AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 59

THE FOCKE WULF F.19 "ENTE"

Tail-First Airplane

Washington
October, 1927

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Tail-First Airplane.

It is a somewhat curious fact that modern times should see a reversal to the type of airplane which first left the ground in controlled flight, and that, by making full use of modern aerodynamic knowledge, this type, which was abandoned back in the childhood of aviation, should now be proved possessed of certain very marked advantages as compared with the type that has supplanted the original to the entire extinction of the latter.

It will possibly be news to those of our readers whose interest in aviation is of fairly recent date to learn that the first airplane to fly under proper control was of the "tail-first" type. Commencing with the very early Wright gliders, the "tail-first" principle was adopted, and the first power-driven airplanesbuilt and flown by the Wright Brothers were of this type. That is to say, the single engine drove two "pusher" propellers via a chain transmission. A narrow outrigger or girder carried two vertical rudders placed side by side and but a small distance apart. The elevator was mounted ahead of the main wings on another outrigger, the pilot sitting on the leading edge of the lower wing. The early airplanes were somewhat tricky to fly,

*From "Flight," September 29, 1927.

and it was not long before the elevator was transferred to the back of the airplane. In France also the "tail-first" principle was used in the very earliest airplanes. Thus, M. Santos Dumont used an airplane of this type for his prize-winning flight of 1906. This airplane had biplane front elevator as well as biplane main wings. Owing to the fact that in those days the action of the front elevator was imperfectly understood, the airplanes were unstable fore and aft, and the tail-in-front arrangement gave way for the tail-behind system as it is used to-day. Actually the tail-first arrangement is capable of giving excellent fore and aft stability, provided certain precautions are taken. When, however, we come to directional stability and control the matter is less favorable, and the "Canard" type, as it used to be called in France, or "Ente" as it is termed in Germany, suffers from certain serious drawbacks. Before referring to these it may be of interest to examine briefly how the "Canard" or "Ente" obtains its longitudinal stability.

It is, of course, well known that an airplane wing reaches a certain maximum lift at some particular angle of attack, the angle depending partly on the wing section used. If that angle is exceeded the lift begins to fall off, rapidly with some wing sections, less suddenly with others. It is this fundamental principle which is made use of in the tail-first wing arrangement. It will be seen that if the same wing section is used both for the wing and for the front plane or elevator, and the center of gravity of the airplane is so arranged that the front plane carries a slightly greater load per unit of area than does the wing; then, to give equilibrium, the front plane must always be set at a slightly greater angle of attack than the wing. (Over the greater portion of its useful range of angles, the normal wing section shows a lift coefficient which is approximately proportional to the angle of attack.) For any particular combination of angles and wing loadings there is a certain definite speed, and an airplane having this arrangement will be stable. Thus if the engine is throttled down, the nose will drop and the airplane will take up its proper gliding angle for that setting. If, on the other hand, the engine is opened from cruising throttle to full throttle, and the front elevator is left at the same setting, the airplane will automatically climb. (We are not, of course, now taking into consideration airplanes in which the center of thrust differs widely from the center of resistance.) Almost the same takes place in the "tail-behind" arrangement if it is stable, but at the stalling angle the difference between the "tail-first" and "tail-behind" system becomes more pronounced.

Let it be assumed that front elevator and wing reach their maximum lift at 16 degrees angle of attack. If the relative setting is such that there is a difference of 4 degrees between front plane and wing, with the former at the larger angle, then it is obvious that the front plane stalls when it has reached 16 degrees, but that when this occurs, the wing is still at 12 degrees angle of attack, i.e., 4 degrees on the "right" side of the stalling angle. The front plane drops, the airplane increases its speed, the front plane unstalls, and the airplane commences to glide. The fundamental difference between the tail-first and tail-behind arrangements is that with the normal arrangement it is the wing which is stalled, while in the "canard" it is the front plane. In the one case a very large percentage of lift is lost; in the other only a small percentage. Moreover, as in the tail-first airplane the main lifting surface does not reach the stall, the airplane <u>does not go into a spin</u>. This fact alone entitles the tail-first arrangement to some consideration.

