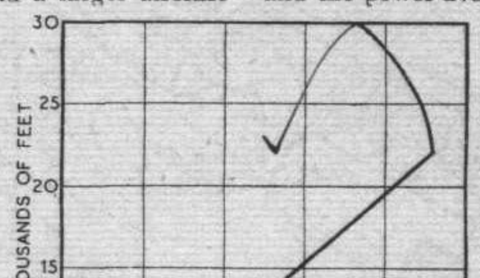
D.H. photo.
DH 1933B.

The D.H. Hornet

An Outstanding Two-engined Fighter: Combination of Wood and Metal Construction: Compact Installation of Merlin 130 and 131 Engines : The Sea Hornet

IN view of the outstanding popularity and success of the Mosquito on its many wartime duties, it is logical that the production of both a smaller and a larger aircraft of similar design should have been considered by the de Havilland company. The larger project, the DH 102, has not been followed up, but the smaller version, the DH 103, now known as the Hornet, has already shown itself to be a very worthy offspring of the Mosquito. This outstanding two-engined fighter was to some extent built around its Rolls-Royce Merlin engines, and although it was not planned to meet any specification existing at that time there was a clear conception of the duties it was to perform and the performance expected. Briefly, a fighter was envisaged which would have speed, climb and manœuvrability rather better than other comparable aircraft, and a range in excess of all.

For a number of reasons a two-engined design was demanded, and an aircraft of similar layout to the Mosquito was agreed upon. The size was determined as the minimum reasonably required to house the engines. Some weeks before the Hornet was conceived, the Rolls-Royce company had suggested the Merlin 130, the most recent addition to their range, as replacement engines in the latest marks of Mosquito. The 130 lent itself to exceptionally close cowling, and the power available at all altitudes from this "Schneiderised" engine showed considerable improvement over earlier marks of Merlin. (A full description of this series of Merlins is given on pp. 92-94.)

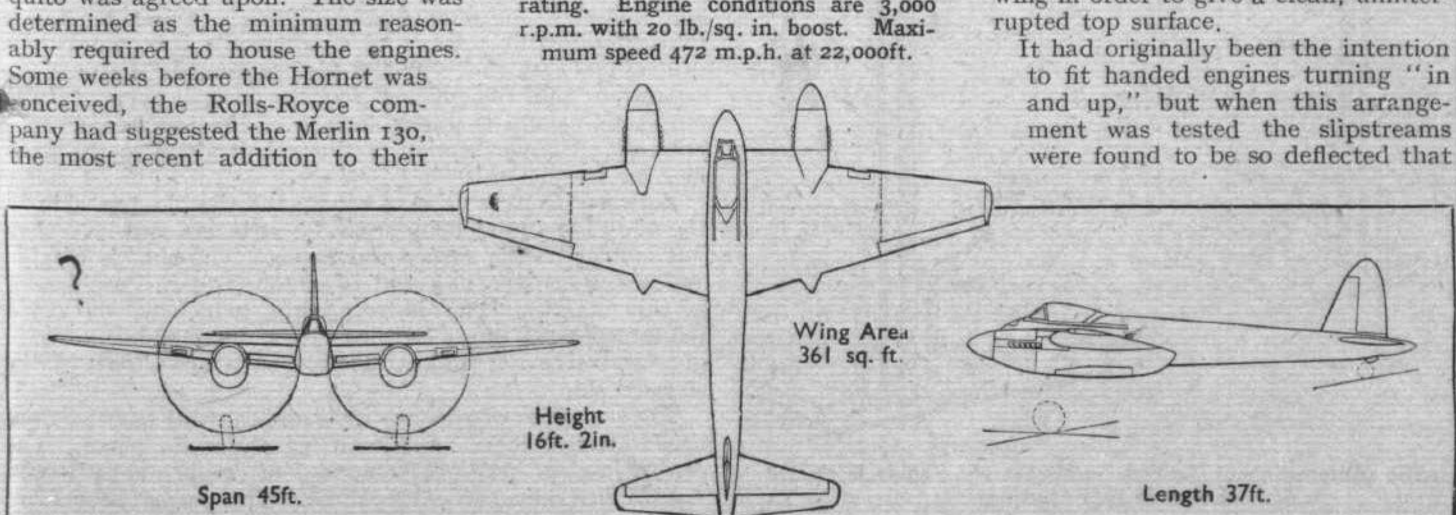


Variation of true air speed with altitude for a Hornet carrying no external tanks or armament and using combat power rating. Engine conditions are 3,000 r.p.m. with 20 lb./sq. in. boost. Maximum speed 472 m.p.h. at 22,000ft.

In determining the acceptable wing loading, it was borne in mind that fully loaded Mosquitos on night operations flew without undue trouble at a wing loading of 42 lb./sq. in., and a slightly larger figure was finally applied to the Hornet.

To obtain the lightest and most compact engine installations possible, main radiators, intercooler radiators and the supercharger air intakes are all placed in the leading edges of the main planes. To minimise moment the engines are as close inboard as airscrew clearance permits, and for the same reason they are backed tight up against the bulkheads, which are themselves level with the front spar. The installation is also very low in the wing in order to give a clean, uninterrupted top surface.

