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No. 146

# THE DEWOITINE D 33 COMMERCIAL AIRPLANE (FRENCH)

## A Low-Wing Cantilever Monoplane

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# THE DEWOITINE D 33 COMMERCIAL AIRPLANE (FRENCH)*

## A Low-Wing Cantilever Monoplane

By Pierre Léglise

The Dewoitine Company endeavored to build an airplane of great fineness by developing a cantilever wing with the greatest aspect ratio ($\lambda = 10$) compatible with a reasonable structural weight of 10 kg/m² (2.05 lb./sq.ft.). This figure, which is rather small for a metal wing, is largely due to the single-spar construction and to the location of the tanks in the strong wing structure. These tanks remained tight after being subjected to the impacts of many take-offs and landings, the vibrations of at least 200 hours of flight (tests, record-breaking attempts) and the deformations of an overloaded wing. The credit for this remarkable achievement goes to Dewoitine and Vincent André. We have been able to secure important information on the D 33, which we owe to the courtesy of the Dewoitine Company and of their engineer Mr. Vautier.

The Dewoitine D 33 (fig. 1) is the outcome of a very exhaustive aerodynamic investigation. The cantilever wing is slightly trapezoidal in plan and has elliptical tips. The wing thickness at the root is only 700 mm (2.3 ft.) for a chord of 4 m (13.1 ft.), the relative thickness being thus only 17.5%. The wing is let into the lower part of the fuselage, an arrangement which greatly facilitates take-off and landing.

One of the greatest difficulties involved by a wing with an aspect ratio of 10 is the elimination of vibration. The wing of the D 33 does not vibrate at any engine speed or angle of attack. Even if the ailerons are suddenly deflected at wide-open throttle in horizontal flight no torsion of the wing tips is noticed. This result is achieved by a wing with a single spar and a box-type leading edge which is used, not only on the D 33 but on all Dewoitine transport airplanes. The wooden wings of the light airplane D 7 and of the gliders built by Mr. Dewoitine in 1922 were designed on the same principles. The main cross section of the fuselage has been reduced to a minimum. It permits communication, however, between the different stations of the crew. Maximum propeller efficiency is insured by keeping the nose of the engine cowling unobstructed and locating the power plant well forward of the leading edge of the wing.

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*From L'Aeronautique, May, 1931, pp. 155-163.

Figure 2 shows the engine cowling and also the free mounting of the metal propeller.

From its first tests the airplane proved very maneuverable and agreeable to fly, even with full load. It possesses excellent inherent stability and its behavior in rough air is very satisfactory. The C.G. of the fully loaded airplane is shifted slightly forward of its position in the empty airplane. While this greatly facilitates the take-off of the loaded airplane (the D 33 takes off easily with a total weight of 9 metric tons (19,836 lb.) not including the tail wheel), it also permits very easy landings of the empty airplane, a point which is often neglected.

The single wing spar is located at one-third of the chord from the leading edge. It consists of two duralumin-section flanges and of two openwork sheet webs. Figure 3 shows its assembly with fuselage. Uniform stress distribution is achieved by a decreasing thickness of the flanges along the span. The vertical compression members, corresponding to the ribs, are of the box type. The oblique members, working normally in tension, are stiffened by $\Omega$ sections. In order to facilitate transportation the wing can be divided into five parts. (Fig. 7. Note dihedral angle which insures fuel flow.) The spar flanges, which have a different width for each portion, are connected by strong hinges (fig. 10), made of special high resistance J. H. steel. These fittings withstand stresses of the order of 100 t (220,462 lb.). The spar is designed to take all the bending stresses. Its width being comparatively small the flanges are consequently rather thick. Local buckling is completely eliminated and the metal works under practically the best conditions. Figure 5 shows central part of spar.

The leading edge is designed to withstand the drag and torsional stresses. It consists of box ribs and plain ribs cross-braced by small longitudinal strips. The covering is smooth sheet duralumin, the thickness varying according to the stresses. (Figs. 6, 9 and 14, the latter taken after the static test.) The leading edge is connected with the spar by two long hinges, the axes of which are made of 20/10 mm (.79/.39 in.) piano wire. All the sections along the span are connected with one another by continuous hinges following the outline of the wing section. (Figs. 7 and 10.) The great advantage of this method is the easy dismantling for repairs.

The trailing-edge stresses are transmitted to the front spar. Following current Dewoitine practice the trailing-edge portion is made of tubular ribs to which is riveted the smooth sheet-duralumin panel covering.

Near the center the lateral boxes form fuel tanks. They increase the strength of the wing, especially in withstanding torsional and drag stresses. Each solid rib is flanked by two lightened ribs as shown in Figure 8, the structure of the eight tanks forming the leading edge of the wing. Figure 9 gives the central portion of the wing before the tanks are installed. Figure 12 illustrates one of the tanks before sides are attached.

Tightness is achieved by the Lefrancois method recently accepted by the Services Techniques. This method permits riveting with a normal distance between rivets and requires no special precautions. Once the tank is completely finished tightness is achieved by pressing a special compound into the tank. Injected in a liquid and hot state, this compound fills all the interstices between sheets and hardens in cooling. The tank is thoroughly cleansed with hot water. The triple protection, thus achieved without difficulty, is fully satisfactory.

The 16 duralumin tanks are distributed in groups of four on both sides of the spar to which they are hinged with their filling orifices and quick-emptying valves arranged as shown in Figure 4. The hinging of the tanks to the spar is shown in Figure 13. Near the top of each tank are two connections for the 12/14 mm (.47/.55 in.) pipes through which the controls of the quick-emptying devices pass. The weight of the tanks including plugs and hinges varies between 3.5 and 4% of the fuel weight. Their total capacity is 8000 liters (2113 gal.). A careful inspection of Figure 11 will explain the spar structure showing the hinges along the top and bottom flanges.

It was endeavored to bring the aileron C.G. close to the hinge axis and to reduce their inertia. Also, in order to avoid possible jamming due to the curvature of the wing tips, the ailerons are divided into several portions, each of which carries only two hinges.

The shell-type fuselage is of the usual Dewoitine type. The structure consists of bulkheads and frames connected by four main U-section longerons and by small stringers of the same shape. The covering consists of sheet-duralumin panels.

Figure 15 shows structure of fuselage. The inverted fuselage is on its assembling jig. Note at top first four frames and crosspieces designed to support floor of cabin.

Figure 16 shows inside of D 33 looking forward. Note free passage which permits easy communication between the different stations, and the large windows. In center of foreground is the control lever of the quick-emptying devices, operated by the navigator whose seat is on the left surrounded by a main box frame. On the right is the map table and, near the forward pilot's seat, the brake lever. Fuel gauge is on the right under map table. Portion of spar is seen through opening in floor.

In order to facilitate assembling the fuselage is cut off behind the wing spar and attached to it by four bolts. The forward portion is connected by two bolts with the rear portion and by four bolts with the leading edge of the wing.

