

AIRCRAFT CIRCULARS
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 87

"VILLIERS 24" SLOTTED-WING AIRPLANE (FRENCH)
Night Pursuit Sesquiplane

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"VILLIERS 24" SLOTTED-WING AIRPLANE (FRENCH).*

Night Pursuit Sesquiplane.

The "Villiers 24 C.A.N. 2" is a night pursuit sesquiplane, equipped with the 450 HP. direct-drive Lorraine 12 Eb engine. It is characterized by the Handley Page slotted wing (Figs. 1, 2, 3, and 4). It is very advantageous for a night airplane to have a low minimum speed, sufficient manageability above the critical angle, elimination of the danger of stalling from loss of speed, and short take-off and landing runs, all of which qualities are supplied by the slotted wing.

In the "Villiers 24" only the upper wing is provided with the slot device. This consists of a separable leading edge or flap interconnected with the trailing edge, excepting the central portion of the latter, which is fixed. The profile adopted is the R.A.F. 31, which has long been used in England. The Etablissements Villiers propose to replace it ultimately by an improved profile which is now being investigated. On the first airplane the device will be operated by the pilot; later, it will be automatic. The opening of the slot causes, at the same time, a positive deflection of the rear flap and of the

*"L'Avion Villiers 24 à aile à fente," in L'Aéronautique, March, 1928.

ailerons, the latter retaining, however, their normal deflection for every position of the device.

The "Villiers 24" is of mixed construction (wood, metal and fabric) with a monocoque fuselage built on six longerons. The tail planes are constructed of wood, the stabilizer being adjustable during flight. The landing struts are two panels of glued wood. The removable engine-propeller group is mounted on a duralumin support. A silencer is mounted on the exhaust.

The slotted wing makes it possible to reduce the speed of the airplane from 212 km (131 mi.) per hour to a minimum of 101 km (63 mi.) with the slot closed, and to 70 km (43.5 mi.) with it open. These figures were obtained in the first flights made early in March by Mr. Descamps and are evidently susceptible of improvement.

Figure 5 shows the trailing edge of a wing with one of the flaps in place. The flaps and ailerons are hinged to their supports, the axis of articulation being outside of the profile and behind the front edge of the flaps so as to balance them automatically. The lowering of the flaps and ailerons is effected by levers mounted on the front tube and by connecting rods. The ailerons retain their freedom of motion of 20° upward and 12° downward in any position of the device.

Figure 6 shows the mechanism for operating the leading-edge flaps. A tube, mounted in the leading edge of the wing, is controlled by a screw and a helicoidal wheel placed in a case.

The front flap is operated by means of levers rigidly attached to said tube and to the leading edge of the wing. The rear flap is controlled by levers mounted on the tube.

Figure 7 shows the cowling of the stabilizer, which resembles the joint of an insect. A duralumin sheet slides between two other sheets so that the rear portion of the fuselage remains covered in any position of the stabilizer, which is adjustable during flight.

Effect of Slotted Wing on Safety of Airplane *

The slotted wing, which has been undergoing development for several years in England under the direction of F. Handley Page, constitutes one of the most important devices from the viewpoint of safety in flight. It is known that above a certain angle of attack (the critical angle there is a separation of the air filaments on the top of the wing, which results in a diminution of the lift accompanied by a considerable increase in the drag. If the ailerons are operated at this instant, the drag is still further increased and stalling occurs with all its well-known consequences.

The introduction of a slot into the leading edge of the wing results in considerably increasing the critical angle of attack. The lift also is greatly increased (sometimes nearly 100%) for angles of attack up to 25 or 30° instead of the usual

*"L'aile à fente et la sécurité de l'avion," in L'Aéronautique, April, 1928, pp.117-120.

14 to 16°. The natural result is a great reduction in the minimum speed, as likewise in the take-off run and landing run.

When the slot is closed, the profile is like the ordinary profile and behaves the same.

Experimentation with this device led to combining it with a rear flap which is operated simultaneously with the front flap.

The tests then showed that it was possible to render the operation of the flaps entirely automatic and thus obtain an automatic lateral control. The test flights demonstrated on many occasions that an airplane, nosed up beyond the critical angle, descended vertically and then began a dive without slipping off on the wing or going into a spin.