It had originally been the intention to fit handed engines turning "in and up," but when this arrangement was tested the slipstreams were found to be so deflected that



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the tail control surfaces were ineffective on take-off speeds under 80 m.p.h. While there was no inherent tendency to swing on take-off or even a likelihood of it with this arrangement, the possibility of the aircraft being deflected from its course by an external influence, and the subsequent difficulty in correcting, could not be overlooked. Handed engines turning "down and in" were, therefore, fitted, and, although the stabilising effect of the arrangement was lost, directional control on take-off and landing was satisfactory.

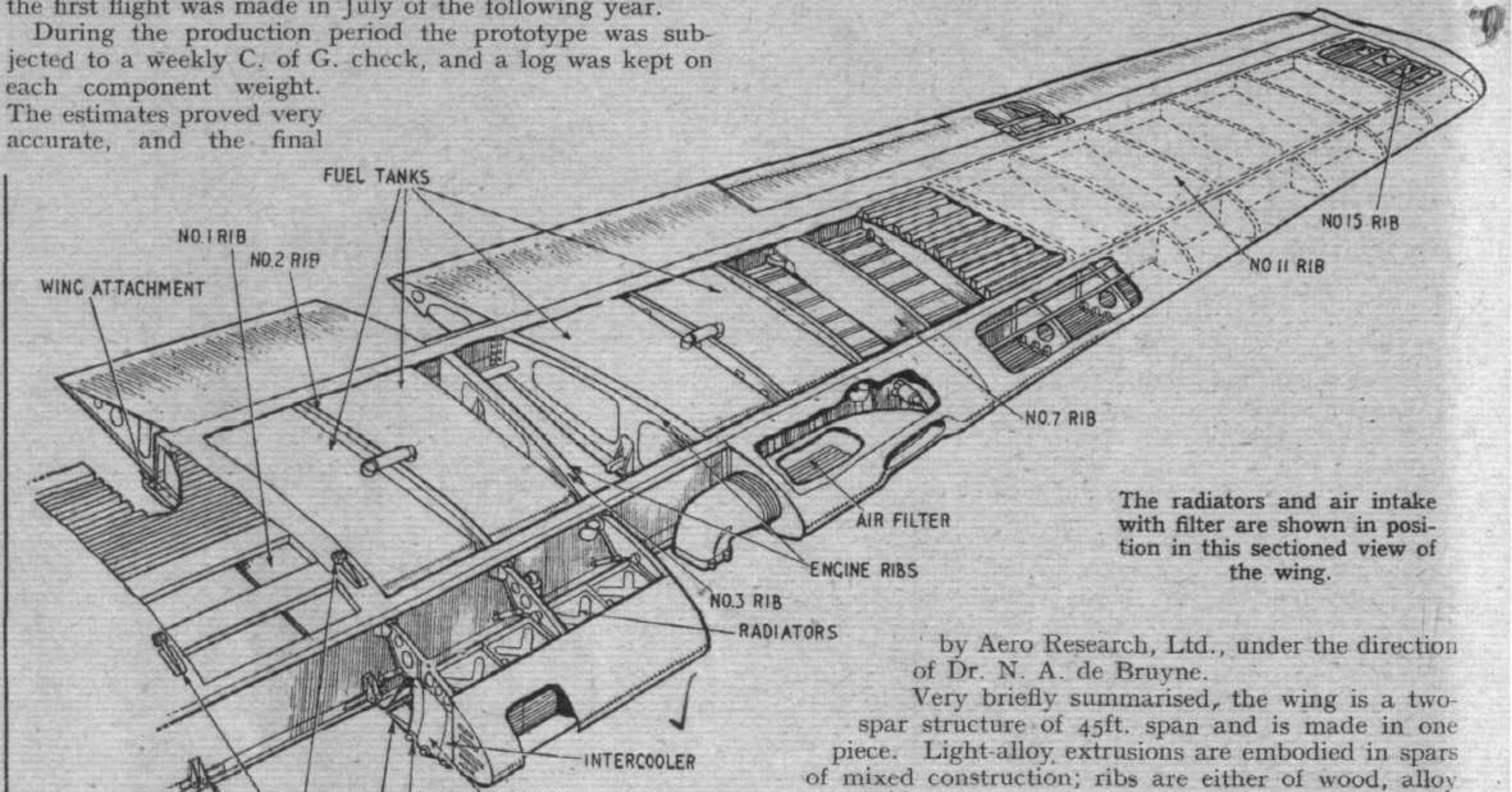
There was a considerable delay after the mock-up stage was reached on the prototype Hornet, but once approval was given (in August, 1943) work went ahead rapidly, and the first flight was made in July of the following year.

During the production period the prototype was subjected to a weekly C. of G. check, and a log was kept on each component weight. The estimates proved very accurate, and the final weight was within 200 lb. and, unusually, on the right side!

In view of the high performance expected of the Hornet, it was apparent that a safety factor of ten would be required, so while the Mosquito type of construction was quite suitable for the fuselage, the wing called for different treatment.

The N.P.L. were behind the design for the wing section, which is similar to that of the Vampire, but with rather less camber. It is understood to have proved satisfactory up to very high diving speeds, with Mach numbers in the region of 0.78 at altitudes and 0.72 lower down.

