS AND RESULTS

A detailed examination of the more important variables indicates that the maximum pitching angular acceleration in a maneuver is a function of the following variables:

(1) Airplane mass and/or pitching moment of inertia

(2) Acceleration or load factor obtained in the maneuver

(3) Degree of abruptness of the maneuver

(4) Dynamic pressure or airspeed

(5) Stability and control characteristics of the airplane

These variables are not necessarily listed in order of their importance.

The available data on maximum angular accelerations were generally obtained as by-products of tests made for other purposes and, for this reason, no one series of tests is sufficient to define completely the influence of any one variable. The data have consequently been analyzed by simply establishing envelopes of the maximum measured values of angular accelerations obtained in various maneuvers in combination with several groupings of the main variables entering the problem.

Effect of weight.- For a series of airplanes in which all lengths vary directly as the scale, referred to hereinafter as a "geometric series of airplanes," the angular acceleration for a given airspeed and type of elevator motion should vary as a function of some geometric parameter. The possible geometric parameters might include such quantities as span, tail length, wing area, moment of inertia, weight, or wing loading. In figure 2, as well as in subsequent figures, the measured maximum values of pitching angular acceleration are plotted as a function of airplane weight. Weight instead of pitching moment of inertia was chosen as the parameter because this quantity is more easily determined in the early stages of design. The solid-line curve in figure 2 represents the relation for an exact geometric series, whereas the dashed-line curve represents a variation obtained by modifying the exponent of the weight to fit the results better. The constants have been determined so as to include all the available data.

Effect of load factor.- Theoretical studies indicate that, for a geometric series of airplanes performing a maneuver prescribed by a given load-factor variation in which the load factor reaches a maximum and quickly subsides, as for example a checked pull-up, the angular acceleration should vary directly with the peak load factor obtained, inversely with the time required to attain it, and inversely with the initial airspeed. The variation with time and airspeed, however, are more complicated functions than that for the load factor. Although all the maneuvers available for analysis were not of the same type, the next step was to plot values of $\frac{\ddot{\theta}_{meas}}{\Delta n}$ as a function of W. The solid-line curve in figure 3, which is given by the equation

$$\ddot{\theta}_{max} = 830\Delta nW^{-2/3} \tag{1}$$

represents the boundary that includes the data. As in the previous case, the exponent of W has been modified to obtain a closer envelope of the data. This envelope is given in figure 3 by the dashed line, the equation of which is

$$\ddot{\theta}_{max} = 125\Delta nW^{-1/2} \tag{2}$$

Rapidity of maneuver.- The inclusion of the load-factor increment $\Delta n$ did not result in any reduction in the scatter of data nor result in the establishment of a better envelope. Successive refinements, made to include the rapidity of the maneuver and airspeed, not only failed to reduce the scatter but actually resulted in less well-defined envelopes. A plot of the time required to reach peak load factor for the various maneuvers of table I indicated (see fig. 4) that the minimum time to reach peak load factor increased as the airplane weight was increased from a minimum value of approximately 0.4 at 5,000 pounds to a value of approximately 1.4 at 75,000 pounds.

## DISCUSSION

When the available data are considered, it appears that either of the empirical relations given in figures 2 and 3 could, with judgement, be used as a guide in preliminary design. The simplest relation

$$\ddot{\theta}_{max} = \frac{40000}{W} \tag{3}$$

gives values of pitching angular acceleration that exceed the maximum measured values only at low airplane weights. The relation

$$\ddot{\theta}_{max} = \frac{125}{W^{1/2}}(n - 1) \tag{4}$$

is likely to furnish values of pitching angular acceleration greater than the maximum measured values for light high-load-factor airplanes.

Both equations (3) and (4) have terms in them which are known at the design stage. Although equation (3) fits the data over a greater range of weights, it may underestimate the angular accelerations for possible future high-weight, high-load-factor airplanes. Equation (4), on the other hand, has been included as a possible relation since the effect of load factor on the maximum pitching angular acceleration is taken into consideration. The tabulated data, however, indicate that computed values of maximum pitching angular acceleration need not exceed 10.0 radians per second per second.

The failure to obtain better correlation as successive improvements were attempted can only mean that a number of factors which cannot be included in a simple approach contribute materially to the maximum angular acceleration obtained in a maneuver. The most important factor contributing to the scatter appears to be that the maneuvers considered were not all the same type, although different accuracies of the data from various sources may also have contributed to the scatter. It is apparent that the best over-all correlation between the experimental and calculated values of maximum angular accelerations would be obtained by using the values calculated from the equations of motion and by using the actual elevator deflections. The procedure of obtaining maximum angular accelerations may not be a practical one at the early design stages because the required parameters would be difficult to obtain to a high degree of accuracy.

The maximum values of pitching angular acceleration shown in figure 2 are absolute values and include the largest ones occurring in the maneuver regardless of the sign. Earlier attempts at correlation for which the positive and negative values were separated showed no reduction in the scatter. An examination of the tabulated values in table II shows that, for all practical purposes, the positive and negative values of pitching angular acceleration are the same; slightly less than 50 percent have larger negative values than positive values.

Although the assumption of the geometric series is known not to hold exactly, the results given in figure 5, in which $I_Y^{2/5}$ is given as a function of $W^{2/3}$, indicate that insofar as the relations between weight and moment of inertia for the airplanes of this investigation are concerned the assumption is justified.

The importance of the rapidity of the maneuver has been established in reference 4. If an envelope of the minimum measured values of $\lambda$ had been drawn from the data in figure 4 of the present paper, the value would increase with airplane weight. This increase indicates that for the larger airplanes a greater time is taken to perform the maneuver and hence less pitching angular acceleration results, as may be seen from figure 2. Thus, W and $\lambda_{min}$ appear to be interrelated.

## CONCLUDING REMARKS

Available flight-test data on pitching angular acceleration have been tabulated and these results indicate the following conclusions:

1. The tabulated data indicated that the maximum pitching angular acceleration need not exceed 10.0 radians per second per second for all intentional maneuvers.

2. The assumption of a geometric series of airplanes is justified for the relationship between airplane moment of inertia and weight for the airplanes considered.

3. An analysis that followed elementary concepts by use of these tabulated data indicates that

(a) At the design stage of an airplane, an expression involving only the weight will give a quick and fairly accurate value for the maximum pitching angular acceleration.

(b) An expression which makes use of the weight and load factor allows for the prediction of maximum pitching angular acceleration for possible future high-weight, high-load-factor airplanes.

(c) The minimum values of time from the start of the maneuver to peak normal load factor have been shown to be a function of airplane weight.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Air Force Base, Va., March 6, 1950

## REFERENCES


1. Pearson, Henry A.: Derivation of Charts for Determining the Horizontal Tail Load Variation with Any Elevator Motion. NACA Rep. 759, 1943.

2. Kelley, Joseph, Jr., and Missall, John W.: Maneuvering Horizontal Tail Loads. AAF TR No. 5185, Air Technical Service Command, Army Air Forces, Jan. 25, 1945.

3. Sadoff, Melvin, and Clousing, Lawrence A.: Measurements of the Pressure Distribution on the Horizontal-Tail Surface of a Typical Propeller-Driven Pursuit Airplane in Flight. III - Tail Loads in Abrupt Pull-Up Push-Down Maneuvers. NACA TN 1539, 1948.

4. Pearson, Henry A., McGowan, William A., and Donegan, James J.: Horizontal Tail Loads in Maneuvering Flight. NACA TN 2078, 1950.

5. Dearborn, C. H., and Kirschbaum, H. W.: Maneuverability Investigation of an F6C-4 Fighting Airplane. NACA Rep. 386, 1931.

6. Dearborn, C. H., and Kirschbaum, H. W.: Maneuverability Investigation of the F6C-3 Airplane with Special Flight Instruments. NACA Rep. 369, 1930.

7. Rhode, Richard V.: The Pressure Distribution over the Wings and Tail Surfaces of a PW-9 Pursuit Airplane in Flight. NACA Rep. 364, 1930.

8. Garvin, John B.: Flight Measurements of Aerodynamic Loads on the Horizontal Tail Surface of a Fighter-Type Airplane. NACA TN 1483, 1947.

9. Pearson, Henry A., and Smull, Leland K.: Control-Motion Studies of the PBM-3 Flying Boat in Abrupt Pull-Ups. NACA MR, Nov. 12, 1942.

