ARR No. 5E22

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WARTIME REPORT

ORIGINALLY ISSUED
July 1945 as
Advance Restricted Report 5E22

A COMPARISON OF TWO FLIGHT-TEST PROCEDURES FOR THE DETERMINATION OF AILERON CONTROL CAPABILITIES OF AN AIRPLANE

By Richard B. Skoog

Ames Aeronautical Laboratory
Moffett Field, California

NACA

WASHINGTON

NACA ARR No. 5B22

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

ADVANCE RESTRICTED REPORT

A COMPARISON OF TWO FLIGHT-TEST PROCEDURES FOR THE DETERMINATION OF AILERON CONTROL CAPABILITIES OF AN AIRPLANE

By Richard B. Skoog

SUMMARY

A comparison, based on actual flight tests of several airplanes, has been made between two flight-test procedures for the determination of the aileron control capabilities of an airplane. The procedures consist of performing rudder-fixed aileron rolls from straight unbanked flight and from steady turning flight.

For the airplanes considered in this report, no significant difference was found to exist in the index of aileron power $pb/2V$ as determined from data taken with either of the testing methods. This agreement was confirmed as being correct in a comparison of sideslip angle occurring at the time of maximum rate of roll. Extension of the close agreement shown in the report to cover all other present-day airplanes is believed to be reasonable.

INTRODUCTION

At the present time an indication of the amount of aileron control available in an airplane is determined in flight from measurements taken in rudder-fixed aileron rolls initiated from straight unbanked flight. The results of these tests are usually presented in a curve of maximum $pb/2V$ as a function of total aileron deflection; where p is the maximum rolling velocity in radians per second, b is the wing span in feet, and V is the true airspeed in feet per second. The method, as conceived originally, admitted the possibility of adverse yaw due to roll affecting the measured

value of rolling velocity. The question now has arisen as to whether rolling from straight flight yields results consistent with the original concept of the test, since enough additional sideslip may develop due to gravity in rolls from straight flight so that a lower determination of $pb/2V$ would be obtained than actually should be attributed to the ailerons.

An alternate testing procedure which is believed to eliminate most of the effect of gravity has been proposed. This method is substantially the same as the present one, except that the aileron rolls are to be made from steady turns, with the airplane banked about 45°. It should be noted that in this method the airplane must be rolled out of the turn.

The purpose of this investigation was to compare the results obtained from the two methods through an analysis based on actual flight tests of several airplanes. The comparison is based on data obtained during the course of flying-qualities investigations conducted at the Ames Aeronautical Laboratory, Moffett Field, Calif. The airplanes which are considered in the analysis are listed below:

Martin B-26B-21
North American P-51B-1-NA
Northrop P-61A
Lockheed PV-1

METHOD OF COMPARISON

Comparison is made between curves of $pb/2V$ and sideslip angle as a function of aileron deflection, as detemined from comparable data obtained by each of the testing procedures. Similar conditions of indicated airspeed, engine power, flap position, and landing-gear position were considered in the selection of comparable data. Tests at widely separated airspeeds under the engine powers listed below and with flap and gear up were chosen as being representative.

Airplane	Power
B-26B-21	Power for level flight at each speed
P-51B-1-NA	Power for level flight at lower speed Normal rated power at higher speed
P-61A	Normal rated power at all speeds
PV-1	Normal rated power at all speeds

The curves of $pb/2V$ and sideslip angle were obtained from a consideration of changes in the variables involved from the steady state before the roll to the state existing at the time of maximum rolling velocity.

RESULTS AND DISCUSSION

The presentation and discussion of the curves of this report will be made in three parts: namely, a rate of roll comparison, a sideslip-angle comparison, and a general discussion.

Rate of Roll Comparison

Curves of maximum $pb/2V$ plotted against aileron angle are presented in figure 1 for the B-26B airplane, in figure 2 for the P-51B airplane, in figure 3 for the P-61A airplane, and in figure 4 for the PV-1 airplane. Data were available from tests at only two airspeeds for the P-51B airplane, while it was possible to consider tests at three airspeeds for the other airplanes. The figures have been divided into several parts according to airspeed so that a comparison can be made more easily.

Examination of the curves for the several airplanes shows reasonably good agreement to exist between the two sets of data at each of the airspeeds tested. Some scatter in the data may be seen, as well as apparent trends indicating the possibility of some disagreement. An analysis of the probable error in the $pb/2V$ determinations revealed that these discrepancies may be attributed to experimental error.

The high-speed curves for the B-26B airplane are not strictly comparable because of the great speed difference. Nevertheless, if all the curves for this airplane are superposed, it will be seen that essentially the same curve was obtained at all airspeeds.

Sideslip-Angle Comparison

Curves are presented for the B-26B, P-61A, and PV-1 airplanes showing sideslip angles existing at the time of maximum rolling velocity for the tests just discussed in the rate-of-roll comparison. Similar curves are not presented for the P-51B airplane due to insufficient sideslip data.

The curves of sideslip angle against aileron deflection are presented in figure 5 for the B-26B airplane, in figure 6 for the P-61A airplane, and in figure 7 for the PV-1 airplane.

For the tests at 150 miles per hour on the B-26 airplane, good agreement may be seen from figure 5. More sideslip is shown to occur in rolls from turns than from straight flight at 224 miles per hour, however, which is opposite to that which might be expected. No correlation between this disagreement and the corresponding $pb/2V$ data (fig. 1(b)) can be seen. The remaining two sideslip curves are for tests at widely separated airspeeds and therefore are not directly comparable. It may be seen, however, that in right roll more sideslip apparently occurred in rolls from turns at 295 miles per hour than in rolls from straight flight at 256 miles per hour.

Good agreement was obtained for the P-61A airplane at all airspeeds considered. This airplane exhibited very small amounts of sideslip due to roll even at low speeds. This was undoubtedly due to the aileron-spoiler type of lateral control system.

Tests on the PV-1 airplane also show good agreement, as may be seen from figure 7.

General Discussion

When the rate-of-roll and sideslip-angle curves are considered as a whole, it appears that no significant differences exist in the results obtained by the two testing procedures. The value of $pb/2V$ determined with either method for practical purposes may be said to be the same for the airplanes considered in this report. This result appears to be well confirmed in the sideslip-angle comparison which shows, in general, no difference in the angle of sideslip at the time of maximum rolling velocity when determined by the two methods.

A possible explanation of this agreement might very well be that the rapidity with which maximum rolling velocity occurs, and the moderate angle of bank at which it occurs when rolling from straight flight, allow for only a negligible sideslip angle to develop due to gravity.

Consideration should also be given to the fact that an airplane necessarily flies at a higher angle of attack in

turning flight than in straight flight for the same airspeed. This fact would indicate that since the adverse yawing moment is ordinarily a function of angle of attack, more adverse yaw should be expected in rolls from turning flight than from rolls from straight flight when no sideslip due to gravity were present in rolls from straight flight.

It is believed that the agreement between the two methods shown in this comparison may be extended to include all present-day conventional types of airplanes.

