RESEARCH MEMORANDUM

TIME-HISTORY DATA OF MANEUVERS PERFORMED

BY A REPUBLIC F-84G AIRPLANE DURING

SQUADRON OPERATIONAL TRAINING

By Harold A. Hamer and Alton P. Mayo

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
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SUMMARY

Preliminary results of one phase of a control-motion study program involving several jet fighter-type airplanes are presented in time-history form and are summarized as maximum measured quantities plotted against indicated airspeed. The results pertain to approximately 1,000 maneuvers performed by a Republic F-84G jet-fighter airplane during squadron operational training. The data include most tactical maneuvers of which the F-84G airplane is capable. Maneuvers were performed at pressure altitudes of 0 to 30,000 feet with indicated airspeeds ranging from the stalling speed to approximately 515 knots.

INTRODUCTION

The determination of the design loads on airplane surfaces requires, among other things, a knowledge of the control motions. In the present methods, the maximum design loads are obtained by specifying what are believed to be the critical control-surface motions and determining the associated airplane response; however, the actual control motions and load-factor variations obtained in regular operational flying may differ appreciably from the specified variations. Although the specified control motions do not exceed the limit of the pilot or airplane, the resulting design criteria may be too conservative so that the structural weight is excessive.

In order to gain information on the actual control motions used by service pilots, the National Advisory Committee for Aeronautics in cooperation with the U. S. Air Force and the Bureau of Aeronautics, Department of the Navy, is conducting a control-motion study program using several jet fighter-type airplanes. This program is directed toward obtaining statistical data on rates, amounts, and combinations...
of control motions actually used in carrying out operational training missions. From tests of this kind, it may be possible to determine more realistic design load criteria as well as obtain information useful in the design of airplane control-boost systems. References 1 to 4 are other papers which originated from this program.

The present paper includes data in time-history form of maneuvers performed by a Republic F-84G airplane during regularly scheduled operational training missions. In order to expedite the presentation of these data, only a minor analysis of the results is included to present maximum values. The time-history figures have been reduced to page size to facilitate the reproduction and distribution of the large amount of material. These figures are considered adequate for limited analysis of the data. If extensive analysis of some of the included data is desired, copies of the time histories, approximately two and one-half times larger, may be obtained upon request to the NACA.

**AIRPLANE**

A standard U. S. Air Force F-84G-1-RE airplane was used in these tests. A photograph of the test airplane is presented as figure 1. The F-84G is a single-place, low-wing fighter-bomber airplane powered by a turbojet engine. The airplane is equipped with a hydraulic aileron boost with a variable boost ratio. A speed brake is installed in the bottom of the fuselage.

Neither the external appearance nor the weight and balance of the airplane was altered by the NACA instrumentation except for the installation of a boom mounted in the nose. A three-view drawing of the F-84G test airplane is presented in figure 2 and its dimensions and physical characteristics are given in table I. The moments of inertia given in table I are values estimated in accordance with the latest information available.

**INSTRUMENTS**

Standard NACA photographically recording instruments were used to measure (1) the quantities defining the flight conditions — that is, airspeed, altitude, and speed-brake position; (2) the imposed control-surface motions; and (3) the response of the airplane in terms of load factors, angular velocities, angular accelerations, angle of sideslip, and angle of attack. The recorders were synchronized at 1-second intervals by means of a common timing circuit. All recording instruments were mounted in the nose section, with the exception of the single- and
three-component accelerometers which were located in the fuselage wing-gun ammunition compartment above the wing and the left wing-gun bay, respectively.

In order to relieve the pilot of any recording-instrument switching procedure and hence assist in obtaining normal operations, a pressure switch was employed to turn on automatically the recording instruments at an indicated airspeed of approximately 95 knots. In conjunction with this, a microswitch was attached to the nose-wheel door, which was actuated when the door was up, to insure continuous operation of the recorders during maneuvers below 95 knots.

A standard two-cell pressure recorder connected to the airplane service system was used to measure the altitude and airspeed. The service system employs a total-pressure tube located in the nose inlet and flush static-pressure orifices on either side of the lower fuselage approximately 5 feet rearward of the nose inlet. (See figs. 1 and 2.)

A switch was incorporated on the speed-brake cockpit control handle to indicate whether the speed brake was in the open or closed position. The control surface deflections were measured by a control-position recorder having remote recording electrical transmitters installed near the control surfaces. The elevator and rudder transmitters were installed inside the tail fairing at the inner hinge, and the aileron transmitter was located in the right wing-gun bay at the link arm connecting the aileron push-pull rods.

Angular velocities and angular accelerations were recorded about three mutually perpendicular axes in which the longitudinal reference axis is the one commonly used for leveling the airplane. (See fig. 2.) Load factors along these three axes were recorded by NACA air-damped recording accelerometers. The single-component accelerometer used to measure the airplane normal load factor was located 16 inches directly above the average flight center-of-gravity location (25 percent of the wing mean aerodynamic chord). The three-component accelerometer, two components of which were used to measure the longitudinal and transverse load factors, was located 11 inches behind, 4 inches below, and 37 inches to the left of the average flight center of gravity.

The angle of sideslip and angle of attack were measured by flow-direction recorders whose transmitters were mounted on a boom extending from the upper right nose-gun port. (See figs. 1 and 2.)

Table II is a summary list of the quantities measured, the instruments used, the accuracy of the measurements, and the natural frequencies of the various measuring elements. The accuracy of each measured quantity is divided into two parts: instrument accuracy, based on the error introduced by instrument characteristics, and the reproduction accuracy, based
on the inherent error resulting from preparing and reproducing the time histories. The addition of these two parts will give the total possible error with respect to the true zero. Incremental values would be associated only with the instrument accuracy.

The natural frequencies of all recording instrument elements were selected so as to minimize the magnitudes of extraneous airplane vibrations and still give correct response to the maneuver. These elements were damped to about 0.65 of critical damping.

TESTS

The recorded measurements were obtained in 20 squadron operational training flights carried out during January 1952. The operational flights included acrobatics as well as simulated dive-bombing, gunnery, and dogfighting missions. Other than to request that the airplane be used in as many types of missions as were normally carried out by the squadron, no attempt was made to specify the type or severity of maneuvers. Since the pilots were aware of the instrumentation, it was stressed that this was not to restrict their normal handling of the airplane since they would not be identified with the test results. The maneuvers were performed at pressure altitudes of 0 to 30,000 feet with indicated airspeeds ranging from the stalling speed to approximately 515 knots.