TABLE I.- GEOMETRIC CHARACTERISTICS OF AIRPLANES

| Airplane | Moment of inertia, $I_Y$ (slug-ft$^2$) | Weight (lb) | Wing area, S (sq ft) | Tail area, $S_t$ (sq ft) | Wing span, b (ft) | Tail span, $b_t$ (ft) | Center of gravity (percent M.A.C.) | Reference |
|---|---|---|---|---|---|---|---|---|
| 1 | 535 | 1,100 | 179 | 25.3 | 35.2 | 9.5 | 27.1 | Unpublished |
| 2 | 550 | 1,050 | 180 | 25.8 | 36.0 | 10:0 | 27.1 | Unpublished |
| 3 | 1,790 | 2,582 | 252 | 32.9 | 31.5 | 10.5 | ------ | 5 |
| 4 | 1,875 | 2,960 | 252 | 32.9 | 31.5 | 10.5 | ------ | 6 |
| 5 | 1,875 | 2,970 | 241 | 29.8 | 32.0 | 10.0 | ------ | 7 |
| 6 | 4,204 | 4,775 | 310 | 42.2 | 34.5 | ----- | 22.1 | Unpublished |
| 7 | 4,267 | 4,662 | 205 | 43.2 | 35.0 | 12.0 | 32.0 | Unpublished |
| 8 | 5,000 | 4,600 | 248 | 49.0 | 42.0 | 13.0 | 34.0 | Unpublished |
| 9 | 5,278 | 5,330 | 327 | 44.8 | 33.3 | 13.0 | 20.3 | Unpublished |
| 10 | 6,380 | 7,600 | 213 | 41.0 | 34.0 | 13.0 | 30.3 | 3 |
| 11 | 7,000 | 7,780 | 233 | 42.0 | 37.0 | 13.18 | Varied | Unpublished |
| 12 | 7,200 | 7,074 | 130 | 26.0 | 28.0 | 11.4 | 25.0 | Unpublished |
| 13 | 7,995 | 6,220 | 305 | 40.2 | 42.0 | 13.33 | 24.4 | Unpublished |
| 14 | 8,000 | 8,800 | 240 | 41.0 | 37.0 | 13.18 | 26.4 | Unpublished |
| 15 | 8,800 | 8,243 | 236 | 48.6 | 37.3 | 12.8 | 30.0 | 8 |
| 16 | 15,600 | 12,000 | 423 | 107.4 | 50.0 | 19.04 | 27.0 | Unpublished |
| 17 | 100,000 | 32,050 | 664 | ----- | 65.0 | ----- | 20.3 | Unpublished |
| 18 | 163,750 | 48,000 | 1,048 | 198.0 | 110.0 | 26.0 | 29.0 | Unpublished |
| 19 | 314,200 | 45,000 | 1,407 | 242.0 | 118.0 | 28.0 | 28.0 | 9 |
| 20 | 572,000 | 72,000 | 1,654 | 463.6 | 123.0 | 50.0 | Varied | Unpublished |

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TABLE II.- TABULATION OF FLIGHT DATA

| Airplane | Speed, $V_o$ (mph) | Load-factor increment, $\Delta n$ | Time to reach peak load, $\lambda$ (sec) | Max. elevator rate, $d\delta/dt$ (radians/sec) | Angular acceleration (radians/sec²) | | Angular velocity, $\dot{\theta}$ (radians/sec) | Pressure altitude, $h_p$ (ft) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | $+\ddot{\theta}$ | $-\ddot{\theta}$ | | | |
| 1 | 74 | 2.95 | 0.65 | 2.44 | 6.90 | ---- | 1.55 | ------ | Abrupt pull-up, power on |
| | 74 | 2.90 | .85 | 3.51 | 5.70 | ---- | 1.48 | ------ | Abrupt pull-up, power on |
| 2 | 78 | 3.25 | .65 | 3.84 | 6.30 | ---- | 1.20 | ------ | Abrupt pull-up, power on |
| | 77 | 2.60 | .65 | 2.27 | 6.00 | ---- | 1.10 | ------ | Abrupt pull-up, power off |
| 3 | 130 | 6.80 | .80 | 3.00 | 3.40 | 2.20 | 1.74 | ------ | Abrupt pull-out |
| | 140 | 7.50 | .83 | 1.50 | 5.80 | 3.00 | 2.50 | ------ | Abrupt pull-out |
| | 175 | 9.30 | .75 | 2.09 | 7.00 | 3.60 | 1.80 | ------ | Abrupt pull-out |
| | 80 | 1.90 | .80 | 1.40 | 2.70 | 1.75 | 1.00 | ------ | Abrupt pull-up |
| | 80 | 1.80 | 1.00 | 1.22 | 2.85 | 1.75 | .85 | ------ | Intermediate pull-up |
| | 125 | 5.20 | .65 | 2.27 | 3.30 | 2.00 | 1.60 | ------ | Abrupt pull-up |
| | 125 | 3.30 | 1.50 | .27 | 1.60 | ---- | .85 | ------ | Intermediate pull-up |
| | 150 | 6.80 | .60 | 1.68 | 3.80 | 1.82 | 1.66 | ------ | Abrupt pull-up |
| | 150 | 5.80 | .65 | 1.50 | 3.30 | 2.00 | 1.48 | ------ | Intermediate pull-up |
| 4 | 140 | 7.50 | 1.25 | 4.00 | 4.80 | 1.30 | 1.45 | ------ | Abrupt pull-out |
| | 137 | 5.20 | 3.00 | .52 | 1.00 | ---- | .70 | ------ | Pull-out |
| | 135 | 5.70 | .60 | 2.19 | 3.70 | 4.00 | 1.50 | ------ | Abrupt pull-up |
| | 130 | 3.70 | 1.80 | .18 | 1.00 | 1.40 | .84 | ------ | Intermediate pull-up |
| | 120 | 4.00 | .53 | 3.49 | 4.00 | 4.00 | 1.30 | ------ | Abrupt pull-up |
| | 117 | 2.80 | 1.70 | .16 | 1.00 | ---- | .73 | ------ | Intermediate pull-up |
| | 90 | 2.00 | .60 | ---- | 3.30 | 2.00 | 1.10 | ------ | Abrupt pull-up |
| 5 | 79 | .80 | 1.13 | 1.54 | .80 | ---- | .50 | ------ | Abrupt pull-up, power on |
| | 94 | 1.50 | 1.07 | 2.27 | 1.80 | 1.10 | .68 | ------ | Abrupt pull-up, power on |
| | 100 | 1.80 | 1.00 | 1.75 | 1.40 | 1.20 | .70 | ------ | Abrupt pull-up, power on |
| | 110 | 2.00 | 1.13 | 1.50 | 1.30 | 1.37 | .80 | ------ | Abrupt pull-up, power on |
| | 116 | 2.80 | 1.13 | 2.44 | 2.30 | ---- | 1.12 | ------ | Abrupt pull-up, power on, stall |
| | 126 | 3.60 | .90 | 2.44 | 2.70 | 2.00 | 1.28 | ------ | Abrupt pull-up, power on, stall |
| | 137 | 3.95 | .92 | 2.00 | 2.60 | 2.35 | 1.31 | ------ | Abrupt pull-up, power on, stall |
| | 149 | 5.30 | .80 | 2.96 | 2.80 | 1.82 | 1.40 | ------ | Abrupt pull-up, power on, stall |
| | 154 | 5.60 | .65 | 2.83 | 4.60 | 2.25 | 1.44 | ------ | Abrupt pull-up, power on |
| | 163 | 6.30 | .87 | 2.27 | 3.60 | 3.20 | 1.60 | ------ | Abrupt pull-up, power on, stall |
| | 172 | 7.30 | .87 | 1.36 | 3.80 | 2.62 | 1.64 | ------ | Abrupt pull-up, power on |
| | 181 | 8.00 | .87 | 4.00 | 5.50 | 3.00 | 1.68 | ------ | Abrupt pull-up, power on |
| | 105 | 1.40 | 2.37 | .23 | .40 | ---- | .37 | ------ | Pull-up, power off |
| | 105 | 1.90 | 2.00 | .30 | .70 | ---- | .70 | ------ | Pull-up, power off |
| | 73 | .75 | 1.13 | 2.58 | .90 | ---- | .51 | ------ | Abrupt pull-up, power off |
| | 93 | 1.70 | .82 | 4.54 | 1.80 | ---- | .82 | ------ | Abrupt pull-up, power off |
| | 103 | 2.40 | 1.13 | 1.96 | 2.30 | 1.51 | .96 | ------ | Abrupt pull-up, power off |
| | 118 | 2.80 | .80 | 5.75 | 2.90 | 2.40 | 1.10 | ------ | Abrupt pull-up, power off |
| | 135 | 4.50 | .87 | 4.88 | 4.10 | 2.38 | 1.26 | ------ | Abrupt pull-up, power off |
| | 160 | 5.60 | .80 | 4.34 | 4.20 | 3.25 | 1.28 | ------ | Abrupt pull-up, power off |
| | 184 | 6.70 | .82 | 2.70 | 4.80 | 3.75 | 1.40 | ------ | Abrupt pull-up, power off |
| 6 | 134 | 3.60 | .90 | 2.67 | 3.75 | 2.60 | 1.07 | 4,000 | Abrupt pull-up, level flight |
| | 148 | 4.60 | .82 | 2.37 | 4.81 | 4.35 | 1.20 | 4,000 | Abrupt pull-up, level flight |
| | 164 | 5.60 | .85 | 3.06 | 5.60 | 3.54 | 1.27 | 4,000 | Abrupt pull-up, level flight |
| | 133 | 3.50 | .75 | 3.00 | 3.60 | 1.87 | 1.00 | 4,000 | Abrupt pull-up, level flight |
| | 150 | 4.50 | .70 | 2.91 | 4.82 | 1.95 | 1.13 | 4,000 | Abrupt pull-up, level flight |
| | 164 | 5.40 | .70 | 3.76 | 5.25 | 2.73 | 1.19 | 4,000 | Abrupt pull-up, level flight |
| | 138 | 5.40 | 1.05 | 1.04 | 2.85 | 1.10 | 1.11 | 4,550 | Abrupt dive pull-out |
| | 152 | 6.00 | .80 | 2.79 | 2.75 | 2.27 | 1.25 | 9,150 | Abrupt dive pull-out |
| | 170 | 6.30 | 1.14 | 1.35 | 2.05 | 1.00 | 1.01 | 5,200 | Abrupt dive pull-out |
| | 212 | 6.10 | .70 | 1.31 | 3.53 | 1.30 | .90 | 5,730 | Abrupt dive pull-out |
| | 300 | 5.10 | .48 | 1.31 | 2.00 | .90 | .53 | 6,160 | Abrupt dive pull-out |
| | 222 | 6.50 | .70 | 1.18 | 3.95 | .74 | .93 | 8,000 | Abrupt dive pull-out |