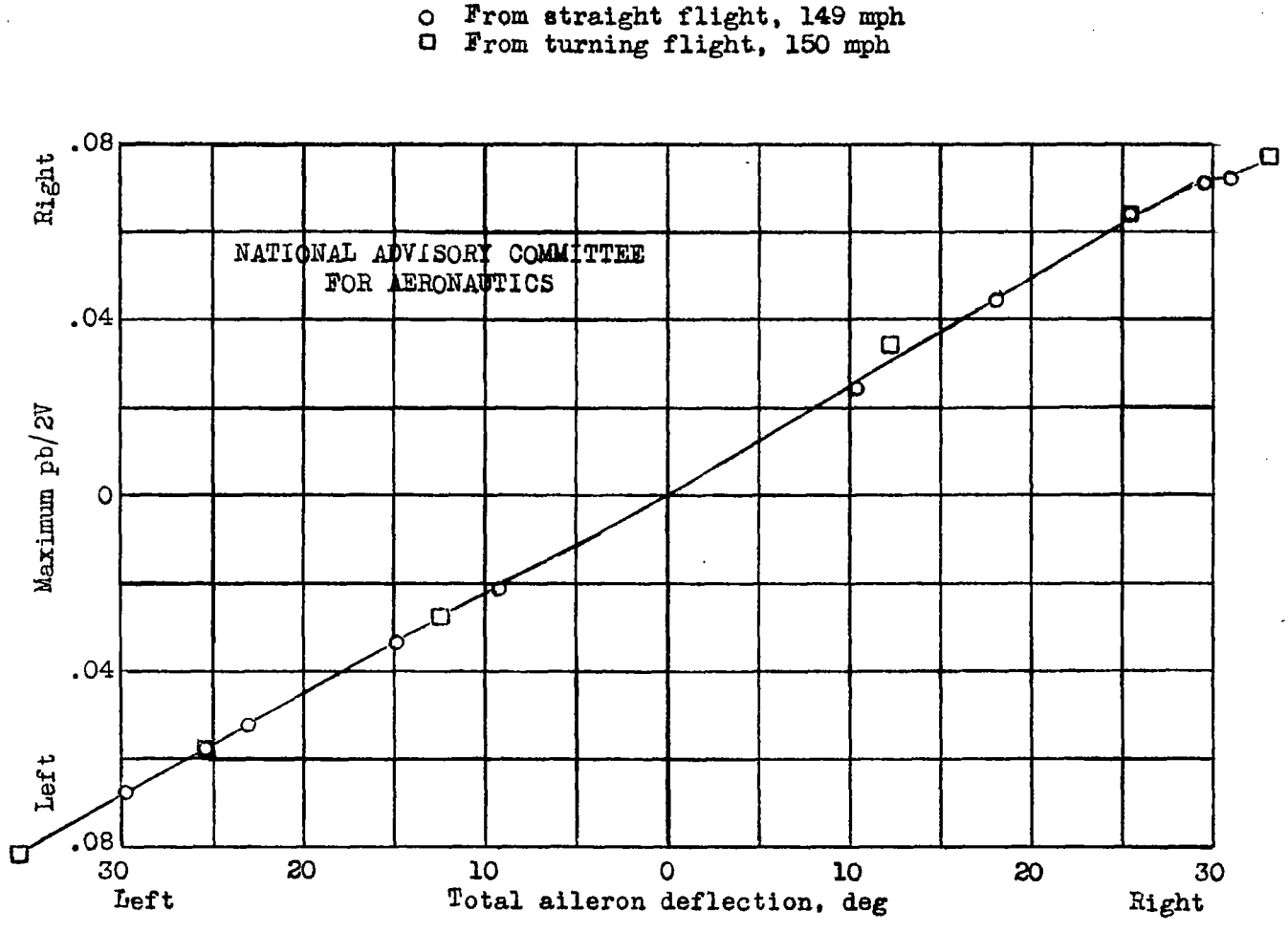
CONCLUSIONS

1. For the airplanes considered in this report no significant differences existed in the curves of $pb/2V$ plotted as a function of aileron deflection as determined from data obtained in rolling from straight flight and rolling out of a 45° bank in steady turning flight.

2. The sideslip angle occurring at the time of maximum rate of roll was essentially the same for rolls made from straight flight as for rolls made from a 45° bank in steady turning flight.

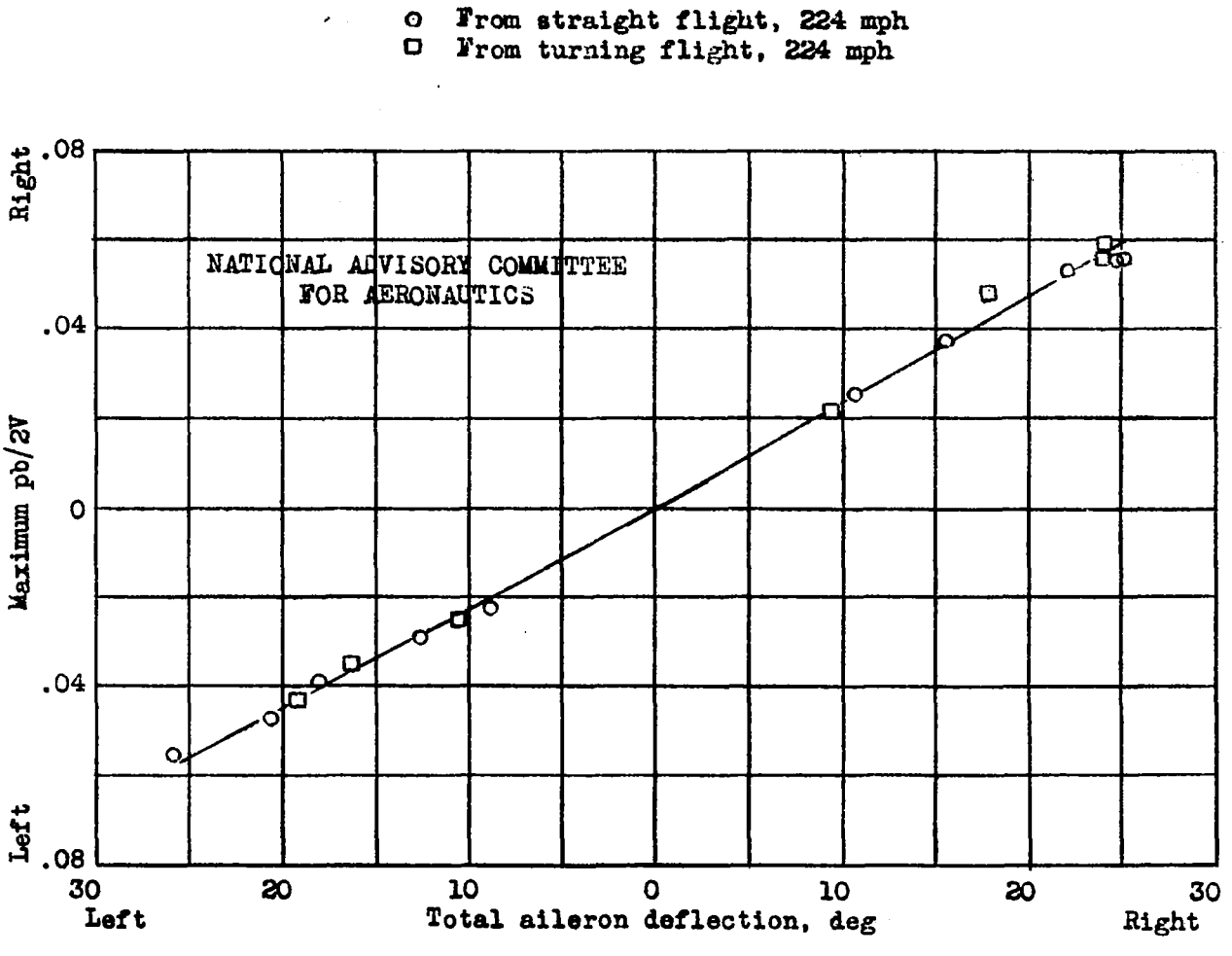
3. It is believed that the agreement between the results obtained with these two methods as shown in this comparison may be extended to include all present-day conventional types of airplanes.

Ames Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Moffett Field, Calif.



