AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 164

THE STIEGER ST. 4 LIGHT AIRPLANE (BRITISH)

A Twin-Engine Four-Seat Low-Wing Cabin Monoplane

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A Twin-Engine Four-Seat Low-Wing Cabin Monoplane

The ST. 4 is a twin-engine low-wing monoplane of the full cantilever type. Great care has been taken to keep the aerodynamic design "clean," and in order to avoid too great interference between fuselage and wing roots, the latter have been brought down to a thin section, while simultaneously the trailing edge near the body has been raised. (Figs. 1, 2, 3.) Structurally, this arrangement has been achieved by continuing the top boom of the wing spar right across the fuselage, while the upper wing surface has been gradually reduced in camber as the fuselage is approached. As this surface drops away from the top spar boom, the latter becomes exposed, and is faired over the portion which extends from the surface of the wing to the side of the fuselage.

The wing consists structurally of three portions, or rather of two portions and a variation of one of them. These are: the wing root, the middle portion, and the wing tip. The middle portion and the tip are of dissimilar construction, although they are permanently attached together, while the wing root, permanently attached to the fuselage and, indeed, forming an integral part of it, shows a type of construction quite different from both the middle and the end portions of the wing. The wing root extends outward to just beyond the engine mounting, and here occurs the hinge around which the wing pivots when folded.

As the middle wing portion is really that which is typical of the wing construction, we will examine it first. (Figs. 4 and 5.) The single spar comprises top and bottom flanges or booms. These flanges are of very simple construction, and consist of "square" section tubes with the corners rounded off, each tube being made in two halves riveted together, the riveting flanges being turned outward to make the rivets easily accessible, and placed on the center line of the boom.

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*From Flight, April 22, 1932.

The shear members of the spar are built-up square boxes arranged in a formation halfway between an N girder and a Warren girder, the ties having a pronounced slope and the struts being not quite vertical, but less sloped than the ties, except for the two which occur where the torsion bracing is attached to the booms. These two struts are vertical in order to take the compression loads caused by the converging top and bottom tie rods of the torsion bracing. The shear members in this portion of the wing are all of the same type of construction: a rectangular box section formed by side members of channel section, turned back-to-back, and top and bottom members of flat duralumin sheet, riveted to the flanges of the channel sections.

The pyramid bracing, which extends in its plain form over this portion of the wing only, consists of tubes parallel with the wing chord, and diagonal bracing in the form of tie rods attached alternatively to the spar booms and pyramid strut ends. The fittings on the spar booms and strut ends are of Habersohn's steel, and are in the form of plain four-armed X's, except for the outer ones, which are the standard fittings with two of the arms cut off.

The tubes of the pyramid bracing are lightly secured at their centers to spar shear members by flat duralumin plates. The tube is a sliding fit in the plates, which only serve to stabilize the tube by halving its free length. Actually, from other structural considerations it is not, surprising as this may seem, necessary to secure the tube to the spar at all.

There are two ways of arranging the drag and antidrag bracing in the monospar system of construction: either by wires joining the front and rear ends of the pyramid struts, in a direction parallel with the spar, or by making the leading edge of the wing the drag member. If this member is able to resist compression, obviously the antidrag wire joining the rear ends of the pyramid tubes can be omitted. (Figs. 6 and 7.) This has actually been done in the ST. 4, the leading edge being a horizontal U section of duralumin, and carried on the front ends of the pyramid tubes. The trailing edge is formed by an oval section duralumin tube.

In the tip portion of the wing, the system changes from a monospar to a triangulated two-spar construction. The main spar continues to the very wing tip, and a rear

spar, which supports the aileron hinges, is added in place of the tie-rod torsion bracing. This rear spar converges on the main spar, which it meets at the tip, and is a plain duralumin channel, with the closed side towards the aileron, lightened by circular flanged holes. The main spar also changes its structure in this wing portion, the spar booms being made up, over the inner part of the portion, of one-half of the standard built-up boom, covered with a flat strip. At the extreme tip the spar booms become open channels, the flat covering strip being omitted. The shear bracing in this portion of the wing is in the form of plain channel sections.

In the wing roots the type of construction is totally changed as a result of the presence of the two engine mountings and the consequent break in the plain torsion bracing. (Figs. 8, 9, 10.) The main spar becomes, in this portion of the wing, a forked member, the upper limb of which, in the form of a large-diameter steel tube, runs in a straight line right across and through the fuselage. The lower spar boom stops short at the lower fuselage longeron, to which it is bolted, a corresponding cross member being placed in the bottom of the fuselage. The shear bracing takes the form of a diagonal member formed by two plain channel sections placed back-to-back, and spaced some little distance apart. Torsion bracing is provided by two tubes forming a horizontal vee with its apex on the leading edge, where this joins the fuselage structure. The leading edge of the wing roots is in the form of a circular section tube, covered with a duralumin strip of horizontal U section, and this is continued across the engine mounting frame, of the structure of which it becomes a part.

The wing ribs are light duralumin girders having flanges of U section with pronounced turning over of the free edges. The shear members or ties and braces are of a slightly different square U section. The ribs are attached to the spar booms by very simple U and L section clips.

Ailerons and elevator, etc., are of very simple construction, with plain duralumin channel sections for the spars and ribs, and a large-size oval duralumin tube for the trailing edge of the ailerons, while in the elevator the trailing edge is a circular section tube. (Fig. 11.)

The inner portion of the wing, adjoining the fuselage, is so arranged that it hinges around horizontal hinges on

the fuselage side. Before the wing can be folded, this portion is hinged upwards until it lies flat against the sides of the fuselage.

