AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 177

THE BOULTON AND PAUL P.64 MAIL-CARRIER

A Two-Engine All-Metal Biplane

Washington
April, 1933

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A Two-Engine All-Metal Biplane

The Boulton and Paul P.64 high-performance mail-carrier has been designed to meet the requirements of a specification which was issued by the Directorate of Technical Development, Air Ministry, early in 1931 (fig. 1).

This specification called for a two-seat all-metal landplane with one or more engines, to have a mail capacity of 1,000 pounds, and range of 1,000 miles at a cruising speed of at least 150 miles per hour in still air.

The P.64 is a two-engine tractor biplane which has been designed to give the specified normal speed with each engine throttled down to approximately half its output. Under these conditions the engines should have an exceedingly long life and a singular freedom from breakdown.

Should one engine fail the P.64 will still be capable of flying level at 4,000 feet at 85 miles per hour, with the remaining engine throttled to 1,950 r.p.m. This should give the nearest approach to absolute immunity from forced landing owing to engine failure that is at present available.

SPECIAL FEATURES

Boulton and Paul, Ltd., have specialized on two-engine airplanes over a considerable period, and with this type they have achieved success. With the engines on the wings, vibration and exhaust fumes and noises are removed from the fuselage and the engines are in a better position to operate to their maximum efficiency.

Experience has shown that there is a very wide margin between the maximum performance which can be obtained un-

*From The Aeroplane, April 5, 1933.

der favorable conditions from a given airplane, and the performance which the same airplane will give regularly in routine operation under normal service conditions. The P.64 will have a maximum speed of about 200 miles per hour at 5,000 feet, and at two-thirds power will cruise at about 175 miles per hour - which performance should be easily obtainable over organized routes under normal conditions.

Aerodynamically the design of the airplane shows no abnormalities, but represents, nevertheless, a notable achievement. Every effort has been made to reduce drag to the utmost.

The shapes of the fuselage, engine nacelles and wheel fairings have been determined on the formula developed by Professor Joukowsky, and have been plotted out and tested in the firm's wind tunnel to give the lowest possible resistance for units which can never be perfect streamlines.

The most obvious departure from standard practice is the mounting of the two engines directly under the upper wings. This gives ample ground clearance for the propeller and at the same time allows the height, and therefore the resistance, of the landing gear, to be reduced.

LANDING GEAR

The obvious method of suppressing landing-gear resistance - retractable wheels - was considered, but wind-tunnel tests showed that the arrangement adopted means a sacrifice of only two or three miler per hour in top speed, and that at the specified cruising speed and range the extra gasoline required to overcome the resistance of the landing gear weighs less than the extra weight of the landing gear. As top speed is not of serious importance, and range and simplicity of construction are the essence of the contract, the fixed landing gear was adopted.

Externally each landing gear unit presents a perfectly streamlined excrescence growing out of the extremities of the lower center section. Each wheel is carried in an oleo fork and a pair of backwardly sloping radius rods. All but the lower portion of each wheel is enclosed in a streamline fairing, which is in two pieces (fig. 2).

The front bulbous portion is attached to the wheel axle and rises and falls with it. The rear section, which is a continuation of the lower portion of the front section, is hinged to a point below the rear spar of the wing so that it may follow the movements of the forward section.

When the airplane is on the ground the wheel casing is out of streamline, that is, the bulbous portion is well above its normal position and above the leading edge of the lower wing. When the airplane is in the air the casing falls with the wheels and takes up its proper position in relation to the undersurface of the wing. The gap which is left between the underside of the wing and the top edge of the rear section of the fairing is filled with laced-on fabric, which "concertinas" with the movements of the fairing.

The resistance of the two landing-gear units of the P.64 is actually fifty percent less than the drag of one bare wheel.

STRUCTURAL FEATURES

The P.64 is really based on the previous very successful two-engine airplane, the Sidestrand, which has now been in service for a number of years and has proved the efficiency of the system of metal construction.

The more highly stressed members of the fuselage, that is, those in the region of the wings and landing gear, are of solid-drawn steel tube, but the remainder of the fuselage structure, both longerons and bracing members, are of the now well-known closed-joint tubes, steel for the longerons and duralumin for the bracing members (figs. 3, 4, 5, and 6).

These closed-joint tubes are cheaper to make than solid-drawn tubes of similar characteristics, and the thickness of the wall, as it is the thickness of the strip from which the tubes are drawn, can be kept within extremely fine limits.

The streamline outer interplane struts are closed-joint tubes and within the rear portions of the rear struts pass the struts which interconnect the ailerons, so that these rather essential units of the control system are tucked away out of the air.

The standard fuselage joint consists of a wrap plate between the flat projections of which are secured the squared ends of the bracing tubes. The squared ends are reinforced by an internal bridge piece and small external reinforcing plates. The whole is held in place by a short length of bicycle spoke, the ends of which pass through ferrules of generous bearing area.

The high-tensile steel wing spars, of different depths, use two of the B.P. standard sections. The front spar is made up of two drawn-tube booms with projecting lips, between which is inserted the corrugated web, where it is secured by hollow rivets. The rear spar is of the figure 8 section formed of two strips with closed joints top and bottom.

THE PILOTS' COMPARTMENT

The accommodation for the normal crew of two is in the nose of the fuselage. Owing to the narrowness of the fuselage the two seats are close together without an alleyway in between, but both seats are on runways so that one or the other may be pulled back to give access to either (figs. 7 and 8).

