AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 16

ALBATROS COMMERCIAL AIRPLANE L 73

By Karl Rühl and Hasso Wiederhold

From "Zeitschrift für Flugtechnik und Motorluftschiffahrt"
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ALBATROS COMMERCIAL AIRPLANE L 73.*

By Karl Rühl and Hasso Wiederhold.

This is a two-engine commercial biplane (2 B.M.W. IV engines) for carrying two pilots, eight passengers and 160 kg (353 lb.) of baggage (Figs. 1 and 2).

The entire framework is metal, principally steel tubing and dural shapes. The fuselage and wings are covered with plywood and fabric. The chief reasons for this manner of construction were: first, maximum simplicity and economy of manufacture, as well as convenience in making repairs; second, saving in weight by using open-work forms, notwithstanding the increased strength requirements.

The method of assembling affords a relatively favorable compromise between the two, often conflicting, requirements. The cost of production is reduced by the employment, wherever possible, of standardized parts for connections, etc. The resulting increase in weight was kept within quite small limits.

The cell structure was made as simple as possible: a biplane cell with engine struts and outer struts, the wings being identical in span and other dimensions. It has two bracing planes, each with main and counter braces, both double, so that

* From "Zeitschrift für Flugtechnik und Motorluftschiffahrt," July 28, 1926, pp. 295-299.

for each half wing, there are four main and four counter cables. The corresponding upper and lower wing spars lie approximately in the same vertical planes, thus simplifying the fittings for the struts and cables. The outer parts of the spars are jointed to the central parts, which pass over and under the fuselage. These joints are not located at the engine struts, but about 85 cm (33.5 in.) outside. The moments in the outer field are accordingly about 30% smaller than if the joints were located at the engine struts.

The wing spars (Fig. 3) have flanges of pressed dural with a U-shaped cross section opening inward, so that the diagonal braces could be easily attached by four rivets at each end. The change in the construction, as compared with the wing spars of the Albatros L 72a ("Zeitschrift für Flugtechnik und Motorluftschiffahrt," May 28, 1926), in which lateral strips were riveted to somewhat differently shaped flanges, was necessitated by the greater height of the spars, about 20 cm (7.87 in.). Special reinforcements were necessary to insure the vertical strips against buckling. On the other hand, the possibility of outside riveting was not so important, since there was here, in the open cross sections, sufficient space for inside riveting. No lateral folding of the flanges and webs is to be feared, as has been demonstrated by experiments, since their necessary thickness is several millimeters. Between the wing spars, there are ribs of welded steel tubing. The whole rib, from the lead-

ing to the trailing edge of the wing, forms a single piece and can be pushed down over both spars, so that the assembling is simplified and, in case of injury, each rib can be removed and replaced separately. The flange tubes of the ribs are held laterally by the fabric covering. Their dimensions could therefore be quite small, the largest tube used for the ribs having a diameter of only 7 mm (0.28 in.).

The interval bracing is entirely separated from the rib structure and arranged double in the plane of the upper and lower flanges of the spars. The diagonals are steel-wire cables, the uprights are steel tubes which also support the spars.

For strengthening the main brace, there is introduced between the two flanges of the spar, a box-shaped piece of sheet steel, which is riveted to the spars above and below. A bolt for securing the brace cable is located in the middle. The spars are drawn together at the joint and enclosed in a riveted housing of sheet steel. The favorable location of the spars in the wing and the arrangement of the joints outside the engine struts renders it possible, without much increase in weight, to give to all the flanges of all the spars, in the outer and central portions of the cell, the same external dimensions and the same thickness. The front upper spar and both the lower spars have, moreover, the same thickness of web and are therefore exactly alike, while the flanges of the rear upper spar differ only in the thickness of the horizontally located web. Accordingly, all

the diagonals and assembly bolts could be alike. The cell is joined to the fuselage by a cabane of steel-tubing struts, consisting of two vertical supporting walls, as shown in Fig. 9. They are joined by the engine nacelle and by struts from the points a to the points b (for absorbing the frontal stresses).

The fuselage and tail group are welded from steel tubes (Figs. 4, 5 and 6). The rear portion of the fuselage is braced by double wire cables. Figs. 5 and 6 show the design of the fuselage.