The very interesting results induced the Etablissements F. Villiers to acquire for France the rights to the Handley Page device, which has first been applied to the night pursuit airplane "Villiers 24."

We consider it of sufficient interest to give a few technical details on this device, which lends itself to various adaptations as illustrated diagrammatically by Figure 8 (A, B, and C).

A.- The wing can be provided with a front flap extending over the entire span, interconnected with a rear flap independent of the ailerons, and also provided with ailerons interconnected or not with the front flap, the operation of the latter being either automatic or controlled by the pilot.

B.- Another arrangement consists in installing two front flaps, covering the same portions of the span as the ailerons, and interconnected or not with the latter, in order to obtain automatic lateral control.

C.- The two preceding arrangements can be combined, the end flaps serving for the automatic lateral control and the central flaps (either automatic or controlled) serving to reduce the minimum speed.

The "Villiers 24" as constructed has the wing profile R.A.F. 31, already tested in England. It seemed, however, that the results could be considerably improved, and it is hoped that the profile "Villiers A 5" (Fig. 9) will show such improvement. At the top of the figure a drawing shows the front flap mounted on a jointed parallelogram whose motions can be controlled by a rotating tube, which simultaneously actuates the rear flap through connecting rods and levers. The two lower diagrams show the extreme positions, while Figure 10 shows the corresponding polars and moment curves. It is seen that the maximum lift of $c_{zm} = 128$, for $i = 16^\circ$ of the normal profile, increases to $c_{zm} = 248$ for $i = 25^\circ$, or an increase of 93.8%, thus corresponding to a reduction of 39% in the minimum speed. This result renders it possible to alight on water at night or when there is no visibility, the pilot having only to hold the airplane at the angle of minimum speed.

We said the operation of the flaps could be either automatic or controlled. Investigation of the action of the air on the flaps has shown, in fact, that it is possible to control the flaps in such manner that they will separate from the wing for a given angle of attack under the sole action of the aerodynamic resultant on its surface. Figure 11 shows the position of this resultant for various angles of attack. For example, a flap can be regulated in such a manner that it will open as soon as the angle of attack reaches 8° and close again when the angle has dropped below 2° . Locking the device will enable the pilot to stop at will its automatic functioning, which will be of advantage in some cases, such as climbing and stunt flying.

The automatic lateral control is based on the following considerations. If i denotes the critical angle of attack of the wing with the slots closed and i' that with the slots open, the opening of the slots between the flaps for lateral control and the central part of the wing affects the polar of the airplane. The critical angle of the whole airplane will be increased and will lie between i and i' . The lift of the whole airplane will also be increased by a certain percentage dependent on the ratio of the span of the lateral-control flaps to the total span. The critical angle of the portion of the wing provided with lateral-control flaps, as well as its lift, will always be greater, however, than the same characteristics of the whole wing. The result is a lateral control which remains very

efficacious above the critical angle of the whole airplane. Of course the range of the angles of deflection of the ailerons remains constant regardless of the position of the lateral-control flaps.

From a note recently sent us by Handley Page following his Stockholm address, we will take a few statements and figures which will supplement what we have already said.

On comparing an ordinary wing having a rear flap with a like slotted wing of normal English profile, it is found that, for a deflection of 20° of the flap, the maximum lift increases only 10% in the former case and 100% in the latter case, thus demonstrating the importance of the simultaneous use of the rear flap and of the slot. Figure 12 shows the connecting system by which the slot is enlarged when the aileron is depressed and is closed when the aileron is raised. A variant is represented by Figure 13. The slot remains constant when the aileron is deflected, a connecting rod with a spring shock absorber acting on a small deflecting plane, which projects vertically above the wing when the aileron is raised. Figure 14 shows diagrammatically the mounting, on a Bristol combat airplane, of the movable part of the leading edge for opening and closing the slot at given angles of attack for the purpose of better automatic lateral control under the sole action of the aerodynamic forces.

These facts indicate that the slotted wing has made an im-

portant contribution to the problem of the safety of flight by airplane. Hitherto an airplane inclined above the critical angle of attack became uncontrollable by the pilot until it had fallen a sufficient distance to regain speed enough to enable its sustentation at an acceptable angle. The new device enables the pilot always to keep control of his airplane, to avoid falls, spins and glides, and also to reduce greatly the take-off and landing runs, while enjoying the benefits of a lower minimum speed.

