AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 117

THE DE HAVILLAND "MOTH THREE" AIRPLANE (BRITISH)

A High-Wing Commercial Monoplane

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THE DE HAVILLAND "MOTH THREE" AIRPLANE (BRITISH).*

A High-Wing Commercial Monoplane.

The "Moth Three" is a cabin monoplane, with the steeply sloping windshield usually associated with airplanes of the "conduite interieure" type, with strut-bracing of the wing, and with a more or less orthodox landing gear in which the strut lengths have certainly not been markedly reduced, rather lengthened. At any rate, the compression legs are quite long, being anchored to the top longerons of the fuselage. And yet, in spite of all this, the airplane comes within measurable distance of the little "Tiger Moth" in the matter of minimum drag coefficient.

As to the possible evil effects which the presence of a fuselage in the center of a wing may have on the aerodynamic efficiency of the latter, it would appear that in the "Moth Three" this affliction has been very greatly reduced, and yet there is no very obvious reason why it should be so. As will be seen from Figures 1, 2, and 3, the two wing-halves stop short at the top longerons, the inner ends of the wings being slightly sloped down towards the fuselage top, which at this point consists of a transparent panel or skylight. Exactly why this arrangement should be better, aerodynamically, than one in which the wing is

*From Flight, April 25, 1930.

continued across the top of the fuselage is not at all clear. That it <u>is</u> better seems to be a fact. What may possibly also contribute towards the efficiency of the "Moth Three" is the fact that the wing span is relatively large in proportion to the cross-sectional area of the fuselage, without, however, being as large in proportion as was the span of the "Fairey" long-distance monoplane which, it may be recollected, was stated, has a maximum L/D of 15. As to the value of this ratio in the "Moth Three" we have no means of knowing. Our opinion that the airplane is a very efficient one is based not upon a knowledge of the maximum L/D but upon the minimum drag coefficient, estimated from Professor Everling's High-Speed Figure.

In British units, the Everling High-Speed Figure is

$$\frac{\eta}{2k_D} = \frac{V^3}{147,000} \times \frac{S}{hp}$$

where V is expressed in m.p.h. and S is the wing area in square feet. The High-Speed Figure, it will be seen, is, when so expressed, the propeller efficiency divided by twice the drag coefficient. As the top speed is used in computing the figure, the drag coefficient obtained is that corresponding to maximum speed, i.e., the minimum drag coefficient. For the "Moth Three," with a maximum horsepower of 120, a top speed of 125 m.p.h., and a wing area of 222 sq.ft., it works out at 25.2.

Constructional Features

Structurally the "Moth Three" resembles the well-known "Gipsy Moth" with metal fuselage in that it has a welded-steel tube fuselage and wooden wings, although the fact that the airplane is a monoplane has naturally resulted in the wing construction being slightly different. The De Havilland version of welded steel-tube construction is rather different from what one has become accustomed to.

Generally speaking, square-section tube is used for longerons and struts in the forward portion, and circular-section tube in the rear. The structure is built up as a girder, without the use of wire bracing, the bracing struts running diagonally from corner to corner in the rectangular panels.

Although the struts, horizontal as well as vertical, are welded to the tubular longerons, the welded joints are not relied upon for taking tensile stresses. Where one or more struts meet a longeron, a thin mild-steel plate digitally shaped to follow the lines of longeron and struts is pinned and welded both to the longeron and to the struts. Thus, each fuselage joint is strengthened against tensile stresses. The fuselage covering is fabric, and in order to prevent it from touching the struts, light fore-and-aft stringers are attached to the struts.

The fuselage is built in halves, a bolted joint occurring in each of the four longerons just aft of the cabin. Each side is perfectly flat so that it can be assembled on a flat jig, the top and bottom bracing struts being welded in afterwards when the complete fuselage is being erected. This arrangement results in a sudden change of direction of the fuselage side aft of the cabin, but the longitudinal, fabric-carrying stringers turn this sudden change into a gradual one as far as the center line of each side is concerned.