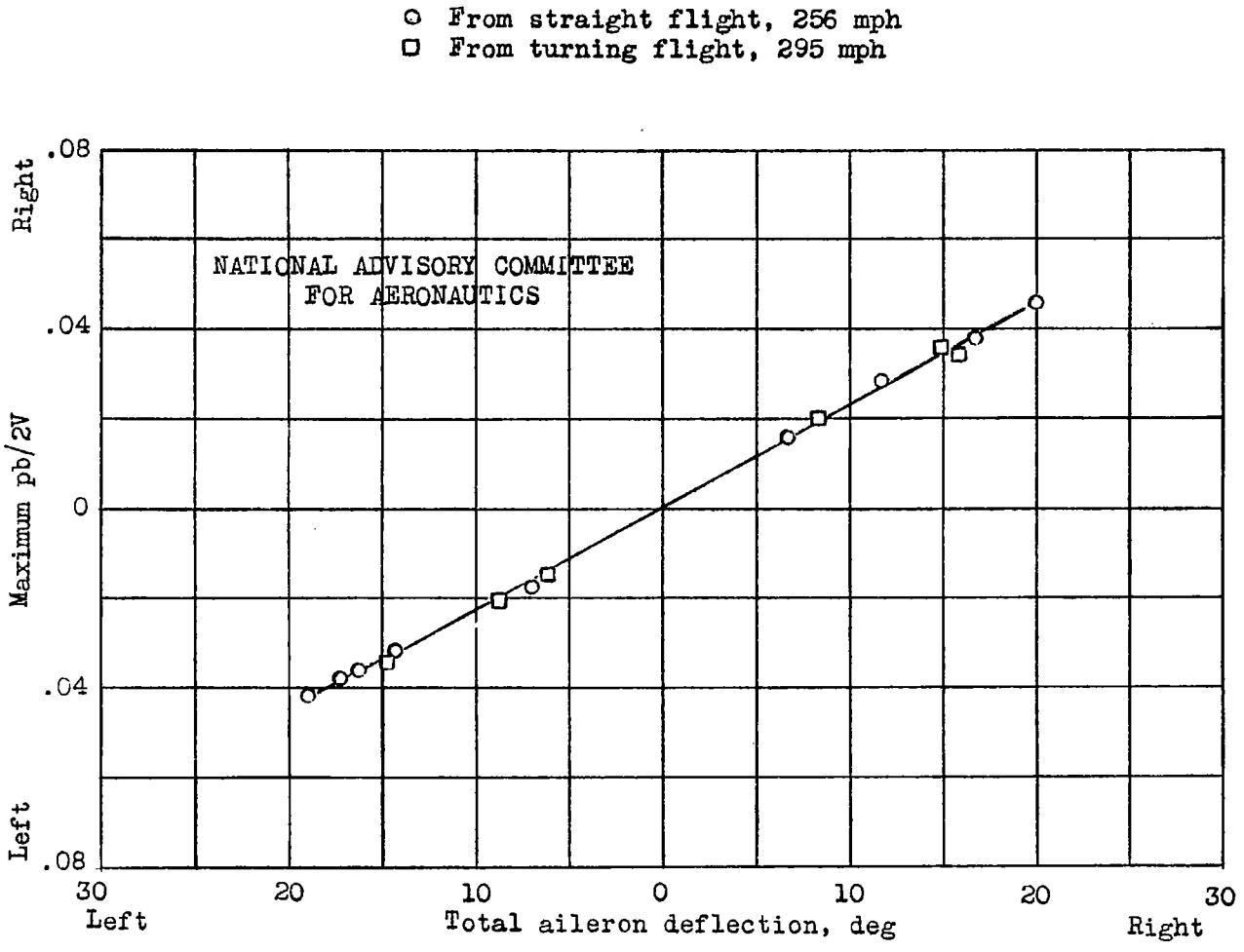
(a) Rolls at low airspeed

Figure 1 (a to c).- Comparison between flight determinations of maximum pb/2V in rudder-fixed aileron rolls from straight, unbanked flight and from steady, turning flight. Clean condition, power for level flight. Martin B-26B-21 airplane.



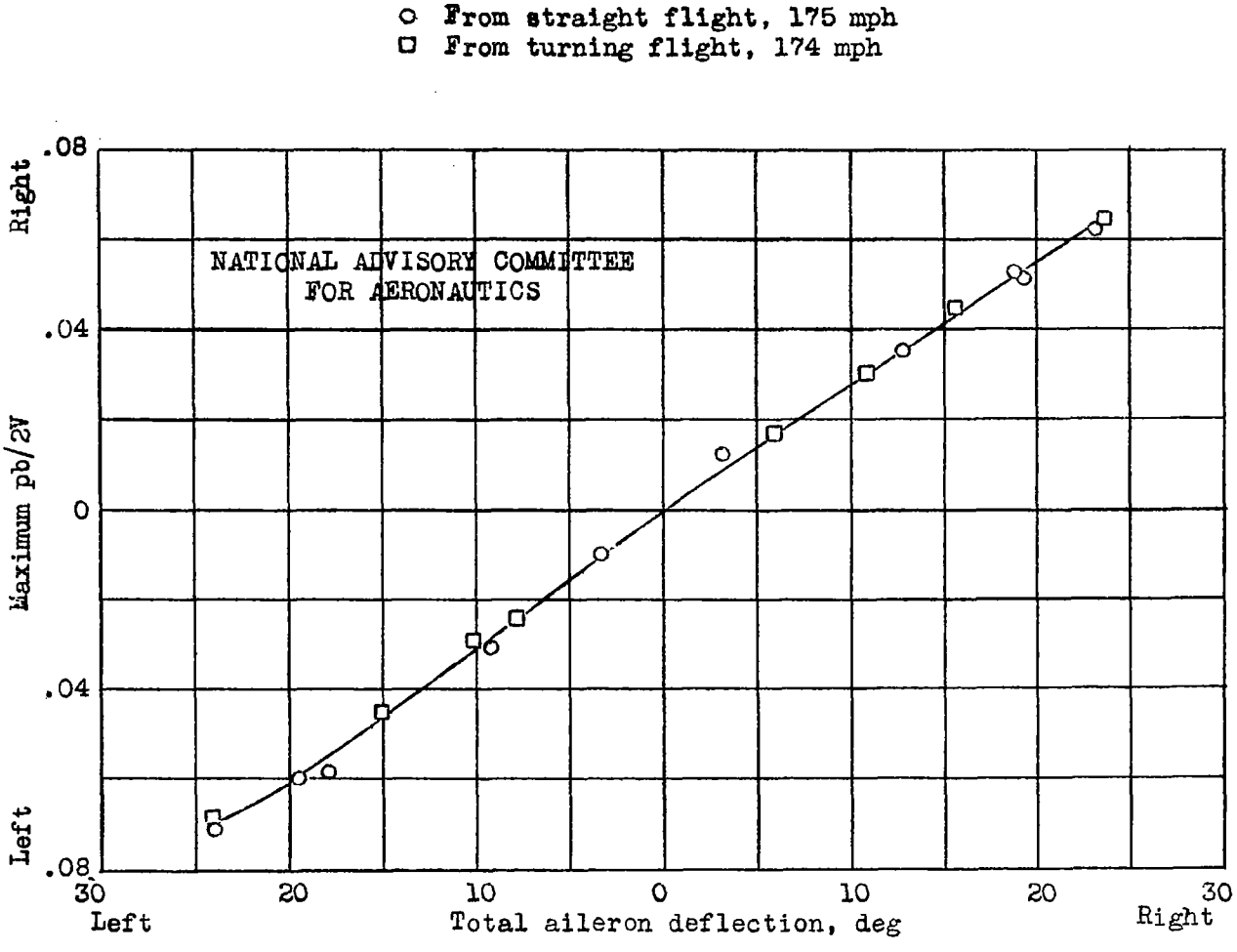
(b) Rolls at moderate airspeed

Figure 1.- (Continued). Martin B-26B-21 airplane.



