The SHORT EMPIRE FLYING BOATS

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FLIGHT
AIRCRAFT ENGINEER AND AIRSHIPS

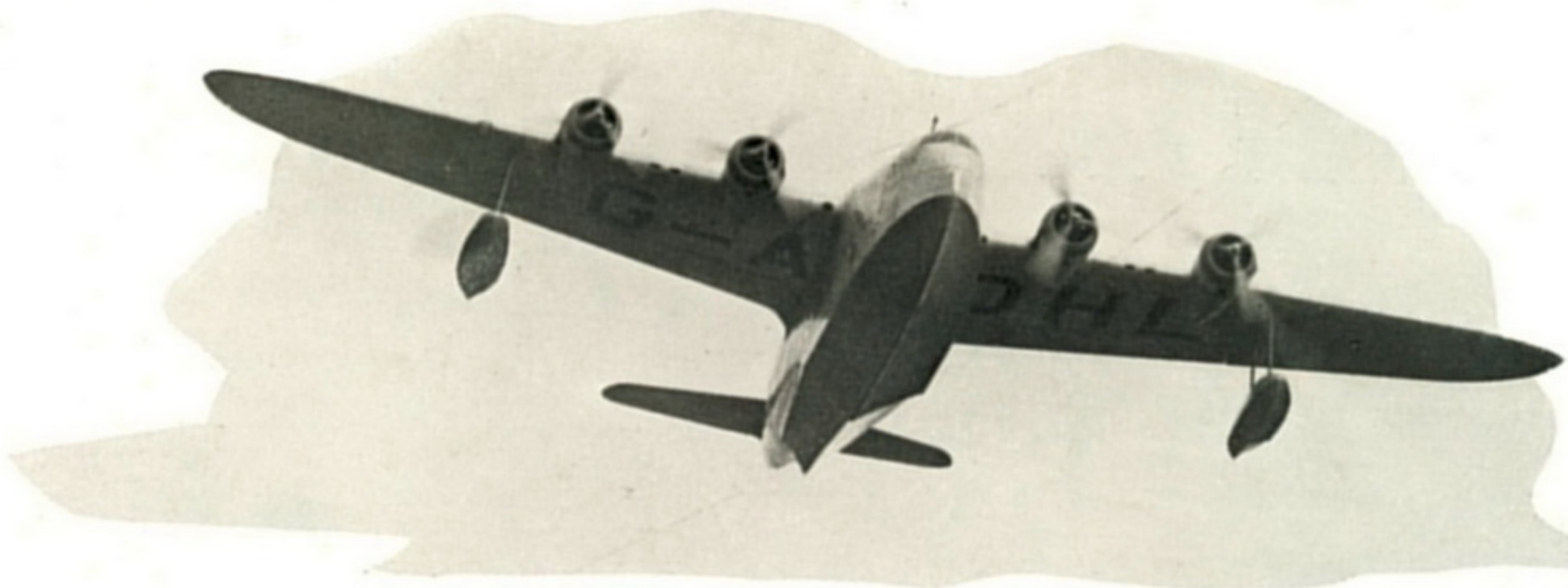
October 29, 1936.

Designed and Constructed by

SHORT BROTHERS (Rochester and Bedford), LTD.,

SEAPLANE WORKS,

Rochester, Kent.



THE SHORT

A Complete Description : Passenger Accommodation : Piloting and Navigational Equipment : The Bristol Pegasus Xc Engines

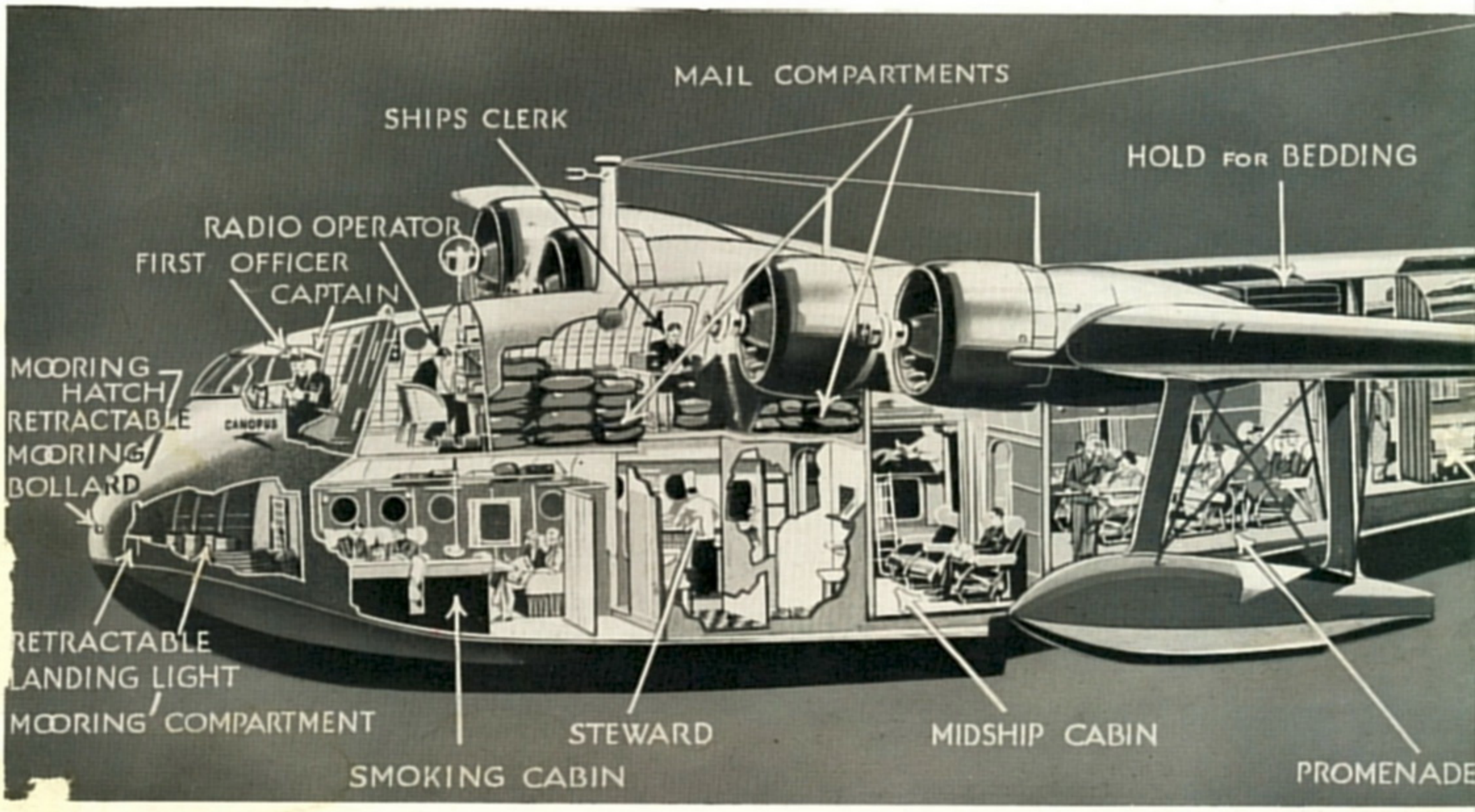
(Constructional details appear in "The Aircraft Engineer" Supplement to this issue)

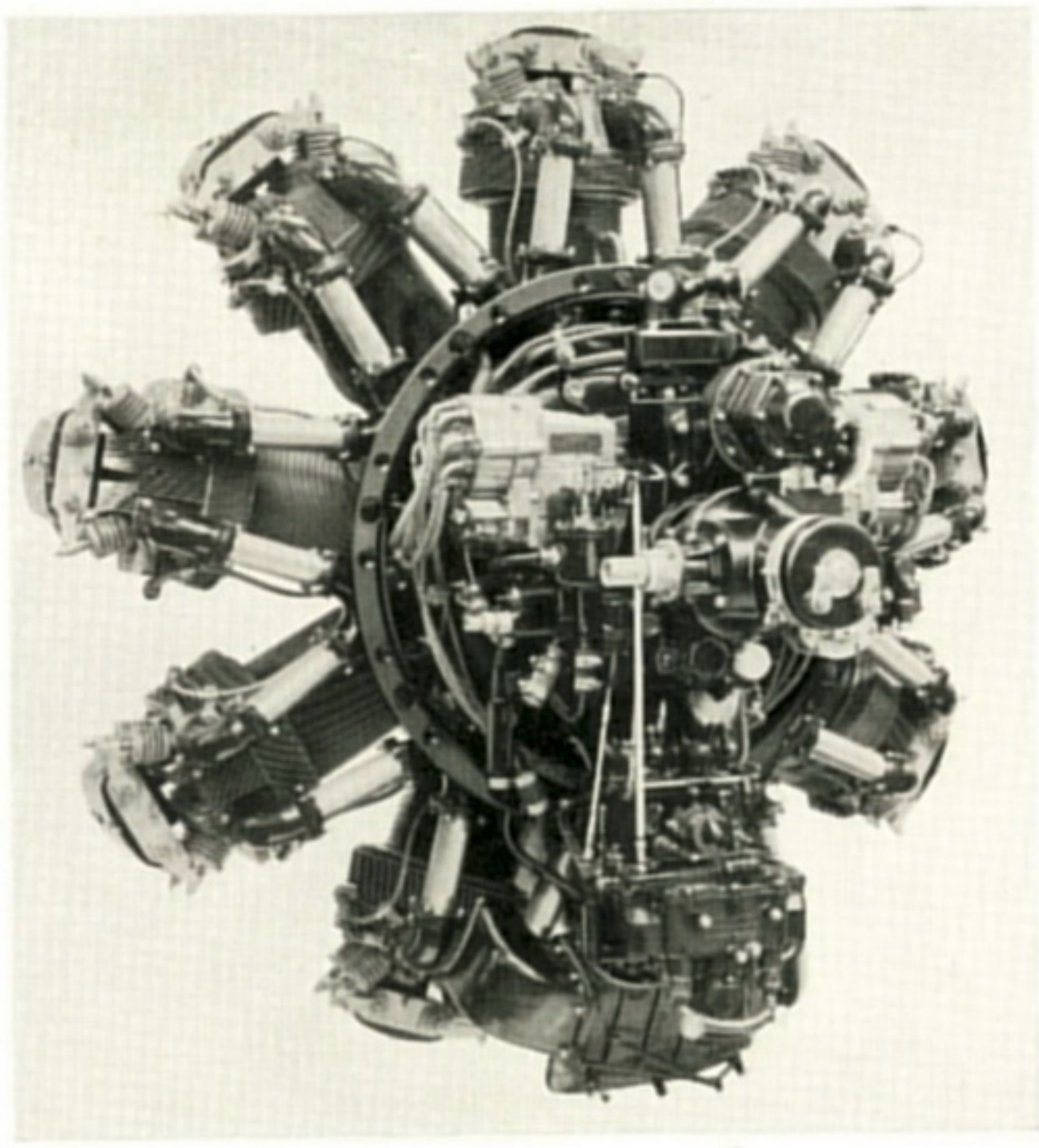
IF evidence were needed that the Short Empire flying boat is a new departure, the writer of these notes could give it, for in setting out to describe the machine it is difficult to decide on a plan. Not only are there several cabins, but the two decks are added complications from a descriptive viewpoint. Gone are the days of "behind the pilots' cockpit is the passenger cabin, with a luggage compartment at the rear." One feels that the time has come to turn up the technical shipbuilding journals and to study their treatment of the *Queen Mary*.