Between the two control columns is a central box which contains the engine controls and the tail-adjustment handle, easily accessible to both seats.

Behind the two seats is the navigating and wireless compartment. This compartment is very roomy, and is well lighted by windows by day and electric light by night. In it are chart table and rack, instrument locker, complete wireless sending and receiving equipment, food locker, drinking-water tank, and a complete starter panel on the front face of the upper front spar from which both engines may be started without external assistance. There is ample space for the accommodation of an additional navigator or wireless operator in addition to the two pilots.

ACCOMMODATION FOR MAILS

Aft of the navigating compartment is the main mail compartment. The specified mail load of 1,000 pounds is stowed in standard mail bags which are carried on hooks on the sides of the net-lined compartment. There are two rows of hooks on each side and the bags are secured against movement by straps. This form of stowage leaves a gangway down the middle of the compartment and allows any one bag to be reached and unloaded, or fresh mail stowed, at any stopping place, without disturbing the remaining bags.

For loading and unloading the mail compartment there is a wide door aft on the port side, and doors in the bulkhead between the mail and navigating compartments allow members of the crew to enter the mail compartment when the airplane is in the air.

THE CONTROLS

The control system uses only solid tie rods, tubular push-pull rods and levers, and ample bearing surfaces with proper lubrication points are used on all moving parts. Parts liable to wear have all been designed so as to be easy to inspect and simple to adjust or replace. The engine controls and part of the rudder control were described in The Aeroplane for February 22, 1933.

The elevators and rudder are controlled by servo-flaps hinged to the trailing edges of these surfaces. The elevator control from the control column connects to two small levers carried on short tubes which are parallel to, and in front of, the elevator spar. At the inner ends of these tubes are two cross levers which are connected to levers on the elevator spar by spring-loaded links. The outer ends of the tubes carry small levers which are connected by push rods to the levers on the servo-flaps (fig. 9).

The object of the interconnection of the servo-control and the elevator spar is to provide a safety measure should the servo fail. Actually when the full slipstream is passing over the tail very small movement of the servo-flap is required to give normal elevator movements.

The stabilizer is balanced aerodynamically round points on the rear spar, which is inset from the trailing edge and worm-gear adjustment raises or lowers the front spar.

POWER PLANT

The engine installation consists of two Bristol Pegasus I.M.2 engines, rated at 555 horsepower at 4,000 feet at 2,000 engine r.p.m. and 1,312 propeller r.p.m. The engines are on duralumin monocoque mountings which have three points of suspension, two on the front spar of the center section and one on the front inter-center-section strut.

Each engine is surrounded by a hexagonal Townend ring, in the leading edge of which is the exhaust collector ring. The exhaust exits are on the side of the engine cowling only a short distance aft of the ring, but in spite of the absence of long tail pipes, the silencing and flame-damping qualities of the exhaust system are very efficient.

The main gasoline tanks are in the outer wing sections, two on each side. The tanks are fitted with jettison valves so arranged that they let in air at the top of the tank as the gasoline is released below.

SPECIFICATION

Wings.- equal span, slightly staggered biplane. Upper center section carried above fuselage on short struts and faired into fuselage. Lower center section wings attached to bottom fuselage longerons. Extremities of upper and lower center sections interconnected by parallel struts. Outer wing sections have one pair of interplane struts. Front center section struts are solid-drawn steel tubes; rest are B.P. closed-joint streamline steel tubes. Wing structure: Two steel spars, built up of standard B.P. sections; duralumin ribs, built up of beaded channel-section booms with tubular bracing; steel compression ribs and tie-rod bracing; the whole covered with fabric. Frise ailerons on all four outer sections. Handley Page auto slots on upper wings (fig. 10).

Fuselage.- Rectangular rigidly braced steel and duralumin framework in three sections. Front section extends back to center section spars, and built up of steel and duralumin closed-joint tubes. Middle section, in plane of wings, built up of solid-drawn steel tubes. Rear section, from wings to tail, built up of closed-joint steel tube longerons and closed-joint duralumin bracing tubes. Nose section covered with streamline plywood structure and rest with fabric.

Tail unit.- Monoplane metal structure with metal covering for stabilizer, and fabric for the rest. Structure similar to wings. Elevators and rudder controlled by servo-flaps. Adjustable stabilizer.

Landing gear.- Two separate streamlined units, each of two built-up forks in form of Vee when viewed from side. Front fork of two oleo legs, one on either side of Dunlop disk wheel. Dunlop pneumatic brakes. Each unit enclosed in streamline plywood casing which rises and falls with wheel. Low-pressure tail wheel with additional rubber-in-compression springing. Tail wheel swivels through 360 degrees and is faired into the rear end of fuselage. Twin metal floats may be substituted for land landing gears.

Power plant.- The 9-cylinder geared radial engines which normally develop 555 horsepower at 4,000 feet (1,220 meters). Duralumin monocoque engine mountings suspended on three points and faired into underside of upper center section by streamline wood and fabric nacelles. B.P. Townend hexagonal cowling rings with exhaust collectors built in. Cowling rings quickly removable in sections. Rear cowling in two detachable sections to give easy access to entire engine unit.

Fuel carried in five tanks, four main tanks (74 gallons each) in outer wing sections, and one collector tank (29 gallons) in center section on right. All five tanks of elektron, and four main tanks, which are interchangeable, have jettison valves. Filling points on lower center section. Gasoline tanks isolated from wing and engine nacelles by bulkheads and so arranged that any escape of gasoline passes into air.

