"THE ARCHÆOPTERYX."

BY R. F. T. GRANGER.

(This is a story of a gallant effort of two amateurs to produce a light tailless aeroplane. Its performance is praiseworthy, especially with an engine of such low horse-power.)

THE origin of the "Archæopteryx" was in the determination of my brother John and myself to learn to fly at a time when flying clubs were not in existence, and the tuition available far beyond our means.

Between 1922 and 1926 we experimented with gliders which we built ourselves, and made a few hops with them. Our last glider was fitted with a small engine, which lacked power to get the machine off the ground, so we had to tow it off with an incredibly ancient car and 100 yards of clothes line. Everything went flat out, and once the "aeroplane" was off, the car dashed for safety as best it could, while a long, flat flight was made, losing height all the time, till a landing was made at full throttle.

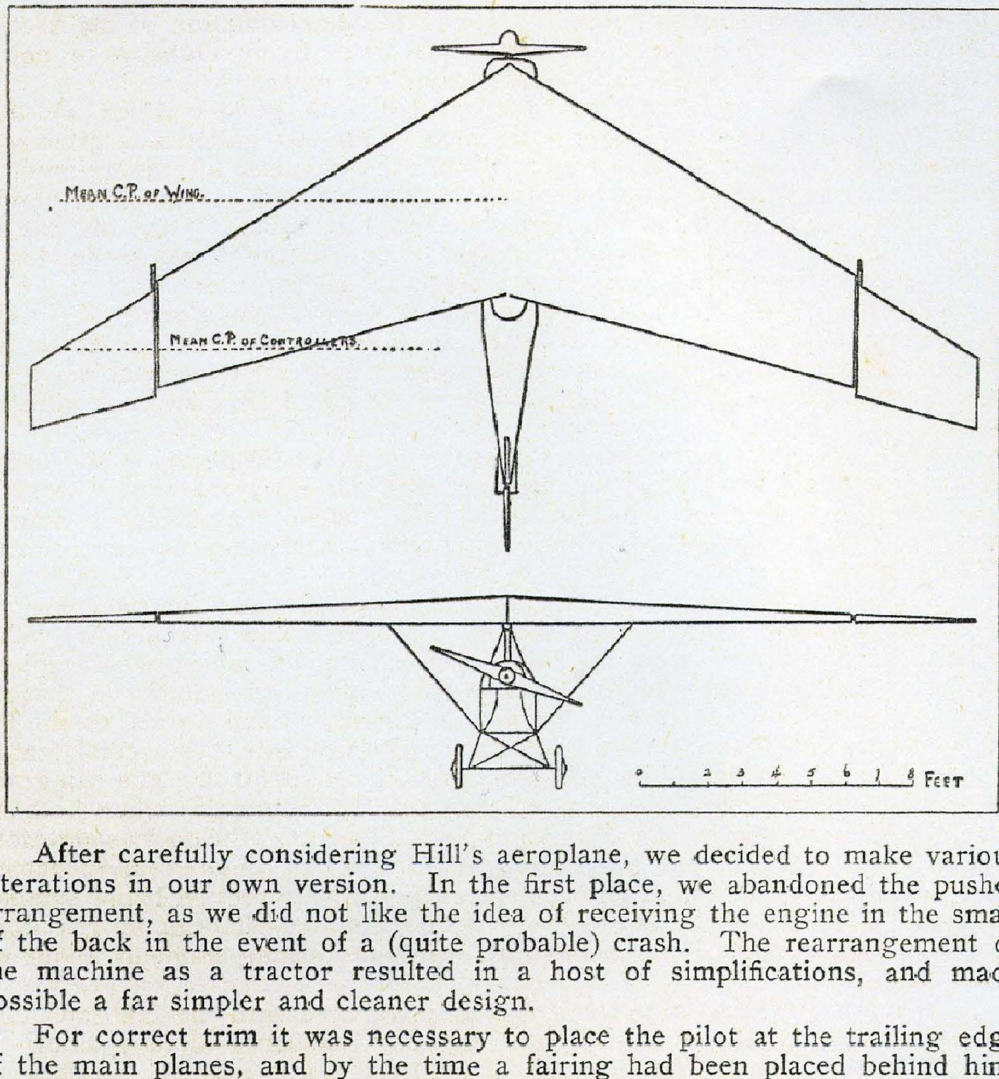
This work prepared us for more serious efforts, and after seeing Capt. Hill's Pterodactyl perform at Hendon in 1926, we decided to set to and build a machine on similar lines. Before describing our own machine, I will give a brief outline of the essential features of the Pterodactyl on which it is based.

In the first place, the centre of pressure on the main planes is stationary. This not only aids stability, but also relieves the elevators of the work of restoring the C.P. to its position on the C.G. when the incidence changes during gusts or manœuvres. This is of great assistance to control near stalling speed.

In the Pterodactyl the stationary C.P. was obtained by sweeping the wings back and washing out the incidence progressively to the tips. When it was designed there were no wing sections known which would give a stationary C.P. The sweep back of the wings also aids stability in that the lifting part of the wing, instead of lying on a narrow band normal to the line of flight, extends over a considerable area in this plane. A second feature is the peculiar nature of the elevator and aileron control. The wing tips from about 70 per cent. of the span outwards are rotatable; when both are moved together, owing to their position behind the C.G., they act as elevators, and when moved differentially act as ailerons. This differential movement does not affect the fore and aft trim since the wing-tip section being symmetrical the up pressure on one side is exactly counter-balanced by the down pressure on the other, and there is no resultant turning moment about the transverse axis.

Provided that the aeroplane is correctly trimmed with the C.P. and C.G. coinciding, these wing tips always lie at "0°" incidence directly along the line of flight, whatever the incidence of the main planes may be. If they are moved to a fresh angle during flight, their sole work (the C.P. being stationary) is to overcome the inertia of the machine, and having done this lie again at zero lift along the line of flight, with the main planes at the new incidence—as determined by the pilot.

