REPORT No. 163

THE VERTICAL, LONGITUDINAL, AND LATERAL ACCELERATIONS EXPERIENCED BY AN S. E. 5A AIRPLANE WHILE MANEUVERING

By F. H. NORTON and T. CARROLL
National Advisory Committee for Aeronautics

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SUMMARY.

This investigation was carried out by the Langley Field Laboratory of the National Advisory Committee for Aeronautics for the purpose of measuring the accelerations along the three principal axes of an airplane while it was maneuvering. The airplane selected for this purpose was the fairly maneuverable S. E. 5 A. and the instruments used were the N. A. C. A. three component accelerometer and the N. A. C. A. recording airspeed meter. The results showed that the normal accelerations did not exceed 4.00 *g*. while the lateral and longitudinal accelerations did not exceed 0.60 *g*.

INTRODUCTION.

The National Advisory Committee for Aeronautics has conducted in the past several investigations on the forces normal to the wings experienced by an airplane in maneuvering. The tests were made however on airplanes of the training type, so that it was felt desirable, now that the committee had a combat airplane in good condition, to determine the loadings on this type of airplane during maneuvers. It was also thought that a record of the accelerations along the longitudinal and lateral axes would also be of interest because as far as it is known no such records have previously been taken. The N. A. C. A. three component accelerometer which has been recently developed allowed the recording of the three accelerations simultaneously.

The maneuvers carried out were the usual ones of a loop, roll, spin, a right and left wing-over turn, some side-slips and some skids. It should be kept in mind that the loads experienced are by no means as great as could be obtained by very rough handling.

Below are given the references to the more important investigations on accelerations in flight:

Accelerometer Design.—N. A. C. A. Report No. 100. 1921.

Accelerations in Flight.—N. A. C. A. Report No. 99. 1921.

A Study of Airplane Maneuvers with Special Reference to Angular Velocities.—N. A. C. A. Report No. 155. 1922.

The N. A. C. A. Three Component Accelerometer.—N. A. C. A. Technical Note No. 112. 1922.

Preliminary Report on the Measurement of Accelerations on Aeroplanes in Flight.—R. & M. No. 376. 1917.

Report on the Measurement of Accelerations on Aeroplanes in Flight.—R. & M. No. 469. 1918.

Notes on the Design of a Recording Three Dimensional Accelerometer for Use in Aeroplanes.—R. & M. No. 627. 1919.

Development of an Airplane Shock Recorder.—A. F. Zahm. Journal of the Franklin Institute, August, 1919.

APPARATUS AND METHOD.

The airplane used in this investigation was a standard S. E. 5A. with a Wright model E engine, but with no military load (Fig. 1). The accelerometer was the N. A. C. A. three-component instrument which has been previously described. This instrument was carefully mounted on sponge rubber within a few inches of the center of gravity of the machine, in order that it should not be affected by angular accelerations. The recording airspeed meter was connected to a swivelling pitot head on the wing strut and a calibration was made by flying this airplane alongside of another airplane whose airspeed meter had been carefully calibrated. Samples of the records obtained are shown in Figure 2.

PRECISION.

The airspeed records have a precision of better than ± 2 miles per hour, and the values of the accelerations are accurate to ± 0.05 g.

RESULTS.

The airspeed and accelerations for the various maneuvers are plotted in Figures 3 to 7 on a uniform time base. In all cases the acceleration is considered positive when the air force, along its corresponding axis, acts in a positive direction, and the longitudinal axis was taken parallel to the top longeron. All of the accelerations given are the total accelerations acting on the airplane; that is, the component of gravity is included. The maximum accelerations experienced along each axis during the various maneuvers are summarized in a table below:

Maneuver.	X	Y	Z
Loop	-0.50 g.	-0.10 g.	3.80 g.
Spin	$-$ .20	$\pm$ .35	3.20
Roll	$-$ .50	$\pm$ .14	2.92
Wing over	$-$ .60	$\pm$ .20	2.60
Skid	.00	$\pm$ .23	1.20
Slip	$-$ .15	$\pm$ .40	1.20

The greatest acceleration along the Z axis occurred in a loop and amounted to 3.80 g.; along the Y axis the greatest acceleration occurred in a side-slip and was -0.40 g.; and the maximum acceleration of 0.60 g. along the X axis occurred in a wing-over.