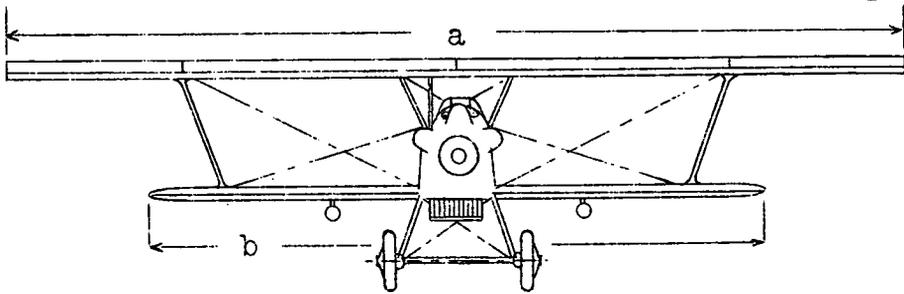
Characteristics

Power	450 HP.		
Span	13.00 m	(42.65 ft.)	
Height	3.30 "	(10.83 ")	
Length	8.75 "	(28.71 ")	
Wing area	42 m ²	(452 sq.ft.)	
Weight empty	1469 kg	(3239 lb.)	
Useful load	450 "	(992 ")	
Fuel "	300 "	(661 ")	
Full "	2219 "	(4892 ")	
Wing loading	52.8 kg/m ²	(10.81 lb./sq.ft.)	
Power "	4.97 kg/HP	(10.8 lb./HP.)	

Performances

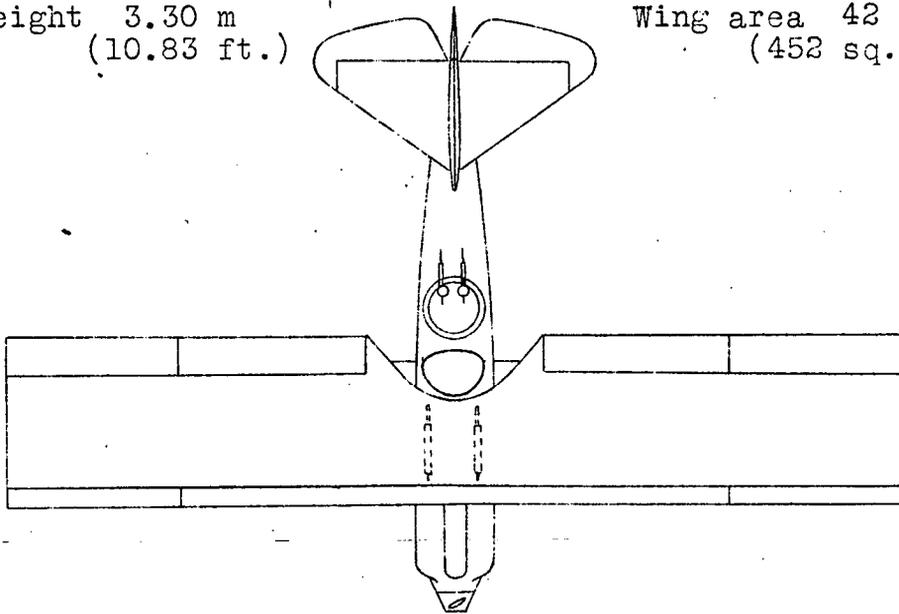
Maximum speed at sea level (1850 R.P.M.)	212 km/h (132 mi./hr.)
Minimum " " 5000 m (16400 ft.)	200 km/h (124 mi./hr.)
Minimum speed, slot closed,	101 km/h (63 mi./hr.)
" " " open,	70 km/h (43.5 mi./hr.)
Climb to 6000 m (19685 ft.)	in 50 minutes.
Flight range	3 hours.

Translation by Dwight M. Miner,
National Advisory Committee
for Aeronautics.



(a) Span 13.00 m (42.65 ft.) (b) Span 9 m (29.52 ft.) Length 8.75 m (28.71 ft.)

Height 3.30 m (10.83 ft.) Wing area 42 m² (452 sq.ft.)



