AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 204

THE SHORT "EMPIRE" COMMERCIAL FLYING BOAT (BRITISH)

An All-Metal Cantilever Monoplane

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An All-Metal Cantilever Monoplane

The Short "Empire" flying boat is an all-metal, four-engine, cantilever monoplane, with the usual two-step hull (figs. 1, 2, 3). The lines of the hull differ somewhat, however, 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 on the small Short "Scion" landplanes.

Earlier Short flying boats, such as the "Calcutta" and "Kent" class, were characterized 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" flying 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 great deal simpler to construct, but chiefly because the space was wanted inside for cabins. In order to utilize 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" flying boats has a much smaller beam-height ratio than earlier Short flying 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 propellers 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.

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*From Flight, October 29, 1936; and The Aeroplane, October 28, 1936.

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" flying 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 certainly does not appear to have suffered as the seaplane gets off remarkably well.

In the construction of the hull, usual Short practice has, generally speaking, been retained (fig. 4), 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 between 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 (fig. 5).

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" flying boats, the stringers being in short lengths between frames, to which they are attached by plain angle brackets and by gussets over the frame flanges. In the original Short flying-boat hulls, the stringers were of an open V section. In the "Empire" flying 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" flying 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" flying boats and provided data which were applied in the design and construction of the large seaplane.

The Short form of wing construction is of the concentrated flange type. The main wing spar 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-section 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 fishplates, as shown in 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 spanwise, and the upper flanges of which support the sheet-metal wing covering (figs. 6 and 7). 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.

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, girderwise, the tails of the ribs having T-section flanges interbraced by tubular members.

A special type of trailing-edge flap is used on the "Empire" flying 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.

An especially 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 gasoline tanks are cheese-shaped, and there is a pair of them between each engine pair.

Special beaching landing-gear legs have been designed for the "Empire" flying boats, and are provided with air bags so that when they are cast off they will not sink. From the data it will be seen that the ratio of gross to tare weight is 1.69, which is a good figure for a flying boat of this size.

The tail-unit structure is shown in figures 8 and 9.

The marine gear is allocated a compartment in the bows. In the "Empire" flying boat this is unusually capacious, extending beneath the pilots' cabin. Its equipment comprises an anchor, two drogues, a retractable mooring bollard (in the extreme bows), and a boathook. Offset to port is a retractable Harley light mounted on a hinged panel. Mooring operations are conducted from a hatchway in the turtledecking.

The pilots' cabin is above the rear portion of the mooring compartment, there being a communicating stepladder. A survey of the lay-out of this interesting region, together with a description of the wireless cabin, which is located immediately behind, follows. (See figs. 10 and 11.)

Butting onto the mooring compartment is the first-passenger saloon with five inwardly facing seats and another pair facing forward (fig. 12). This is the only compartment in the airplane 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 lavatories. The kitchen is 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 pounds 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 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 minimize 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 stepladder 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 lavatories, 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 intakes 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, and the tables are of a special folding design, being adjustable to form book rests. The upholstery over the double, soundproof 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 wing. 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 ounces. 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 Bristol Pegasus Xc medium-supercharged, 9-cylinder, radial, air-cooled engines (fig. 13) mounted in staggered nacelles (which means that the outboard propellers are not in the same plane as the inboard ones) forward of the wing. The Pegasus Xc may be regarded as the commercial version of the famous X and is normally rated at 740 b.hp. at 3,500 feet. For take-off, 910 b.hp. is available with the D.H. variable-pitch propeller, permitting the engine to turn at 2,475 r.p.m. The normal cruising output will be 510 b.hp. Geared 0.5:1, the engine is of 1751.37 cubic-inche capacity, weighs 1,010 pounds, and measures 55.3 inches in diameter. It is the first unit operating on fuel of 87 octane number 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 tuns 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 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 (fig. 14). 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 traveling at a comparatively low speed. A description of the gear was given in Flight of July 23, 1936.

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 propellers are of the two-position three-blade De Havilland variable-pitch type, measuring 12 feet 9 inches in diameter.

PILOTING AND NAVIGATIONAL EQUIPMENT

The bridge has been arranged and equipped so that each flying boat will be almost independent of the outside world as a liner. The installation will enable the aircraft to fly, when necessary, as self-contained units, and this installation has been designed so that no possible emergency will leave the flying boat without the very necessary contact with civilization.

From this point of view, therefore, the special Marconi radio equipment can reasonably be considered as the most important. In the lay-out of the "Empire" flying boats the radio operator's compartment, with chair and desk, lies immediately 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 wave lengths of 600 to 2,000 meters and from 16 to 75 meters. 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 aircraft, feeds the motor which, in turn, drives the generator. When the aircraft 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 flying 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 athwartship and used for "homing" either aural or visual on-course indications being given to the pilot. In normal flight the fair-lead 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 fair-lead is drawn up through a spring trapdoor and this is sealed by means of a rubber joint.

The Control Cabin

The completeness of navigational equipment is even more marked in the control compartment. Yet, though there are probably more instruments in the "Empire" flying boat than in any other civil aircraft in this country, there is none of the appearance of overcrowding or 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 instrument board itself. Every essential control is both easily reached and easily operated and every essential instrument is easily picked out (fig. 15).

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 lay-out 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 aircraft.

Extending away from the instrument board and downward 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 flying 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 propeller 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 windshield 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

The panel in front of each pilot carries 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 Smith's chronometer for navigational purposes. The first officer's panel also carries the normal revolution counters, boost gages, and oil-pressure gages. 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 gages, and so on, which do not necessarily need constant attention. Above, in the roof, there is a hatch with a retractable windshield for use when celestial observations are being made.

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 aircraft is, in any case, a high-wing monoplane.

SOME TECHNICAL POINTS*

The structure of the wings and the process of building them have been briefly outlined. Technically, the most interesting thing about the wings is the use of extrusions in Hiduminium R.R.56 alloy. Extruded tubes and sheets of the same material are also used.

The extrusions for the flanges of the wing girders are supplied to the required section and with the flanges set over the appropriate amount. But they require machining to the necessary taper.

This is done on a special form of milling machine. But besides being tapered, these sections have also to be twisted. No way of doing this on the machine has yet been devised, and the operation has to be done by hand.

These extrusions are linked with vertical and diagonal tubular struts of R.R. 56 alloy into which tongued fittings, machined from Hiduminium, are fixed by tubular rivets. The girders so formed are then linked by compression ribs, built up girder-fashion from more extruded sections. In place of webs between the top and bottom ribs, swaged rods provide the necessary cross-bracing.

The top and bottom surface between the spars is then covered with a stressed skin of Alclad. This is stiffened on the inside with Z-section stringers which run the length of the wing. The nose and trailing edges are similarly sheeted.

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*From The Aeroplane, October 28, 1936.

All the skin plates are fixed in position with countersunk rivets, and all joints, whether running along or across the wing, are "joggled." As a result, the outer surface is perfectly smooth.

