Testing Racing Planes

by JIMMY DOOLITTLE

A most interesting account of racing plane tests by one of the most noted racing pilots in the world. An address delivered by Mr. Doolittle before the *Institute of the Aeronautical Sciences.*

INASMUCH as my work for the past three years has been the developing and selling of petroleum products for aviation usage, I am scarcely in a position to deliver a truly up-to-date dissertation on scientific flight testing.

With your indulgence, I will, however, detail a few personal experiences encountered while testing and grooming a modern racing airplane. Since experimental high speed airplanes differ radically in certain phases of design, admitting numerous specific problems peculiar to each of several types; for the sake of brevity, I shall confine this discussion to the recent Laird 400 Racer.

In the mid-part of 1931, the ailerons and a good sized piece of right wing fluttered off my Travel Air "Mystery S" airplane which had just been rebuilt, cleaned up and obviously speeded up. This failure was probably due to the Frieze type ailerons being overbalanced at the higher speed or to flexibility in the aileron control tubes.

The failure of my own airplane made available the new racing plane that was built by Mr. E. M. Laird and financed by the Cleveland Speed Foundation. This little job had a 21 foot span, 108 square feet of wing area, carried 112½ gallons of gasoline, 8 gallons of oil and weighed 1,580 pounds when light and about 2,500 pounds fully loaded. (With the geared engine it weighed about 75 pounds more.)

The first test flight was made from the old Aero Club Field, south of the Chicago Municipal Airport. Laird felt or hoped that the high speed of the airplane would be around 300 m.p.h. The geared Pratt and Whitney Wasp Jr., originally mounted in the airplane, developed 560 h.p. at 2,500 r.p.m. The propeller was 9 feet in diameter and set at 37½ degree pitch at the 42 inch station. Due to the high pitch angle, the ground revs and static thrust were very low.

The airplane ran about a half a mile before it could be pulled into the air and then flew for about two miles more before it picked up sufficent speed to come under complete control. In succeeding flights, the propeller setting was reduced 5 degrees and the takeoff was satisfactory though the engine over-revved somewhat (2,600 r.p.m.) in level flight at full throttle.

THE tail surfaces were identical with those of the last year's racer. The airplane was stable longitudinally and laterally, but extremely unstable directionally. This directional instability increased with speed and the airplane was barely manageable at a speed of 200 m.p.h.

"Jimmy" Doolittle, then a U. S. Army pilot is shown with the U. S. Army racing plane that he flew in the last Schneider trophy race to be held in America. It was this race that brought Doolittle into public view.

This was due to the increased fin area forward, resulting from the longer N. A. C. A. cowl employed with the geared engine, the large pants and the fairing which filled in the space between the front and rear landing gear struts. All of this fin area was forward of the c. g.

The culpability of pants and fairing were proved by removing them and making a flight. The airplane was directionally stable with pants and fairing off. To correct the directional instability, the fin and rudder were increased in height nine inches. Thereafter the airplane was directionally stable, but not as stable laterally as before.

There did not appear to be any appreciable torque resulting from the large propeller and geared engine except an accelerational torque when the throttle was moved quickly.

Although the pilot was sitting on 50 pounds of lead shot, the airplane was so stable longitudinally that it was difficult to get the tail down in landing and the airplane landed very fast. The fast landing tendencies of this airplane were attributable largely to the fact that the tail could not be brought all the way down and advantage taken of the maximum angle of attack when landing, and also the blanketing effect of the large propeller disc on the small wings.

This is indicated by the fact that the airplane, when mounting the direct drive engine and 8 foot propeller, was only slightly lighter but was less stable and landed considerably slower; I should say fully five miles per hour.

In order to ventilate the pilot's cockpit, fresh air was led through a flexible conduit from two holes located in the leading edge of the upper wing. These holes were about three feet from the center line of the wing, located in the slip stream, but well outside the "fume area."

The center of each of these circular holes was somewhat above the center-line of the leading edge and the tops of the holes were aft of the bottoms. In flight the starboard hole blew slightly and the port hole sucked slightly. The efficiency of the ventilating system increased somewhat as the speed increased. The trouble was corrected by putting a scoop on the top of each hole.

The geared engine ran much cooler than the direct-drive. The head temperature averaged from 50 to 75 degrees lower. This appeared to be due to two things. First: The nose of the N. A. C. A. cowl on the geared engine was longer and tended to direct the air over the cylinder heads better than the blunt nosed N. A. C. A. on the direct-drive engine. Second: The geared engine was throwing more oil than the direct-drive engine. This was indicated by greater oil consumption and higher oil temperature in the use of the geared engine.