Lorraine 12 Eb 450 HP engine (W type).

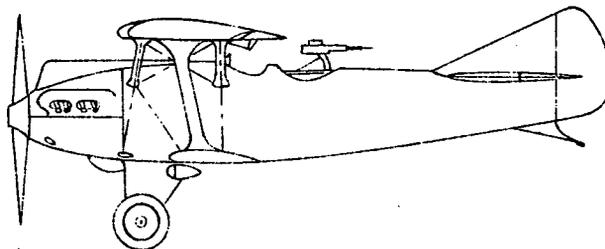
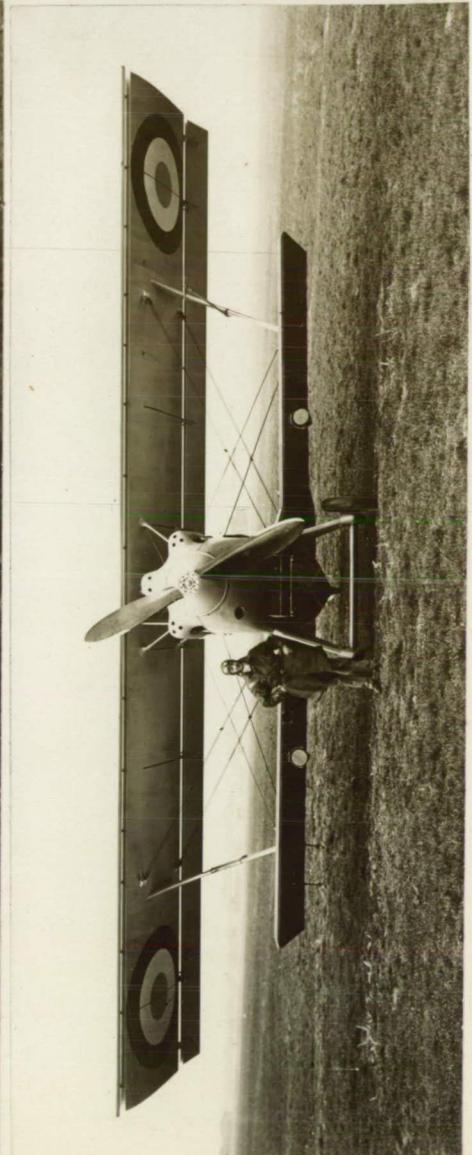


Fig.1 The Villiers 24 C.A.N.2 night pursuit airplane with slotted wing.



Figs.2,3,4 Views of the Villiers 24 C.A.N. 2 night pursuit airplane with slotted wing.