At the forward end the lower longerons project some distance ahead of the cabin, while the top longerons are dropped nearly 2 feet so as to provide the forward view from the cabin. The top longerons themselves act as engine bearers, and carry trunnion supports for the feet of the engine (Figs. 4 & 5).

The monoplane wing is, as already mentioned, mainly of wood construction. The two main spars have top and bottom flanges of spruce and walls of three-ply. The leading edge is covered with plywood up to the rear edges of the front spar, the resulting D-section wooden "tube" being very strong in torsion.

Internal drag bracing is in three bays, of which the inner two are braced by duplicate cables and the outer by piano wire. In the bay at the root of the wing the drag bracing is dropped towards the bottom of the wing section so as to accommodate the gasoline tanks (Fig. 6) which are carried in the wing. The drag bracing struts are round-section steel tubes, and those in way of lift-strut attachments are in duplicate, the two forming a vee with its single point on the rear spar. On the front spar one tube runs straight across, while the second slopes forward and downward to support at its forward end the lift-strut fitting. This, of course, in order to take care of the compressive load which arises from the fact that the rear lift struts are in the plane of the rear spars for folding purposes, while the forward lift struts slope back at a considerable angle from front spar to lower longeron, thereby producing a rearward component. The wing ribs are of spruce, and of normal construction. The ailerons, of large span and small chord, are hinged to false spars placed a short distance aft of the rear spar. They are provided with the usual De Havilland type of differential control.

Streamline steel struts forming a vee brace the wings to the lower longerons. A light jury strut is carried on each side, and when the wings are folded this jury strut supports the forward corner of the inner end of the wing, the gasoline tanks being carried inside the wing near this point.

A "split" type of landing gear is fitted to the "Moth Three," consisting on each side of a telescopic member running to the top longeron (Fig. 7), a bent axle to the lower longeron, and a radius rod to the forward bottom corner, near the engine mounting. Rubber blocks of streamline shape provide the shock-absorption, and the telescopic legs are further made to act as air brakes by being swivel-mounted at their ends in such a manner that they can be turned through an angle of 90°.(Fig. 8). Operation of the air brakes is by short cranks connected to a lever by the side of the pilot's seat (Fig. 3).

The tail skid is sprung by a coil spring, and is steerably mounted to facilitate taxying on the ground. The rudder operates the tail skid via a peg in the bottom of the rudder and a fork on the tail-skid spindle (Fig. 9). The object of the fork is to permit the rudder a certain amount of movement before the tail skid comes into operation. In this manner shocks transmitted to the rudder by the tail skid are reduced. On the lower end of the tail-skid spindle is a crank, the two arms of which provide stops for the skid and limit its angular movement. Rubber pads are carried on the ends of the crank arms to avoid transmitting hard knocks to the sternpost of the fuselage.

One of the most interesting features of the "Moth Three" is the power plant installation, which consists of a "Gipsy III" inverted engine. This engine is practically identical with the "Gipsy II," except for certain modifications necessitated by the inversion. Owing to the fact that the cylinders are below the crank case, the forward view from the cabin is remarkable and is, in fact, very nearly as good as the view one used to obtain from the nacelle of our old "pushers." The four feet which connect the crank case to the engine bearers rest in trunnions on the latter, and rubber pads are interposed between the feet and the trunnions in order to reduce the amount of vibration transmitted to the aircraft structure (Fig. 5). A fireproof bulkhead separates the engine from the cabin. The engine is almost entirely cowled-in by a five-piece cowl, the parts of which are held on by long "skewers." At the back there is a slight gap between the side cowls and the side of the fuselage, so as to provide an escape for the air which enters through a small opening in the forward end of the cowling. Partly let into the port side of the fuselage covering, just aft of the fireproof bulkhead, is an oil tank which also serves as a cooler, this being made necessary because the "Gipsy III" engine is of the dry sump type.