The ailerons, of the Frise type, are mounted on inset hinges. The ailerons have a metal-covered nose forward of the spar but are covered with fabric back to the trailing edge. They are worked in a perfectly ordinary way by swaged rods.

How the Flaps Work

Between the inner ends of the ailerons and the hull are the special flaps. These have a circular upper surface and are flat underneath. They are built entirely of metal, including the covering (fig. 16). They are supported by special roller bearings working in curved tracks and move extremely easily. Each flap is worked by a screw jack with a stroke of some 30 inches. These jacks are turned by a shaft which runs at 500 r.p.m. This consists of a number of sections linked by Mollart universal joints.

Both shafts are coupled to a Rotax electric motor of ½ horsepower which runs at 6,000 r.p.m. (fig. 17). This pushes the flaps down in 60 seconds and brings them home in 90. The interesting thing about this mechanical equipment is that it is some 40 pounds lighter than any equivalent hydraulic system.

Each wing is bolted directly to four fittings on the side of the hull. Details of these are shown in the figures.

The structure of the hull follows along well-proved lines. There are a large number of closely spaced frames linked with closely pitched longitudinal stringers of Z section. These are covered with Alclad sheeting, and an absolutely smooth surface is obtained in the same way as on the wings.

The tail unit is built into the stern of the hull. The structure of the fixed stabilizer resembles that of the wings except that, instead of the skin covering between the spars, the latter are linked by a number of diagonal tubes. The nose is covered with metal and the middle section with fabric.

The elevator is built much like the ailerons and in the same way; the trailing edge is covered with fabric. The fin is built like the stabilizer and the rudder is covered with fabric. Both the rudder and the elevators are provided with trimming tabs. These are set by simple mechanical control from the cockpit.

When the flying boat is at rest on the water, it is balanced by floats just outboard of the outer engines. These floats are built along the usual Short lines and are divided into a number of watertight compartments. Provision is made for extracting any bilge water through connections in the upper surface to which a hand pump can be fitted.

Sprung Floats

Each float is carried on a pair of struts in tandem depending from the main spars. These are braced laterally with a pair of streamlined rods on each side. To prevent undue torsional loads being transmitted to the wing by shocks when the floats are struck by a large wave or moving fast through broken water, a special form of shock absorber is placed between the cross-bracing wires between struts. This allows the float to move backward some 4 inches and the shocks are absorbed by rubber in compression. The system has already proved its use on another monoplane flying boat built by the firm. The arrangement has the additional advantage of absorbing any oscillations which might arise from the pendulum effect of so large a mass being hung so far below the wing.

Power is supplied by four Bristol Pegasus X.C engines which drive four De Havilland three-blade variable-pitch propellers, 12 feet 9 inches in diameter, through a reduction ratio 0.5/1. These run on fuel to Air Ministry specification D.T.D. 230.

The engines provide a maximum power of 790 horsepower at 2,600 r.p.m. at 5,500 feet, and 910 horsepower at 2,475 r.p.m. for take-off. They are carried on short nacelles built out from the front spar.

The fuel capacity of the flying boats varies according to the duties for which each is intended. The first boat, "Canopus," has a normal range in still air of about 760 miles, when carrying a pay load plus crew of five, equal to 8,200 pounds (3.65 tons). Fuel for this range is carried in two tanks of 325-gallon capacity each. The big size of the wing makes possible the building of fuel tanks in a really economical shape. The tanks for the "Empire" flying boats are just cylindrical drums, rather wide for their height. They are made of anodically treated duralumin and have a cruciform baffle which divides the tank into four equal communicating quadrants. The tanks are De Bergue riveted and the flat top and bottom surfaces are tied together with tubular rods. They are carried on wooden floors in the wings and bolted down into position.

The oil coolers are carried in ducts in the leading edge, as shown in the sketches.

The passenger accommodation of the big flying boat is divided into four main sections. Right in the nose is the smoking cabin, 10 feet long by 8 feet wide and nearly 7 feet high. There is a door in the port side. A hatch in the forward bulkhead gives access into the mooring cabin in the nose.

Behind this is the midship cabin, 10 feet wide by 6 feet 6 inches long and 8 feet high. Joining the two is a white-painted passage on the starboard side of which is the steward's pantry. The two lavatories are on the port side.

Behind the midship cabin is the so-called promenade cabin because of the large amount of floor space left free between the chairs and the port side of the flying boat. The main door is in that wall at the back of the cabin. There is thus plenty of room for people coming in and out through that door to move down the whole length of the boat.

The promenade cabin is the largest. It is 13 feet long, 9 feet wide, and 7 feet 9 inches high. The after cabin is 10 feet long, 8 feet 6 inches wide, and 9 feet high.

In the bulkhead at the back of the after cabin is a hatchway into the enormous after hold. Access to this from outside is by a two-section door in the starboard wall. Normally the lower portion is used. But by taking up the top part of the door as well a whole radial engine can be shipped.

Provision is made to mount a temporary derrick on the side of the hull and with this the engine can be lifted onto a block and pulley. The latter runs along an overhead rail into the hold.

The flying boat is provided with two entirely separate ventilating systems. Each passenger has a controllable punkah-louver so that he can control the supply for his own immediate wants in the way of cold fresh air.

The second ventilating system is under control of the captain. Fresh air is taken in through the wing in the same way as in the other system, but passes through a radiator to ducts which have their outlets arranged down near the floors of the cabin.

The radiator is supplied with steam produced in a boiler built around the exhaust pipe of one of the engines. In this way the fullest possible advantage is taken of the enormous latent heat of water. If a supply of hot air is not wanted the radiator can be by-passed and the cabins supplied with fresh air only.

Except for the very large ducts which are of aluminum sheet, the air is taken through ducts which are built up from doped fabric. Strips of fabric are laid onto suitable formers and doped in place. When the material has set, the formers can be removed and an extremely light and effective tube is obtained. Ordinary foundry cores serve very satisfactorily as they can be broken up without much trouble.

The only communication between the crew's quarters and the passengers' quarters is by way of a tubular ladder which runs vertically up at one end of the steward's pantry. This takes one up the whole of the 17 feet out on top of the wing, or one can step off halfway onto the upper deck.

Here one is in the middle of everything and as there is no upholstery to hide the works, the immense complexity of the accessory installations is apparent.

Behind the center section of the wing is the space for mail and freight. Still farther aft behind this is the space for the storage of bunks and bedding. Actual access to this storage space is obtained through a hatch in the promenade cabin.

As one moves forward along the upper deck there is a space for the mail on the port side. Then comes the Marconi radio equipment with the retractable loop aerial and the full direction-finding equipment. The short- and medium-wave transmitter works on wave lengths of 16.9 to 75 meters and 600 to 1,100 meters. The output on the former is 100 watts, and on the latter 120 watts.

By means of the V-shaped dipole aerial on top of the wing and hull, the operator can "listen through" while transmitting. When his key is not depressed he is connected to the receiver and so can pick up any calls, in between the sending of his own signals. The receiver works on 15 to 75 meters and on 600 to 2,000 meters. The direction-finder also works on the latter wave band.

