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SUPERMARINE S.5 SEAPLANE (BRITISH)  
Winner of the 1927 Schneider Cup Race

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

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SUPERMARINE S.5 SEAPLANE (BRITISH)\*

Winner of the 1927 Schneider Cup Race.

As the winner of the 1927 race for the Schneider Seaplane Trophy, and as a potential holder of the world's speed record in the near future, the Supermarine S.5 with Napier "Lion" racing engine is one of the most interesting of modern British aircraft, and it is with a good deal of satisfaction that we are able to place before our readers some particulars and a number of illustrations of its more interesting features. In his paper read recently before the R.Ae.S. & I.Ae.E., Mr. R. J. Mitchell, chief engineer of the Supermarine Aviation Works, gave certain very interesting figures relating to the S.5, but owing to the fact that the results of wind tunnel tests could not be published, much information which would have been extremely interesting had to be withheld. Nor are we, for obvious reasons, in a position to give these here. For instance, the proportion of the total drag represented by the fuselage, the floats, the float struts, and the wings. But in the absence of such information it is permissible to speculate a little and to attempt to form, from other sources, an idea of the efficiency of a seaplane like the S.5. Probably the "Everling Quantities"\*\*\* afford the simplest

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\*From "Flight," February 16, 1928.

\*\*See "The Aircraft Engineer" (Technical Supplement to "Flight"), November 25, 1926, and February 24, 1927.

available means of doing this, and of the three "Everling Quantities" it is, in this case, particularly the "High-speed Figure" in which we are interested. In his article, Professor Everling arrived at a value of the "High-speed Figure" of 40 as a sort of theoretical maximum or "ideal," and pointed out that actual seaplanes never attained this, but generally reached a value of about half of the "ideal." The Everling formula for "High-speed Figure" is, for ground level flight such as would apply to a racing seaplane like the S.5

$$\frac{\eta}{C_w} = \frac{V^3 \times F}{56,000 \times N}$$

where  $\eta$  is the propeller efficiency,  $C_w$  the drag coefficient,  $V$  the speed in km/hour,  $F$  the wing area in square meters and  $N$  the brake horsepower of the engine. The brake horsepower of the Napier engine may be assumed to be 875 HP. The wing area of the S.5 is 115 sq.ft. = 10.68 sq.m, and if we assume a top speed of 300 M.P.H. (484 km/h), a figure which is probably somewhere very near the actual speed on a straight-line course without previous diving, we obtain a value of the "High-speed Figure" of

$$\frac{484^3 \times 10.68}{56,000 \times 875} = 24.8.$$

This figure, of course, represents propeller efficiency divided by drag coefficient, and in the absence of accurate information concerning the sort of efficiencies that obtain in the actual seaplane we are again compelled to make the best guess we

can. Probably 80 per cent would be somewhere near the mark, and if this is assumed as the value of  $\eta$ , the drag coefficient of the whole seaplane at top speed is 0.032. As the German coefficients are twice the value of ours, we obtain a drag coefficient, in British "absolute" units, of 0.016. Admittedly we have had to "guess" several of the figures upon which this value is based, but probably it is at least approximately correct. When it is remembered that the machine is a seaplane, and that therefore the float landing gear must offer considerably greater drag than a land landing gear, this low value of the drag is very remarkable.

Concerning the features of design which enabled this low drag to be attained, Mr. Mitchell gave in his lecture, previously referred to, the main changes as between the S.4 and the S.5, and the gain in speed which he attributed to the various changes. As these figures were given in "Flight," of February 2, 1928, it is not proposed to repeat them here. Figure 1 will serve to show how small are the frontal areas of fuselage and floats in the S.5, and these and other illustrations give an idea of the care taken in streamlining unavoidable projections, and in fairing the various surfaces into the fuselage. The brief specification at the end of these notes contains the main available data relating to the seaplane, and it is of interest to note that the "Wing Power" is the highest of any plane ever described in "Flight," being no less than 7.6 HP./sq.ft. (81.7 HP./sq.m).

## Constructional Features

Although in a pure speed seaplane like the S.5, the aerodynamic design is perhaps the more interesting, there are a number of constructional features which are somewhat unusual, and which were developed as a result of the special conditions to be met with in a high-speed plane.