In a wing of reasonable depth, it was not possible to obtain the requisite strength and rigidity from all-wood construction, and it is in the ingenious combination of wood and metal in the design of the Hornet wing that the main structural interest lies. Wide use is made of the Redux bonding process introduced some three years ago by Aero Research, Ltd., under the direction of Dr. N. A. de Bruyne.



The radiators and air intake with filter are shown in position in this sectioned view of the wing.

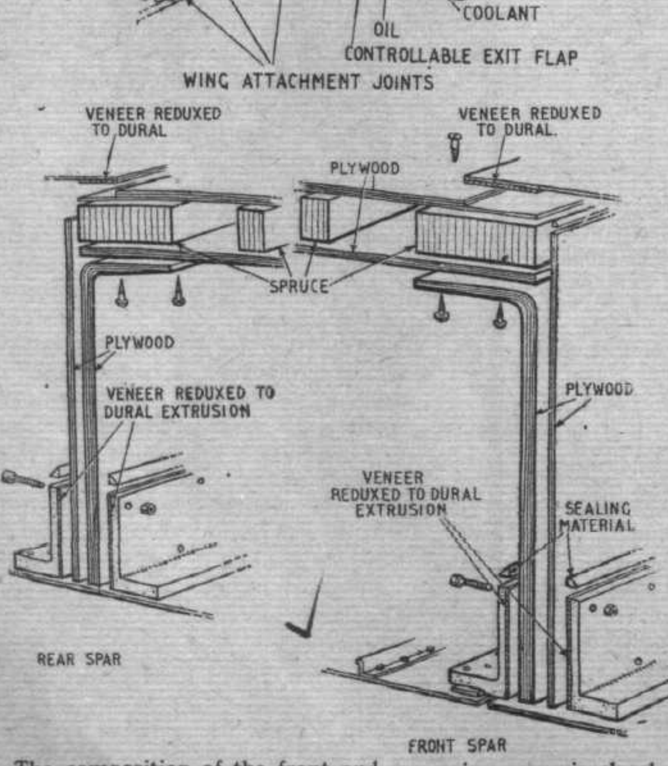
Very briefly summarised, the wing is a two-spar structure of 45ft. span and is made in one piece. Light-alloy extrusions are embodied in spars of mixed construction; ribs are either of wood, alloy or a mixture of the two, and the skin is a wood sandwich on top and metal below. In the main, wood is used in compression and shear, and metal in tension.

Wood and Duralumin

The lower booms of the spars are dural extrusions, the top booms are of spruce and the webs compressed plywood. Details of construction are shown in the illustrations. It will be seen that the bottom boom comprises two duralumin right-angle extrusions to each of which is bonded a wood veneer. The two are cold-glued and bolted to the compressed ply web, and the joint is finished off with a layer of Chatterton's compound as a protection. At the top, the ply veneers of the web are separated and the thicker section curved over at right angles to meet the under surface of the top boom. The remaining thinner section of the web is glued to the front face of the boom.

Between front and rear spars, the double top skin of the wing is reinforced by spanwise stringers narrower than but similar to the spruce top boom. The skin is of glue and screw construction and is attached to the top booms in this manner. The bottom skin, which is of alclad reinforced with dural stringers, has detachable panels to give access to the tanks. These panels are a part of the stressed skin.

Various types of ribs are used and, as will be seen from the drawings, there are fifteen in each main plane. The centre fuselage pair are composed of compressed plywood sandwiched between alloy sheet. The lower booms are duralumin extrusions of inverted "T" section, the upright

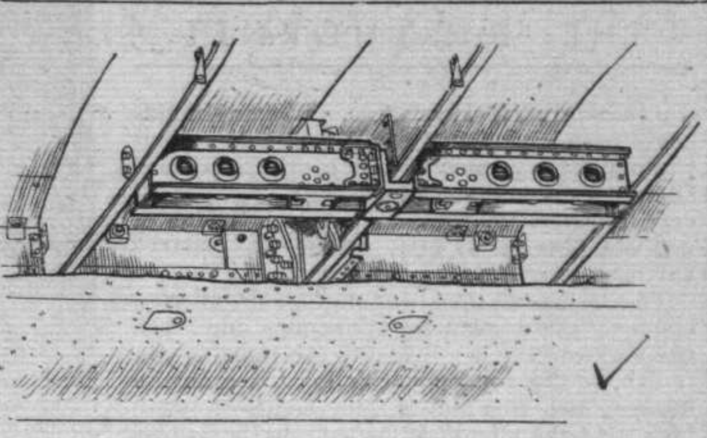


The composition of the front and rear wing spars is clearly shown in this drawing.