The upper covering of the leading edge forms the floor of the cabin. The trailing edge does not pass through the fuselage. This facilitates the installation of the navigator's and radio operator's stations, for which all the rear space remains available. During long-distance and endurance flights the crew must remain in the air for about three days and nights and requires comfortable accommodations. These are shown in Figure 17, as follows:

<u>Chief pilot's cockpit</u>.- The pilot, seated in front, has perfect visibility. Roof can be quickly opened for parachute jumping. Wind shield has sliding panes. Instrument board is placed within easy view of pilot and suspended elastically. Seat located on left, leaving free passage on right. Stabilizer control wheel is at left of pilot. At his right and slightly in front are the brake-control levers. Hot air can be let in from behind radiator through adjustable trap. This system is very satisfactory for heating cabin.

<u>Navigator's station</u>.- This is located behind chief pilot's cockpit. There is no bulkhead from pilot's seat to end of fuselage. In front of navigator there is a small dashboard with navigation instruments (compass, clock, speed indicator, altimeter). Navigator can also see pilot's instrument board. Drift indicator in floor permits vertical sighting. Panels in top of fuselage permit forward and backward sighting. Map table is at his right. This table folds against wall, leaving free passage. Dual controls enable navigator to relieve pilot without leaving his seat.

<u>Radio operator's station</u>.- This is equipped with a long-wave set and a short-wave set. The operator is comfortably seated and his instruments are readily accessible. Radio sets do not affect compasses, which are located at other end of

cabin. The retractable generator is mounted on a telescopic mast. Couch and lavatory are abaft the radio station.

Diagram of D 33.- 1, water tank; 2, oil cooler; 3, gravity fuel tank; 4, oil tank; 5, retractable water radiator; 6, fuel tanks in leading edge; 7, pilot's seat; 8, lower fuel tank; 9, navigator's seat; 10, rear fuel tank; 11, radio set; 12, radio operator's seat; 13, retractable generator; 14, W.C.; 15, reserve water tank; 16, couch.

The landing gear consists of a bent axle of uniform strength supported in front by a biconical tube and vertically by a shock absorber. The wheels, of 1300 mm (4.27 ft.) diameter, mounted on ball bearings, are equipped with brakes which can be operated separately by the pilot.

The axle is attached below the wing spar and the compression member rests on a fuselage frame at the connecting point of the engine bearer. The shock absorber transmits its stress directly to the spar. Wheel track, 4.5 m (14.8 ft.). The tail skid has a dirigible rubber-tired wheel and is supported by a shock absorber (multiple-braked spring type) in the stern post.

The stabilizer (fig. 18) has two parallel spars connected by ribs. It has a span of over 7 m (about 23 ft.). The covering, in strips parallel to the spars, is stiffened by flanged edges and sections. The bending stresses are absorbed by the boxes formed by the spars and covering. The demountable leading edge is hinged to the front spar.

The rear part of the fuselage being strongly tapered in order to increase the efficiency of the controls, the small contact area does not permit the use of a cantilever stabilizer. The spars are therefore braced by small tubular struts.

The stabilizer is adjustable in flight by a square-threaded screw mounted on the rear spar and operated by a nut, cable and wheel. The angle of incidence of the stabilizer is indicated by a pointer.

The elevator flaps consist of a channel-section front spar on which are mounted two panels internally stiffened by section members. These panels are removable and simply hinged to the spar. The fin is hinged to the stern post and its front spar is secured by two bolts to one of the fuselage frames. The rudder is of the same construction as the elevator flaps.

The engine, a direct-drive 650 hp Hispano-Suiza, is mounted clear of any obstruction in the nose of the fuselage.

Details are shown in Figure 19 as follows: 1, air-intake heating tube; 2, fuel filter; 3, oil filter; 4, fire extinguishers; 5, gravity fuel tank; 6, space for retractable water radiator.

Water circulation.- The honeycomb radiator is located in the bottom of the fuselage. It is partly retractable by tubular controls working in torsion and by a square-threaded screw. A reserve water tank is located above the engine cylinders. Additional water can be supplied from a small reserve tank in the fuselage.

Oil circulation.- The tank, containing 380 liters of oil, is located behind the engine from which it is separated by a fireproof bulkhead. Before reaching the engine the oil flows through a large easily removable filter. The oil piping is of duralumin. The blade-type radiator is located in the cowling.

Figure 20 shows the fuel circulation as originally devised for the D 33. This scheme is characterized by great simplicity, the pilot having merely to open all circulation cocks at the start, viz., the two of the collector Q and the one at R. As shown in Figure 21 this scheme was changed by the Dewoitine Company chiefly in order to prepare the D 33 for record-breaking attempts with useful load, the latter being the fuel in some of the tanks which were sealed for this purpose.

Tank arrangement.- The tanks are grouped in rows of four, e.g., $E_1$, $E_2$, $E_3$, $E_4$, and connected by 14/16 mm (.55/.63 in.) pipes which insure free flow in any position of the airplane. The deliveries of the two rows of each half wing are checked at the twin-cock collector Q (gravity feed due to wing dihedral) from which the fuel flows to the feed tank N in the fuselage. The bottom of N forms the low point of the circulation. Low points are necessary to avoid accidental penetration of air into the fuel system in flight when all the tanks are approximately on the same level. This proposed system of communicating vessels insures a symmetrical and very direct fuel flow toward the feed tank.

Air intakes.- The air intakes of each tank are connected by 6/8 mm (.24/.31 in.) tubes which lead into the open air in the fuselage. The air intake of the feed tank is on the same level as those of the lateral tank groups. This general level is sufficient to prevent the fuel from overflowing owing either to the wing dihedral or to transverse inclinations in flight.

<u>Pumps</u>.- Two pumps, $P_1$ and $P_2$ supply the feed tank N. A manometer M is connected with the pressure-feed collector. In the above scheme it was proposed to use strainers on the way from the feed tank to the pumps, but owing to the length of the contemplated flights it would have been necessary to use very large strainers and to provide a set of cocks for inspection of the valves. It was thought safer to extract the strained water and impurities by means of a small hand pump P' draining a small cup in the bottom of the feed tank. This simple method has already given good results in endurance flights. It permits a very safe installation of a suction pipe for the mechanical pumps, with the smallest possible number of joints, thus greatly reducing the possibility of defective operation. The small cup at the bottom of the feed tank does not produce any appreciable drag if properly faired.

Figure 21 shows the actual fuel circulation of the D 33. This differs from the scheme in Figure 20 chiefly in the tank arrangement and in the additional feed tank $N_s$, which can be filled with fuel by the hand pump $P'_1$, in case of failure of mechanical pumps. Besides all the tanks can be isolated and sealed. Each one has its own filling plug and the communication orifices can be easily closed.

<u>Tank arrangement</u>.- The tanks are connected two by two on both sides of the spar ($E_5$ with $E_1$ ..., $E_7$ with $E_3$, etc.) by 8/10 mm (.31/.39 in.) pipes. These pairs of tanks are matched symmetrically with respect to the airplane axis ($E_5$-$E_1$ with $E_{16}$-$E_{12}$) by means of a four-cock collector Q. The ball pressure valves in c prevent, during transverse inclinations of the airplane, the transmission of the fuel pressure, e.g., from the pair of tanks $E_5$-$E_1$ to the pair $E_{16}$-$E_{12}$, under the action of the difference in level between the raised and the depressed wing. The pressure head with respect to the bottom of the feed tank N is approximately 30 cm (11.81 in.). The level gauge n, although connected with a pipe through which the fuel flows, gives sufficiently accurate indications. The four end tanks are normally filled with benzolated gasoline and the others with pure gasoline.

