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AIRCRAFT CIRCULARS
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 148

THE MONO-SPAR LIGHT AIRPLANE (BRITISH)
A Twin-Engined Low-Wing Cabin Monoplane

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THE MONO-SPAR LIGHT AIRPLANE (BRITISH)*

A Twin-Engined Low-Wing Cabin Monoplane

About a year ago, the Mono-Spar Co., Ltd., decided to build a small airplane in order to test out the mono-spar principle in actual flight, and arrangements were made with the Gloster Aircraft Co., Ltd., to build the airplane at their Brockworth works. For various reasons, the work has taken a considerable time, but the airplane was finished some time ago, and has now been to Martlesham for tests. Consequently, a description and illustrations may now be published. (Figs. 1 and 2.)

The Mono-Spar system obviously provides a way of increasing the useful load. In current practice to-day the structure weight, especially that of the wing, is a large proportion of the total weight of the airplane. As the load which can be carried per unit of wing area can only be increased at the expense of landing speed and take-off speeds, with subsequent decrease in performance, the ratio of useful load or pay load to all-up weight has become more or less fixed.

On the whole this ratio of useful to total load only permits airplanes to compete with other forms of transport at commercial rates, even in spite of its increased speed, when conditions are exceptional. The Mono-Spar system seems to offer a way out, for even in this first experimental model the structure weight is only 26 per cent of the total weight.

There is another way of using the extra lift which the system makes available and that is to increase the safety factor.

In the design of the airplane, the monospar principle has been applied not only to the wing, but also, in effect, to the fuselage. That Mr. Stieger's claims for low structure weight are borne out, seems to be indicated

*From The Aeroplane, July 8, 1931, and Flight, July 10, 1931.

by the fact that the structure weight is a considerably lower percentage than is usually found in an airplane of this type and size. Originally, the airplane was intended to be fitted with two of the Redrup axial engines but, as the experiments with these took longer than had been expected, two 50 hp Salmson engines of the 9 AD type were fitted instead, and with these the airplane flies very well, indeed.

The engines are completely encowled, but the covering is so arranged that the cooling air is free to flow away, over and under the wing.

The airplane is a three-seater, with pilot and one passenger side by side, but slightly staggered, and a third seat behind them. Owing to the forward position of the pilot's seat and the absence of an engine in the nose of the fuselage, the view forward is exceptionally good. Large windows in the cabin give a good view outwards, although from the back seat the view is, as in most low-wing monoplanes, slightly interfered with.

A direct gravity feed is provided by carrying the gasoline in a tank in the fuselage nose, in front of the instrument board.

Structural Features

The main reason for producing the monospar airplane was, as already stated, to try out in flight the Stieger system of single-spar construction, and some notes on it here may be of interest.

It will probably be recollected from previous references to the monospar system that this consists of a single main spar, strong in bending, but braced against torsion by what may best be described as "spiral" bracing wires, these wires consisting of two sets, which may be imagined as running around the wing in opposite directions. The single spar may, of course, be of any suitable construction. In the airplane with which we deal here, it is an I beam of duralumin, built up of several members. The web itself is a plain duralumin plate, with triangular holes stamped out for lightness, leaving a series of lattice bars to act as braces between top and bottom flanges.

The spar flanges or booms are built up of strips, and may be said to consist of angle sections riveted to the web, with reinforcing cover plates added on the outside. The angle sections are not, however, of the usual plain flat type, but are of curved shape, as shown in the sketch A, Figure 3. A flange of this shape should be a good deal stronger in compression than one consisting of plain flat angle sections, as the members composing it help to brace each other. At the same time, the spar should not be an expensive one to manufacture, and, where local reinforcement is necessary, this can be provided by extra laminations on the outer faces of the spar. The spar web being, as already stated, perfectly flat, is stiffened here and there by vertical members of V-section, also shown in sketch A, Figure 3.

The "spiral" bracing of the wing takes the form of tie rods anchored at their ends to the apices of tubular king-post ribs, and to plate fittings on the spar flanges, where the tie rods of a bay cross each other. This "spiral" bracing does not extend right out to the wing tips, but finishes on the spar just beyond the inner end of the aileron. From this point to the wing tip the bracing is taken over by the false spar carrying the aileron. This spar is placed at a pronounced angle with the main spar, which it meets at the wing tip, thus triangulating the structure. The false spars run inwards from the wing tips, where they are attached to the main spars, to the last compression members of the monospar system, which junctions are effected through flanged duralumin plates. The wing forward of the aileron is further stiffened with two hinge ribs.