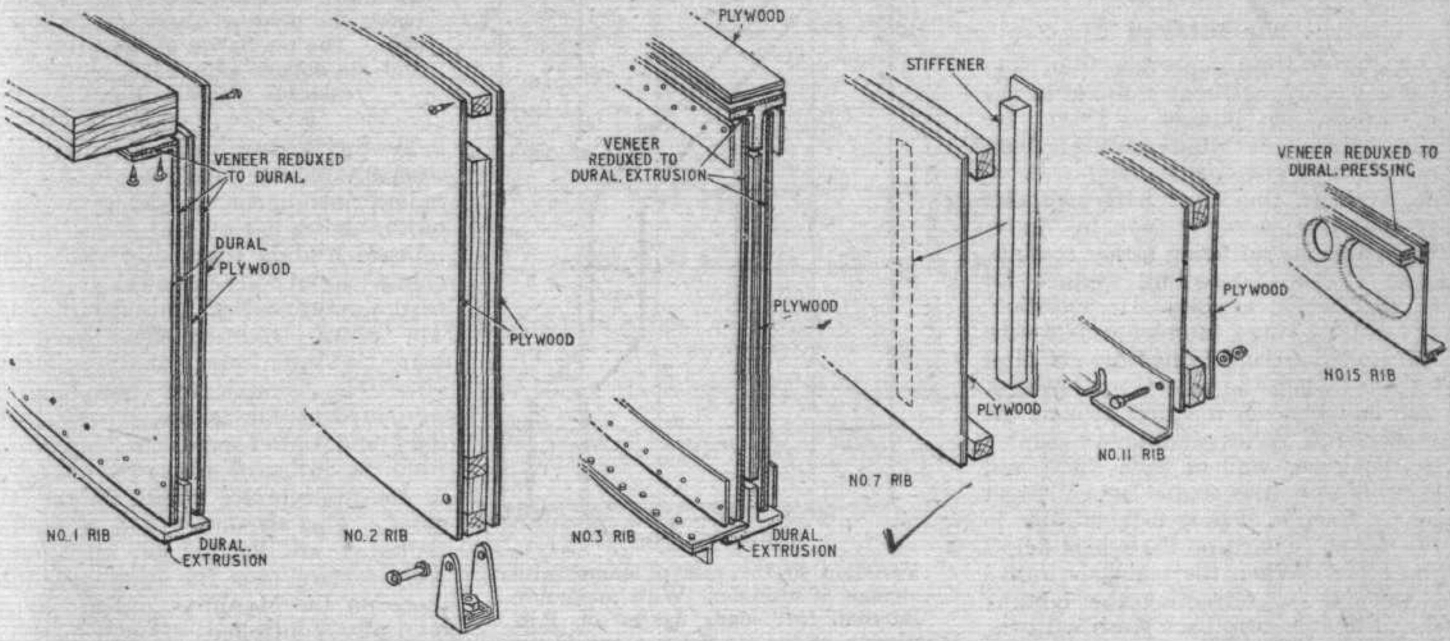
limb being riveted between the alloy sheets of the web, which overlap the edge of the plywood for this purpose. The top boom is of spruce, glued and screwed like the main spar. Number six ribs are a scaled-down version of the number ones. Numbers two, five, seven and eleven ribs are each built up from plywood sheet screwed and glued to spruce frames. Two and five carry pick-up fittings for the tank doors, while seven and eleven have metal flanges.

Metal-clad

The engine ribs, numbers three and four, are alloy/ply/alloy sandwiches rather similar to the fuselage ribs but having "T" section extrusions for both top and bottom booms. The top skin is glued to the top booms after a thin veneer has been Reduxed to them. With the exception of number fifteen, which is an all-metal pressing, the remaining ribs are built up with single plywood webs screwed and glued to spruce booms.



An example of inter-rib strengthening members in the wing for attachment of drop tanks or R.P. gear.



Details of rib construction can be followed in conjunction with the illustration on the facing page.

To ensure a smooth surface and torsional stiffness in the wing, the leading edges are of all-metal construction. Except for their attachment by Reduxing to the top of the front spar they are quite conventional. The attachment and construction of the all-metal flap and aileron shrouds is similar to that of the leading edge.

Six main bolts and fittings attach the wing to the fuselage and, like the Mosquito, the Hornet has a balsa-ply sandwich fuselage made in halves split vertically. Small differences are the use of a thinner balsa core to the sandwich, which saves about one-third of balsa weight, and the use of duralumin strengthening plates on the fuselage walls for the attachment of equipment and the like. On the Mosquito, plastic plates or attachment ferrules are generally used, and bolt holes are necessarily wide apart to prevent splitting. By the use of Redux bonding, small metal plates can be substituted for the plastic ones with considerable advantage. On the underside of the fuselage just aft of the rear spar is a hatch giving access to equipment and control cables.

PRINCIPAL DATA AND PERFORMANCE FIGURES

Engines.	R.R. Merlins 130 (R.H. port) 131 (L.H. starboard).
Airscrews.	D.H. Narrow, 4-blade, 12ft. diameter.
Wing span	45ft.
" area	361 sq. ft.
" loading	44.5ft.
Length	37ft.
Height—tail up	16ft. 2in.
" tail down	14ft. 2in.
Tail span	18ft. 1½in.
Max. speed	473 m.p.h. at 22,000ft.
" range	2,900 miles.
" climb	4,000ft./min. to 15,000ft.
Operational ceiling	35,000ft.