<u>Air intakes and quick-emptying devices</u>.- The four end tanks $E_1$, $E_5$, $E_{12}$, $E_{16}$, have no quick-emptying devices and are connected with the open air individually by small tubes t of 4/6 mm (.16/.24 in.). The other twelve tanks are provided with tight-closing, quick-emptying devices operated by a single lever. The seats of the air-intake valves are indicated by two concentric circles. The airplane would float if forced down on water.

Groups of three tanks, such as $E_{13}$, $E_{14}$, $E_{15}$, are connected by a double 12/14 mm (.47/.55 in.) pipe running through the top of their sides and leading into the open air. The chief purpose of these pipes is to guide the two control cables of the quick-emptying device. This double pipe is immersed in the fuel when the tanks are full but its openings are cleared when the level drops. The connection of such a series of three tanks with the open air is established by a 4/6 mm (.16/.24 in.) tube t' which extends about 6 cm (2.36 in.) above the wing.

The system of extracting the strained water from the bottom of N below the filter, shown by a horizontal dash line in the figure, is similar to that of the preceding scheme. (Fig. 20.) A small hand pump P' is used. The legend of Figure 20 relating to the diameter of the fuel pipes also applies to Figure 21. In order to simplify the representation, the 8/10 mm (.31/.39 in.) pipes connecting two by two the tanks on both sides of the spar are indicated by lines of the same thickness as those representing the 10/12 mm (.39/.47 in.) pipes.

Engine equipment.- Scintilla magnetos and switches, Ratier metal propeller, Vincent André water radiator, Viet starter, A.M. joints, cocks and pumps, "Superflexit" flexible fuel piping, Lévy fire extinguishers, Jaeger revolution counter, L.T.I. oil and water aerothermometers, Amyot oil manometer, A.M. fuel-pressure gauge.

Navigation instruments:- Aéra turn-and-bank indicator, order-transmission device and inclinometer, Morel-Krauss compass, Krauss drift indicator, Richard altimeters, Ramondou map holder, Gyrorector, Wilhelm-Morell air-speed indicator, Radio-Industrie long-wave and Minguet short-wave radio equipment.

Miscellaneous equipment:- Aéra and Jaeger clocks, Gouet pilot belts, Therm'x catalytic heater, Triplex glass, round Jacottet wires (for flight controls) and Avionol dopes.

## Characteristics

| | | | | |
|---|---|---|---|---|
| Span | 28 | m | 91.86 | ft. |
| Length | 14.4 | " | 47.24 | " |
| Height (upper propeller tip, tail skid on the ground) | 4.85 | " | 15.91 | " |
| Height (top of fin in line of flight) | 5 | " | 16.4 | " |
| Weight empty | 3100 | kg | 6834.32 | lb. |
| Total weight | 9200 | " | 20282.5 | " |

Translation by W. L. Koporindé,
Paris Office,
National Advisory Committee
for Aeronautics.

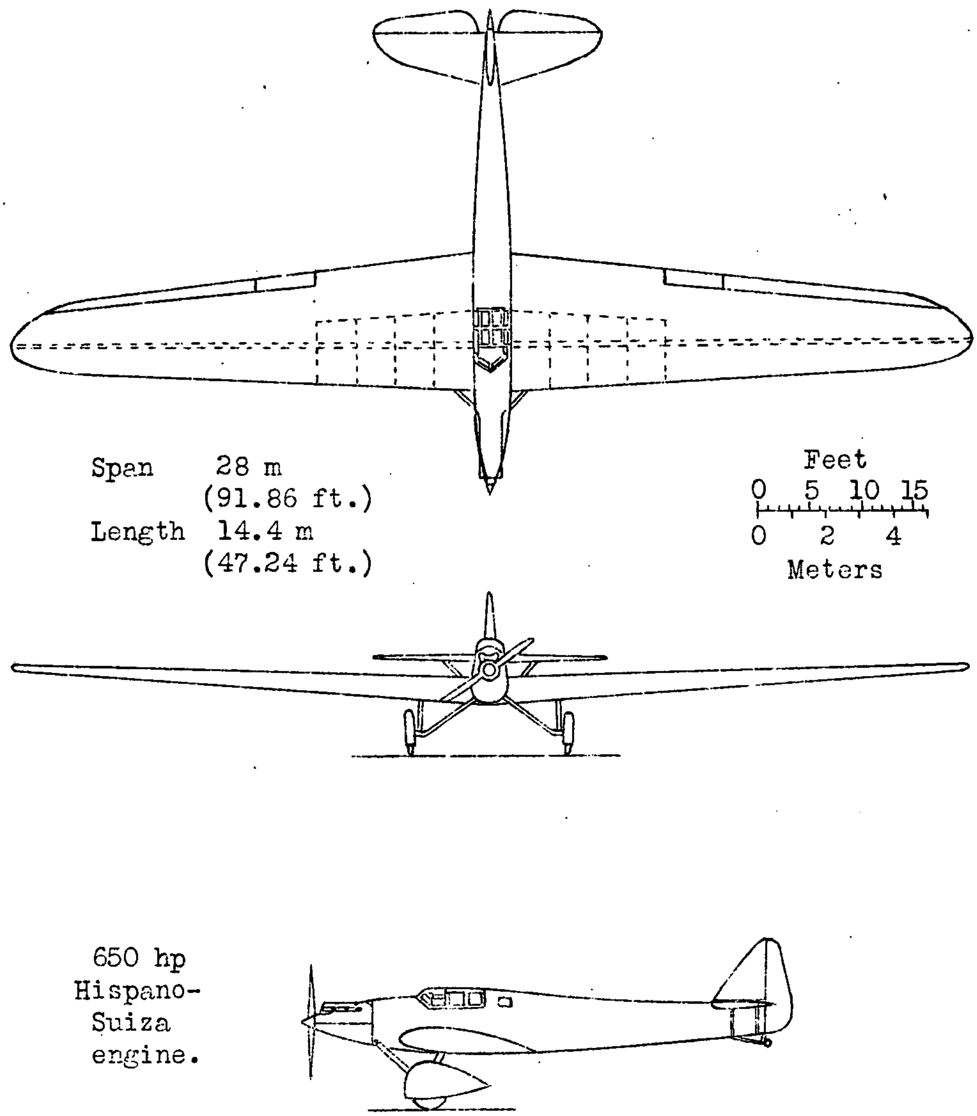



Fig.1 General arrangement drawing of the Dewoitine D.33 airplane.