On consideration, it seems that the simplest way to go about the job will be to work from stem to stern, dealing with the upper compartments, which house the crew, in relation to the main lower deck with its passenger accommodation for twenty-four by day and sixteen by night.

As is customary, the marine gear is allocated a compartment in the bows. In the Empire Boat this is unusually capacious, extending beneath the pilot's cabin. Its equipment comprises an anchor, two drogues, a retractable mooring bollard (in the extreme bows) and a boat hook. Off-set to port is a retractable Harley light mounted on a hinged panel. Mooring operations are conducted from a hatchway in the turtle decking.

The pilots' cabin is above the rear portion of the moor-





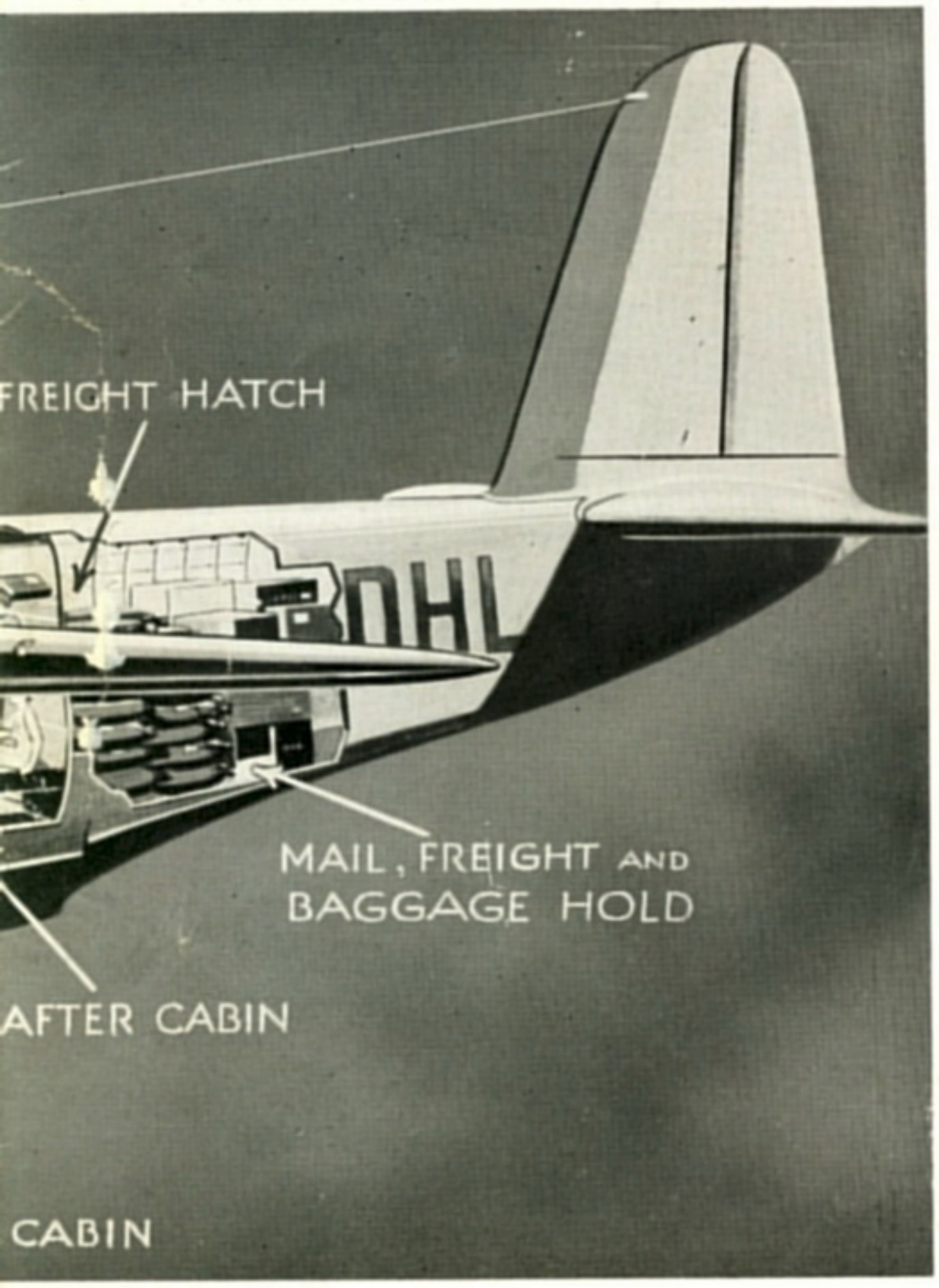
More than thirty-six hundred horse-power is delivered for take-off to the finely pitched blades of the D.H. variable-pitch airscrews. It is provided by four of these Bristol Pegasus Xc radials.

ing compartment, there being a communicating step ladder. A survey of the layout of this absorbingly interesting region is given in the two following pages, together with a description of the wireless cabin, which is located immediately behind.

Butting on to the mooring compartment is the first passenger saloon with five inwardly facing seats and another pair facing forward. This is the only compartment in the machine where smoking is permitted. A small foyer on the port side leads aft into a central corridor flanked to starboard by a kitchen, and on the opposite side by ladies' and gents' toilets. This kitchen, or as they seem to prefer to call it down at Shorts, stewards' pantry, is bound to evoke the envy of flatlet holders, being easily as large as their culinary recesses at home and better equipped, with plate racks, sink, draining-board, hot cupboard, thermos jugs and ice chest.

On the upper deck above the main portion of the smoking cabin, kitchen and lavatories, is a large compartment partitioned off longitudinally to form an office for the ship's clerk to starboard and a large hold for 3,000 lb. of mail and freight to port. The clerk's office can be entered from the starboard side of the hull and has a sliding door communicating with the hold. By the side of the clerk's desk is the main switch panel, containing fuses and switches for all circuits, ammeter and voltmeter, and controlling the

EMPIRE FLYING BOATS



instrument lights, the illumination of the cockpit and W/T cabin, wall lights in the interior, cabin ceiling lights, navigation lights and illumination for the loading hatch, mail stowage and bunk stowage. The main leads in the generator-switchboard-battery circuit are run in a completely shielded flexible metallic conduit to minimise radio interference.

On port and starboard sides respectively of the hold and office are handles controlling the opening of the annular skirt of cooling flaps on the long-chord cowlings over the four Pegasus engines out on the wings.

At the rear of the office is a step-ladder leading down to the kitchen and up to the top of the hull. On one wall of the companionway are the fuel cocks and the air intake controls which adjust the shutters for various conditions of flight.

For Promenading

The midship cabin is located behind the mail compartment, kitchen and toilets and accommodates three passengers by day and four at night. Then, farther astern comes the big promenade cabin seating eight or resting four. On the port side is a rail for elbow resting by the windows and a surprising amount of space for promenading. Leg-stretching space is always welcome on long trips. Above this cabin is a loft for bedding stowage and behind it the after cabin with six seats for daylight flying or sleeping accommodation for four. The rear wall of this cabin coincides with the after step of the planing bottom and behind it, extending well into the stern portion of the hull, is another hold for mail, freight and baggage.

Every bunk has a little window above it with a cover flap and by each row of seats are universally mounted hot and cold air in takes and a light incorporating a switch and a bell-push for calling the steward. Little hold-alls are let into the walls at appropriate points. Light luggage racks of railway carriage pattern are installed

From the outside a metallic, winged whale, the Empire flying boat has the most inviting internal accommodation as this Imperial Airways drawing bears witness. Hours can be spent exploring its interior which, in actuality, is even more intriguing than suggested here.

Even this excellent view of activity in the Short works does not do justice to the impressive scene, for it does not include the row of nine towering hulls packed side by side for plating. Incidentally, when a completed boat is moved out on to the slipway there is a clearance of about six inches between the tail and the lintel.