The result of this is that even when the main planes are completely stalled, the wing tips, *which are ailerons as well as elevators*, are at 0° incidence, and at their maximum efficiency as control organs. Valuable as this is for elevator control, it is even more so for aileron. In a normal aeroplane the moving down of an aileron when the wing is stalled merely increases the stall at that tip and reverses the effect of control. The rotatable wing tip on the tailless aeroplane is always at full efficiency, however badly the wing may be stalled, and so an involuntary spin is almost impossible. The rotatable wing tip has not been used on the latest Pterodactyl, but I have described it in detail because we use it on our machine.



After carefully considering Hill's aeroplane, we decided to make various alterations in our own version. In the first place, we abandoned the pusher arrangement, as we did not like the idea of receiving the engine in the small of the back in the event of a (quite probable) crash. The rearrangement of the machine as a tractor resulted in a host of simplifications, and made possible a far simpler and cleaner design.

For correct trim it was necessary to place the pilot at the trailing edge of the main planes, and by the time a fairing had been placed behind him, the fuselage, though short, was quite long enough to enable us to fit an effective rudder and fin in the usual place, while a normal undercarriage and tail skid were used. This at one sweep cleaned all excrescences off the wings—a notable clean-up, since the pusher has to carry fins, air brakes and landing gear on its wings, to the detriment of efficiency in flight. At the same time, powerful control on the ground was given by the rudder in the slip stream, and construction was greatly simplified. Our wing plan was similar to that of the Pterodactyl, but with slightly greater sweep back and a modified section. The wing was semi-cantilever, and placed on a tubular structure over the fuselage. The controllers were operated by torque tubes and push rods from a normal wheel and column control, while the rudder was operated by pedals.

The stressing was complicated by the loads induced on the wings by the controllers, and as stress calculations had not been attempted before, and our only guide was an elderly manual, much midnight oil was burnt over the problem. When the main structure was nearly complete, we got into touch with Capt. H. L. Needham, who took great pains to re-calculate the whole machine. Our figures were not regarded as legitimate mathematics by him, but fortunately our structure needed very little modification.

Work was carried out in a small garage, which also housed our previous biplane glider, a car and two motor-cycles. We are fully occupied as business men, and as we made every part from raw materials, including the airscrew, it took us nearly four years to complete the machine. To these difficulties may be attributed some of the minor crudities of design which our means of construction rendered unavoidable. We had originally intended using a Douglas motor-cycle engine, but when the machine was nearly finished a friend presented us with a Bristol "Cherub." The greater weight of this engine in the nose, although allowed for as far as possibe, nearly caused disaster.

In the spring of 1930 the machine was ready for flight, and though known to be nose heavy owing to the new engine, cautious trials were made in a large field. We were delighted to find that it stood up sturdily to taxying over rough ground, and a few very short hops were made. We decided to load the tail slightly, although as far as we could tell the trim seemed reasonably good, before removing to the aerodrome.

We had by this time learned to fly at the newly-formed local Aero Club, but as we only shared some twenty-five hours' solo experience between us, errors in deductions from the early trials were excusable.

The first difficulty was that the effect of the rotation of the slip-stream on the rudder was unusually large owing to the short fuselage, and nearly full rudder control was needed when taking off. Also, owing to our lightly sprung narrow track undercarriage and small wheels, the engine torque, just before flying speed was attained, sometimes twisted the machine so far over that one undercarriage leg caught the ground and caused a violent swing. We did not find out the cause of this swing for some time, and the take-offs were usually hectic.

On the first straight hop the machine got off after a very long run, and at rather high speed; it flew level and felt quite O.K., but when the engine was shut off it tucked its nose down and glided at a steep angle into the ground, with the stick hard back.

Six months later the engine was restored to its proper position (right at the front) and a new undercarriage built. We were not really certain of the cause of the crash since although the machine was theoretically nose heavy, the indications to the pilot had been those of stalled controls. So a few more spectacular hops were made before we decided to load the tail and bring the C.G. right up to its calculated position. The next hop was a perfect success, and the machine was then taken up to 1,000 feet and flown round for half an hour. Since then we have had no trouble, the undercarriage has been modified, larger wheels fitted, and the take-off made controllable.

The torque effect has never been troublesome in the air; a little left rudder is needed, but all the controls are quite normal. The first thing one notes is their extreme lightness; you have a feeling that you must be completely stalled and dare hardly breathe for fear of upsetting the balance. This soon passes, and you find how very easy the machine is to handle. In spite of their lightness, the controls are not over sensitive, but they are amply powerful to perform any manœuvres that may be required, and the machine is still under control at its lowest speed of some twenty-five miles per hour.

The properties of the machine at the stall are remarkable. One can apply full rudder and full opposite bank and ease the stick back and hold on. No cataclysm follows: one just skids round as long as one likes, with very little loss of height at three-quarter-throttle. Another feature is that after the stall the nose does not drop before resuming normal flight. These properties of stability in abnormal conditions are not obtained by sacrifice of performance. The top speed is ninety miles per hour, which I do not think has been exceeded by any machine with the same engine, and can undoubtedly be improved by cleaning up detail, while the landing speed is about thirty-seven miles per hour.

The machine is very quick on turns, and in spite of the unusual elevator control is perfectly easy to land.

The following are the principal features of the machine:—

Span: 30 ft.
Length: 14 ft. 10 in.
Area of main plane: 102 sq. ft.
Weight (all up): 616 lb.
Wing-loading: 6 lb. per sq. ft.
Engine: Bristol Cherub, Series 1, 29 B.H.P. at max. R.P.M.