FUSELAGE

For an understanding of the fuselage construction, it is necessary to refer to the figures. The primary structure is in the form of a single built-up girder at the rear, forking just behind the cabin to form two side girders, which then converge in front to form the nose of the fuselage. (Fig. 12.) The single girder at the back would not transmit very much torque, and a system of torsion bracing exactly similar in principle to that of the wing is employed. (Fig. 13.) The whole primary structure is very simple, indeed, but unfortunately, the secondary structure tends to complicate it considerably, and the attachment of the formers which carry the longitudinal stringers that support the fabric becomes somewhat involved. (Figs. 14 and 15.) The airplane is light, the tare weight being about 1250 pounds, and the gross weight 2300 pounds, but much of the low weight is probably due to the wing construction.

The fuselage girder has top and bottom booms similar to those of the wing spar, but the shear members are open duralumin channels with the free flanges turned over. The side members are tubular girders, duralumin being the material except for one tube, which may ultimately have to take the stresses of a float landing gear, and which has therefore been made of steel. The fabric-supporting stringers are very deep U's of duralumin.

POWER PLANT

The two Pobjoy R engines are mounted "en porte a faux" from the single wing spar. (Figs. 8, 9, 10.) Two horizontal vees whose apexes meet on spar and engine frame in such a way as to form a double wedge carry the engine mounting proper, which consists of steel tubes so arranged as to give triangulation. The whole engine attachment is free to swing laterally around the vertical hinges on the spar, but are prevented from doing so by the continuation of the leading edge which crosses the engine mounting framework.

The gasoline tanks are mounted inside the wing and straddle the wing spar. Each tank has a capacity of 21 gallons, and is made of tinned sheet steel, so that in the event of a leak during operation, anyone who can use a soldering iron can make the repair. The tanks are actually in the middle wing portions, so that to permit folding of the wings a length of flexible tubing connects with the carburetors. This placing of the gasoline tanks does not give sufficient "head" to produce gravity feed when the airplane is climbing and accelerating, and the gasoline system therefore includes two A.C. pumps, the system being so arranged that either pump can supply either or both engines. All the engine controls are of the Arens remote type.

LANDING GEAR

By making use of the new telescopic legs marketed recently by Aircraft Components Company (Mr. G. H. Dowty), it has been possible to design a very neat landing gear (figs. 10 and 15) for the ST. 4. The telescopic legs incorporate coil springs for the actual aircraft load, and an oleo gear for checking bouncing. A feature of these legs is the exceedingly compact arrangement, which makes it possible to get the whole shock-absorbing mechanism into a circular tube of very small outside diameter. Each tripod is completed by an axle and a radius rod, and further to reduce drag the wheels are partly enclosed in "spats." The wheels are Dunlops (19 × 7) of the low-pressure type (wired), and Bendix brakes are fitted. The brakes are operated by a lever centrally placed in the cabin, between the two joy sticks. The lever applies both brakes, and for steering on the ground use is made of the fact that the engines are placed on the wings. A castoring tail wheel is fitted, the tire being a Goodyear, 12 × 5. (Fig. 16.)

Seats for two pilots are placed in front with a complete set of dual controls placed side-by-side, while the passengers are situated behind the wing spar, far enough to have very ample leg room. The seats are arranged side-by-side, and there is space for yet another seat on the wing spar, so that the airplane could quite well accommodate five.

The flying controls are of orthodox type, with dual joy sticks and parallel-motion rudder pedals. The brake lever is, as already mentioned, located centrally between

the two joy sticks, where it is within reach from either seat. The instrument board contains Smith's instruments exclusively, but is not the standard Smith board, the width of the cabin being rather greater than in most airplanes and the available space therefore of somewhat different proportions. A sliding map tray disappears into the instrument board when not in use.

It is not often that one has cause to complain that a cabin is too light. In the ST. 4, however, the windows in side and roof are so large that it seems quite possible that tinted blinds will have to be provided.