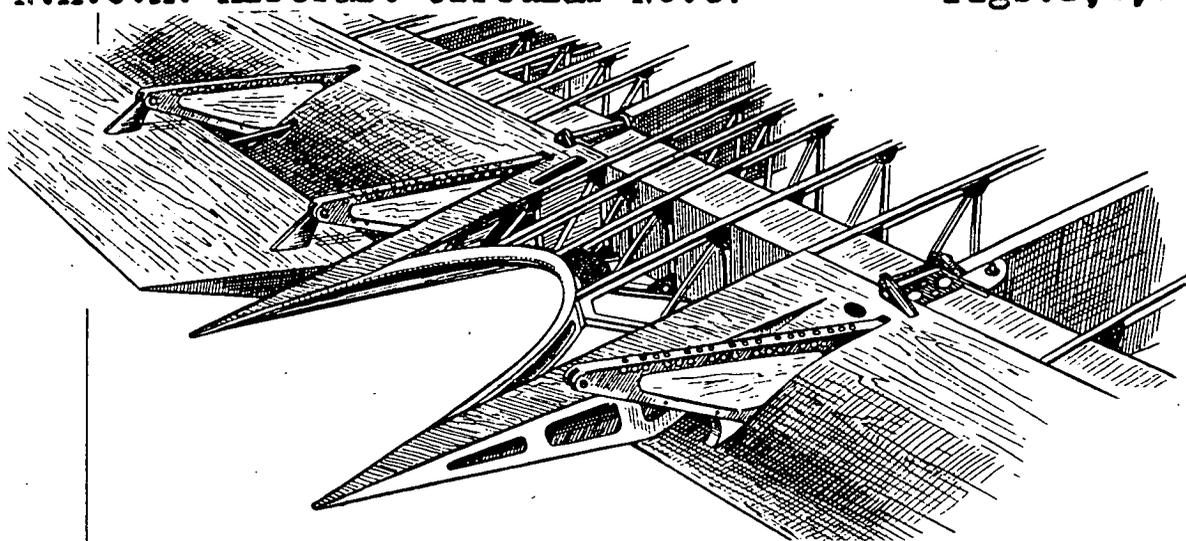


Fig.5

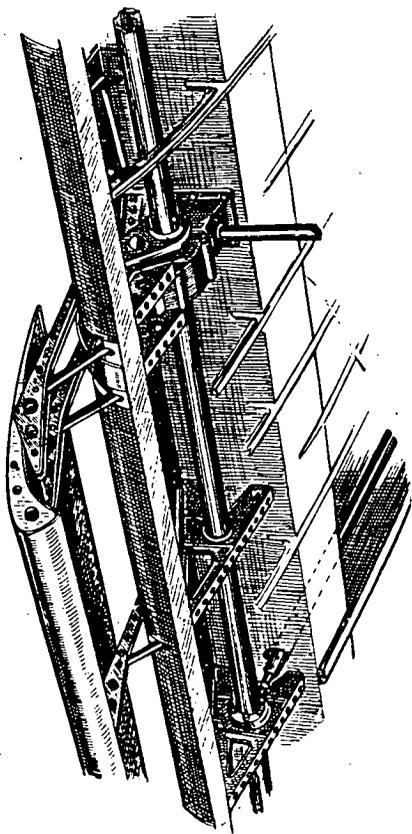


Fig.6

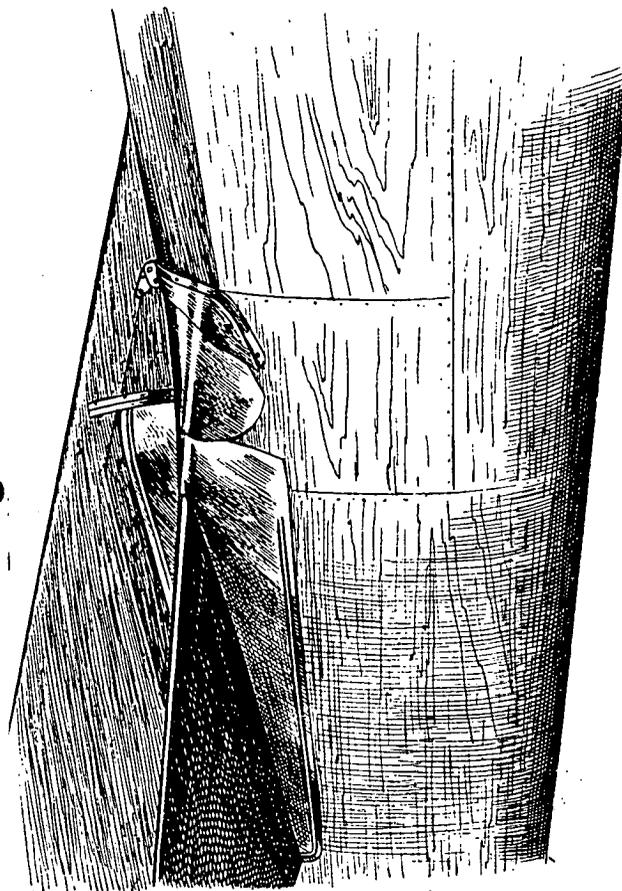
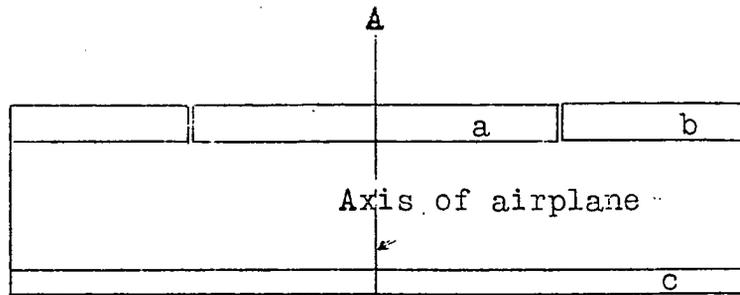
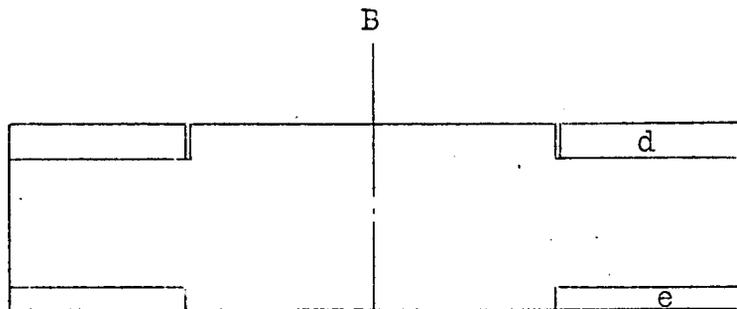


