AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 189

D.H. 86 "EXPRESS AIR LINER" (BRITISH)

A Four-Engine Biplane

Washington
April 1934

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A Four-Engine Biplane

The De Havilland Express Air Liner is a two-bay biplane of extremely clean and well-streamlined form, with the four Gipsy Six engines housed in nacelles on the lower wings.

The cabin space is particularly large (figs. 1 and 2) permitting a variety of arrangements. As shown, accommodation is provided for ten passengers. The illustration also shows the deep long windows which are built either side of the fuselage, (figs. 3, 4, 17, 18) making the cabin light and pleasant, a feature which is enhanced by the two top lights normally provided in the roof of the cabin through two emergency exit panels. There is generous head room as the average height of the cabin is 6 ft. 3 in. (1.9 m), and the total cubic capacity in the airplane available for the carriage of load is 594 cu. ft. (16.82 m^3). A fully controllable fresh-air ventilator system, which ventilates without causing draft, and a cabin-warming equipment is, of course, fitted.

The airplane has no dual control in its present form, but the pilot sits right forward in a cabin separated from the passenger compartment by a bulkhead and door. In this position he has a well-nigh perfect outlook, and the slope of the windshield, combined with the speed of the airplane, should obviate any obstruction of the glass due to snow or rain. Nevertheless, the two large side panels are single pieces of triplex glass which may easily be lowered, to give a clear and unobstructed outlook forward and to the side. The second member of the crew is accommodated on the starboard side of the pilot and behind him, in which position there is ample room for a full wireless equipment as well as a chart table and stowage for the navigating equipment generally.

Structurally the "86" is interesting, as it is the first airplane incorporating a new method of using plywood

*From Flight, February 22, 1934.

and spruce. The sectional sketch shows that the fuselage is primarily a three-ply box, but it has this great difference from the normal type, in that the fuselage is built with the plywood inside the box, and with the spruce longerons, struts, and stringers, outside it. Outside this again is a complete fabric covering, doped, as are the other covered units, with Titanine, giving a weatherproof and durable finish. This method of forming the fuselage provides clear walls, floor and roof, and also conserves space, as the sound proofing material, in this case Cabot quilting, can be packed between the plywood and the fabric in the space made by the longerons and stringers (fig. 5). Aft of the main wings sheet elektron guards are placed over the corners of the fuselage, serving both to give a better shape to the fuselage and to obviate taking the fabric over the otherwise sharp corner.

The tail units are, in general, normal De Havilland design and construction. Their shape is, of course, typically "D.H.", and their construction is of spindled spruce spars, fairly substantial spruce ribs, and a covering of 0.8 mm (0.03 in.) plywood. Over the whole there is a covering of fabric and then the usual dope. The elevators (and the ailerons) are not aerodynamically balanced and are controlled by straightforward dual cables between the control column and top and bottom steel horns on the center of the elevator spar. The stabilizer is adjustable throughout a wide range by a vertically mounted square cut screw acting on the leading edge and controlled by an endless cable from a handwheel in the pilot's cockpit (fig. 16). The fin is particularly interesting, because it, also, has its leading edge mounted on a similar screw, allowing it to be offset either side, thus counteracting the unbalanced thrust in the case of engine failure (fig. 6). The rudder is also balanced by means of a small movable surface inset into its trailing edge. This, being attached to the fin by means of cables either side of the rudder, automatically produces a balancing force when the rudder is operated by the main controls. The attachment point on the fin is mounted on a vertical rotatable tube having at its lower end a fore and aft horizontal slotted lever with a pin fixed to the fuselage through the slot. When the fin is offset by its own trimming device the tube will rotate, operate the balance, and compensate the rudder for the effect of the offset thrust. The fully castoring tail wheel is fitted with rubber blocks in compression to absorb the shock of landing.