Two oil tanks (30 gallons total capacity), one over each engine nacelle, in fireproof cradles which drain into open air. Oil cooler and quick-circulating device in each tank.

R.A.E. Mk. II gas starter, combined with hand-starting magneto and change-over switch. Engine-starting panel in fuselage. Air compressor in one engine nacelle supplies compressed air for engine starter and wheel brakes. Lighting generator in one nacelle.

Accommodation.- Normal crew of two in front section of fuselage. Side-by-side controls in extreme nose with room for wireless operator or navigator behind pilots' seats. Dimensions of space behind seats: 7 feet long by 7 feet high by 4 feet 4 inches wide (2.1 m by 2.1 m by 1.3 m). Openable side windows and roof lights for upward visibility and ventilation. Chemical lavatory with outside ventilation.

Aft of crew's compartment is mail compartment 10 feet 3 inches long by 5 feet 2 inches high (mean) by 3 feet 4 inches wide (mean) (3.1 m by 1.5 m by 1 m). Total capacity: 175 cubic feet (5 m^3).

Door for mail loading aft on left side. Double doors separate mail compartment from crew's cabin.

Equipment includes engine and flying instruments, navigation, instrument and cabin lighting, two-way wireless, landing light let into underside of fuselage, etc.

Controls.- Complete dual controls. All controls by tubular rods or tie rods, with levers for changes of direction. Engine controls and part of rudder control by S.C. units. With the exception of small levers on surfaces all controls are internal.

Dimensions:

Span	16.47 m	54 ft.
Length	12.96 "	42 " 6 in.
Height (tail down)	3.96 "	13 "
Chord	2.13 "	7 "

Areas:*

Wings (including ailerons)	70.23 m^2	756 sq.ft.
Ailerons (4), each	1.83 "	19.7 "

*Taken from Flight, April 6, 1933.

Areas (continued):

Stabilizer	4.90 m^2	52.7 sq.ft.
Elevators	3.88 "	41.7 "
Elevator servo-flaps (2)	0.56 "	6.0 "
Fin	0.71 "	7.6 "
Rudder	3.13 "	33.7 "
Rudder servo-flap	0.39 "	4.3 "

Weights:

Empty	2,780	kg	6,125	lb.
Pay load	454	"	1,000	"
Disposable load	1,986	"	4,375	"
Weight loaded	4,766	"	10,500	"
Wing loading	67.8	kg/m^2	13.9	lb./sq.ft.
Power loading (on rated output)	4.3	kg/hp	9.5	lb./hp

Performance (landplane):

Speed at 1,525 m (5,000 ft.)	312	km/h	195	mi./hr.
Cruising speed at two-thirds power	275	"	172	"
Landing speed	96	"	60	"
Initial rate of climb	427	m/min.	1,400	ft./min.
Service ceiling	6,862	m	22,500	ft.
Cruising range at 240 km/h (150 mi./hr.)	1,600	km	1,000	miles
Maximum range	2,000	"	1,250	"

Performance (seaplane):

Speed at 1,525 m (5,000 ft.)	291 km/h	182 mi./hr.
Cruising speed at two-thirds power	256 "	160 "
Alighting speed	98.4 km/h	61.5 "
Initial rate of climb	305 m/min.	1,000 ft./min.
Service ceiling	5,947 m	19,500 ft.
Cruising range at 240 km/h (150 mi./hr.)	1,400 km	900 miles
Maximum range	1,760 "	1,100 "