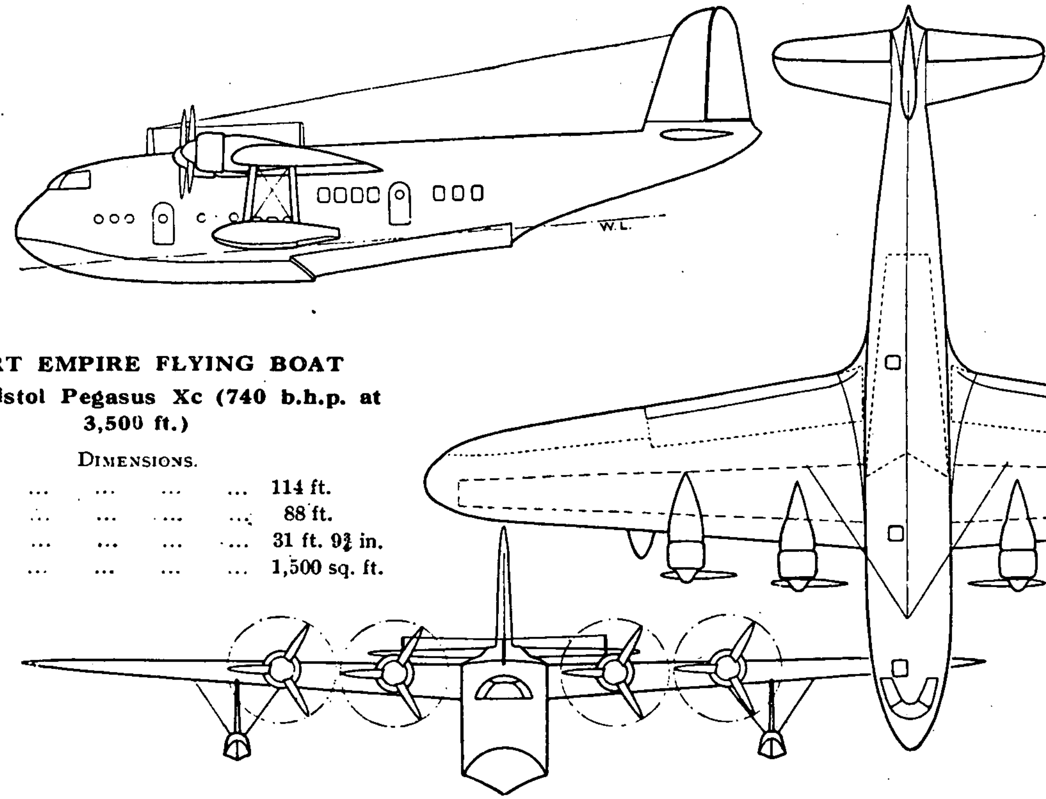
On the left is the mounting for a Sperry automatic pilot and then the two pilots' seats with all the controls in front of them. Between the seats is the hatch which leads to the forward chain locker where all the marine gear is stowed.

Exactor hydraulic controls link the throttles in the cockpit with the carburetors. There is a full range of Smith's aircraft instruments with the new colored dials, also a new Husun P.4 L compass.

Each flying boat is provided with two Harley searchlights, one in the port side of the nose for taxying on the water, and another in the starboard wing. Both have Osram lamps.

CHARACTERISTICS

Dimensions:		
Span	34.75 m	(114 ft.)
Length, over-all	26.82 "	(88 ")
Height, over-all to top of fin	9.70 m	(31 ft. 9-3/4 in.)
Wing area	139 m^2	(1500 sq.ft.)
Weights (standard flying boat):		
Weight, empty	10900 kg	(24000 lb.)
Gasoline (600 gal.)	2070 "	(4560 ")
Oil (44 gal.)	182 "	(400 ")
Equipment	1515 "	(3340 ")
Pay load plus crew (5)	3720 "	(8200 ")
Weight, loaded	18380 "	(40500 ")
Performance (standard flying boat):		
Maximum speed at 1680 m (5500 ft.)	322 km/h	(200 mi./hr.)
Maximum cruising speed (510 hp. per engine)	266 km/h	(165 mi./hr.)
Minimum flying speed	118 "	(73 ")
Rate of climb at sea level (coarse pitch)	28.8 m/min.	(950 ft./min.)
Absolute ceiling	6100 m	(20000 ft.)
Time to take off	21 seconds	
Normal range in still air	1220 km	760 miles



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.

From Flight

Figure 1.- General arrangement drawings of the "Empire" flying boat

Figure 3.- The Empire "Canopus" in flight. From Flight

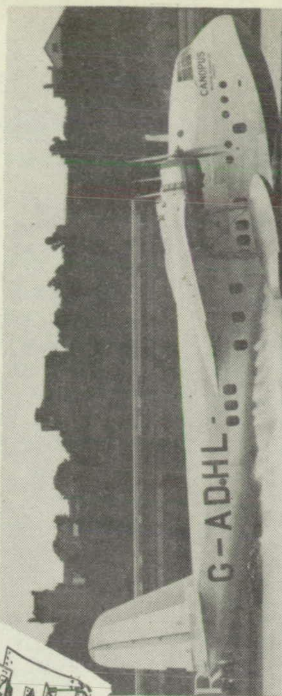


Figure 2.- The Empire "Canopus" on the step.