The wing construction, as regards the outer portions, is more or less standards "Dragon", the heavily tapered airfoil section being R.A.F. 34 modified. The spars are of spruce, spindled to I-section. The ribs are of spruce fixed to the spars with the "D.H." capping clips of light alloy. The drag bracing is, for the most part, of double piano wire with steel drag struts. The leading edge is completely covered with plywood which is carried right back to the rear spar round about the region of the single interplane strut separating the top and bottom wings in the outer bay. This strut is a streamline steel tube and in subsequent models of this airplane the aileron interconnecting gear will, instead of being cables as at present, consist of a tube running up inside this strut. The interplane main bracing is by dual streamline wires in the front bay only (figs. 9, 10, 11). The ailerons are of the same construction as the tail units and are completely covered with 0.8 mm plywood. They are actuated, as are all the flying controls, by Brunton Tru-Lay cable running over large pulleys without the use of fiber blocks at any point, thus providing a control system with extremely little frictional loss. To facilitate inspection of the controls to the tail units, the fabric in the bottom of the fuselage is brought together with a zip fastener so that it can be opened at any time without difficulty. The inner bays of the main wings are, of course, very interesting structurally, as the bottom one carries all four engines and the landing gear. The sketch shows one of the inner engine mountings built up of welded steel tubes, and incorporating the cantilever landing gear. In the sketch this landing gear has dual compression legs either side, (figs. 7, 14, 15), but we understand that for subsequent models a considerable saving in weight will be made by having only a single leg either side. Between the points of attachment of the two inner engines the wing spars are continuous underneath the fuselage and are steel tubes of circular section. Those between the roots and the top main wings are the same. The engine mountings are all similar, those of the inner engines carrying behind them fuel tanks of 57 gallons each, each tank sufficing for the two engines on that side. The oil tanks are slung below the engine mountings in the case of the inner engines and behind in the case of the outer engines (figs. 8, 12, 13). The engine cowlings and the fairings over the rear portion of the mounting are all of sheet elektron, which is chromated before being painted as an anticorrosion measure. It is interesting to note that, throughout the whole airplane, where sheet light alloy is

used, as the fairings over the wheels, the frames of the windows and doors, elektron is used.

The engines have already been described in Flight (January 25, 1934), and there is therefore no need to go into detail here. In this airplane they drive Fairey metal propellers and are fitted with Eclipse direct acting electric starters fed from a 20-ampere electric battery (Caple electric inertia starters can be fitted if required). This seems small, but we are told that 70 engine starts have been obtained from this battery without recharging. Fuel is fed from the tanks to each engine by dual Amal pumps. The fuel cocks will be operated on subsequent airplanes from the pilot's cockpit, as will be the altitude controls to the carburetors, by Simmonds-Corsey controls. The revolution counters are of the Record electrical type operating neat vertical dials either side of the dashboard. The two Claudel-Hobson carburetors of each engine take fresh air through a Vokes flame trap during slow running, and the throttle control is operated by an endless cable over pulleys from normal levers close to the pilot's left hand. The Bendix wheel brakes, acting in Dunlop wheels with low-pressure tires, are differentially connected to the rudder bar and controlled by a hand lever in the same way as other "D.H." aircraft.

In the pilot's cockpit the control column is of the spectacle type. The seat can readily be raised for landing. The dashboard, which is very neat though carrying instruments for four engines, swivels forward allowing ready access to the wiring behind it. The trail trim wheel comes readily to the pilot's left hand and the fin trim to his right. A Smith's electric fuel gage is placed behind, and to the left of, the pilot.

CHARACTERISTICS

Dimensions:

Span	64 ft. 6 in.	(19.66 m)
Length, over-all	43 " 11 "	(13.39 m)
Height, over-all	12 " 6 "	(3.81 m)
Mean chord	5.29 ft.	(1.61 m)
Aspect ratio	12.3 : 1	
Incidence (both main wings)	1.5°	
Dihedral (both main wings)	3.0°	
Sweepback (both main wings)	4 ft. 9 in.	(1.45 m)
Gap	6 " 4.8 in.	(1.95 m)
Stagger	8.5 "	(216.8 mm)

Areas:

Main wings, including ailerons and body	641 sq. ft.	(59.55 m²)
Ailerons, four	44.0 sq. ft.	(4.09 m²)
Stabilizer	29.9 " "	(2.77 m²)
Elevators, two	27.6 " "	(2.56 m²)
Fin	11.1 " "	(1.03 m²)
Rudder	19.9 " "	(1.84 m²)

Weights and Loadings:

Tare weight		5520 lb. (2503.83 kg)
Disposable load		
Crew	340 lb. (154.22 kg)	
Fuel, 114 gal. (518.4 liters)	855 lb. (387.82 kg)	
Oil, 12 gal. (54.5 liters)	116 lb. (52.61 kg)	
		1311 lb. (594.65 kg)
Cabin furniture	270 lb. (122.47 kg)	
Wireless equipment	130 lb. (58.97 kg)	
Lavatory	30 lb. (13.61 kg)	
Pay load	1939 lb. (879.51 kg)	
		2369 lb. (1074.56 kg)
Maximum permissible weight		9200 lb. (4173.04 kg)
Wing loading		14.35 lb./sq. ft. (70.06 kg/m²)
Power loading		11.2 lb/b.hp. (5.08 kg/b.hp)

Engines, 4 "gipsy Six" each, giving
184 b.hp. at 2,100 r.p.m.
205 b.hp. at 2,350 r.p.m.

Fuel consumption 36 gal./hr. (163.65 liters/h)
at 145 m.p.h. (233.36 km/h) at 2,000 r.p.m.

Performance:

Top speed, over	170 m.p.h.	(273.59 km/h)
Landing speed	72 m.p.h.	(115.87 km/h)
Cruising speed, at 2,000 r.p.m., over	145 m.p.h.	(233.36 km/h)
Climb, from rest, 1 min.	1,200 ft.	(365.76 m)
" " " 2 "	2,300 ft.	(701.04 m)
" " " 3 "	3,250 ft.	(990.60 m)

Performance (continued):

Ceiling, absolute	20,500 ft.	(6,248.4 m)
" service	19,000 ft.	(5,791.2 m)
" on 3 engines at 92 m.p.h. (148.06 km/h)	15,000 ft.	(4,572.0 m)
" on 2 engines on the same side, under full control	3,600 ft.	(1,097.3 m)