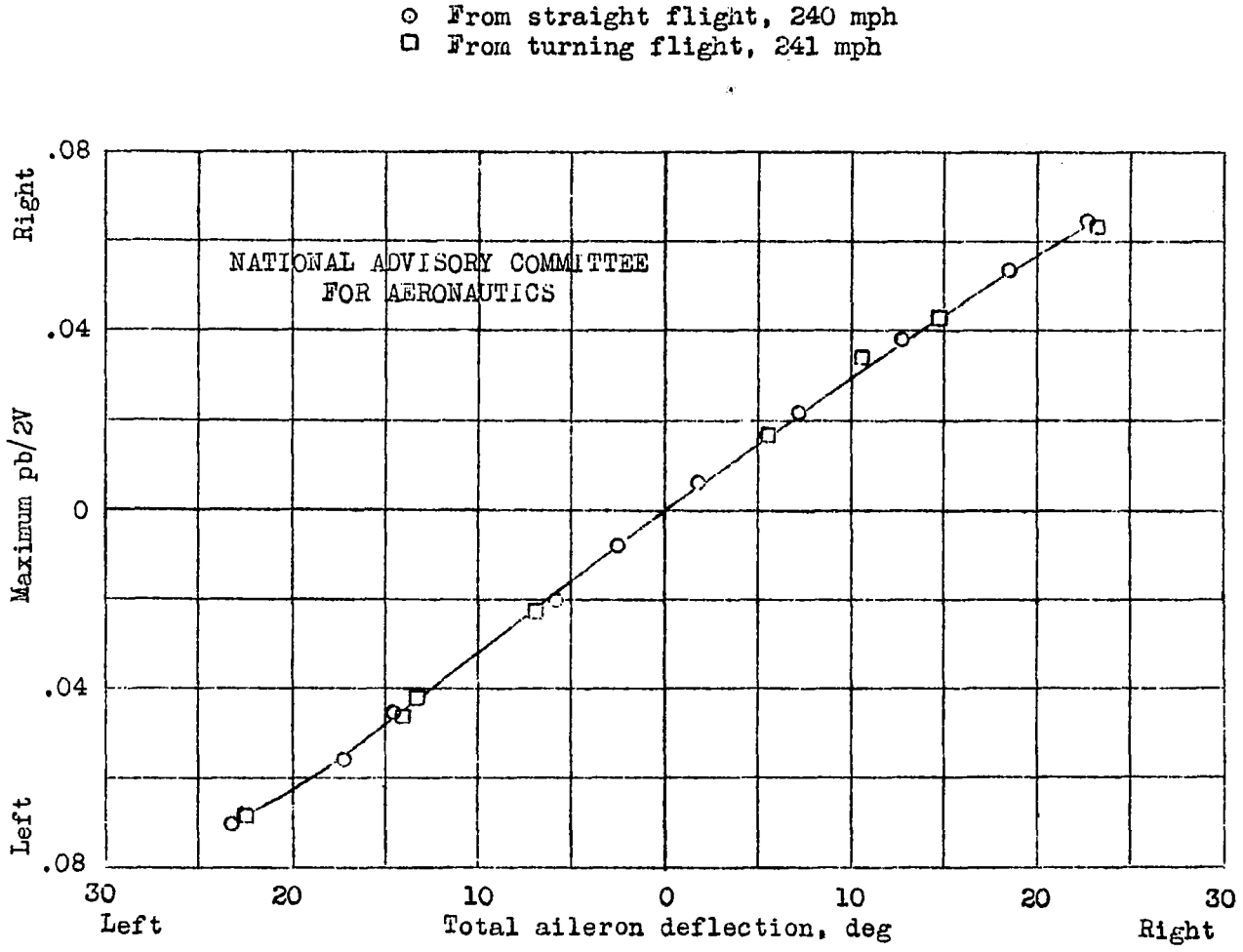
(c) Rolls at high airspeed

Figure 1.- (Concluded). Martin B-26B-21 airplane



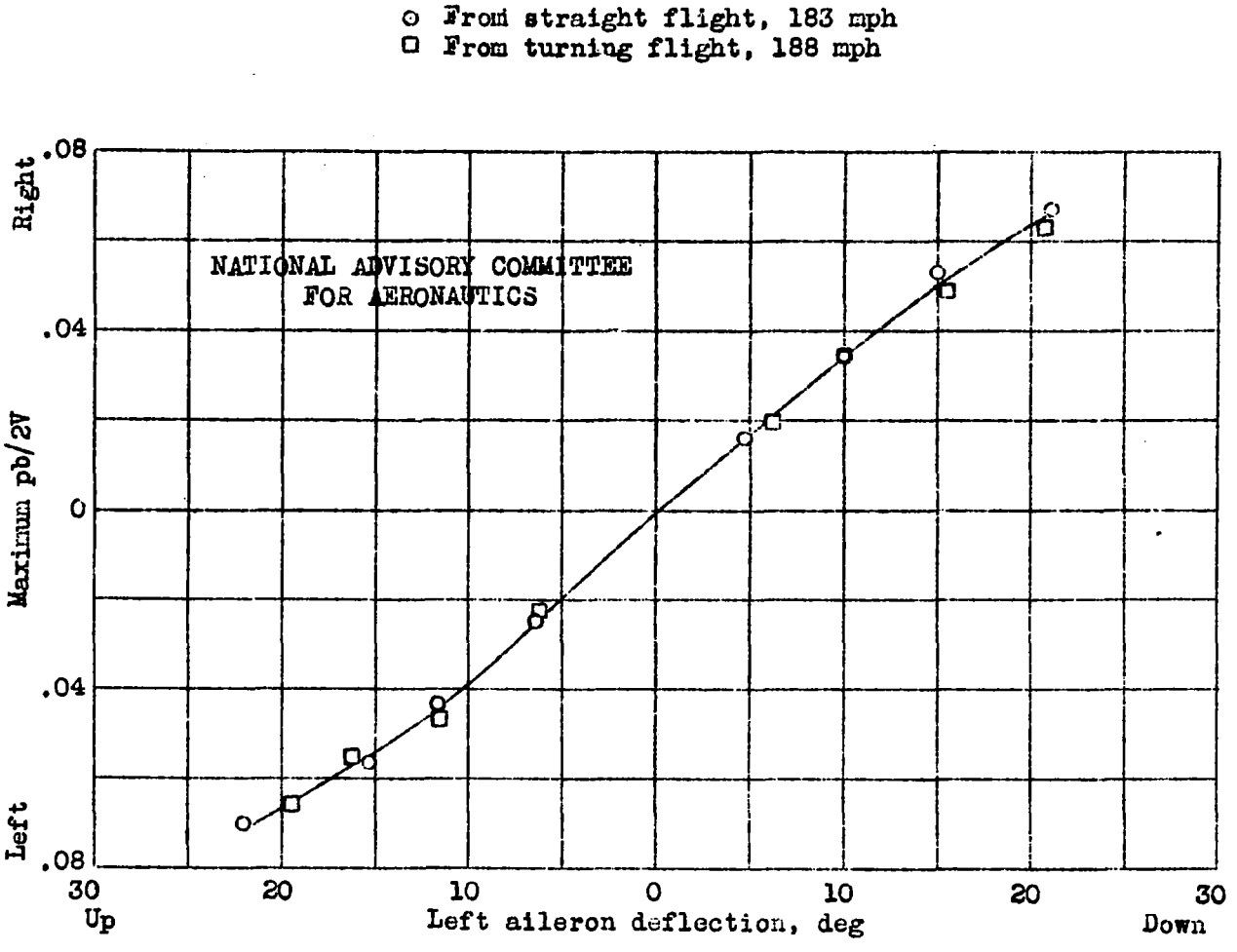
(a) Rolls at low airspeed, power for level flight

Figure 2a,b.- Comparison between flight determinations of maximum pb/2V in rudder-fixed aileron rolls from straight, unbanked flight and from steady, turning flight. Clean condition. North American P-51B-1-NA airplane.