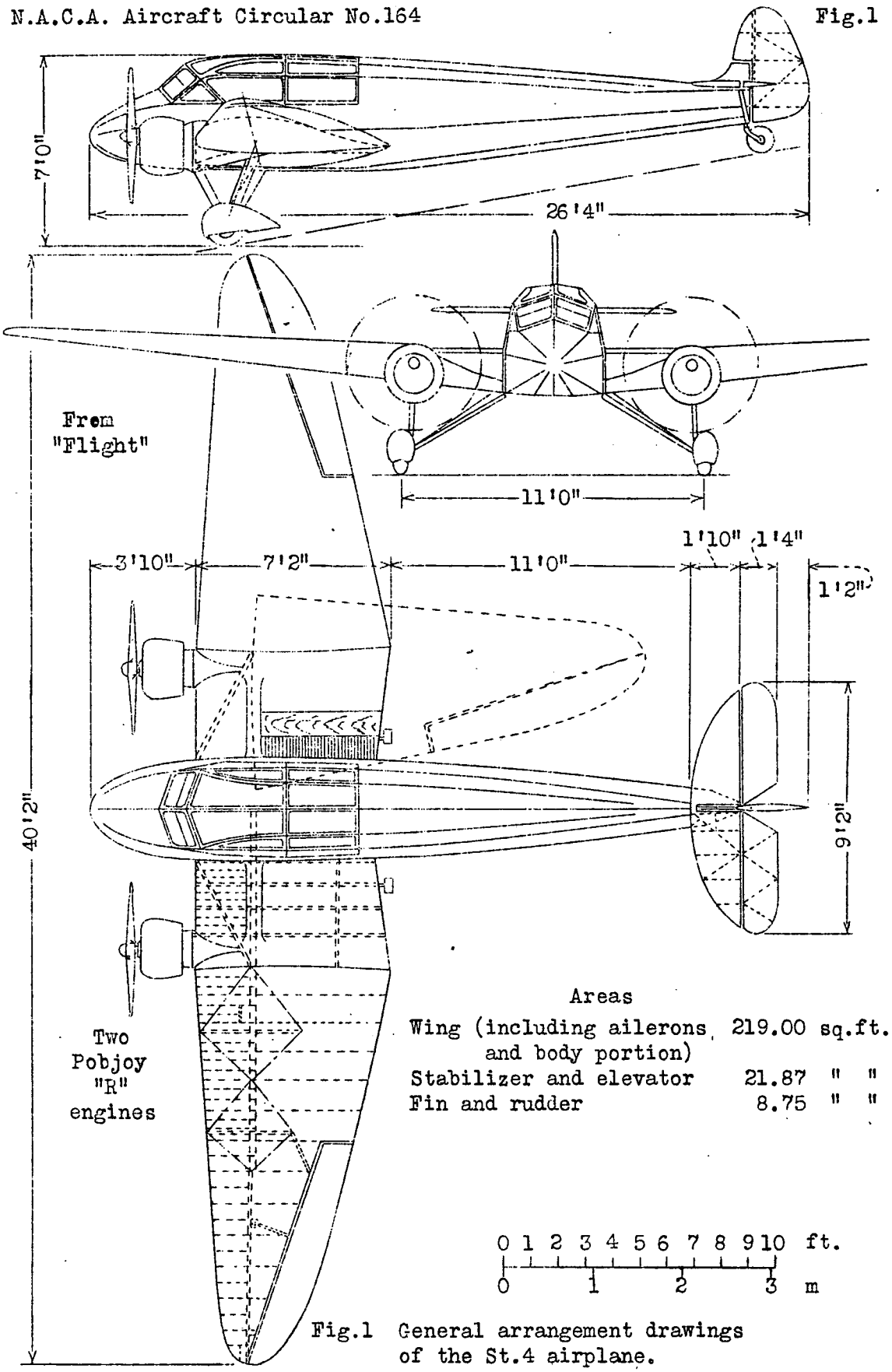
Owing to the position of the engines in relation to the fuselage, the view from the front seats is quite remarkably good. From the passengers' seats the wing obscures the view somewhat, but even so quite a good deal of ground can be seen, and, of course, the whole upper hemisphere.

Access to the cabin is by doors formed of combined fuselage sides and roof, the hinges being along a diagonal line on the fuselage side. Steps are provided on the trailing edge of the wing roots, although the wing is not very high above the ground when the airplane is standing with its tail down. The wing root structure has been made strong enough to withstand walking on. The cabin floor is of plywood, carried on transverse fuselage members of I section, built up from two channels of duralumin placed back to back. Light fore-and-aft stringers give the floor the necessary stiffness in the spaces between floor bearers. A comfortable feature of the cabin is that the floor is perfectly flat, i.e., there is no curvature in it in any direction. All controls, etc., pass under the floor, which is left perfectly clear.

CHARACTERISTICS AND PERFORMANCE*

Span	40 ft. 2 in.
Length, over-all	26 " 4 "
Height, "	7 "
Width, wings folded	14 " 10 "
Wing area, including ailerons and body portion	219 sq.ft.
Area, stabilizer and elevators	21.87 sq.ft.
Engines, 2 Pobjoy, type R (geared)	2 x 75 b.hp
Weight, empty	1,200 lb.
Weight loaded, normal	2,200 "
Weight loaded, maximum with 100 lb. luggage	2,300 "
Weight of fuel and oil	340 "
Pilot and passengers	660 "
Maximum speed at ground level	134 m.p.h.
Stalling speed	42 "
Rate of climb at ground level	975 ft./min.
Power loading	13.75 lb./hp
Wing loading	10.04 lb./sq.ft.

*From Aircraft Engineering, May, 1932.



Areas

Wing (including ailerons and body portion)	219.00	sq.ft.
Stabilizer and elevator	21.87	" "
Fin and rudder	8.75	" "

Fig.1 General arrangement drawings of the St.4 airplane.

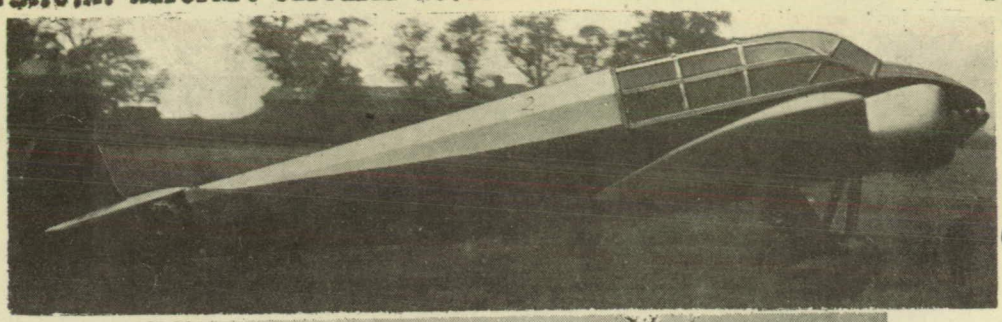


Fig.2 View of model of St.4 airplane. (Flight Photo)

