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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 423

LINDBERGH'S FLIGHT

By August Von Parseval

From "Motorwagen," May 31, 1927

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LINDBERGH'S FLIGHT.*

By August Von Parseval.

"What does man call great? To what responds his awe-struck soul in the oft-repeated tale, but the boldness of the hero in the face of fearful odds?"

(Goethe)

Aviation is the favorite child of modern time. It is promoted by a technical idealism, which receives its inspiration from difficulties and dangers and has little regard for sacrifices and losses. Many and grievous are its disappointments. When, however, a great and brilliant exploit is accomplished, then enthusiasm blazes forth and the whole world, which has become so small (oh, so small!), acclaims the hero. Lindbergh, the American, comes of hardy Swedish ancestry. In 1897 his kinsman Andree made a foolhardy and ill-fated attempt to fly over the North Pole in a free balloon, an exploit which was accomplished much later, in 1926, by the Norwegian Amundsen with a dirigible airship. Andree was never heard from again, but others have continually pressed to the front, eager for fame and honor. The airplane seemed compelled to halt at the

*From "Motorwagen," May 31, 1927, pp. 347-349.

shores of the ocean. It appeared impossible to fly across the vast wastes of water, but danger stimulated desire. The first attempt brought death to the venturesome aviators, but another, unafraid, immediately stepped into the gap. Lindbergh brought to the dangerous task qualifications which gave him an advantage over the others: his youthful nerves of steel, his skill and coolness which did not desert him in critical moments, and that sixth "sense of the air" (the sense of equilibrium and an instinctive sense of direction), which is possessed by only a few. He ventured upon the long and dangerous flight in a small Ryan monoplane. He was all alone and without a helper. To be sure, he had, in several respects, more favorable conditions than his European competitors. For him the most difficult part, the way through the cloud banks of Newfoundland, came at the beginning of his journey, instead of the end, and then he could hope to be materially aided by the west wind which almost always prevails on this course. A long preliminary flight familiarized him with his new airplane, a high-wing monoplane with a dihedral shape, small and easy to control. It is not, therefore, a modern giant airplane, to which has fallen the honor of the first ocean crossing, but a small gnat of only eleven meters span. The whole world knows that Lindbergh took off from Roosevelt Field in New York on May 20, at seven o'clock in the morning, American time, and landed at Le Bourget, Paris, on May 21, at 10:22 p.m., after a flight of 33 hours and 47 minutes, thereby making a new distance record. Aside from the purely human aspect, concerning which so much has been published in all the newspapers, we are especially interested in the technical aspects of the undertaking. The route chosen was the shortest possible, namely, the arc of a great circle on the surface of the earth, which passes across Newfoundland and the ocean to France. In the clouds the aviator deviated somewhat to the north of this course, so that he passed over Ireland and England on his way to France. This deviation, however, was not important.

The great difficulty in such a long flight is the carrying of sufficient fuel. This necessitates a very great carrying capacity combined with the smallest possible rate of fuel consumption.

If it be assumed that the mean drag W of the airplane is known, then this drag had to be overcome for the flight distance S of about 6000 kilometers, i.e., the work $A = WS$.

The question now arises as to how much fuel this work requires. This may be determined as follows: One horsepower, i.e., 270,000 kgm = 0.27 km/ton, requires 0.25 kg of fuel and oil. Hence a kilometer-ton K = 0.926 kg or 0.000926 metric ton, i.e., 0.926 kg of gasoline is required to raise a load of one ton one kilometer. The effective power WS must now be divided by the propeller efficiency η. For the fuel consumption, we then obtain the formula

$$B = 0.000926 \times \frac{SW}{\eta} \text{ tons},$$

in which S represents kilometers and W stands for tons.

We will put the propeller efficiency η at the now generally assumed value of 0.666. In the formula, therefore, only W and B are unknown. The speed of the airplane does not appear in the formula and, since the remaining values are fixed, the solution of the problem depends on making the drag of the airplane very small. It does not depend primarily, as many erroneously believe, on a high absolute speed, but on the economical speed, and all the more in the present instance, due to the prevailing west or following wind. The economical speed depends on the wing loading and the structural drag. It is increased by increasing the former and by diminishing the latter. In the case under consideration the economical speed must have been at first over 180 km (112 miles) per hour and subsequently about 140 km (87 miles).

According to the data in my possession, the airplane had a 200 HP. engine and a span of 11 meters (36.1 feet). The wing area was accordingly about 25 m² (269.1 sq.ft.). According to reports, the fuel load was 2500 liters or 1750 kg (3858 lb.), of which there remained after the flight about 500 liters or 350 kg (771.6 lb.). Therefore, about 1400 kg (3086 lb.) of gasoline was consumed during the flight. The empty weight of the airplane with the pilot and the necessary reinforcements for the heavy loading may be put at 700 kg (1543 lb.). This gives a take-off weight of 2450 kg (5401 lb.) and a landing weight of 1050 kg (2315 lb.). Hence the wing loading was 100 kg/m² (20.5 lb./sq.ft.) on taking off and 42 kg/m² (8.6 lb./sq.ft.) on landing.

The take-off speed is computed at 50 m/sec (164 ft./sec.) and with a propeller efficiency of 0.666 the power of the engine would not have sufficed to leave the ground. Presumably, the airplane had an over-dimensioned engine which developed considerably more than 200 HP. at the start.