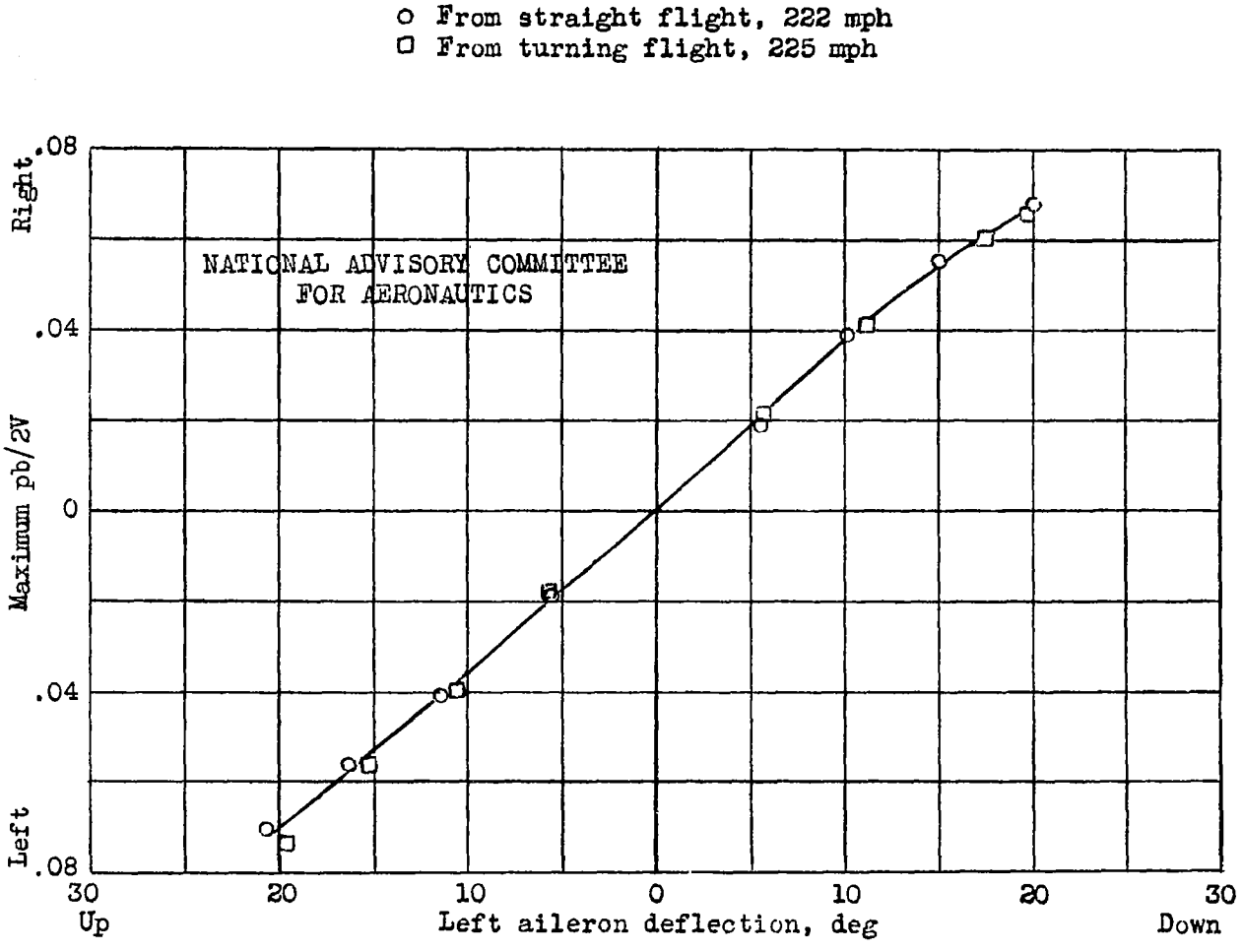
(b) Rolls at moderate airspeed, normal rated power

Figure 2.- (Concluded). North American P-51B-1-NA airplane.



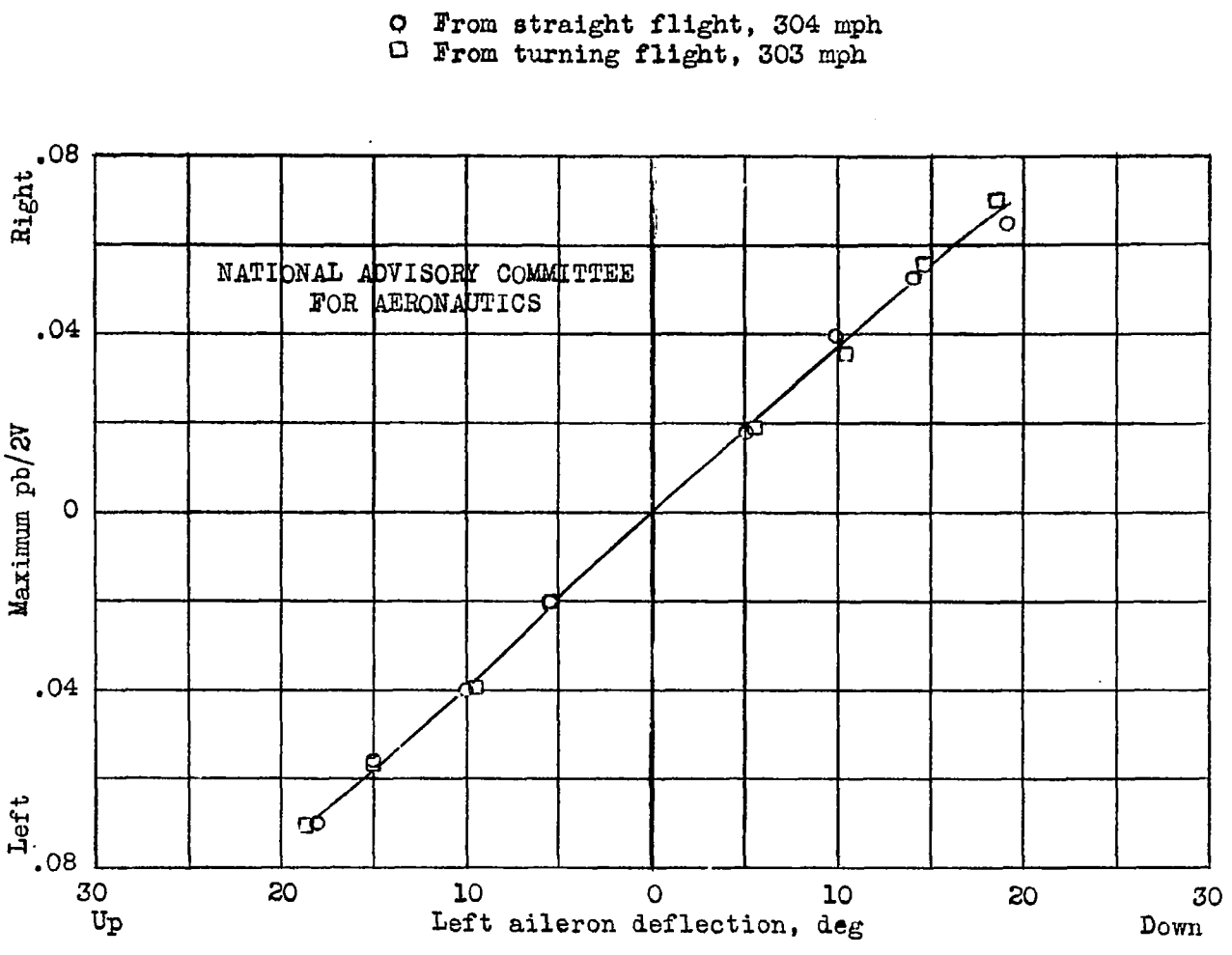
(a) Rolls at low airspeed

Figure 3 (a to c).- Comparison between flight determinations of maximum pb/2V in rudder-fixed aileron rolls from straight, unbanked flight and from steady, turning flight. Clean condition, normal rated power. Northrop P-61A airplane.