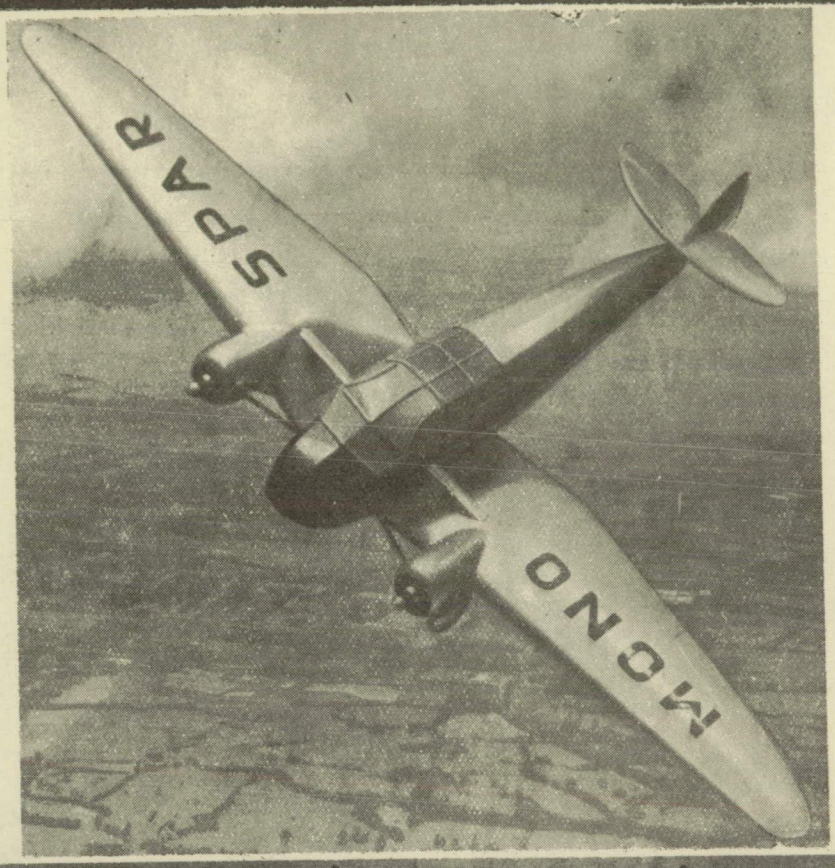


Fig.3 As it will appear. A composite photograph of a scale model of the St.4 . The actual cowling over the Pobjoy engines will not be of the totally-enclosing type. (Flight Photo)

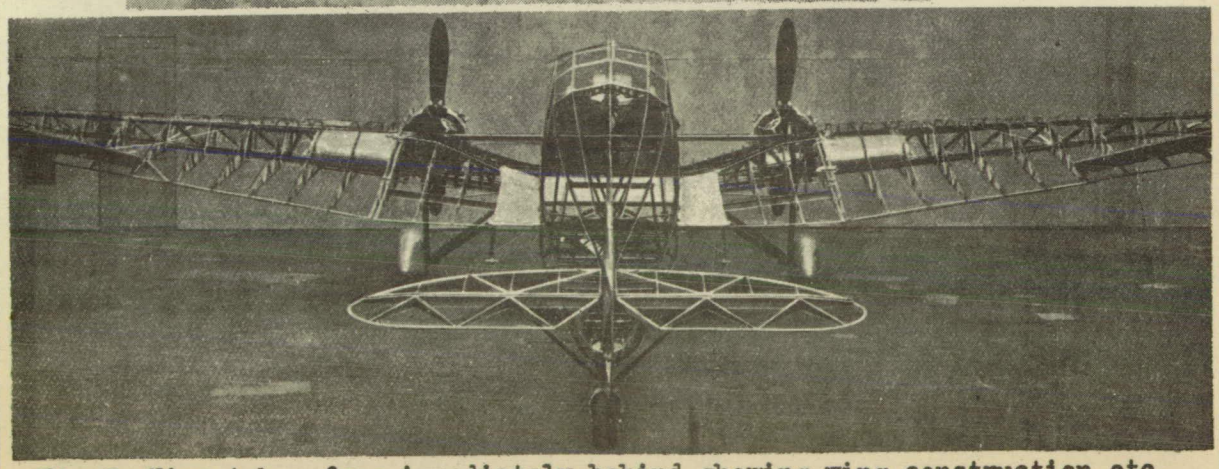


Fig.5 View taken from immediately behind, showing wing construction, etc. Note the placing of the gasoline tanks in the wings. The top boom of the wing spar continues right across the fuselage. (Flight Photo)