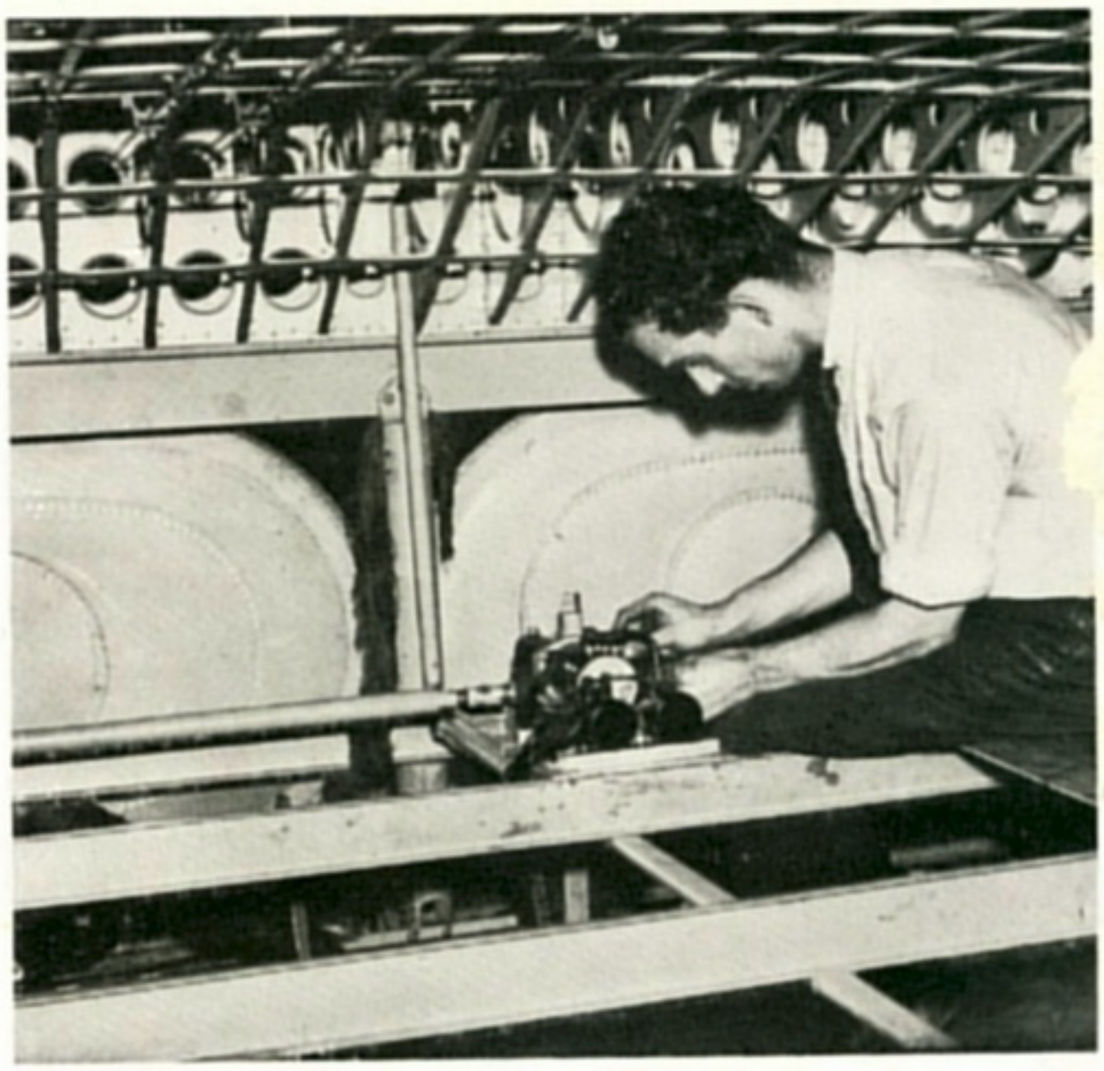
and the tables are of a special folding design, being adjustable to form book rests. The upholstery over the double sound-proofed walls and on the seats is mainly in a dark restful green and has been installed by Rumbold. The seats are of a new type, adjustable for height and tilt, with special Moseley "Float-on-Air" pneumatic cushions. The flow of air between the tubes in these cushions is restricted to counteract the effect on the passengers of aircraft movements. Rotax cabin roof lights are used, with 6- and 12-watt bulbs.

There are three Harley lamps—one, already mentioned, on the port side of the mooring compartment and one in the leading edge of each main plane. That in the bows is an 11-inch 250-watt type operated by two separate Teleflex controls, one rotary control operating the vertical movement and a similar one controlling horizontal movement. This lamp is used only for taking off and for searching when taxying. When not in use it fits flush with the side of the hull. The lamps in the wings are 500-watt models and are not controllable. They are fixed at a predetermined angle of dip and are used for landing purposes.

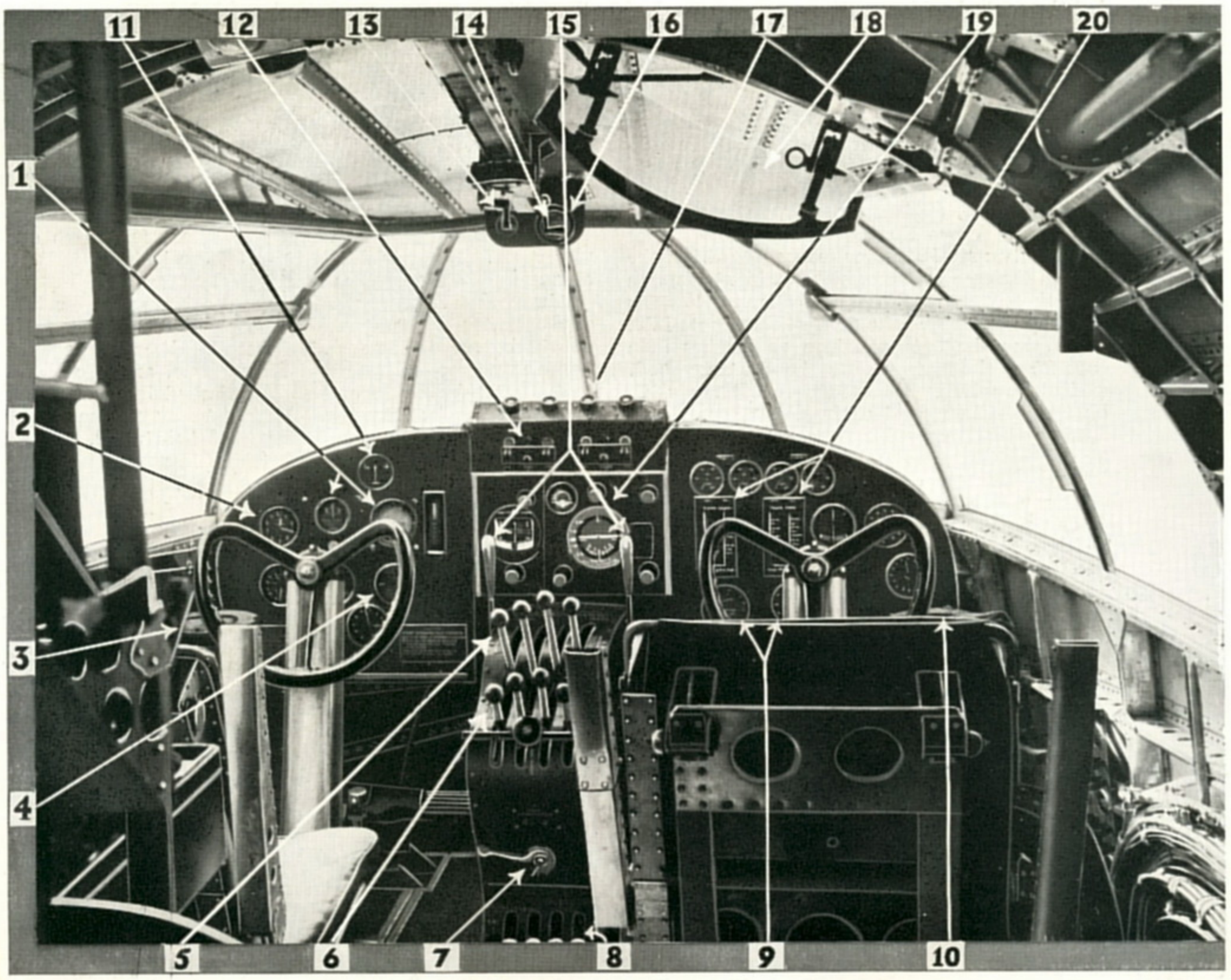
The Rotax navigation lamps are of the latest pattern, moulded in bakelite and weighing 4 oz. For wing-tip lighting a 20-watt bulb is fitted and there is a 10-watt bulb for the tail.

Each of the Empire flying boats is to be fitted with four P istol Pegasus Xc medium supercharged nine-cylinder r ial air-cooled engines mounted in staggered nacelles ich means that the outboard airscrews are not in the plane as the inboard ones) forward of the wing. The sus Xc may be regarded as the commercial version he famous X and is normally rated at 740 b.h.p. at oo ft. For take-off, 910 b.h.p. is available with the H. variable-pitch airscrew permitting the engine to n at 2,475 r.p.m. The normal cruising output will be b.h.p. Geared 0.5 : 1, the engine is of 28.7 litres capay, weighs 1,010 lb., and measures 55.3 inches in diter. It is the first unit operating on fuel of 87 octane mbe to go into service with a British air-line.

The engines are started by Rotax Eclipse direct-cranking starters with hand turning gear. This type of starter operates from 12 volts and turns a Pegasus at 25-30 r.p.m. The distributors of the Rotax-Watford magnetos are screened and adapted to take Marconi screened ignition harness. Booster coils are provided for easy starting, being automatically brought into circuit when the starter push button is operated. Engine temperature indicating equipment is



The great flaps of the Empire boat are operated by this little Rotax electric motor. Note also in this view the wing construction and tanks.