Type	Condition	Weight lb.	Total fuel capacity gal.
Fighter	Short-range Long-range	16,100 20,900	358 928
Photographic Reconnaissance	Short-range Long-range	15,900 20,200	418 928

The Tail

The tailplane is of conventional two-spar all-metal construction, with ribs from the rubber press. By virtue of its attachment it is adjustable for rigging, two turnbuckle-type fittings being incorporated. Later marks of Hornet have two extra ribs in the tailplane, with a corresponding increase in span. This modification followed the adoption of "down and in" airscrew rotation and to some extent offsets the de-stabilising effect of this arrangement. The area of the horn balances was also slightly increased.

The tail fin is of all-metal construction and does not call for any special attention. The addition of a fairly long shallow dorsal fairing up to the fin is now under consideration.

All elevator and rudder control mechanisms on the Hornet are placed behind the fin and are exposed for inspection when the tail cone is removed.

Both frame and covering of the main controls are metal, and in each case they are noticeably flat-sided, no doubt to obviate any tendency towards reversal at high altitudes.

DH photo SC. 4-10.

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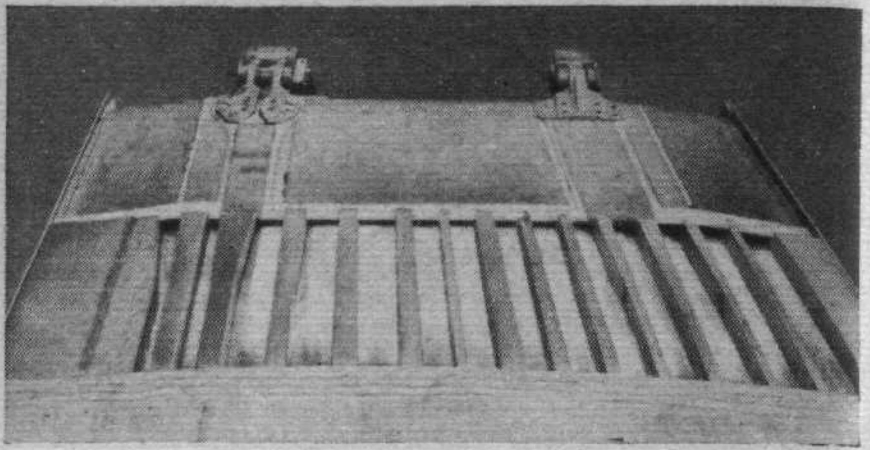
On the Mark III Hornet, the aileron shrouds have been redesigned, and an independent trimming tab is now fitted to the starboard aileron. Aerodynamically the ailerons proved very sensitive to shrouding, and although it was not planned at first, a little nose balance has been provided.

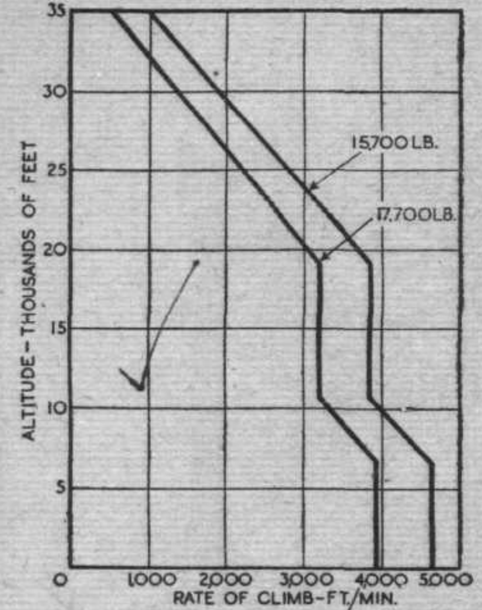
The spring-tab operating unit on the ailerons employs the torsion-bar principle, and until the surface is under load the tab remains stationary. The torsion bar is located spanwise between two ribs and is some eighteen inches long. As the aileron is loaded, the bar winds up until a stop is reached, and from that point the movement of the control is positive.

Air Intakes

An interesting departure from conventional arrangement is found in the induction air intakes. These are situated in the wing leading edges, outboard of the engines, and are connected with the supercharger intakes of the down-draught type by ducts, the whole layout being rather reminiscent of the air-cooling system for Gipsy Twelve engines. In addition, a rotating valve interconnected with the undercarriage brings an air filter into use when the wheels are lowered, that is, whenever the aircraft is on the ground. A Vokes air filter is situated in the lower wall of each duct, and suction from the engine supercharger opens a series of hinged metal gills in the lower surface of the wings below the filter. When the main air intake is opened on retracting the landing gear the gills drop back flush with the wing surface and the filter no longer operates. The layout of the system in the wing is shown in a drawing on a previous page.



The folding wing hinge fittings are bolted to a metal "belt" composed as shown of alloy sheets let in between the plywood sheets of the top skin. The top halves of the stringers and the outside skin have yet to be replaced. See also Fig. C.