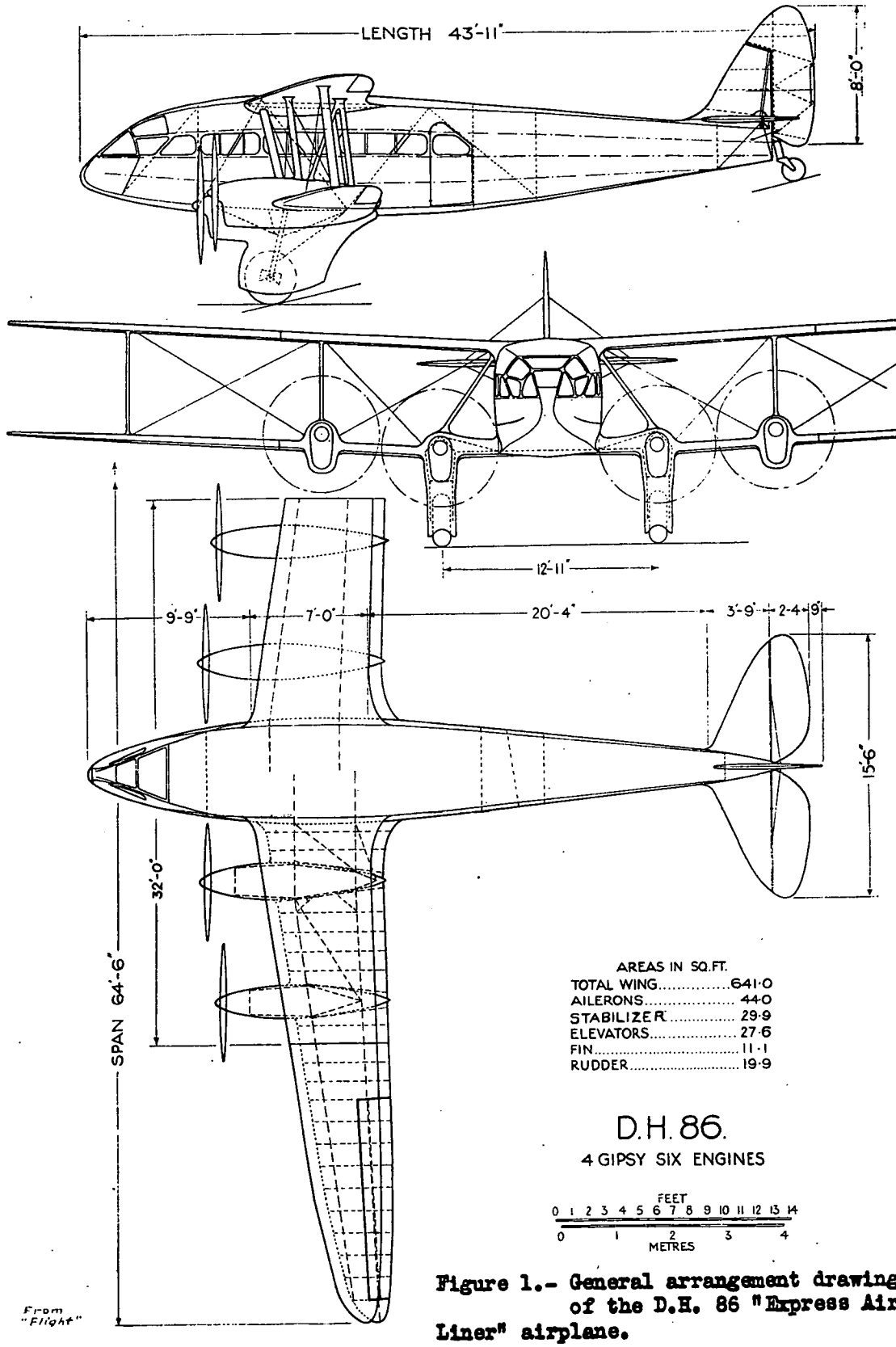


Figure 1.- General arrangement drawings of the D.H. 86 "Express Air Liner" airplane.

Figure 2.-An artist's impression of the inside of the D.H. 86 "Express Air Liner" showing the seating arrangement for ten passengers. It can be seen how light and comfortable the cabin is.

From "Flight"

Figure 3.-Three-quarter front view of the D.H. 86 "Express Air Liner" airplane.

Taken from "Aeroplane"

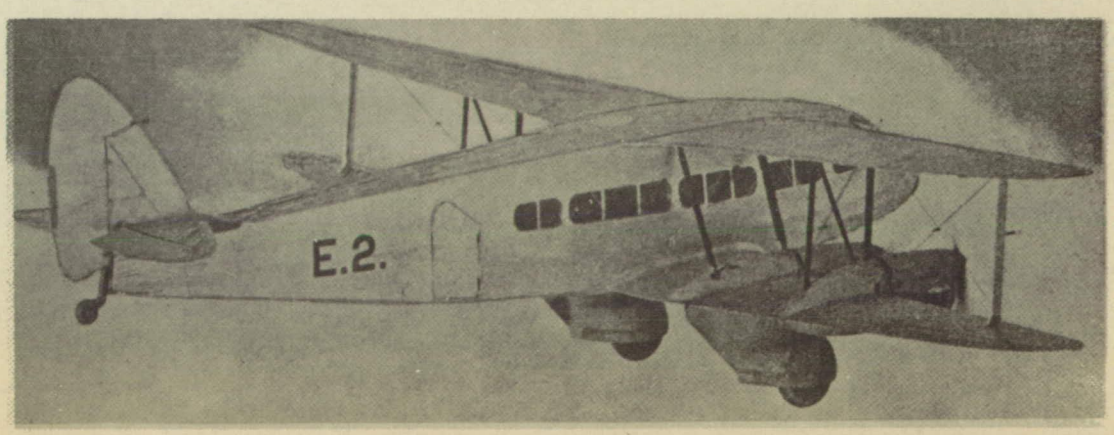


Figure 4.-Three-quarter rear view of the D.H. 86 "Express Air Liner" in flight.