The horizontal empennage has a total area of about 11.6 m^2 (125 sq.ft.) including an adjustable stabilizer of about 8.5 m^2 (91.5 sq.ft.) and two coupled elevators. The latter have a triangular framework, like the elevator and rudder of the Albatros L 72, as shown in Fig. 10. The torsional moments are received by a triangular cross section, through a system of three girders with common flanges. The ribs and diagonal brace-wires of the flat framework girders, need thereby to be only a little stronger than if a torsion-rigid spar (with a nearly circular cross section) were assembled with parallel ribs. The vertically located girder receives only bending moments, no torsion moments, and the torsion moments themselves generate stresses only in the diagonals and uprights, but not in the flanges.

The horizontal stabilizer has two spars or girders composed of a thin sheet-metal web riveted to flanges drawn from steel tubing. These spars are somewhat heavier than dural spars of

equal strength, but are easier to use, since the ribs can be welded directly to the spar flange. The web is 0.5 mm (0.02 in.) thick. This is sufficient, as shown by careful experiments with relatively shallow and hence easily impressed corrugations, to withstand the transverse stresses. The vertical empennage consists simply of a rudder of about 2.75 m² (29.6 sq.ft.) area, in the form of a dural box girder with riveted steel-tubing ribs.

The landing gear has a combination oil and rubber shock absorber, as illustrated diagrammatically by Fig. 11. On contact with the ground, the oil is forced through the opening a and the rubber columns are compressed. The full stroke of the shock absorber is 20 cm (7.87 in.). The force on the rubber is small at first and gradually increases. The force on the oil is large at first. The total effect is therefore relatively great. In order to reduce the weight and the structural drag, the landing gear axles (which also serve as struts) are made of chrome-nickel steel, with a strength of 100-120 kg/mm² (142235-170682 lb./sq.in.). Each axle strut is pivoted to the outer edge of the fuselage and turns about this point of suspension. A strut, which is attached to the bottom of the shock absorber and extends backward, receives the forces acting from the front (Fig. 8).

The cabin has seats for eight passengers (Fig. 12). Each seat has a high adjustable back and can be changed into a reclining couch for night flights. There is then room, however,

for only four passengers. The entrance is from the rear and is near the ground. Behind the entrance door, there is a toilet room and a small baggage room, the main baggage room being in the bow. Access to the pilots' room is also through the cabin. In front of the pilots' seats there is the instrument board, which is provided with all the modern instruments for both day and night flight. The steering gear is dual. Under the pilots' seats there is a radio outfit.

Distribution of Dead Load

	%	%
1. Cell		
Spars, including attached fittings	9.85	
Ribs, excluding ailerons	2.26	
Wings, completely covered and doped, including ailerons but excluding fuel tanks in upper wing		22.60
Brace wires	1.28	
Outer struts	1.05	
Cabane and engine supports	4.64	
Total weight of struts and wires		6.97
2. Power plants and fuel tanks		
Engine mountings	1.36	
Fuel tanks	2.17	
Total driving gear, including radiators, propellers, engine mountings, housings, engine rods, exhaust pipes, oil and fuel tanks		32.67

3. Fuselage and furnishings		
Fuselage frame	8.12	
Cabin (walls, doors, windows, seats, etc.) including toilet and rear baggage room	8.98	
Fuselage covering	1.36	
Pilots' seats, front baggage room, instruments and steering gear	7.35	
Total weight of fuselage and furnishings		25.81
4. Landing gear		7.75
5. Tail skid with rubber		0.54
6. Tail group, complete		3.66
		100.00

The useful load is equal to about 53% of the dead load, the specially installed instruments being included in the dead load.

For judging the given percentages, the strengths are important, which were taken as the basis of the computations. These strengths, corresponding to present-day views, are considerably greater than formerly called for by the B.L.V. (construction and delivery specifications). The computed breaking strengths of the airplane in the principal flight cases are as follows:

Case A (Pulling out of a dive)	6.0 (According to the B.L.V. 4.0),
Case B (Gliding)	3.5 (According to the B.L.V. 2.5),
Case C (Diving)	2.0 (According to the B.L.V. 1.5),
Case D (Flying upside down)	3.0 (According to the B.L.V. 0.0).

It is important in this connection, especially for Case C, that the application points of the forces were not here based on the old specifications, but were computed from the known wing-section coefficients.