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TABLE II.- TABULATION OF FLIGHT DATA - Continued

| Airplane | Speed, $V_e$ (mph) | Load-factor increment, $\Delta n$ | Time to reach peak load, $\lambda$ (sec) | Max. elevator rate, $d\delta/dt$ (radians/sec) | Angular acceleration (radians/sec²) | | Angular velocity, $\dot{\theta}$ (radians/sec) | Pressure altitude, $h_p$ (ft) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | $+\ddot{\theta}$ | $-\ddot{\theta}$ | | | |
| 7 | 164 | 3.30 | 0.75 | 1.92 | 4.25 | 5.40 | ---- | ------ | Abrupt pull-up, level flight |
| | 176 | 3.70 | .75 | 1.47 | 3.70 | 6.00 | ---- | ------ | Abrupt pull-up, level flight |
| | 184 | 4.20 | .68 | 2.66 | 4.65 | 5.65 | ---- | ------ | Abrupt pull-up, level flight |
| | 182 | 4.10 | .66 | 3.14 | 4.65 | 6.75 | ---- | ------ | Abrupt pull-up, level flight |
| | 193 | 4.60 | .60 | 3.14 | 4.85 | 6.80 | ---- | ------ | Abrupt pull-up, level flight |
| | 208 | 4.60 | .71 | 1.96 | 3.65 | 4.55 | ---- | ------ | Abrupt dive pull-out |
| | 212 | 4.60 | .88 | 1.15 | 2.45 | 3.30 | .72 | ------ | Abrupt dive pull-out |
| | 228 | 5.50 | .95 | .86 | 2.00 | 4.90 | .74 | ------ | Abrupt dive pull-out |
| | 271 | 5.60 | .80 | 1.15 | 2.90 | 6.08 | .69 | ------ | Abrupt dive pull-out |
| | 219 | 5.30 | .76 | 1.54 | 3.40 | 4.50 | .83 | ------ | Abrupt dive pull-out |
| | 238 | 5.50 | .90 | 1.22 | 2.80 | 4.05 | .75 | ------ | Abrupt dive pull-out |
| 8 | 100 | 1.30 | 1.25 | .42 | .60 | ---- | ---- | 6,000 | Mild pull-ups, cam-actuated control |
| | 109 | 1.80 | 1.35 | .43 | .80 | ---- | ---- | 6,040 | Mild pull-ups, cam-actuated control |
| | 121 | 2.20 | 1.37 | .44 | .90 | ---- | ---- | 6,000 | Mild pull-ups, cam-actuated control |
| | 137 | 2.80 | 1.27 | .46 | 1.00 | ---- | ---- | 6,000 | Mild pull-ups, cam-actuated control |
| | 147 | 3.30 | 1.30 | .46 | 1.00 | ---- | ---- | 6,000 | Mild pull-ups, cam-actuated control |
| 9 | 197 | 4.40 | 1.03 | 1.06 | 1.70 | .67 | .56 | 6,050 | Dive pull-out |
| | 221 | 4.70 | .86 | 1.23 | 2.65 | .52 | .62 | 9,600 | Dive pull-out, stick release |
| | 206 | 5.90 | 1.25 | 2.00 | 4.10 | .75 | .75 | 6,950 | Dive pull-out, stick release |
| | 277 | 6.90 | .63 | 1.90 | 6.10 | .62 | .70 | 6,350 | Dive pull-out, stick release |
| | 133 | 3.30 | .80 | 3.50 | 4.38 | 2.34 | 1.11 | 6,350 | Abrupt pull-up, level flight |
| | 138 | 3.50 | .90 | 3.56 | 3.80 | 1.85 | .94 | 6,900 | Abrupt pull-up, glide stall |
| 10 | 358 | 5.60 | .50 | .95 | 2.50 | 3.40 | .60 | 20,400 | Pull-up |
| | 262 | 4.40 | .50 | 1.66 | 4.00 | 4.40 | .90 | 24,700 | Pull-up |
| | 378 | 5.00 | .60 | .44 | 1.30 | 1.51 | .30 | 10,200 | Pull-up |
| 11 | 406 | 3.10 | 1.40 | .12 | .66 | ---- | .21 | 19,400 | Pull-out |
| | 435 | 6.00 | .90 | .12 | 1.23 | ---- | .44 | 19,400 | Pull-out |
| | 463 | 3.80 | .75 | .15 | .90 | ---- | .27 | 19,400 | Pull-out |
| | 403 | 5.00 | .90 | .24 | 1.27 | ---- | .40 | 19,900 | Pull-out |
| | 497 | 2.20 | .60 | .03 | .28 | ---- | .18 | 18,750 | Pull-out |
| | 510 | 2.50 | .60 | .06 | .60 | ---- | .19 | 18,250 | Pull-out |
| | 502 | 4.30 | 1.10 | .07 | .22 | ---- | .20 | 19,500 | Pull-out |
| | 527 | 2.00 | 1.05 | .05 | .17 | ---- | .16 | 18,600 | Pull-out |
| | 516 | 2.60 | 1.25 | .03 | .10 | ---- | .09 | 19,000 | Pull-out |
| | 408 | 5.90 | 1.45 | .04 | .60 | ---- | .44 | 19,600 | Pull-out |
| | 454 | 5.20 | 1.60 | .04 | .28 | ---- | .28 | 18,950 | Pull-out |
| | 383 | 3.80 | 1.25 | .09 | .69 | ---- | .64 | 19,850 | Pull-out |
| | 535 | 4.60 | 2.05 | .02 | .09 | ---- | .19 | 16,900 | Pull-out |
| 12 | 435 | 6.00 | .42 | .66 | 1.50 | 2.80 | .60 | 14,000 | Acceptance tests, pull-up |
| | 440 | 7.30 | .66 | .55 | 1.40 | 2.25 | .65 | 11,600 | Abrupt-stall buffeting pull-up |
| 13 | 97 | 1.30 | 1.10 | 3.78 | 1.78 | 1.40 | .68 | 3,600 | Abrupt pull-up, full stick |
| | 126 | 2.70 | .91 | 2.94 | 3.05 | 4.33 | 1.02 | 3,750 | Abrupt pull-up, power on |
| | 144 | 3.80 | .85 | 3.22 | 3.60 | 5.43 | 1.25 | 3,900 | Abrupt pull-up |
| | 164 | 5.00 | .78 | 3.57 | 4.10 | 4.30 | 1.41 | 3,450 | Abrupt pull-up |
| | 184 | 6.30 | .73 | 3.79 | 4.50 | 4.60 | 1.50 | 3,400 | Abrupt pull-up |
| | 148 | 3.80 | .91 | 1.82 | 2.60 | 3.15 | 1.15 | 9,500 | Pull-out, power off, full stick |
| | 358 | 10.00 | .90 | .23 | 1.70 | 1.55 | .95 | 5,400 | 70° dive pull-out |
| | 280 | 4.40 | .90 | .11 | .60 | .20 | .37 | 6,800 | Dive pull-out |
| | 300 | 6.20 | .60 | 1.74 | 3.10 | .59 | .70 | 5,800 | 65° dive pull-out |
| | 193 | 3.20 | 1.20 | 1.00 | 2.10 | .20 | .47 | 7,580 | Pull-out, glide |

