PROGRESS REPORT

On the Sailplane Projects of the Engineering Research Station of Mississippi State College

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The year 1950 was a most interesting and fruitful one for the Sailplane Projects. Supplementary researches on the broad program have begun feeding information to the four principle research projects:

a. Laminar boundary layer flow studies.
b. Convective structure in the atmosphere.
c. Automatic yaw control.
d. Bird flight research.

In the laminar boundary layer studies a measurement of the profile drag of the NACA 632-615 airfoil has been made on Dick Johnson's RJ-5 sailplane. It was 0.0088 whereas from wind tunnel data it should have been 0.0056. Divergences as large as 0.2 inches were apparent on the wing contur. Dick Johnson is now rebuilding the wing to higher accuracy striving to gain the additional performance. If the profile drag reaches 0.0056 the RJ-5 will have a maximum glide ratio of 42 to 1.

Even more important to the field of aerodynamics is the fact that in the flight tests on RJ-5 a method was developed whereby the profile drag could be separated from the total drag obtained by the performance measurement. Since the profile drag is a function of lift coefficient its removal from the total drag leaves only the sum of parasite drag and induced drag. Assuming for the time being that the parasite drag be a constant the induced drag is then known as a precise function of lift coefficient. On the RJ-5 the effective aspect ratio was found by means to be equal to the geometric aspect ratio. In other words the wing behaved as though it had an elliptic lift distribution and no measureable intereference between fuselage and wing existed.

A further contribution from the flight tests of RJ-5 resulted when efforts were made to reduce the losses due to air leakage through the spoilerons. When the spoileron slots were sealed to prevent leakage and the spoilerons removed, it was found that the roll controllability was not materially reduced. Now this is an extremely interesting effect and it was realized that it required more study. Here was a relatively heavy wing of considerable inertia being rolled by a total aileron area of only 6 square feet. On a comparable span sailplane, the Weihe, there is an aileron area of 38 square feet, yet the time to roll the Weihe from a bank of —45° to +45° is 6 seconds, identical to the RJ-5 (These rolling times are made at a speed of 20% above the stall.)

Since it was felt that this interesting phenomenon of aileron effectiveness should be studied further, Fred Obarr undertook to determine the effectiveness of only the outboard portions of the ailerons on his Pratt-Read. He was surprised to find that the ship rolled in six seconds and had much lower stick forces at high speed. The research was carried further along by a complete test on the TG-3A sailplane by Fred Obarr and Al Backstrom. With the complete aileron acting (34 square feet) the sailplane rolled in 7 seconds. When only the outboard portions were used (16 square feet) the ship rolled in 6.1 seconds and this with much lower stick forces.

Now it must not be inferred from the foregoing account that this discovery of aileron effectivness improvement with smaller ailerons was accidental. During the time that Dick Johnson was designing the ailerons for the RJ-5 an experimental study of the adverse yaw of the aileron on the TG-4 A sailplane was being carried on with Dick Johnson, Ray Parker and Lou Everett as research pilots. (See Thermal, January 1950). We realized after making a series of measurements of aileron control with various differential ratios from 1.5:1 to 9:1 on the ailerons that it was not possible to remove the adverse yaw while retaining passable stick force gradients. Dick Johnson, therefore, took the initiative on his RJ-5 and determined to eliminate the adverse yaw with spoilerons and as a result the discovery described above was made.

How to explain this anomolous aileron behavior is our next and present problem. Certainly the ordinary flap theory for ailerons is not sufficient to explain the fact that smaller ailerons toward the tip are better than large area ailerons. We must look to the adverse law again for an explanation. For a certain asymmetrical lift distribution as induced by the ailerons a wing possesses a rather large adverse yawing moment. The problem is to find the greatest ratio of rolling moment to yawing moment. The solution to this problem was published by Dr. A. M. Lippisch in the ISTUS of 1938. What we now need to do is to apply this theory to modern sailplane and airplane design.

As a result of this new development in aileron design it will be possible for us to go back to our automatic yaw control research and determine if the modification of the ailerons on the TG-4A sailplane will not permit the simple bellows type of servo to control the yaw on this sailplane. Such a servo was installed in the sailplane and flown with passable results, but unfortunately the adverse yaw of the ailerons introduced a yaw which required the bellows several seconds of time to correct. It was then thought that a stage of amplification would be required between the yaw detector and the servo, but when the adverse yaw is removed or at least reduced to a low value, the simple system may perform correctly.

In the Bird Flight research program previous measurements on the very low drag coefficents of the turkey buzzard and the black buzzard have been confirmed by an independent set of measurements made under better controlled conditions. In addition, the two flight modes of the black buzzard have been separated on the profile drag polar of this bird. By closing his tip slots for cross-country gliding the bird is able to lower his drag coefficient from 0.019 to 0.0057. By the same token the bird is able to increase his effective aspect ratio by opening the tip slots.

The paper "Performance Measurements of a Soaring Bird" covering this work was presented at the Orebro, Sweden meeting of the Organization Scientifique Technical du Vol a' Voile in July. The paper has been published in the English magazine, Gliding, in the Aeronautical Engineering Review, December 1950 and will be published in the OSTIV proceedings.

The profile drag coefficient of the bird is of such a low value that we must accept the fact that the flow over the entire surface of the bird is laminar. If we ask ourselves by what mechanism does the bird (or Nature) achieve such perfect flow control we must