Lest it should be assumed that the tail-first principle is necessarily foolproof, it should be pointed out that it is possible to arrange the two wings in such a manner that the longitudinal stability suffers. For instance, if the main wing section has a large travel of the center of pressure, and the front section is very heavily loaded and with a sudden stall, trouble may arise. For a given airplane, it is, however, possible so to arrange matters that perfect fore and aft stability is attained. It would seem that a fairly gentle lift curve in the region of the stall is desirable for the front elevator, and it appears likely that it is this which has caused the designers of the Focke-Wulf firm to adopt the Handley Page-Lachmann slot for the front elevator. In the early Wright airplane the trouble probably was that the front elevator was too small and insufficiently loaded, making the airplane too sensitive. It is not intended here to go deeply into the subject, as this would lead to technicalities outside the scope of this article, but it may be pointed out that there are definite limits to the difference in angle and loading of the two planes, too heavy a loading of the front plane reducing the possible speed range, and too small a difference in loading and angle reducing the stability. A compromise between the two extremes has to be found.

As regards the difficulties connected with directional stability in a tail-first airplane, this is a matter of fin areas in relation to the center of gravity, and it will be observed that the new German airplane has a very large fin, indeed, and a fairly large rudder. It is claimed that this has effectively cured any directional instability, and it seems possible that there are other ways in which the desired result could have been obtained without such a large vertical surface at the back.

With these general and elementary considerations of the subject of the tail-first airplane, written mainly for the benefit of those of our readers who have not given the matter much thought, let us see how the problems have been attacked in the modern airplane incorporating the "canard" arrangement.

The modern airplane, which has given rise to the revival of the subject of the tail-first arrangement, is the F.19, designed and built by the Focke-Wulf Company, of Bremen. Before proceeding to the actual construction of the airplane, a model was very thoroughly tested in the wind tunnel at Göttingen, and an arrangement was evolved which proved perfectly stable around all three axes, i.e., longitudinally, laterally, and directionally. Not until then was the work put in hand, but the actual airplane has now been finished and has passed its preliminary test flights, which appeared to bear out all the Göttingen results. That more searching tests may reveal certain vices in the airplane is still a possibility, although at present there is no cause for believing that such will be the case. The wind tunnel tests indicated that the new airplane cannot be stalled, and so far the full-scale appears to confirm this.

The "Ente" (duck) had been ready for some time, but unfavorable weather delayed the first test flight until September 2. On that date the airplane was brought out, the two Siemens engines run up, and the airplane prepared for flight. On this first test flight, the empty weight of the airplane was 1155 kg (2546 lb.), and the flying weight 1405 kg (3097 lb.). The angles of attack of wing and front plane, as well as the location of the center of gravity, were carefully arranged to tally exactly with the Göttingen values. Herr Wulf took his seat in the airplane, the chocks were removed and the engines opened out. The airplane accelerated quickly, still maintaining its negative angle of attack. After a run of 200 m (656 ft.), during which the controls were tested, the pilot pulled the control back, and the front wheel left the ground. Pulling very gently at first, and later a little stronger, the pilot soon had the airplane in the air. Keeping it low to gain speed, he presently rose, gently at first, but later, as all seemed in order, more steeply, and before long the "Ente" was at 500 ft. Next a turn was attempted; this also was perfectly normal, and increasing the turn to quite a short one, the pilot passed over his starting point at about 600 ft., waving his hands to show that the airplane would fly itself. He then flew over the town and made several left- and right-hand turns, some of which were carried out by tilting the front plane around its longitudinal axis. The landing also was made without a hitch although, owing to a defect in the wheel brakes, the run before coming to a standstill was rather long. The air-speed indicator fitted was not above suspicion, but experts who watched the flight estimated the speed to be approximately 140 km/h (87 mi./hr.), which is about the designed speed. The pilot reported good stability around all three axes, and also that the control surfaces acted promptly and powerfully.

General Construction

In the matter of constructional features, the F.19 follows closely the normal practice of the Focke-Wulf Aircraft Works.