In spite of these greater breaking loads, the deflections are relatively small. The importance of the deformation for the strength of the whole wing has continually received more emphasis in recent years (Cf. the lecture of Dr. Dornier on the 1925 session of the Wissenschaftliche Gesellschaft für Luftfahrt). Hence the deflections were computed for a safe load in Case A, first at the location of the outer struts, and second at a distance of 1.5 m (4.92 ft.) beyond the struts. By "safe load" is understood one-half of the breaking load. The following values were obtained: deflection at the struts, 3 cm (1.18 in.); deflection of spar at the designated point of the overhang, an additional 1.5 cm (0.59 in.). With a strut distance of about 15 m (49 ft.), the deflection is therefore about 1/500 of the strut distance.

The L 73 is the first two-engine commercial biplane made in Germany. The task was therefore a new one and gave rise to a number of questions which could not be satisfactorily answered even on similar types produced during the war. Moreover, an upper limit was set by the stipulations to the maximum power for the best economy. In order to obtain as thorough a knowledge

as possible of the aerodynamic conditions, experiments on a model were undertaken at the Göttingen Aerodynamic Institute, on the results of which a special report is to be made.

For the aerodynamic computation, it was necessary to try to fulfill the following conditions:

1. Good propeller efficiency,
2. Favorable power conditions with one engine stopped,
3. Good stability.

For determining the best location of the power plants, the height and depth location of the nacelles between the wings and their decentralization was decisive. The present location, in about the middle of the cell, gives favorable conditions for the propeller efficiency, which is about 60%, and also for the stability. The decentralization was kept as small as possible, in order to avoid too great a yawing moment with only one engine running. The nacelles are located quite far forward, for stability considerations and for the improvement of the propeller efficiency. In order to obtain a general idea of the performance conditions, the speed data were determined by a method similar to Konig's shearing-force diagram. Even if, with respect to the limiting of the engine power, the idea of holding a commercial airplane, with two decentralized engines at full load, to speed without altitude loss with one engine had to be abandoned, it was still important to obtain the best value possible. For this purpose, the lower limit was established by the reduction

conditions, in which it was required that the airplane should have a radius of action of 20 km (12.4 miles) at an altitude of 500 m (1640 ft.) with half the pay load. The reserve power therefore had to be almost 50%, which was possible only with the most favorable aerodynamic arrangement. It is known that a braced biplane, as regards its drag, is fully equivalent to a cantilever monoplane, if the structural drag of the struts and wires is kept so small that they do not exceed the sum of the reduction of the profile drag (of a thin airfoil) and the induced drag (favorable lift-drag ratio). The employment of streamlined wires for the cell bracing was thereby necessitated.

It was first attempted to offset the falling out of one engine by using a fan-type rudder, whereby both the auxiliary rudders, on the right and left of the main rudder, lay in the propeller slip stream. The experiment gave a necessary rudder deflection of about 12°, in order to offset the turning moment about the vertical axis. Practical experience, however, showed an unfavorable and varying rudder efficiency for starboard and port flying, so that the vertical empennage was replaced by a single balanced rudder without any fin. The lateral stability of the airplane was somewhat impaired, but the steerability in any position was improved and it was easily possible to turn against the moment of yaw. The rotation of both propellers in the same direction would, in any case, have an unfavorable effect on the tail group.

For the stability, the balancing of all the longitudinal moments had to be required under the condition that it is possible without any considerable trimming by means of the loads or adjustment of the stabilizer. Hence the conditions for gliding flight and engine flight with either one or both propellers running were thoroughly investigated. Static balancing is provided for full-load flight with aerodynamic zero limitation of the stabilizer and the tail group accordingly finds itself in an unsteerable position for horizontal flight. A value nearly 25% greater than the calculated one could be found from the experimental curves for the outflow inclination. The propeller slip stream, by increasing the dynamic pressure in front of the tail group, produces a 50% greater negative moment than in gliding flight, thereby rendering an adjustment of the stabilizer necessary in passing from one flight condition to the other.