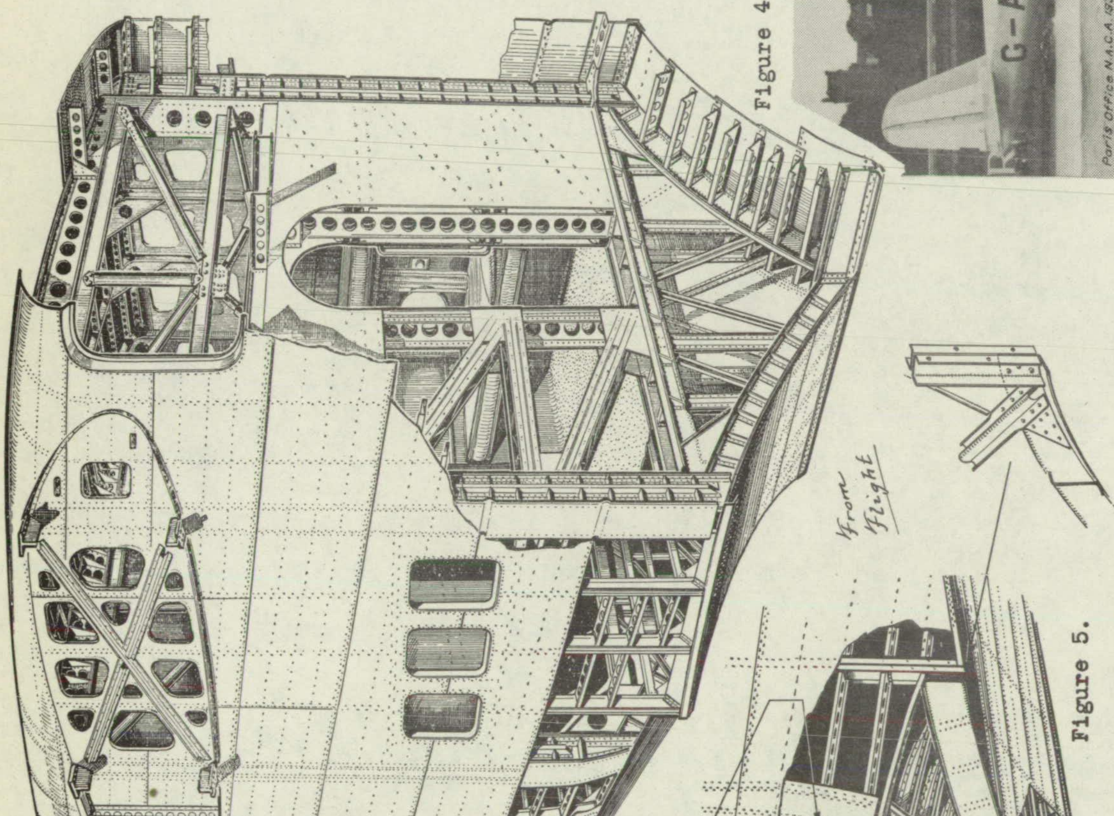
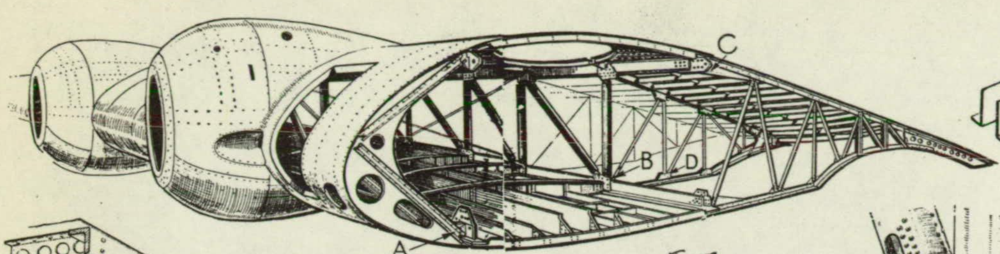


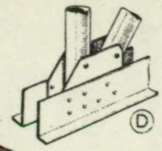
Figure 4.

From Flight

Figure 5.

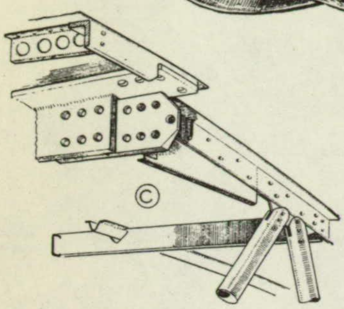
Figures 4,5.- Details of hull and step of the Empire flying boat.

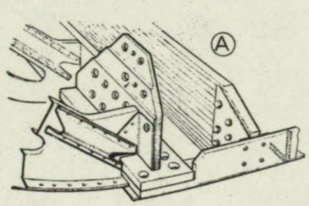


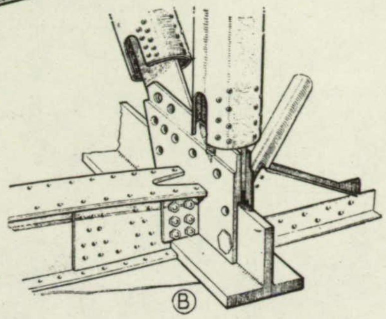


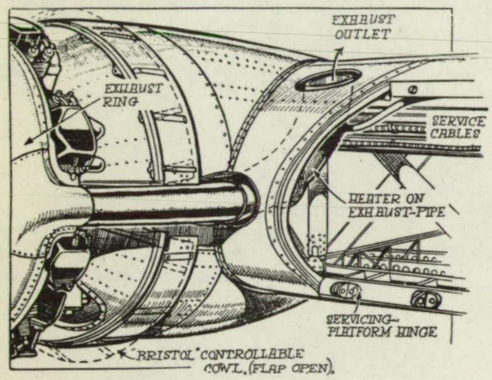
From Flight

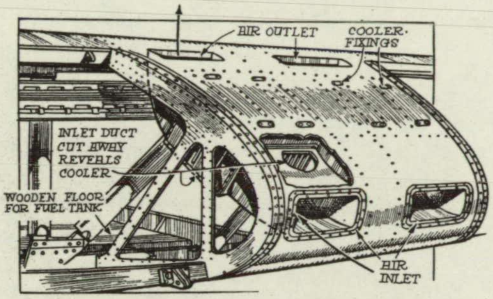
Figure 6.











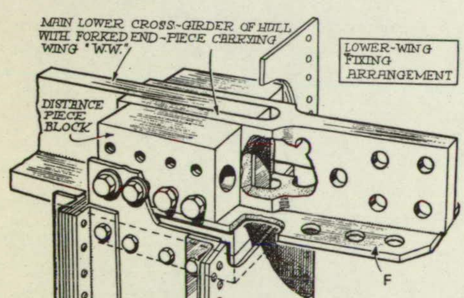
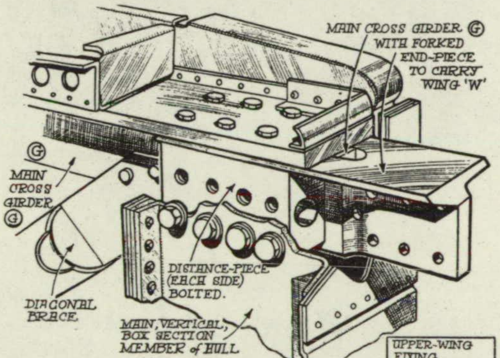
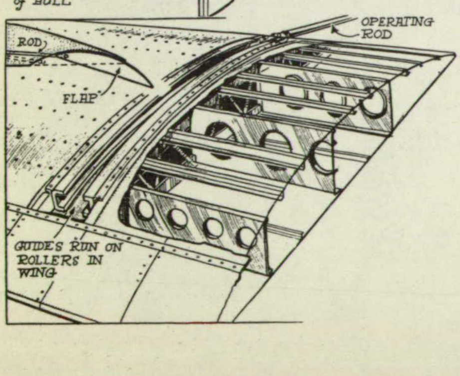
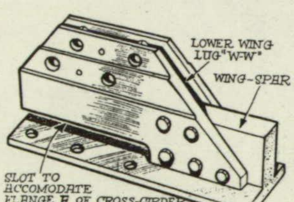


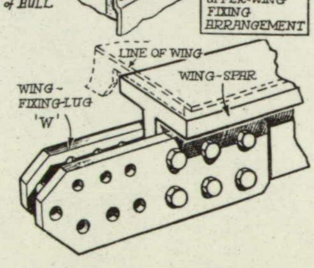
Figure 7.

