AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 6

ALL-METAL JUNKERS AIRPLANE, TYPE F 13

Translation from the German

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The all-metal Junkers airplanes are the result of several years' work at Professor Hugo Junkers' Research Institute in Dessau, Germany, which has furnished new fundamental ideas in the domain of aerodynamics, as also in the employment and working of the light metals.

The characteristics of these airplanes are: (1) the thick cantilever Junkers wing without stay-wires, and (2) the all-metal construction.

1. The system previously employed, which for lack of other possibilities, had to place struts and guy-wires outside the wings, had the disadvantage of an excessive head resistance or drag. Attempts were made to diminish the drag by streamlining the struts and wires, which resulted in a certain degree of improvement. The problem was finally solved by removing all the braces from exposure to the air current, i.e., by putting them inside the wing itself.

The wing section or profile had to be made thicker for this purpose (Fig. 1). As the result of careful experimentation, its aerodynamic qualities were found to be very favorable, contrary to previous assumptions in favor of thin profiles.

While the polar curve for thin profiles presents only a

*Translation from the German.

relatively restricted range of application, such profiles being adapted only for the exigencies either of a greater speed or of a higher climb, the polar (b) of the thick profiles largely provides for both conditions.

Even in the critical zone (the top of the curve in Fig. 1), the polar (b) of the thick profiles is much more stable, i.e., the danger of a slip or fall is much less, even at a pronounced angle of inclination. The shifting of the center of pressure is thus kept within narrow limits, so that any nose or tail-heaviness can be more easily counteracted.

2. Not only as regards the aerodynamic system, but also as regards materials, Professor Junkers abandoned the method of construction involving the use of wood and cloth and adopted all-metal construction from the first. The mechanical strength of wood depends on a number of conditions more or less difficult to obtain. As to the crude wood, the source, the age, the zone, the vicinity and the period of storing of each timber, play an important role and require a careful selection and consequently entail considerable waste.

During the working there are also many influences which make themselves felt. The relatively weak cellular structure and the predominating importance of the direction of the fibers greatly restrict the working from the viewpoint of the variation and the combination of the forms, as also the thickness of the walls. Since, moreover, wood warps, it is impossible to maintain the calibrated dimensions and the interchangeability of wooden parts. It is needless to dwell on the fire risks of the easily inflammable wooden airplanes. These disadvantages are all avoided by all-metal construction.

The first Junkers airplane was made entirely of steel. It was found to be impossible, however, to reduce the thickness of the metal sufficiently to offset its high specific gravity. The steel airplane was too heavy.

The material now employed in the construction of Junkers airplanes is duralumin, a light metal alloy containing 95% aluminum, 4% copper, 0.5% manganese, and 0.5% magnesium. Duralumin has a specific gravity of 2.8 combined with the strength of Siemens-Martin steel, which is three times as heavy. After solving the problems of working, which were often very difficult, at the Dessau Research Institute, the great advantages of metal construction soon became apparent. The close structure of the metal and its much more uniform strength furnish a basis for accurate calculation. This results in a more economical utilization of the material, less waste and the need of less storage space. The possibility of exact working assures perfect calibration and the interchangeability of all parts. Metal alone enables quantity production, without regard to immediate use or storage. The manufacture of the parts and the assembling can be easily supervised, which considerably increases the safety of the structure.

As to service, a metal airplane has the following advantages over a wooden one. The latter soon becomes fatigued, i.e., its aerodynamic qualities of speed and climbing ability soon diminish. On the contrary, the first airplanes of the type F 13 have seen daily service since 1919, without the least loss in their superior aeronautic qualities. For protection against humidity and atmospheric influences in general, they require much less expensive care than wooden airplanes, on which it is necessary to tighten the wires after each change in the weather and for which very expensive hangars must be built, in order to protect them from excessive wear. On the contrary, some of the Junkers all-metal airplanes have been exposed for months to snow and rain without detriment (Figs. 5-6).

The particular utility of the type F 13 for tropical countries has been demonstrated by various expeditions and by the daily air traffic in South America. The termites, which are so destructive to wooden airplanes in tropical countries, cannot hurt metal airplanes. In short, the life of a metal airplane is practically unlimited.