Mention has already been made of the fact that the gasoline tanks are mounted in the wing, one on each side. The tanks are slung on steel straps fastened to light brackets on the main spars, and the removal of a tank is a simple matter. Each tank is provided at its lowest point with a combined gasoline gauge and sump, in the form of a plunger working in a tube, the glass of which projects below the wing covering. Thus not only can the pilot see at a glance how much gasoline is left in the tanks, but any impurities, etc., drain into the sump and glass, where they are at once seen and can easily be removed. Three sizes of tanks have been standardized, giving ranges of 440 miles, 570 miles, and 700 miles, respectively, the useful load being, of course, correspondingly decreased.

The Cabin

The "Moth Three" is built as an occasional three-seater. That is to say, the cabin layout is such that, normally, the airplane is equipped with two seats, arranged in tandem, with ample leg and elbow room. The seats, upholstery, interior decorations are very attractive. Owing to the enclosed cabin, the inverted engine, and the enclosure of the valve rockers, etc., in steel casings, the noise which reaches the occupants is reduced to a point where it is not in the least objectionable. The profusion of windows, skylight and windshield admit plenty of light, so that, although the cabin is not large in actual dimensions, one has not that sense of being "cooped up," which is apt to spoil for some the enjoyment of flying in a small cabin airplane.

The rear seat is arranged to slide along grooves running diagonally across the cabin floor. When the airplane is to be used as a three-seater, the rear seat can be slid forward and across the cabin towards the starboard side, and the third seat added behind it, but on the port side. Leg room for the two passengers is then just a little bit cramped, but not seriously so.

The pilot's seat is the forward one, and the view from it is remarkable. Not only does the inverted engine arrangement make an almost incredible difference to the view, but the windows in front and in the sides, as well as the large skylight in conjunction with the tapering down of the wing spars towards the roots, afford views in nearly all directions above and below the wing.

The pilot's controls are the usual, but are very neatly arranged so as to give the impression of the driver's seat of a car rather than the cockpit of an airplane (Fig. 10). On the port side is the tail trimming gear, and on the starboard the lever which operates the air brakes. In front of the pilot is a very neatly arranged dash with instruments, and below that, a map table, running right across the width of the cabin, and with wire spring clips for holding maps, etc., down on the map board. The instrument board is pivoted so as to facilitate access to the back of the various instruments.

Dual controls are provided so that, if desired, the airplane can be used for instructional work. When not in use, the rear control stick is unshipped and placed in clips on the side. Details of the trimming gear are shown in Figure 11.

The airplane is also built as a twin-float seaplane.

