AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 84

THE CAPRONI MONOPLANES "Ca 97" (ITALIAN)

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THE CAPRONI MONOPLANES "Ca 97" (ITALIAN).*

The "Ca 97" airplane, constructed by our firm, was designed to serve various uses and purposes equally well. Its essential structural characteristics are:

1. Monoplane structure with wings half overhung;

2. Large fuselage to enable the most varied adaptations and the necessary installations according to the purpose of the airplane;

3. Stabilizer of variable incidence;

4. Landing gear with wide track and with struts forming an integral part of the framework of the cell;

5. Possibility of obtaining the necessary power for the various uses of the airplane by the installation of one, two or three engines;

6. Gravity feed, the fuel tanks being in the wings;

7. All-metal construction with steel tubing.

Description

The structural principle of the "Ca 97" differs absolutely from that of all other metal airplanes thus far constructed either in Italy or in any other country. Caproni, after a long and thorough investigation of the problem and of all the types

*From Bollettino Aeronautico, May-June, 1928, published by the Caproni Aeroplane Company.

of metal construction adopted by different constructors, became convinced that, in order to obtain, on the one hand, great structural lightness combined with great strength and, on the other hand, the greatest possible elasticity similar to that of wood, two essential principles must be established, namely:

a) Homogeneity in the material employed not only in the sense of using (possibly) a single kind of material, but also of not altering its strength at any point by thermal treatment, as is sometimes done, e.g., in joining vital parts by autogenous welding, which causes annealing and therefore a local weakness, which must be offset by greater thickness with resulting increase in weight.

b) Possibility of giving an initial tension to the principal elements of the structure, in order to offset the inevitable settling, which is the cause of permanent deformations.

These principles are the basis of Caproni metal construction, as exemplified by the small monoplane from which the 600 HP. colonial monoplane "Ca 101" is derived and by the 3000 HP. three-engine monoplane "Ca 95," while in the 2000 HP. four-engine "Ca 79" and in the 6000 HP. six-engine "Ca 90," already designed and under construction, we again find in some elements, especially for reasons of weight the common practice of using high-tension steel in the more heavily stressed parts and light

alloys (electron, duralumin, etc.) in the less heavily stressed parts. The abandonment of light metals in the framework of the Caproni airplanes was principally due to the fact that they require, for certain work, very difficult thermal treatment (annealing and tempering) which, notwithstanding the utmost vigilance, easily produces local alterations which constitute critical points in the resistance of the airplane. This is probably the cause of the unexpected and inexplicable failures of airplanes in flight during recent years.

Thus in the "Ca 97" the material used is exclusively carbon steel in the form of tubing in the construction of the spars and girders and as constituent elements in the construction of the joints. Only a few joints of vital importance are made from chromium steel. The tubes are joined by soldering and by steel screws. With this system, the soldering being done at about 200°C (392°F), the characteristics of the material are not altered at any point, thus giving the structure great homogeneity and a uniform reaction to dynamic stresses and temperature variations. Moreover, the use of the material throughout the whole structure in the form of tubing greatly simplifies the method of construction, because the manner of assembling the different parts is the same for every joint. Repairs are thus rendered very simple and easy.

All pieces are soldered both internally and externally. The tubes, however, are soldered externally, lubricated internal-

ly and plugged at the ends. Rusting is thus prevented as, for example, by the action of sea water.

The elasticity of the structures which, as mentioned at the beginning, constitutes a very important characteristic, is thus fully obtained. Experiments on selected parts (longerons, wings, ribs) or on the whole airplane in the static tests with the cell inclined, have shown a high limit of elasticity very close to the load of permanent deformation. A proof of the excellence of the structural system is also given by the ribs (chord 2.5 m = 8.2 ft.; weight 0.8 kg = 1.76 lb.), which broke with a coefficient 15, i.e., at a load of 510 kg (1124 lb.). The wings, fuselage, and tail are covered with canvas for the sake of economy and structural simplicity.