It is interesting to compare the normal acceleration on this airplane with those found on the JN4h in Report No. 99. The S. E. 5A. showed a slightly greater loading in the loop, the same acceleration in a spin, and a markedly lower acceleration in a roll. It is noticeable that the S. E. 5A rolls smoothly and easily, whereas the JN4h must be forced through a roll with a very high initial speed.

CONCLUSIONS.

It may be concluded from these tests that the accelerations acting along the longitudinal and lateral axes are very small compared with the acceleration along the vertical axis. It is also shown that the normal acceleration experienced by an airplane such as the S. E. 5A. in ordinary maneuvering are no higher than for a training airplane of the JN4h type.

It should be noted that the accelerations in a given maneuver and with a given airplane are dependent on the manner in which the pilot handles the controls. If he is rough the airplane will be heavily loaded, but if he is skilful the loadings will be small. In general, however, the pilot feels the accelerations and unconsciously keeps from reaching high values, except under the stress of a combat when the loads may be much higher than in ordinary maneuvering.

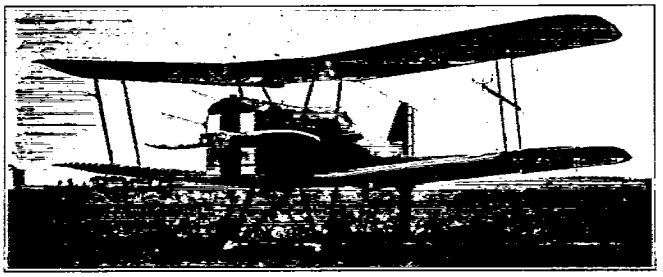

FIG 1.—S. E. 5A, used in these tests.

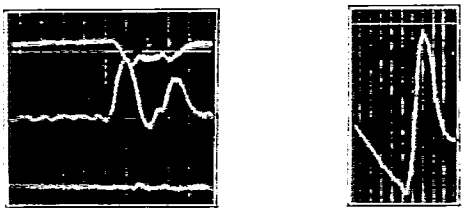

FIG. 2.

Accelerations. Airspeed.

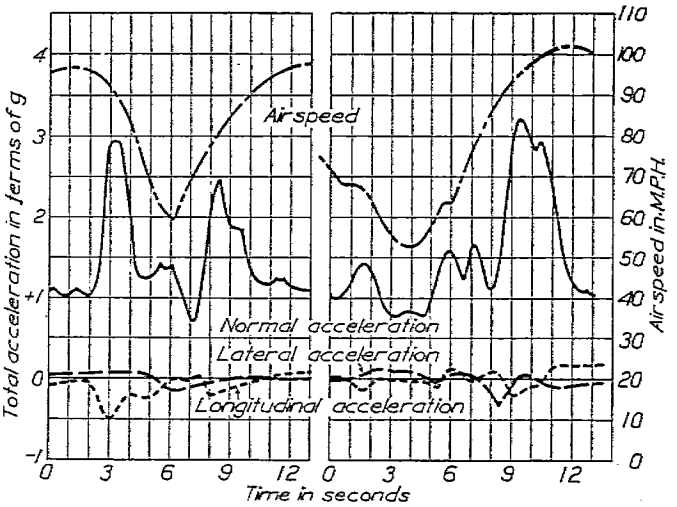

FIG. 5.