Characteristics

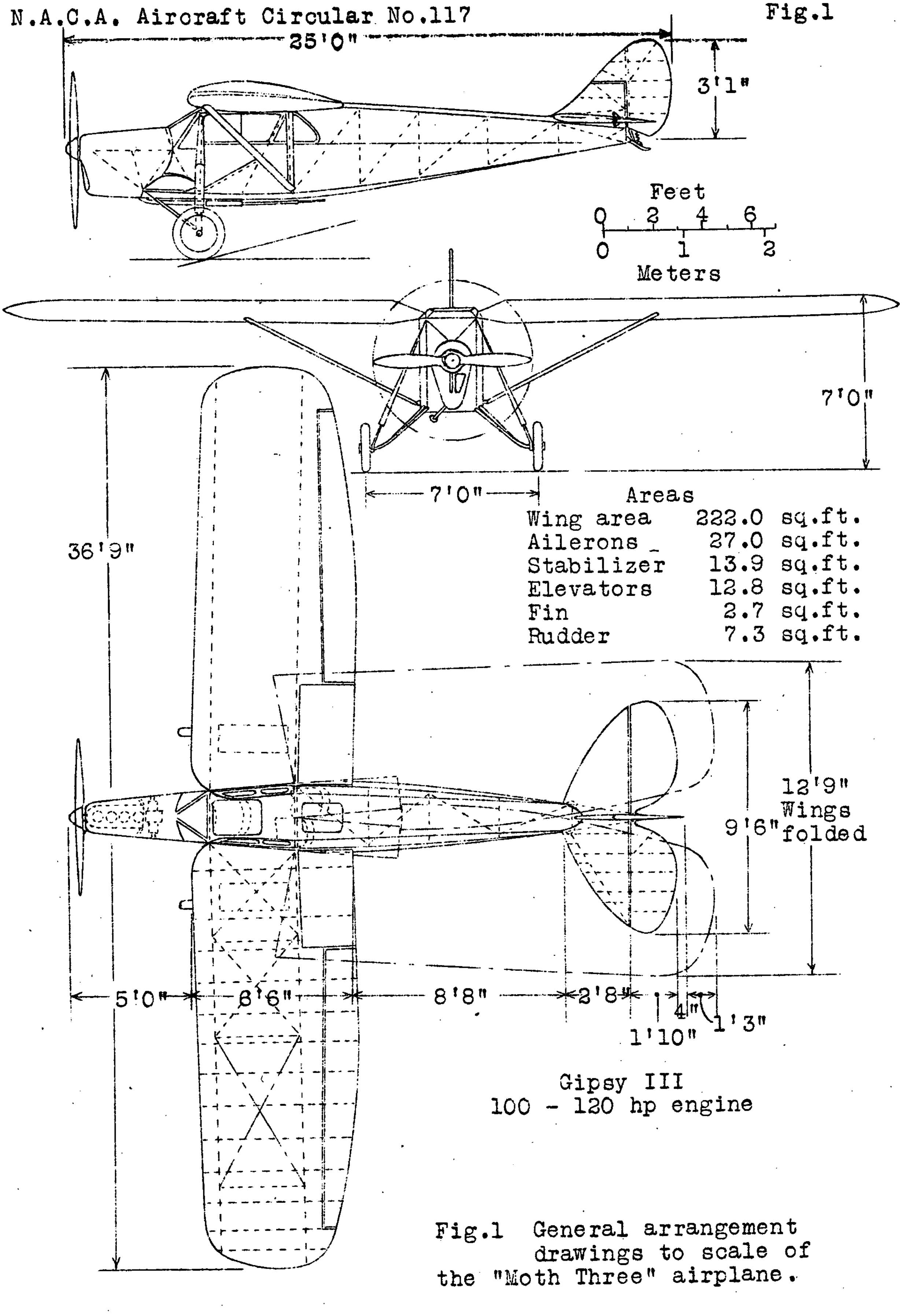
Length, over-all	25 ft. 0 in.	7.62 m
Wing span	36 " 9 "	11.2 "
Width, folded	13 " 0 "	3.96 m
Wing chord	6 " 6 "	1.98 "
Wing area	222 sq.ft.	20.6 m²

Weight, empty	1150 lb.	522 kg
Fuel and oil	178 "	81 "
Useful load	572 "	260 "
Gross weight	1900 "	863 "
Wing loading	8.56 lb./sq.ft.	42 kg/m²
Power loading (on maximum power)	15.8 lb./hp	7.2 kg/hp

Performances

Maximum speed	125 m.p.h.	201 km/h
Cruising "	105 "	169 "
Stalling "	48 "	77 "
Rate of climb (initial)	660 ft./min.	3.35 m/s
Service ceiling	13,000 ft.	4000 m
Range (cruising)	440 mi.	708 km*

*With small tanks.



Areas	
Wing area	222.0 sq.ft.
Ailerons	27.0 sq.ft.
Stabilizer	13.9 sq.ft.
Elevators	12.8 sq.ft.
Fin	2.7 sq.ft.
Rudder	7.3 sq.ft.

Gipsy III
100 - 120 hp engine

Fig.1 General arrangement drawings to scale of the "Moth Three" airplane.