At a later date, the direct-drive engine was returned to the factory. The bearing clearances were increased so it would "sling" more oil and overheating difficulties were eliminated. The oil consumption was increased from about one quart to three quarts per hour. This increased oil consumption, however, was not a problem as there was ample oil tankage. Using the oil for a cooling medium caused the oil temperature to run too high and it was necessary to cool the oil by directing cold air taken from in front of the engine and over the oil tank.

The fuel used was a straight-run gasoline containing 3 cc's of tetraethyl lead and having a knock rating of 87 octane. For full throttle operation, an 89 octane gasoline, containing 5 cc's of lead was used. This was a safety measure with the 6:1, 10:1 Wasp Jr. as the 87 octane fuel operated satisfactorily.

The 87 octane fuel was probably on the border line as I later flew a 6:1, 12:1 Wasp Sr. and with this engine at full throttle operation, the 87 octane fuel started detonating almost at once and the thermocouple showed a head temperature of over 600° F. With the 89 octane fuel there was no detonation and head temperature was steady at about 520° F. The 87 octane fuel was satisfactory at cruising speed.

THE 400 Racer was extremely temperamental to rig. It seemed impossible to adjust the landing and flying wires so that it would not be wing heavy on one side or the other. On one flight it balanced perfectly for a while and then gradually became left wing heavy.

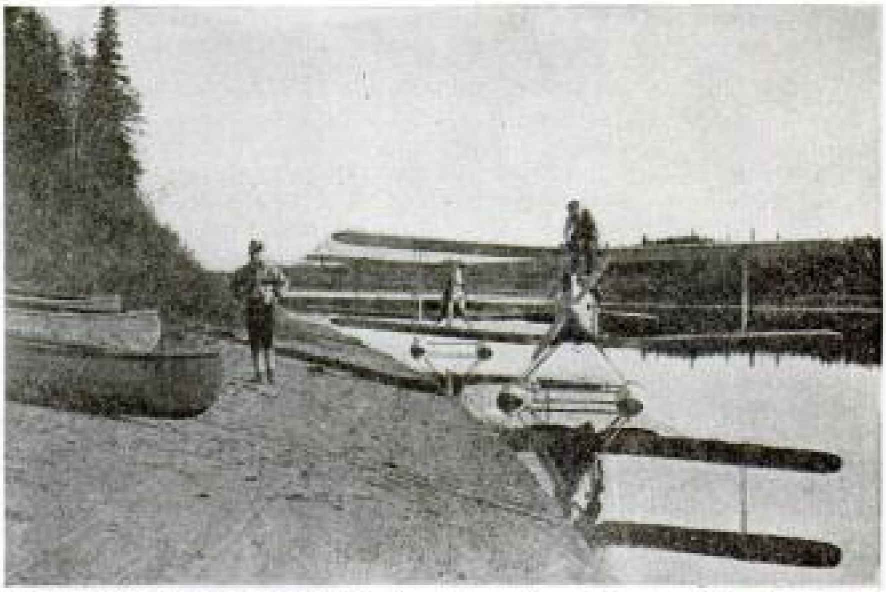
Finally, in desperation, the stick was slapped over hard to lift the left wing and the wing heaviness after leveling off was greatly increased. This gave me an idea. The right wing was depressed and the stick moved sharply to the left. The airplane was then only slightly left wing heavy. The maneuver was repeated and the airplane balanced perfectly. Repeated again and actual right wing heaviness resulted. Here was an airplane that could be rigged in flight!

The difficulty was that it wouldn't hold its rig. This fault became continually and rapidly more apparent and annoying. On one flight, in very rough air, the rigging became so flabby that an actual lateral motion of the trailing edge of the upper wing could be observed when the ailerons were moved and when a bump hit one wing more severely than the other.

Before the flight was completed, it was found impossible to get the airplane out of the left bank at cruising speed without throttling back; so all turns, even around the landing field,

(Continued on page 338)

The Canadian Sky-Cops Patrol Great Areas



Members of the Ontario Provincial Air Service who have dropped down to refuel and swap a few yarns in their leisure moments.

THE accompanying photo shows two "Sky Cops," members of the Ontario Provincial Air Service, who have just dropped down on the Moose River near James Bay at a gas cache on the northernmost boundary of their "beat," to refuel and grab a quiet smoke.

Northern Ontario provides very tricky flying country for seaplanes—and is an utter impossibility for landplanes. Tangled scrub, jagged lava rocks and mile upon mile of heavy forest are some of the hazards.

Plenty of lakes dot the terrain and rivers snake through it, but the pilot must constantly watch his altitude and keep an eye on the proximity of the nearest water. Landings have to be made carefully, for lakes and rivers are infested with "deadheads" or partly submerged logs, the enemies of seaplane floats.

In spite of these handicaps, however, the Ontario Provincial Air Service has gone quietly and efficiently about its work, covering its gigantic beat with a very small percentage of accidents; three serious crackups in the past five years.

