# SYSTEMATIC IMPROVEMENT OF THE DRAG POLAR OF THE SAILPLANE RJ-5

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In July 1948 the author gave a paper "Ultimate Performance Sailplane" (Ref. 1) at a joint meeting of the Institute of the Aeronautical Sciences and the Soaring Society of America in which the basis for low loss sailplanes was laid down. In that paper emphasis was placed on the laminar airfoil as means of reducing the overall drag of a sailplane. During the discussion (Ref. 2) of the paper two schools of thought developed, one claiming that any little protruberance would disturb the fine qualities of the laminar section and the other feeling that the laminar profiles had a best chance of success on a sailplane where there is no noise or vibration to disturb the flow. To the former school belonged aeronautical engineers who had had quite considerable experience on laminar sections on pursuit airplanes. Evidently the resolution of the problem lay in an experimental study of a laminar airfoil on a sailplane. It is the purpose of this paper to present a preliminary report on the behavior of the sailplane RJ-5 which was designed with the laminar profile NACA $63_2$-615

### Description of the Sailplane RJ-5

In May 1948, R. H. Johnson commissioned Harland Ross, well known designer of the outstanding sailplanes, Zanonia and Ibis, to build a high performance sailplane based on characteristics to be jointly decided. At the end of 1949 Johnson brought the unfinished sailplane to Mississippi State College to complete it. The Engineering Research Station, realizing the contribution which the results of this development could make to fine aerodynamics, furnished space and some mechanical and technical help. The major effort on the completion of the craft was made by Johnson himself.

The RJ-5 employs a wing of 55 foot span and an aspect ratio of 24.5. It is made up of the $63_2$-615 profile of constant thickness. The wing tapers from a root chord of 42 inches to a tip of 12 inch chord. A twist of about 1.5 degrees is built into the wing. The area of the wing is 123.5 sq. ft. The structure consists of an aluminum alloy box spar and a closed D - tube leading edge. The after portion of the wing consisted of aluminum ribs covered with cloth and the trailing edge of the wing was fitted with plain flaps and a conventional though small aileron and spoileron. The wing is flush-riveted and was smoothed with glazing putty in order to remove the small amount of waviness existing in the prime metal skin.

The fuselage of RJ-5 is a monocoque structure of mahogany plywood with spruce stringers. It is made of a series of conical developments intersecting at relatively small angles. The nose is carved from a block of balsa in order to get a smooth curved surface approximating an oblate ellipsoid. The landing gear consists of a wood skid suspended on rubber shock absorbers.

The tail surfaces are conventional in all respects. They are of wood cloth covered construction. In one respect, though, the same unique approach, first tried on the Flat Top was used. The mass balance for the elevator was not placed in horns or on arms extending into the airfoil as is usually done but was placed on a level at the center of gravity of the sailplane. This technique gives a definite improvement in control in rough air. It makes for less fatigue on long flights.

The lateral control system also followed an original bent. For years sailplane designers had been using conventional ailerons of rather large proportions (as much as 20% of the wing area). It was felt that an attempt should be made to reduce the rather strong adverse yawing moments experienced on high aspect ratio wings employing conventional ailerons. For this reason Johnson designed a lateral control consisting of a spoiler and a smaller aileron meant only to give feel to the spoiler control.

Johnson also diverged from the classical approach of using spoilers on top of the wing for glide path control in landing. Since he wished to reduce the landing speed and steepen the angle of glide he decided on a dive flap on the bottom of the wing only. In order to reduce pitching moments due to the flap, the flap was hinged at the rear edge of the spar (50% chord). This dive flap also proved very useful during takeoff since the wing was set onto the fuselage at a low angle of incidence in order that the drag at high speeds would be low. This meant that the wing could not develop its maximum lift when the ship rested on its skid and tail skid. However, the application of dive flaps a short time after start of takeoff enabled the sailplane to literally hop into the air.

The total weight of the sailplane empty was 492 pounds. With pilot and parachute the wing loading in flight was 5.4 pounds per square foot.

### Flight Test Procedure

The technique used for determining the total drag coefficient of the sailplane as a function of lift coefficient is based on potential energy loss measurements. In essence the rate of loss of altitude is determined for a series of different forward speeds of the sailplane. This is relatively precise measurement since these exists no disturbance from an engine or propellor. In addition the flights are made just at dawn so that the atmosphere, still labially stratified, contains only slight vertical motions of large dimensions and no turbulence of small scale except within 500 feet of the ground if there is a wind. Usually even the wind is weak at that time.

Instruments used for flight polar measurements with sailplanes consist of a sensitive altimeter and a sensitive airspeed indicator such as used on helicopters. In addition a vibrator made by mounting an unbalanced flywheel on a small motor is used to