The fuselage is a plywood covered structure of the type used as standard by this firm, and structurally shows no difference from the fuselage of the types A.16 and A.16a, etc. Its shape is, of course, altered to conform to the new conditions. The monoplane wing is, both in its sections, plan form, etc., identical with that of the A.16; the only difference is that certain small changes in angles of attack (the wing is not uniform) have been made. The structure is an all-wood one, with box spars. The front plane or stabilizer shows a pronounced taper in chord and thickness, and the elevator flaps are hinged to the fixed plane in a somewhat peculiar manner on large external cranks. It appears from the photographs that some form of aileron slot action is incorporated, but the exact nature of this cannot be ascertained. There is little doubt that a neater arrangement could easily be designed and, doubtless, this will be done in later airplanes, this first "Ente" being purely an experimental type. The front plane is so mounted that it can be rocked laterally around a longitudinal axis. In this manner it is made to assist the rudder, and this feature is chiefly intended for use when one engine cuts out.

The landing gear consists of vertical telescopic legs attached at the top to the wing, and at the lower end to the apex of a vee formed by the axle and its radius rod. It would appear that the ground clearance of the fuselage is rather small, and possibly the incorporation of some form of "spring bottom" might be an advisable addition in a production type of airplane, so that in case of landing gear failure the fuselage itself would absorb a certain amount of shock. Under the forward portion of the fuselage is a third wheel, partly buried in the fuselage. As far as we know, this wheel is not made steerable, but there should be no difficulty in making it so, when the airplane should be very easy to taxi about on the ground at speeds so low that the air rudder would have little effect. Wheel brakes are incorporated in the main wheels, and owing to the location of the third wheel well out in front, these can be applied without fear of turning the airplane over. In fact, it would probably be next to impossible to turn the airplane over on the ground.

Two Siemens radial air-cooled engines of 75 HP. each are mounted under the wing, in streamline cowlings. The two gasoline tanks are built into the leading edge of the wings, one on each side, and fireproof bulkheads separate the engines from the wing structure. The location of the gasoline tanks is such that direct gravity feed can be employed.

As already stated, no performance figures are available, but the wind tunnel tests indicated that the efficiency of the "Ente" is about the same as that of a good modern commercial airplane of orthodox type.

The main characteristics other than dimensions, of which none is available, of the Focke-Wulf "Ente" are:

Power Unit

2 Siemens Sh 11 engines	290 kg	(638 lb.)
Engine starter	3 "	(7 ")
2 propellers with bosses	30 "	(66 ")
2 gasoline tanks (20 gal. each)	24 "	(53 ")
2 oil tanks (2.7 gal. each)	6 "	(13 ")
Engine equipment, accessories, etc.	27 "	(59 ")
Total	380 "	(836 ")

The Airplane

Fuselage and cabin	330 "	(728 ")
Fuselage equipment	25 "	(55 ")
Controls	17 "	(37 ")
Fin and Rudder	13 "	(29 ")
Wing, with flaps and engine supports	240 "	(528 ")
Front plane with elevator	60 "	(132 ")
Main landing gear	60 "	(132 ")
Front wheel with springing	15 "	(33 ")
Airplane weight	760 "	(1676 ")
Total weight empty	1140 "	(2512 ")

Useful Load

Gasoline and oil for 3 hours	140 kg	(308 lb.)
Pilot	80 "	(176 ")
	220 "	(484 ")
Pay load - 3 passengers	230 "	(506 ")
Total load	450 "	(990 ")
Total loaded weight	1590 "	(3502 ")

Fig. 2 →
Three-quarter rear view.
To get the side areas correct, a very large fin is necessary