Characteristics

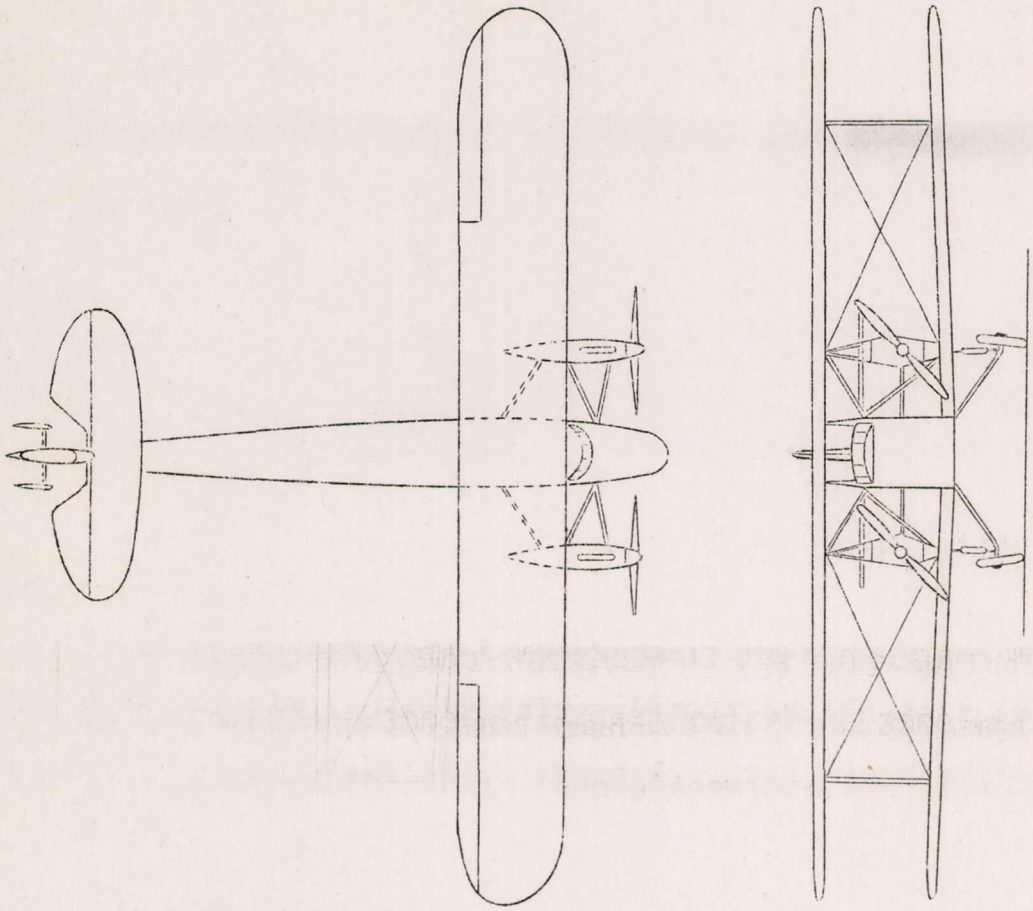
Length	14.6 m	47.9 ft.
Height	4.7 "	15.4 "
Span	19.7 "	64.6 "
Wing area	92.0 m²	990.3 sq.ft.
Horizontal empennage	11.3 "	121.6 "
Vertical "	4.5 "	48.4 "
Weight empty (dead load)	2914 kg	6424 lb.
Full load	4610 "	10163 "

Flying wt. with half of pay load	4210 kg	9281 lb.
Wing loading	50 kg/m²	10.24 lb./sq.ft.
Load per HP. (460 HP.)	10 kg	22 lb.
Power loading	5 HP./m²	0.465 HP./sq.ft.

Performances

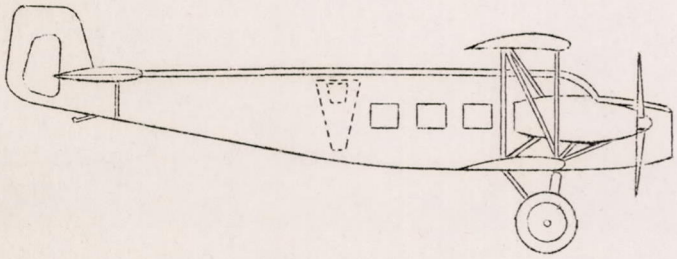
Flight time with full load	4 hours	
Speed near ground with both engines and full load	145 km/h	90 mi./hr.
Speed with half of pay load and only one engine	110 "	68 "
Landing speed	95 "	59 "
Ceiling with full load	3000 m	9843 ft.
Climbing time to 1000 m (3281 ft.)	14 minutes	
" " " 2000 " (6562 ")	30 "	