The principal characteristics of Junkers airplanes, as mentioned under numbers (1) and (2) on the first page, constitute very great progress in airplane construction. The aerodynamic necessity of installing all the supporting framework within the wing (Figs. 2-3) has resulted in an entirely new arrangement. On the other hand, the employment of metal has rendered possible a large number of new constructions. Due to a thorough study of static laws, the weight of the Junkers airplane was reduced below that of all other airplanes (wood or metal) of the same class, although the specific gravity of duralumin is greater than that of wood.

The Junkers all-metal airplane F 13 has a large, elegantly furnished cabin, with accommodations for four passengers and room for another passenger or assistant beside the pilot. It can be equipped as a land airplane on wheels F 13_L; on skis F 13_S; and as a seaplane F 13_W. The characteristics and performances of these three types are as follows:

Type	F 13_L			
Span	17.75	m	58.23	ft.
Length	9.60	m	31.50	ft.
Height (with tube for air-speed indicator)	4.10	m	13.45	ft.
Wing area	40.00	m²	430.56	ft.²
Horsepower, about	200		197.3	
Fuel consumption, about	45	kg/h	99.2	lb./hr.
Oil " "	2	kg/h	4.4	lb./hr.
Dead load	1150	kg	2535.3	lb.
Useful "	700	kg	1543.2	lb.
Speed per hr., about	170	km	105.6	mi.

Table of Characteristics (Cont.)

Type	F 13_W			
Span	17.75	m	58.23	ft.
Length	10.15	m	33.30	ft.
Height {with tube for air-speed indicator}	4.50	m	14.76	ft.
Wing area	40.00	m²	430.56	ft.²
Horsepower, about	200		197.3	
Fuel consumption, about	45	kg/h	99.2	lb./hr.
Oil " "	2	kg/h	4.4	lb./hr.
Dead load	1350	kg	2976.2	lb.
Useful "	600	kg	1322.8	lb.
Speed per hr., about	170	km	105.6	mi.

Type	F 13_S			
Span	17.75	m	58.23	ft.
Length	9.60	m	31.50	ft.
Height {with tube for air-speed indicator}	3.80	m	12.47	ft.
Wing area	40.00	m²	430.56	ft.²
Horsepower, about	200		197.3	
Fuel consumption, about	45	kg/h	99.2	lb./hr.
Oil " "	2	kg/h	4.4	lb./hr.
Dead load	1200	kg	2645.5	lb.
Useful "	650	kg	1433.0	lb.
Speed per hr., about	170	km	105.6	mi.

The supporting surface, which is the basis of the structure, is made in three parts, in order to facilitate transportation. The wings proper are secured to the framework of the central portion of the wing (Fig. 15), whose spars consist of nine duralumin tubes, by means of cap nuts of chromium and nickel steel to the number of nine on each side, thus assuring the symmetry of the wings (Figs. 7 and 15). The wings can be mounted and demounted by two men in a few minutes.

The wing framework is in the form of a cantilever girder (Fig. 3) whose interior shows the resolution of the forces into many component forces. The external metal covering, corrugated to increase its strength, helps to withstand the stress of torsion. Thus a structure has been created which can stand much dynamic overloading.

Contrary to previous practice, the fuselage is placed on the wing, so that the framework of the central portion of the wing also forms the base of the fuselage and of the cabin. This gives a very strong superstructure and a great reduction in weight. This position of the wing has the great advantage (as demonstrated by experience, especially on passenger airplanes) of affording the best possible protection to the cabin and its occupants, in case the airplane is damaged in making a bad landing.

The elevator and ailerons are operated in the usual way by means of a column with a wheel. The rudder is operated by pedals (Fig. 9a). The elevator and ailerons are controlled by a device with duralumin levers and tubes (Fig. 9b), a mechanism which effects a transmission always uniform, exact and sure. The rudder cables are retained, which, in this case, are not subjected to deviations causing wear. All the important parts are easily accessible through slide doors (Fig. 9c). Provision is made for installing dual control, so that the pilots can relieve each other on long trips.

All the tail surfaces have large areas and give satisfaction even in the greatest exigencies, both as regards steadiness of flight and maneuverability of the airplane. The device for adjusting the height of the stabilizer, employed on other airplanes for compensating the weight variations, is replaced in the Junkers by a so-called "trimming-tank" (Fig. 9e) located near the rear end of the fuselage. In order to offset nose-heaviness or tail-heaviness, the pilot, by means of a pump, withdraws or adds sufficient fuel to restore equilibrium. This device enables one to fly always at a small angle of attack (i.e., at the angle of least resistance), and eliminates all derangement of the tail group sometimes caused by the non-functioning of other devices.

