NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL MEMORANDUM 1219

THE INFLUENCE OF THE APPLICATION OF POWER DURING SPIN RECOVERY OF MULTIENGINE AIRPLANES

By P. Höhler

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THE INFLUENCE OF THE APPLICATION OF POWER DURING SPIN RECOVERY OF MULTIENGINE AIRPLANES*

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Abstract: The effect of application of power, so far not clarified, is investigated in the present report in order to give the pilot, in addition to the control measures, an expedient for spin recovery of multiengine airplanes. To this end, a series of spins was performed with an airplane of the Go 150 type. It was possible to set up a uniform rule regarding the effect of power, for right and left spins as well as for any combination of the direction of rotation of the propellers.

Outline:

I. INTRODUCTION

A number of recent spin accidents of multiengine airplanes gave cause to investigate the effect of the propeller during spin recovery. The present brief report will show the principal effects of the application of power and illustrate them by the results of a few test flights. Due to the gyroscopic moment of the propeller the effect of application of power will be different for right and left spins. Hence the tests must be performed in both directions, for every engine combination. Due to the centrifugal forces and particularly to the additional gyroscopic moments caused by application of full power, the stress on the suspension of the outer engine may exceed the breaking-load. Thus an airplane of the Go 150 type was chosen for the tests because the engines are located at a small lateral distance from the center of the fuselage and are subjected to small centrifugal accelerations (fig. 1).

*"Einfluss des Gasgebens beim Beenden des Trudelns mehrmotoriger Flugzeuge." Zentrale für wissenschaftliches Berichtswesen der Luftfahrtforschung des Generalluftzeugmeisters (ZWB), Berlin-Adlershof, Forschungsbericht Nr. 1536, February 12, 1942.

II. EFFECT OF THE PROPELLER THRUST AND THE GYROSCOPIC MOMENTS

If power is applied during a spin, the propeller thrust S gives a vertical component S_v which causes an increase in the rate of descent. The centripetally directed component S_h augments the radius of spin since, for reasons of equilibrium, the centrifugal force must increase, and the angular velocity about the spin axis varies only slightly. (See fig. 2.) The moments of the forces are of greater importance than the forces themselves. If both propellers are assumed to be rotating clockwise as is customary for German airplanes, a noseheavy gyroscopic moment arises for right spins, a tailheavy one for left spins. Figure 3 illustrates the sense of direction of the gyroscopic moments. The thrust of the inner engine produces a moment that has a retarding effect on the spinning rotation whereas the thrust of the outer engine produces a moment that excites the rotation. Table I gives a compilation of the effects of application of power for right and left spins. If two opposed effects are superimposed, the influence is uncertain and depends in each case on the data of the airplane.

TABLE Ia

(Clockwise Rotating Engines)

State	Right spin	
full power with:	Effect	Influence
right engine	anti-spin moment, noseheavy	very favorable
left engine	pro-spin moment, noseheavy	uncertain
both engines	noseheavy	slightly favorable

TABLE Ib

(Clockwise Rotating Engines)

State	Left Spin	
full power with:	Effect	Influence
right engine	pro-spin moment, tailheavy	very harmful
left engine	anti-spin moment, tailheavy	uncertain
both engines	tailheavy	slightly harmful

III. PERFORMANCE OF THE TESTS

All test flights were started at an altitude of 2000 meters. The entry into the spin was effected by slowly moving the control stick rearward until the airplane was almost stalled, then pulling the stick back to its limit followed with a simultaneous sudden rudder deflection to obtain the desired spin direction. The rudder was kept in this position until a recovery attempt was made. After a steady state with engines idling had been attained, the throttles were opened wide – according to the combination to be investigated – and the second steady state now arising was awaited. As soon as the latter had set in, several turns were measured. Recovery from spin was made by means of the expedient described in Forschungsbericht Nr. 1100 of the DVL which will be indicated here once more.

1. Sudden full rudder deflection opposed to the direction of rotation; no pressing forward of the stick but yielding to the elevator if it tends to move forward by itself; ailerons in mean position.

2. Immediately after the cessation of the spinning rotation all control surfaces neutralized and a gentle pull-out of the ensuing nose dive effected.

After the control surfaces were moved for recovery the turns for recovery were measured to determine the influence of the propulsing unit in each case. No measuring instruments were installed for this brief investigation. In order to be able to determine the number of turns required for recovery, the spin was made over a characteristic pattern of lines (in the present case over the Oder river). The controls were moved for recovery when the longitudinal axis of the airplane was parallel to the direction of the line fixed relative to the ground. In this manner it was possible to count continually from half-turn to half-turn and to determine the recovery within an angle of approximately 20° with respect to this direction. In order to determine the angular velocity of the steady spin several turns were timed and the corresponding rate of descent ascertained from the loss of altitude occurring during the timing. Of course, this simple test method may be applied only when the pilot has had extensive experience with spins.