The first airplane of the "Ca 97" series constructed by our firm is of the three-engine civil type, i.e., equipped with three fixed air-cooled radial Lorraine-Dietrich engines, each of 100-130 HP. and 1300-1350 R.P.M. with propeller in direct drive. The photographs (Figs. 1, 2 and 3) give a good idea of its construction. The ample fuselage, of the completely closed type, consists of four longerons of steel tubing and crosspieces and uprights also of tubing, the whole being made rigid by means of adjustable brace wires (Fig. 4). In the front central part, however, the sides are braced with tubing and carry, above and below, eight junctions of high-resistance steel for attaching the wings and landing gear, the struts supporting the cradles of the

lateral engines, the wing struts and the landing-gear struts (Figs. 5, 6 and 10). The junctions between the longerons, struts, cross-pieces and brace wires are made from tubing and sheet steel, while the junctions of the wings and landing gear are made of nickel steel. The fuselage terminates in front with a square cross section with four junctions for attaching the tubular pyramid which supports the engine mounting (Fig. 7). The pyramid is secured with four bolts. The oil tank is located behind and above the engine and the starter is placed below. Next comes a single pilot seat with control stick or a double seat with steering wheel. The pilot is in front of the wings and is completely shielded by an ample hood, which connects with the leading edge of the wing and is provided above and in front with sliding windows and is covered with mica on the sides.

The central part of the fuselage is occupied by the cabin, which can seat six persons comfortably in easy willow chairs placed in two rows along the sides. At the rear of the cabin a door affords access to the baggage room and toilet. A door on the left side is used for entering and leaving the cabin. The cabin is lighted by long slide windows. The floor is corrugated sheet duralumin, while the doors are wood. At the rear the fuselage terminates in the tail group constructed entirely of steel tubing (Fig. 8). The incidence of the stabilizer can be varied by the pilot during flight and is rigidly held by steel wires

attached to the lower fuselage longerons and to the vertical fin. The rudder is balanced. A skid of the orientable type with rubber shock absorbers is mounted on the terminal upright of the fuselage.

The wing structure (Fig. 9) is normal, consisting of two wing spars to which the ribs are attached, the whole being stiffened by brace wires. The central portion of the wing, to which the four upper junctions of the fuselage are attached, is horizontal for the width of the fuselage and then forms a slight dihedral. The spars consist of two tubular stringers connected by tubular uprights and adjustable steel crosspieces. The union between the stringers, uprights and crosspieces is effected by junction pieces. The tubular steel ribs are of the moderately thick lattice type with the bottom flange perfectly straight from the front spar to the trailing edge. Special ribs with central compression struts support the reactions of the interior crosspieces of the wing. The leading edge of the wing is covered with sheet duralumin, while the trailing edge consists of a steel wire. The wings are equipped with ailerons, each one being controlled by a single central lever.

In the wings there are two fuel tanks, one on each side of the fuselage, which supply the engines by gravity. Provision is also made, however, for the installation of a single central tank.

Each wing is half overhung, being stiffened fore and aft by struts which transmit the stresses to the center of the spars. Each strut is attached below the apex of the triangular structure supporting each lateral engine, as already described. To the apex of the front triangle there is also fastened the hinged strut (provided with a rubber shock absorber) which is also hinged to the point of union of the two landing-gear struts forming a V. The wing struts are joined to the wings and to the apexes of the above-mentioned triangles with the interposition of Cardan joints to neutralize the vibrations. The reactions of the struts are transmitted to the center of the wing spars.

The triangular supports of the lateral engines are attached to the apexes of the same triangular supports of the wing struts. In front, the engine mounting is also secured by two struts which unite at the top in a single attachment to the front wing spar. The triangular frame supports, in front, the circular engine mount and, behind the latter, the oil tank.

Both the fore and aft triangles are stiffened by tubular braces, while there are adjustable steel crosspieces in the plane of the fore and aft struts, thus assuring the rigidity of the wing in its plane.

Each half of the landing gear consists of two tubular struts hinged to the fuselage by a universal joint and united to a single tube forming the axis of a large balloon-tired wheel, which can be readily removed. The track gauge is very wide, thus avoid-

ing the danger of overturning, even on very rough ground. As already mentioned, the vertical oscillations of each half of the landing gear are absorbed by a vertical shock absorber hinged to the top of the landing gear. This tubular strut is provided with a crossbar and oscillates between two tubes also joined transversely and attached to the apex of the front attachment triangle of the wing strut. Both crossbars are in turn held together by rubber rings. The whole is covered with aluminum cowling in the form of least resistance, as likewise all the tubular girders and struts.

Principal Dimensions

Span	15.97 m	(52.39 ft.)
Length	10.71 "	(35.14 ")
Height	3.35 "	(10.99 ")
Chord	2.50 "	(8.20 ")
Wing area	40.00 m^2	(430.55 sq.ft.)
Track gauge	4.07 m	(13.35 ft.)