Sufficient film was available during each flight to obtain approximately 80 minutes of continuous records. This amount of time was generally enough to record the complete flight. A total of 14 pilots, performing approximately 1,000 maneuvers, participated in these tests. A total of 19.7 hours of flight time were recorded, of which approximately 8 hours are presented in this paper as maneuvers in time-history form. A ratio of flight time to maneuver time of 2.5 to 1 is not necessarily representative of normal operation because the pilots were requested to perform as many maneuvers as practical during each flight in order to minimize the time required to collect the data. All except two flights were made with the use of external fuel tip tanks. Table III is a summary of the scope of the tests and lists for each flight, the pilot, scheduled mission, configuration, airplane weight and center-of-gravity position, and pertinent remarks.

During the course of the tests it became evident that the F-84G airspeed system had a rather large airspeed-altitude error; therefore, an airspeed calibration was made. A plot of this static-pressure position error is presented in figure 3.

METHOD AND RESULTS

The basic results obtained are presented in figures 4 to 357 as time histories of the measured quantities. The time-history data are
summarized in figures 358 to 366 as maximum measured quantities plotted against indicated airspeed.

In order to expedite the conversion of the flight data to time-history figures, a photographic method of reproducing the records was developed. This method consisted of direct reproduction of the film records and the photographing of the assembled records for each particular maneuver through a master-grid overlay. The use of this method has resulted in maintaining a high over-all accuracy and in preserving many of the film-record details.

The master-grid overlay was constructed to conform to the various instrument sensitivities, calibrations, and film-drum speeds. Because of this, some of the quantities have nonlinear vertical scales; also the dimensions of the linear vertical scales vary slightly for each quantity measured. Since a constant time scale was used in reproducing the time histories, error was introduced due to variation of drum speed throughout a flight. This error falls within the ±1 percent limit as given in table II for over-all time accuracy, except for figures 68, 69, and 240. The amount of time-scale error in these figures is indicated by a correction factor in the figure legends.

In most cases a time-history figure includes a series of maneuvers in which one merged into another. Care was taken to begin and end each time-history figure at a relatively normal steady-flight condition. The time-history figures are arranged according to the maneuver classification shown in table IV. Where a figure included more than one maneuver, its classification was established by that portion which was of greatest interest. Included in the legends of the figures are a description of the type of maneuver or maneuvers and the estimated in-flight airplane weight and center-of-gravity location. The flight from which each time-history figure was taken is also included. The description of the maneuvers is, of necessity, done in a general sense since it was sometimes difficult to determine from the flight records exactly the type of maneuver performed. Most of the maneuvers were interpreted from descriptions given in references 5 and 6. The in-flight airplane weight and center-of-gravity location were determined by interpolation with respect to total amount of fuel used and the length of time for the flight including warm-up and taxiing.

In the time histories, the altitude is the NACA standard pressure altitude and the airspeed is given in terms of indicated airspeed which is defined as the reading of a differential-pressure airspeed indicator, calibrated in accordance with the accepted standard adiabatic formula to indicate true airspeed for standard sea-level conditions only. No correction has been made to the recorded quantities for static-pressure position error. Figure 3 contains the necessary information for applying
these corrections. In figure 3 the static-pressure position error $\Delta p$ is defined as

$$\Delta p = p' - p$$

where $p'$ is the uncorrected static pressure and $p$ is the true static pressure, so that

$$q_c = q'_c + \Delta p$$

where $q'_c$ is the uncorrected impact pressure and $q_c$ is the true impact pressure. The impact pressures corresponding to the values of indicated airspeeds in the time-history figures may be obtained from tables such as found in reference 7. In a few of the figures abrupt changes in the airspeed record will be noted without a corresponding change in the longitudinal acceleration. This change is due to total-pressure error which is characteristic of total-pressure tubes when at high angles of attack. Examples of this may be seen in figures 246 and 338.

The control positions shown in the time-history figures were measured with respect to the streamline position of the surfaces. Only the right aileron position was measured. Periods during which the speed brake was open are indicated in the figures by dashed lines and the words "brake open." Load factors associated with forces acting up, forward, and to the right are positive. No corrections have been made in the time histories to the recorded load factors for the effect of angular velocities and angular accelerations due to the displacement of the accelerometers from the airplane center of gravity. Nose up, nose right, and right wing down are positive for the pitching, yawing, and rolling angular velocities and angular accelerations which are given in radians per second and radians per second per second, respectively. In some of the time histories the angular-acceleration records are missing either in whole or in part. In these cases, airplane structural vibrations caused the angular accelerometers to vibrate at high frequencies and amplitudes, so that the records were of poor quality for reproduction. The angular accelerations are represented by the vibratory or dashed lines. The dashed lines indicate that the traces have been faired, with the long dashes denoting better accuracy in fairing than the short dashes.

The angle of sideslip shown in the time histories is the angle between the longitudinal axis and the projection of the relative wind in the horizontal plane of the airplane. The angle of attack is the
angle between the longitudinal axis and the projection of the relative wind in the vertical plane of the airplane and is positive for a nose-up attitude. In several figures it was necessary to fair the angle-of-sideslip and angle-of-attack records with a dashed line because excessive vibrations, ordinarily incurred during take-offs, stalls, and landings, made them of poor reproductive quality. The angle-of-sideslip and angle-of-attack values in the figures are uncorrected for angular-velocity, sidewash, and upwash effects. It is estimated that the effects of sidewash and upwash increase the measured angle of sideslip and angle of attack by approximately 5 percent and 10 percent, respectively.

The variation of normal load factor with indicated airspeed is presented in figure 358. The V-n envelopes shown in this figure are the operational limits for the test airplane, with the exception of the curves showing the stall boundaries at the various altitudes. These curves were determined from maximum-lift data obtained in these tests at the average flight gross weight of 15,000 pounds. No correction was made for position error. At maximum lift the position error varies between 5 and 10 percent of $q'c$. The load-factor test points shown in figure 358 were taken directly from the time histories and were selected so as to demonstrate to what extent the operational limit envelopes for altitude, airspeed, and normal load factor were obtained. The load factors are plotted without corrections for angular velocity or angular acceleration since such corrections were found to be small.