Accelerations in a R. roll. Accelerations in a R. spin, two turns

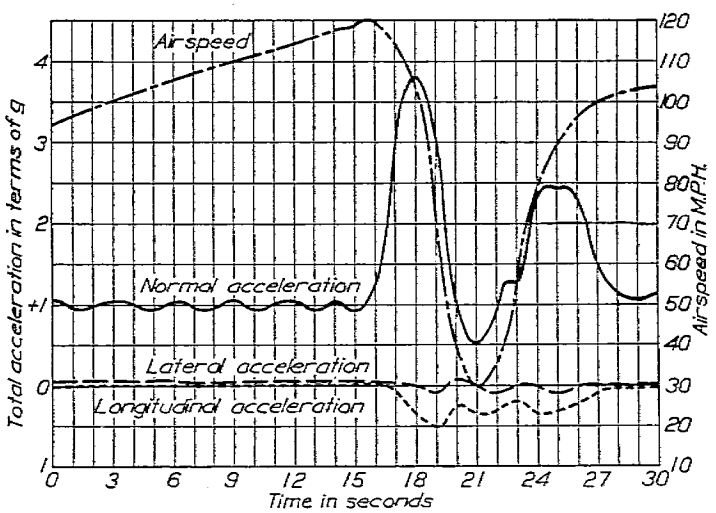

FIG. 3.—Accelerations in loop.

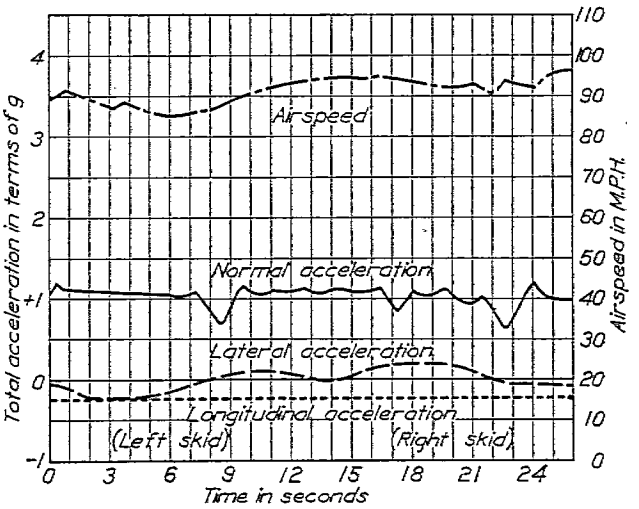

FIG. 6.—Accelerations in skid.

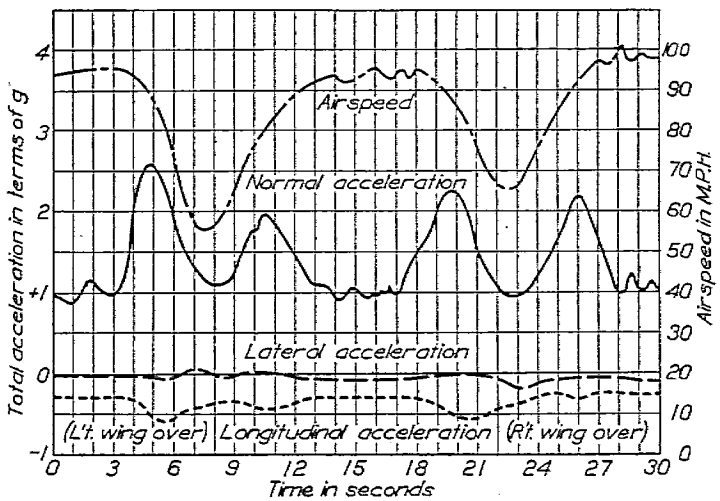

FIG. 4.—Accelerations in wing over.

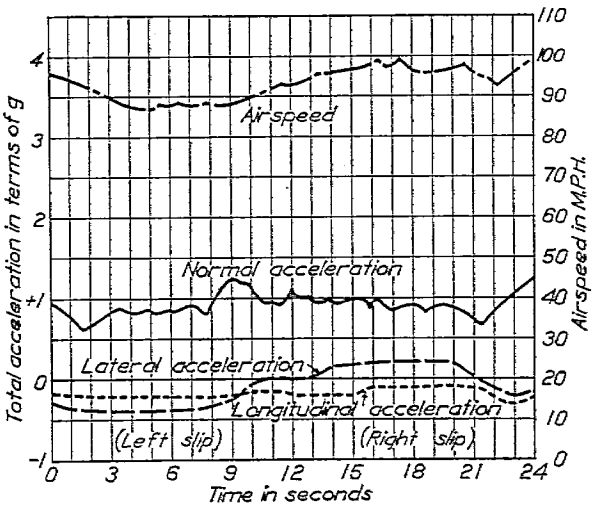

FIG. 7.—Accelerations in slip.