TABLE II.- TABULATION OF FLIGHT DATA - Continued

| Airplane | Speed, $V_e$ (mph) | Load-factor increment, $\Delta n$ | Time to reach peak load, $\lambda$ (sec) | Max. elevator rate, $d\delta/dt$ (radians/sec) | Angular acceleration (radians/sec$^2$) | | Angular velocity, $\dot{\theta}$ (radians/sec) | Pressure altitude, $h_p$ (ft) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | $+\ddot{\theta}$ | $-\ddot{\theta}$ | | | |
| 14 | 192 | 2.60 | 0.60 | 0.93 | 1.70 | ---- | ---- | 15,000 | Abrupt pull-up |
| | 192 | 2.60 | .55 | 1.08 | 1.83 | ---- | ---- | 15,000 | Abrupt pull-up |
| | 192 | 2.60 | .70 | .53 | 1.31 | ---- | ---- | 15,000 | Abrupt pull-up |
| | 192 | 2.70 | .70 | .61 | 1.43 | ---- | ---- | 15,000 | Abrupt pull-up |
| | 214 | 3.40 | .73 | .57 | 1.40 | ---- | ---- | 10,000 | Abrupt pull-up |
| | 214 | 3.20 | .76 | .42 | 1.20 | ---- | ---- | 10,000 | Abrupt pull-up |
| | 214 | 3.60 | .70 | .60 | 1.59 | ---- | ---- | 10,000 | Abrupt pull-up |
| | 185 | 2.10 | .70 | 1.11 | 1.51 | ---- | ---- | 22,500 | Abrupt pull-up |
| | 185 | 2.10 | .75 | .95 | 1.34 | ---- | ---- | 22,500 | Abrupt pull-up |
| | 185 | 1.70 | .55 | .79 | 1.37 | ---- | ---- | 22,500 | Abrupt pull-up |
| | 141 | 1.10 | .61 | 1.14 | 1.21 | ---- | ---- | 30,000 | Abrupt pull-up |
| | 141 | 1.00 | .72 | .46 | 1.00 | ---- | ---- | 30,000 | Abrupt pull-up |
| | 141 | 1.30 | .55 | 1.52 | 1.30 | ---- | ---- | 30,000 | Abrupt pull-up |
| | 164 | 1.5 | ---- | .75 | 1.40 | ---- | 0.47 | 19,900 | |
| | 210 | 2.3 | ---- | .64 | 1.60 | ---- | .44 | 20,200 | |
| | 210 | 2.6 | ---- | .62 | 1.43 | ---- | .49 | 20,400 | |
| | 236 | 3.2 | ---- | .44 | 1.33 | ---- | .51 | 19,800 | |
| | 263 | 3.8 | ---- | .42 | 1.74 | ---- | .53 | 20,100 | |
| | 324 | 5.1 | ---- | .64 | 2.32 | ---- | .47 | 19,200 | Abrupt push-over, pull-ups at increasing Mach numbers |
| | 338 | 4.4 | ---- | .35 | 1.70 | ---- | .42 | 19,500 | |
| | 347 | 5.4 | ---- | .41 | 2.22 | ---- | .44 | 19,850 | |
| | 356 | 4.7 | ---- | .31 | 1.40 | ---- | .39 | 19,800 | |
| | 368 | 4.7 | ---- | .39 | 2.38 | ---- | .40 | 20,200 | |
| | 373 | 4.1 | ---- | .49 | 2.20 | ---- | .34 | 20,300 | |
| | 379 | 4.1 | ---- | .66 | 3.20 | ---- | .35 | 20,250 | |
| | 375 | 4.6 | ---- | .50 | 2.44 | ---- | .40 | 18,900 | |
| | 178 | 1.2 | ---- | .68 | 1.58 | ---- | .49 | 29,300 | |
| | 197 | 1.8 | ---- | .86 | 2.04 | ---- | .52 | 29,500 | Abrupt push-over, pull-ups at increasing Mach numbers at high altitude |
| | 286 | 4.0 | ---- | .34 | 2.13 | ---- | .46 | 29,000 | |
| | 261 | 2.3 | ---- | .19 | 1.83 | ---- | .40 | 29,400 | |
| | 315 | 3.5 | ---- | .21 | 2.00 | ---- | .38 | 28,150 | |
| | 330 | 2.4 | ---- | .18 | 1.36 | ---- | .27 | 27,400 | |
| | 196 | 2.4 | .87 | .50 | 1.32 | ---- | ---- | 30,400 | Abrupt pull-ups, buffeting |
| | 220 | 2.9 | .77 | .33 | 1.80 | ---- | ---- | 29,900 | Abrupt pull-ups, buffeting |
| | 231 | 3.5 | 1.00 | .26 | 1.78 | ---- | ---- | 29,500 | Abrupt pull-up, stall |
| | 268 | 4.7 | .93 | .27 | 1.60 | ---- | ---- | 28,200 | Abrupt pull-up |
| | 152 | 1.0 | .95 | 1.04 | 1.44 | ---- | ---- | 31,000 | Abrupt pull-out |
| | 167 | 1.5 | 1.00 | .90 | 1.80 | ---- | ---- | 30,600 | Abrupt pull-out |
| | 189 | 1.9 | .95 | 1.14 | 2.14 | ---- | ---- | 30,600 | Abrupt pull-out |
| | 208 | 2.5 | 1.00 | .74 | 2.15 | ---- | ---- | 30,700 | Abrupt pull-out, severe buffeting |
| | 196 | 2.2 | .90 | .71 | 2.00 | ---- | ---- | 30,500 | Abrupt pull-out |
| | 226 | 3.2 | .85 | .66 | 2.10 | ---- | ---- | 29,600 | Abrupt pull-out |
| | 233 | 3.6 | .90 | .66 | 2.20 | ---- | ---- | 29,600 | Abrupt pull-out |
| | 255 | 4.3 | .85 | .58 | 2.65 | ---- | ---- | 29,600 | Abrupt pull-out |
| | 224 | 3.2 | .90 | .50 | 2.03 | ---- | ---- | 29,600 | Abrupt pull-out |
| | 234 | 3.8 | .80 | .79 | 2.35 | ---- | ---- | 29,600 | Abrupt pull-out |
| | 252 | 4.3 | .75 | .59 | 2.43 | ---- | ---- | 29,600 | Abrupt pull-out |
| | 272 | 4.7 | .90 | .29 | 2.09 | ---- | ---- | 29,300 | Abrupt pull-out, vicious right roll |
| | 279 | 4.2 | 1.20 | .21 | 1.28 | ---- | ---- | 29,600 | Abrupt pull-out |