The fuselage of the S.5 is built entirely of metal (Fig. 2), chiefly duralumin, and an examination of the photograph of the fuselage in skeleton will show that by using this material and making the body more or less a monocoque, a good deal of space was saved so that it became possible to keep the cross section down to a minimum. In fact, the pilot sits on the floor, and as his shoulders touch the metal skin of the fuselage the only space lost is represented by the thickness of the duralumin skin! The method of building up the fuselage is fairly clear from Figure 2. Closely spaced frames or formers of flat U-section give the form of the fuselage from point to point, while the skin is made to serve in the capacity of longerons, i.e., is a part of the stress-resisting structure, reinforced here and there by fore-and-aft stringers.

In the forward portion there are specially strong frames for the support of wing roots, landing gear struts and, at the top, for the attachment of the anti-lift wire bracing. The reason why the latter point is one of great importance in the design is that with the system of bracing used, this point serves to stabilize the bracing of the whole seaplane, floats as well as wings. The

location of this "key point" may be seen in Figure 6, and details of the fittings, etc., are shown in a sketch.

The front bottom portion of the fuselage is built up as an engine bearer, with two main bearers of box section secured to cradles. In this region, as well as between the spar frames, the duralumin plating is laminated so as to give extra strength, a maximum of three thicknesses of 18 G. being required in places. With the scoop-formed engine mounting used, the engine becomes very accessible, as Figure 3 shows.

The two floats are also of all-duralumin construction with the exception of the center section of the starboard float, which is made of steel so as to support the main gasoline tank, which is situated here. The floats are of the single-step type, and have single central longitudinal bulkheads to which are attached the transverse frames, spaced some 2 feet apart. A number of longitudinal members are fitted between the frames (Figs. 7 and 8).

The controls are of perfectly normal type, and there is no form of variable gearing except the slight amount introduced in the ailerons by the forward angle of the aileron cranks. In spite of this the seaplane is reported to be relatively easy to handle in so far as a seaplane flying at somewhere in the neighborhood of 300 M.P.H. can be called "easy."

Owing chiefly to lack of time in which to produce an all-metal wing, the wings of the S.5 are of wood construction. Doubtless a certain amount of experimentation would have had to be done

before an all-metal wing could be produced, and to save time the well-tried and proved wood construction was adopted. The two wing halves of the seaplane are built on the normal two-spar principle, with ribs of normal type except for the somewhat unusually wide flanges necessary in order to secure the screw fixings of the wing radiators. From the bracing wire fittings to the tip of the wing there is a diagonal member introduced, the function of which is to stiffen the wing tip against torsion and thus reduce the chances of wing flutter being set up (Fig. 4). The wing covering is 1/8 inch three-ply, and over this are placed the radiators which are of the wing-surface type and have a perfectly smooth exterior. The radiators form a large percentage of the total wing surface, and when it is remembered that the average wing loading is 28 lb./sq.ft., which may be increased to 2 G. or more during rapid turns, etc., while the local loading may in places reach a much higher figure still, it will be realized that to design radiators of low weight and yet subject to such great loads was no easy task. It is not possible to give details of the radiators ultimately evolved, and which gave no trouble whatever, beyond stating that they lie snug against the wing surfaces, and are divided into top surface and bottom surface units, the method of feeding them from the header tank being illustrated in Figure 9. The wing section is a biconvex (symmetrical) one of medium thickness.

Bracing of the wings is, as already mentioned, entirely by

streamline wires, the top point of the fuselage deck fairing serving to stabilize the whole bracing system of wings and floats.

### Gasoline, Oil and Water Systems

With a fuselage of such very small cross-sectional area, the subject of gasoline system, and also to some extent oil and water system, became somewhat of a problem. It was found that there would be no room in the fuselage for a gasoline tank, and ultimately it was decided to place the main tank in the starboard float. This has the advantage of lowering somewhat the center of gravity of the seaplane, and also the offset load on the starboard side helped to counteract engine torque both when accelerating on the water and in flight. The distance the gasoline had to be lifted was, however, such that although in normal straight flight the gasoline pump could handle it, during a steep turn, with centrifugal force increasing the virtual distance, the engine would be momentarily starved, and so a small service tank was placed in the fairing behind the starboard cylinder block. Thus during a turn the engine takes its gasoline from the small tank, the straight leg of the Schneider course giving the pump an opportunity of filling this tank from the float tank before the next turn was reached. The actual gasoline system is diagrammatically illustrated in Figure 9. The gasoline capacity, by the way, is 55 gallons.