1. Directional gyro and artificial horizon.
2. Sensitive altimeter.
3. Port compass.
4. Rate-of-climb indicator.
5. Throttles.
6. Mixture controls.
7. Automatic pilot master control.
8. Airscrew pitch controls.
9. Boost gauges.
10. Starboard compass.
11. Homing indicator.
12. Engine switches.
13. Rudder bias.
14. Fore-and-aft trimmer.
15. Cut-out levers.
16. Flap gear.
17. Starter switches.
18. Retractable windscreen for upper hatch.
19. Automatic pilot panel.
20. Engine revolution indicators.

The Captain's Bridge : The Short Empire boat must be one of the most completely equipped machines so far seen in this country. Convenience has been studied very carefully in the disposition of the controls and instruments and this *Flight* photograph also conveys a good impression of the good view provided for the two pilots. The more important details of the installation are indicated and numbered in this photograph.

also incorporated. This is of the Rotax-Weston type, employing the Bristol thimble couple.

Like all current Pegasus models, the Xc has been developed to operate in close-fitting long-chord cowlings, and to this end has an abundance of fin area. The cowlings are provided with adjustable cooling arrangements which take the form of a ring of controllable flaps on the trailing edge. Thus it is possible to limit the flow of cooling air to necessary proportions under various flight conditions and to benefit performance. This form of cowling maintains uniform cylinder temperatures under all conditions of flight; provides an adequate control of air flow for running up and taxying under tropical conditions; and in the event of an engine failure permits increased cooling air to be supplied to the remaining engines while they are working at higher output but with the aircraft travelling at a comparatively low speed. A description of the gear was given in *Flight* of July 23 this year.

Hot air for cabin heating is taken from the exhaust systems of the inboard engines, and cold air for delivery to the cabin is scooped up from points on the leading edge of the wings.

The airscrews are of the two-position three-bladed De Havilland variable pitch type, measuring 12ft. 9in. in diameter.

Piloting and Navigational Equipment

IT might be expected that Imperial Airways' very latest long-distance machine would be more completely equipped than any yet produced in this country as far as the piloting and navigational section is concerned. When sheer planning is considered, the Short Empire flying boat is probably in advance of, and certainly equal to, anything yet seen in the air transport world. Yet only well-tri features appear in the special equipment installed.

As far as is humanly possible, the "bridge" has b arranged and equipped so that each boat will be almost independent of the outside world as a liner. The insta tion will enable the machines to fly, when necessary, self-contained units, and this installation has been designe so that no possible emergency will leave the boat witho the very necessary contact with civilisation.

From this point of view, therefore, the special Marco radio equipment can reasonably be considered as the mos important. In the layout of the Empire boats the rad operator's compartment, with chair and desk, lies amm

diately behind the control cabin, and the whole area, raised as it is, and reached by ladder from the lower deck, can only be alluded to as a "bridge." In front of the operator, who has his back to the pilots, are the normal transmitting and receiving sets for wavelengths of 600-2,000 metres and from 16-75 metres. Beside him on the floor of the upper deck, in series, is the auxiliary power supply unit, an electric motor and a special double-output generator.

In the ordinary way a 24-volt battery, for the electrical supply of the whole ship, feeds the motor, which in turn drives the generator. When the machine is on the water a small fan-cooled two-stroke motor is used to drive the generator through the free motor, which, incidentally, can be used to start the engine. If the battery is very low the engine is started by handle and the motor becomes an L.T. dynamo for charging the battery. The engine lies in a gasproof box as far as the interior of the boat is concerned. Normal electrical supply is obtained from Rotax D.C. generators on two of the Bristol engines.

Special shockproof supports have been developed for the mounting of the radio sets, with which is incorporated the direction-finding receiver. The loop for this is so mounted that it can be retracted into the hull when not in use, and this can also be fixed athwartships and used for "homing," either aural or visual on-course indications being given to the pilot. In normal flight the fairlead for the trailing aerial extends some two feet through the bottom of the hull in the marine equipment "forecastle." When the aerial has been wound in before arrival and the equipment has been switched over to the fixed aerial, this fairlead is drawn up through a spring trapdoor and this is sealed by means of a rubber joint.

The Control Cabin

Needless to say, the completeness of navigational equipment is, to the observer's eye, even more marked in the control compartment. Yet, though there are probably more instruments in the Empire boat than in any other civil machine in this country, there is none of the appearance of overcrowding or painful complication that is apparent in, for instance, some American transport types. The fact is, of course, that there is plenty of room both in the compartment and on the dashboard itself. Every essential control is both easily reached and easily operated, and every essential instrument is easily picked out.

All the major controls are centrally placed, so that they can be operated from either seat without trouble. At the top of this central control bank there are the starter buttons and engine switches, and it is typical of the thought expended on the whole layout that the safety cover for the starter buttons should be engraved with the queries: "Are all boats clear?" and "Are all hatches closed?" Below is the Sperry automatic pilot panel—an unusual but encouraging sight on an English machine.

Extending away from the dash and downwards are the throttle and mixture lever gates, with a master control for the latter. On either side of this gate are two levers which must be fairly new to pilots. These are cut-out levers, and their purpose is to make the engines absolutely dead after switching off. Particularly after the amount of taxying that will be necessary in a boat of this kind, air-cooled engines will tend to continue firing intermittently, and these controls, which actually cut the fuel off at the jets, will obviate this difficulty. At the base of this bank are the Sperry master control lever and the four airscrew pitch controls, these being pressed down to obtain fine pitch and vice versa. Level with the backs of the instantly adjustable seats are the various master fuel cocks.

Above the screen centre is a panel carrying the electrically operated flap switch and the position indicator. No effort whatever is demanded of the pilot when the flaps are being raised or lowered at a steady rate, and the Rotax motor used for the operation is switched into circuit by means of a solenoid. Special switches break the circuit when the flaps have reached the end of their travel. Behind this panel are the fore and aft trim and rudder bias controls, with an indicator for the former. These controls are small handles, and the spindles lie in different and obvious axes, so that there could be no possibility of making an emergency adjustment of the trim with the bias control.

Instrumental

So much for the major controls. The panel in front of each pilot carries, in *Centaurus* at any rate, duplicated versions of the essential flying instruments, including a Hughes turn indicator. That before the captain, however, also carries Sperry artificial horizon and directional gyro, a Kollsman sensitive altimeter, a liquid pitch indicator, a Hughes rate-of-climb indicator, the Marconi "homing" indicator, and a special Smiths chronometer for navigational purposes. The first officer's panel also carries the normal revolution counters, boost gauges, and oil pressure gauges. In addition there are two Hughes P/4/11 compasses, one for each pilot.

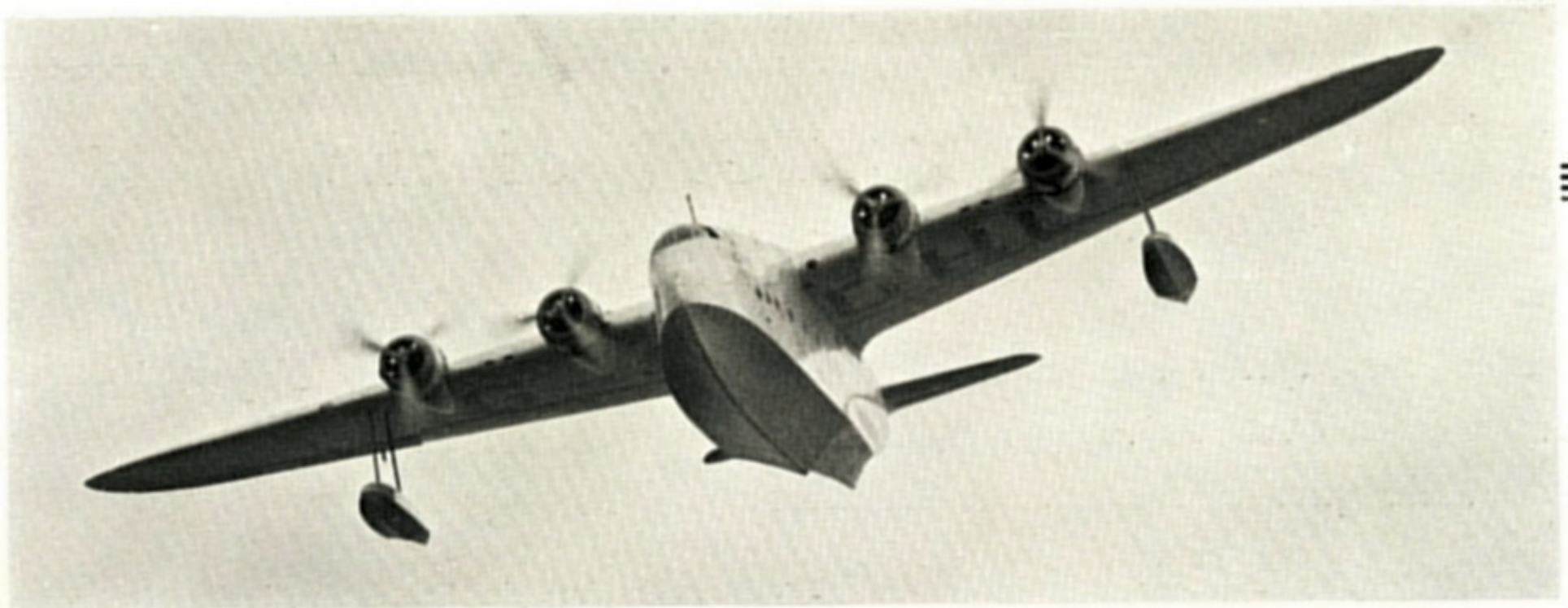
At the captain's left side are panels carrying switches for the various instrument lights and landing lights, while the main electrical control panel is at the rear of the upper deck. In addition there are the Sperry servo-speed control valves for varying the effect of the automatic pilot in the three separate axes. Behind the first officer's seat is a large instrument board carrying those engine and vacuum pump gauges and so on which do not necessarily need constant attention. Above, in the roof, there is a hatch with a retractable windscreen for use when celestial observations are being made.