NACA

TABLE II.- TABULATION OF FLIGHT DATA - Continued

| Airplane | Speed, $V_e$ (mph) | Load-factor increment, $\Delta n$ | Time to reach peak load, $\lambda$ (sec) | Max. elevator rate, $d\delta/dt$ (radians/sec) | Angular acceleration (radians/sec$^2$) | | Angular velocity, $\dot{\theta}$ (radians/sec) | Pressure altitude, $h_p$ (ft) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | $+\ddot{\theta}$ | $-\ddot{\theta}$ | | | |
| 15 | 126 | 0.8 | 0.80 | 2.93 | 1.2 | ---- | 0.59 | 25,100 | Abrupt pull-up |
| | 156 | 1.9 | .70 | 2.82 | 2.5 | ---- | .69 | 25,200 | Abrupt pull-up |
| | 184 | 2.6 | .80 | 2.05 | 2.4 | ---- | .62 | 25,250 | Abrupt pull-up |
| | 111 | .8 | .84 | 3.07 | 1.3 | ---- | .49 | 25,000 | Abrupt pull-up |
| | 158 | 2.0 | .70 | 2.58 | 1.8 | ---- | .74 | 24,900 | Abrupt pull-up |
| | 182 | 2.6 | .75 | 2.79 | 2.1 | ---- | .76 | 24,400 | Abrupt pull-up |
| | 188 | 2.2 | .88 | 1.40 | 2.2 | ---- | .30 | 9,000 | Pull-up |
| | 186 | 2.9 | .80 | 1.88 | 2.6 | ---- | .49 | 9,000 | Pull-up |
| | 184 | 2.6 | .82 | ---- | 2.2 | ---- | .40 | 9,000 | Pull-up |
| | 183 | 2.8 | .77 | ---- | 2.5 | ---- | .60 | 9,000 | Pull-up |
| | 211 | 3.3 | .85 | 1.12 | 1.8 | ---- | .41 | 7,020 | Pull-up |
| | 213 | 3.8 | .80 | 1.61 | 2.6 | ---- | .51 | 7,000 | Pull-up |
| | 209 | 4.1 | .85 | 1.26 | 2.3 | ---- | .60 | 6,970 | Pull-up |
| | 232 | 4.4 | .80 | 1.40 | 2.5 | ---- | .46 | 6,800 | Pull-up |
| | 241 | 1.1 | 1.05 | .42 | .8 | ---- | .25 | 8,500 | Pull-up |
| | 241 | 1.5 | 1.35 | .39 | .9 | ---- | .29 | 8,670 | Pull-up |
| | 241 | 3.8 | .95 | .38 | .9 | ---- | .44 | 8,670 | Pull-up |
| | 161 | 1.4 | 1.25 | .98 | .7 | ---- | .15 | 7,800 | Pull-up |
| | 163 | 2.1 | 1.60 | 1.40 | .9 | ---- | .35 | 7,700 | Stalled pull-up |
| | 161 | 1.2 | 1.50 | .89 | .5 | ---- | .18 | 7,900 | Pull-up |
| | 293 | 3.8 | 1.20 | .18 | .5 | ---- | .26 | 7,000 | Pull-out |
| | 288 | 4.6 | 1.05 | .31 | .9 | ---- | .35 | 7,000 | Pull-out |
| | 297 | 4.0 | 2.05 | .07 | .3 | ---- | .25 | 7,000 | Pull-out |
| | 293 | 4.3 | 1.60 | .09 | .5 | ---- | .28 | 7,000 | Pull-out |
| | 290 | 3.9 | 1.80 | .11 | .4 | ---- | .33 | 7,000 | Pull-out |
| | 290 | 4.0 | 1.45 | .19 | .6 | ---- | .30 | 6,000 | Pull-out |
| | 285 | 4.5 | .80 | .45 | 1.2 | ---- | .39 | 7,500 | Pull-out |
| | 286 | 3.8 | 2.50 | .04 | .3 | ---- | .30 | 7,500 | Pull-out |
| | 260 | 2.8 | .93 | .38 | .7 | ---- | .32 | 8,500 | Pull-out |
| | 252 | 4.1 | 1.00 | .38 | .8 | ---- | .40 | 8,000 | Pull-out |
| | 227 | 3.8 | 1.35 | .30 | .8 | ---- | .31 | 8,900 | Pull-out |
| | 236 | 3.5 | 1.00 | .82 | 1.2 | ---- | .41 | 9,000 | Pull-out |
| | 275 | 2.9 | .95 | .49 | .7 | ---- | .24 | 7,500 | Pull-out |
| | 263 | 3.0 | 1.00 | .35 | .6 | ---- | .33 | 7,500 | Pull-out |
| | 259 | 3.7 | 1.05 | .34 | .7 | ---- | .32 | 7,500 | Pull-out |
| | 259 | 3.1 | 1.10 | .27 | .7 | ---- | .27 | 7,500 | Pull-out |
| | 288 | 2.7 | .90 | .27 | .8 | ---- | .07 | 7,300 | Pull-out |
| | 296 | 2.9 | 1.10 | .19 | .5 | ---- | .23 | ---- | Pull-out |
| | 281 | 3.4 | 1.30 | .28 | .6 | ---- | .20 | 8,500 | Pull-out |
| | --- | 3.2 | 1.15 | ---- | .6 | ---- | .26 | 8,500 | Pull-out |
| | 253 | 3.1 | 1.00 | ---- | 1.1 | ---- | .28 | 4,500 | Pull-out |
| | 241 | 3.3 | 1.10 | ---- | 1.0 | ---- | .32 | 6,500 | Pull-out |
| | 227 | 3.0 | 1.25 | ---- | .7 | ---- | .33 | 7,000 | Pull-out |
| | 231 | 3.7 | 1.14 | ---- | 1.0 | ---- | .41 | 7,000 | Pull-out |
| | 251 | 3.6 | 1.00 | ---- | .6 | ---- | .20 | 7,000 | Pull-out |
| | 290 | 3.6 | .90 | ---- | .6 | ---- | .28 | 8,100 | Pull-out |
| | 284 | 2.9 | 1.10 | ---- | .5 | ---- | .22 | 8,000 | Pull-out |
| | 289 | 3.5 | 1.25 | ---- | .5 | ---- | .28 | 8,000 | Pull-out |
| | 373 | 4.5 | 1.35 | ---- | .5 | ---- | .26 | 6,000 | Pull-out |
| | 372 | 4.7 | 1.40 | ---- | .3 | ---- | ---- | 6,000 | Pull-out |
| | 384 | 4.7 | 1.90 | ---- | .3 | ---- | .22 | 5,000 | Pull-out |
| | 263 | 4.6 | 1.00 | ---- | 1.1 | ---- | .36 | 8,400 | Pull-out |
| | 289 | 4.9 | 1.30 | ---- | .6 | ---- | .34 | 8,000 | Pull-out |