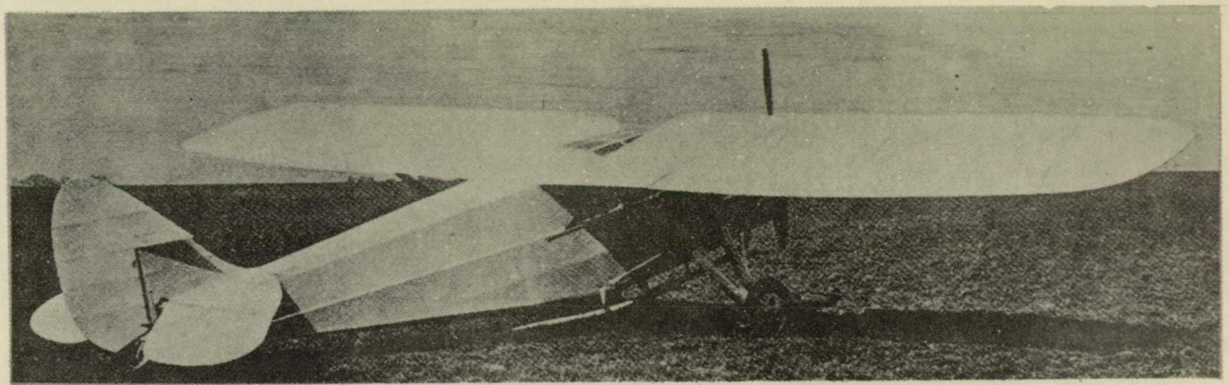


Fig.2 Three-quarter rear view of the "Moth Three". airplane.

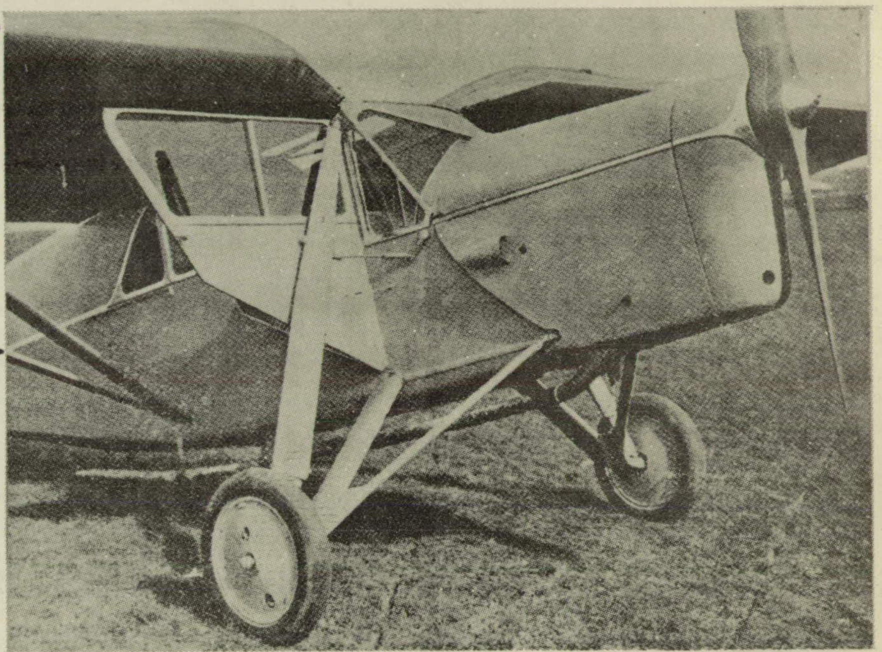


Fig.3 Note the starboard door open, and the air brake on.