Needless to say, the essential range of vision from the pilot's compartment is extremely good, and this range is considerably helped by the facts that the compartment is so well ahead of the engines and that the machine is, in any case, a high-wing monoplane.

PROPRIETARY EQUIPMENT

Some Idea of the Multiplicity of Equipment in the Empire Boats is Obtainable from this List of the Firms who are among the Chief Contributors of Large and Small Items

ARENS CONTROLS, LTD.—Arens controls.
BELL'S ASBESTOS, LTD.—Asbestos covering.
D. H. BONNELLA, LTD.—Electrical parts, terminal blocks, etc.
BOWDEN (ENGINEERS), LTD.—Bowden control cables, etc.
BRISTOL AEROPLANE CO., LTD.—Engines, exhaust rings, air intakes, cowls, etc.
BRITISH ALUMINIUM CO., LTD.—Aluminium sheets, tubes, ingot and bar.
BRITISH INSULATED CABLES, LTD.—Electric cable.
BROWN BROS., LTD.—A.G.S. parts, special stainless and duralumin bolts and nuts.
BURLEY, LTD.—Rubber bushes, blocks, hose, etc.
CALLENDERS CABLES AND CONSTRUCTION CO., LTD.—Electric cable.
CORK MFG. CO., LTD.—Langite and cork floats.
CORNERCROFT, LTD.—Aluminium and Alclad spinnings.
DE BERGUE'S PATENTS, LTD.—Patent duralumin rivets.
HAVILLAND AIRCRAFT CO., LTD.—Controllable-pitch airscrews.
DUNLOP RUBBER CO., LTD.—Rubber tyres and wheels for beaching gear.
EDISON SWAN ELECTRICAL CO., LTD.—Electric bulbs.
EXACTOR CONTROL CO., LTD.—Hydraulic controls.
FIRTH-VICKERS STAINLESS STEELS.—Stainless steel bars and sheet.
FLEXO PLYWOOD CO. (INDUSTRIES), LTD.—Aero birch plywood.
GUEST, KEEN AND NETTLEFOLDS, LTD.—Light alloy screws.
H. M. HOBSON (AIRCRAFT AND MOTOR) COMPONENTS, LTD.—Carburetters and automatic boost controls.
J. J. HABERSHON AND SONS, LTD.—Carbon steel strip, stainless steel sheets and strips.
HENLEY'S TELEGRAPH WORKS, LTD.—Electric cables.
HIGH DUTY ALLOYS, LTD.—Hiduminium alloy sheets.
HOFFMANN MFG. CO., LTD.—Bearings.
MANGANESE BRONZE AND BRASS CO., LTD.—Oilite bushes.
MARCONI'S WIRELESS TELEGRAPH CO., LTD.—Wireless equipment.
MAY AND BAKER, LTD.—Rhodoid sheeting.
MOLLART ENGINEERING CO., LTD.—Universal ball joints.
D. MOSELEY AND SONS, LTD.—Rubber sheet.
NORTHERN ALUMINIUM CO., LTD.—Aluminium alloy sheets, D.T.D. 111 and D.T.D. 275, and aluminium alloy bar.
POWER FLEXIBLE TUBING CO., LTD.—Avioflexus tube and connections.
REYNOLDS TUBE CO., LTD.—Hiduminium RR. 56 extrusions, tubes, bars, etc., and steel tubes.
ROTHERHAM AND SONS, LTD.—A.G.S. parts, bolts, nuts, screws, etc.
ROTAX, LTD.—Electrical equipment.
RUBERY OWEN AND CO., LTD.—Detail fittings.
L. A. RUMBOLD AND CO., LTD.—Cabin decorations and upholstery.
G. SALTER AND CO., LTD.—Springs.
SIMMONDS AEROCESSORIES, LTD.—Simmonds nuts.
SMITH'S AIRCRAFT INSTRUMENTS, LTD.—Instruments—all types.
SPERRY GYROSCOPE CO., LTD.—Lord shock absorber Sperry horizons, automatic pilots, etc.
STERLING METALS, LTD.—Manganese castings.
TECALEMIT, LTD.—Greasers.
TECHNICAL PLATINGS, LTD.—Anodising.
WEBLEY AND SCOTT, LTD.—Signal pistols.



The Short Empire Flying Boats

DETAILED DESCRIPTION AND SKETCHES OF CONSTRUCTION

Reprinted from "The Aircraft Engineer," Supplement to "Flight," October 29, 1936.

THE CONSTRUCTION of the EMPIRE BOATS

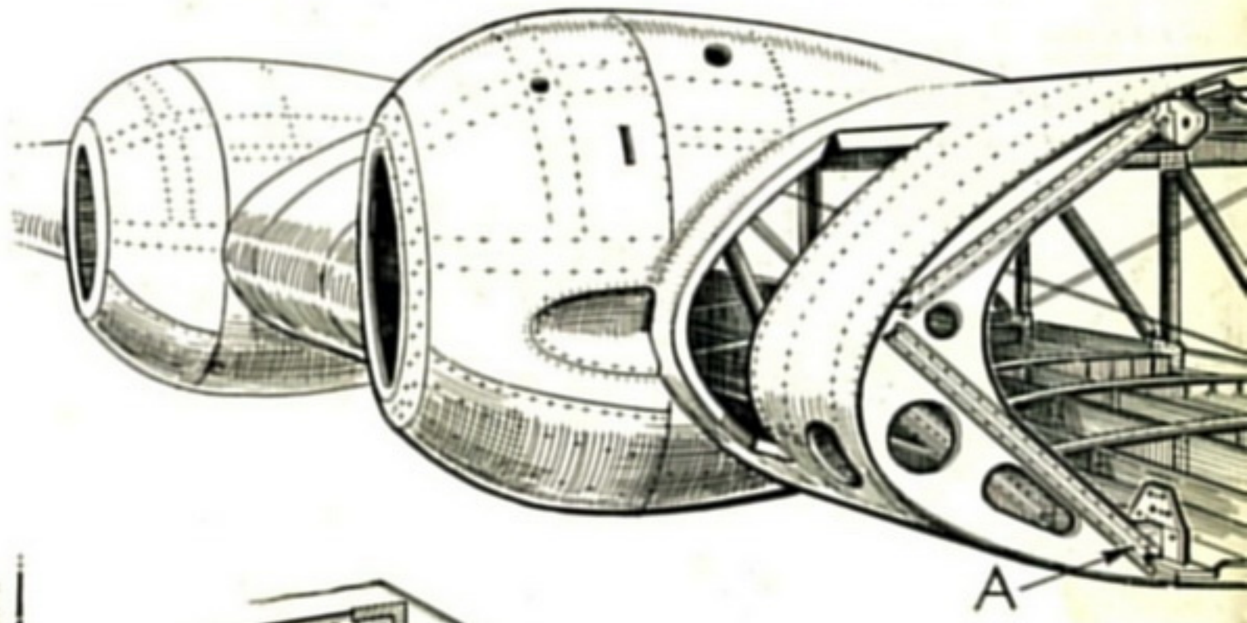
First Detailed Description and Sketches of the Structure : Clever Types of Construction Used in Wings and Hull : Light Metal Employed Throughout, with a Few Stainless Steel Fittings

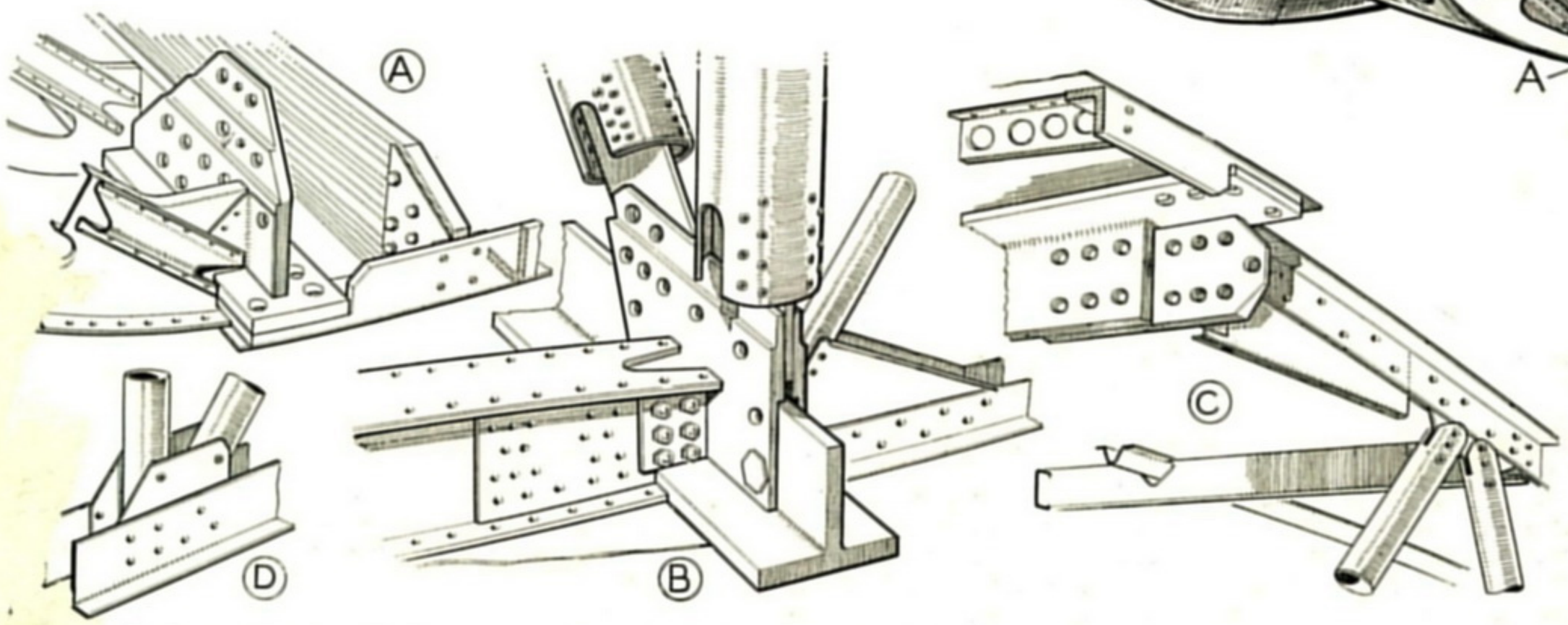
A CONSIDERABLE amount of information has been published about the passenger accommodation and general layout of the new Empire flying boats which Short Brothers, of Rochester, are building for Imperial Airways, Ltd., and some further important details appear elsewhere in this issue. The boats are intended, in the main, for the England-South Africa and England-Australia routes, although a few will be modified slightly in the matter of fuel tankage in order to give them sufficient range for making the flight across the Atlantic, both *via* Bermuda and *via* Newfoundland. Hitherto the details of the construction have been kept secret, but now that the first two boats, *Canopus* and *Caledonia*, have carried out their test flights and have been found to fulfil all the expectations of the designers, it has become possible to describe the constructional details, which *Flight* is placing before its readers for the first time this week.