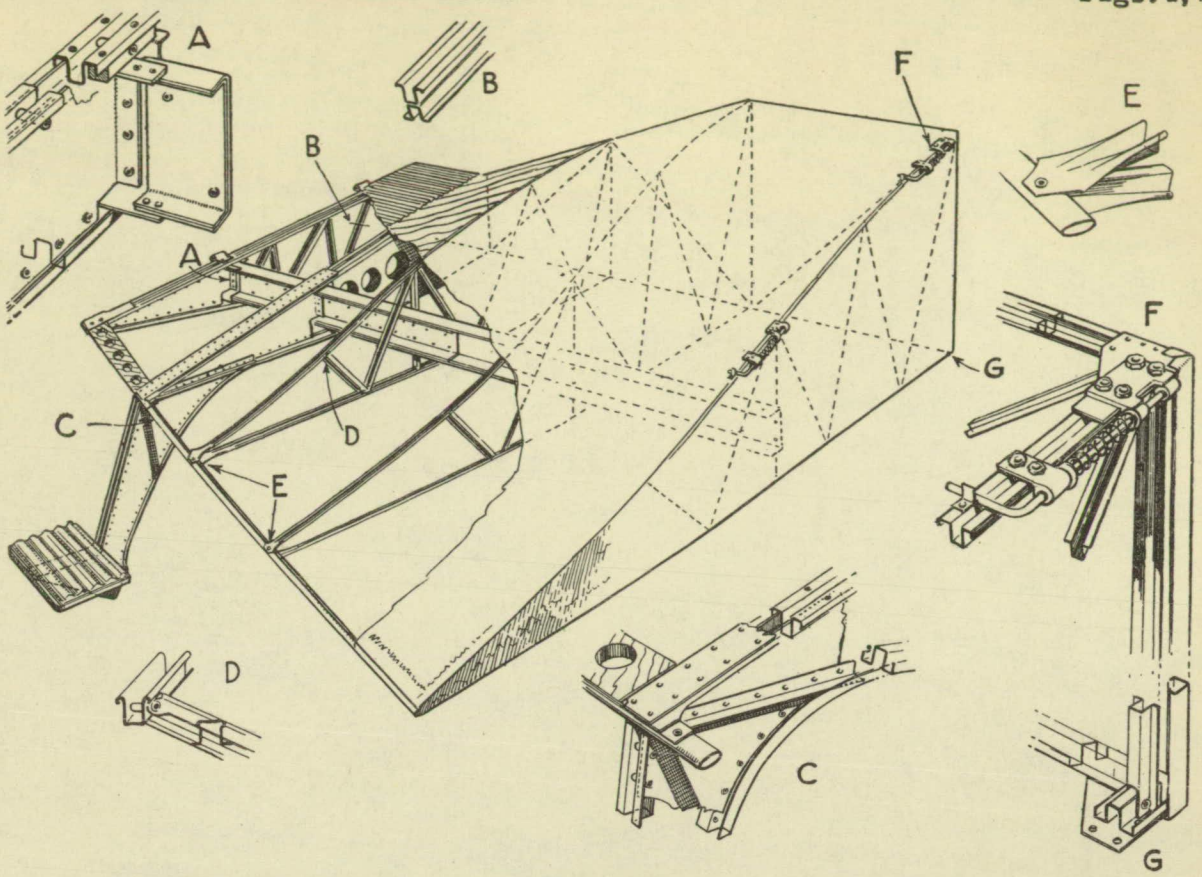


Fig.4 The trailing portion of the wing roots hinges up along side the fuselage to allow of folding the wings. It is in this position of the wing that the lifting of the trailing edge occurs, the object being to reduce interference drag. A step on the trailing edge facilitates getting into and out of the cabin. (Flight Sketches)

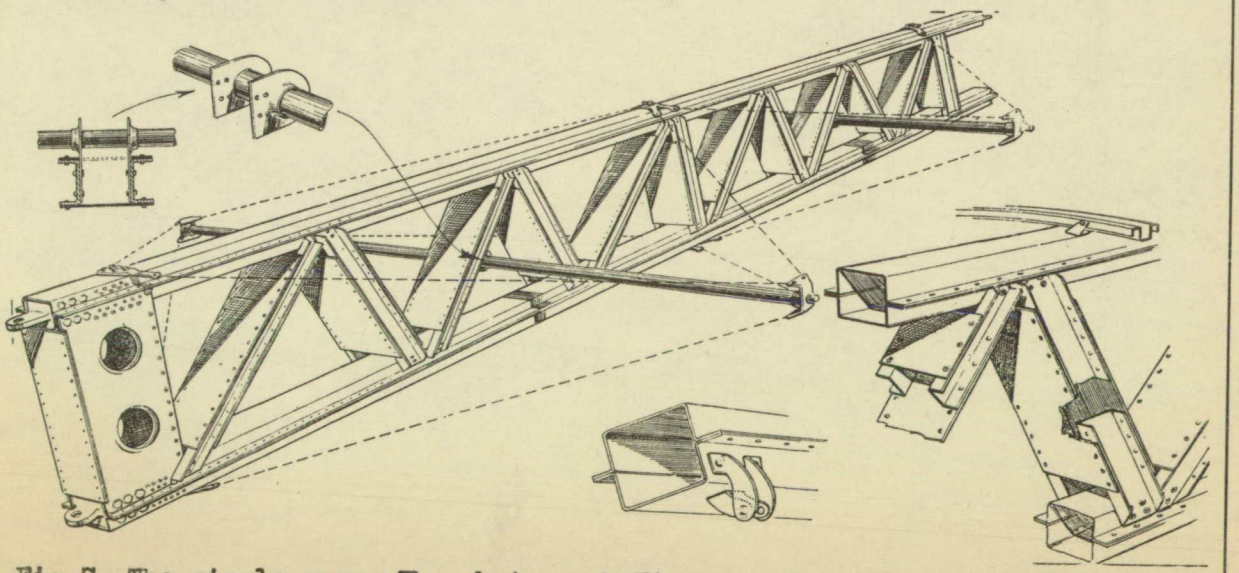


Fig.7 The single spar. The photograph, Figure 6, shows the general arrangement of the shear members, while the sketches illustrate structural details. The small sketch shows the rib-supporting brackets. (Flight Sketches)

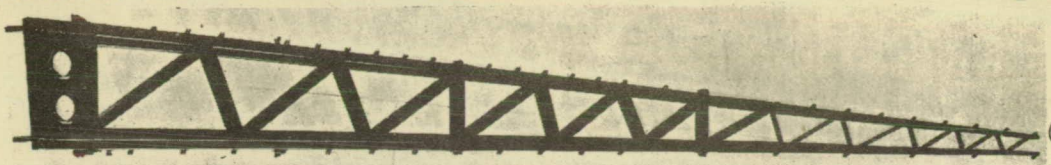


Fig.6
(Flight Photo)