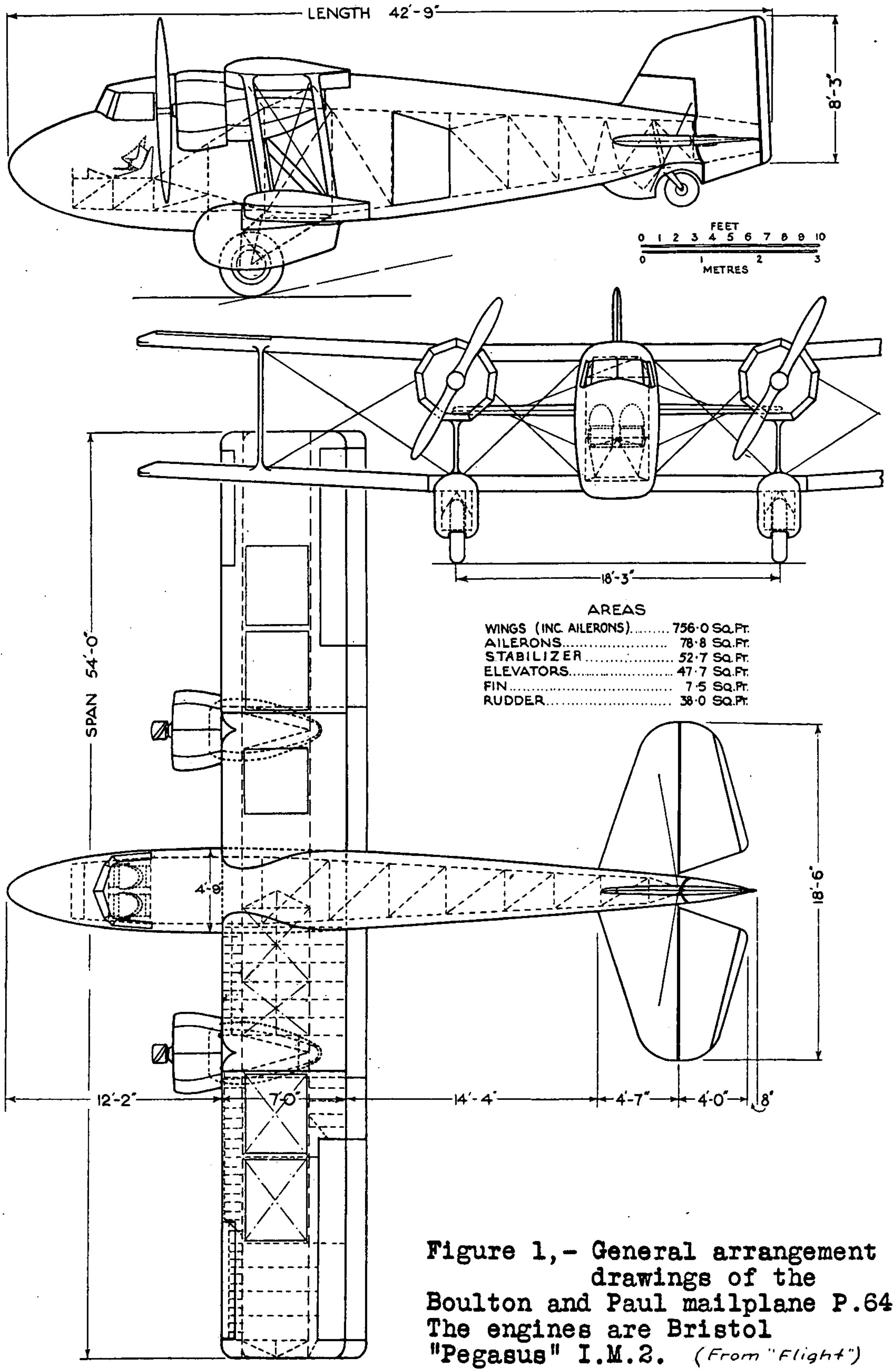


Figure 1,- General arrangement drawings of the Boulton and Paul mailplane P.64. The engines are Bristol "Pegasus" I.M.2. (From "Flight")

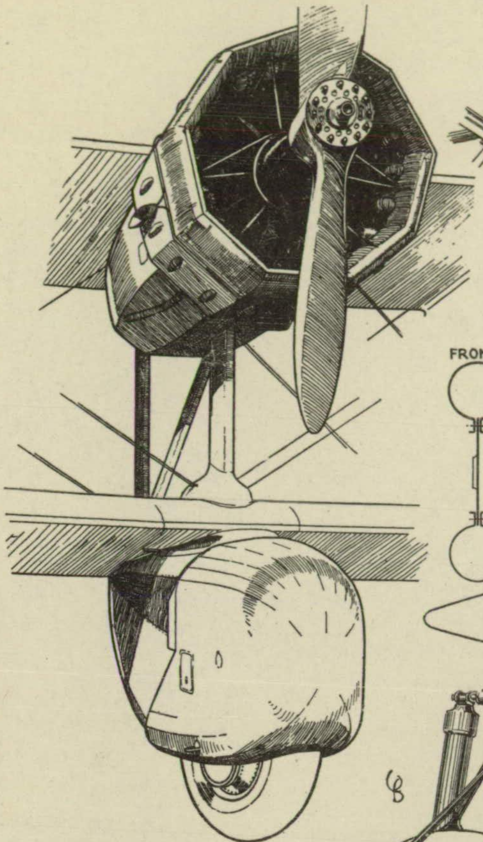
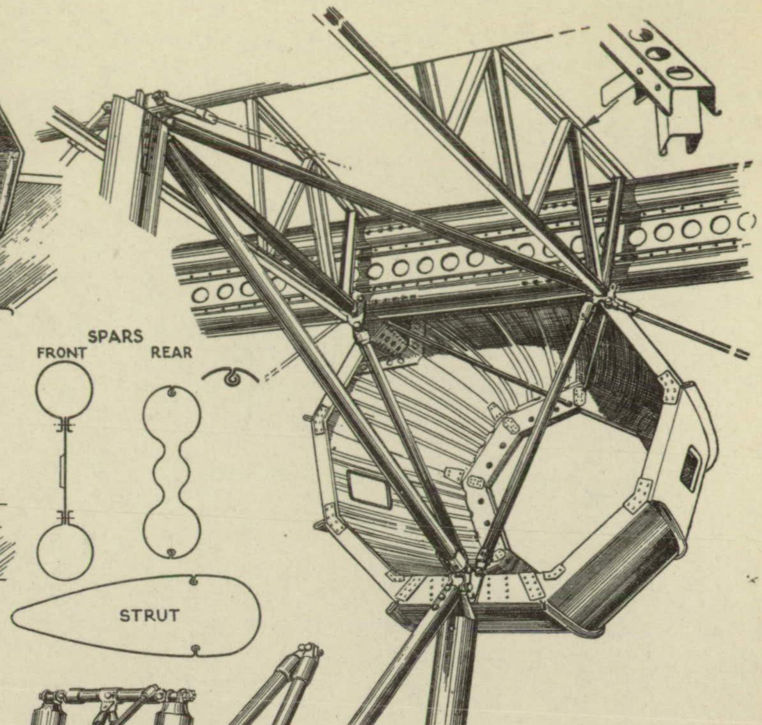