The "Ca 97" may be equipped as a

1. Three-engine civil airplane 3 (100-130 HP.),
   One-engine " " (250 HP.),
   " " " (420 "),

2. Three-engine colonial airplane 3 (100-130 HP.),

3. One-engine observation " (420 HP.),

3. One-engine observation airplane (500 HP.).

4. " day-bombing " (420 ")
" " " (500 ")

5. " training " (250 ")

I. Civil Airplane

The three-engine type (Figs. 1, 2 and 3) has a range of 700-800 km (435-497 miles).

Weight empty		1200 kg (2645 lb.)
Useful load: 1 pilot, 6 passengers and baggage,	600 kg (1323 lb.)	
Fuel and oil	400 " (882 ")	1000 kg (2205 lb.)
Full load		2200 kg (4850 lb.)

The flight characteristics may be summed up as follows:

$V_{max.}$ 150 km/h (93 mi./hr.);

V_{min} 99 " (61.5 ");

Service ceiling, 5000 m (16,400 ft.)

Ability to continue flight with one engine stopped.

The one-engine type can be equipped either with a 250 HP. or a 420 HP. engine. In the former case it is particularly suitable for civil use over lowlands, being very economical, while in the latter case it is more particularly adapted for civil use

at high altitudes. Their relative weights are:

Weight empty	1000 kg (2205 lb.),	1200 kg (2645 lb.),
Useful load	1000 " (2205 "),	1000 " (2205 "),
Full load	2000 " (4410 "),	2200 " (4850 ").

The flight characteristics of the low-altitude and of the high-altitude type may be summed up as:

Type	Low-Altitude	High-Altitude
V_{max}	177 km/h (110 mi./hr.),	212 km/h (132 mi./hr.)
V_{min}	94 km/h (58 mi./hr.)	99 km/h (61.5 mi./hr.)
Service ceiling	4150 m (13615 ft.),	6400 m (20997 ft.)

The low-altitude type can also be used for long-distance flights like crossing the Atlantic. According to calculations of range with an overloading to a total of 3000 kg (6614 lb.), its ceiling is high enough to clear obstacles near the field of departure.

Since the empty weight of the airplane is 1000 kg (2205 lb.) (the remaining 200 kg (441 lb.) being regarded as divided between the weight of the pilot, the extra fuel tanks and the fittings), the initial fuel load will be about 1800 kg (3968 lb.). The necessary data were determined for an angle of flight intermediate between the angle of minimum power and the angle of minimum traction, on assuming, moreover, for simplicity, a constant fuel

consumption of 0.26 kg (0.57 lb.) per HP./hr., and a propeller efficiency of $\eta = 0.7$. The results of the calculation are:

Distance range 7600 km (4723 mi.);

Time range 61.5 hours.

II. Colonial Airplane

As a "colonial airplane" the "Ca 97" is also equipped with three 100-130 HP. engines and, being able to carry 400 kg (882 lb.) of fuel and oil, has a range of over 800 km (497 mi.), which is sufficient for colonial operations. Desiring to retain the same flight characteristics as the three-engine civil airplane, the relative weights are:

Weight empty		1200 kg (2645 lb.)
1 pilot, 2 observers	210 kg (463 lb.)	
M.R., R.T. (radio),		
2 machine guns, parachutes, etc.	190 kg (419 lb.)	
Fuel and oil	400 " (882 ")	
Explosives	200 " (441 ")	
Useful load	1000 "	1000 kg (2205 lb.)
Full load		2200 kg (4850 lb.)

If 500 kg (1102 lb.) of bombs are added, making a total load of 2700 kg (5952 lb.), its characteristics may be summarized as

follows:

V_{max}	192 km/h	(119 mi./hr.)
V_{min}	110 "	(68 ")
Service ceiling	3200 m	(10498 ft.).

The two load cases considered for this type include respectively, 200 and 500 kg (441 and 1102 lb.) of explosives. In case 1, the load of explosives is rather small for bombing operations, but the airplane has excellent flight characteristics. In case 2, on the other hand, the 500 kg of explosives are more than enough, but there is a lowering of the ceiling and an increase in the minimum speed.