The maximum transverse load factors and the corresponding indicated airspeeds are presented in figure 359. Because of the large number of transverse load factors available from the time histories, only the values above the arbitrary limit of 0.05 are shown. The load factors given in this figure have been corrected for the effects of angular velocity and angular acceleration.

The maximum control rates and their variation with indicated airspeed are shown in figures 360, 362, and 364. These maximum values for elevator, aileron, and rudder rates were obtained from the maximum slope of the appropriate control-position record. In these figures only those control rates which resulted in significant airplane response or large control deflections are included.

The variations of maximum pitching, rolling, and yawing angular accelerations with indicated airspeed are given in figures 361, 363, and 365. Where the angular-acceleration records were missing in the time histories, the maximum angular accelerations were obtained from the maximum slope of the appropriate angular-velocity record. Only the maximum angular-acceleration values above the arbitrary limit of 0.2 radian per second per second for pitch, 0.5 radian per second per second for roll, and 0.1 radian per second per second for yaw are
considered to be significant and are presented in these figures. Directional oscillations are distinguished in figure 365 at the higher speeds by a different symbol.

The variation of maximum angles of sideslip with indicated airspeed is shown in figure 366. These angles, which were taken from the time histories, have not been corrected for sideward effects. In figure 366, the angles of sideslip are classified under four categories. The term rolling pull-out was used for maneuvers in which the maximum angle of sideslip occurred simultaneously with a noticeable amount of rolling velocity and at or above a normal load factor of 2.0. (See figs. 170, 183, 184, and 188.) The term roll was used for rolling maneuvers in which the normal load factor was less than 2.0. (See figs. 208, 210, and 307.) Sideslips included maneuvers in which no rolling velocity existed, and stalls were considered only at the lower airspeeds.

As mentioned previously, it was seldom that each time history contained only a single maneuver. Therefore, in general, several values for the maximums, given in figures 358 to 366, were available from each time history. Because of the large quantity of data, only those maximum values which established the boundaries and trends are presented. In these summary figures the maximum values obtained during or as a result of stalled maneuvers are indicated by a different symbol only at low speeds, since the envelope at the higher speeds was not materially affected by stalls. The maximum values obtained in the vicinity of take-off and landing were taken only when the airplane was completely airborne and are also denoted by a different symbol on the control-rate summary figures. In figures 358 to 366 no corrections have been made to the indicated airspeeds for position error. It will be noted in these figures that there are some data given at indicated airspeeds close to zero knots. These data were taken directly from the time histories and are considerably in error because of the large position error at low speeds and high angles of attack.

DISCUSSION

Although this investigation was limited to relatively few hours of actual flying, the data obtained represent a cross section of the maneuvers performed during operational training and include most of the tactical maneuvers within the capabilities of the F-84G airplane.

The operational limits of the V-n diagram shown in figure 358 were approached for many combinations of normal load factor, airspeed, and altitude and the positive load-factor region was utilized to a much greater extent than the negative load-factor region. Examination of the figure shows that the positive limit load factor of 7.33 was reached at
an indicated airspeed of 375 knots during a turn and a high-speed pull-out shown in figures 146 and 174, respectively. The largest negative load factor of -1.1 was obtained at 235 knots in a push-down. (See fig. 202.) Positive load factors of about 6.5 were also obtained in pull-ups and turns. The high positive load factors in the right-hand portion of the diagram were associated mainly with pull-out or turn recoveries from dive-bombing and strafing runs. (See figs. 299 and 328.) At indicated airspeeds near 330 knots, positive load factors up to 4.8 were experienced in barrel rolls. (See figs. 172 and 183.)

Examination of figure 359 shows that the maximum corrected transverse-load-factor values were usually between ±0.2. All values greater than ±0.22 were obtained in snap rolls. The largest corrected value of 0.35 at an indicated airspeed of 250 knots occurred during the snap roll shown in figure 188 at time 23 seconds. During this snap roll the transverse load factor reached a value of 1.0; however, this recorded value is reduced to 0 when corrected for effects of the rolling and yawing velocities. Other transverse load factors of about 0.2 were produced in barrel rolls, sideslips, and fishtails, examples of which may be seen in figures 250, 259, and 261. Although a value of 0.18 was measured during a stall (fig. 25 at time 94.5 seconds), the transverse load factors rarely exceeded ±0.1 in such maneuvers.

The maximum elevator rates, shown in figure 360, decreased with increasing airspeed. Except for the high rates which occurred at low indicated airspeeds during stalls, take-offs, and landings, the maximum elevator rates maintained nearly a constant value at airspeeds up to 300 knots. As a whole the maximum positive elevator rates were somewhat larger than the negative values. The high positive and negative elevator rates at indicated airspeeds greater than 150 knots were not associated particularly with any one type of maneuver. In several cases, high positive and negative rates were obtained by rapid elevator movement of small amplitude during a maneuver. Even though the rates were large, the amount of deflection was not enough to cause appreciable changes in airplane motion. Examples of this are illustrated in figure 86 at time 7 seconds and figure 90 at time 18.5 seconds where the elevator rates are 0.38 and -0.41 radian per second, respectively. The largest negative value of -0.68 radian per second at 320 knots occurred in an abrupt pull-up. (See fig. 190 at time 96.8 seconds.) A value of -0.58 radian per second at 240 knots occurred near the stall during a turn. (See fig. 189 at time 71.7 seconds.) At the higher airspeeds the largest positive elevator rates of about 0.45 radian per second were produced during barrel rolls (fig. 213 at time 78.6 seconds) and abrupt push-downs (fig. 190 at time 111.4 seconds and fig. 202 at time 5.6 seconds). Values up to 0.4 radian per second were obtained during snap rolls. Examples of large positive and negative rates during stalls or spins can be seen in figures 345 and 347. Many of the stalls occurred
during Immelmanns and loops with the result that excessive control was used in an attempt to hold the maneuver. (See figs. 205 and 246.)