Figure 2.- One engine nacelle and landing gear, the latter in flying position with the fairing properly aligned.
(From "The Aeroplane")



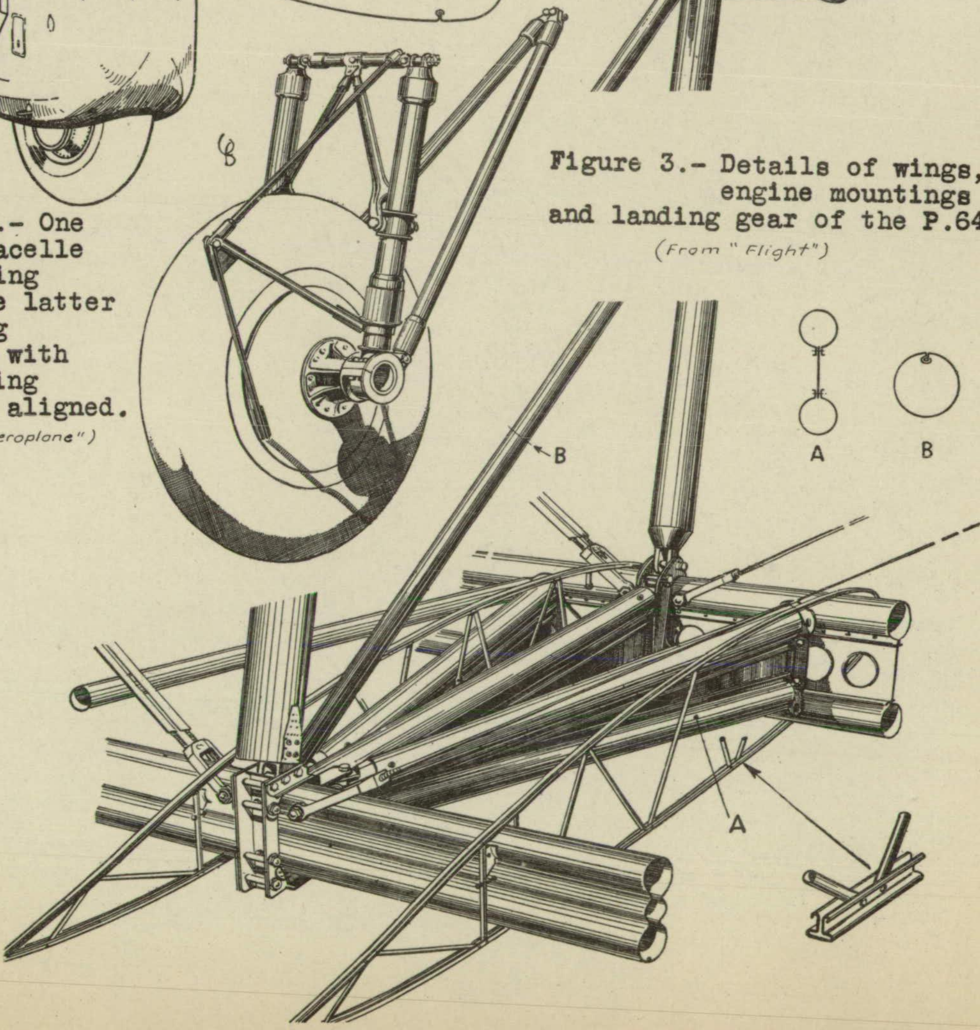


Figure 3.- Details of wings, engine mountings and landing gear of the P.64.
(From "Flight")