Some surprise has been expressed at the fact that a large batch of these machines is not already in service. By the time the reader has perused the sketches which illustrate this article, and has studied the numerous details of the construction, he will realise the magnitude of the task with which Mr. Bibby, Short's works manager, was confronted. Let it be remembered that the original order was for a total of 29 of these large, four-engined flying boats, and that at the time the works were only normally busy, so that a very large expansion was needed. For example, apart from questions of jigging and tooling, the number of workers had to be nearly trebled, and with every firm in the aircraft industry competing for skilled workers, this was no easy matter. Ultimately the solution was found in getting hold of as many skilled workers as possible, completing the number with unskilled or semi-skilled workers who had to be taught the intricacies of flying boat work before they could become really useful.

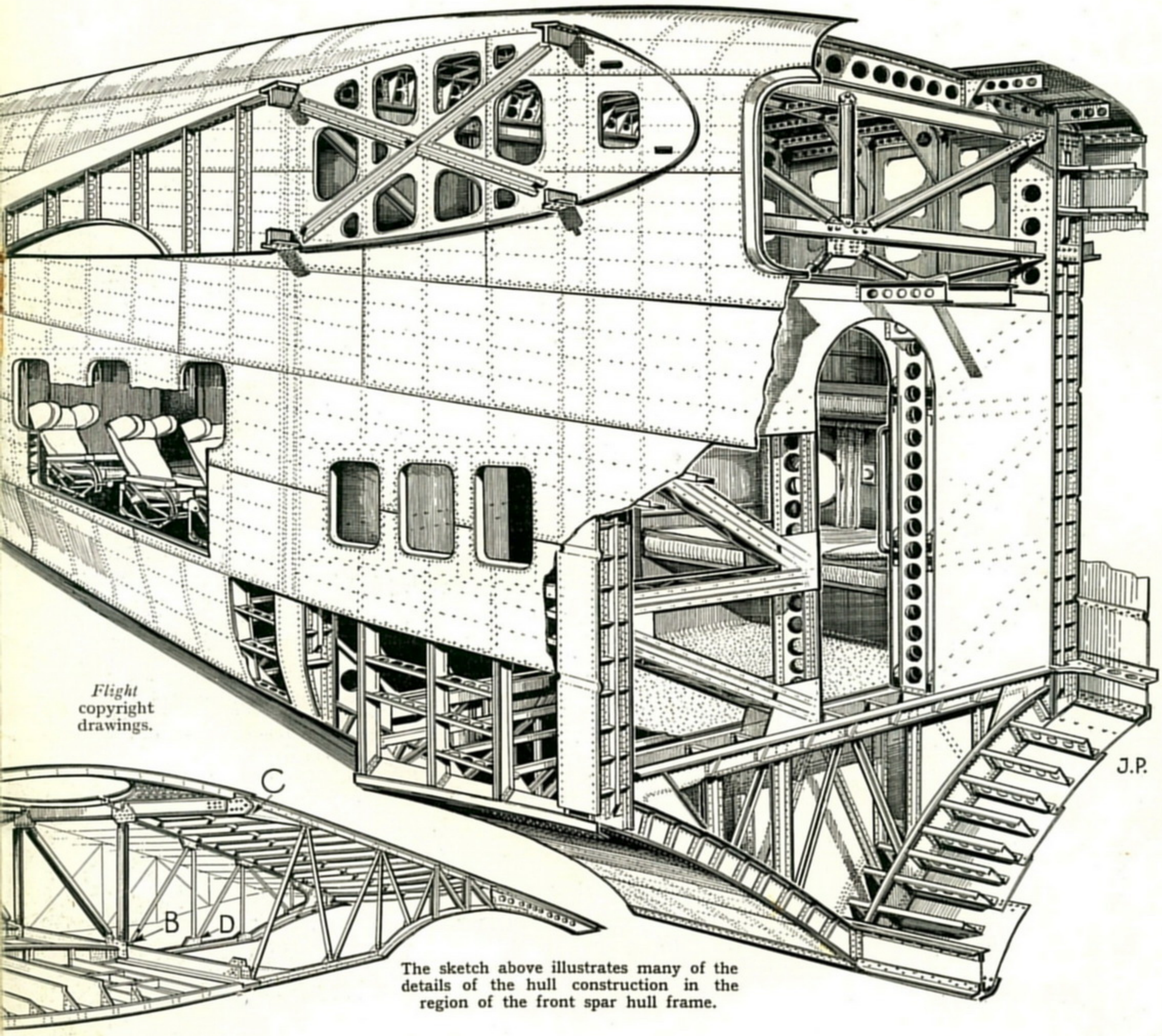
The Short Empire flying boat is an all-metal four-engined cantilever monoplane, with the usual two-stepped hull. The lines of the hull differ, however, somewhat from those of earlier Short flying boats, and the wing structure is entirely new as far as flying boats are concerned, although it has been thoroughly tested-out on the small Short Scion landplanes.

Earlier Short flying boats, such as the Calcutta and Kent class, were characterised by a reduction in beam above the chines, the sides being faired into the chines by a planking of double or "S" curvature. That form of construction was comparatively difficult, and a certain amount of "panel beating" was inevitable. In the Empire boat the double curve has disappeared and there is but a slight hollow curve sweeping the sides into the chine. This shape was chosen partly because it is a good deal simpler to construct, but chiefly because the space was wanted inside for cabins. In order to utilise the space to the best advantage, it was also decided to keep the beam of the hull relatively narrow and to arrange the quarters of passengers and crew on two "decks." A result of these various considerations was that the hull of the Short Empire boats has a much smaller beam-height





of the construction of the centre-section of the wing. The locations of the different joints are shown in the general Attachment of the leading edge to the spar is shown at A ; a typical joint between the extruded spar flange and the N-girder of the spar at B ; the wing spar joint is illustrated in C, and a rib joint at D.



Flight copyright drawings.

The sketch above illustrates many of the details of the hull construction in the region of the front spar hull frame.