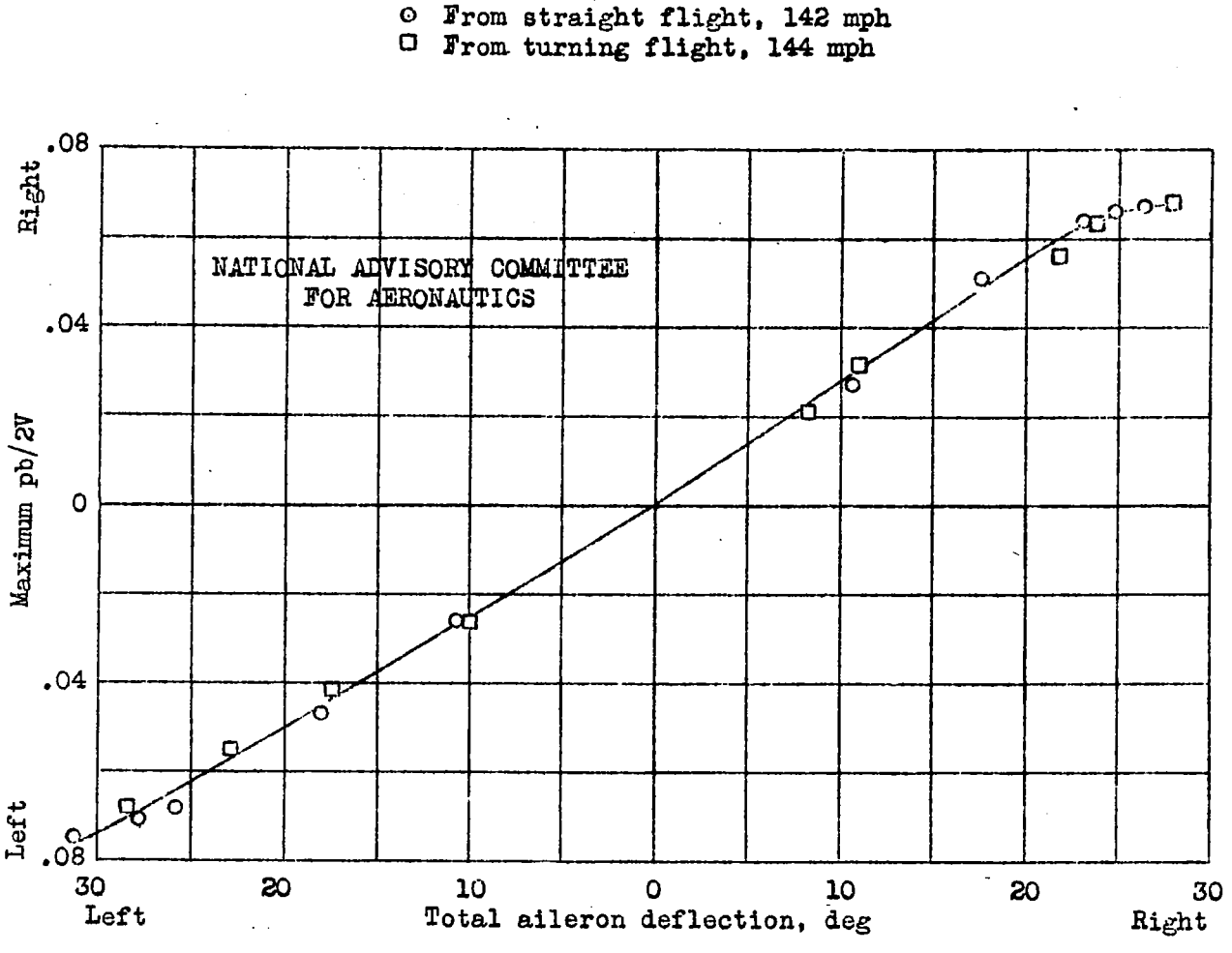
(b) Rolls at moderate airspeed

Figure 3.- (Continued). Northrop P-61A airplane.



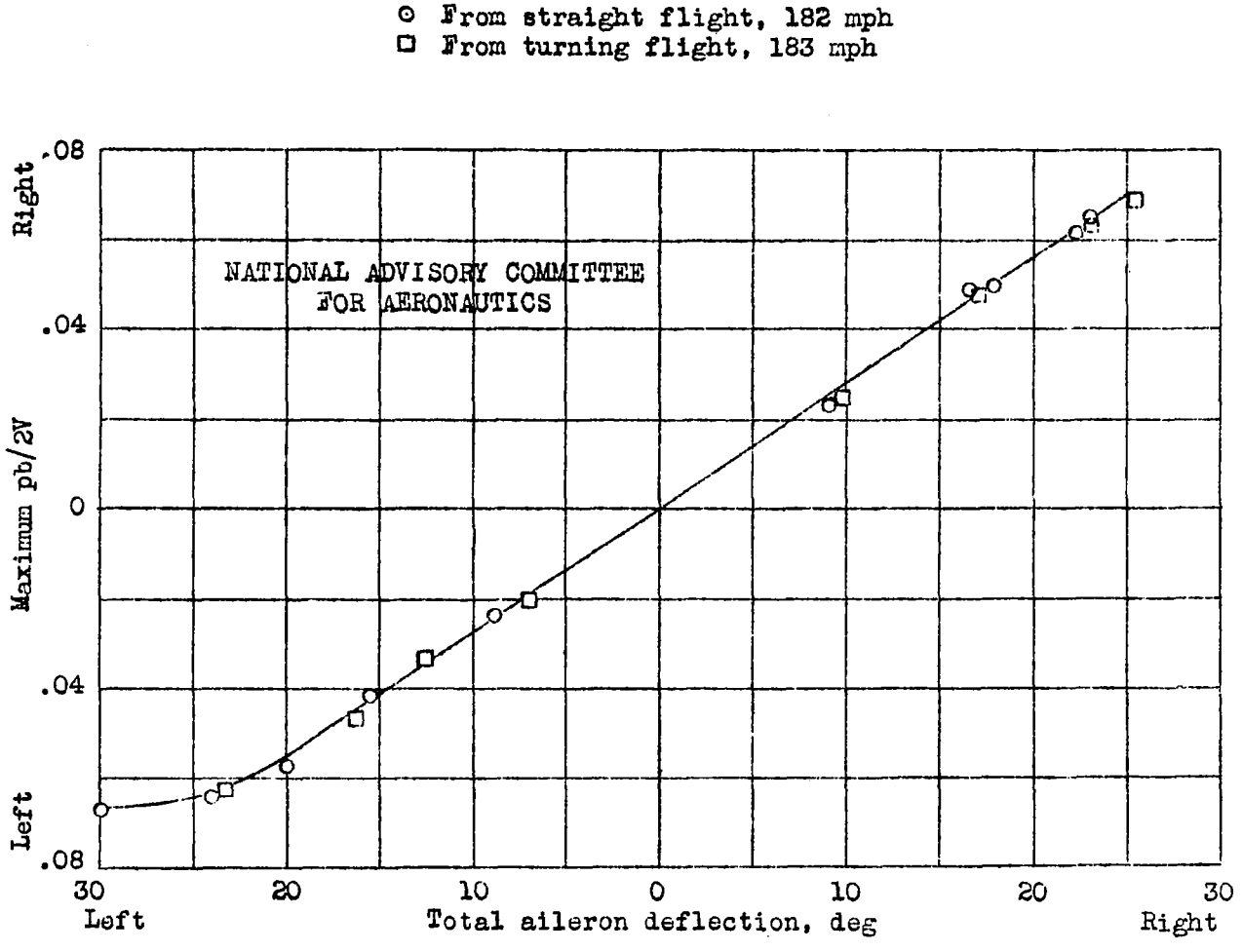
(c) Rolls at high airspeed

Figure 3.- (Concluded). Northrop P-61A airplane.