Taken from "Aeroplane"

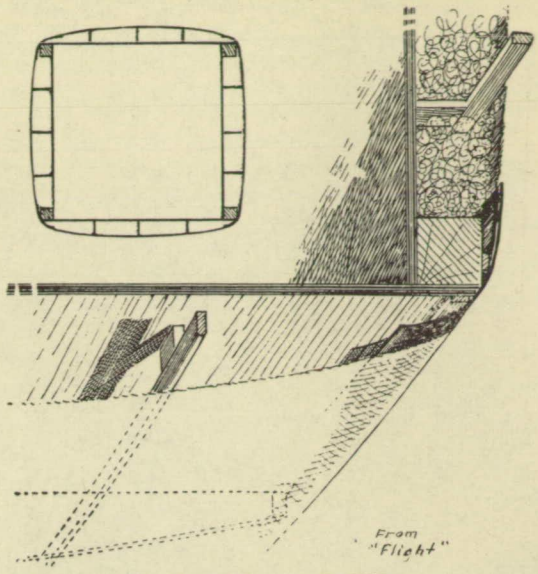
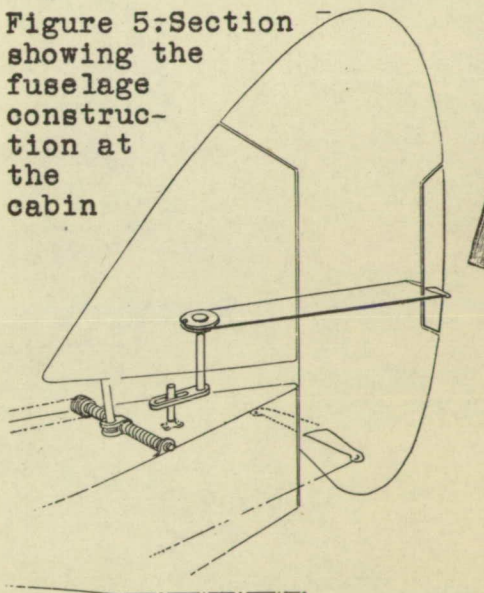


Figure 5.-Section showing the fuselage construction at the cabin



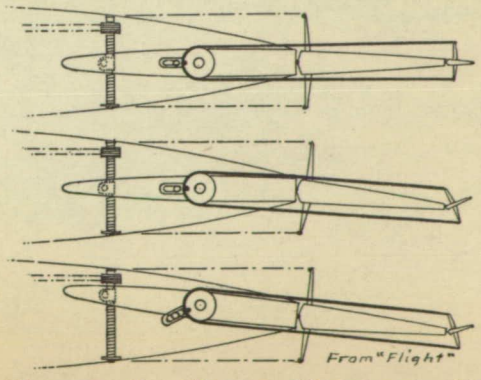


Figure 6.-These diagrams illustrate the operation of the fin and stabilizer adjustment and rudder balance.

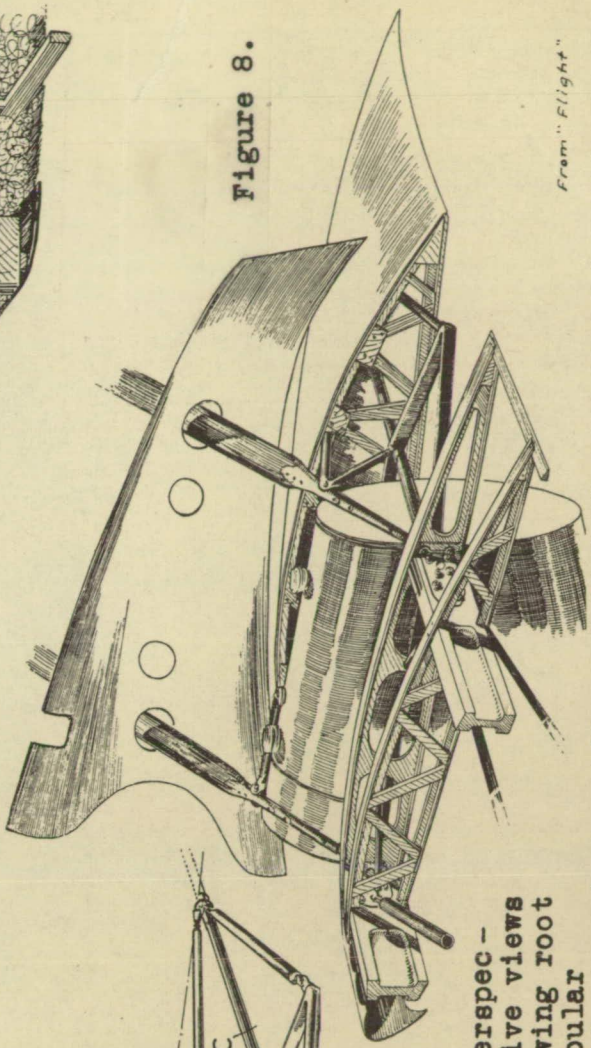


Figure 8.