Not only because of the high speed at which the Napier "Lion"



racing engines were run in the Schneider Race, but also on account of the propeller gearing in the winning seaplane, which naturally called for efficient lubrication, bearing in mind that frictional losses in the gears must have amounted to a good many horsepower, the oil system of the S.5 required rather close attention, and the normal disposition was not regarded as being sufficient. Consequently, the oil coolers were arranged along the sides of the fuselage, where presumably they would be in the slipstream and always getting a good supply of fresh, cool air. Whether that position is the best possible is, perhaps, open to doubt, since it would seem likely that the air does not follow smoothly the surface of the fuselage but is considerably churned up and also already heated to some extent by passing over the engine. Be that as it may, that was the arrangement chosen, and in the geared-engine seaplanes further cooling of the gears was obtained by cutting openings in the cowlings over the cylinder blocks.

The water system is, chiefly due to the use of wing radiators, somewhat unusual, although not by any means particularly complicated. The water header tank is in the fairing behind the central cylinder bank, and the water is led to the trailing edge first, there dividing into two branches, of which one goes to the top surface radiator and one to the lower surface. After passing through the radiators the water emerges at the inner end of the leading edge and thence to the engine.

The main characteristics of the S.5 which it is permissible to give are as follows:

Wing span	26 ft. 9 in.	(8.15 m)
Wing chord	5 " 0 "	(1.525 m)
Wing area	115 sq.ft.	(10.68 sq.m)
Weight fully loaded	3242 lb.	(1475.00 kg)
Wing loading	28.2 lb./sq.ft.	(138 kg/sq.m)
Gasoline (55 gallons)	380.0 lb.	(172.6 kg)
Oil (5 gallons)	50.0 "	( 22.7 ")
Pilot	170.0 "	( 77.3 ")

Everling "high-speed figure" (metric) 24.8

For obvious reasons performance figures cannot be given. Some time in March the S.5 will be tested over Southampton Water over a measured course, when it is hoped that it will beat the world's record established by de Bernardi.



Fig. 1 Views of the Supermarine S.5 seaplane, giving an excellent idea of the clean lines. Note particularly how neatly "the Napier" "Lion" racing engine is faired into the fuselage.

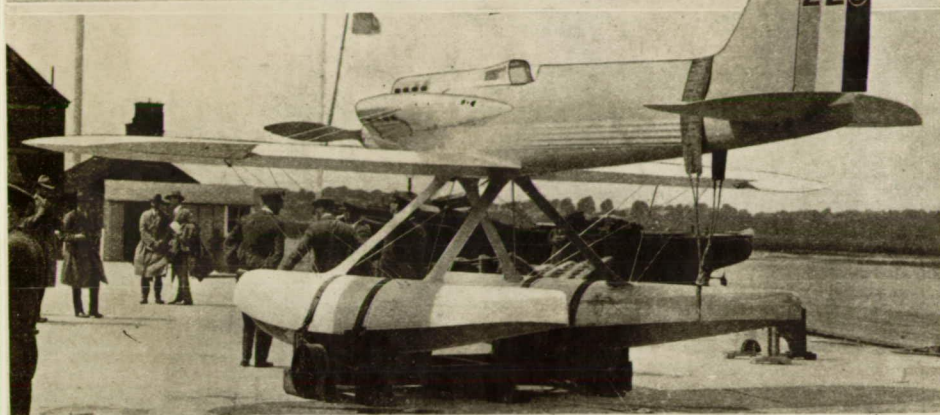
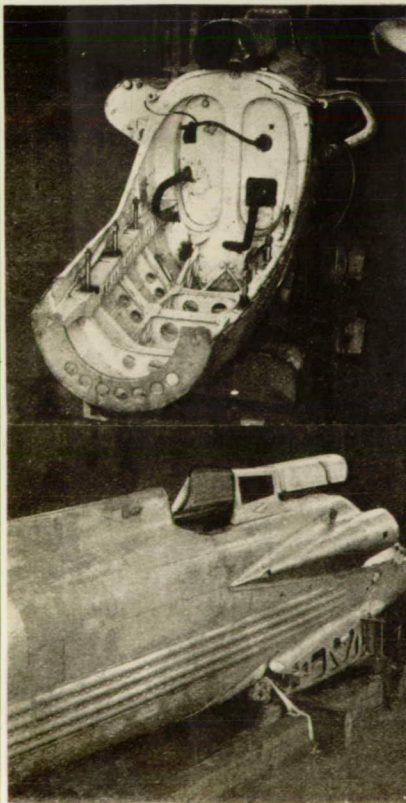


Fig. 2 Three views of the all-metal fuselage of the S.5. In the upper view the "Lion" racing engine is in place. Note the supports for the cylinder block fairing. The sand-load test is shown in the center.