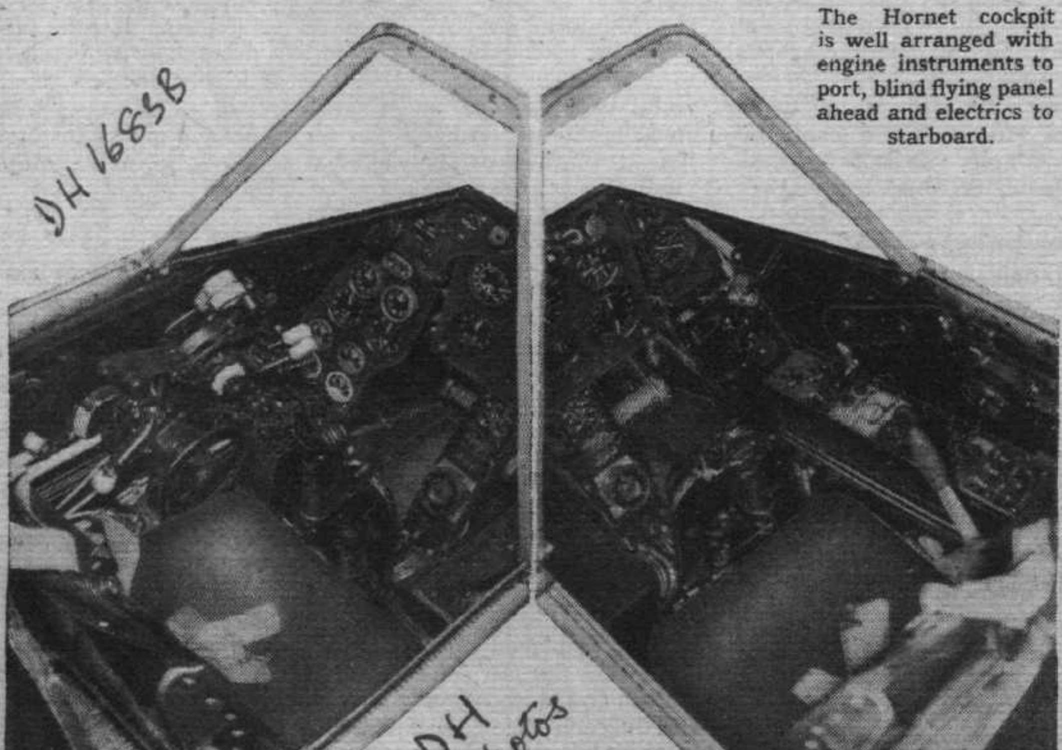
Variation in the rate of climb with change of altitude. With maximum internal fuel load, fighter or P.R. version of the Hornet are capable of averaging 3,500 ft./min. climb to 20,000 ft. at combat rating and more than 4,000 ft./min. in the case of the short-range fighter version.

Another feature making for a clean, compact engine installation is the radiator arrangement. As in the Mosquito, the radiators are placed in the inboard leading edges, but the supercharger intercooler radiators are added to the main coolant and oil radiators. The order, counting from front to rear, is intercooler, main coolant, oil. The complicated plumbing is simplified as far as possible by both inlet and outlet pipes leading direct from the outboard side of the radiators to the appropriate points on the engines. The air outlet flap from the radiators are located on the under wing surface near the front spar like those on the Mosquito and are automatically controlled through part of their travel.

Each main wheel is carried on a single leg sprung by rubber blocks in compression. The retractable tail wheel has rubber compression springing and Ferodo friction disc dampers. Retraction normally takes 7 seconds. In the event of hydraulic pump failure, a hand pump, also an emergency air system, are provided to lower the wheels.

According to duties, whether P.R.U. or standard fighter, up to twelve tanks can be carried, ten being internal and of the self-sealing type. The main tankage comprises two tanks in each main plane, inboard of the engines, and one fuselage tank behind and below the pilot. To these basic five can be added another fuselage tank, four more wing tanks in pairs, outboard of each engine, and two drop tanks of either 100 or 200 gallons capacity.

All tanks feed to the common central fuel gallery, and either engine separately may



The Hornet cockpit is well arranged with engine instruments to port, blind flying panel ahead and electrics to starboard.

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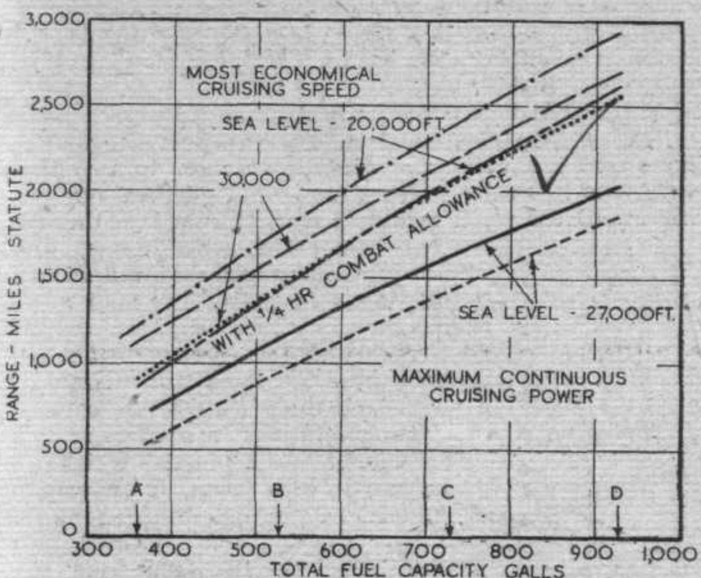
be isolated from the fuel system. The pneumatically operated balance-cock is spring-loaded for opening in the event of pneumatic failure.