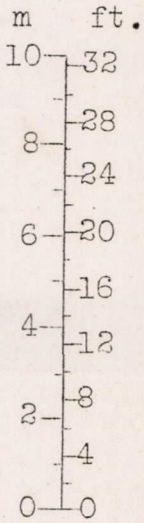
Translation by Dwight M. Miner,
National Advisory Committee
for Aeronautics.



Wing area 92m^2(990.3 sq.ft.)
Length 14.6m(47.9ft.)
Height 4.7m(15.4ft.)
Span 19.7m(64.6ft.)

Two 240HP.
BMW IV
engines





(Taken from Les Ailes Aug.27,1926)

Fig.1 Albatros two-engine commercial airplane, L 73.

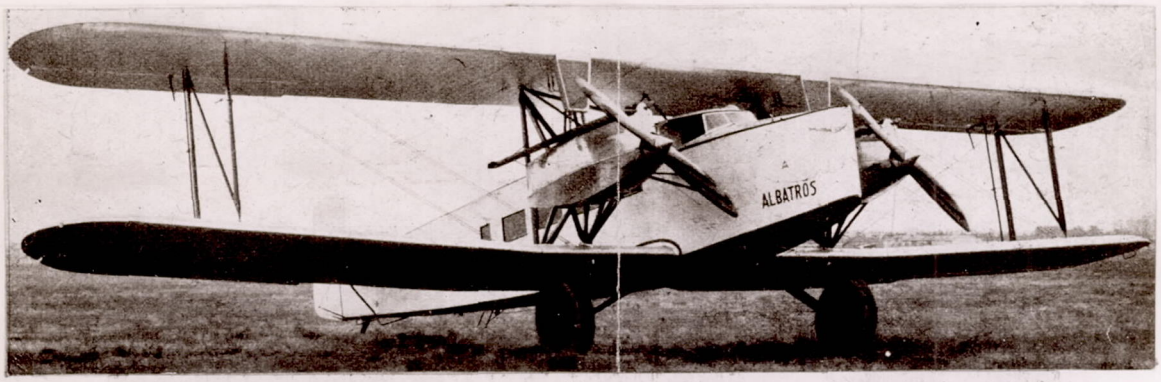


Fig. 2 Albatros two-engine commercial airplane L73

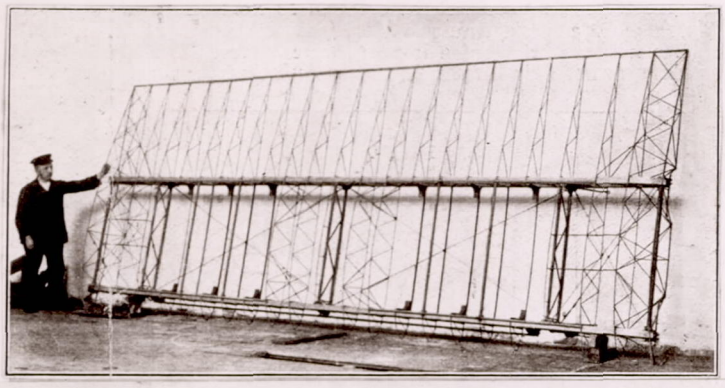