The results given in figure 361 reveal that the maximum positive and negative pitching accelerations measured during these tests increased with increasing airspeed up to about 325 knots and decreased sharply beyond this point. In general, the high accelerations were equally distributed between the positive and negative values and were obtained in various types of maneuvers. The highest positive pitching acceleration obtained, 1.75 radians per second per second at 320 knots, occurred in the abrupt pull-up shown in figure 190 at time 97 seconds and corresponded to the highest positive elevator rate obtained at that speed. (See fig. 360.) In the present tests, pull-ups into maneuvers such as Immelmanns, chandelles, and loops and pull-outs from dive-bombing and ground-gunnery runs were always gradual with relatively low pitching accelerations, usually 0.1 to 0.2 radian per second per second. The largest negative pitching acceleration obtained was -2.0 radian per second per second and occurred at an airspeed of 320 knots during a recovery from a turn (fig. 44 at time 67 seconds) and at an airspeed of 340 knots during a recovery from an abrupt pull-up (fig. 201 at time 5.5 seconds). Negative pitching accelerations of -1.0 radian per second per second were obtained in the abrupt push-downs shown in figures 42, 190, and 202 and these values corresponded to the largest negative elevator rates at those speeds. Maneuvers, other than abrupt pull-ups and push-downs, which produced positive and negative pitching accelerations greater than ±1.0 radian per second per second were barrel rolls and turns, as well as stall-type maneuvers such as snap rolls and stall turns. Comparatively small positive and negative pitching accelerations were obtained during low-speed stalls or spins, with the largest value of 0.85 radian per second per second being recorded during the spin shown in figure 346.

In general, the maximum aileron rates shown in figure 362 remained at a nearly constant value up to 300 knots and gradually decreased with increasing airspeed beyond this point. The largest aileron rate measured during this investigation was 1.21 radians per second at 110 knots and occurred during a stall at the top of an Immelman as shown in figure 205 at time 44.2 seconds. As in the case of the elevator, large aileron rates were used during such maneuvers to hold the maneuver at the approach of stall. During take-offs and landing, the aileron rates were usually less than ±0.4 radian per second. Examples of the highest rates used during take-off and landing can be seen in figure 10 at times 7 and 12.5 seconds and in figure 350 at times 45.5 to 48 seconds. At the higher airspeeds, the largest positive and negative aileron rates used occurred during banks and rolling into or out of turns. Such maneuvers where values of about ±1.0 radian per second were obtained may be seen in figures 119, 178, 213, and 349 and examples of the largest rates at 490 knots are illustrated in figure 267 where values of 0.45
and -0.33 radian per second were obtained. Other aileron rates up to about ±0.8 radian per second were recorded in barrel and snap rolls.

The maximum rolling accelerations, shown in figure 363, increased with increasing indicated airspeed up to about 300 knots and then decreased beyond this point. The highest rolling accelerations, which were between 4.0 and 4.7 radians per second per second and near 240 knots, were the result of the turn in the landing pattern as can be seen in figures 349, 350, and 355 and were associated with the highest aileron rates at that speed. In other cases, rolling into or out of turns produced values of rolling acceleration up to ±4.0 radians per second per second at indicated speeds up to 350 knots and values up to about ±2.0 radians per second per second from 350 to 500 knots. It was usual for this type of maneuver and these high rolling accelerations to be found during ground-gunnery runs such as the banks in figures 310 and 313 and the peel-off in figure 317. Values of rolling acceleration obtained during barrel and snap rolls were usually less than ±3.0 radians per second per second; however, a value of 4.0 radians per second per second was obtained at 315 knots at the completion of the barrel rolls shown in figure 174.

For all types of maneuvers, the maximum rudder rates which are shown in figure 364 were low relative to those measured for the elevator and aileron. In general, the maximum rudder rates decreased with increasing airspeed, with the higher values occurring during take-offs, landings, stalls, and spins. Values up to about ±0.5 radian per second were obtained in fishtail maneuvers such as seen in figures 261 and 263. Rudder rates up to about ±0.4 radian per second were measured in all types of rolling maneuvers such as turns, split-S's, vertical recoveries, barrel rolls, and Cuban eights. During sideslips the rudder rates used did not exceed ±0.25 radian per second except during the landing approach shown in figure 357 where values of -0.38 and -0.32 radian per second were measured at times 14.9 and 17 seconds, respectively. During dive-bombing runs the rudder rates used for peel-offs, banks, and turns never exceeded ±0.18 radian per second; however, in maneuvering near the ground such as in ground-gunnery or strafing runs, values up to ±0.46 radian per second were measured.

As would be expected, because of the larger moment of inertia about the airplane vertical axis, the maximum angular accelerations for yaw which are shown in figure 365 are lower than those measured for pitch or roll. The maximum yawing accelerations increased with increasing indicated airspeed up to about 300 knots and then tended to decrease with further increase in airspeed. However, the airplane was subjected to some large yawing accelerations at the higher speeds or Mach numbers where the effect of the inadvertent directional oscillations was especially pronounced. (See fig. 199 at time 15 seconds and fig. 328 at time 26 seconds.) The highest yawing accelerations obtained during
these tests were -0.9 and -1.05 radians per second per second at 305 and 260 knots and occurred in snap rolls. (See figs. 189 and 190.) Yawing accelerations above ±0.5 radian per second per second were also obtained in barrel rolls (figs. 172, 174, 180, and 181) and fishtails (figs. 261, 262, 264, and 265). As would be expected, the yawing accelerations obtained in fishtails were usually associated with the largest rudder rates at those speeds. Values of yawing acceleration during turns were generally low, the largest occurring in the stall turns shown in figure 25 and the chandelle shown in figure 278. Values during stalls or spins were generally below ±0.3 radian per second per second although such values as 0.58 and 0.55 radian per second per second were obtained in the stall shown in figure 25 at time 26 seconds and in the spin shown in figure 345.

The maximum angles of sideslip as shown in figure 366 were largest at low indicated airspeed and decreased in magnitude with increasing airspeed. In several cases, large angles near 32.0° were recorded during stalls or spins. (See figs. 211 and 346.) It will be noted that the vertical scale was broken in figure 366 to include these large angles. In the case of the two largest angles of sideslip of 31.0° and 32.0° which were recorded during the spin shown in figure 346 the limits of the recorder were exceeded. It is shown that almost any type of maneuver may produce large angles of sideslip throughout the speed range, and in this connection equally as large vertical-tail loads may be possible.