Fire spotting, transportation of men and fire-fighting apparatus, photography and game preservation are their chief duties. Up until a few years ago, game preservation did not come under the jurisdiction of the Ontario Provincial Air Service, but it was found to be the most effective means of combatting the canny bushwise fur poachers who invade the Provincial Parks in large numbers every winter. The Flying Wardens swoop down out of a cloudy sky and catch the poacher redhanded.

De Haviland Moths, as pictured, and HS2L flying boats are the types of ships used for this work.

L. A. A. Memberships Grows Slowly but Surely

SLOWLY but steadily, the enrollment of the L. A. A. continues to increase. During the last month, the daily average is about the same so that this gives us renewed confidence in the outcome.

It has taken a lot of plugging, both by our committee-men and ourselves, to make it move along. At the time we go to press with this issue, the total membership is 352 so that we have only 148 members to go.

Here in Illinois, the Governor of the state has revived the aeronautic commission after it was once killed. Landis is no longer on the Illinois Aeronautic Commission, but the board is filled with an altogether different staff that may deal more leniently with the amateur.

We are putting our trust in one of the members who has proved his valor and squareness in the past, Commander Eugene MacDonald, president of the Zenith Radio Corporation and at one time the mainstay of the radio amateur. If he should have his way, there is no doubt but what the amateur in aviation would also get a break.

We have also had very favorable news from the Texas legislature on the subject of amateur aviation laws so that things look bright in that state. Altogether, there are about eight safe and sane states where freedom really reigns. If given the assistance of all the amateurs, it is likely that we can make this a total of 48 states. Let's try and do this, anyway.

All Weather Flying

(Continued from page 290)

and sharp, he tunes from 344 k. c. (Fresno) to 332 k. c., the frequency on which Oakland broadcasts and flies the beam for Oakland.

As he approaches, he understands that stratus clouds overlie Oakland airport, but that he will have a visibility of 10 miles and a thousand-foot ceiling once he gets below them. So it is safe for him to approach the field and come through the clouds.

Following the beam and approaching the field are, perhaps, the most delicate operations of all his navigational problems. Embryo pilots are taught the rudiments of these procedures before they go onto an airline. Carefully following the beam he finally locates the "cone of silence," which is directly over the beam transmitting station. Knowing his relationship to the field and also with the assistance of the field manager at his remote microphone and the two-way radio communication, he is guided to the proper position for descent through the clouds.

END.

Climb

(Continued from page 310)

loaded only with 15 pounds per horsepower will climb faster than another ship loaded with 20 pounds to every horsepower because in the former case, there will be a greater excess of power. Fast military pursuit ships, which must have a very rapid rate of climb in order to out-maneuver enemy planes, have a very low power loading.

But we must not confuse "steepness" of climb with "rapidity" of climb. A ship can ascend along a steep slanting path and yet not have the climbing rate of another ship that can only ascend along a flatter path. A steep climb, rather than a rapid climb is required of commercial planes that must clear obstacles quickly when taking off from a small field.

Steep climb calls for a low wing loading, or a small weight per square foot of wing surface in addition to a good power reserve. This is contrary to the case of the fast climbing military machine which has both a high power loading and a high wing loading.

As a rule, the steepest climb is had at a horizontal speed that is somewhat less than the optimum speed at which the best rate of climb is had. The angle of attack for the steep climb will be greater than that for the most rapid climb, which of course means a lower forward speed. The steep climb is assisted by the use of wing slots and flaps, or most any other factor that will improve the lift coefficient of the wing although the excess power is less than for the best rate of climb.

There is an approximate formula for the best rate of climb which is based upon the top and stalling speeds. This is as follows:

$$\text{Best climbing speed (m.p.h.)} = C - S \text{ plus } \frac{M - S}{3}$$

Where S = stalling speed. M = Top speed. C = Best climbing rate. This agrees very well with the previous examples given in the graph where this particular ship has a stalling speed of 30 m.p.h. and a top speed of 120 m.p.h. Thus:

$$\text{Best climbing speed} = 30 \text{ plus } \frac{(120-30)}{3}$$

$$= 30 \text{ plus } 30 = 60 \text{ m.p.h.}$$

(Concluded on page 345)

Testing Racers

(Continued from page 292)

were made to the right. In this airplane the main wing truss was incomplete. The auxiliary wing truss had depended upon a fitting around the center of the continuous rear spar in the upper wing to take unevenly distributed wing loads. A careful inspection showed that the spar had crushed at this point and the bolt holes had elongated.

As a temporary expedient, an eighth inch thick piece of sheet steel was driven between the fitting and the spar to take up the play. This corrected the trouble temporarily, but after a few hours' flying it again appeared due to further crushing of the spar.