The construction of the outer sections of the wing can be readily seen from Figure 4, in which can be easily distinguished the rigid bracing, the swaged-rod bracing and the triangulated structure of the wing tips.

The ailerons, which are of the Frise type and covered with fabric, have a built-up spar on which are threaded diaphragms of duralumin spaced by a flattened tube of duralumin along their trailing edges. The spars are U-shaped and closed with a flanged plate with suitable lightening holes. The hinges are simple plate fittings made from welded sheet steel.

The wing is built entirely of duralumin with the exception of some steel fittings and wiring plates.

The wing is in three pieces, of which the center portion is built integral with the fuselage, and contains the engine mountings. The two outer wing portions are attached by three bolts each, two on the spar flanges and one on the forward king-post. In the center section the struts supporting the engine bearers are used as the king-posts in the wing bracing system.

The drag and anti-drag loads are taken by the duralumin sheeting over the nose of the wing which is fastened to the ribs.

Wing ribs of orthodox type are employed, and resemble those used on Gloster airplanes for several years, with the fabric wired on to the ribs in the Gloster manner.

The ribs are built up from drawn channels of duralumin, the webs of which are curled over. These channels are indented along their flanges and where used as booms have eyelets inserted therein - thus providing a simple method for attaching the fabric covering. The ribs are fastened to the main spar with a special clip.

At the leading edge is the duralumin sheeting and towards the trailing edge is a duralumin angle which is attached to the apices of the compression members and serves to locate the ribs. (Fig. 5.)

As already mentioned, the monospar system of construction has been applied to the fuselage also, although naturally in a modified form. (Figs. 6 and 7.) The main structure member of the fuselage is a beam of relatively shallow depth, and reminds one, in principle if not in actual form, of the steel tube used in early Breguet airplanes. In the monospar airplane, however, this beam is an open girder of duralumin, of square section, and "standing on a corner." The four corner booms of this beam are of built-up D-section, and are joined by an outer cover of duralumin sheet, stamped out to form lattices like the main wing spar web. This cover braces the fuselage beam, and consists in two halves, the free edges of which overlap on the top and bottom booms. This form of construction appears needlessly expensive, and one would have thought that a number of standardized short lattice bars would have been much cheaper to manufacture.

A hollow square-section tube like that just described would collapse inward under low load, and to prevent this the four booms are kept apart by tubular distance pieces running from corner boom to corner boom, vertical distance pieces alternating with horizontal ones.

The fuselage beam is placed at the bottom of the fuselage, and is anchored to the wing spar of the center section by a large tubular vee. The attachment is considerably complicated by the fact that the fuselage boom is "standing on a corner."

The fuselage shape proper is obtained by hoops of trough-section duralumin and fore- and aft-stringers of similar section. In the side view of the airplane in skeleton no wiring is shown, but actually a certain amount of "spiral" wiring was added to the fuselage after the first test flight to get greater torsional strength. This wiring had the desired result, and the airplane is thoroughly rigid and free from torsional and flutter troubles of any kind.

The tail unit is of the normal monoplane type. The fin is cantilever and the stabilizer is rigidly braced to the underside of the fuselage. The elevators and rudder are both balanced.

The stabilizer has one spar along its rear edge. Forward from this are flanged duralumin plates arranged triangularly. Through their apices runs the flattened tube which forms the leading edge. Five duralumin ribs aside complete the assembly. The elevators and rudders are simple structures of the same type.

The landing gear is of the divided type and has a very wide track. The use of Bendix brakes with a castoring tail skid makes the airplane extremely maneuverable on the ground - so much so that it can be kept straight with only one engine working although each wheel is directly under an engine.

An experimental arrangement for coupling the brakes to the control column has been incorporated, so that, when the pilot pulls the stick back for a three-point landing, the brakes are operated. The interconnection can, however, be released when the brakes are operated by a centrally placed lever in the orthodox manner.

The axle of each landing gear unit is hinged to the wing girder or main spar on the underside of the fuselage. Each vertical leg, which incorporates a Vickers oleo shock absorber, runs up from the axle to a strong point in the engine mounting. A streamline radius rod braces each spring-leg back to the wing girder. The tail skid, which is fully castoring, is sprung with rubber-in-compression.