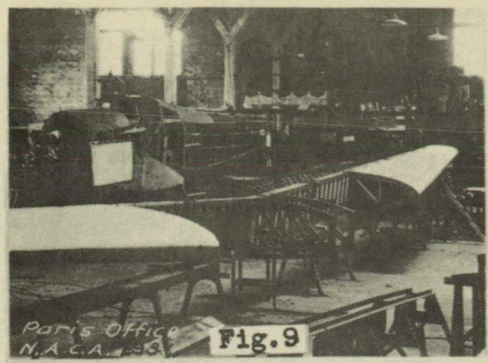



Fig.9

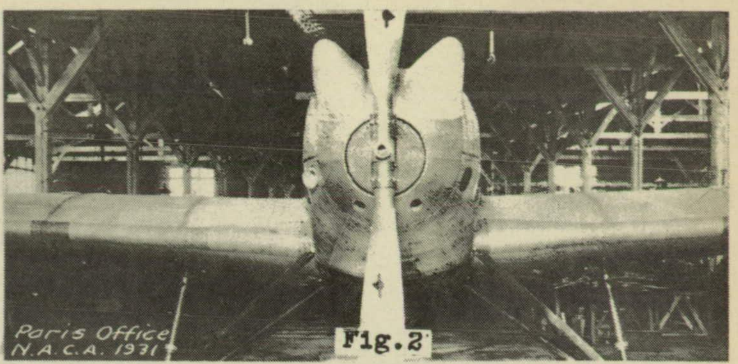



Fig.2

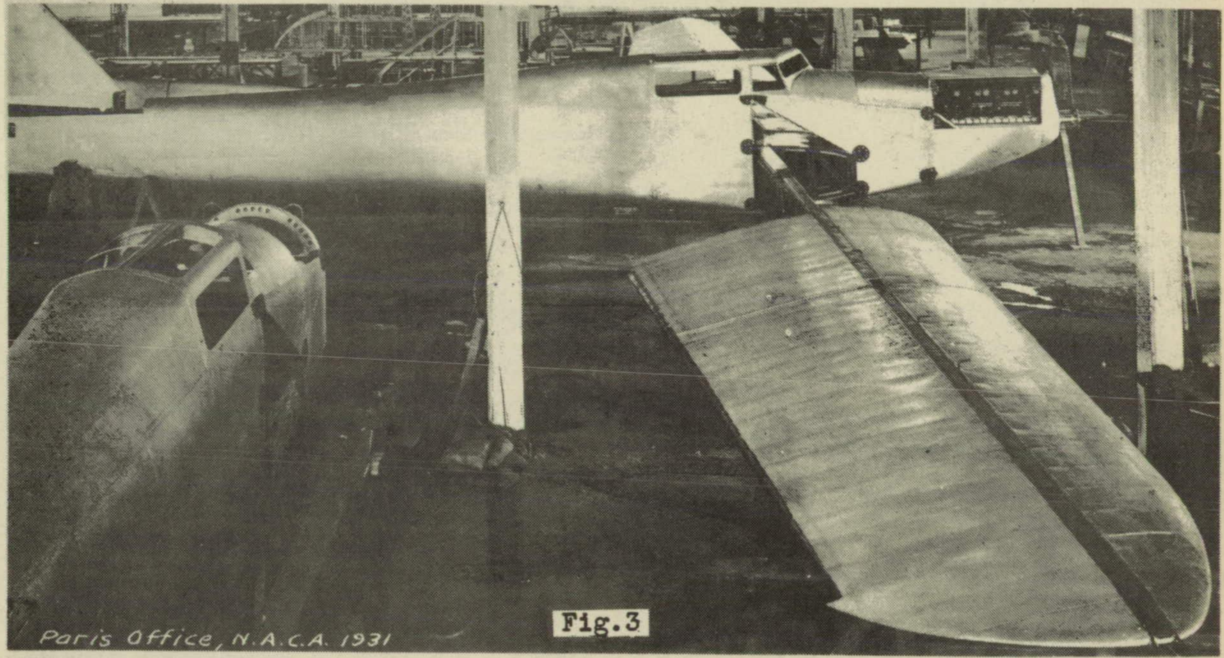



Fig.3

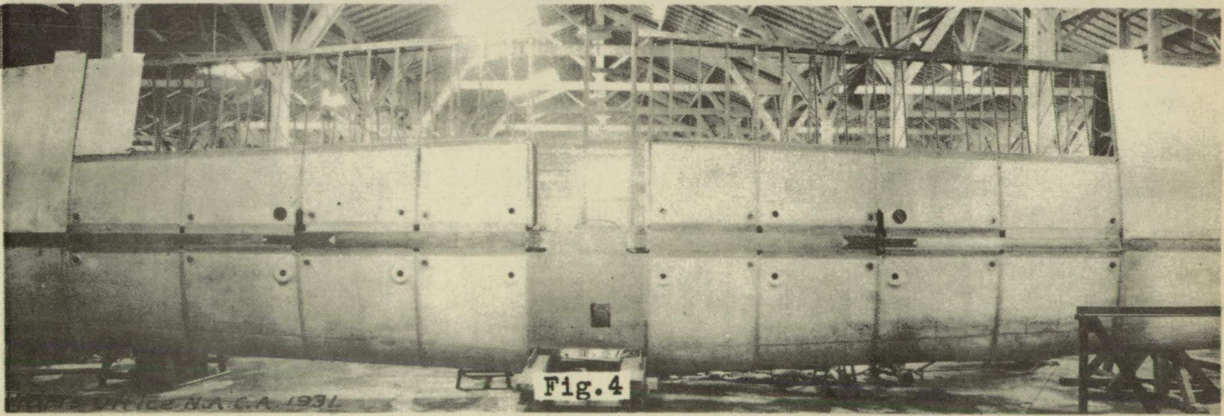


Fig.4