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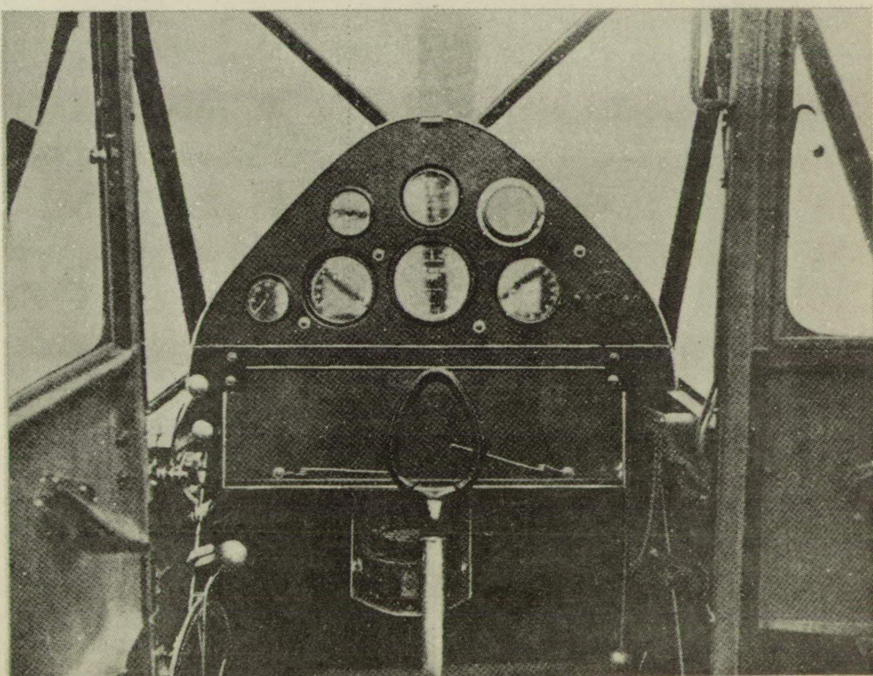


Fig.10 View of the very neat instrument board and, below it, the sloping map table. On the left is the tail trimming gear, and on the right the lever which operates the air brake.

Fig.4 Side elevation, showing main parts of structure of the "Moth Three" airplane.

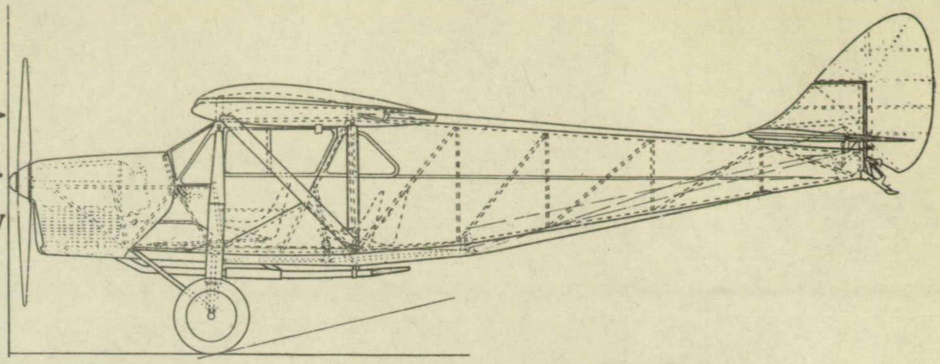
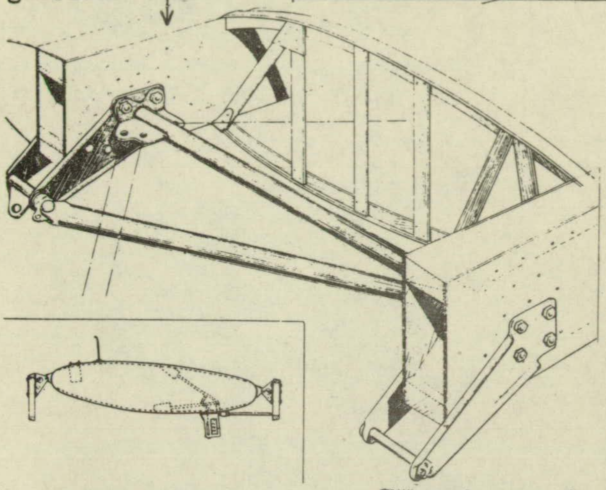


Fig.6 The internal drag strut of the "Moth Three" in way of lift strut attachments form a vee. Inset, mounting and gauge of a gasoline tank.