IV. RESULTS

With the engines idling the state of spin became steady between the third and fourth turns. The rate of rotation and the rate of descent were measured from the fourth to tenth turns and the recovery was started after the eleventh turn. The spin was rather steep, the angle of attack being approximately 30°. The airflow at the tail was such that the elevator tended to float at its full-up position. The rate of descent with the engines idling was about 25 meters per second. Recovery from spins in either direction required about one turn; therefore the spin behaviour of the Go 150 may be considered absolutely harmless. For the present investigation an airplane with a flatter state of spin would have been more desirable since the recovery would have taken more time, and the difference between the various engine adjustments would have been more clearly marked. In the flights with power application the second steady state was attained after the fifth turn. The rate of rotation and the rate of descent were measured from the sixth to tenth turns and the recovery was started after the eleventh. The results are compiled in table II. Three tests were conducted for each condition listed on table II so that, apart from the preliminary tests for orientation, 24 test flights were performed. Thus every point may be considered sufficiently proved, in spite of the simple test method.

TABLE II

State	Right spin			Left spin		
	Rate of Descent w_s m/sec	Angular Velocity Ω 1/sec	Number of Turns Required for Recovery Δn	Rate of Descent w_s m/sec	Angular Velocity Ω 1/sec	Number of Turns Required for Recovery Δn
engines idling	24.5	3.2	3/4	27	3.1	1
full power with:						
right engine	does not spin			29	3.2	$1\frac{1}{2}$
left engine	26	3.3	1	29	3.2	1
both engines	27	3.2	3/4	30	3.1	1

As anticipated, the effect of the right engine proves to be most favorable for recovery from a right spin. In spite of the rudder being held in the direction of the spin, recovery is made solely by application of power. Just as clearly illustrated is the harmful influence of the outer engine in a left spin.

V. SUMMARY

Summarizing it may be said:

For multiengine airplanes use should be made of the inner engines in any case, for right as well as left spins.

If the propellers turn clockwise, the favorable effect of the inner engines is strongest in right spins. In the case of the Go 150 spinning even becomes impossible when the inboard engine is operated under full power. If the propellers rotate counter-clockwise, the favorable effect of applying power to the inboard engines is most marked in left spins.

For airplanes having propellers that operate in opposite directions such that the right propellers turn clockwise and the left propellers turn counter-clockwise (German type) the favorable influence of the inner engines is equally strong for right and left spins. For airplanes having the right propellers turning counter-clockwise and the left propeller turning clockwise (French type) the effect of operating the inner engines is equally weak for the right and left spins.

The outer engines are to be kept idling since they, first, impair the recovery and, second, could be torn from their suspension when the large centrifugal forces which occur during the spin are combined with the large gyroscopic moments which occur when full power is applied to the engine. Hence it is also undesirable to apply full power to both inboard and outboard engines simultaneously during spins.

Translated by Mary L. Mahler
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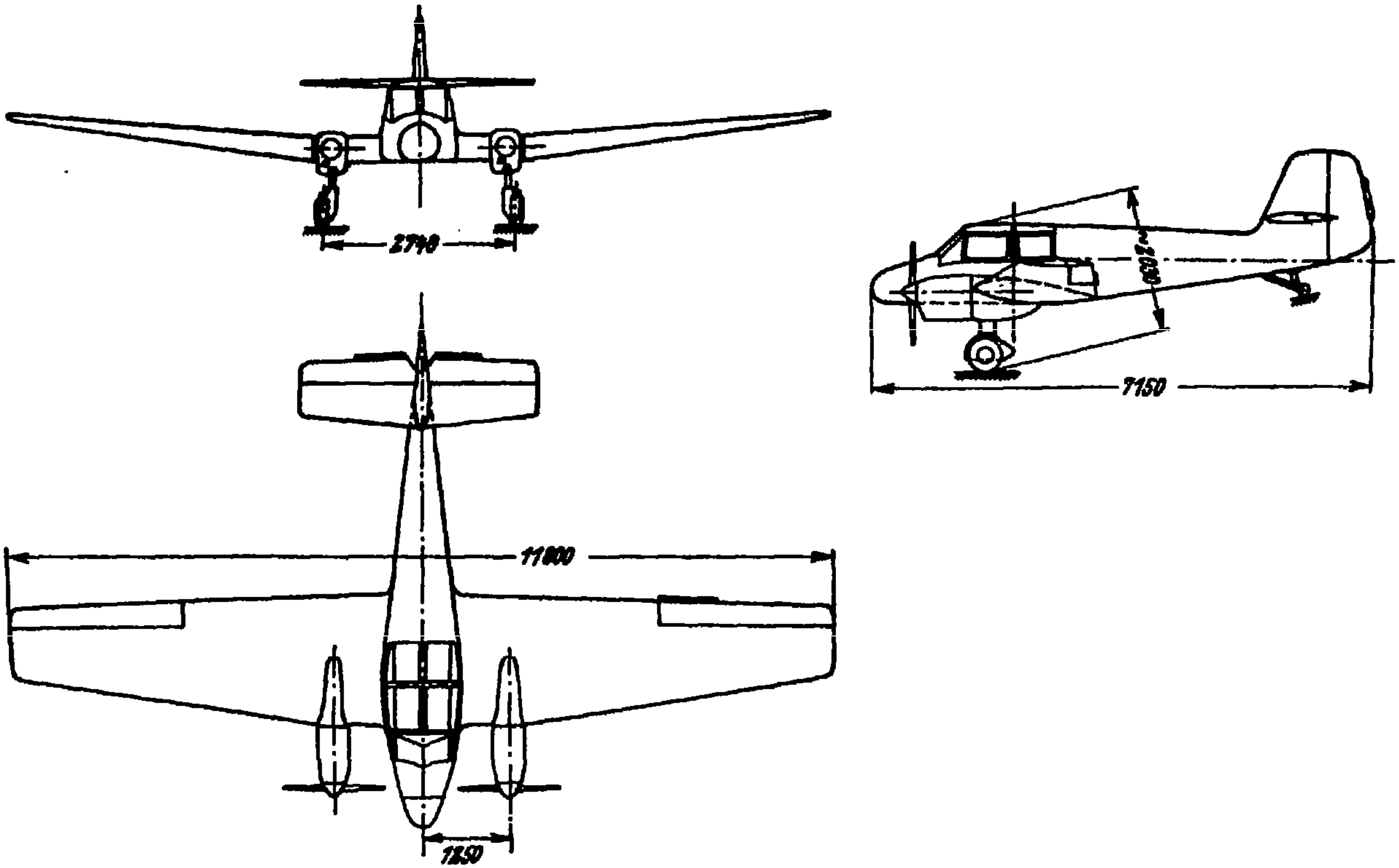