Considering the data of all maneuvers obtained during this investigation, as summarized in figures 358 to 366, no particular type of maneuver can be singled out in which the maximum values for all the quantities occurred simultaneously. The types of maneuvers which most nearly approach this condition appeared to be the barrel roll or rolling pull-out. In such maneuvers it was usual to obtain combinations of high load factors and angular accelerations with corresponding changes in the angles of attack and sideslip.

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REFERENCES


### TABLE I

**DIMENSIONS AND PHYSICAL CHARACTERISTICS OF THE F-84G TEST AIRPLANE**

**Wing (true dimensions and areas):**
- Total wing area with tip tanks off (including flaps, ailerons, and 38.3 sq ft covered by fuselage), sq ft... 261.0
- Span, in.
  - Without tip tanks.......................... 438.8
  - With tip tanks (fin to fin).................. 498.2
- Aspect ratio (based on plan dimensions)......... 5.10
- Taper ratio (Tip chord/Root chord)............. 0.57
- Root chord, in.............................. 110.3
- Location of root chord (below horizontal center line of fuselage), in........ 11.0
- Mean aerodynamic chord (at wing station 98.3 measured normal to horizontal center line of fuselage), in........ 88.8
- Distance from nose to leading edge of wing M.A.C. (parallel to fuselage center line), in........ 169.6
- Sweepback (leading edge), deg.................. 6.2
- Sweepforward (trailing edge), deg.............. 6.2
- Root and tip airfoil section (theor.)......... R4,45-1512-.9 (12-percent thickness)
- Incidence (intersection of wing and fuselage), deg............... 0
- Incidence (at tip), deg........................ -2.0
- Dihedral (from jig reference plane to horizontal), deg........ 5.0
- Total aileron area (two), sq ft................ 32.2
- Aileron span, in.............................. 100.0
- Aileron root chord (hinge center line to trailing edge), in........ 20.6
- Aileron tip chord (hinge center line to trailing edge), in........ 15.4
- Aileron static control limits (from neutral position), deg
  - Up........................................ 17.2
  - Down.................................... 15.2
- Aileron root-mean-square chord, in................ 18.1

**Horizontal tail (true dimensions and areas):**
- Total area (including elevator, tabs, and 2.2 sq ft covered by vertical tail), sq ft........ 48.4
- Span, in........................................ 179.3
- Aspect ratio (based on plan dimensions).......... 4.65
- Taper ratio...................................... 0.56
- Root chord, in................................. 50.0
- Mean aerodynamic chord, in........................ 40.1
- Root and tip airfoil section (theor.)........... R4,40-010
TABLE I.- Continued

DIMENSIONS AND PHYSICAL CHARACTERISTICS

OF THE F-84G TEST AIRPLANE

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence, deg</td>
<td>0</td>
</tr>
<tr>
<td>Dihedral (from horizontal to chord plane), deg</td>
<td>5.0</td>
</tr>
<tr>
<td>Sweepback (leading edge), deg</td>
<td>10.0</td>
</tr>
<tr>
<td>Sweepforward (trailing edge), deg</td>
<td>4.5</td>
</tr>
<tr>
<td>Location of root chord (above horizontal center line of fuselage), in.</td>
<td>24.0</td>
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<tr>
<td>Distance from 25 percent wing M.A.C. to 25 percent horizontal-tail M.A.C., in.</td>
<td>217.0</td>
</tr>
<tr>
<td>Total elevator area (two including tabs), sq ft</td>
<td>16.9</td>
</tr>
<tr>
<td>Elevator root chord (hinge center line to trailing edge), in.</td>
<td>15.0</td>
</tr>
<tr>
<td>Elevator tip chord (hinge center line to trailing edge), in.</td>
<td>8.8</td>
</tr>
<tr>
<td>Elevator span (one), in.</td>
<td>79.7</td>
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<tr>
<td>Elevator static control limits (from neutral position), deg</td>
<td></td>
</tr>
<tr>
<td>Up</td>
<td>25.0</td>
</tr>
<tr>
<td>Down</td>
<td>10.0</td>
</tr>
<tr>
<td>Elevator root-mean-square chord, in.</td>
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Vertical tail:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total area (including rudder, 2.1 sq ft of dorsal fin, and 3.5 sq ft of ventral fin), sq ft</td>
<td>36.5</td>
</tr>
<tr>
<td>Aspect ratio</td>
<td>2.23</td>
</tr>
<tr>
<td>Root chord, (at fuselage center line), in.</td>
<td>77.8</td>
</tr>
<tr>
<td>Tip chord, in.</td>
<td>30.0</td>
</tr>
<tr>
<td>Mean aerodynamic chord, in.</td>
<td>63.0</td>
</tr>
<tr>
<td>Span (from fuselage center line), in.</td>
<td>99.5</td>
</tr>
<tr>
<td>Airfoil section</td>
<td>R4,40-010</td>
</tr>
<tr>
<td>Distance from 25 percent wing M.A.C. to 25 percent vertical-tail M.A.C., in.</td>
<td>218.3</td>
</tr>
<tr>
<td>Total rudder area, sq ft</td>
<td>10.0</td>
</tr>
<tr>
<td>Rudder span, in.</td>
<td>70.2</td>
</tr>
<tr>
<td>Rudder root chord, in.</td>
<td>17.8</td>
</tr>
<tr>
<td>Rudder tip chord, in.</td>
<td>9.5</td>
</tr>
<tr>
<td>Rudder static control limits, deg</td>
<td>±23.5</td>
</tr>
<tr>
<td>Rudder root-mean-square chord, in.</td>
<td>14.8</td>
</tr>
</tbody>
</table>

Fuselage:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length (excluding nose boom), in.</td>
<td>461.4</td>
</tr>
<tr>
<td>Maximum width, in.</td>
<td>49.9</td>
</tr>
<tr>
<td>Frontal area (excluding canopy), sq ft</td>
<td>17.0</td>
</tr>
</tbody>
</table>
**TABLE I.** Concluded  