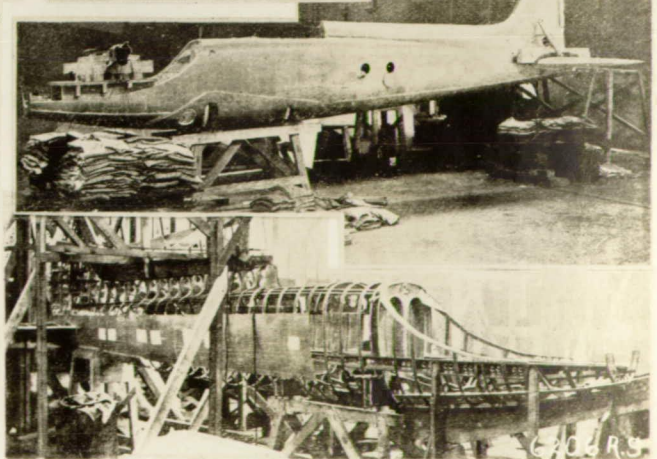
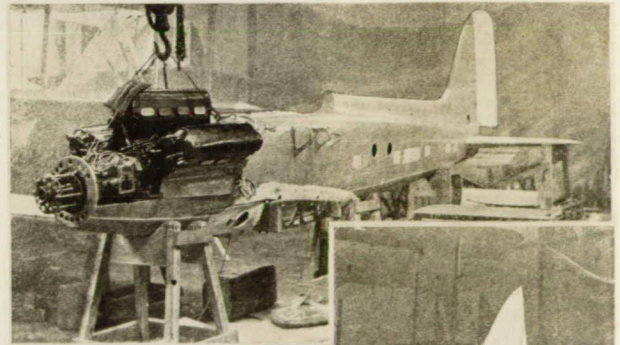
From "Flight"



The lower view shows the skeleton.

From "Flight"

Fig. 3 The top view shows inside of the engine cradle and bearings, of the S.5. In the bottom view the wind screen and cylinder block fairings are shown.





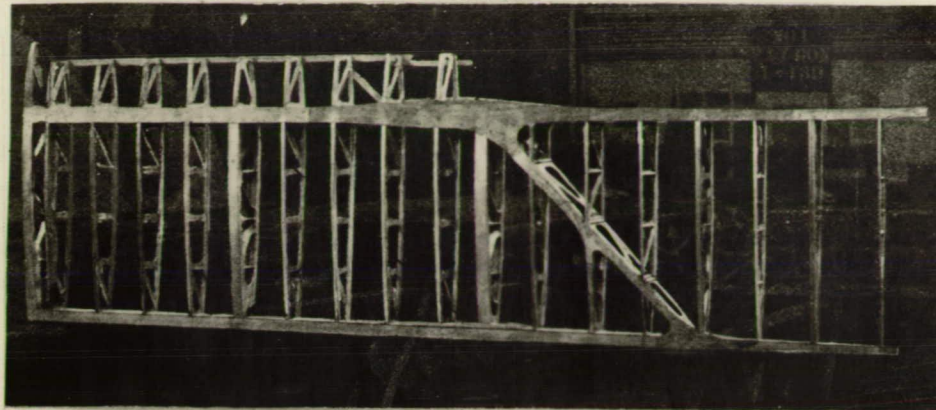


Fig. 4

Skeleton of one wing of the S.5. Note the diagonal member which stiffens against torsion.



Fig. 7 The steel center portion of the starboard float, forming the gas-oil tank. Standing on end is the water header tank. Inset shows central bulkhead of steel portion of the float.

From "Flight"

Fig.5 The tail of the S.5 Supermarine winner of the Schneider Trophy. The control cranks are inside the stern portion of the fuselage.