NACA

TABLE II.- TABULATION OF FLIGHT DATA - Concluded

| Airplane | Speed, $V_c$ (mph) | Load-factor increment, $\Delta n$ | Time to reach peak load, $\lambda$ (sec) | Max. elevator rate, $d\delta/dt$ (radians/sec) | Angular acceleration (radians/sec²) $+\ddot{\theta}$ | Angular acceleration (radians/sec²) $-\ddot{\theta}$ | Angular velocity, $\dot{\theta}$ (radians/sec) | Pressure altitude, $h_p$ (ft) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 16 | 396 | 4.4 | 2.00 | 0.02 | 0.50 | ---- | ---- | 8,800 | Pull-out |
| | 400 | 5.7 | 1.57 | .04 | .40 | ---- | 0.28 | 8,670 | Pull-out |
| | 280 | 4.2 | 2.00 | .03 | .40 | ---- | .45 | 7,000 | Split flaps, pull-out |
| | 160 | 2.8 | .70 | .40 | 1.83 | ---- | 1.16 | 12,250 | Stall pull-up |
| | 333 | 5.0 | 1.25 | .09 | .74 | ---- | .42 | 7,000 | Pull-out |
| | 290 | 6.2 | 1.37 | .22 | .72 | ---- | .55 | 4,800 | Pull-out |
| | 335 | 4.0 | 3.37 | .02 | .50 | ---- | ---- | 8,200 | Pull-out |
| 17 | 210 | 1.9 | .98 | 1.80 | .64 | 1.00 | ---- | 10,000 | Sharp pull-up |
| | 210 | 2.1 | .93 | 1.92 | .88 | .96 | ---- | 10,000 | Sharp pull-up |
| | 240 | 2.2 | 1.10 | .80 | .89 | 1.23 | ---- | 10,000 | Sharp pull-up |
| | 240 | 2.6 | 1.10 | .52 | .87 | .72 | ---- | 10,000 | Sharp pull-up |
| | 270 | 1.9 | 1.00 | .61 | .64 | .42 | ---- | 10,000 | Sharp pull-up |
| | 270 | 2.1 | .97 | .47 | .60 | .91 | ---- | 10,000 | Sharp pull-up |
| | 300 | 2.1 | .87 | .28 | .63 | .81 | ---- | 10,000 | Sharp pull-up |
| | 300 | 2.0 | .98 | .52 | .92 | .90 | ---- | 10,000 | Sharp pull-up |
| | 330 | 1.9 | .75 | .37 | .86 | .81 | ---- | 10,000 | Sharp pull-up |
| | 330 | 2.0 | .96 | .30 | .48 | 1.11 | ---- | 10,000 | Sharp pull-up |
| 18 | 200 | 1.0 | 1.50 | .52 | .43 | ---- | .18 | 9,500 | Pull-out |
| | 250 | .7 | 1.50 | .09 | .21 | ---- | .11 | 9,500 | Pull-out |
| | 255 | 1.6 | 1.85 | ---- | .74 | ---- | .20 | 9,500 | Pull-out |
| | 195 | 1.1 | 1.75 | .31 | .30 | ---- | .13 | 9,500 | Pull-out |
| | 254 | 1.5 | 1.35 | .33 | .36 | ---- | .15 | 9,500 | Pull-out |
| | 254 | 1.7 | 1.85 | .36 | .48 | ---- | .17 | 9,500 | Pull-out |
| | 190 | .8 | 2.00 | .35 | .29 | ---- | .09 | 9,500 | Pull-out |
| | 255 | 1.5 | 2.00 | .09 | .17 | ---- | .12 | 9,500 | Pull-out |
| | 196 | 1.2 | 1.50 | .26 | .29 | ---- | .18 | 9,500 | Pull-out |
| | 252 | 1.2 | 1.40 | .32 | .48 | ---- | .17 | 9,500 | Pull-out |
| 19 | 184 | 1.9 | 1.50 | 1.17 | .67 | .65 | .30 | 8,500 | Pull-up |
| | 184 | 1.8 | 1.60 | 1.14 | .54 | .45 | .30 | 8,500 | Pull-up |
| | 184 | 1.1 | 1.00 | 1.19 | .52 | .24 | .23 | 8,500 | Pull-up |
| | 184 | 1.6 | 1.10 | 1.22 | .95 | .71 | .27 | 8,500 | Pull-up |
| | 201 | 2.0 | 1.35 | .87 | .50 | .37 | .28 | 8,500 | Pull-up |
| | 201 | 1.8 | 1.30 | 1.20 | .97 | .42 | .26 | 8,500 | Pull-up |
| | 201 | 1.5 | 1.15 | .82 | .58 | .20 | .23 | 8,500 | Pull-up |
| | 201 | 1.8 | 1.17 | 1.05 | .65 | .37 | .27 | 8,500 | Pull-up |
| | 219 | 1.9 | 1.20 | .87 | .95 | .28 | .25 | 8,500 | Pull-up |
| | 219 | 1.6 | .95 | .79 | .55 | .40 | .23 | 8,500 | Pull-up; A study in control motion of abrupt pull-ups and recovery |
| | 219 | 1.7 | 1.15 | .89 | .70 | .32 | .23 | 8,500 | Pull-up |
| | 219 | 1.7 | 1.00 | .79 | .58 | .35 | .23 | 8,500 | Pull-up |
| | 184 | 1.6 | 1.35 | .80 | .62 | .21 | .25 | 8,500 | Pull-up |
| | 184 | 1.7 | 1.30 | .87 | .50 | .42 | .29 | 8,500 | Pull-up |
| | 184 | 1.6 | 1.25 | .86 | .53 | .21 | .25 | 8,500 | Pull-up |
| | 184 | 1.5 | 1.15 | .84 | .52 | .33 | .26 | 8,500 | Pull-up |
| | 201 | 2.1 | 1.25 | .86 | .50 | .34 | .28 | 8,500 | Pull-up |
| | 201 | 1.5 | 1.00 | .75 | .61 | .30 | .23 | 8,500 | Pull-up |
| | 201 | 2.1 | 1.30 | .77 | .46 | ---- | .28 | 8,500 | Pull-up |
| 20 | 196 | 1.1 | 1.90 | .30 | .26 | .16 | ---- | 5,000 | Intermediate pull-up |
| | 166 | 1.1 | 1.65 | .56 | .35 | .21 | ---- | 3,000 | Intermediate pull-up |
| | 178 | .9 | 1.49 | .80 | .43 | .21 | ---- | 10,100 | Abrupt pull-up |
| | 230 | 1.7 | 2.50 | .13 | .16 | .26 | ---- | 10,000 | Stall, mild pull-up |
| | 189 | .7 | 1.70 | .24 | .22 | .09 | ---- | 10,000 | Mild pull-up |
| | 189 | 1.2 | 1.65 | .95 | .49 | .16 | ---- | 9,500 | Abrupt pull-up |
| | 191 | 1.5 | 1.50 | .81 | .51 | .29 | ---- | 9,500 | Abrupt pull-up |

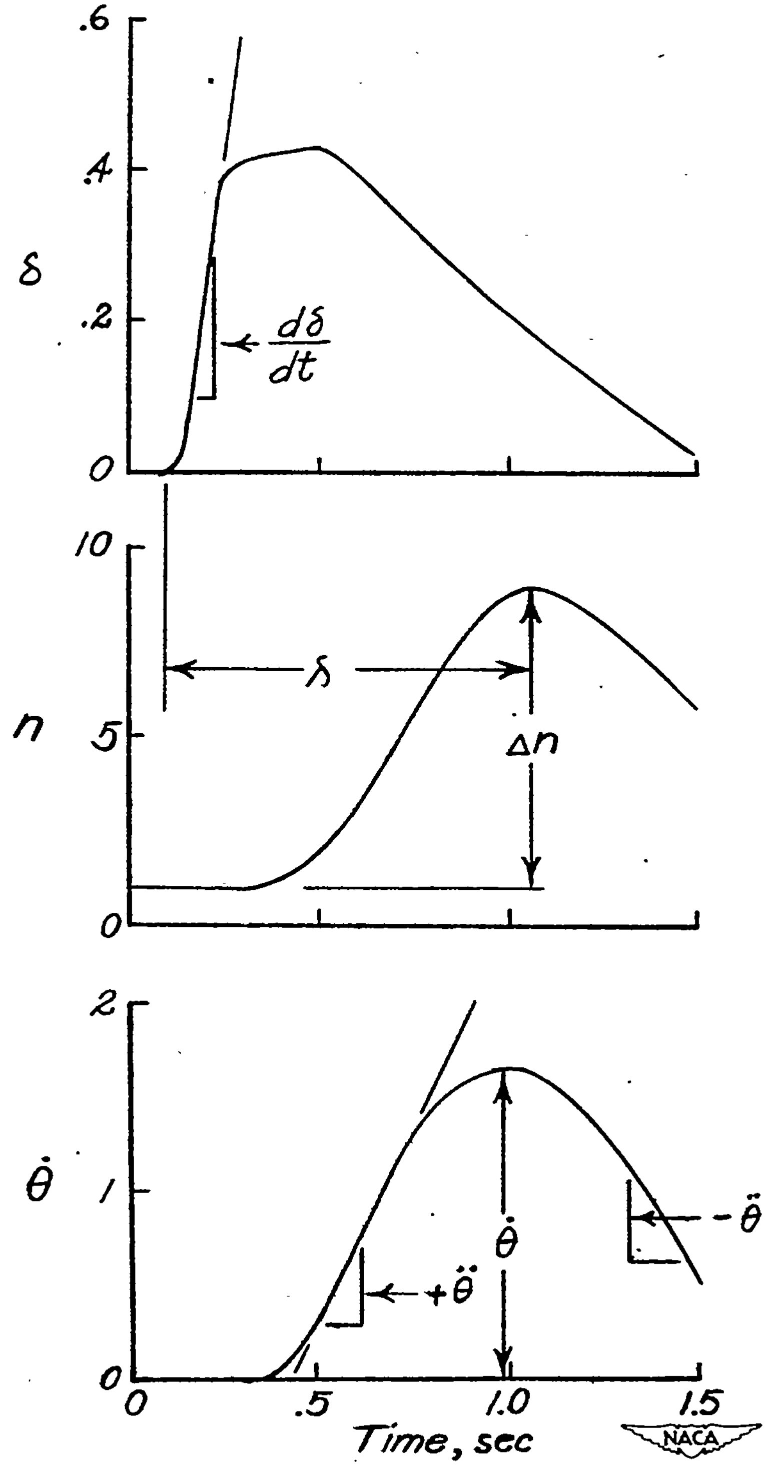


Figure 1.- Typical time histories showing method by which the slopes were taken.