**DIMENSIONS AND PHYSICAL CHARACTERISTICS**  
**OF THE F-84G TEST AIRPLANE**  

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dive brake (frontal area exposed), sq ft</td>
<td>3.4</td>
</tr>
<tr>
<td>Dive-brake open position, deg down</td>
<td>54.8</td>
</tr>
<tr>
<td>Tip tanks:</td>
<td></td>
</tr>
<tr>
<td>Length, in.</td>
<td>162.0</td>
</tr>
<tr>
<td>Maximum diameter, in.</td>
<td>28.8</td>
</tr>
<tr>
<td>Weight (one empty), lb</td>
<td>178</td>
</tr>
<tr>
<td>Capacity (one), U. S. gal</td>
<td>230</td>
</tr>
<tr>
<td>Fin root chord (measured parallel to tank center line), in.</td>
<td>34.9</td>
</tr>
<tr>
<td>Fin tip chord (measured parallel to tank center line), in.</td>
<td>4.0</td>
</tr>
<tr>
<td>Fin span, in.</td>
<td>25.0</td>
</tr>
<tr>
<td>Airplane serial number</td>
<td>AF 51-835</td>
</tr>
<tr>
<td>Power plant (one)</td>
<td>Allison J-35-A-29</td>
</tr>
</tbody>
</table>

Measured airplane weights (including three 50-caliber machine guns without ammunition, 200-pound pilot, recording instruments, and 302 pounds of ballast in the nose), lb:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full internal fuel and full tip tanks</td>
<td>18,200</td>
</tr>
<tr>
<td>Full internal fuel and empty tip tanks</td>
<td>15,440</td>
</tr>
<tr>
<td>Full internal fuel and no tip tanks</td>
<td>15,090</td>
</tr>
<tr>
<td>No internal fuel and empty tip tanks</td>
<td>12,790</td>
</tr>
<tr>
<td>No internal fuel and no tip tanks</td>
<td>12,430</td>
</tr>
</tbody>
</table>

Measured center-of-gravity locations (gear up), percent M.A.C.:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full internal fuel and full tip tanks</td>
<td>25.2</td>
</tr>
<tr>
<td>Full internal fuel and empty tip tanks</td>
<td>23.8</td>
</tr>
<tr>
<td>Full internal fuel and no tip tanks</td>
<td>23.4</td>
</tr>
<tr>
<td>No internal fuel and empty tip tanks</td>
<td>27.9</td>
</tr>
<tr>
<td>No internal fuel and no tip tanks</td>
<td>27.5</td>
</tr>
</tbody>
</table>

Approximate moments of inertia about airplane axes (gear up), slug-ft²:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Iₓ</th>
<th>Iᵧ</th>
<th>Iᵦ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full internal fuel and full tip tanks</td>
<td>51,280</td>
<td>21,920</td>
<td>72,150</td>
</tr>
<tr>
<td>Full internal fuel and empty tip tanks</td>
<td>18,560</td>
<td>21,300</td>
<td>38,870</td>
</tr>
<tr>
<td>Full internal fuel and no tip tanks</td>
<td>14,740</td>
<td>21,160</td>
<td>34,920</td>
</tr>
<tr>
<td>No internal fuel and empty tip tanks</td>
<td>13,690</td>
<td>20,380</td>
<td>33,210</td>
</tr>
<tr>
<td>No internal fuel and no tip tanks</td>
<td>9,810</td>
<td>20,250</td>
<td>29,210</td>
</tr>
</tbody>
</table>

---

*aTip tank fuel is used before internal fuel.
### TABLE II
SUMMARY OF INSTRUMENTATION AND ACCURACIES

<table>
<thead>
<tr>
<th>Quantity measured</th>
<th>Instrument used</th>
<th>Units</th>
<th>Instrument accuracy excluding reproduction error (units as given)</th>
<th>Reproduction accuracy (units as given)</th>
<th>Instrument natural frequency, cps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure altitude</td>
<td>Airspeed-altitude recorder</td>
<td>feet</td>
<td>--------------------------</td>
<td>----</td>
<td>&gt;100 (diaphragm)</td>
</tr>
<tr>
<td>Indicated airspeed</td>
<td>Airspeed-altitude recorder</td>
<td>knots</td>
<td>--------------------------</td>
<td>----</td>
<td>&gt;100 (diaphragm)</td>
</tr>
<tr>
<td>Rudder angle</td>
<td>Control-position recorder</td>
<td>degrees</td>
<td>±0.4 (-10° to 10°)</td>
<td>±0.5</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>±0.7 (large angles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aileron angle</td>
<td>Control-position recorder</td>
<td>degrees</td>
<td>±0.4 (-12° to 12°)</td>
<td>±0.3</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>±0.7 (large angles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elevator angle</td>
<td>Control-position recorder</td>
<td>degrees</td>
<td>±0.4 (-4° to 15°)</td>
<td>±0.3</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>±0.7 (large angles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal load factor</td>
<td>Single-component accelerometer</td>
<td></td>
<td>±0.03</td>
<td>±0.05</td>
<td>19</td>
</tr>
<tr>
<td>Longitudinal load factor</td>
<td>Three-component accelerometer</td>
<td></td>
<td>±0.01</td>
<td>±0.02</td>
<td>14.7</td>
</tr>
<tr>
<td>Transverse load factor</td>
<td>Three-component accelerometer</td>
<td></td>
<td>±0.01</td>
<td>±0.02</td>
<td>14.7</td>
</tr>
<tr>
<td>Pitching velocity</td>
<td>Angular-velocity recorder</td>
<td>radians/sec</td>
<td>±0.02</td>
<td>±0.01</td>
<td>14</td>
</tr>
<tr>
<td>Quantity measured</td>
<td>Instrument used</td>
<td>Units</td>
<td>Instrument accuracy excluding reproduction error (units as given)</td>
<td>Reproduction accuracy (units as given)</td>
<td>Instrument natural frequency, cps</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------</td>
<td>--------------</td>
<td>-------------------------------------------------------------------</td>
<td>---------------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Pitching acceleration</td>
<td>Angular accelerometer</td>
<td>radians/sec²</td>
<td>±.08</td>
<td>±.02</td>
<td>14 (transmitter) 12.2 (galvanometer)</td>
</tr>
<tr>
<td>Yawing velocity</td>
<td>Angular-velocity recorder</td>
<td>radians/sec</td>
<td>±.01</td>
<td>±.01</td>
<td>9.5</td>
</tr>
<tr>
<td>Yawing acceleration</td>
<td>Angular accelerometer</td>
<td>radians/sec²</td>
<td>±.04</td>
<td>±.02</td>
<td>9.5 (transmitter) 12.5 (galvanometer)</td>
</tr>
<tr>
<td>Rolling velocity</td>
<td>Angular-velocity recorder</td>
<td>radians/sec</td>
<td>±.08</td>
<td>±.05</td>
<td>25.5</td>
</tr>
<tr>
<td>Rolling acceleration</td>
<td>Angular accelerometer</td>
<td>radians/sec²</td>
<td>±.40</td>
<td>±.10</td>
<td>25.5 (transmitter) 12.6 (galvanometer)</td>
</tr>
<tr>
<td>Angle of sideslip</td>
<td>Flow-direction recorder</td>
<td>degrees</td>
<td>±.3 (-4° to 12°) ±.7 (large angles)</td>
<td>±.50</td>
<td>18</td>
</tr>
<tr>
<td>Angle of attack</td>
<td>Flow-direction recorder</td>
<td>degrees</td>
<td>±.3 (-10° to 10°) ±.7 (large angles)</td>
<td>±.50</td>
<td>18</td>
</tr>
<tr>
<td>Time</td>
<td>Timer</td>
<td>seconds</td>
<td>0</td>
<td>±.6 in 60 sec (over-all) ±.1 (synchronous)</td>
<td></td>
</tr>
</tbody>
</table>
### TABLE III