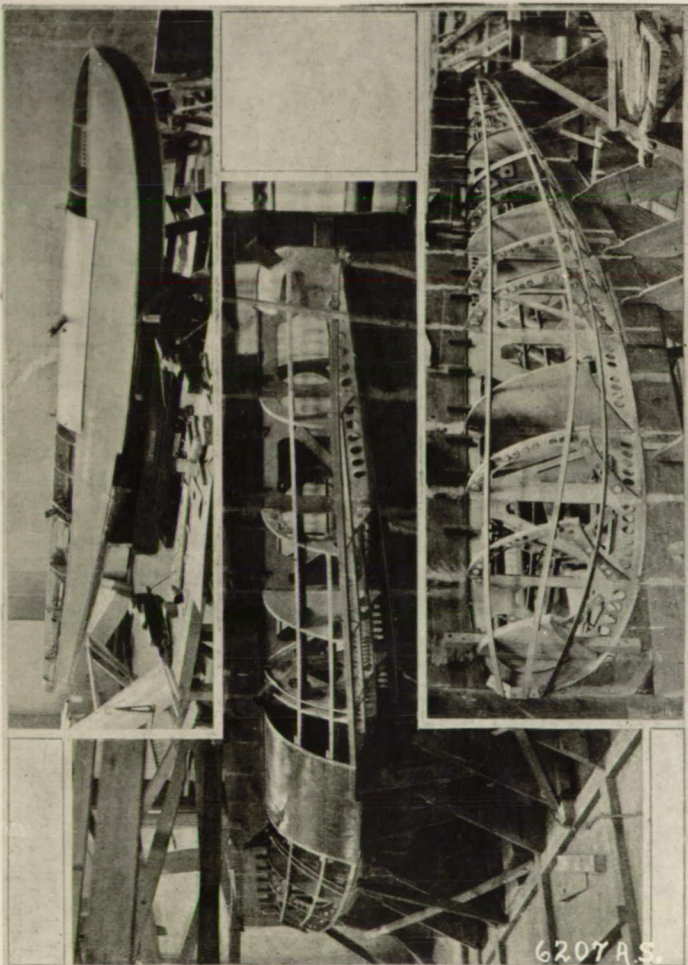
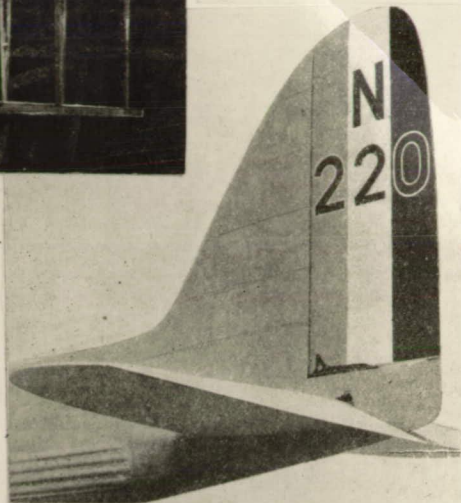
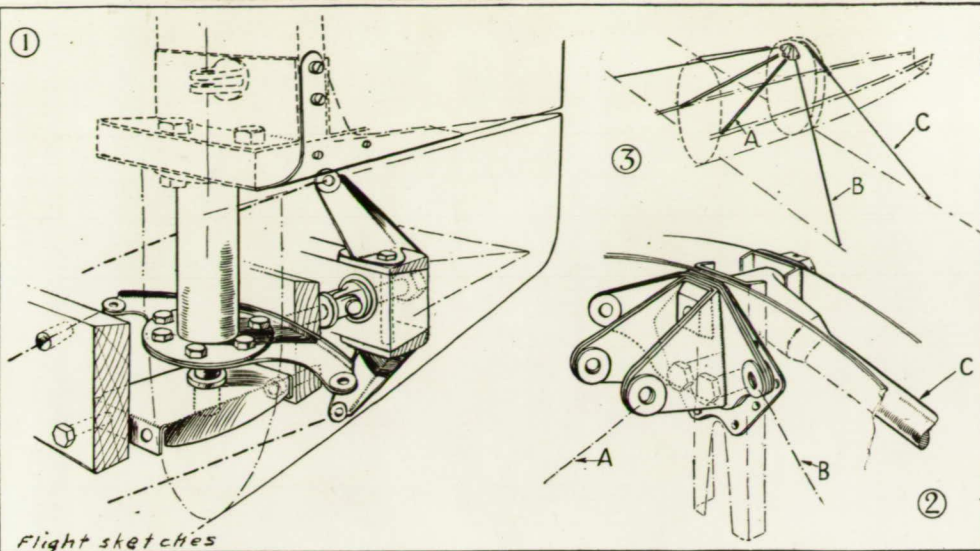


Fig. 6 Three views of a float, in skeleton, with the gas-oil tank finished, except for deck planking.