From "The Aeroplane"









Figures 6 and 7.- Details and assembly of portions of wing structure of the Empire flying boat.

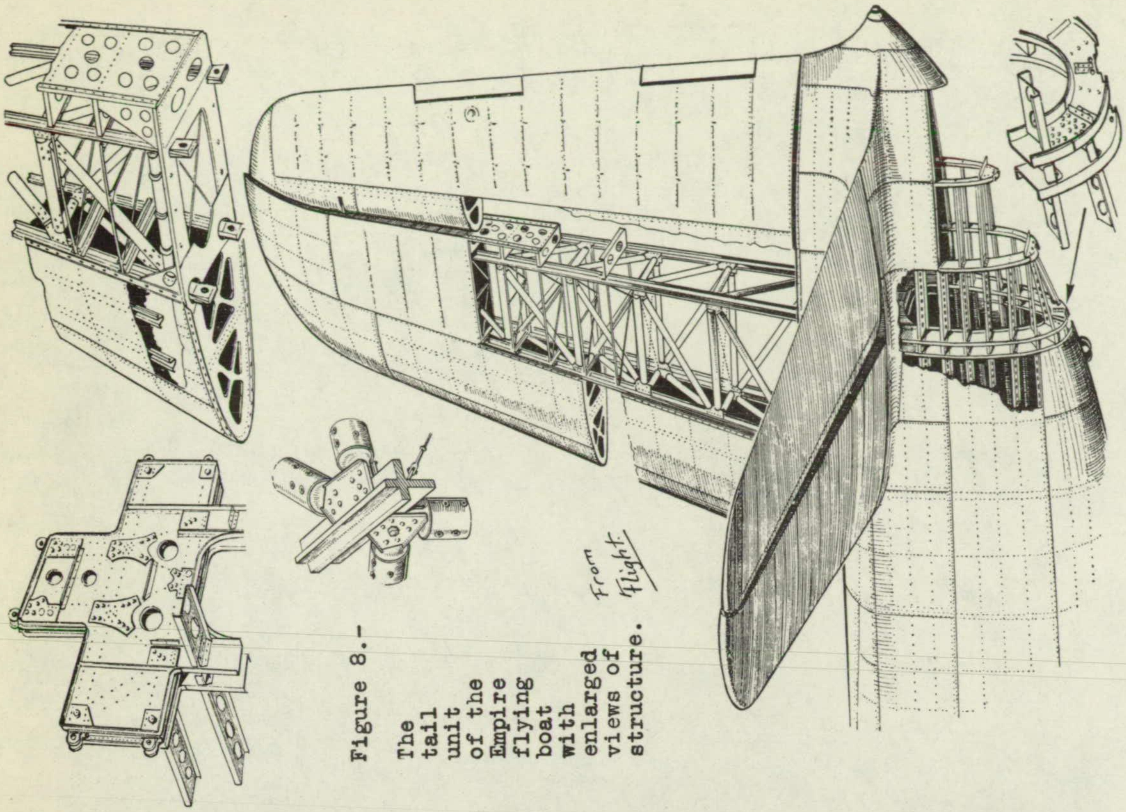


Figure 8.- The tail unit of the Empire flying boat with enlarged views of structure.