If it be observed, however, that the attainable altitude with 500 kg (1102 lb.) of explosives is more than sufficient for colonial operations and that the high minimum speed is only apparent because the landing would ordinarily be made with less than the maximum weight of fuel, and because it is always possible to relieve the airplane of the weight of the explosives.

Moreover, this airplane is very economical, both as to its first cost and as to its cost of operation. This is due to its limited power, with regard also to the serious problem of replenishment in the colonies. Other advantages, not to be disregarded, proceed from its limited dimensions relative to housing, to maneuvering on the ground and to upkeep. Lastly, the large dimensions of the fuselage, as compared with the dimen-

sions of the whole airplane, render it possible to adapt the same airplane to a greater variety of colonial uses from the transportation of troops and the wounded to observation and bombing.

III. Observation Airplane

The dimensions of the fuselage and the monoplane structure of the "Ca 97" render it particularly suitable as an observation plane. This very important service of the aviation arm is performed by the "Ca 97" in a sane and rational manner, which consists in allotting a special task to each of its three occupants: to one, the task of observation proper; to another, the task of offense and defense; leaving the pilot free to operate the airplane. To accomplish its purpose successfully, it is necessary for the crew to be able to perform its task conveniently, which is not the case in other airplanes. The "Ca 97" observation airplane, however, enables, behind the pilot's compartment, the installation of a convenient and spacious cabin, where, sheltered from the wind and able to move about, the two persons assigned to do the observing can perform their allotted tasks with every convenience. The "Ca 97" observation plane can be equipped with either a 400 or a 500 HP. engine, the relative weights of the two types being:

Weight empty		1200 kg (2645 lb.)
1 pilot, 1 observer		
1 gunner	210 kg (463 lb.)	
M.F., R.T., 2 guns	190 " (419 ")	
Fuel and oil	600 "(1323 ")	
Useful load		1000 kg (2205 lb.)
Full load		2200 kg (4850 lb.)

The characteristics of this type may be summarized as follows:

Engine of	420 HP.	500 HP.
V_{max}	212 km/h (132 mi./hr.)	225 km/h (140 mi./hr.)
V_{min}	99 km/h (61.5 mi./hr.)	99 km/h (61.5 mi./hr.)
Service ceiling	6400 m (20997 ft.)	7400 m (24278 ft.)
Range	1000 km (621 mi.)	1000 km (621 mi.)

IV. One-Engine Day-Bombing Airplane

The "Ca 97" equipped with a 450 or 500 HP. engine, can be used also as a day-bombing airplane. The large size and monoplane structure of the fuselage, which leaves its bottom entirely free, render it particularly suitable for use as a day bomber. The relative weights of this type are practically the same as those of the colonial type with 500 kg of explosives, but its greater power, in comparison with the colonial type, gives it

valuable flight characteristics, which may be summarized as follows:

Engine of	420 HP.	500 HP.
V_{max}	210 km/h (130.5 mi./hr.)	224 km/h (139 mi./hr.)
V_{min}	110 km/h (68.4 mi./hr.)	100 km/h (62 mi./hr.)
Service ceiling	4600 m (15092 ft.)	5600 m (18373 ft.)

The calculated ranges for this type, with the 500 HP. engine, are nearly the same as for the low-altitude civil airplane, that is:

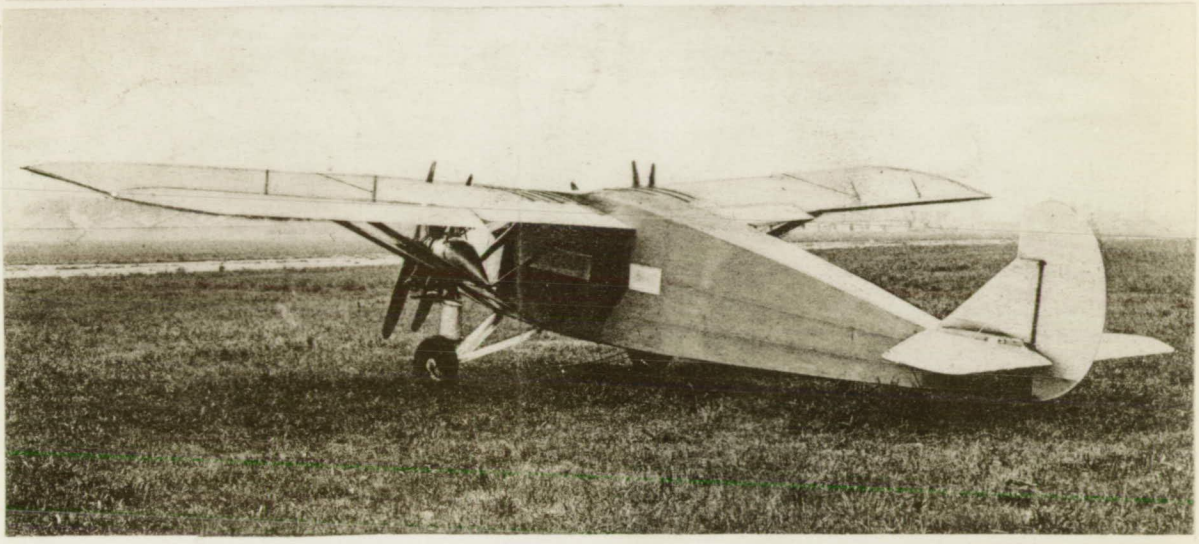
Distance range	8000 km	(497 mi.)
Time "	61 hours.	