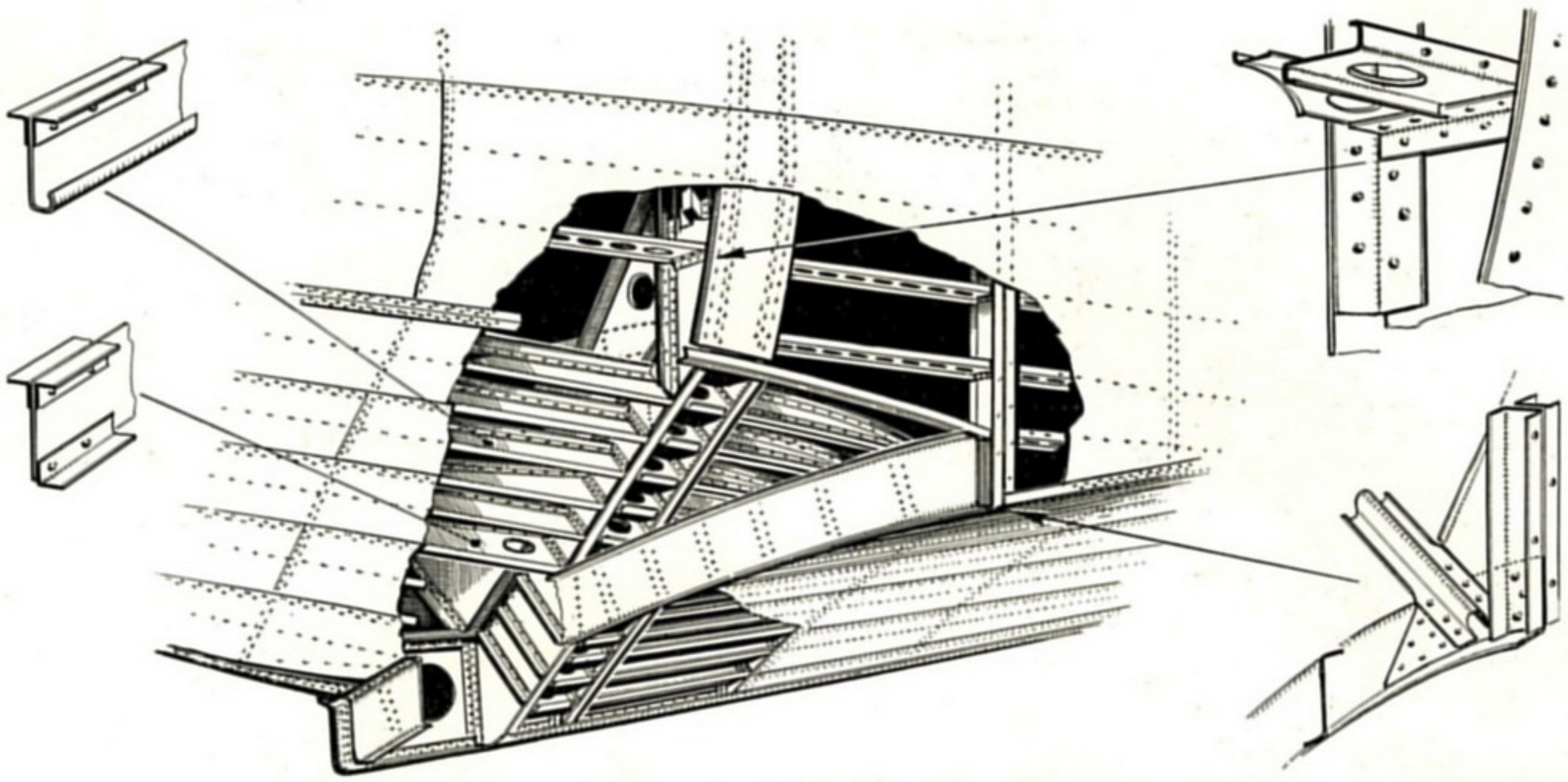
ratio than earlier Short boats, although the hull does not quite achieve the "plank-on-edge" proportions of some of the Rohrbach flying boats, for example.

From a seaworthiness point of view, the great height of hull is a considerable advantage in that it gets the engines and airscrews well clear of flying spray, although against this must be offset a much smaller disadvantage in that the struts which carry the outboard wing floats are slightly increased in length. In this connection it should, perhaps, be made clear that lateral stability on the water has not been reduced by the new beam-height ratio, as it has been a case of increasing the height rather than of reducing the beam.

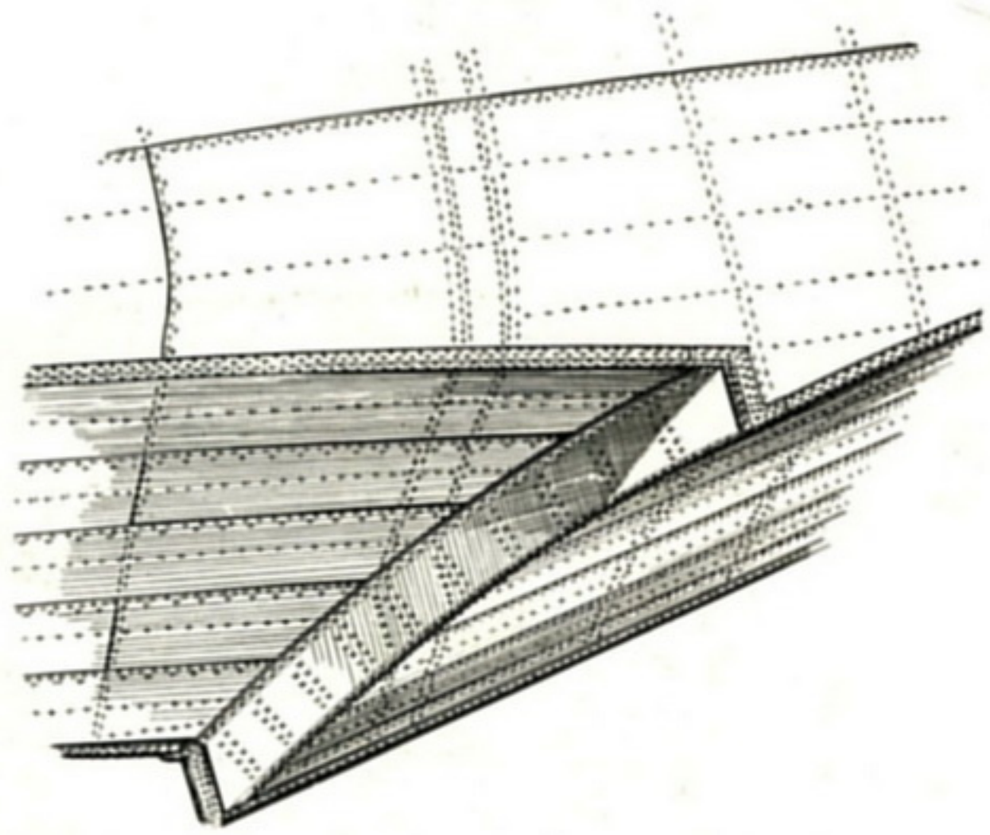
Apart from the difference in the shape of the hull sides, changes in design are also to be found in the steps, notably the front one. Hitherto it has been customary to run the main step straight across the hull, that is to say, with the step forming a straight line in plan view. In the Empire boats a slightly different arrangement has been employed. The step is no longer vertical but may be regarded as sloping forward at an angle. This is done by having the points where the outer ends of the step meet the chines located ahead of the point where the step crosses the chine. This arrangement brings the transverse plane through the step into a forwardly-sloping attitude. Judging by the clean running and absence of "porpoising" the new step arrangement is a success and the length of the take-off certain does not appear to have suffered as the machine gets off remarkably well.

In the construction of the hull, usual Short practice has, generally speaking, been retained, although certain detail differences are met with here and there where the increase in size and slight change in shape has made such changes profitable. Structurally, the keel and the two chines form a triangulated structure in section. The keel is a built-up I-beam, with a single flat sheet for the flange and L-sections riveted through the flange edge to form the top and bottom flanges of the I. The keel is lightened by circular holes in the web, the holes having their edges slightly flanged over to stiffen them.

The transverse frames are mostly of Z-section bet



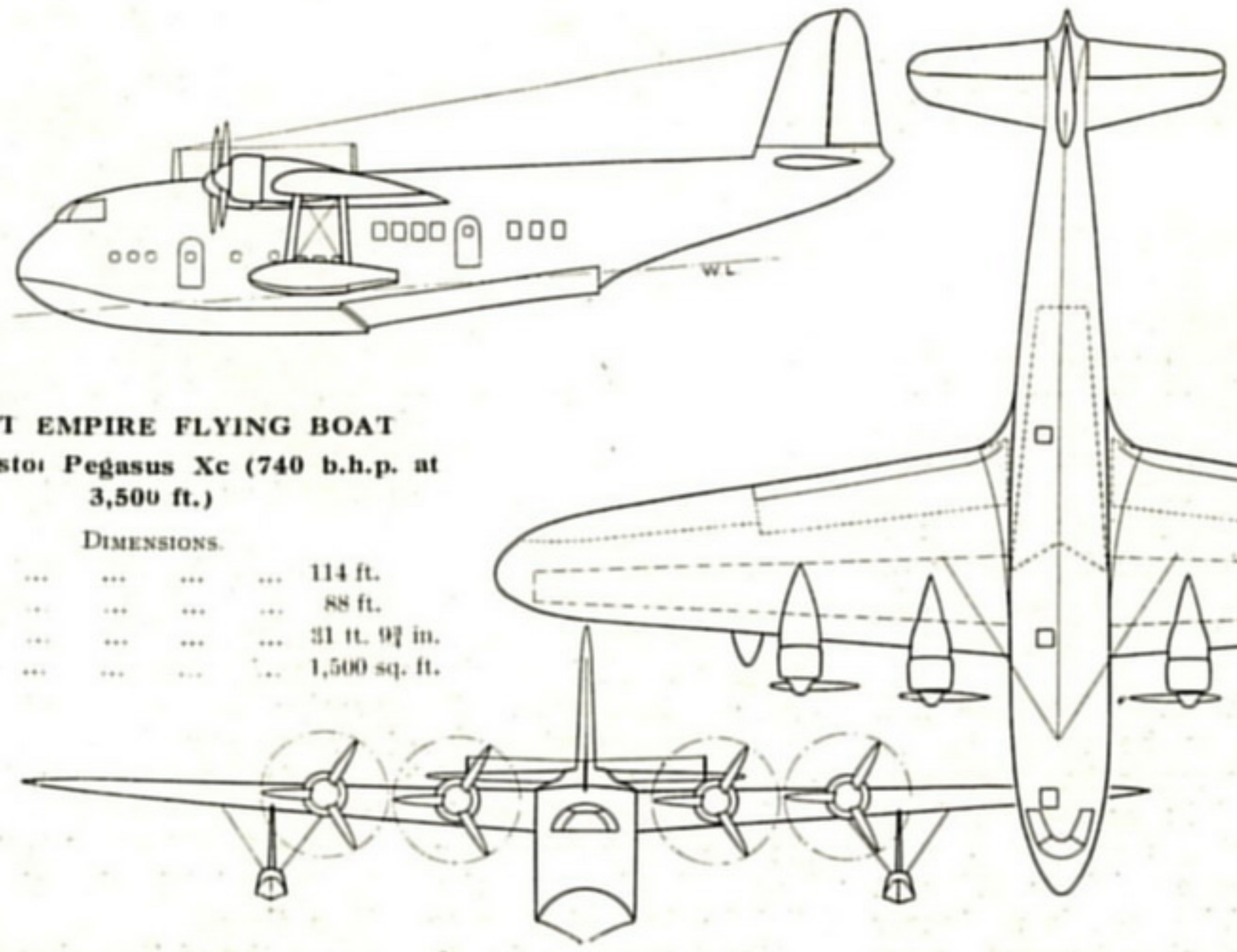
The main step slopes forward, as shown in the sketch on the left. Details of the step and frame construction are illustrated above.



keel and chines, and the top horizontal member of the triangular construction referred to above is of channel section, braced to the planing bottom frames by "N" ties. These latter are of what may be described as "open omega" section.