The controls are duplicated and are of the conventional stick and rudder-bar type. The braking system has been arranged to prevent nosing over on landing. The brakes are set by pulling back a lever in the middle of the cabin floor, and are put on by pulling back the stick. (Fig. 8.) If for any reason the stick is eased forward the brakes come off, so that the brakes are only applied when the tail is down. The brakes are also arranged for differential control through the rudder bars, so that steering on the ground is easy.

From the mechanism for the differential control of the brakes the rudder cables run straight back to the rudder. The control columns are mounted in forks on the ends of short fore-and-aft torque tubes, which are mounted beneath the seats. These torque tubes are linked together and to a lever from which wires run to the ailerons. The elevators are operated through a torque tube to which each control column is linked through a universally jointed push-pull tube. Wires run back to a lever on a lay-shaft in the tail unit whence the elevators are operated through a push-pull tube

The slipstream from the two propellers, running as they do close to the fuselage and wing roots, caused a certain amount of trouble at first, but the designers have now succeeded in finding means for smoothing out the air flow, and the airplane is reported to be remarkably pleasant to fly. In landing, it shows no tendency to "kite," but sits down without any trouble at all.

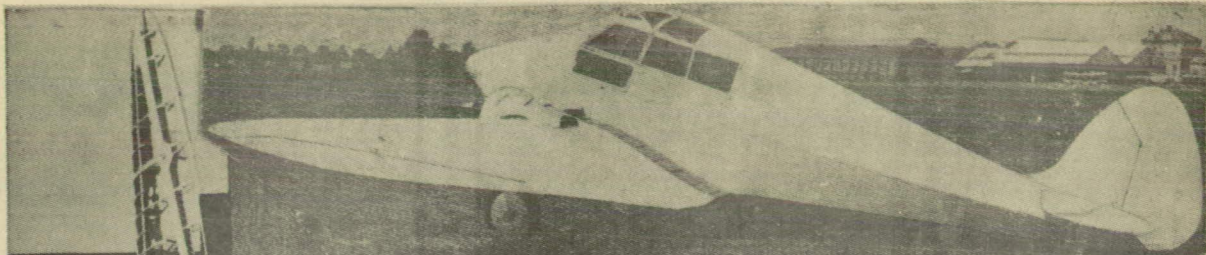
Characteristics

Span,	38 ft.
Height,	9 "
Length,	21 ft. 11 $\frac{1}{2}$ in.
Wing area,	183 sq.ft.
Fully loaded,	1800 lb. (of which only 1057 lb. is tare weight)

Performance

Top speed	110 m.p.h.
Rate of climb at ground level,	950 ft. per min.
Ceiling,	18,000 ft.
Landing speed	below 40 m.p.h.

With two people and three-quarters full load of gasoline, the airplane has kept height on one engine.



Figs. 1 & 2 Three-quarter view of the MonoSpar airplane

Figs.1,2,6 Taken from "Flight"

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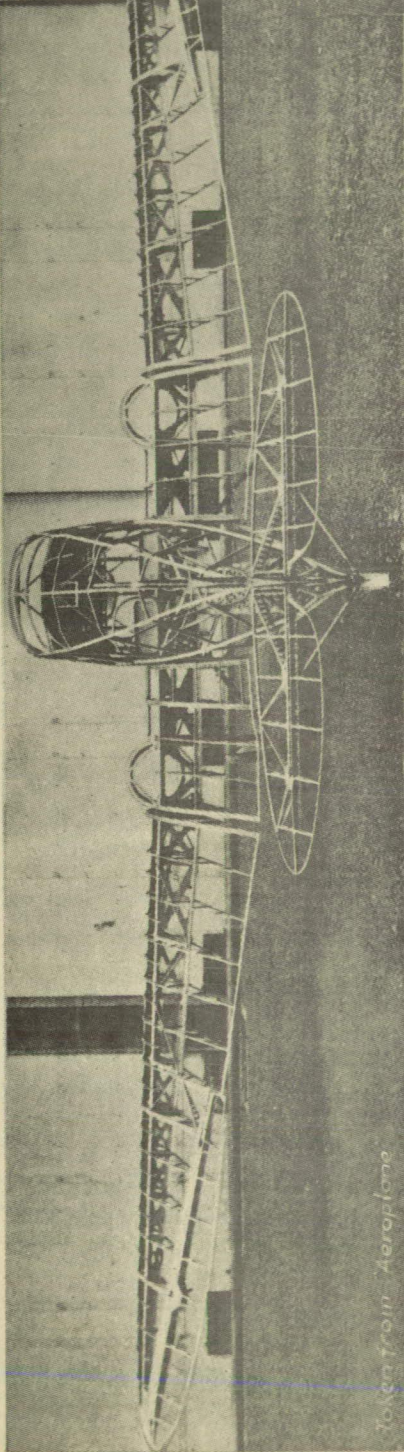