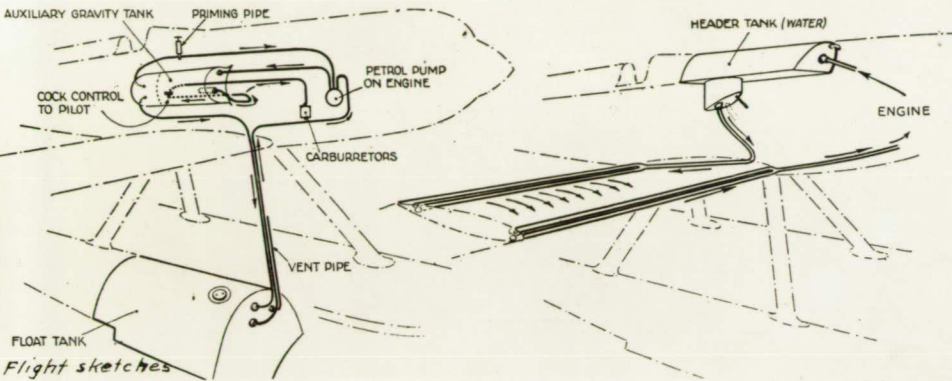


Fig. 6



1, details of rudder and elevator cranks, the latter being offset to clear rudder post.  
 2, fittings at top of fuselage to which are attached the landing wires. This point stabilizes the entire bracing system.  
 3, diagrammatic view of two main frames showing bracing wires, tubes engine bearers and mounting.

Flight sketches



Flight sketches

Fig.9 On left diagram of gasoline system. Water system shown at right. S.5

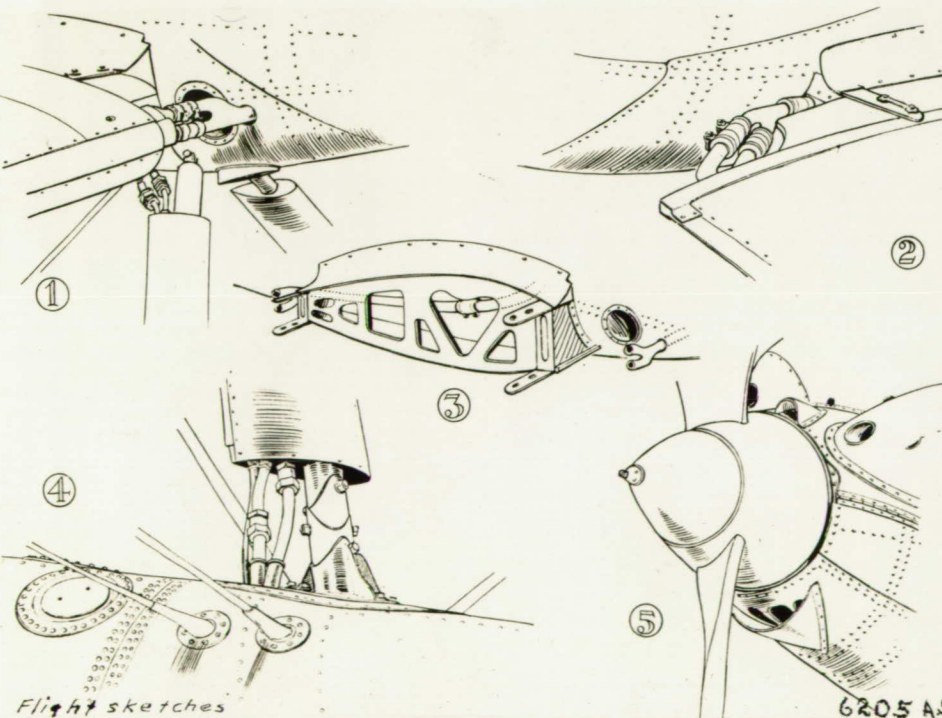


Fig. 10 1, water pipes in leading edge of wing from wing radiators. Note gasoline pipes, from float, in strut fairing. 2, water pipes from trailing edge entering fuselage at the wing root. 3, starboard wing root. Note water pipe inside. 4, details of float strut and gasoline pipes where entering starboard float. Note filler cap. 5, propeller boss, spinner and air scoops for cooling the engine gear.

Flight sketches