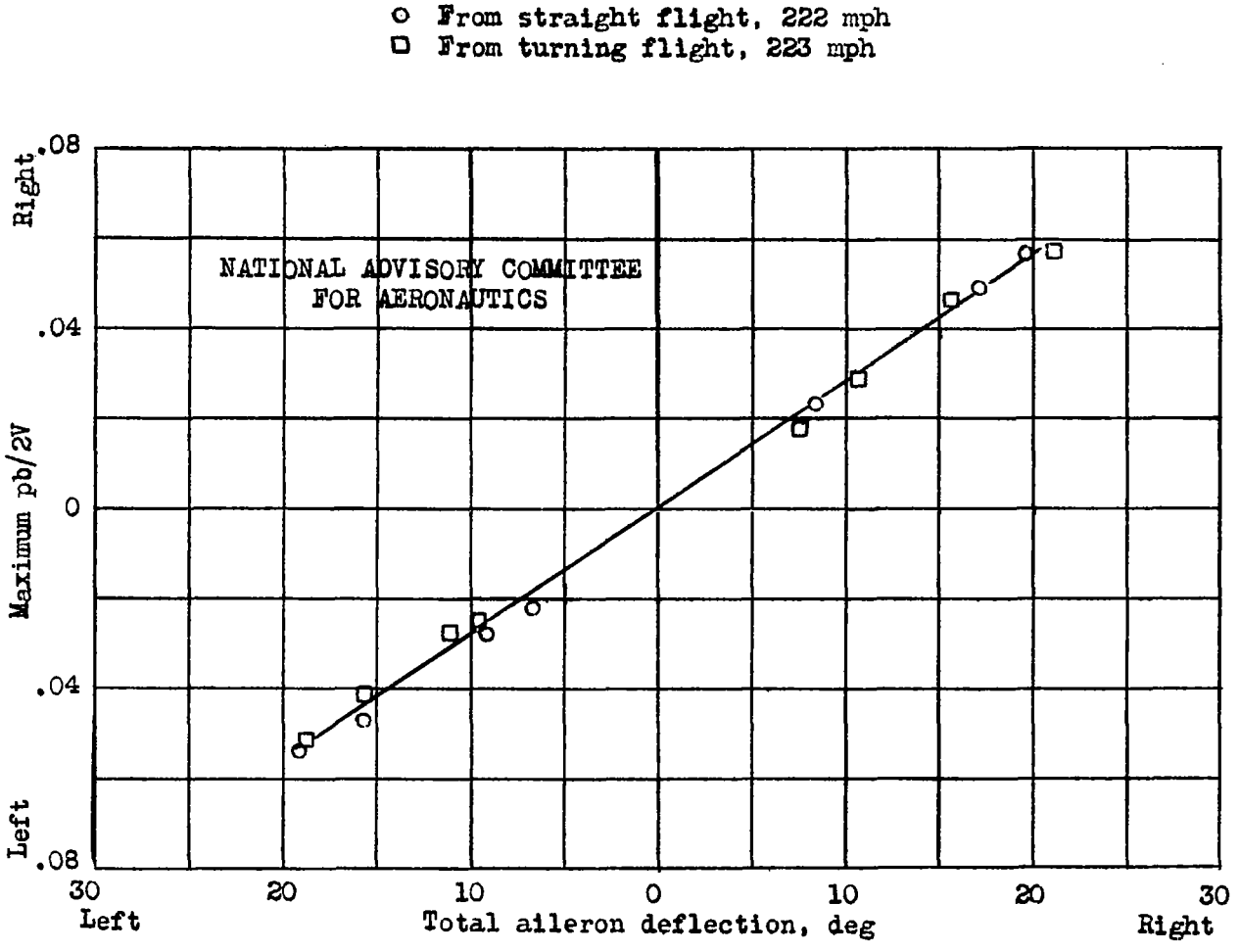
(a) Rolls at low airspeed

Figure 4 (a to c).- Comparison between flight determinations of maximum pb/2V in rudder-fixed aileron rolls from straight, unbanked flight and from steady, turning flight. Clean condition, normal rated power. Lockheed PV-1 airplane.



(b) Rolls at moderate airspeed

Figure 4.- (Continued). Lockheed PV-1 airplane.



(c) Rolls at high airspeed

Figure 4.- (Concluded). Lockheed PV-1 airplane.

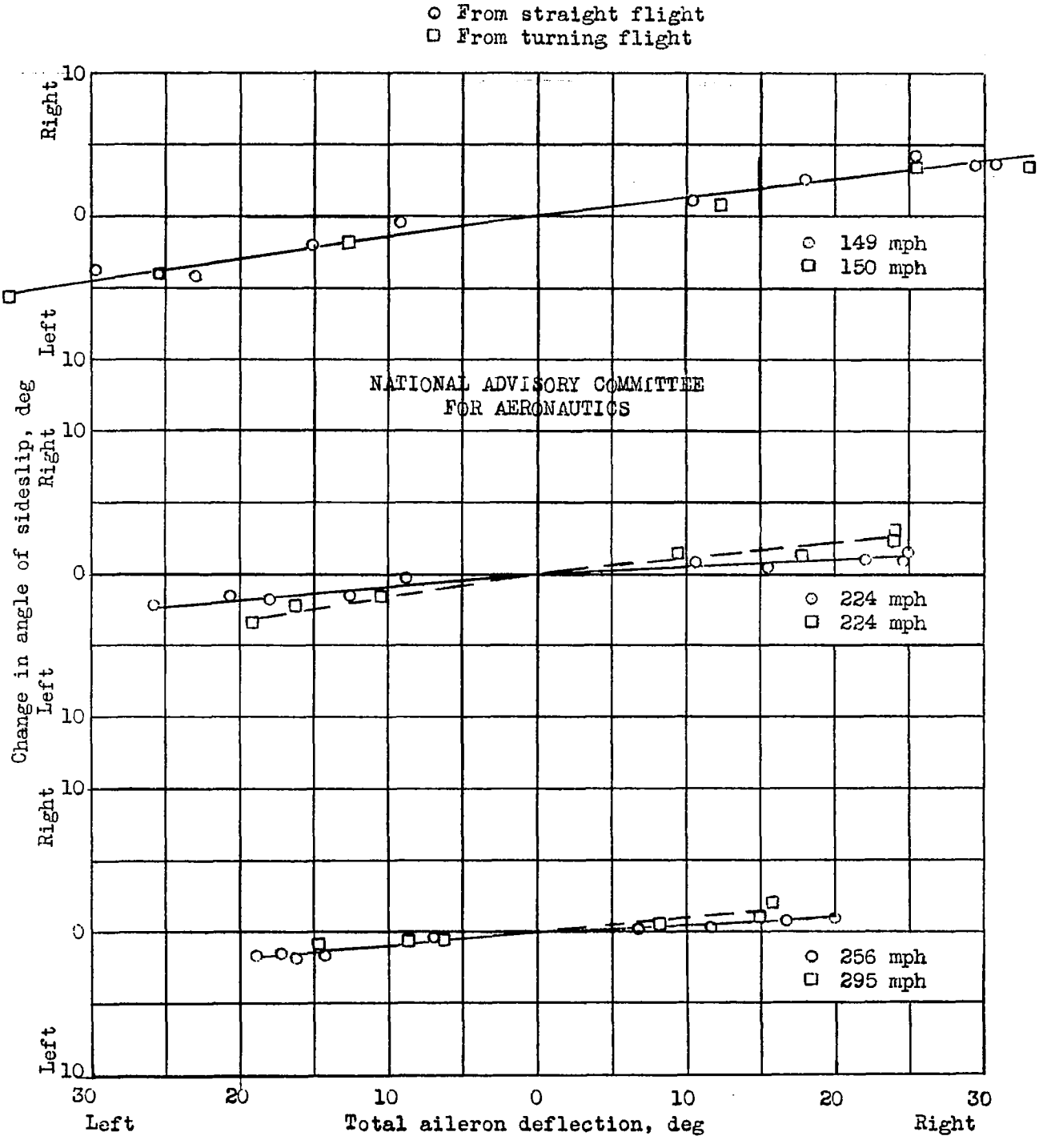


Figure 5.- Comparison between flight determinations of change in sideslip angle corresponding to maximum rolling velocity in rudder-fixed aileron rolls from straight, unbanked flight and from steady, turning flight. Clean condition, power for level flight. Martin B-26B-21 airplane.