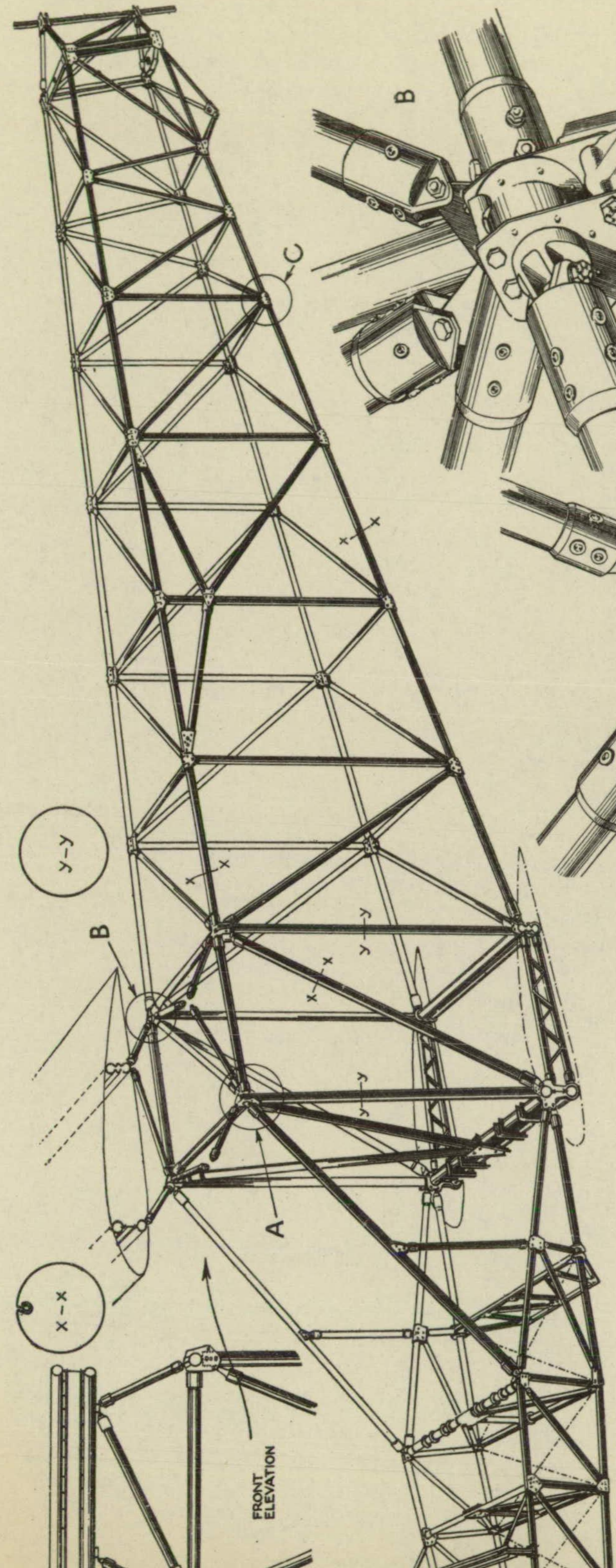
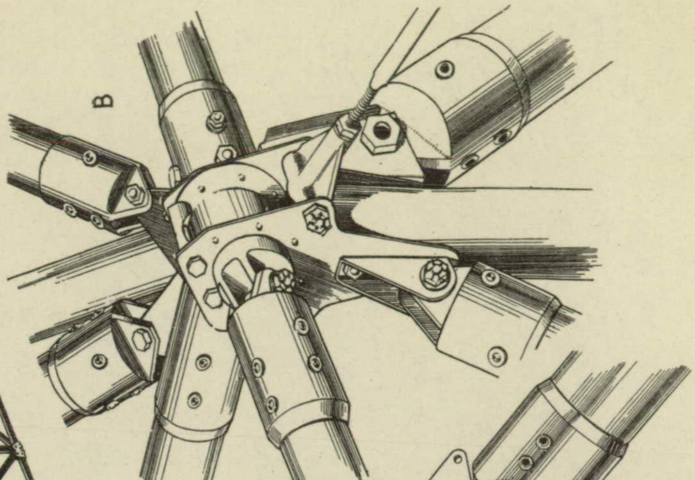
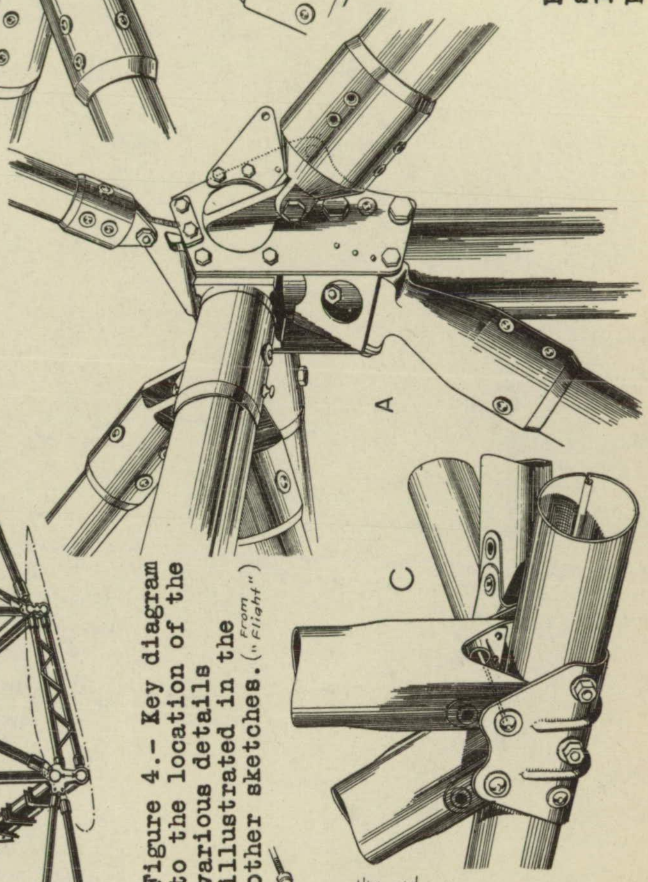


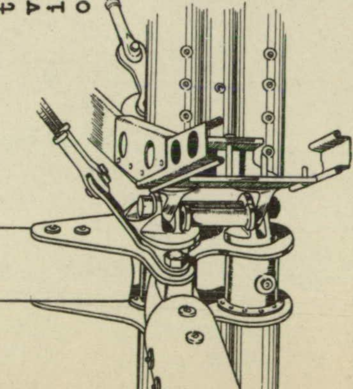
Figure 4.- Key diagram to the location of the various details illustrated in the other sketches. ("From "Flight")





From "Flight"

Figure 5.- Details showing the general lay-out of the fuselage primary structure.



From "The Aeroplane"

Figure 6.- Joint between the rear spar of the lower center-section and the fuselage.