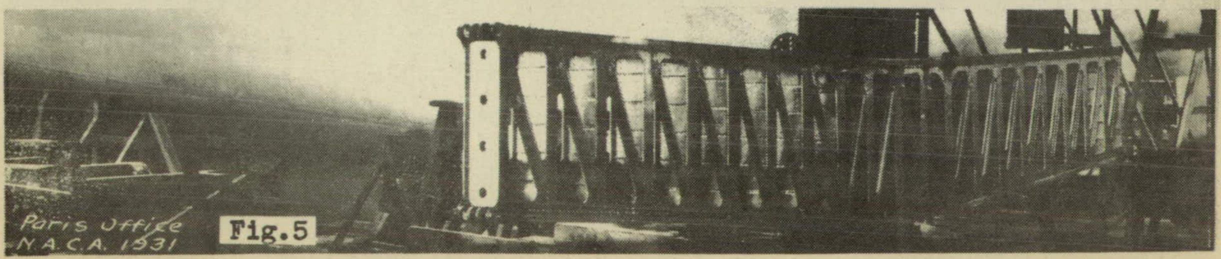



Fig.5

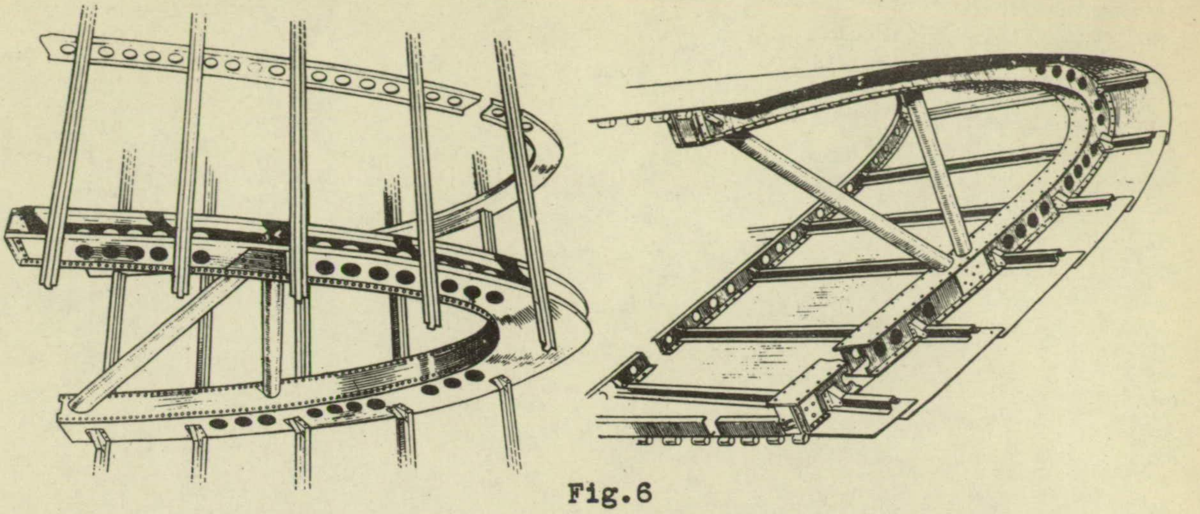


Fig.6

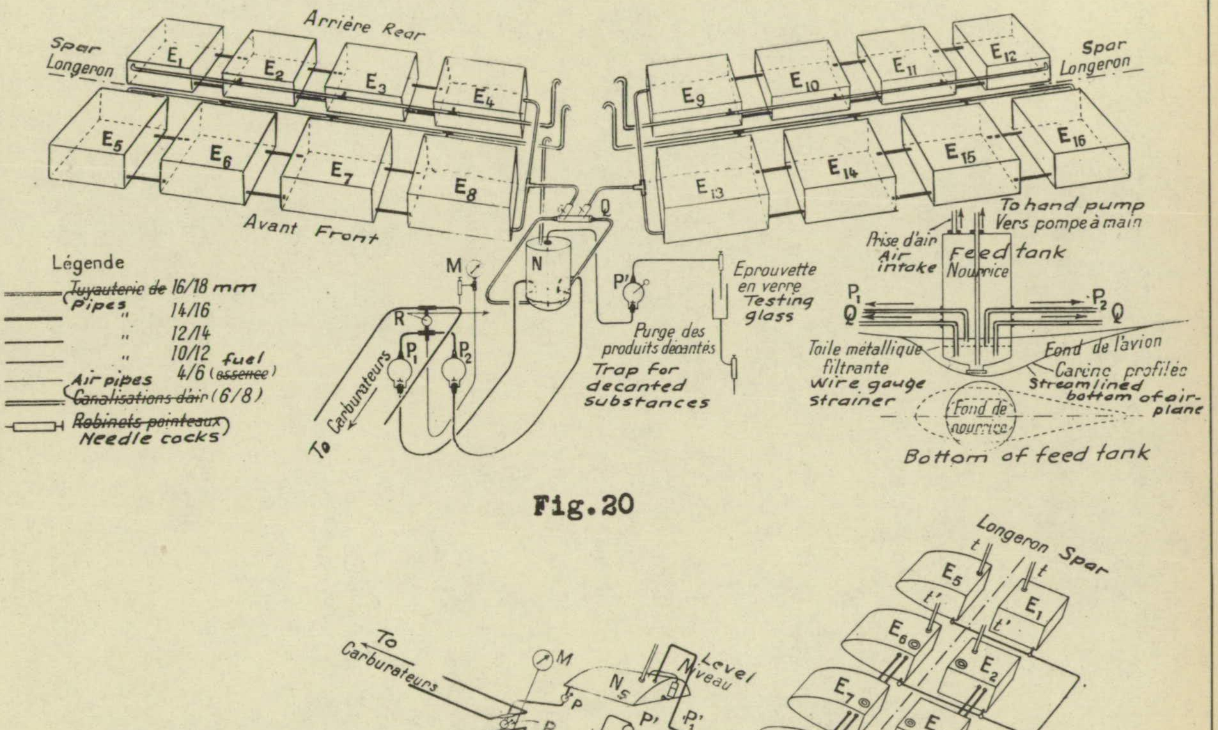



Fig.20

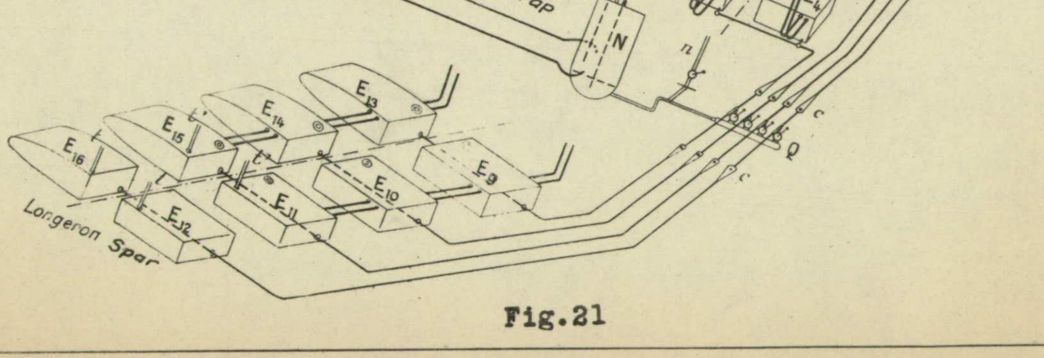



Fig.21

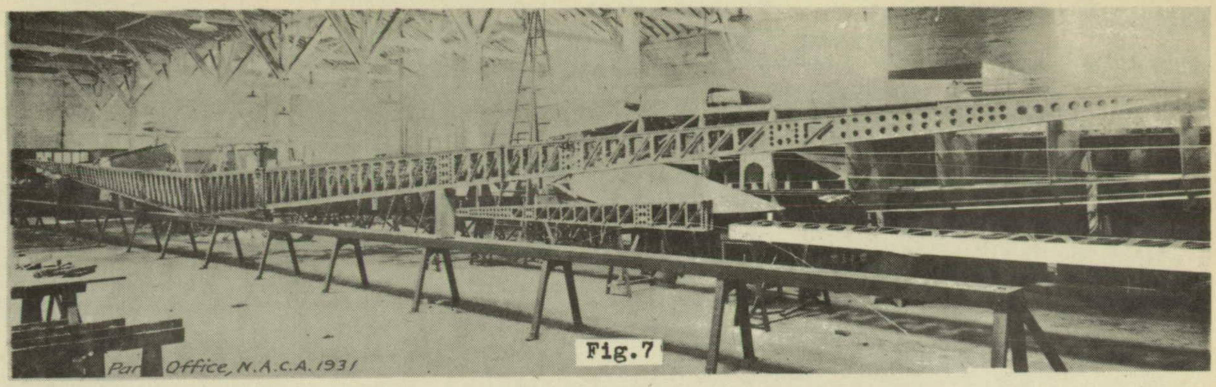