Fig.7

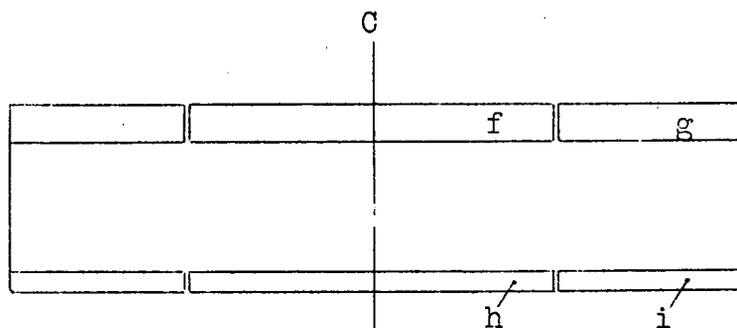
Sketches showing structure of the Villiers 24 C.A.N. 2 night pursuit airplane.



- a, Rear flap interconnected with front flap.
- b, Aileron interconnected or not with front flap.
- c, Flap automatic or controlled by pilot.



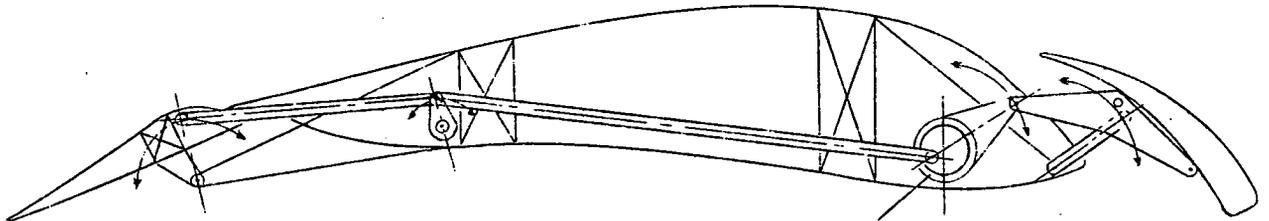
- d, Aileron interconnected or not with front flap of automatic lateral control.
- e, Front flap of automatic lateral control.



- f, Central rear flap interconnected with front central flap.
- g, Aileron interconnected or not with the central part of front flap or with the front flap of automatic lateral control.
- h, Central part of front flap, either automatic or controlled by pilot, serving simply to reduce the minimum speed.
- i, Front flap of automatic lateral control.

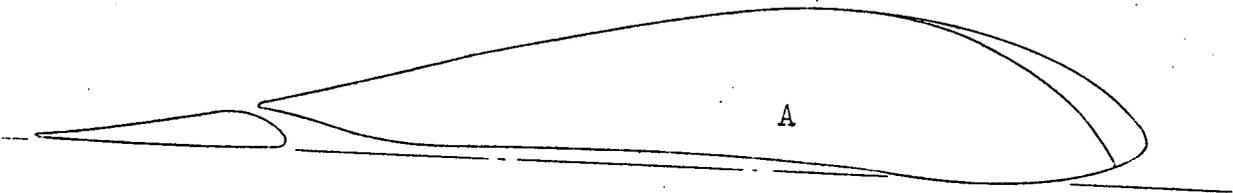
Fig.8 Slotted-wing arrangements.