Fig. 3 Framework of middle section of wing

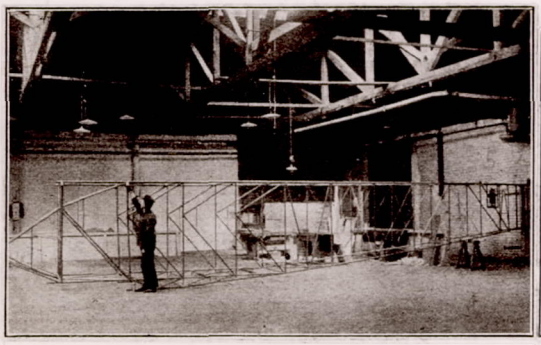


Fig. 5 Framework of fuselage

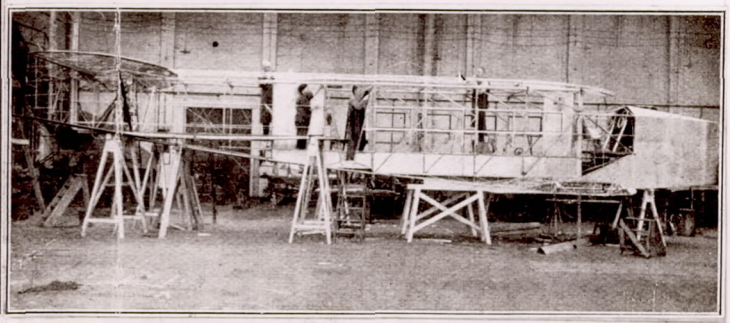


Fig. 6 Framework of fuselage

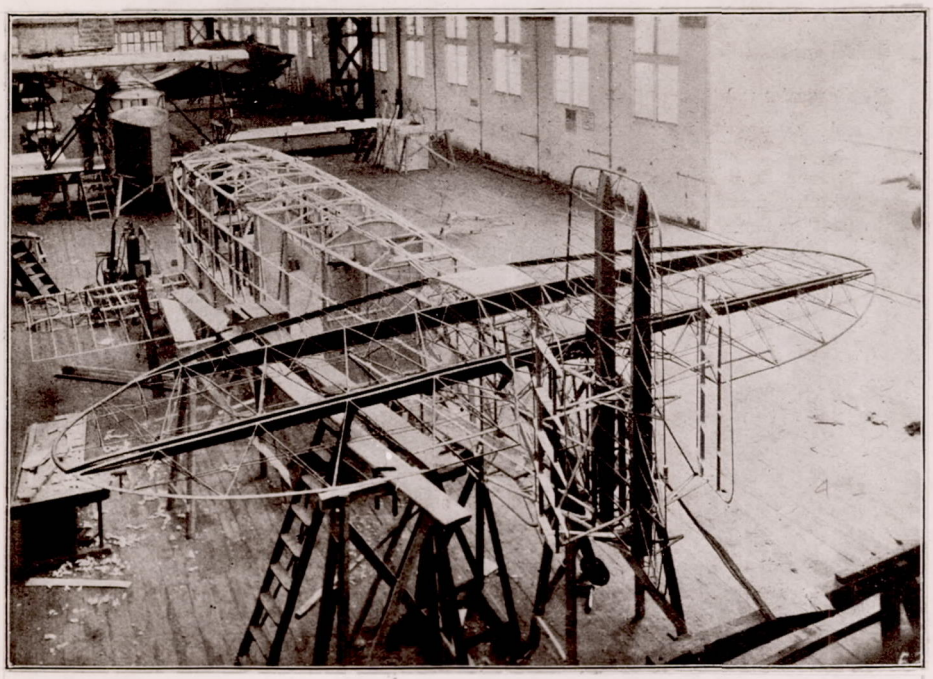


Fig. 4 Framework of fuselage and tail group

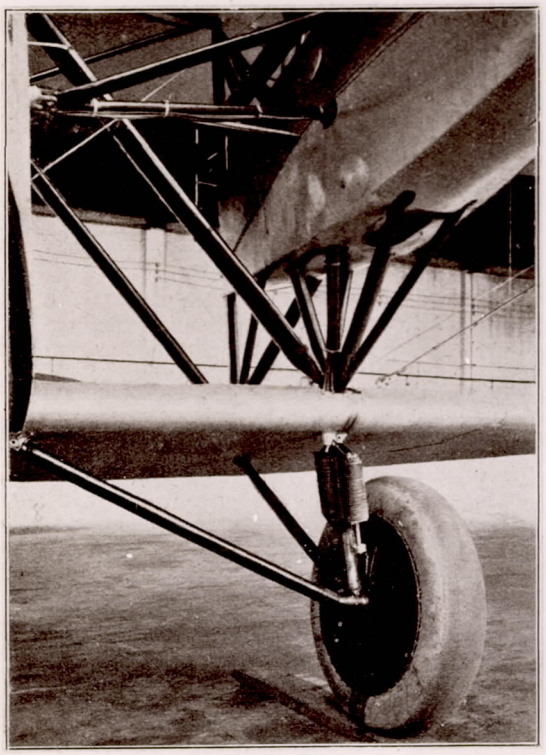


Fig. 8 Landing gear

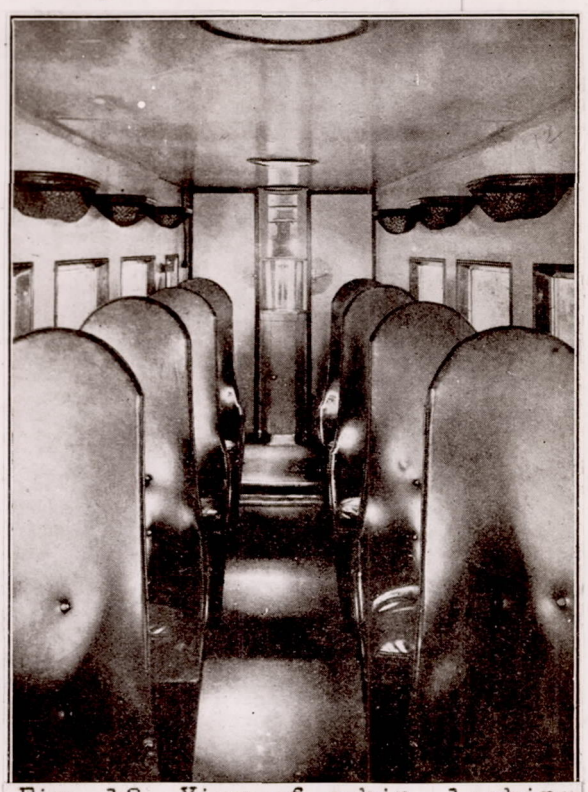