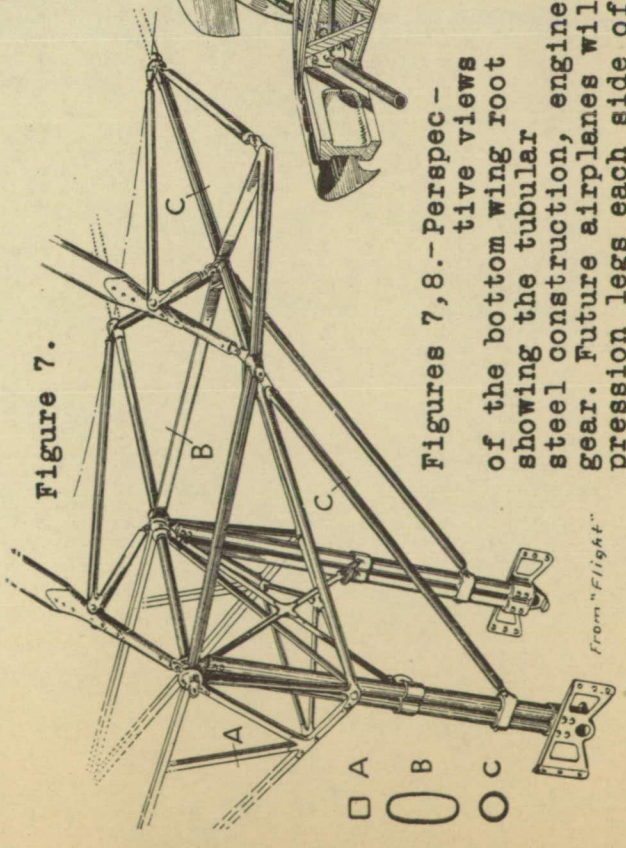


Figure 7.

Figures 7,8.- Perspective views of the bottom wing root showing the tubular steel construction, engine mounting, fuel tank stowage and landing gear. Future airplanes will have single, instead of double, compression legs each side of the wheel.