Fig.7

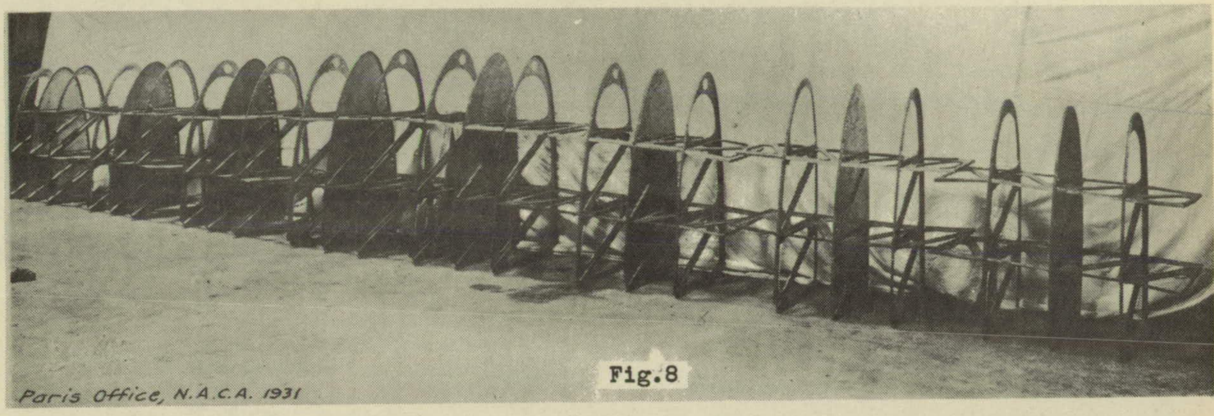


Fig.8

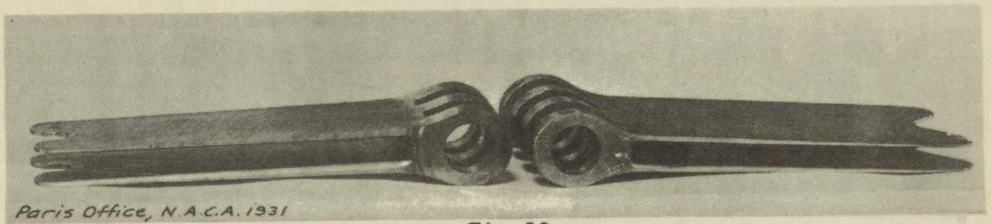


Fig.10

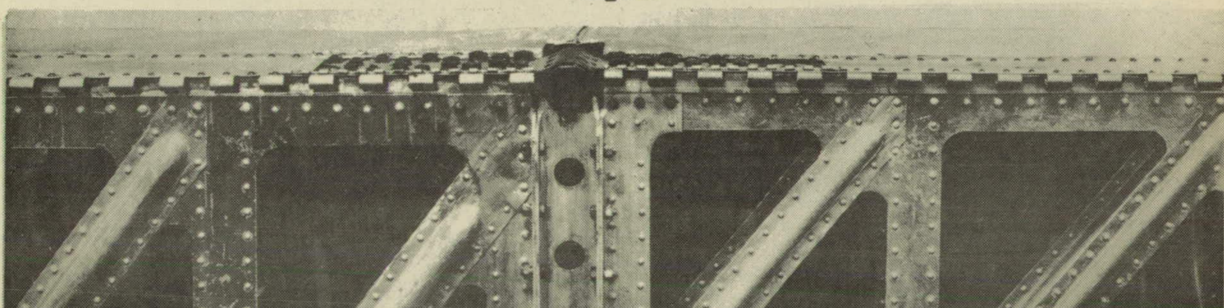


Fig.11

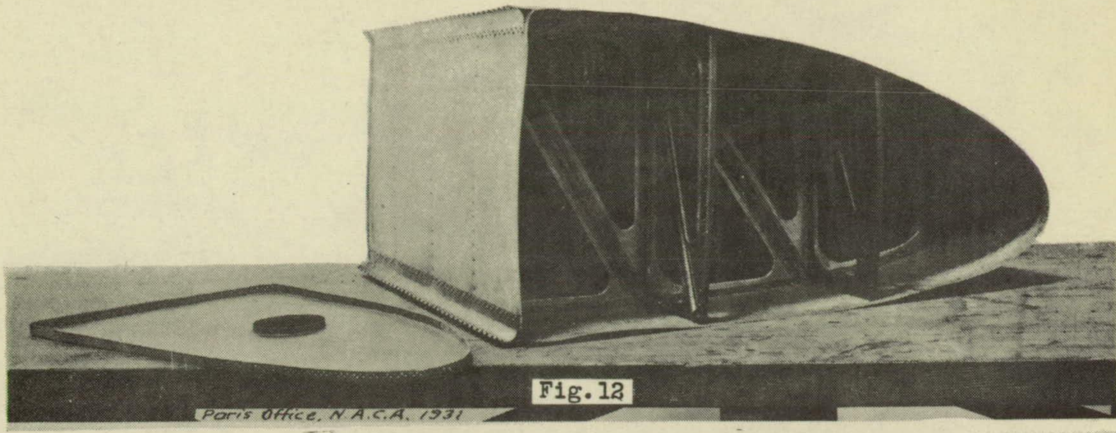