The frame of the landing gear is made of steel tubing. Four streamlined supports, the spring struts (Fig. 9,f), form the elastic elements. They can yield a distance of 74 mm (2.91 in.) (rubber), to which is added a supplementary reserve of 47 mm (1.85 in.) (copper). From the articulation of the two parts of the axle, a V-strut (Fig. 9g) assures the rigidity of the landing-gear frame.

The distance between the wheels is 2.1 m (6.89 ft.), which is sufficient to prevent turning over, even in an oblique landing. The tires are 810 x 125 mm (31.89 x 4.92 in.) and, for bad fields, 965 x 150 mm (38 x 5.91 in.).

The tail skid is shock-absorbing and jointed. It can be readily replaced and is large enough to protect the fuselage against serious damage.

Each airplane is provided with special connections for installing floats, which can be substituted for the wheels in a very short time, thus converting it into a seaplane. The floats are made of duralumin and are each divided into six tight compartments.

The airplane can likewise be equipped for taking off or landing on snow or ice by removing the wheels and substituting duralumin runners and attaching a shoe to the tail skid.

Due to the great efficiency of the F 13, it was found possible to reduce the engine power to a surprising degree. The following engines have been tested in air traffic:

Mercedes,	160 HP.
"	185 "
B.M.W.,	185 "
Junkers L II,	195 "
Siddeley-Puma,	230 "

The engine is easily accessible at all points, on turning back the hinged hood (Fig. 13), and can be exchanged in a short time.

The frontal radiator on the F 13 was specially designed by the Junkers Company and surpasses all others for lightness and efficiency. It can be regulated for different temperatures by the pilot, who can operate the radiator shutters from his seat (Fig. 11, left). The airplane is also provided with an additional radiator for tropical countries.

Since air-traffic conditions are now so different from what they have been hitherto, it is necessary to develop new propeller models by extensive researches regarding pitch, blade section and diameter. The propellers now in use are made of superior laminated wood protected by metal on their leading edges and possessing a mechanical efficiency of 75-80%. Another particularly favorable circumstance is the free field for the slip stream, due to the low position of the wing.

The Junkers Company has recently initiated the use of metal propellers of its own make, whose hollow section diminishes according to the laws of bodies of uniform resistance. The advantages of metal propellers are manifest. They are not sensitive to climatic influences, i.e., they neither warp nor splinter. Moreover, the hub can be so made as to enable the variation of the propeller pitch at will for speed or for climbing, i.e., for a quick take-off. In the event of one blade being damaged, it can be replaced instead of having to discard the whole propeller. The mechanical efficiency of metal propellers is at least equal to that of wooden ones.

The fuel is contained in two tanks located in the central portion of the airplane at a considerable distance from the engine (Figs. 9h and 15). It is pumped from the main tank to a gravity tank above the pilot's seat (Fig. 9i). The functioning of the pump can be observed by means of a fuel-flow indicator at the level of the pilot's eyes and a level-gauge in the gravity tank. This pump can be replaced, in case of derangement, by a hand pump.

Several filters, intercalated between the tank and the carburetor, keep the fuel pure at the carburetor. The safety measures employed in this connection deserve special mention. If the pipe leaks, the fuel, instead of flowing into the engine bed, is conducted outside the airplane by a second pipe surrounding the conduit proper. A special partition between the engine and the pilot's seat (Fig. 9k) protects the pilot and passengers in case of fire in the carburetor. All pipes (namely, between the main tank and the pump, the main tank and the trimming tank, etc.) can be closed with respect to the others. In case of fire in the carburetor, the intake of fuel into the engine can be immediately shut off by closing a single cock.

All the instruments, designed for the control of the engine, of flight and of the fuel (such as the tachometer, oil manometer, starter, interrupter, speed indicator, altimeter, clock, compass and fuel-level gauge) are mounted so as to be easily observed. The throttle and radiator shutter are of simple construction and are conveniently located (Fig. 11).

The passenger cabin contains four comfortable padded chairs (Fig. 16), of which the two front ones (Fig. 91) can be removed to make room for bulky baggage. Three windows, on two sides of the cabin, can be partially opened and afford a lateral and downward view.