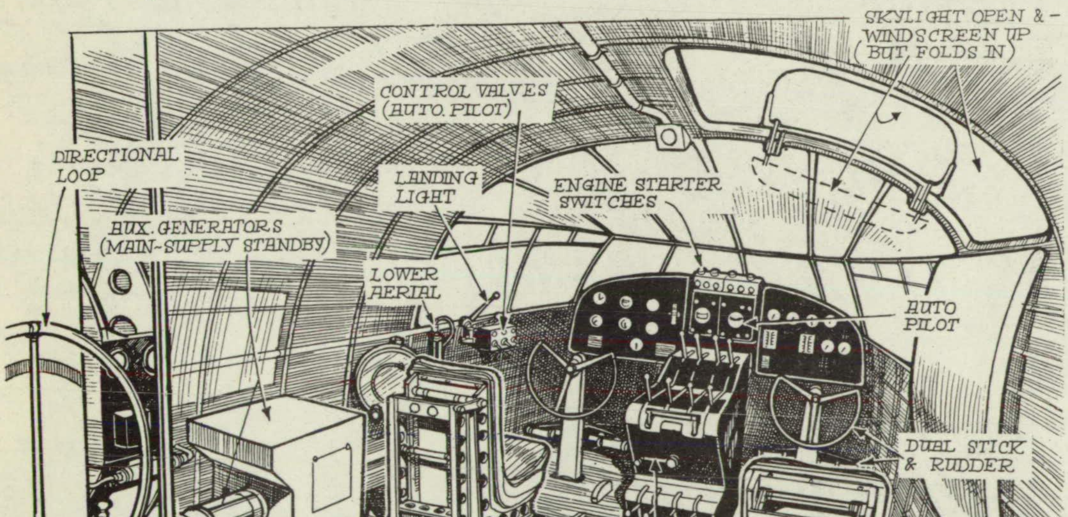


Figure 15.- The Pilots' cabin or the "Captains Bridge" on the Empire

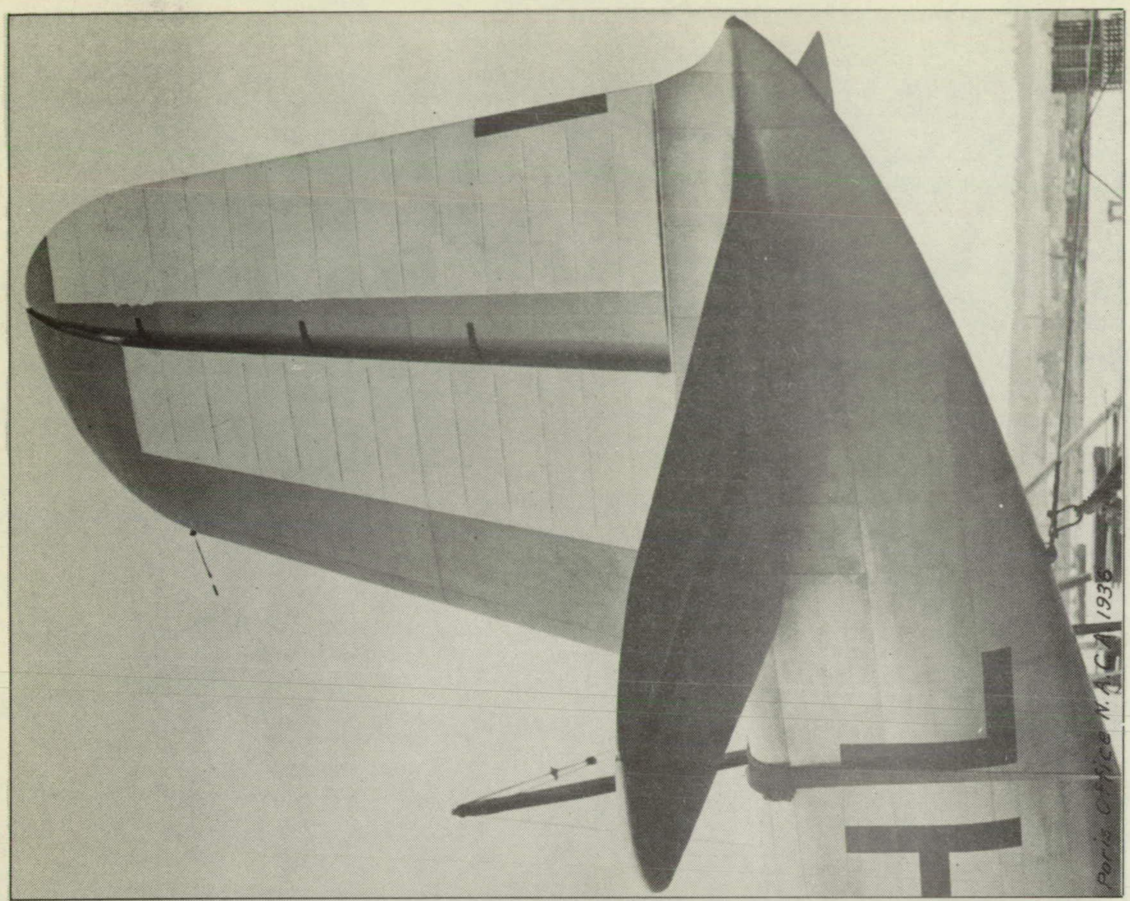


Figure 9.- Tail of Short Empire Boat.

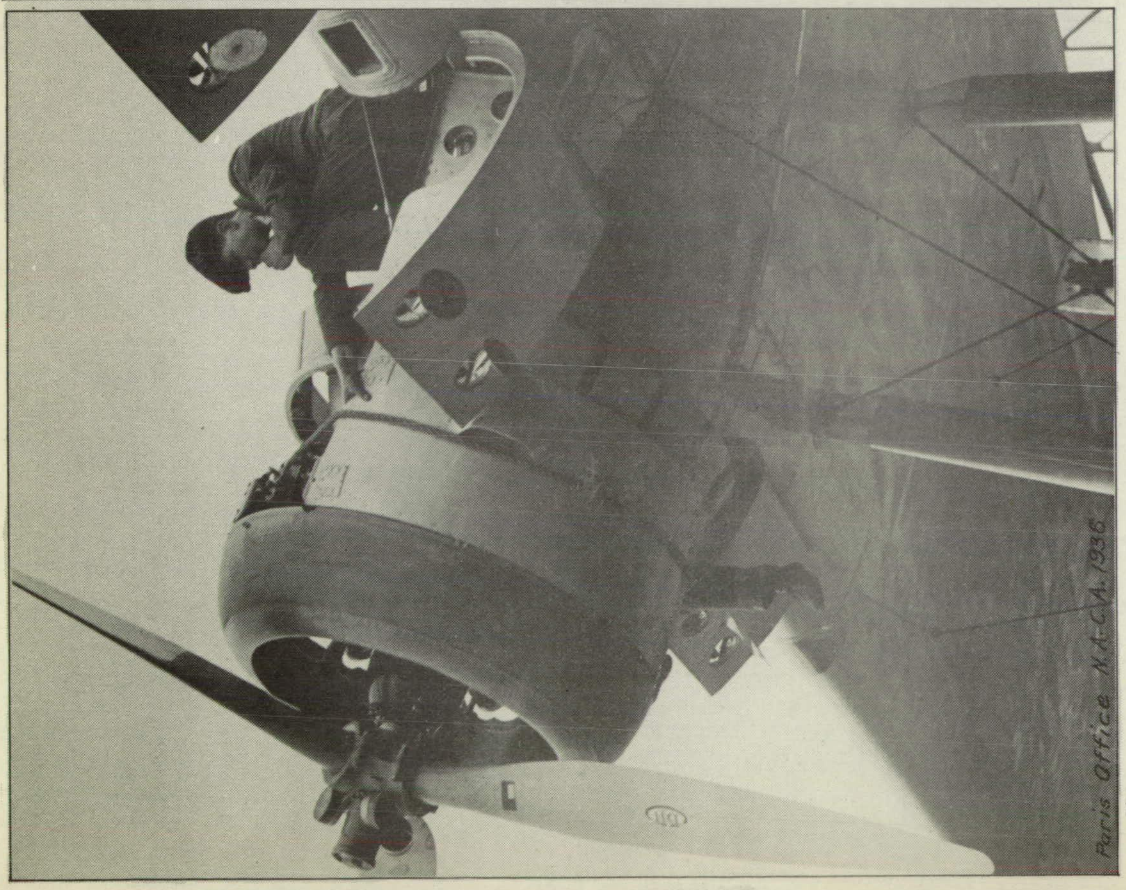


Figure 14.- Engine mechanic's platform on Short Empire Boat.

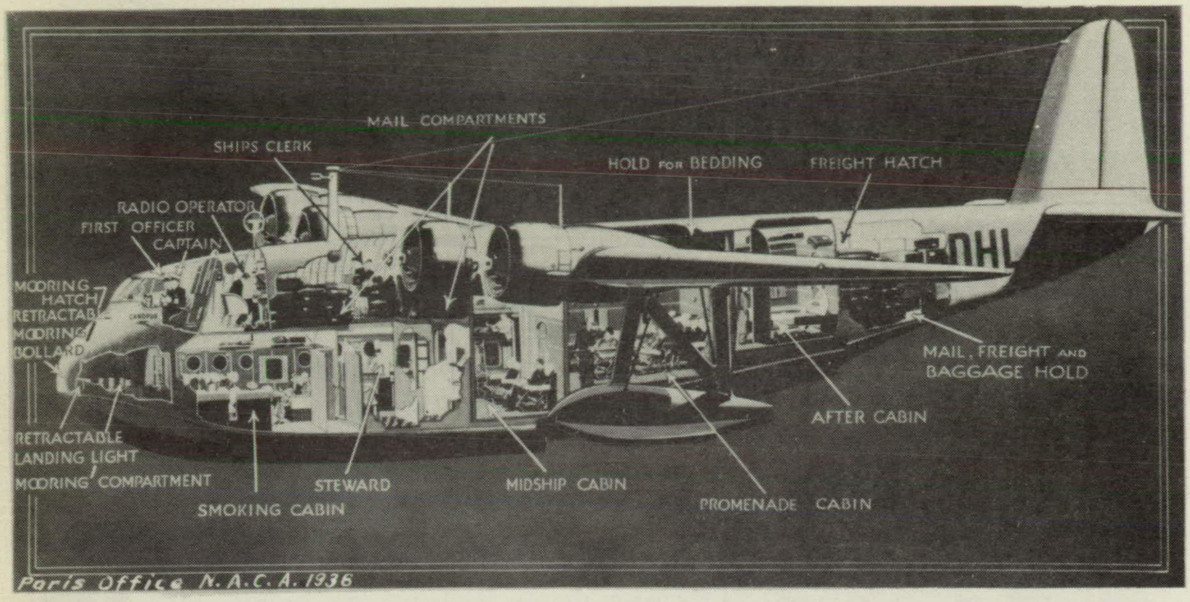


Figure 10.- Short Empire Boat (internal arrangements)