Fig.12

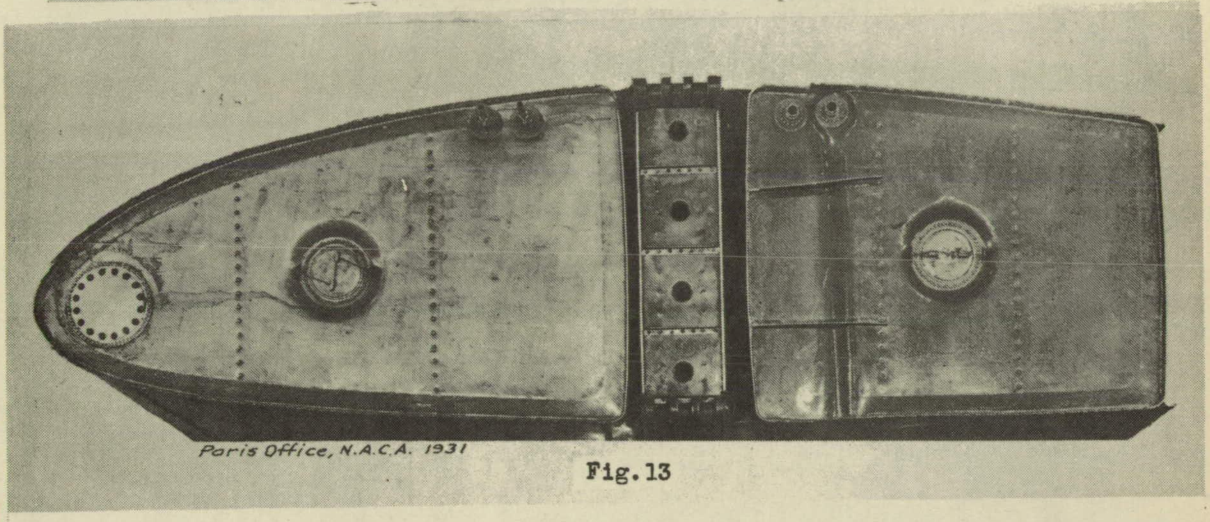



Fig.13

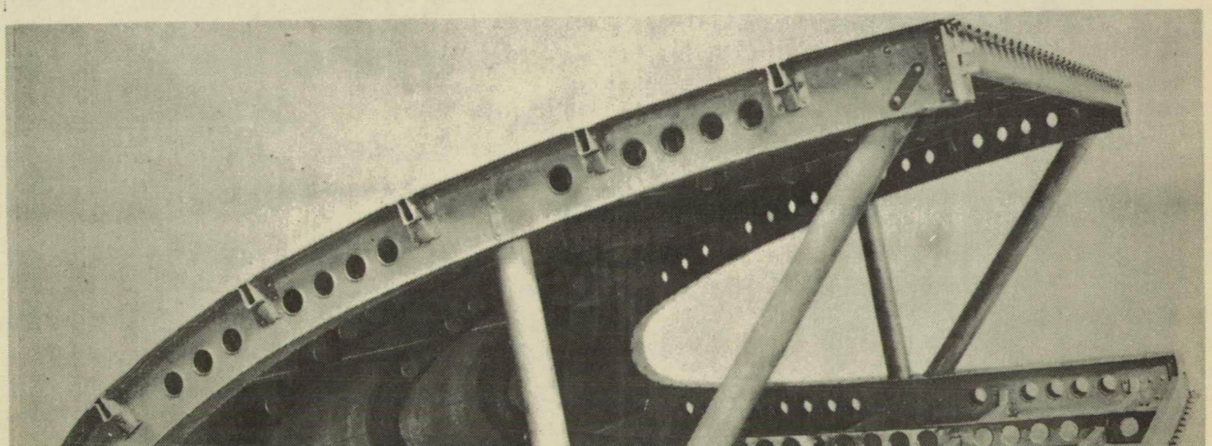



Fig.14

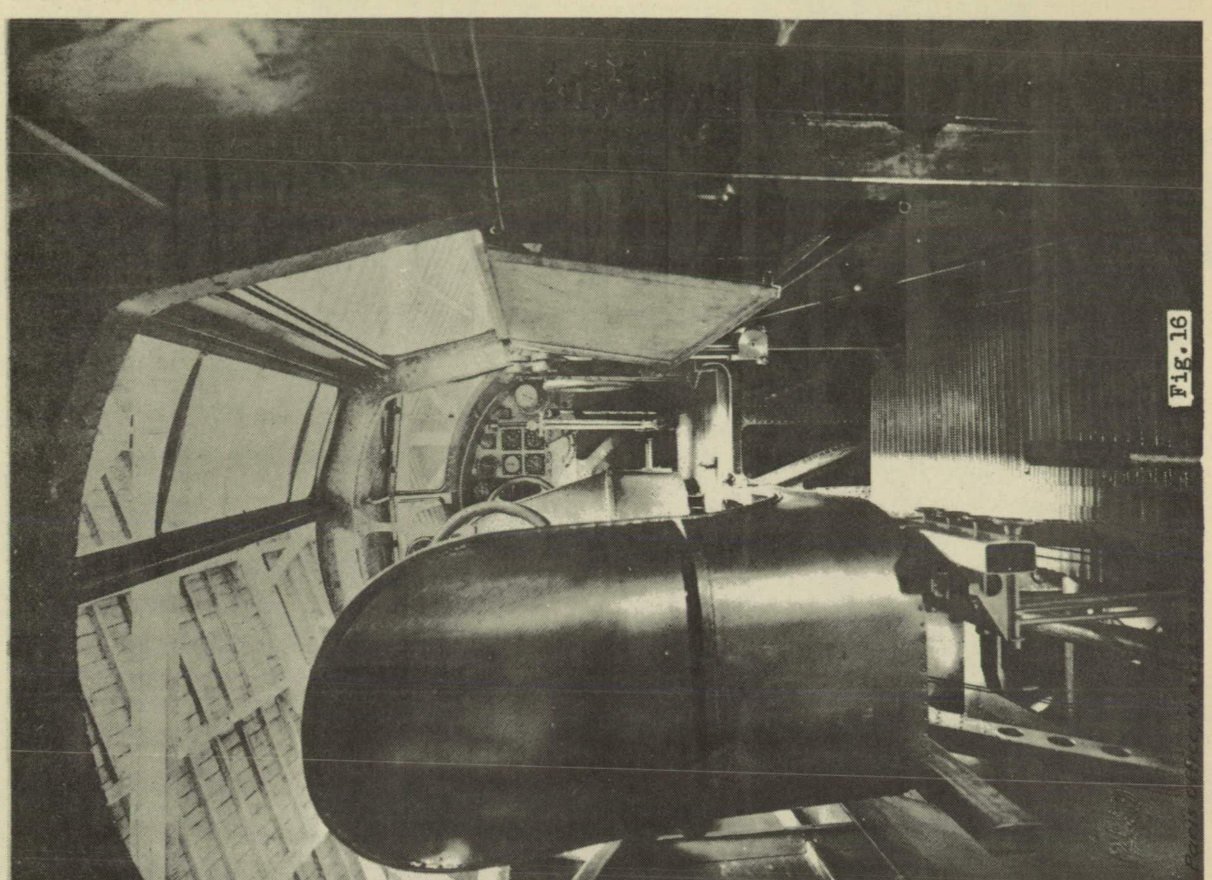


Fig.16

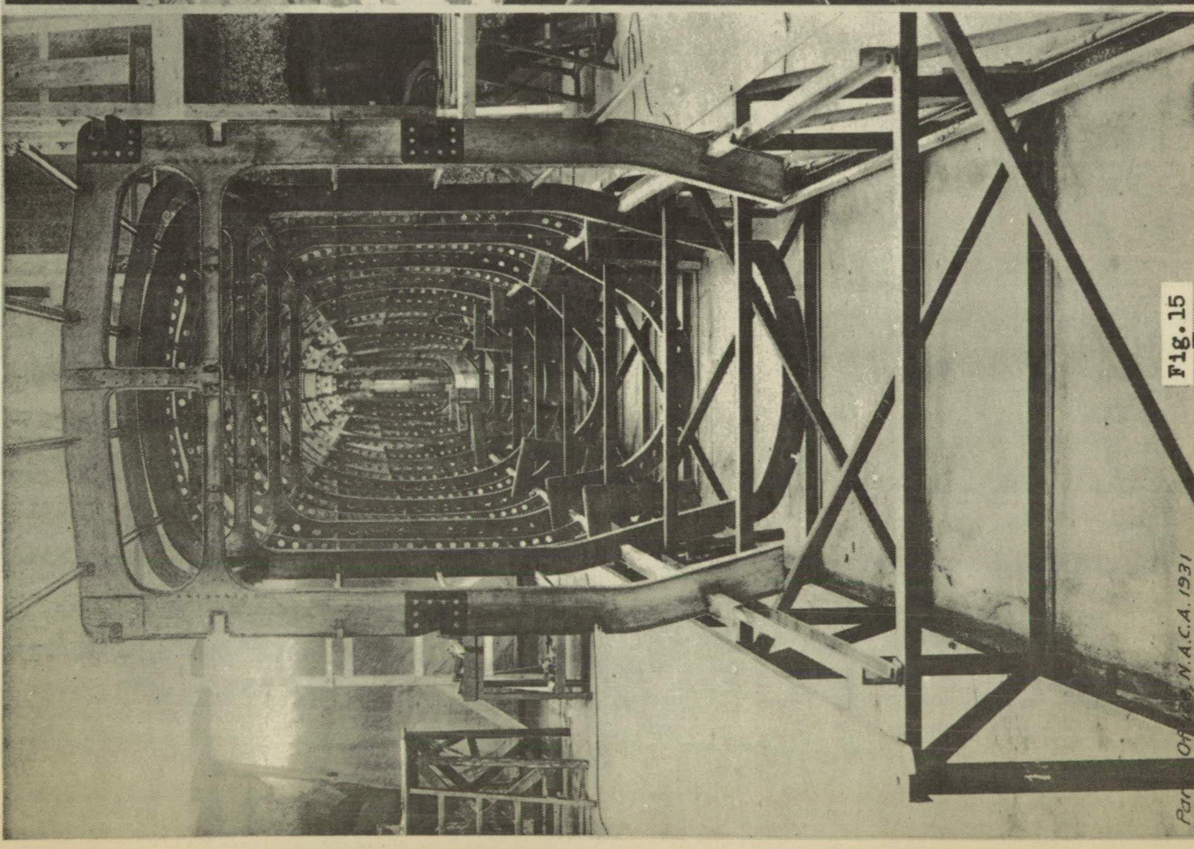