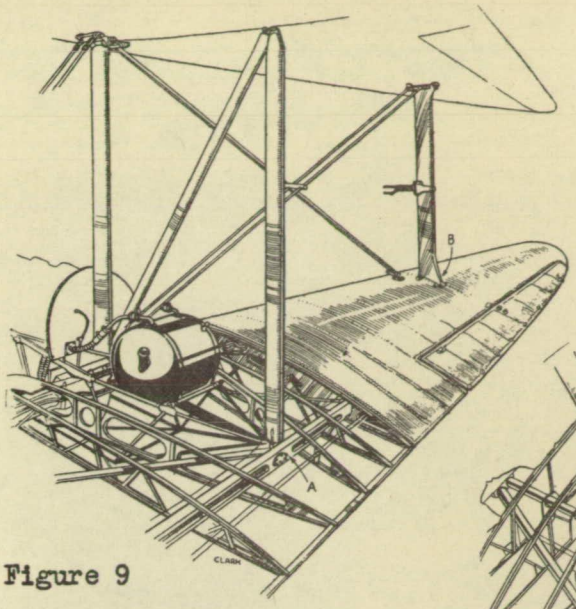


Figure 9

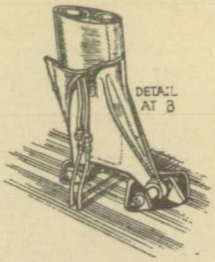


Figure 11

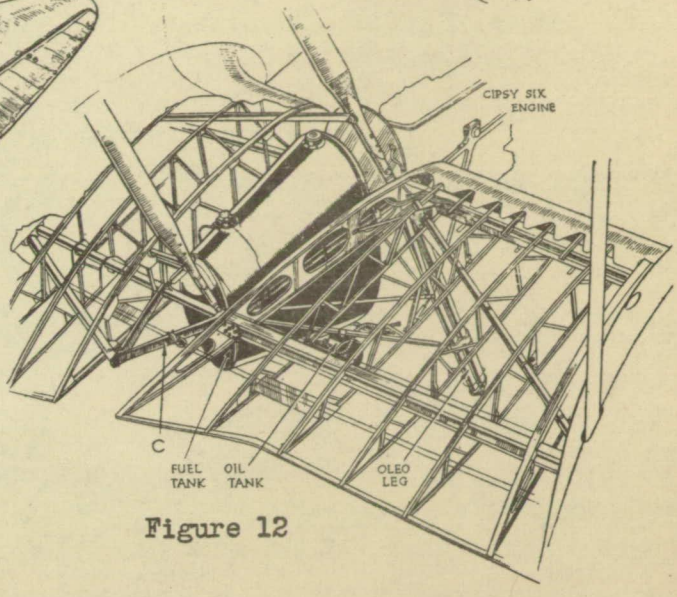


Figure 12

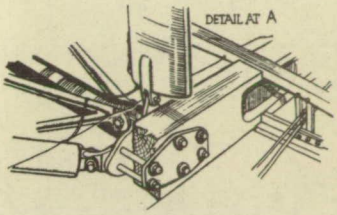


Figure 10

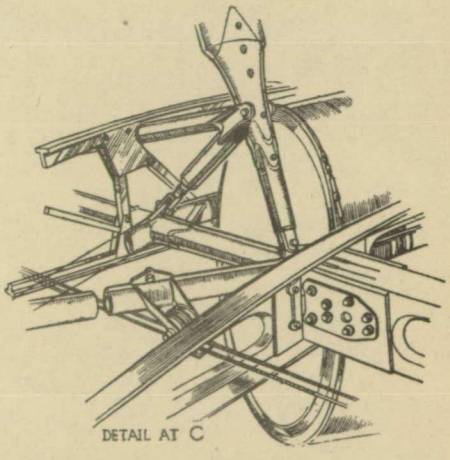


Figure 13

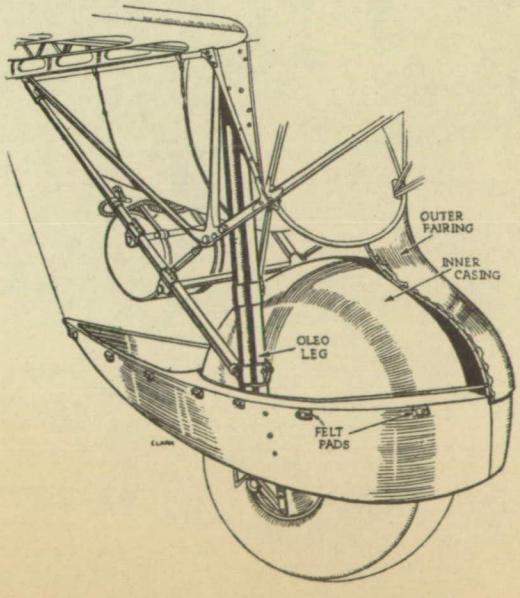


Figure 14.-One unit of the landing gear.

Figures 9,10,11,12,13.-Some details of the lower wing structure of the D.H.86. These views show the inner and outer engine mountings and the interplane strut arrangements. The single "I" strut, the structure of which is shown at Detail B, will in future airplanes be made of steel sheet instead of two tubes as in the prototype.

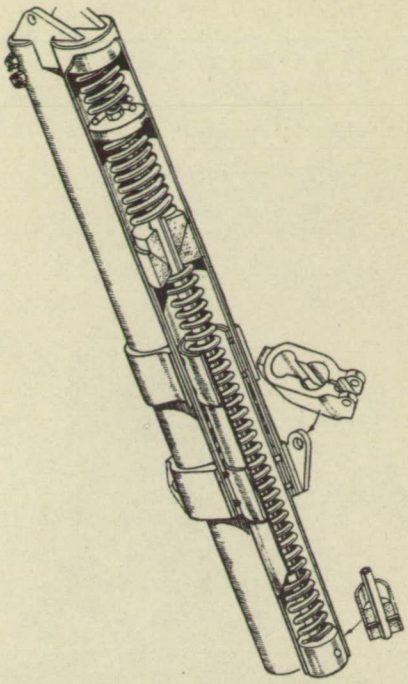


Figure 15.-A section of one of the shock-absorbers.