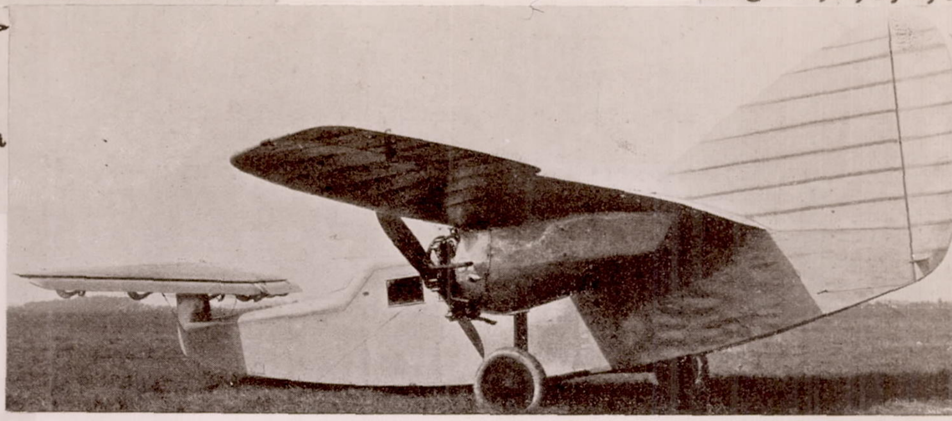


Fig.1 The Focke-Wulf "Ente" airplane. Three-quarter front view. Note negative

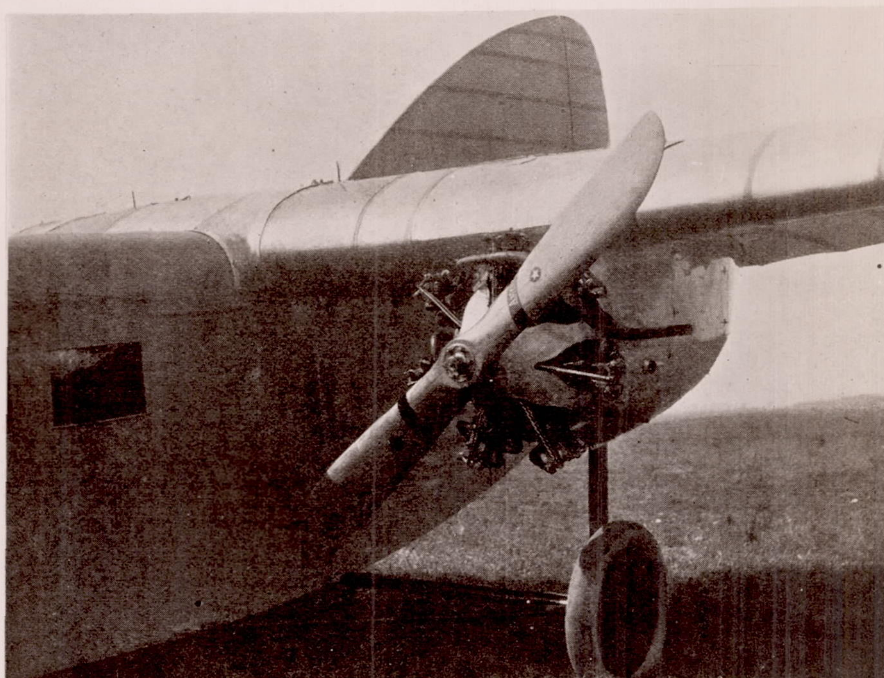
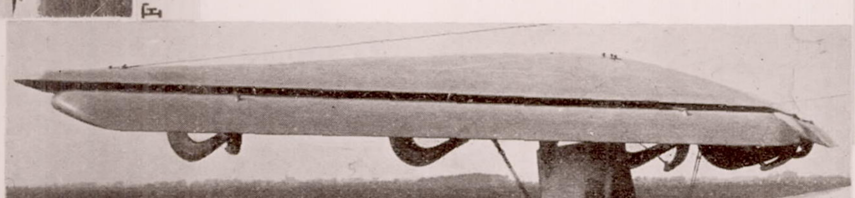
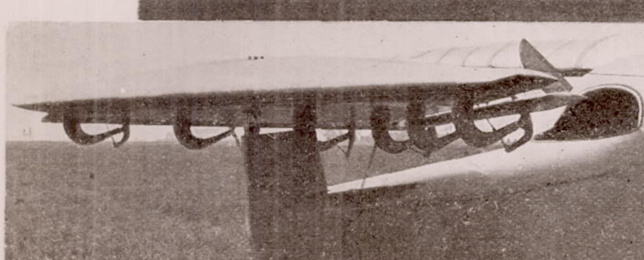


Fig. 3 ↑ View of port engine and landing gear. Note gasoline tanks in leading edge of wing.





Figs. 4 & 5 Two views of the front plane. Note that the elevator is so hinged as to give a slot action.

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