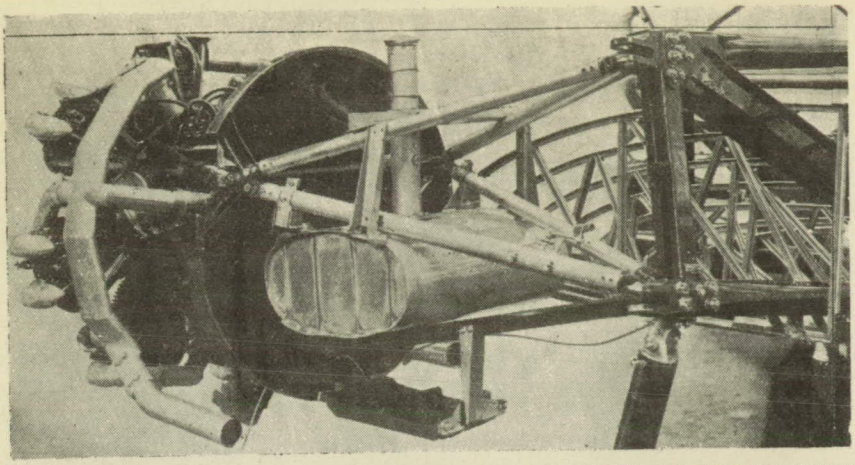


Fig.8 Engine support. The engine plate proper is carried on four tubes forming a double wedge, and prevented by a continuation of the leading edge from swinging laterally. Note the oil tank and cooler. (Flight Photo)

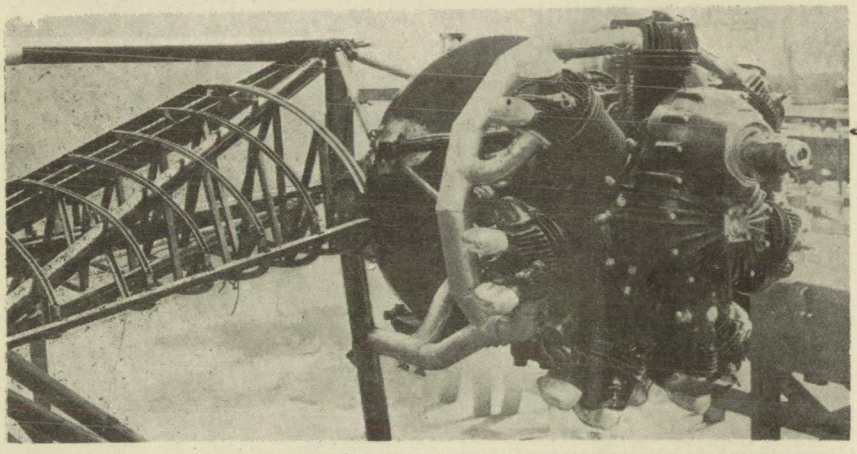
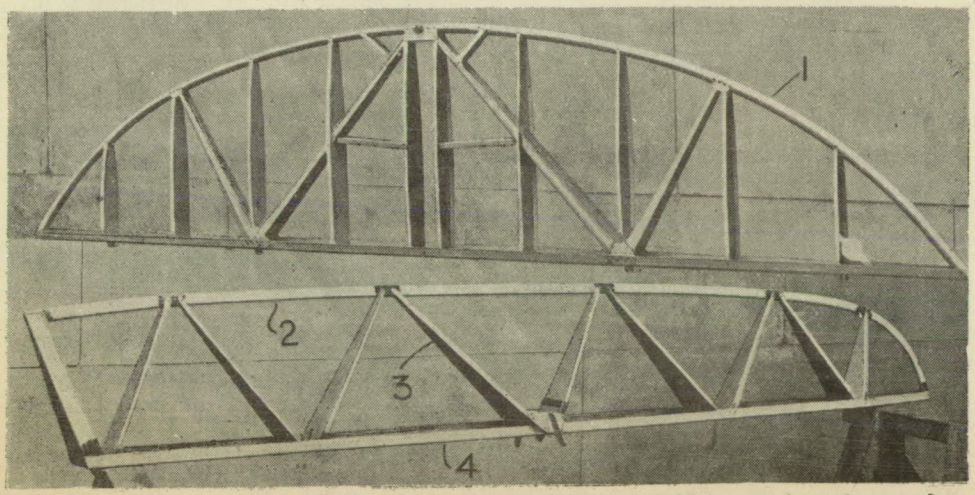


Fig.9 The port Pobjoy engine. Some wing root details may also be seen. (Flight Photo)



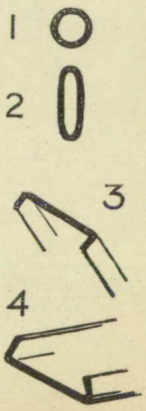


Fig.11 Stabilizer and aileron. The stabilizer is shown in the upper photograph and an aileron in the lower. Details of the various members are shown on the right. (Flight Photo)