**HISTORY AND SUMMARY OF FLIGHTS**

<table>
<thead>
<tr>
<th>Flight</th>
<th>Pilot</th>
<th>G-suit</th>
<th>Configuration</th>
<th>Mission</th>
<th>Take-off weight, lb</th>
<th>Take-off center-of-gravity location (gear up), percent N.A.C.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>Yes</td>
<td>External tip tanks; no external stores</td>
<td>Acrobatics</td>
<td>16,720</td>
<td>24.5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>No</td>
<td>do</td>
<td>Acrobatics and dive-bombing</td>
<td>18,130</td>
<td>25.2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>No</td>
<td>do</td>
<td>Acrobatics and dogfighting</td>
<td>16,790</td>
<td>24.5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>No</td>
<td>do</td>
<td>Acrobatics</td>
<td>18,130</td>
<td>25.2</td>
<td>Left tip tank failed to drain; tank contained 1,300 pounds of fuel</td>
</tr>
<tr>
<td>5</td>
<td>D</td>
<td>No</td>
<td>do</td>
<td>Acrobatics</td>
<td>18,150</td>
<td>25.2</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>E</td>
<td>No</td>
<td>do</td>
<td>Acrobatics, dive-bombing, and ground and aerial gunnery</td>
<td>16,840</td>
<td>24.5</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>D</td>
<td>No</td>
<td>do</td>
<td>Acrobatics, dive-bombing, and ground gunnery</td>
<td>16,890</td>
<td>24.5</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>D</td>
<td>No</td>
<td>do</td>
<td>do</td>
<td>16,880</td>
<td>24.5</td>
<td></td>
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<tr>
<td>9</td>
<td>F</td>
<td>No</td>
<td>do</td>
<td>Acrobatics</td>
<td>16,740</td>
<td>24.5</td>
<td>Right tip tank failed to drain; tank contained 750 pounds of fuel</td>
</tr>
<tr>
<td>10</td>
<td>G</td>
<td>No</td>
<td>do</td>
<td>Acrobatics, dive-bombing, and strafing</td>
<td>16,790</td>
<td>24.5</td>
<td></td>
</tr>
</tbody>
</table>
TABLE III.- Concluded  
HISTORY AND SUMMARY OF FLIGHTS

<table>
<thead>
<tr>
<th>Flight</th>
<th>Pilot</th>
<th>G-suit</th>
<th>Configuration</th>
<th>Mission</th>
<th>Take-off weight, lb</th>
<th>Take-off center-of-gravity location <em>(gear up)</em>, percent M.A.C.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>H</td>
<td>No</td>
<td>External tip tanks; no external stores</td>
<td>Acrobatics, dive-bombing, and strafing</td>
<td>16,770</td>
<td>24.5</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>I</td>
<td>Yes</td>
<td>--------do---------</td>
<td>Acrobatics</td>
<td>16,840</td>
<td>24.6</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>J</td>
<td>Yes</td>
<td>--------do---------</td>
<td>Acrobatics, dive-bombing, and ground gunnery</td>
<td>16,820</td>
<td>24.6</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>K</td>
<td>No</td>
<td>--------do---------</td>
<td>Acrobatics, dive-bombing, and strafing</td>
<td>16,740</td>
<td>24.5</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>M</td>
<td>Yes</td>
<td>--------do---------</td>
<td>Acrobatics and dive-bombing</td>
<td>16,720</td>
<td>24.6</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>L</td>
<td>Yes</td>
<td>--------do---------</td>
<td>Acrobatics and strafing</td>
<td>16,790</td>
<td>24.6</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>M</td>
<td>No</td>
<td>--------do---------</td>
<td>Acrobatics, dive-bombing, ground and aerial gunnery, and dogfighting</td>
<td>16,840</td>
<td>24.6</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>L</td>
<td>No</td>
<td>--------do---------</td>
<td>Acrobatics, dive-bombing, and dogfighting</td>
<td>16,820</td>
<td>24.6</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>M</td>
<td>No</td>
<td>No external tip tanks; no external stores</td>
<td>Acrobatics, dive-bombing, and strafing</td>
<td>14,940</td>
<td>23.6</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>M</td>
<td>No</td>
<td>--------do---------</td>
<td>Acrobatics and dogfighting</td>
<td>14,940</td>
<td>23.6</td>
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</table>
**TABLE IV**