Of the two Merlin engines, the 130 has right-hand rotation and the 131 left, the difference being achieved simply by the introduction of an idler gear in the reduction gear assembly. The engine bearers have a four-point attachment at the bulkhead and are of a new D.H. design. The cowling is quickly detachable, and large over-centre catches are used in place of the normal screw fasteners both on these and the cannon inspection panels.

Cable operation is employed for the engine controls, and



The six curves represent from top to bottom :—One and two, the most economical cruising range from sea level to 20,000ft. and at 30,000ft. respectively ; three and four (dotted), the same, but with allowance for ¼-hr. combat at the altitude ; five, the maximum continuous cruising range from sea level to 27,000ft., and six the same with ¼-hr. combat allowance. Letters A, B, C and D indicate respectively the following fuel loads :—Standard, maximum internal, maximum internal plus 100 gall. drop tanks, maximum possible, including 200 gall. drop tanks.

A hold back snap coupling is provided on the Sea Hornet in connection with accelerated take off. The tongue is here seen attached to lugs on the tailwheel compression leg.

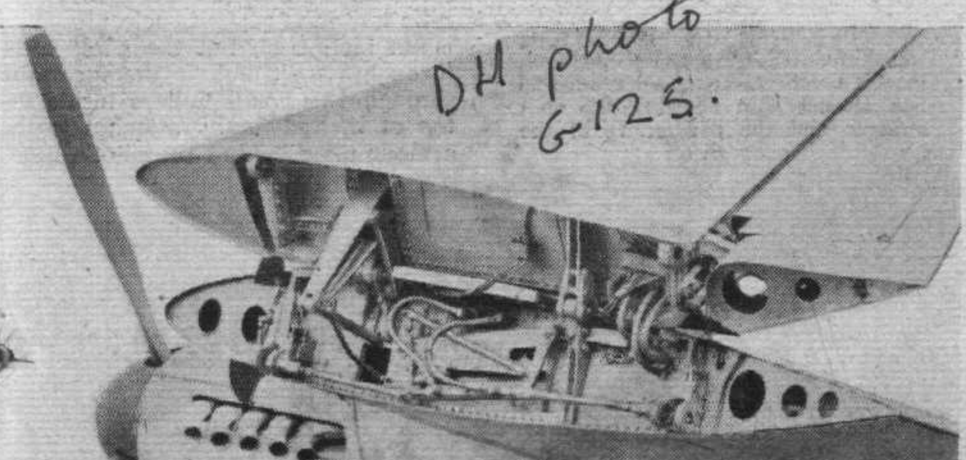
the throttle lever has a 50 per cent. increase in travel over that of the Mosquito. This will give the finer movement required to meet the 100 per cent increase in engine power over early Merlins and will make for easier movement, over-stiff throttles being a slight fault of most Mosquitos.

The Cockpit and Visibility

Very properly the cockpit has received a great deal of attention, and the aim of first-class view has been achieved. For long-range work a pilot must not be at all cramped for space. On the other hand, for low weight and good performance, minimum dimensions are essential. The Hornet cockpit seems to be a fair compromise. Although the screen is made in three panels, the joints are so arranged optically that the frame member at the joint cannot be seen from inside the cockpit, and view appears to be continuous. In fact, a thin strip, about half an inch wide, is lost to view at each joint of the front panel, but as these strips are parallel-sided there is no increased loss due to divergent lines of vision, as is usually the case with frame members. The cockpit enclosure is a single transparent moulding which will slide far back down the fuselage to give access to equipment and ammunition boxes located behind the pilot's seat. A chain-and-crank mechanism is employed to open or shut the enclosure.

Adjustment for both height and tilt is provided on the pilot's seat, and pedal-length adjustment is similar to that of the Mosquito. No anti-"g" pedals are provided, but the normal position is high with this purpose in mind.

The Hornet carries four 20 mm. cannons grouped in the lower part of the fuselage nose, to which access is given by two large detachable panels. Full armour protection is provided, and two 1,000 lb. bombs and four rocket projectiles, all carried beneath the wings, complete the Hornet's complement in this section.



The folded Sea Hornet wing. The main locking mechanism may be seen between the inboard spars and attention is drawn to the linkage between the folding jack and outer wing. Note also the two "flags" protruding above and below the wing at the front spar and indicating the withdrawal of the small mechanically operated locking pins.

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Manufacture of the Sea Hornet and all associated drawing-office work are the job of the Heston Aircraft Company. While this separation of parent and child is far from an ideal arrangement, good co-operation and understanding, particularly between the two design staffs, has enabled work to progress satisfactorily. Main units are sent dry-screwed as required, from Hatfield to Heston, where modification and final assembly take place.