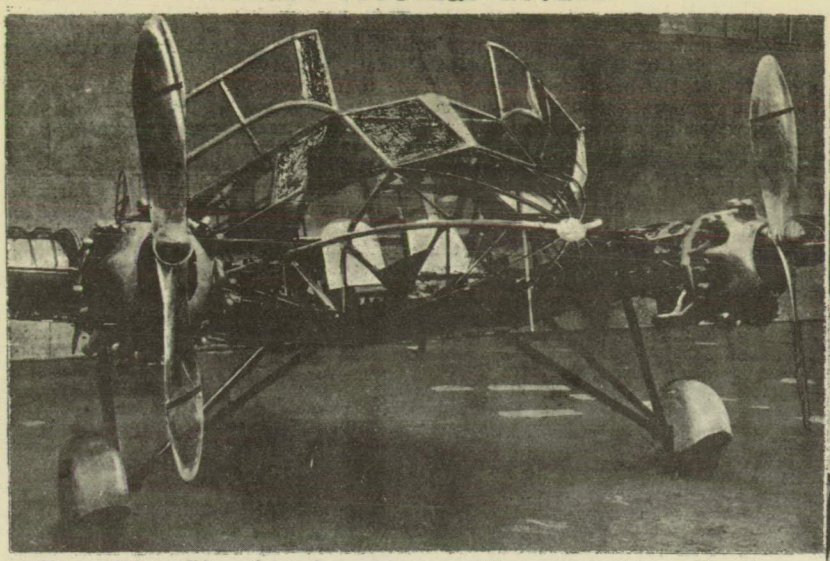


Fig.10 The business portion of the St.4. The Pobjoy "R" engines drive Fairey metal propellers. Note the slimness of the Dowty telescopic legs. The cabin is reached via hinged combined doors and roof. (Flight Photo)

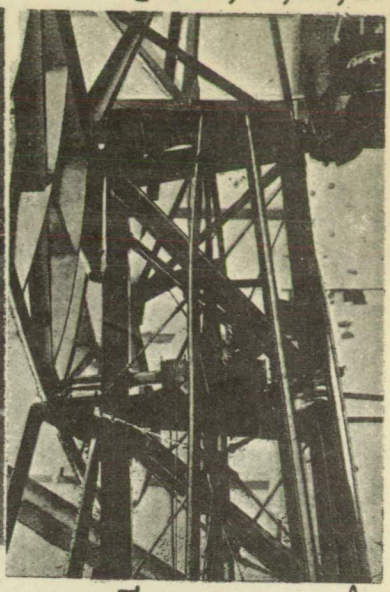
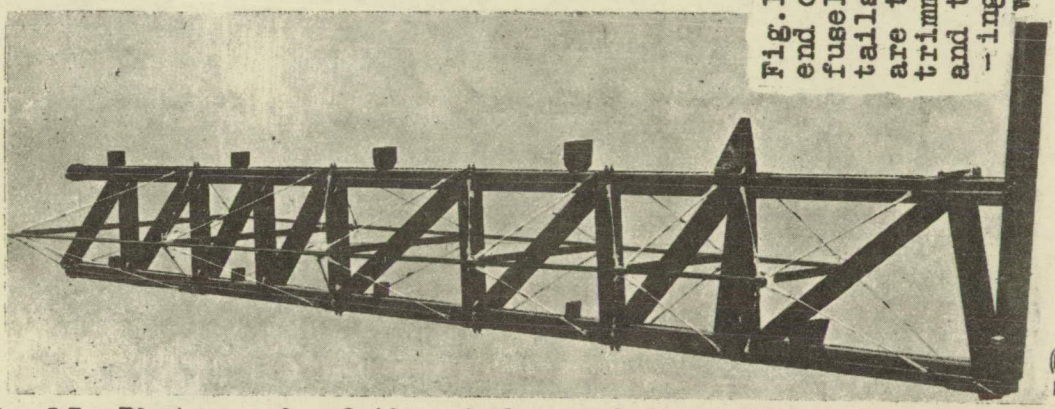


Fig.16 Rear end of the fuselage. Details included are the tail-trimming gear and the castoring tail wheel. (Flight Photo)



(Flight Photo)

Fig.13 Photograph of the girder and the torsion bracing, etc.

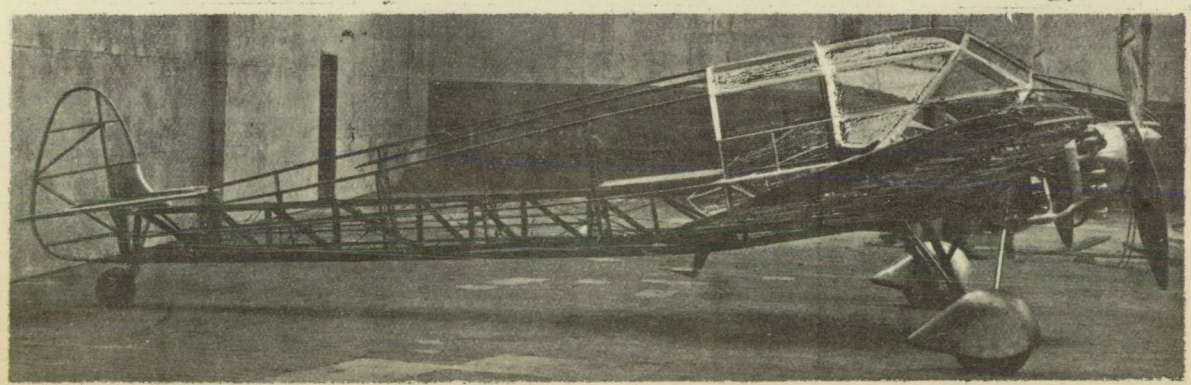


Fig.15 Side view of the St.4. The single girder of the fuselage primary structure can be clearly seen. Note also swivelling tail wheel. A corresponding view of the scale model is shown in Figure 2. (Flight Photo)