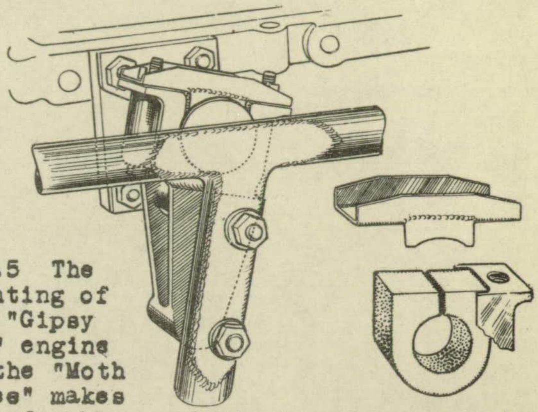


Fig.5 The mounting of the "Gipsy III" engine in the "Moth Three" makes use of rubber pads in trunnion supports to damp vioration.

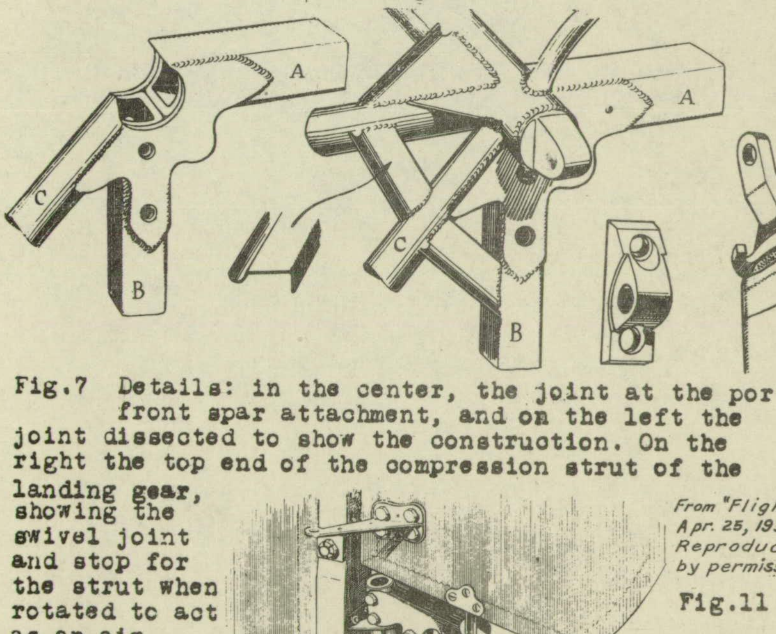


Fig.7 Details: in the center, the joint at the port front spar attachment, and on the left the joint dissected to show the construction. On the right the top end of the compression strut of the landing gear, showing the swivel joint and stop for the strut when rotated to act as an air brake.

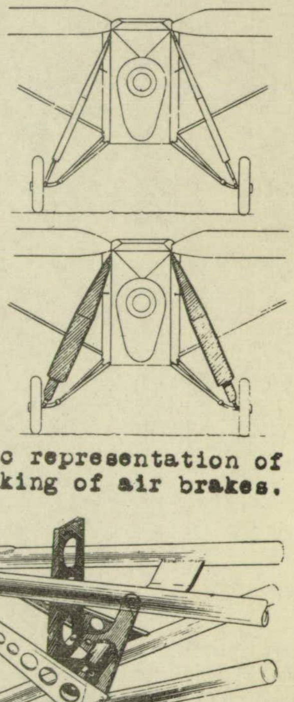


Fig.8 Diagrammatic representation of the working of air brakes.

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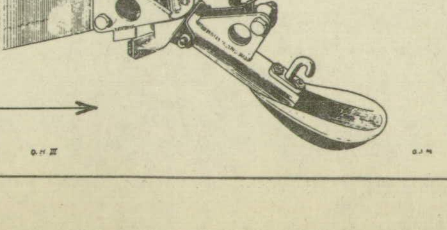

Fig.9 Sketch of the steerable tail skid of the "Moth Three".

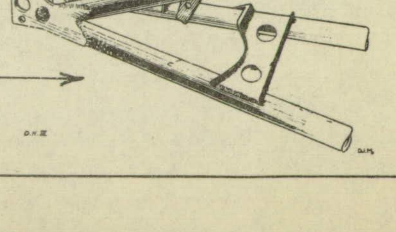

Fig.11 Details of tail trimming gear of the "Moth Three" airplane.