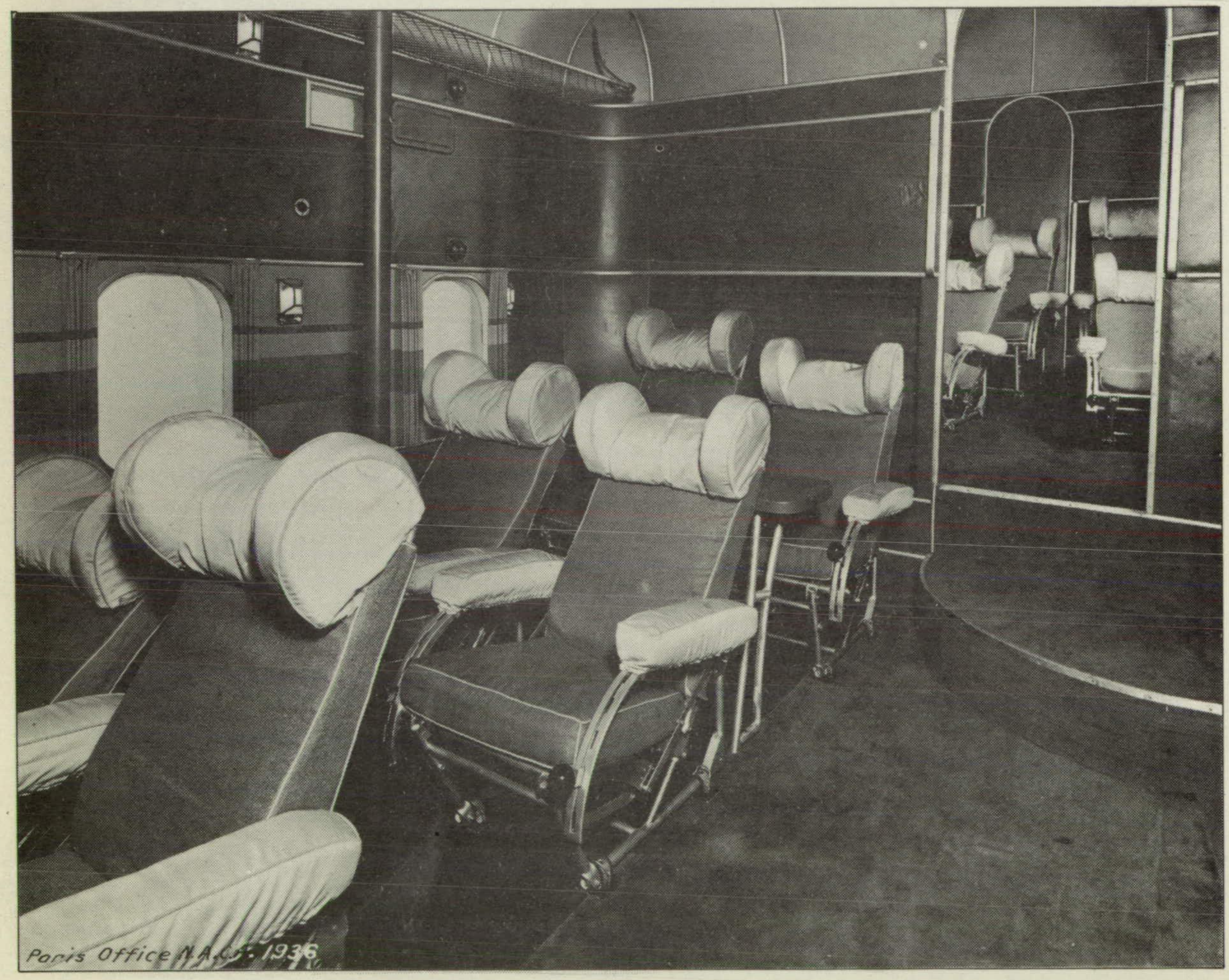
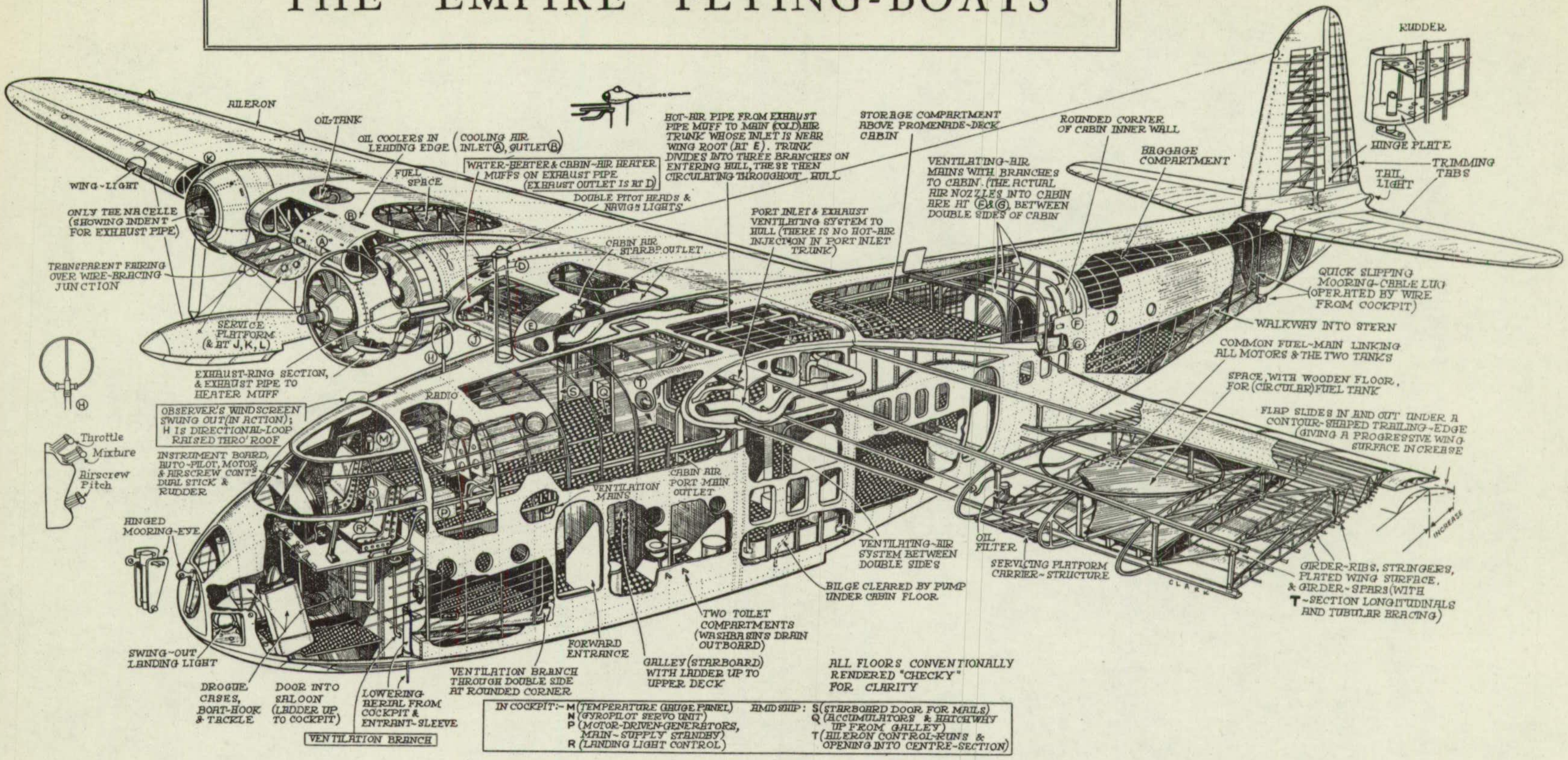