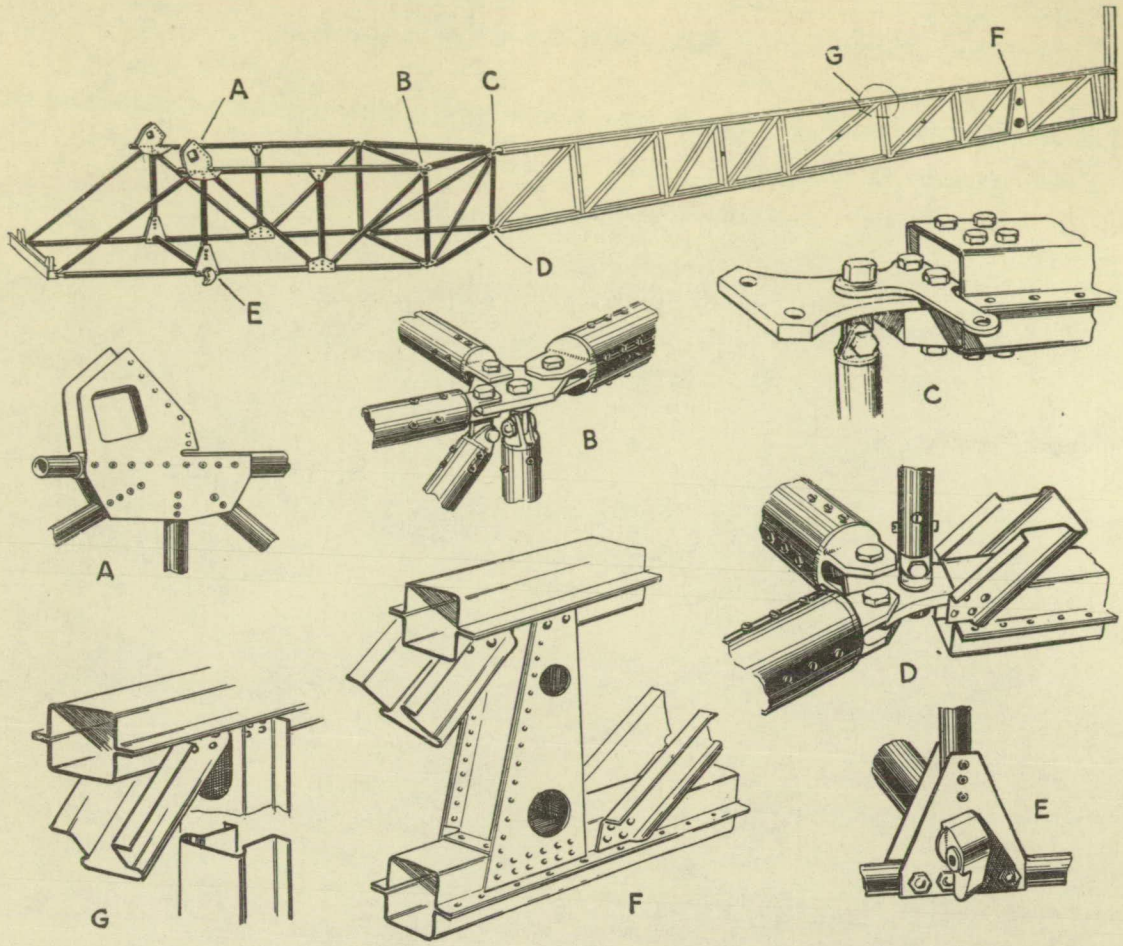


Fig.12 The primary structure of the fuselage. The key diagram gives the locations of the details. The torsion bracing has been omitted. (Flight Sketch)

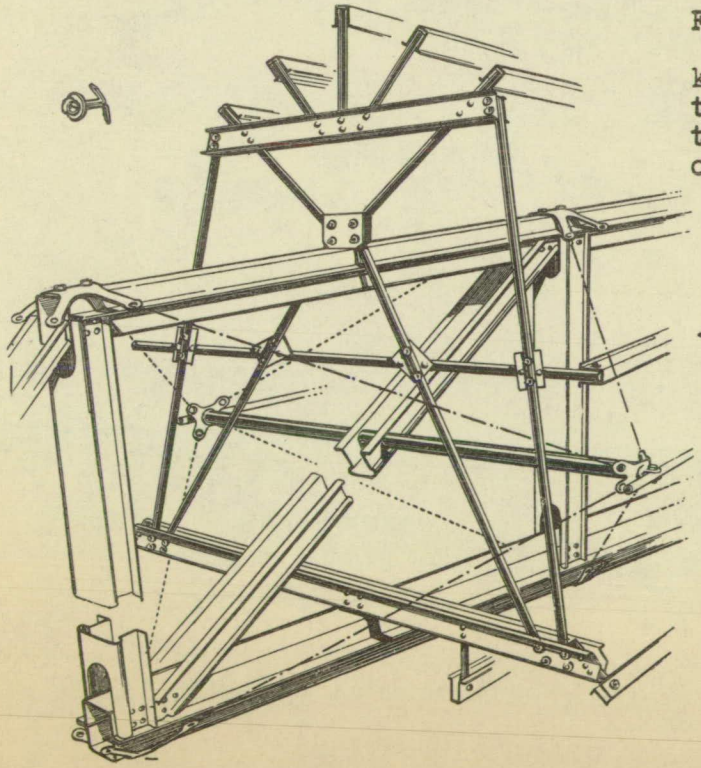


Fig.14 The fuselage girder. Sketch showing details of the girder and the torsion bracing, etc. The photograph Figure 13 should be examined in conjunction with the sketches in Fig.12. (Flight Sketch)