Control device



Control tube for front slot

A, Rear slot, front slot closed.



B, Rear slot 20°, front slot open.

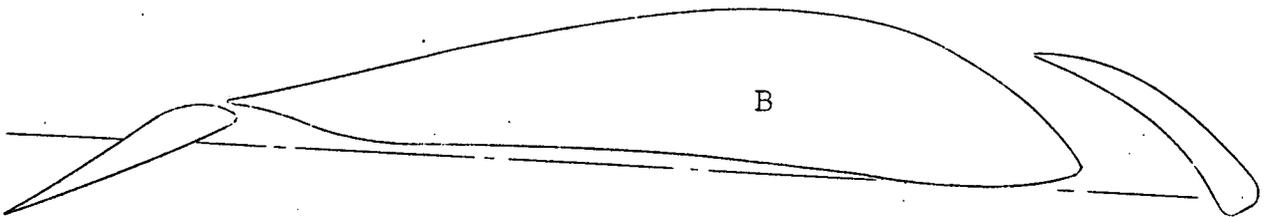


Fig.9 F.Villiers A-5 airfoil.

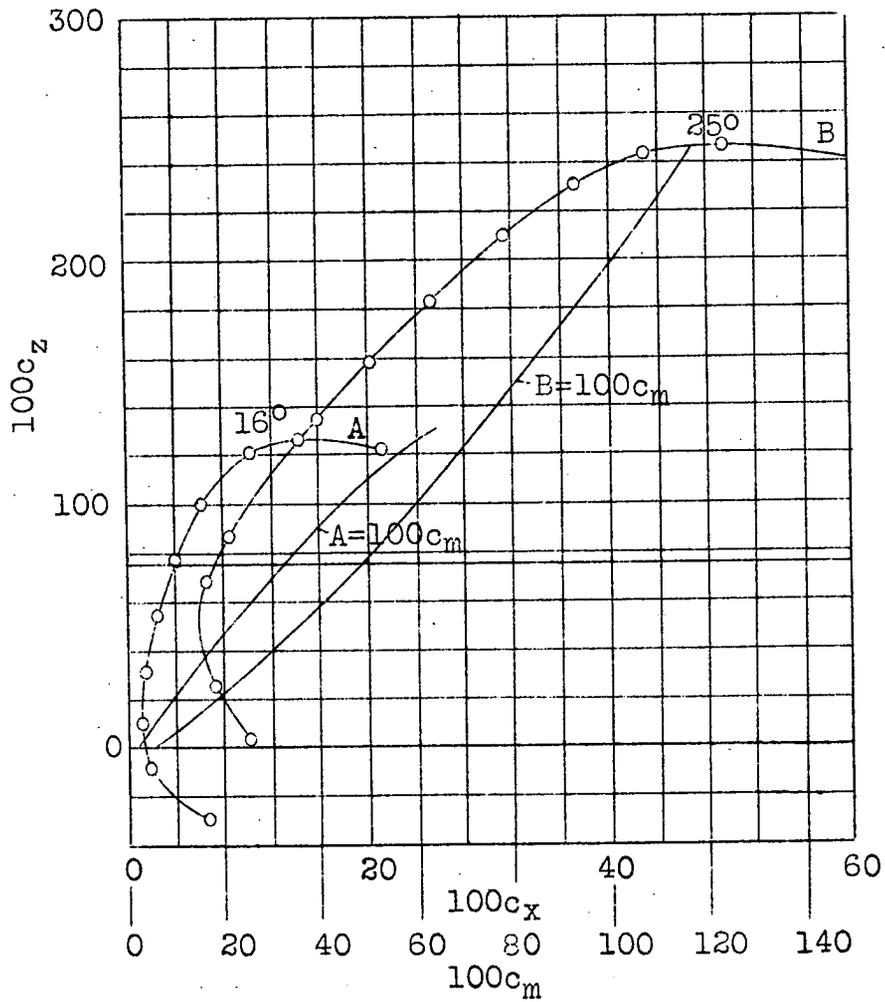


Fig.10 Polar curves for profile A-5. Velocity 40m/s. St.Cyr laboratory.