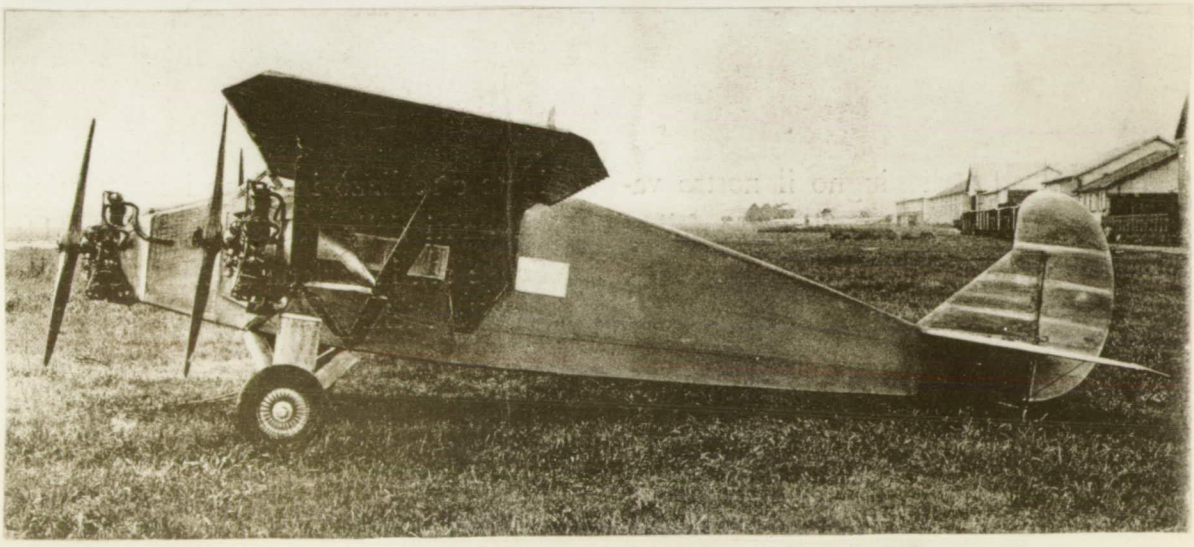
V. One-Engine Training Airplane

By reducing the useful load from 1000 kg (2205 lb.) to 500 kg (1102 lb.), the same airplane, equipped with a 250 HP. engine, can be used economically and with excellent flight characteristics as a training airplane. Its flight characteristics are as follows:

V_{max}	175 km/h	(109 mi./hr.)
V_{min}	80 "	(50 ")
Service ceiling	6600 m	(21653 ft.)
Range	1000 km	(621 mi.)

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





Figs.1,2,3 Views of the Ca 97 airplane.