Figure 1.- General arrangement drawing of Go 150 airplane.

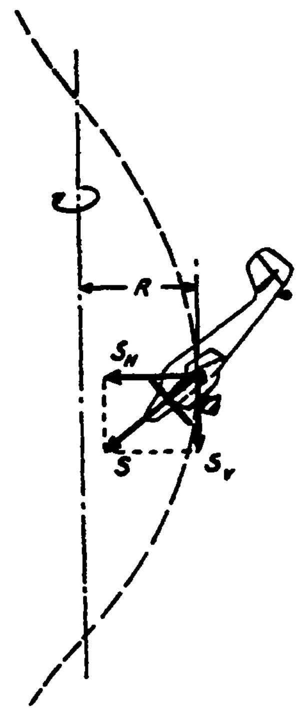

Figure 2.- R radius of spin; S propeller thrust.

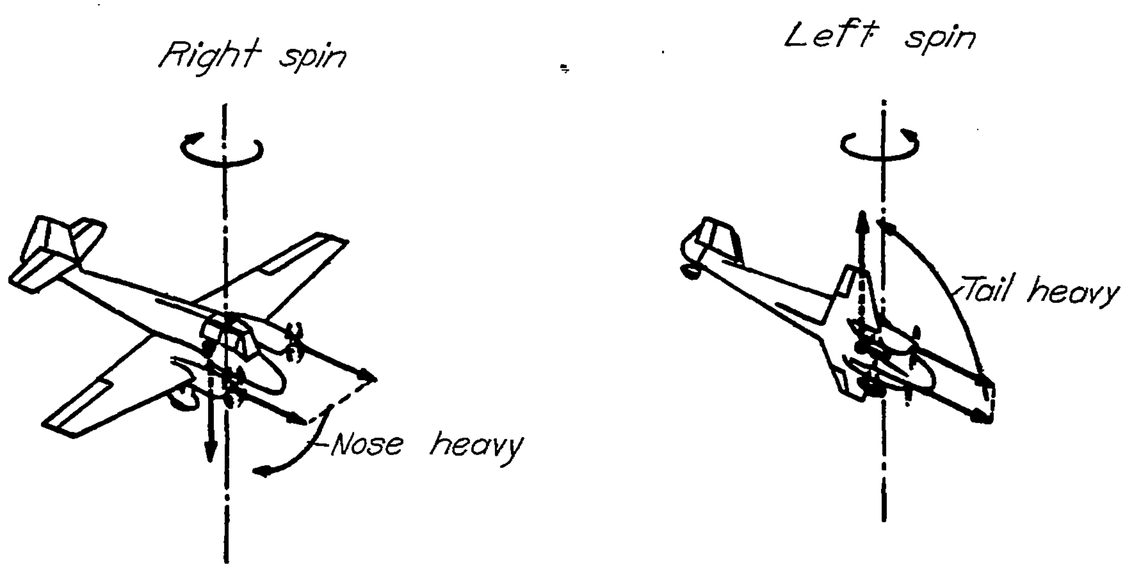

Figure 3.- The rotation vector of both propellers tends to be turned toward the angular-velocity vector of the motion of spin.