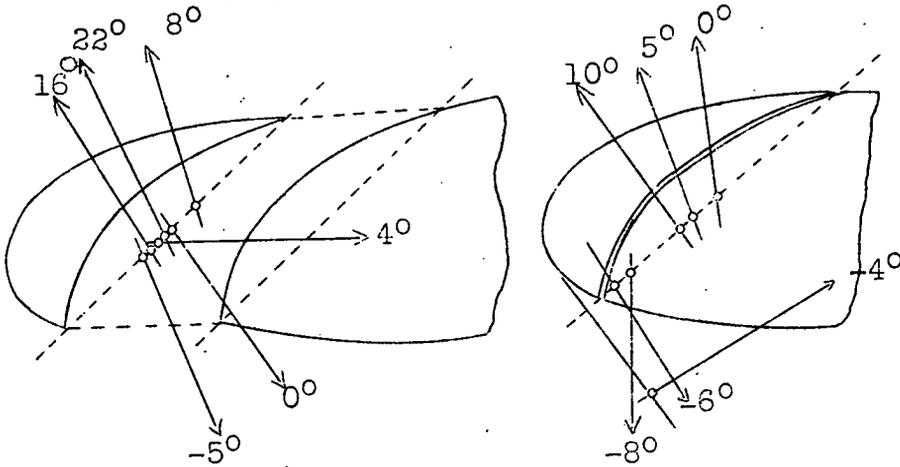


Fig. 11

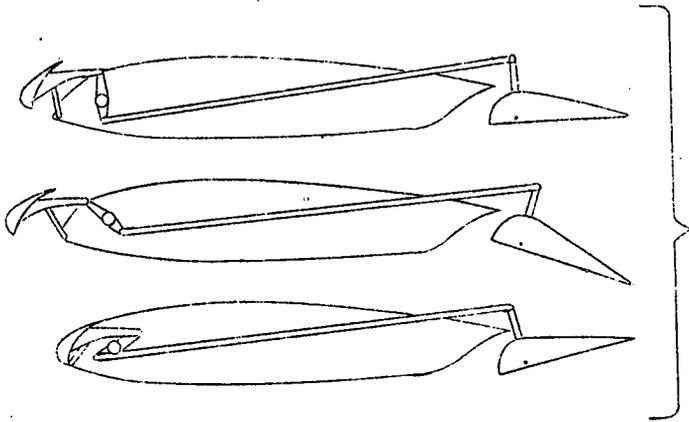


Fig. 12

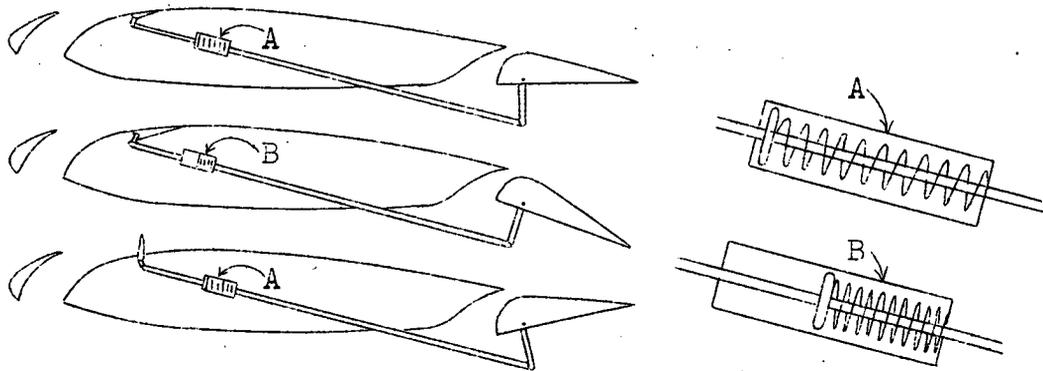


Fig. 13

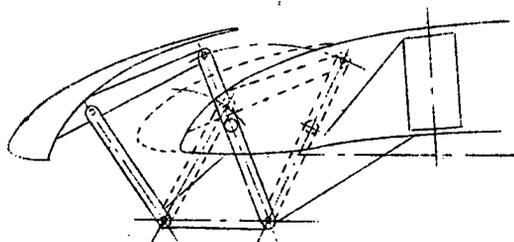


Fig. 14