Fig. 4 The skeleton of the MonoSpar airplane. This picture shows clearly the method of construction and the way the fuselage fairing is mounted.

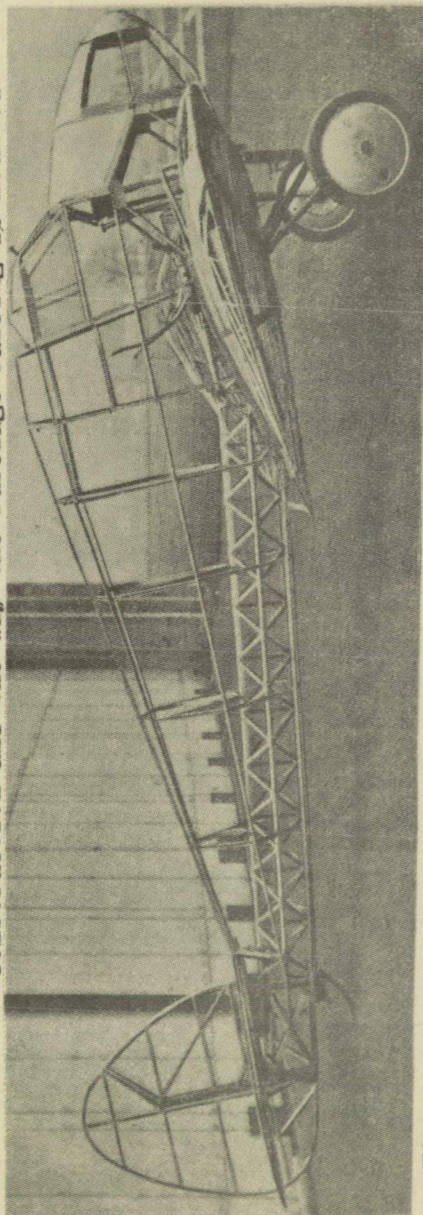


Fig. 6 The MonoSpar airplane before it was covered. The shallow depth girder which forms the main fuselage member is clearly seen.