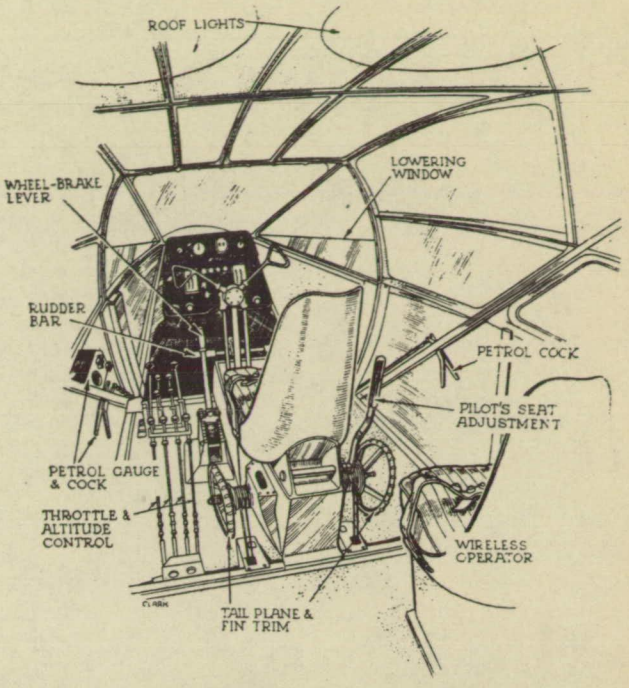


Figure 17.-The pilot's cockpit of the D.H.86.

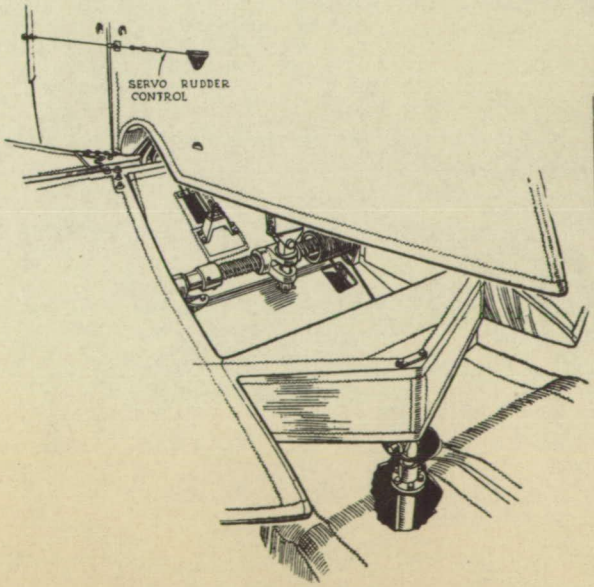


Figure 16.-Stabilizer and fin adjustments.

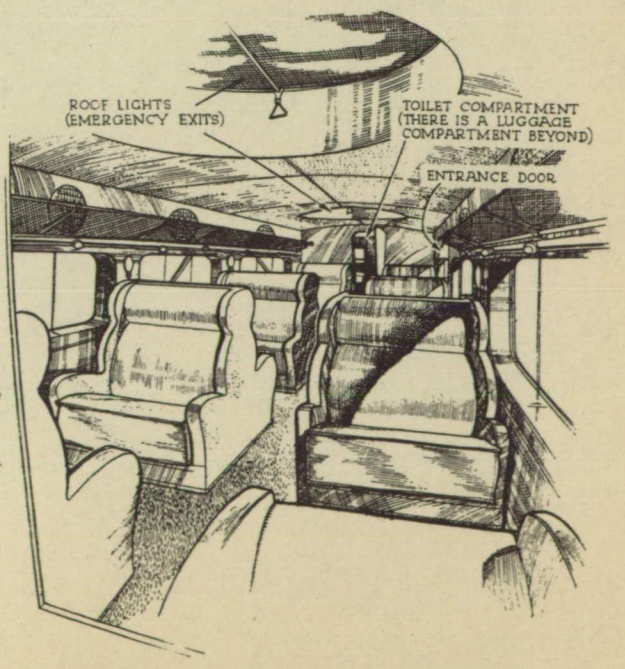


Figure 18.-The cabin of the D.H.86.