Fig. 12 View of cabin, looking aft, showing the eight seats. The backs can be tilted to various angles; two seats forming but one sleeping berth.

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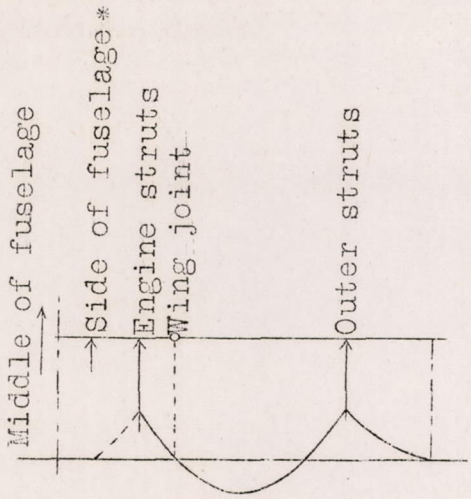
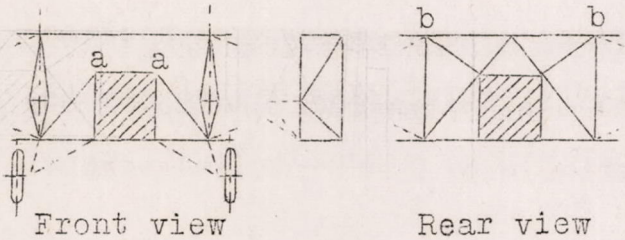


* Attached to lower spars only

Fig.7 Wing spars



Front view Rear view

Fig.9 Cabane

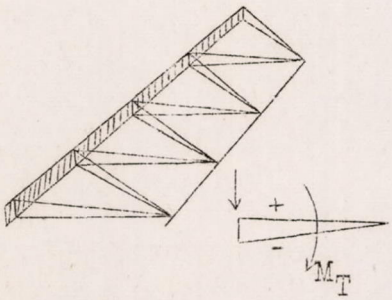


Fig.10 Framework of rudder and elevator.

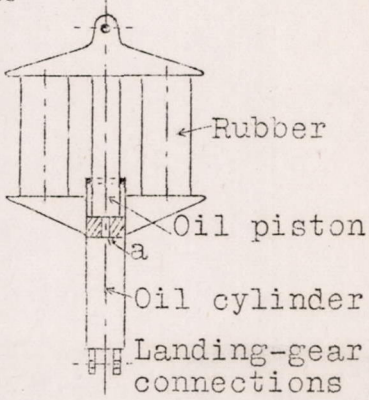


Fig.11 Shock absorber