The incomplete wing trussing, mentioned above, explains a difficulty experienced when running the 3 km. speed trials. The airplane was clocked at 255 m.p.h. with the direct drive engine Up to 240 m.p.h. no trouble was experienced, but above this speed a tendency to turn to the left and difficulty in removing the airplane from a left bank was observed. A right bank at full throttle gave very little trouble.

The direct drive engine was removed and the 3.2 geared engine installed. The air-speed indicator showed about eight miles per hour more speed with this engine. There was a very strong tendency to roll to the left. The airplane was then rigged very right wing heavy in order to correct this tendency at full throttle, but it is doubtful if it could be handled in a race.

The course was flown in practice for a few laps at 240 m.p.h., then the throttle was gradually opened until wide. A team mate on the ground was instructed to watch until I rocked my wings and then to time the next lap as it would be the only one at full throttle.

Coming down the home stretch, I rocked the stick laterally but the rolling motion of the airplane was so slight that I was afraid my ground observer would not be able to notice it. The 10 mile course in 1931 was an irregular pentagon. The first two pylons were executed successfully but at the third, where the angle was sharper, the left wing would not come up and I was unable to recover from the bank until after overturning. Rolled in to a steep right bank to get back on the course and had difficulty getting out of the right.

Banked to the left of No. 4 pylon. The bank increased even with controls reversed and it was necessary to throttle to regain control of the airplane. Obviously the geared engine could not be used in the Thompson Trophy Race. Not because of any torque difficulties but because wing warping at high speeds induced the aileron reversal. This condition became critical at about 260 m.p.h.

In order to check the speed of the airplane with "geared-versus-direct-drive-engine," an attempt was made to fly the 3 km. course. On the first run the airplane gradually rolled to the left until out of control. Throttled and tried again. This time entered the course with the right wing down about 30°. After about 1 km., the airplane was level and at the 2 k. mark the left wing was down some 30° and depressing rapidly.

I throttled and landed, unable to make even one run across the 3km. speed course. It would have been possible to make runs at say 220 m/h and 250 m/h, note the corresponding R. P. M.'s; plot air-speed versus R. P. M. and, knowing that the maximum level flight R. P. M. was 2600, produce the curve and obtain the high speed.

HOWEVER, the Thompson Trophy Race was scheduled for the next day and flights previously made indicated that the direct drive engine could surely be handled, though sloppily, on the course. The engines were changed over night and the morning of race day spent trying to rig the airplane.

The difficulty experienced in test flights and in the race itself indicated that something was loosening up and that the wing warping tendencies were rapidly becoming worse. The airplane was finally rigged very right-wing-heavy to facilitate getting out of left banks and entered in the race. It was forced down in the seventh lap due to overheating and piston failure.

Had we been able to use the cooler running geared engine; had the wing trussing been complete, or the center rear cabane fitting more secure so the wings couldn't warp; had we known as much then as we know now, none of these difficulties would have arisen; but that is experience. The main difficulties in this airplane were:

1. Engine overheating.
2. Wing warping.
3. Poor vision (a. when flying, b. when landing).
4. Insufficient gasoline capacity.
5. Poor takeoff characteristics.
6. Excessive longitudinal stability.
7. It was too slow.
8. Poor cockpit ventilation.

In the 1932 400 Racer these inherent defect were corrected as follows:

1. A longer sharper nose was put on cowling. The engine was adjusted to throw more oil and the oil tank was air cooled.
2. Wing trussing was redesigned and made complete.
3. The pilot was raised 10 inches so he could see over the upper wing. A slide door was arranged in cockpit covering so pilot could stick his head and shoulders out and see ahead when landing.
4. To increase gas capacity, the fuselage was fattened out near the c. g. without decreasing fineness ratio or streamlining.
5. A controllable pitch propeller greatly improved take-off characteristics.
6. The c. g. was moved aft to correct the excessive longitudinal stability.
7. A retractable landing gear was designed and incorporated to increase speed.
8. The cockpit ventilation intake holes were put exactly on the center line of the leading edge.

It seemed that we had corrected all faults in the original design and the first test flight of the redesigned airplane tended to prove our belief correct until time came to land. Then a new problem arose. The landing gear, in ground tests, dropped all the way out and then was spread and locked into place.

In actual flight, the air loads and the rotation of the slip stream spread the gear before it had dropped out, locked it in an intermediate position and it was necessary to make the first landing on the bottom of the fuselage without landing gear. This was corrected by means of a rubber shock cord which held the wheels together until the telescoping struts were fully extended.

In later flights, it was found that the tail fluttered badly when gliding in slowly for a landing. The exact reason for this has not, as yet, been determined, but an effort is now being made to correct it through the use of larger rear fillet between the lower wing and the fuselage. It may or may not work.

There is no work as intensely interesting as testing and improving high speed airplanes. Not even air racing. But I have yet to hear of the first case of anyone engaged in this work dying of old age.

END.