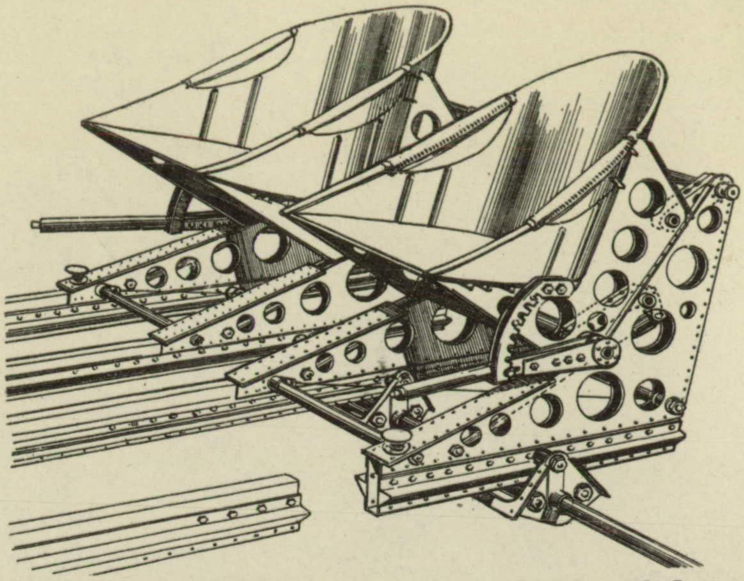


Figure 7.- The side-by-side seats are raised and lowered by means of the levers shown, while their fore-and-aft position can be varied within considerable limits when the button releases on the side frame are depressed. In addition, the rudder bars are adjustable. (From "Flight")

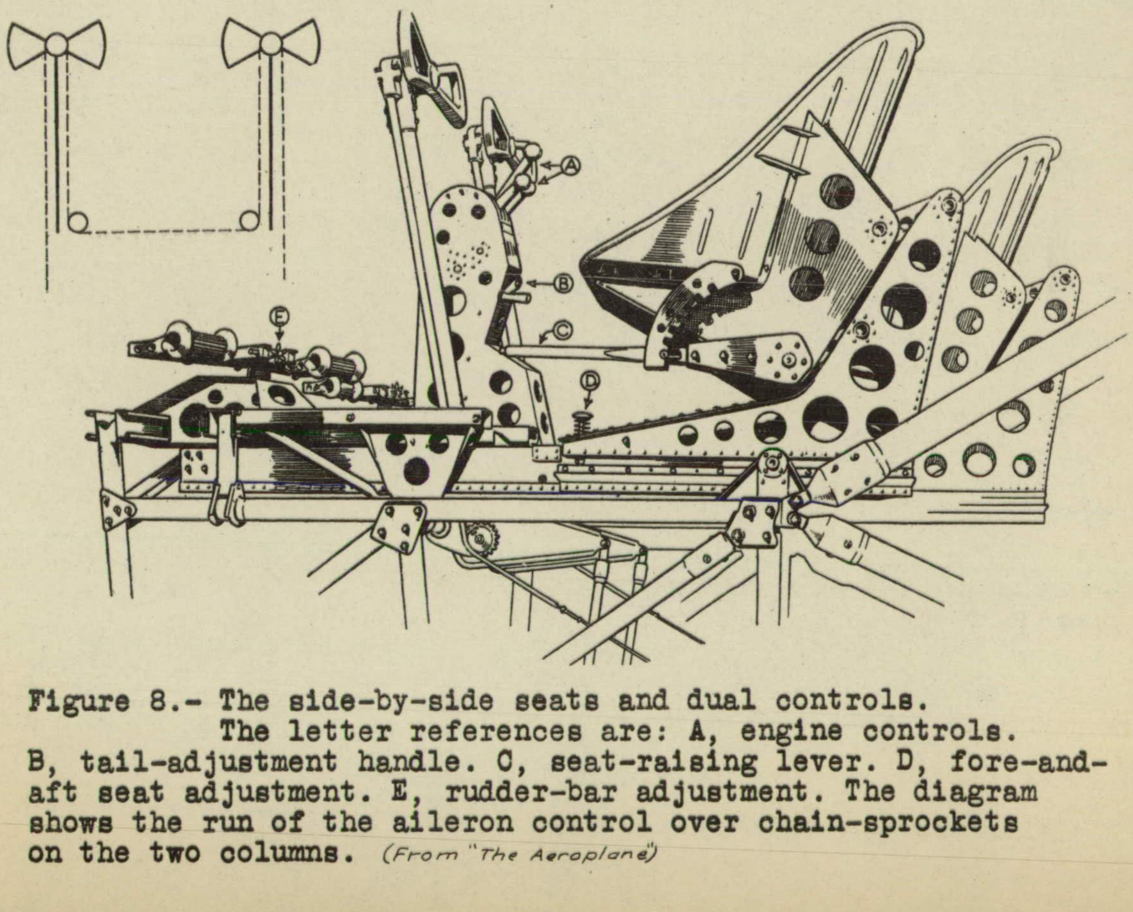


Figure 8.- The side-by-side seats and dual controls. The letter references are: A, engine controls. B, tail-adjustment handle. C, seat-raising lever. D, fore-and-aft seat adjustment. E, rudder-bar adjustment. The diagram shows the run of the aileron control over chain-sprockets on the two columns. (From "The Aeroplane")