With every minute of flight, however, the airplane at first lost more than one kilogram in weight, thus rapidly increasing its flight capacity. Therefore, the pilot, by diminishing the angle of attack, was soon able to reduce the drag and consequently the fuel consumption.

From the available data, a formula can now be developed for the weight and drag during the flight. The fuel consumption equals the loss in weight

$$dB = - dG$$

and

$$dB = \frac{G \epsilon K}{\eta} dx$$

in which G is the variable airplane weight, ϵ the drag expressed in % of the weight, K the fuel coefficient 0.00093, and x the distance flown at the time.

Hence the formula says that the fuel consumed at the time is equal to the drag of the airplane $(G \epsilon)$ multiplied by the distance flown (dx), times the fuel coefficient K. Accordingingly

$$l \frac{G}{G_o} = - x \frac{K \epsilon}{\eta}$$

$$\epsilon = - \frac{\eta}{x K} l \frac{G}{G_o}$$

This means that the take-off weight was 2.45 tons (metric) (5401 lb.). If we substitute for G the landing weight of 1.05 tons (2315 lb.), for the total distance flown, 6000 km (3728 miles), and for $\eta = 0.66$, we obtain $\epsilon = 0.1$.

According to this computation, the air resistance or drag of the airplane would amount to about 10% of its own weight, which would seem quite possible from the pictures, for the struts and landing gear are necessarily large with relation to the small wing area. With a larger wing area the lift-drag ratio ϵ could probably be still further improved.

The mean speed of the airplane was 6000/33.75 = 178 km (110.6 miles) per hour. Presumably the airplane had a following wind, for a west wind is the rule on this course. This is very important. If we assume, e.g., that the following wind had a velocity of 20 km (12 miles) per hour (a very moderate wind), then, without it, the flight would have lasted 38 hours. If, however, there had been a head wind of 20 km/hr, the flight would have required 43.5 hours. As a rule, one making the flight in the opposite direction would find himself in the latter case. In this case Lindbergh's fuel supply would have been insufficient, like that of the unfortunate Nungesser.

The actual engine power can be computed from the fuel consumption as follows. In order to raise one ton one kilometer, 0.926 kg (=K) of fuel is required. With one kilogram of fuel, therefore, a power of 1/K is developed. Hence the effective horsepower, with the quantity of fuel B and the propeller efficiency η, is

$$L = \frac{B\eta}{K} = \frac{1400 \times 0.666}{0.926} = 1008 \text{ km-tons.}$$

The mean drag of the airplane is then

$$W = \frac{L}{x_{max}} = \frac{1008}{6000} = 0.168 \text{ t} = \begin{array}{c}168 \text{ kg} \\ (370.4 \text{ lb.})\end{array}$$

and its mean weight is 1680 kg (3704 lb.). The arithmetical mean of the take-off and landing weights is 1750 kg (3858 lb.). The discrepancy is due to the fact that the curve of the actual weight, as plotted for the whole flight, is not a straight line, but lies throughout below the straight line. The mean horsepower was accordingly

$$1400/33.75 = 41.5 \text{ kg/hr} = 166 \text{ HP.}$$

These figures probably furnish an approximate picture of what took place. A more accurate presentation would be possible only on the basis of data supplied by the builders of the airplane. The total weight and the horsepower must, however, be quite near the values given above.

We will now consider the technical and practical significance of the flight, which is very great. Of course, it can not be assumed that we will all, like Colonel Lindbergh, soon be flying over the ocean in 34 hours, even though we have the money to pay for it. Such a remarkable exploit can not be repeated daily. The vehicle consisted of a powerful engine, an enormous fuel tank and a small man on a small seat, together with a small wing and tail - in short, a flying fuel tank. Everything possible was left off, including floats and radio apparatus, in favor of fuel, and without favorable weather the flight even then would have failed. A race-horse can cover a kilometer once in 3/4 minute. An ordinary rider can not, however, on this account attain such a speed, and neither can Lindbergh's exploit be repeated with a "normal airplane." What then has this flight demonstrated? It has demonstrated that a small airplane can carry a heavy load, amounting in this case to more than twice its empty weight. Even though half of this load must be utilized on a commercial airplane for safety and comfort, considerable improvement in this direction will still remain. This flight has also indicated the direction in which progress must be made. The small airplane could surely be built even more efficiently for such a flight, and here the sporting activity must come in. Two chief obstacles to economy, namely, fuel consumption and landing costs, must be substantially reduced by making the stages longer and the landings fewer. In this connection, the maximum speed assumes a role quite subordinate to the economical speed, and it is the pilot's task to maintain the correct economical speed, whereby not only the characteristics of the airplane but also the wind conditions must be taken into consideration. If one has a following wind, he must choose the speed at which the fuel consumption is least. With a head wind the speed should be so chosen that the ratio $\frac{B}{v+w}$ (in which w represents the velocity of the wind) will be a minimum. It is not possible for one person in an airplane to do this, but in large airplanes it is an extremely interesting sport, which promises important results for the art of flying.

What enthuses us in Lindbergh's deed, however, is not alone his skill, nor even his endurance and tenacity, but most of all the courage with which he plunged into the undertaking with certain death confronting him, if his engine should fail him over the ocean or if, as the result of a strong contrary wind, his fuel supply should prove insufficient. But fortune favors the brave and here fortune smiled on the brave and the skilled, with his excellent airplane and remarkable engine. We wish the victor many more successes and hope, above all, that, even in triumph, he may not lose the necessary prudence and plunge to destruction through overweening boldness.

Translation by Dwight M. Miner,
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