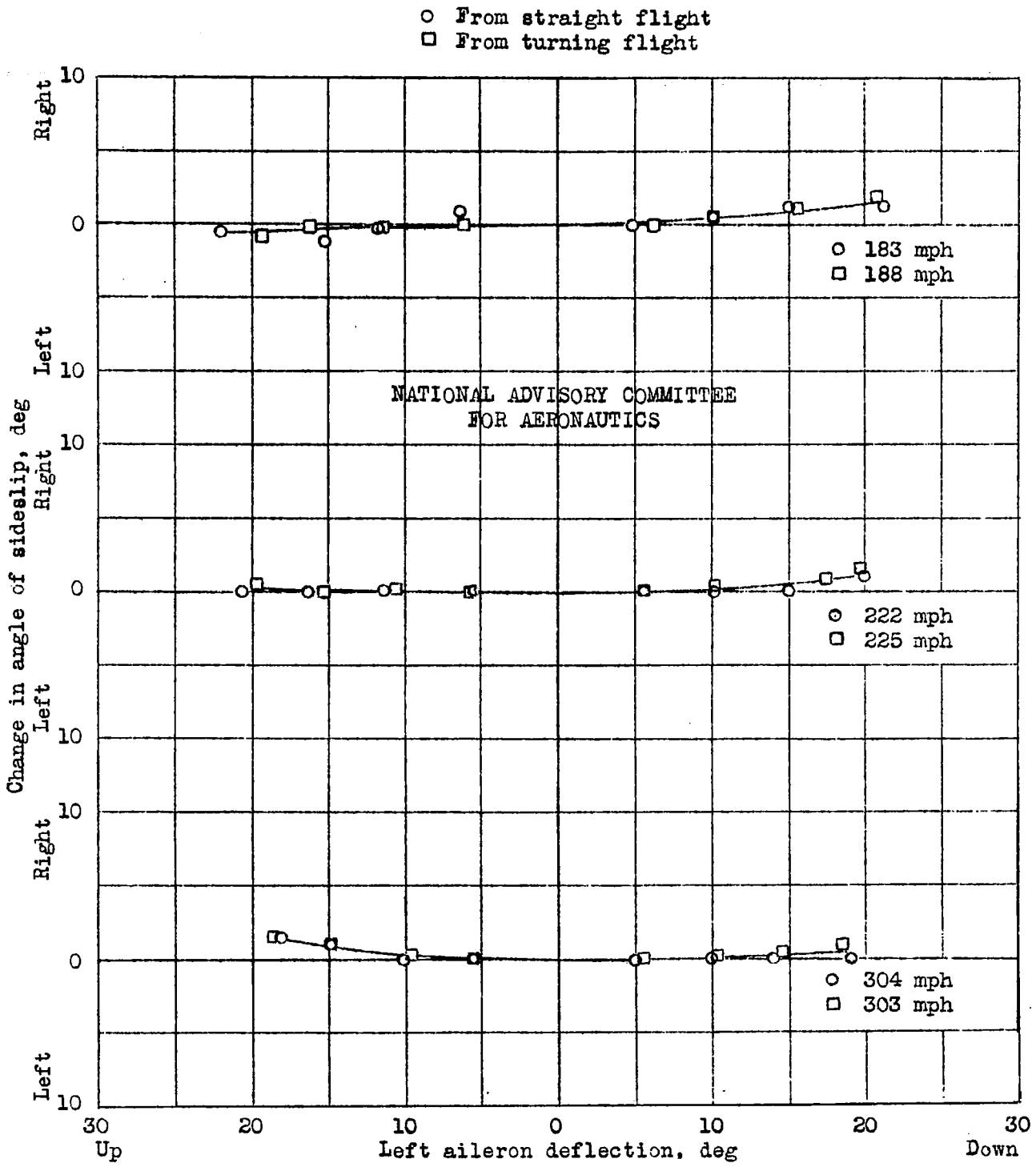


Figure 6.- Comparison between flight determinations of change in sideslip angle corresponding to maximum rolling velocity in rudder-fixed aileron rolls from straight, unbanked flight and from steady, turning flight. Clean condition, normal rated power. Northrop P-61A airplane.

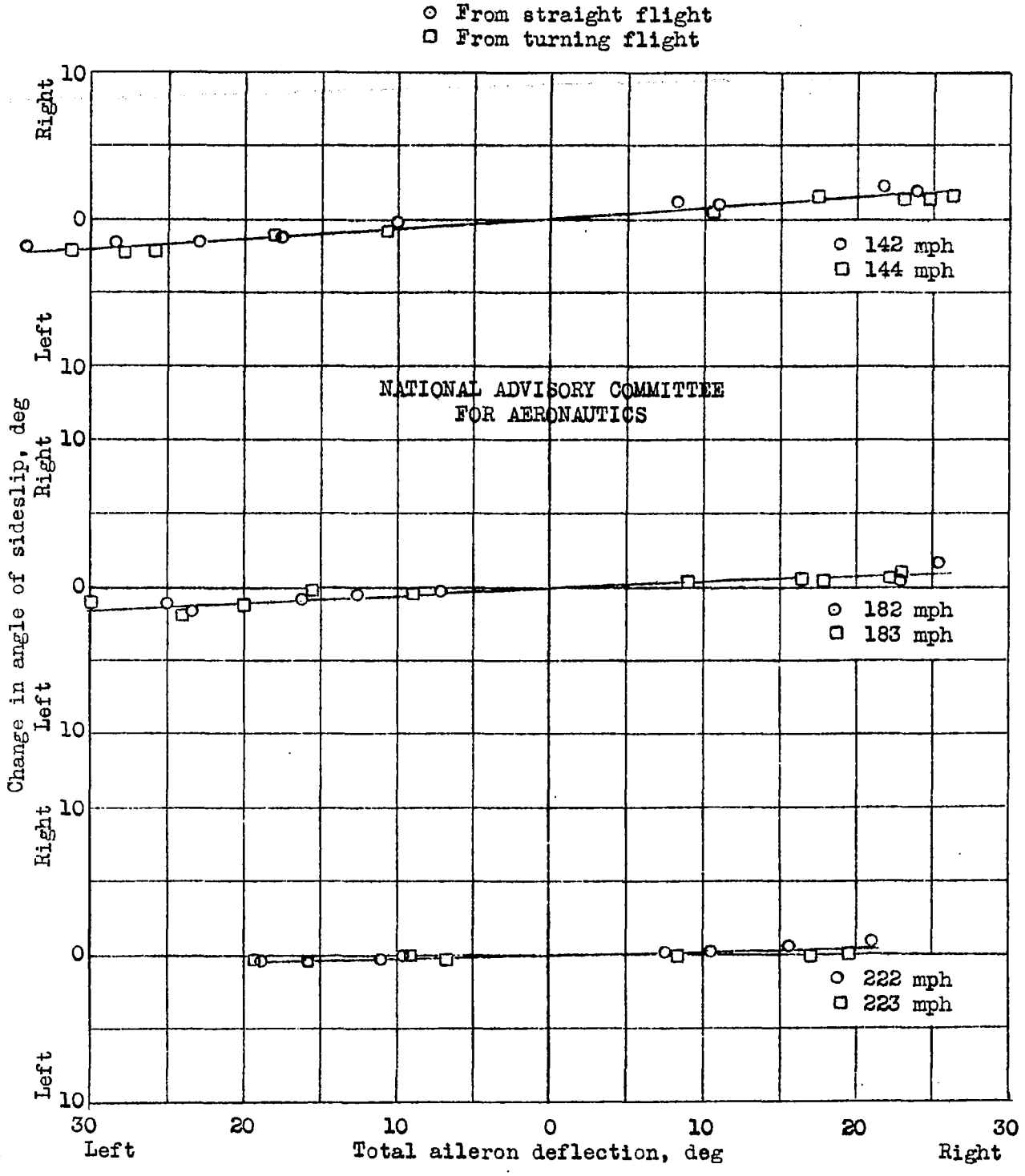


Figure 7.- Comparison between flight determinations of change in sideslip angle corresponding to maximum rolling velocity in rudder-fixed aileron rolls from straight, unbanked flight and from steady, turning flight. Clean condition, normal rated power. Lockheed PV-1 airplane.