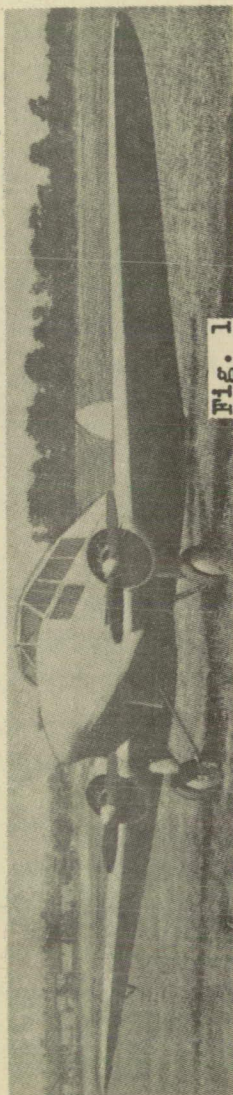


Fig. 1

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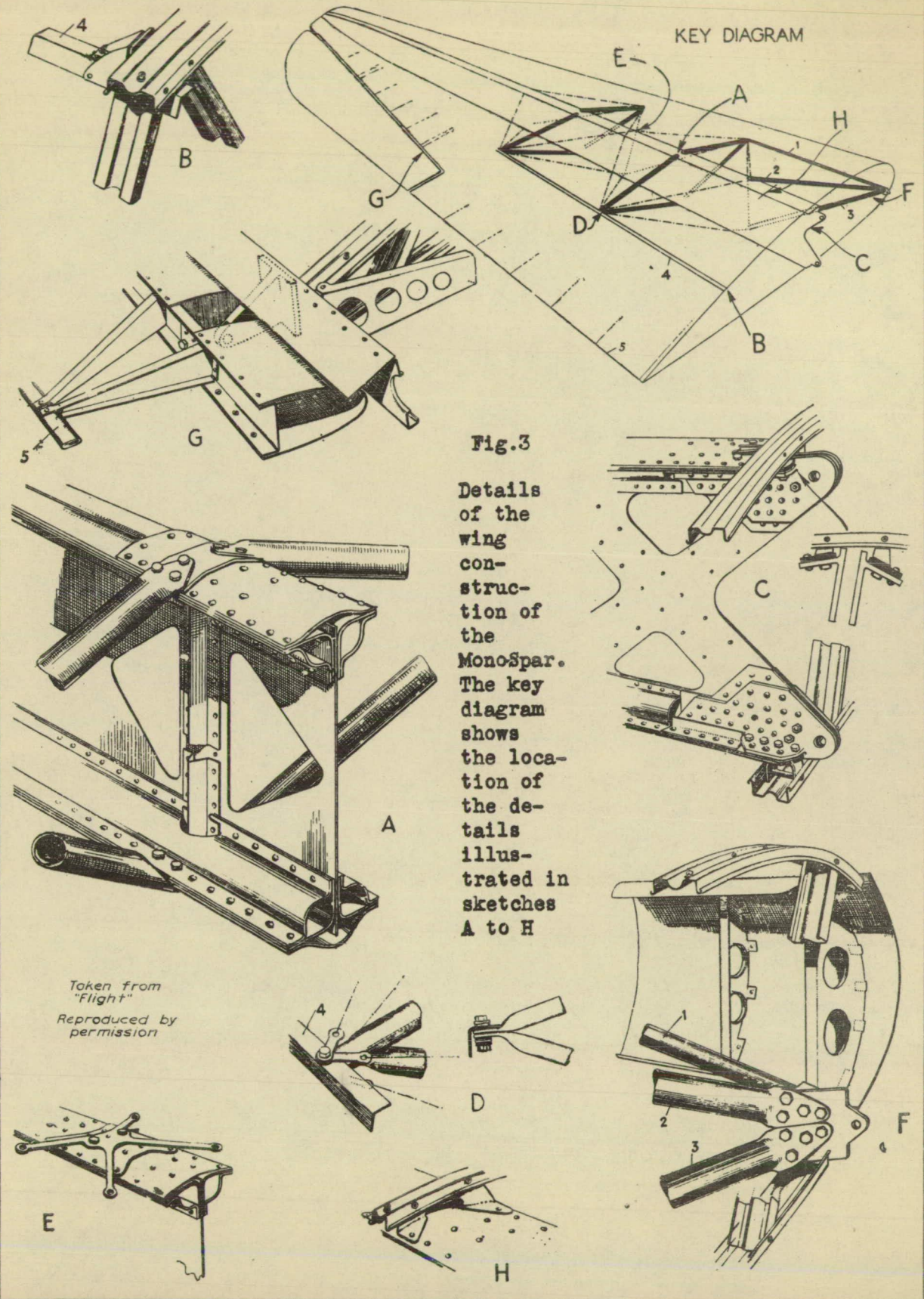


Fig. 3
Details of the wing construction of the Monospar. The key diagram shows the location of the details illustrated in sketches A to H