A supplementary gasoline tank (Fig. 17) can be installed for a longer flight, as also a table, the space beneath the latter serving, in case of need, as a compartment for carrying mail.

There is a small sliding window for communicating with the pilot (Fig. 17).

The cabin can be entered through two large side doors, with convenient steps.

On request, a heating plant for the cabin can also be furnished ready for installing. This has given satisfactory results at a temperature of -20°C (-4°F). An electric lighting system is also provided for the cabin.

The baggage compartment (Fig. 9m) is entirely separated from the cabin, so that the passengers may not be annoyed by the baggage.

Each airplane is provided with a bag containing all the spare parts necessary in ordinary service, as also a complete set of tools.

The name of Junkers, as well as the continual and brilliant successes obtained by these airplanes at home and abroad constitute the best guaranty of construction, both as regards materials and workmanship,

In addition to a rigorous inspection of all the materials used and all the parts, each airplane, before leaving the factory is subjected to a detailed inspection by an inspection department entirely separate from the manufacturing department. The acceptance test of each airplane is a flight of one hour at full load.

Translation from the German, by Dwight M. Miner,
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for Aeronautics.

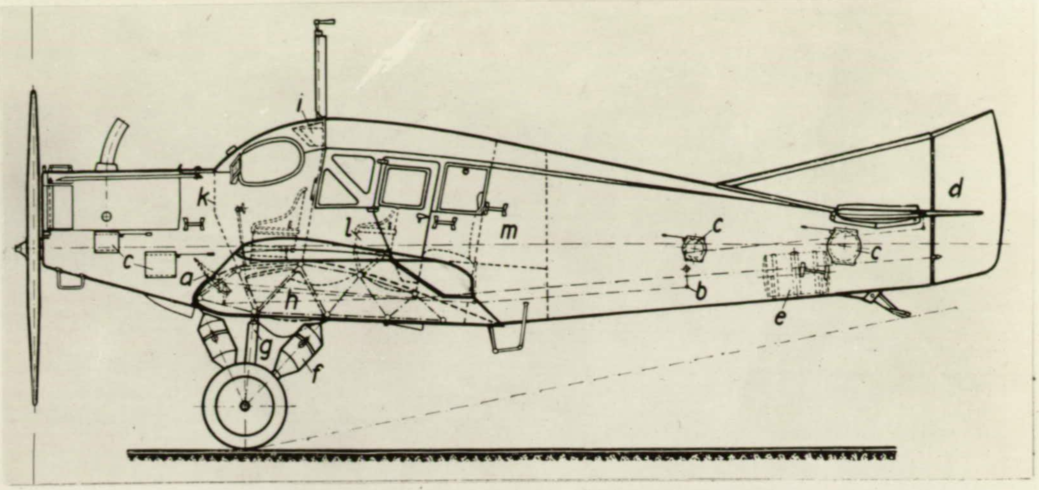

Fig.9 Fuselage of the F13

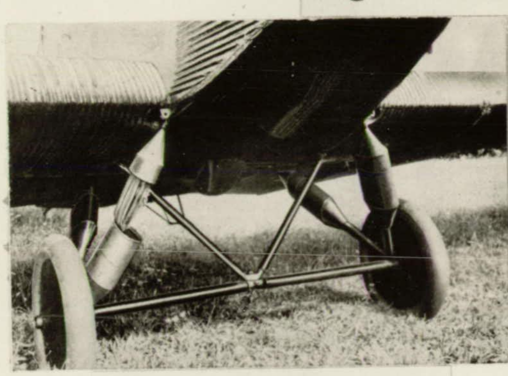

Fig.10 Landing gear

Fig.12 Type F13 on runners

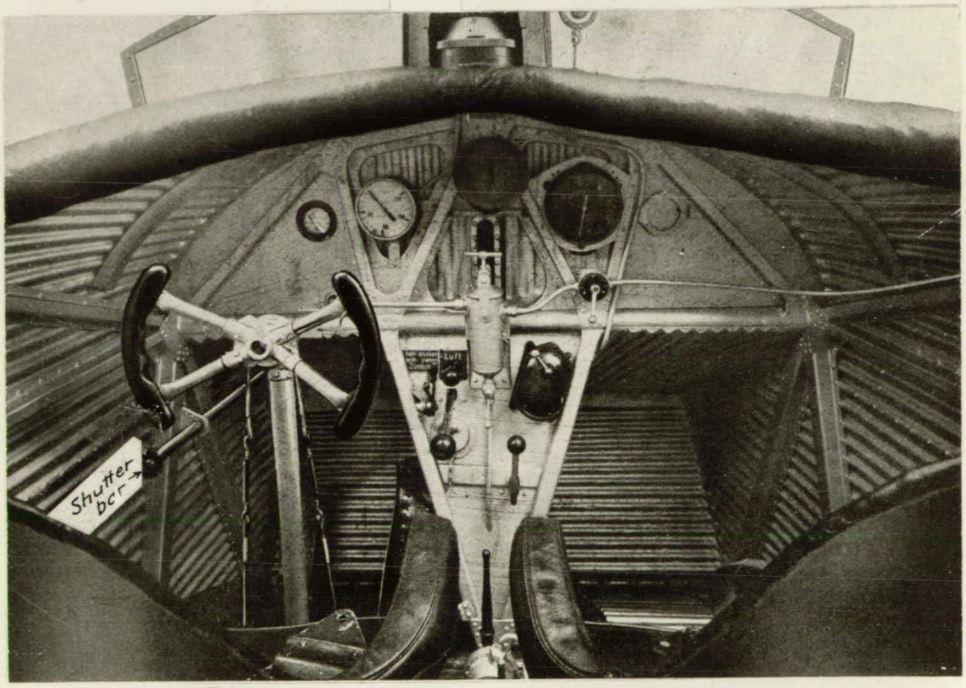

Fig.11 Pilot's compartment

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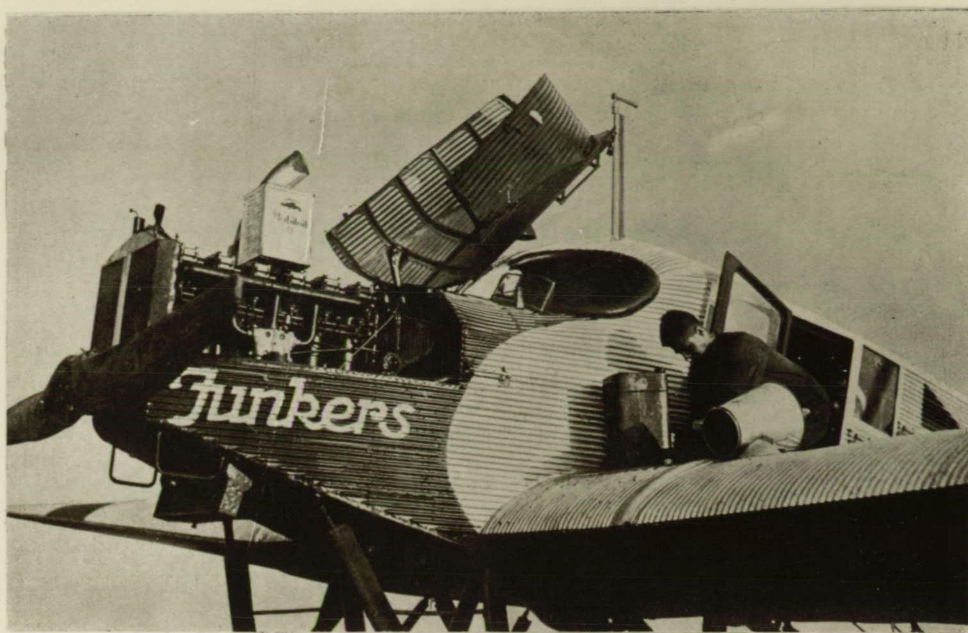

Fig.13 Filling fuel tank

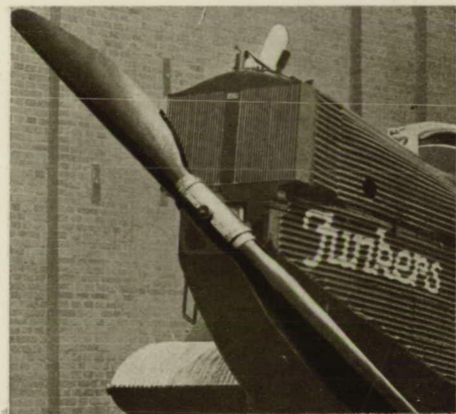

Fig.14 Junkers metal propeller.