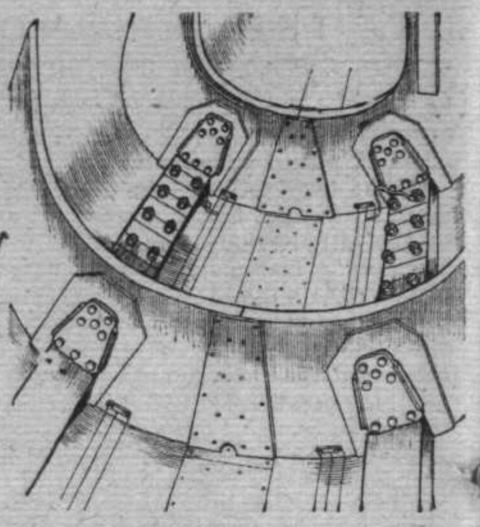
Navalising the Hornet

In addition to the folding wings, the Sea Hornet is equipped with arrester and accelerator gear, and these two call for major modifications to the fuselage unit.

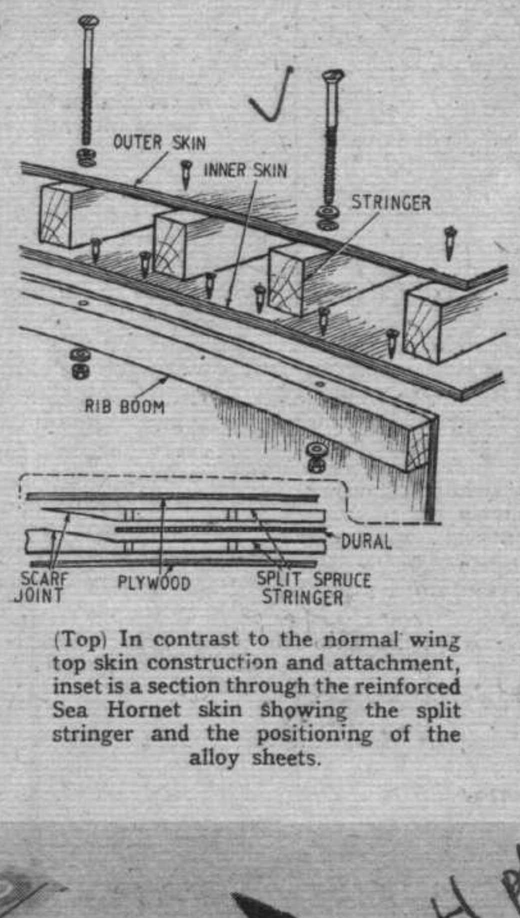
A property of the normal Hornet wing is the even distribution of load throughout the frame members and skin. In direct contrast to this, the load for the folding wing must be concentrated at the hinge point and then redistributed through the outer and inner wing sections. This is achieved by increasing the number of spanwise stringers, particularly in the region of the front spar, by reinforcing the spar webs (this is inherent strengthening in view of the joint fittings) and by inserting sections of dural sheet between the plywood sheets of the top skin near the wing joint. This metal "belt" is actually inserted between the stringers, which are split horizontally to receive it. The sheets are Reduxed to the wood, and the separated part of the stringers replaced and scarf-jointed outboard of the alloy sheets. Bolts are then put through the reinforced skin in place of screws.

The number seven ribs of the original wing would lie at the folding point, but are removed in favour of two new reinforced metal ribs, 7 and 7a, which carry the joint fittings for their respective sections.

Two separate levers in the cockpit operate the folding mechanism. Small locking pins must first be withdrawn mechanically by moving one control; then the second brings the Lockheed hydraulic jacks into operation through a sequence valve, the main bolts being withdrawn first and the folding commencing afterwards. A small flag on each wing shows at once if the mechanical locks are withdrawn. The wings can be folded in five seconds or spread in twelve. They can be spread with a 1,000 lb. bomb in position, can be folded separately, and may be stopped at any position desired.



Inside the Sea Hornet fuselage, two modified bulkheads are seen, also part of the longeron reinforcements to which (on the outside) are bolted the arrester hook attachment fittings.



(Top) In contrast to the normal wing top skin construction and attachment, inset is a section through the reinforced Sea Hornet skin showing the split stringer and the positioning of the alloy sheets.

The arrester hook is attached at two points to the fuselage, and the fittings are bolted through to two heavy longerons ironically called "straights." These long curving laminated wood members reach forward to the lower rear wing-attachment fittings, which are of steel in place of the standard duralumin forgings. The hook attachment fittings are also screwed and Reduxed to the fuselage. The steel hook itself is coated with Colmony to withstand the sawing of the cable.

Three fittings comprise the accelerator attachments which can be used with twin, close-twin or American-type single-track equipment. Two large hooks are located below and bolted to the front-wing spars beside the attachment points, and the snap coupling is attached to lugs which are a part of a saddle-like addition to the tail-wheel compression leg. A modification which may be adopted on all Hornets is the provision for slinging, the pick-up points being on the inboard engine ribs.

It will be noticed that the external aerial on the Hornet appears to stretch from tail fin to cockpit enclosure. This is, in fact, true, but the wire passes through a small hole in the enclosure, through two small pulleys inside the top of it, and finally attaches to the armour plate behind the pilot's head.

The Sea Hornet with wings folded and arrester hook slung under the fuselage. The wing-folding modification has added 280 lb. to the total weight and the entire "navalising" including equipment, 550 lb.