Between chines and gunwales the vertical frame members are mostly plain double-channel sections, the two channels being placed back-to-back.

Short Brothers were the first British constructors to use a form of metal-clad construction in which the longitudinal members or stringers were interrupted at the frames. Previously it had been customary, when flying boat hulls were built of wood, to notch the stringers into the frames so as to get all longitudinal members running continuously from end to end. The Short method has been retained in the Empire boats, the stringers being in short lengths between frames, to which they are

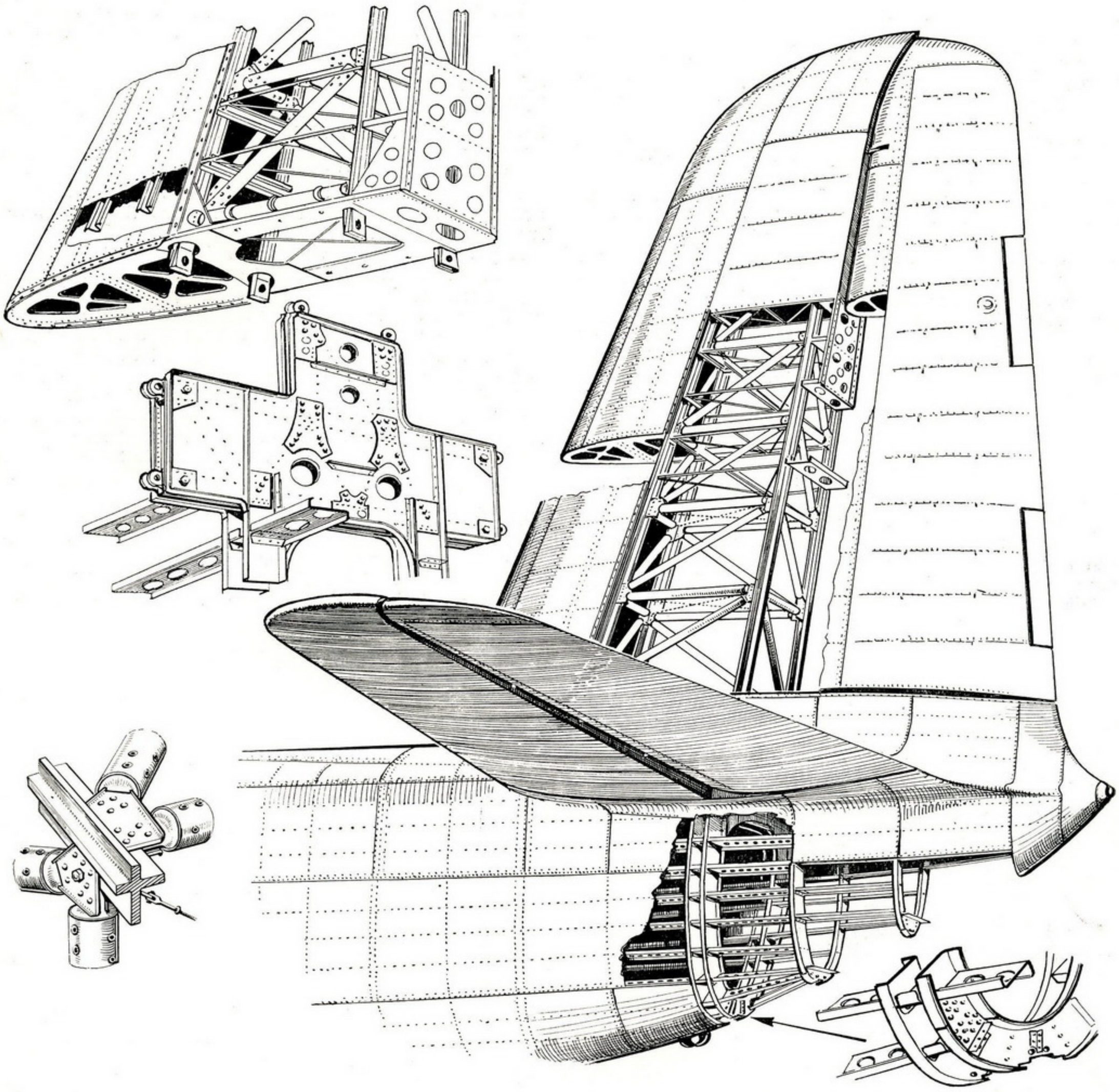


SHORT EMPIRE FLYING BOAT

Four Bristol Pegasus Xc (740 b.h.p. at 3,500 ft.)

Dimensions.	
Span	114 ft.
Length	88 ft.
Height	31 ft. 9¾ in.
Wing area	1,500 sq. ft.

Weights. (Standard Boat.)	
Weight empty	24,000 lb.
Petrol (600 gall.)	4,560 lb.
Oil (44 gall.)	400 lb.
Equipment	3,340 lb.
Payload and crew of five	8,200 lb.
All up weight	40,500 lb.
Performance.	
Maximum speed (5,500 ft.)	200 m.p.h.
Cruising speed (4 × 510 b.h.p.)	165 m.p.h.
Stalling speed	73 m.p.h.
Rate of climb at sea level	950 ft./min.
Absolute ceiling	20,000 ft.
Take-off time	21 sec.
Normal range in still air	760 miles.



The tail unit of the Empire Boat. The upper sketches on the left show details of fin attachment to the double frame, and the lower sketch illustrates the joints of the bracing tubes in the fin to the cruciform-section fin spars.

attached by plain angle brackets and by gussets over the frame flanges. In the original Short boat hulls, the stringers were of an open vee section. In the Empire boats, however, the stringers are of Z-section. The Alclad sheet planking is joggled where two edges overlap, and the stringers themselves have their flanges indented to accommodate the joints of the planking. In this way a perfectly smooth surface results.

Aft of the rear step, the hull frames are of channel section from the keel to the decking, which is deeply cambered.

As already mentioned, the new hull form is such that double curves and S curves have disappeared. The result is that with one or two exceptions there is no need for panel beating, and the sheet planking can be applied in quite large panels. Countersunk rivets are used, so that the hull planking presents an absolutely smooth surface.

Some very interesting innovations have been introduced in the wing construction of the Short Empire boats. The fundamentals of it were tried out in the little Short Scion landplane, which was also in other respects something of a flying model of the Empire boats and provided many data which were applied in the design and construction of the large machine.

In his lecture to the Royal Aeronautical Society recently, Dr. Lachmann referred to two main types of cantilever wing construction, the shell type of stressed skin and the "concentrated flanges" type. The Short form of wing construction belongs to the latter. The main wing spa is a girder box, the four corners of which are formed by extruded T-sections of light alloy. The "box" tapers both in plan and depth, and the extruded T-sections taper in size and thickness, the taper being obtained by machining. Thus the material is at all points along the span proportioned to the stress at that point. The front and rear sides of the spar "box" are formed by tubular members arranged as "N" girders. These girders are, of course, in the planes of what are front and rear spars in a more orthodox two-spar wing.

The method of attaching the tubes to the T-sectio

flanges is interesting. A plug of what may be described as I-section with curved flanges is inserted in the end of the tube and riveted to it. To facilitate the riveting process, portions of the tube walls are cut away at the end, and in this manner the rivet positions become quite accessible. The central web of the plug extends beyond the end of the tube, the extension being attached to the single flange of the T-section spar flange by fish-plates, as shown in a sketch.

Ordinarily, there would be wing ribs between the front and rear walls of the spar "box." In the Short construction there are none of these ribs; instead, there are Z-section stringers which run span-wise, and the upper flanges of which support the sheet-metal wing covering. These stringers are in turn supported on fore-and-aft members which occur only at the points where there are uprights in the front and rear spar girders. The "box" section is prevented from assuming a rhomboidal shape by incidence wires running diagonally between front and rear spar box corners.

LE and TE

To the main wing "box" the leading and trailing edges are attached as complete units. The leading edge is entirely of sheet construction, with short nose ribs and curved leading edge covering forming a half-open shell, attached to the main spar box corners. When the leading and trailing edge units are removed, they give complete access to the interior of the wing "box" and all its details.

The trailing-edge unit is built up, girder-wise, the tails of the ribs having T-section flanges inter-braced by tubular members.

A special type of trailing-edge flap is used on the Empire boats. The section of the flap is a segment of a circle, and the flap moves back and down so that it provides both increased area and increased camber.

Wing Covering

The covering of the entire wing is of light-metal sheet, and flush-riveting is used extensively so that the wing surface is particularly smooth.

A particularly neat type of engine support has been designed for the Empire flying boats. The Bristol Pegasus engine is carried on a metal *monocoque* support, which is cantilevered out from the front of the spar "box," and which fairs very neatly into the wing covering. The main petrol tanks are cheese-shaped, and there is a pair of them between each engine pair.

Special beaching undercarriage legs have been designed for the Empire boats, and are provided with air bags so that when they are cast off they will not sink.

From the data on p. 10 it will be seen that the ratio of gross to tare weight is 1.69, which is a good figure for a boat of this size.

Most of the structural features have been dealt with in above article. Readers who are interested in the general layout, furnishing and equipment of the Empire boats are referred to the article on pp. 2-6, which deals more particularly with these features.

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