Fig.15

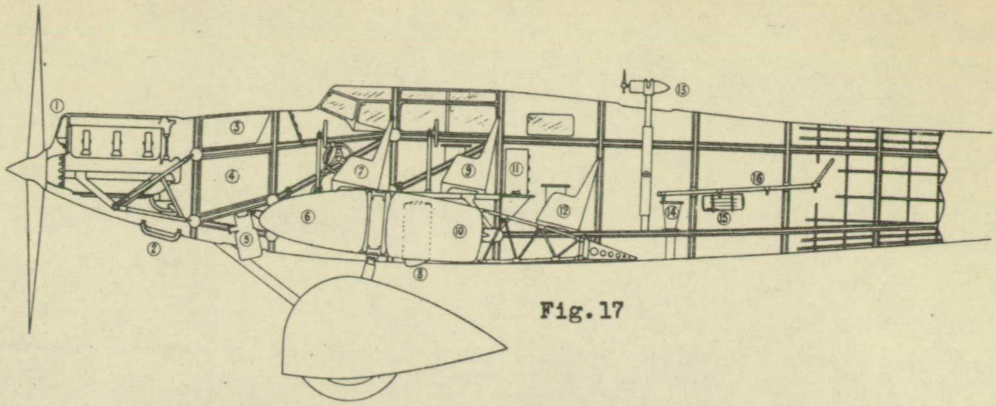
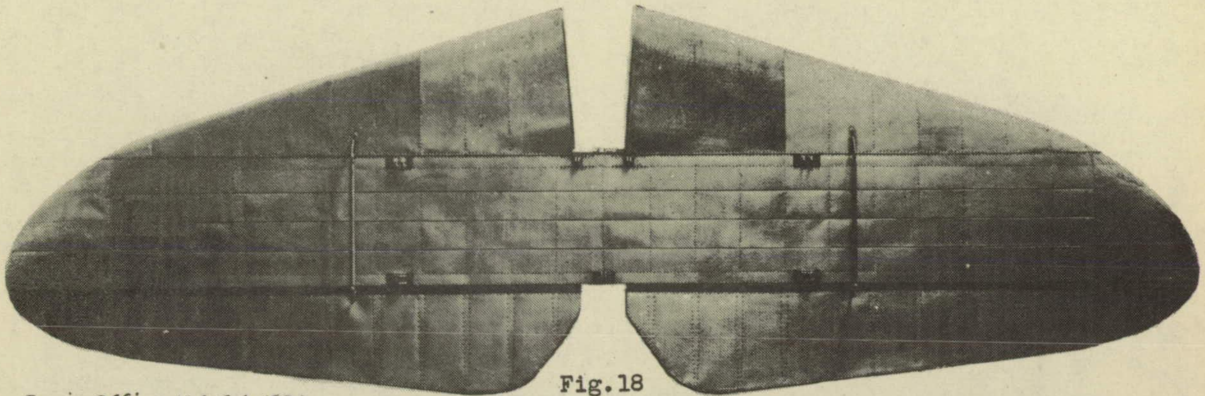



Fig.17



Paris Office, N.A.C.A. 1931

Fig.18

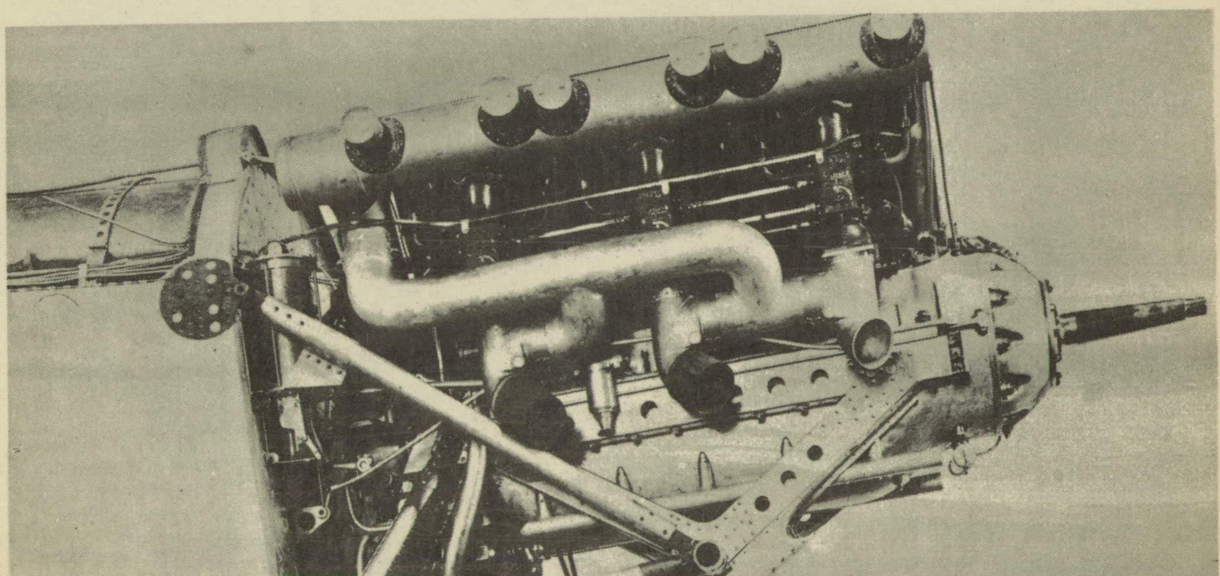


Fig.19

Paris Office, N.A.C.A. 1931