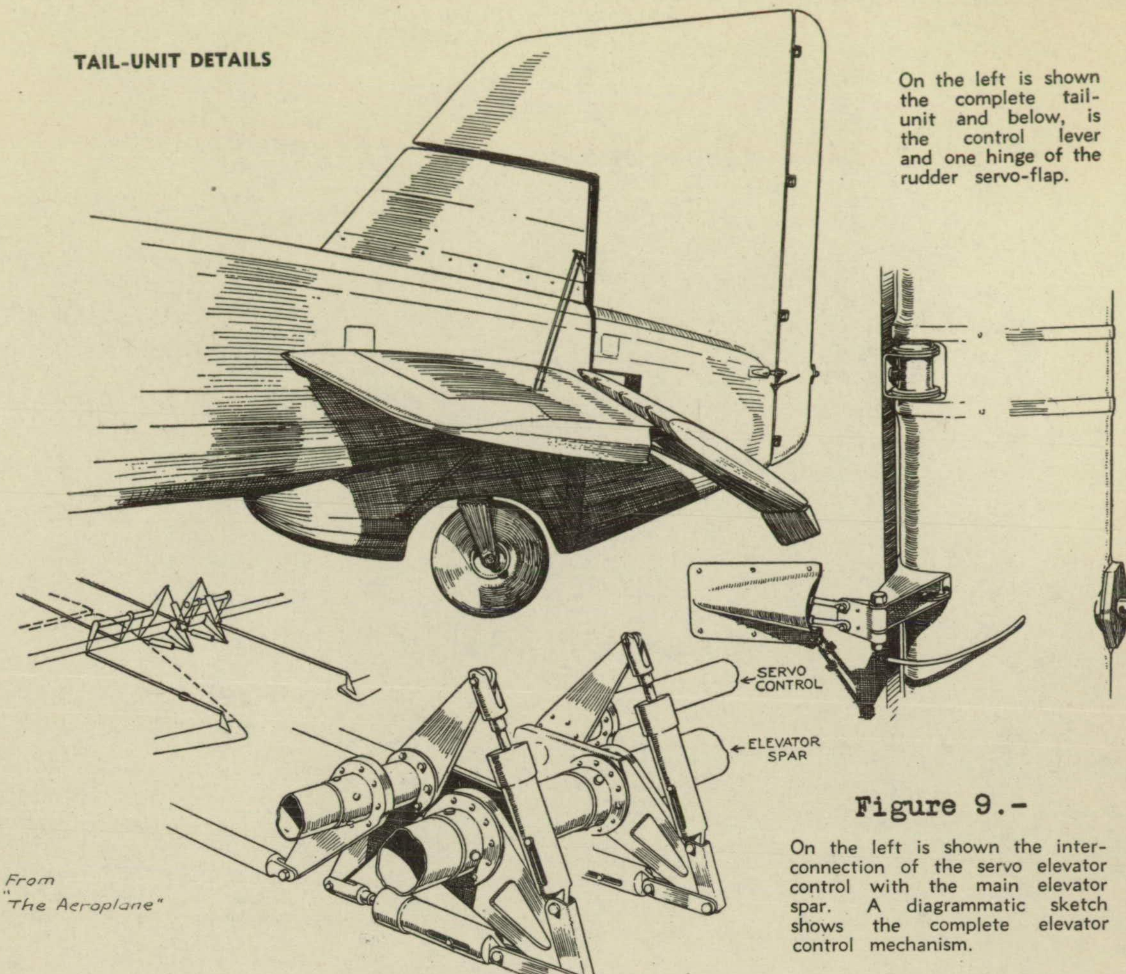


Figure 9.-

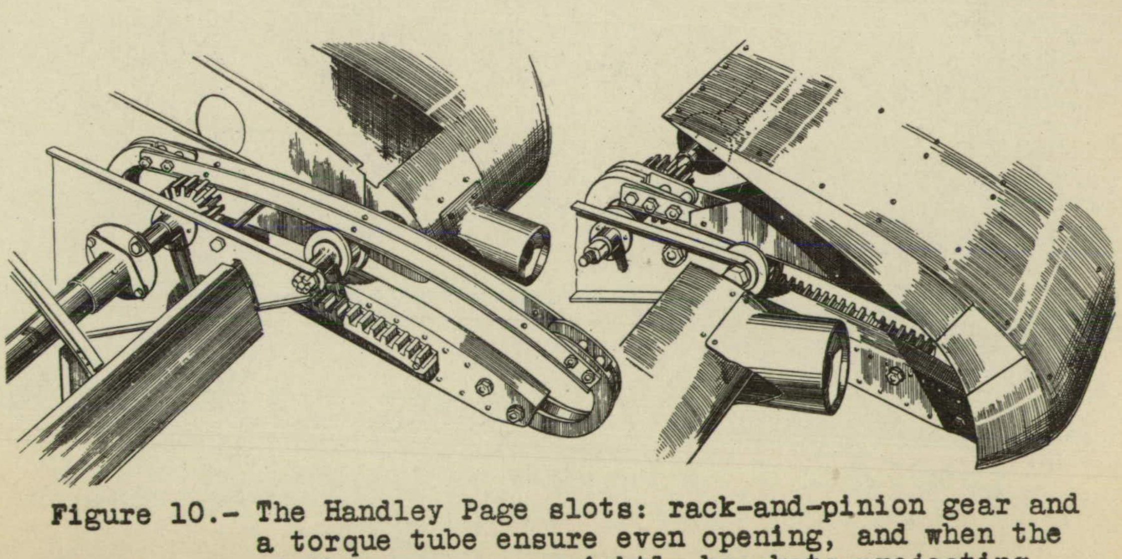


Figure 10.- The Handley Page slots: rack-and-pinion gear and a torque tube ensure even opening, and when the slot is closed there are no unsightly brackets projecting from the wing. (From "Flight")