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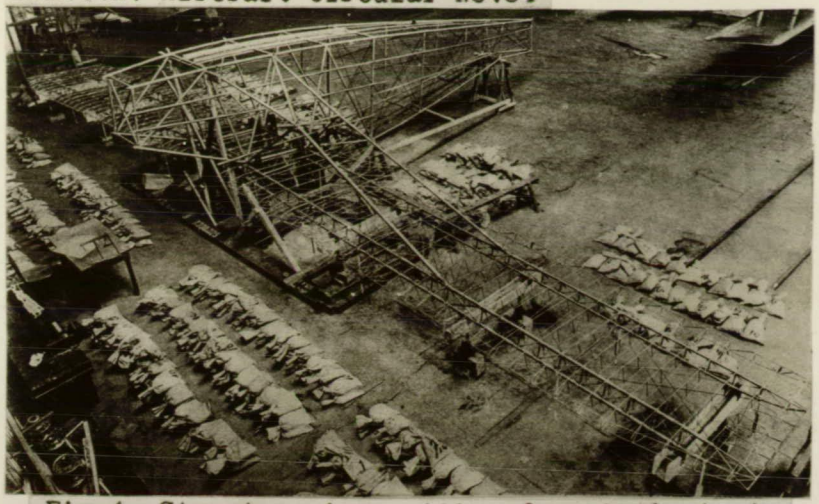
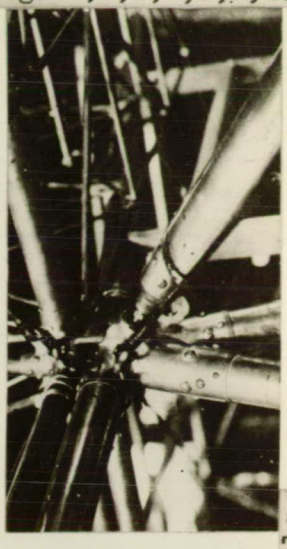


Fig.4 Structure in position for static test.



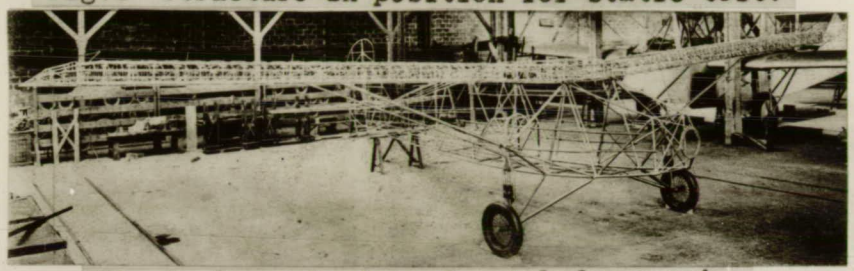


Fig.7 General view of metal framework.

Fig.5,6,10 Structural details.

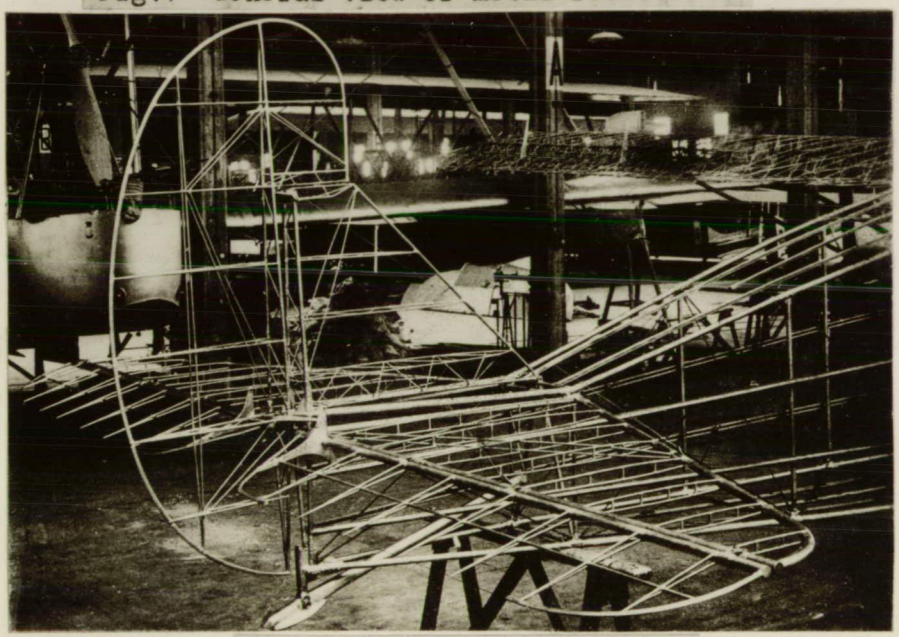
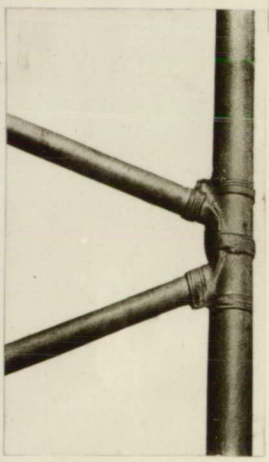


Fig.8 Tail unit structure.