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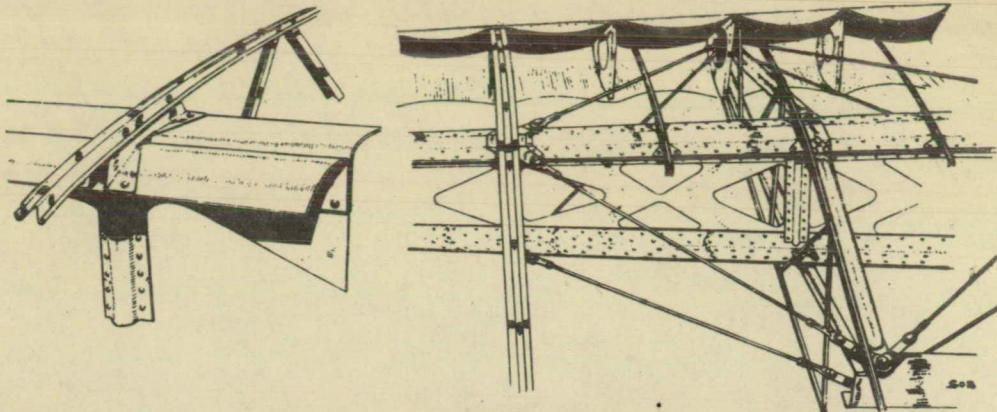
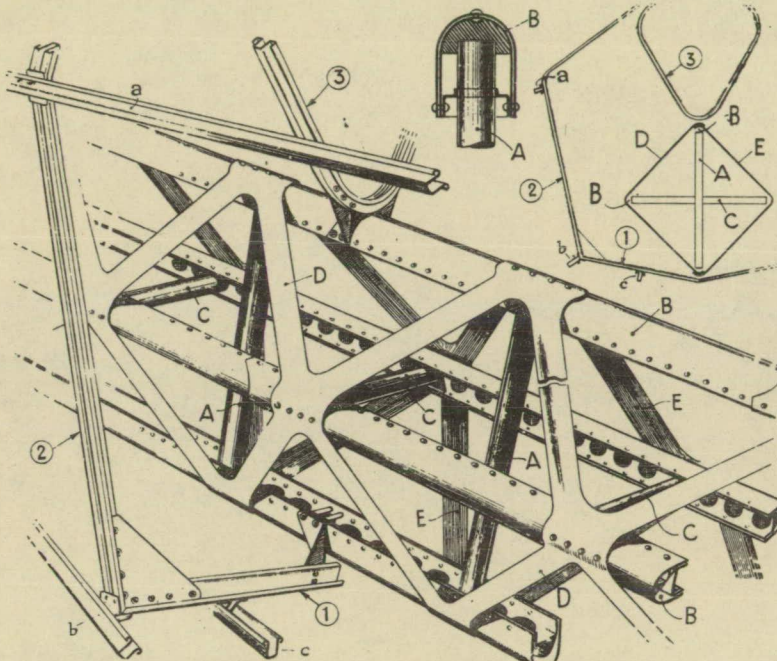


Fig. 5 A sketch which shows the way the swaged rods brace the spar against torsion. On the left is a typical rib attachment.



Figs. 5,8 Taken from "Aeroplane"

Fig. 7 The fuselage boom. Details of the construction. The corner strips and surrounding bracing are of duralumin. The depth of the boom is approximately one foot, and it is placed in the bottom of the fuselage, the outer form of which is produced by hoops and stringers.

Fig. 7 Taken from "Light"
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Details of the Mono-Spar airplane

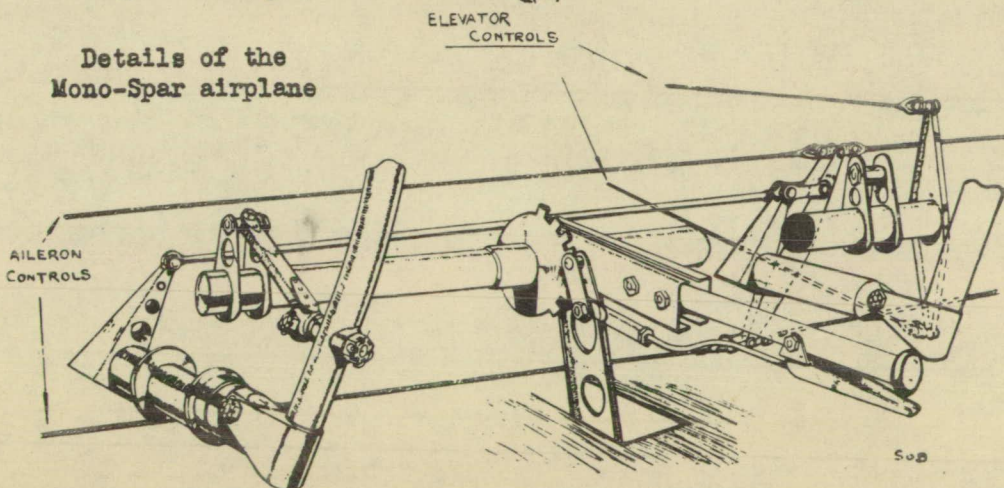


Fig. 8 The control system. The large lever in the middle with the ratchet gear is the lever for setting the brake.