**MANEUVER CLASSIFICATION**

<table>
<thead>
<tr>
<th>Type of maneuver:</th>
<th>Figures</th>
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<tbody>
<tr>
<td>Take-offs</td>
<td>4 to 13</td>
</tr>
<tr>
<td>Turns</td>
<td>14 to 104</td>
</tr>
<tr>
<td>Chandelles</td>
<td>105 to 112</td>
</tr>
<tr>
<td>Wing-overs</td>
<td>113 to 118</td>
</tr>
<tr>
<td>Lazy eights</td>
<td>119 to 124</td>
</tr>
<tr>
<td>Aileron rolls</td>
<td>125 to 167</td>
</tr>
<tr>
<td>Barrel rolls</td>
<td>168 to 187</td>
</tr>
<tr>
<td>Snap rolls</td>
<td>188 to 190</td>
</tr>
<tr>
<td>Vertical recoveries</td>
<td>191 to 193</td>
</tr>
<tr>
<td>Pull-ups</td>
<td>194 to 202</td>
</tr>
<tr>
<td>Push-down</td>
<td>203</td>
</tr>
<tr>
<td>Immelmanns</td>
<td>204 to 230</td>
</tr>
<tr>
<td>Loops</td>
<td>231 to 247</td>
</tr>
<tr>
<td>Split-S's</td>
<td>248 to 253</td>
</tr>
<tr>
<td>Cuban eights</td>
<td>254 to 256</td>
</tr>
<tr>
<td>Sideslips</td>
<td>257 to 260</td>
</tr>
<tr>
<td>Fishtails</td>
<td>261 to 266</td>
</tr>
<tr>
<td>Dives</td>
<td>267 to 272</td>
</tr>
<tr>
<td>Dive-bombing runs</td>
<td>273 to 308</td>
</tr>
<tr>
<td>Ground-gunnery and strafing runs</td>
<td>309 to 334</td>
</tr>
<tr>
<td>Stails</td>
<td>335 to 344</td>
</tr>
<tr>
<td>Spins</td>
<td>345 to 347</td>
</tr>
<tr>
<td>Landings</td>
<td>348 to 357</td>
</tr>
</tbody>
</table>
Figure 1.— Three-quarter view of F-84G test airplane.
Figure 2.- Three-view drawing of F-84G test airplane.
Figure 3. - Static-pressure position error for the F-84G airplane. Level flight; altitude, 290 feet; weight, 14,000 pounds.
Figure 4.- Take-off. Airplane weight, 16,710 pounds; center of gravity at 24.5 percent M.A.C.; flight 1.
Figure 5.- Take-off. Airplane weight, 18,110 pounds; center of gravity at 25.2 percent M.A.C.; flight 2.
Figure 6.- Take-off. Airplane weight, 16,780 pounds; center of gravity at 24.6 percent M.A.C.; flight 3.
Figure 7.—Take-off. Airplane weight, 18,110 pounds; center of gravity at 25.2 percent M.A.C.; flight 4.
Figure 8.- Take-off. Airplane weight, 16,790 pounds; center of gravity at 24.6 percent M.A.C.; flight 8.
Figure 9.- Take-off. Airplane weight, 16,780 pounds; center of gravity at 24.6 percent M.A.C.; flight 10.
Figure 10.- Take-off. Airplane weight, 16,820 pounds; center of gravity at 24.6 percent M.A.C.; flight 12.
Figure 11.- Take-off. Airplane weight, 16,700 pounds; center of gravity at 24.5 percent M.A.C.; flight 15.
Figure 12.- Take-off. Airplane weight, 16,800 pounds; center of gravity at 24.6 percent M.A.C.; flight 18.
Figure 13.- Take-off. Airplane weight, 14,920 pounds; center of gravity at 23.6 percent M.A.C.; flight 20.
Figure 14.- Series of turns. Airplane weight, 15,330 pounds; center of gravity at 23.9 percent M.A.C.; flight 1.
Figure 15. - Series of turns. Airplane weight, 15,280 pounds; center of gravity at 24.0 percent M.A.C.; flight 1.
Figure 16.- Series of turns. Airplane weight, 14,670 pounds; center of gravity at 24.8 percent M.A.C.; flight 1.
Figure 16.- Concluded.
Figure 17.- Series of turns. Airplane weight, 17,310 pounds; center of gravity at 24.8 percent M.A.C.; flight 2.
Figure 18.- Left turn. Airplane weight, 16,700 pounds; center of gravity at 24.5 percent M.A.C.; flight 2.
Figure 19.- Diving right turn. Airplane weight, 16,640 pounds; center of gravity at 24.5 percent M.A.C.; flight 2.
Figure 20.- Diving right turn. Airplane weight, 16,590 pounds; center of gravity at 24.5 percent M.A.C.; flight 2.
Figure 20.- Concluded.
Figure 21.- Right and left turn. Airplane weight, 15,810 pounds; center of gravity at 24.0 percent M.A.C.; flight 2.
Figure 22.- Climbing right and left turn. Airplane weight, 15,570 pounds; center of gravity at 23.9 percent M.A.C.; flight 2.
Figure 23.- Left turn followed by right barrel roll. Airplane weight, 15,090 pounds; center of gravity at 24.2 percent M.A.C.; flight 3.
Figure 23. - Concluded.
Figure 24.- Left turn. Airplane weight, 14,220 pounds; center of gravity at 25.4 percent M.A.C.; flight 3.
Figure 25.- Series of stall turns. Airplane weight, 14,000 pounds; center of gravity at 25.7 percent M.A.C.; flight 3.
Figure 25. - Concluded.
Figure 26. Left turn.
Airplane weight, 18,070 pounds; center of gravity at 25.2 percent M.A.C.; flight 4.
Figure 27.—Right and left turn. Airplane weight, 17,250 pounds; center of gravity at 24.8 percent M.A.C.; flight 4.
Figure 27.— Concluded.
Figure 28. Right and left bank. Airplane weight, 16,980 pounds; center of gravity at 24.7 percent M.A.C.; flight 4.
Figure 29.- Left turn. Airplane weight, 16,810 pounds; center of gravity at 24.6 percent M.A.C.; flight 4.
Figure 30. - Left turn. Airplane weight, 18,090 pounds; center of gravity at 25.2 percent M.A.C.; flight 5.
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