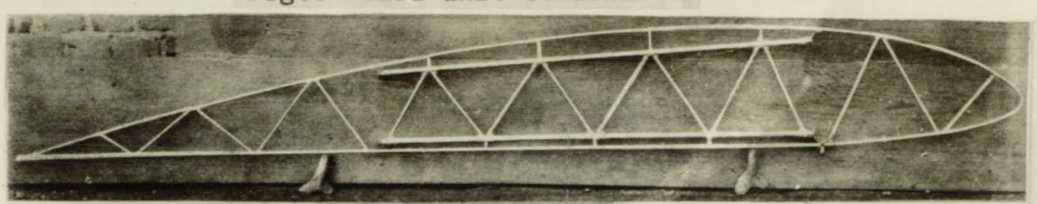
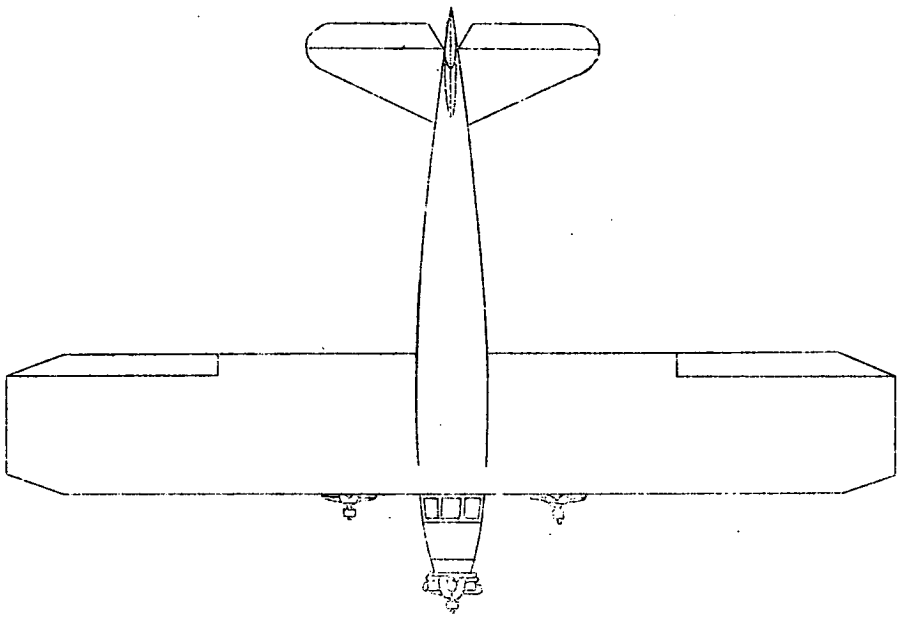
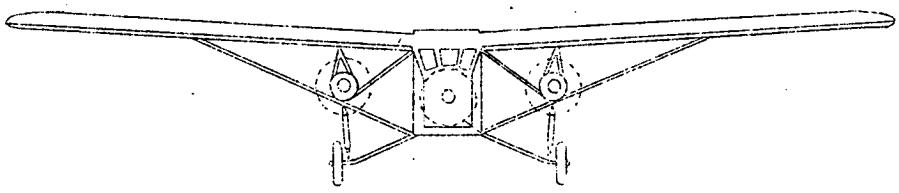


Fig.9 Rib with central compression strut.

Details of the "Ca 97" airplane.



Span	15.97m(52.39ft.)	Height	3.35m(10.99ft.)
Length	10.71"(35.14ft.)	Wing area	40 m^2(430.55 sq.ft.)



Three Lorraine-Dietrich air-cooled radial engines.

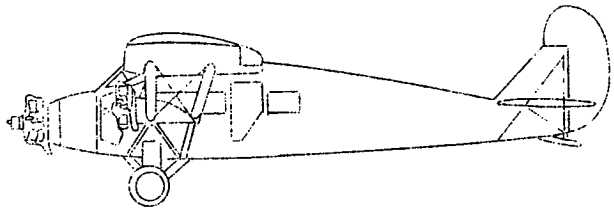


Fig.11 The Ca 97 commercial airplane.