Figure 12.- Short Empire Boat.
View of "Promenade" cabin in mock up.

OCTOBER 28, 1936

THE AEROPLANE

THE EMPIRE FLYING-BOATS



A sectioned view of one of the thirty twenty-ton flying boats which are to be built by Short Bros. (Bedford and Rochester) Ltd., for Imperial Airways Ltd., to be used on the British Empire Air Routes, from England to Australia and on to New Zealand, from England to South Africa and possibly from England to Canada and the United States. Two were already flying at the end of October 1936.

From "The Aeroplane"

Figure.-11

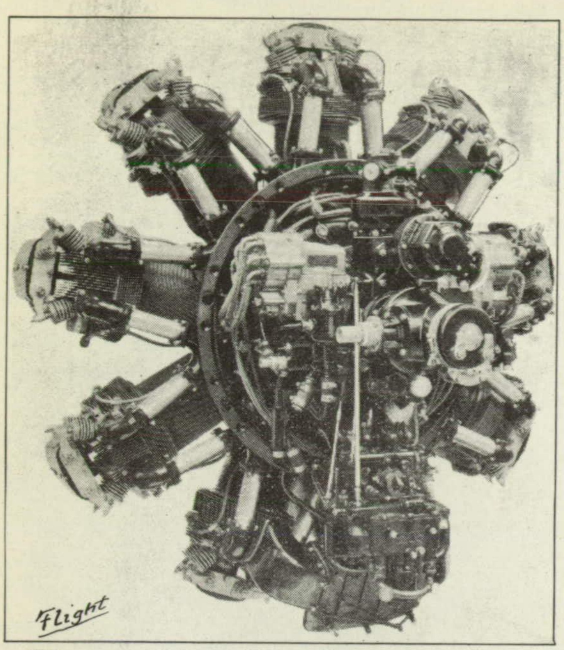


Figure 13.- The Pegasus Xc radial engine. More than 3600 hp. is delivered by four of these engines, to the finely pitched blades of the D.H. variable-pitch propeller, in the take-off.

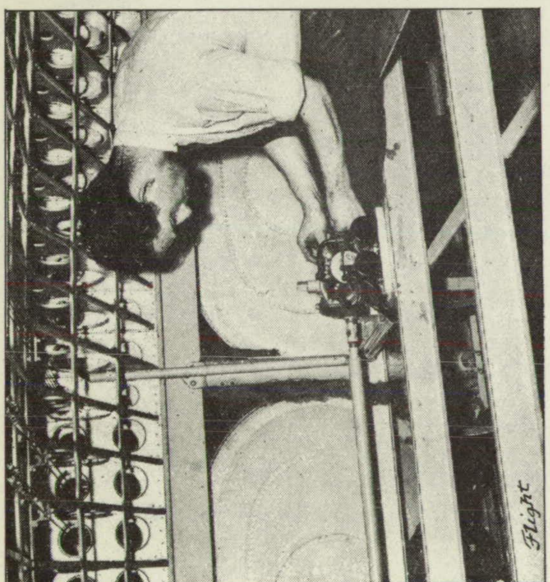
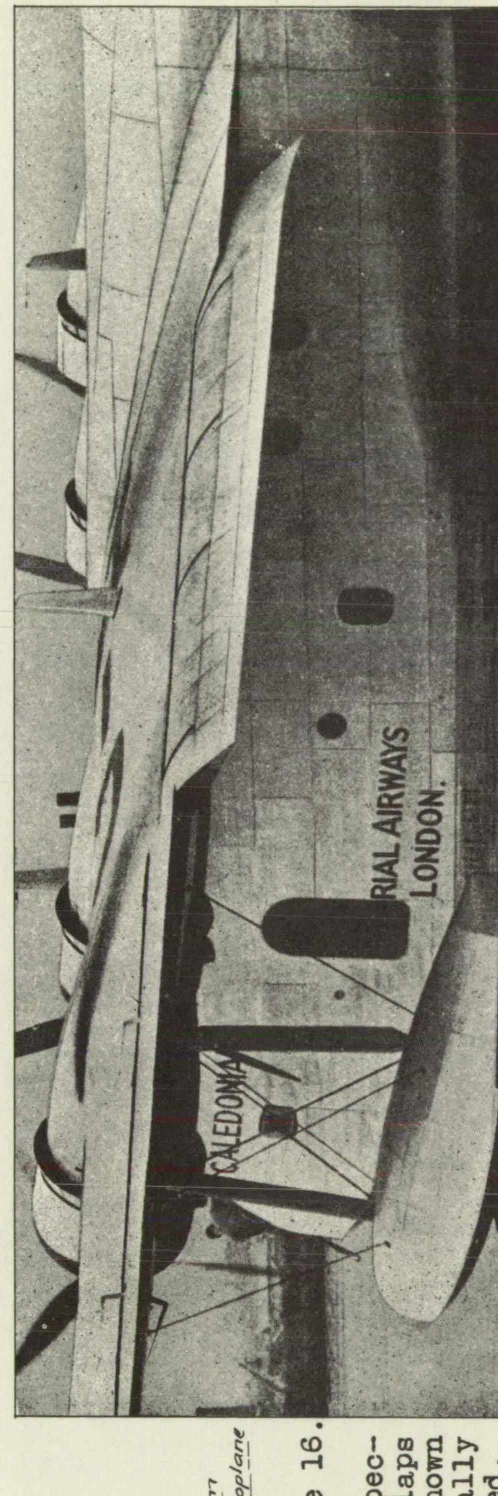


Figure 17.- This little Rotax electric motor operates the great flaps of the Empire boat.



From The Aeroplane

Figure 16.

The special flaps are shown partially lowered. They increase the lift by about 30 per cent and reduce the landing speed from 10 to 12 m.p.h.