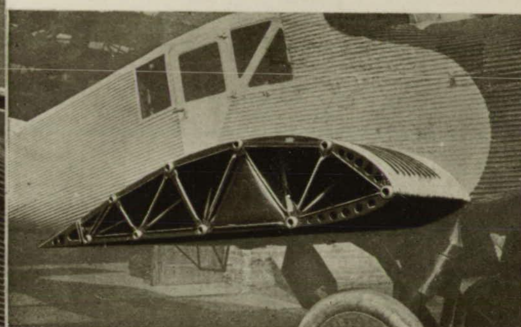

Fig.15 Fuel tank in central part of wing.

Fig.16 Passenger cabin

Fig.17 Supplementary fuel tank

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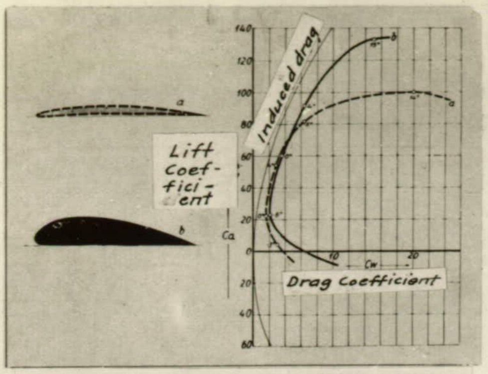

Fig.1 Polar diagram of thin wing (a) and of thick wing (b)

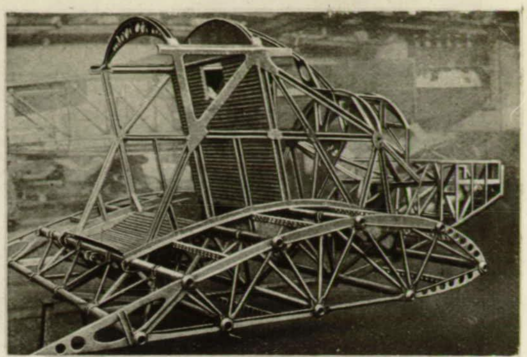

Fig.2 Tubular frame of central part.

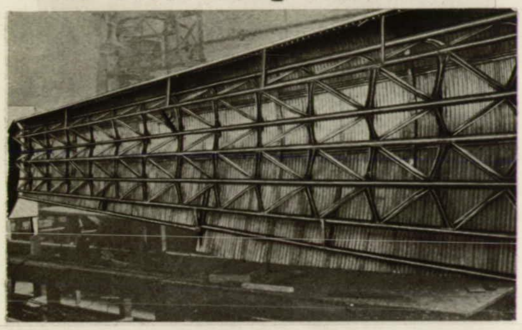

Fig.3 Interior of a Junkers wing

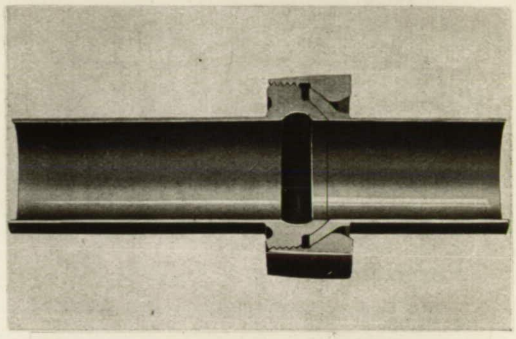

Fig.4 Threaded joint of tubular members.

Fig.5 Junkers all-metal airplanes require no hangars.

Fig.6 In the snow on the Boujouriste aviation field near Sofia.

Fig.7 Mounting the right wing

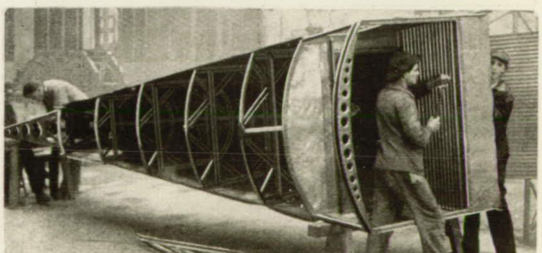

Fig.8 Constructing the fuselage

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