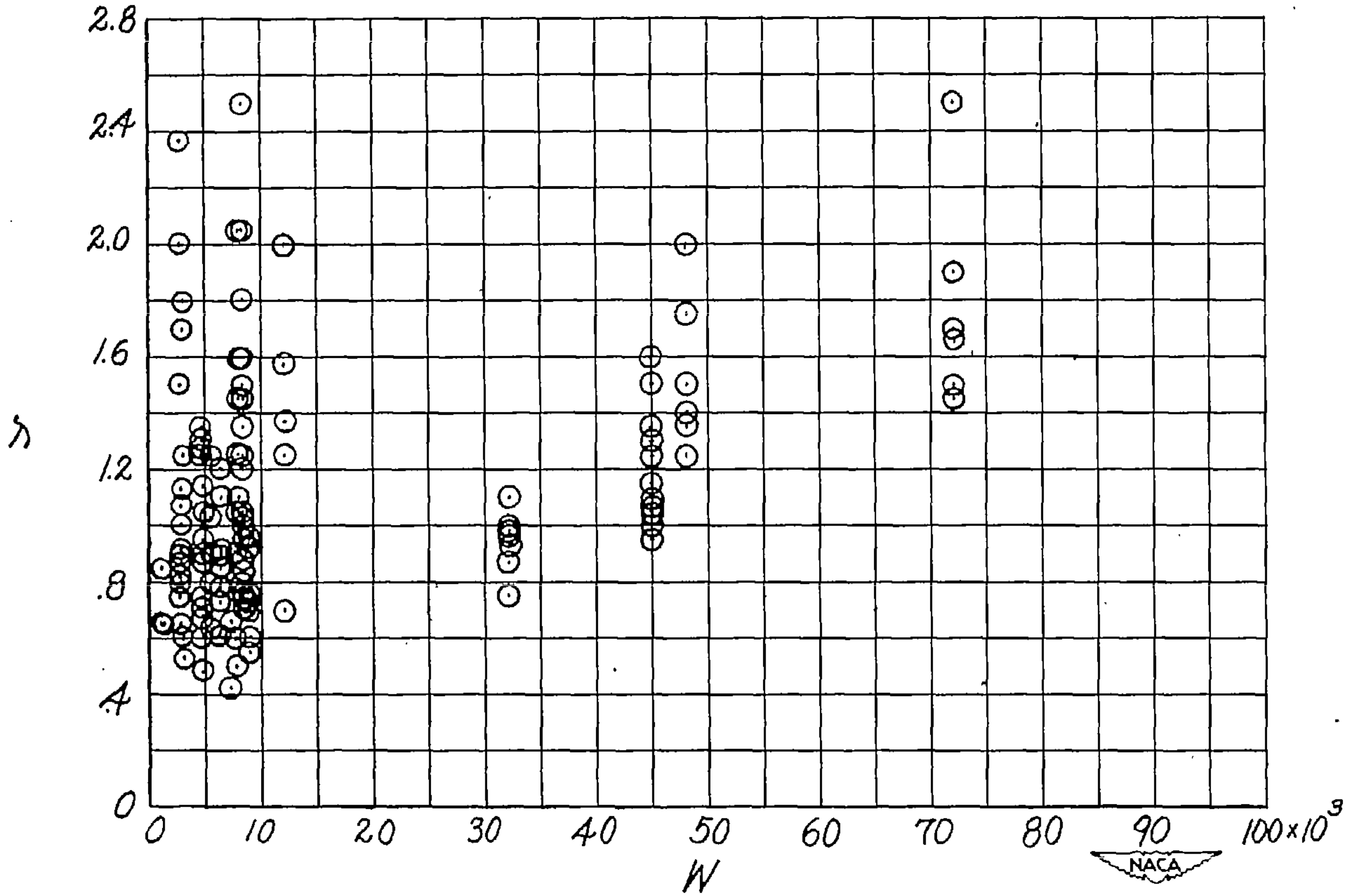


Figure 4.- Time to reach peak acceleration as a function of airplane weight.

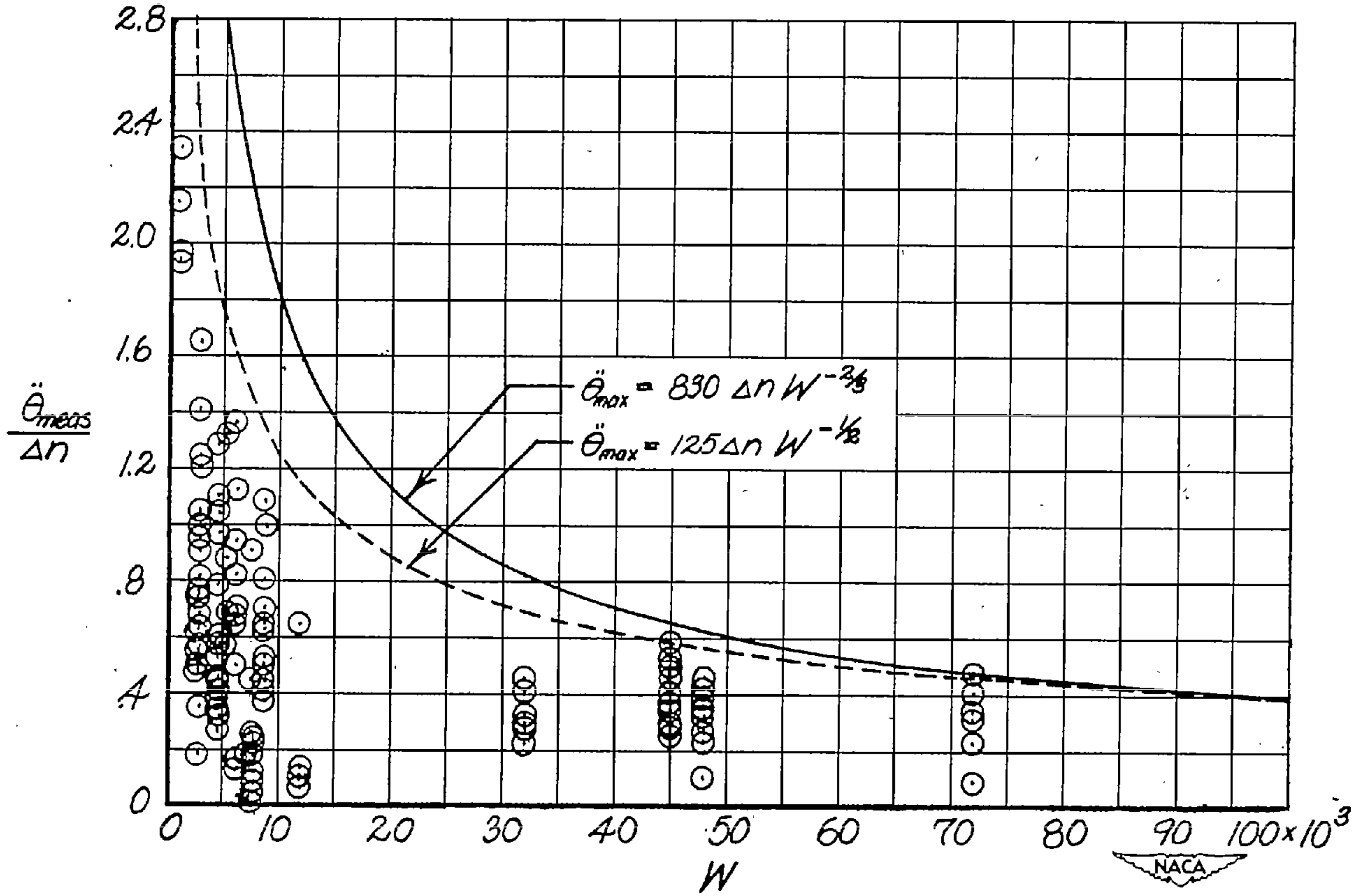


Figure 3.- Variation between measured maximum pitching acceleration for unit value of load factor and airplane weight.

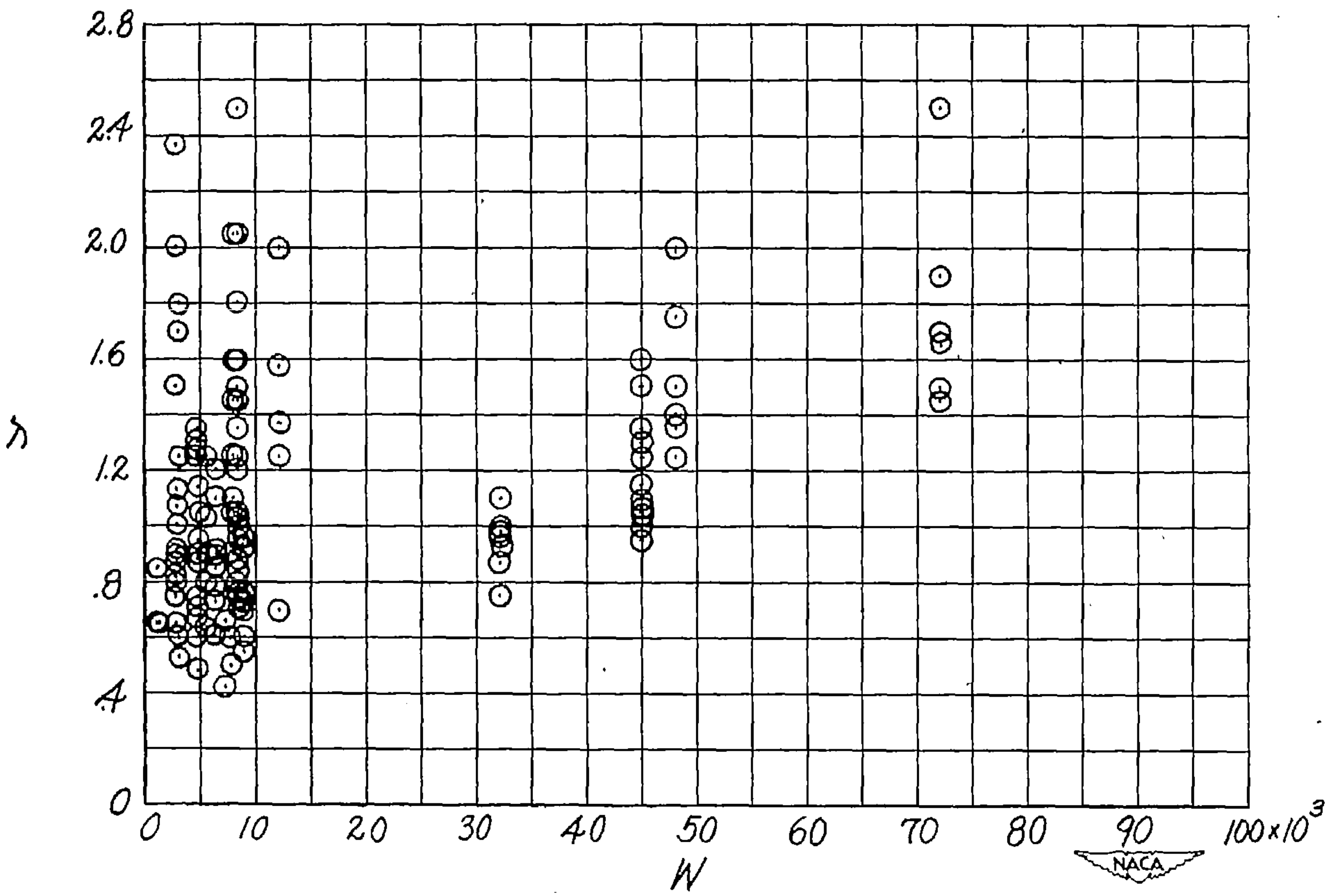


Figure 4.- Time to reach peak acceleration as a function of airplane weight.

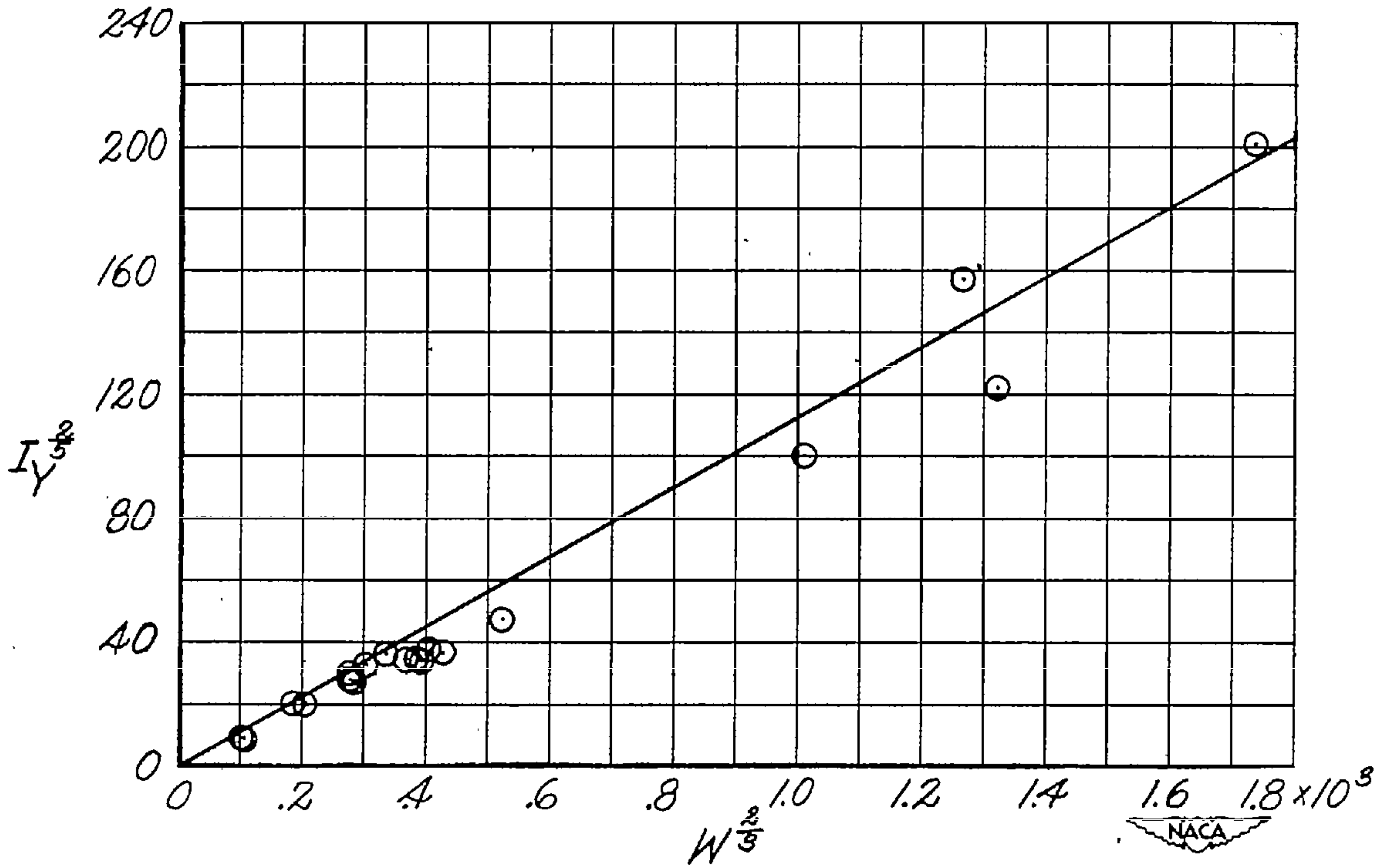


Figure 5.- Relation between pitching moment of inertia and weight.



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