U.S.A. NAVY F-5-L FLYING BOAT

(Concluded from page 1026)

THE hull is built up around four *longerons*, as is a land plane, and has in addition a keel and a planked V-bottom that is flared out to present more landing surface. The flared out portions are called fins, and in this place are an integral part of the hull structure, and are continued aft, and streamline into the hull sides. This is not the case in many previous seaplanes, namely, the H-12 and the HS-1 and 2, where the fins are stopped abruptly about one-third the hull length aft from the bow, and the advantage is increased strength and better streamline form.

Before entering into a detailed description of the hull construction, it may be well to define some of the terms used. The following defines them roughly, and is the order in which they enter the hull construction :—

Keelson.—A wide thin plank extending from near the bow to the stern, above the keel.

Keel.—The bottom-most longitudinal member forming the backbone of the hull.

Floor Frames.—The transverse planks jointed at right angles to the keelson.

Longerons.—All longitudinal members extending from the bow to the stern with the exception of the keel.

Fin Edges.—The two outside longitudinals of the fins.

Stringers.—The longitudinal strips connecting the floor frames on the bottom and the strips on the fins.

Bulkheads.—All transverse veneer structures dividing the hull framing.

Transverse Bracing.—The central structure connecting the hull to the two wing beams extending through the hull.

The keelsons are ½-in. basswood, built in not more than five sections, having at least a 9-in. scarf at the joints and held together with copper rivets. To this the floor frames, also ½-in. basswood, are notched and securely riveted by two corner stringers. Throughout it will be noted that built-up members are used, permitting the use of readily available material.

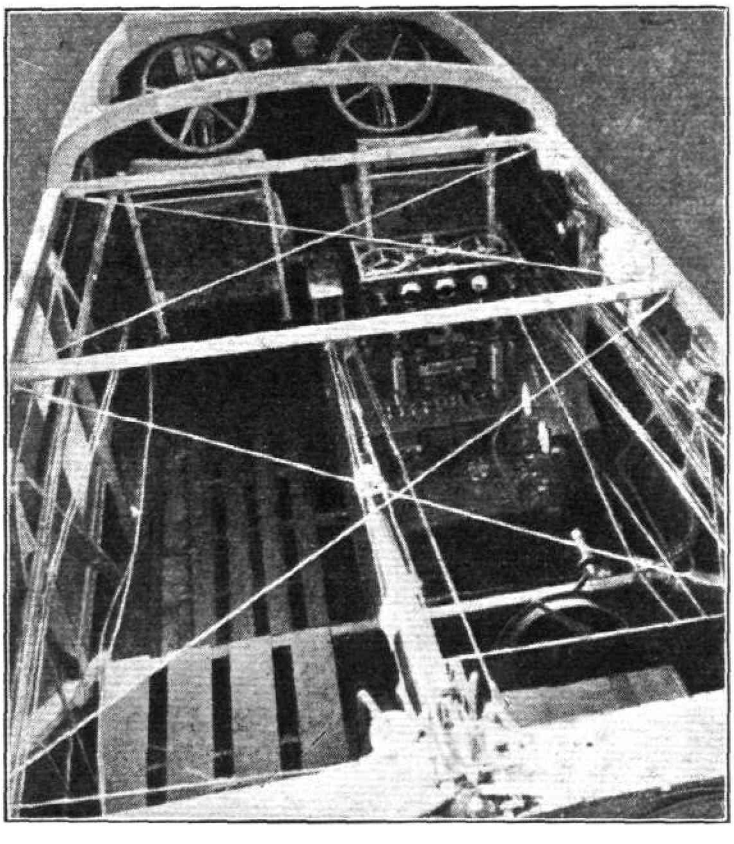
White ash is used for keel, *longerons*, fin edges and the bent ends of the stringers. These two may be built up or spliced, but not more than four sections may be used. The scarfs in the keel must be at least 18 ins. long, and are copper riveted. Formerly a straight scarf was used, as it was considered a better production proposition, but now a stepped scarf is used, as it was found that the time saved in making the straight scarf was lost in assembly.

Similar methods of splicing are used in the case of the *longerons*, fin edges and stringers, and here the joints are served and doped. Care is taken in the location of all splices in longitudinal members, so that a number of splices will not occur in any one section, causing a weak section and failure. For example, not more than two *longeron* splices may appear in any one bay, and these must both appear in either the upper pair—to balance each other. By this method of splicing ash longitudinals, and the careful location of joints, short lengths of ash can be used. And this is important, as airplane ash under any condition is not easy to secure. All ash members are steam bent to assembly shape before assembly on the hull forms. This bending and the splicing of the complete longitudinals are done in a separate part of the shops. Likewise the keelsons and floor frames, stringers, bulkheads, posts, struts, braces, etc., are sub-assembled, and when delivered to the hull erection floor are ready for assembly but with little fitting. This idea is carried out even to the bottom planking, which is delivered in amounts sufficient for one hull. But a detailed description of this sub-assembly is too involved for comment here.

Throughout the hull construction all parts are tied together by metal fittings—and concerning these metal fittings three points are noteworthy as aiding increased production. The first is a choice of material used. One generally considers the steel entering into airplane construction as being the best possible, and heat-treated to the greatest strength. But fittings on this plane are in general soft or mild carbon steel. The reasons for this are that such steel can be procured almost anywhere, is easily worked and welded, and loses little of its strength through abuse in brazing, welding or forming. The second point to be noted in the fittings is that, with few exceptions, they are built up from flat patterns bent and brazed or welded. This eliminates drop forgings, which were so difficult to secure, and permitted production to go ahead without waiting on the construction of dies. The third feature of the fittings is the use of identical fittings in many places. For example, throughout the hull, the junction of the posts and the *longerons*, the point of attachment of the floor frames to the *longerons*, and the plates covering the joints of the hull bracing—fittings differed only slightly at the different stations.

However, originally each similar fitting differed slightly, necessitating a separate template, a separate print, part number, operations, etc., throughout the whole construction. But a study was made, and an " average fitting " produced that would suffice for several similar stations. The fact that such fittings did not exactly fit anywhere, or had lugs that were not needed in other places, amounted to less than they saved time in production. And they were structurally as good.

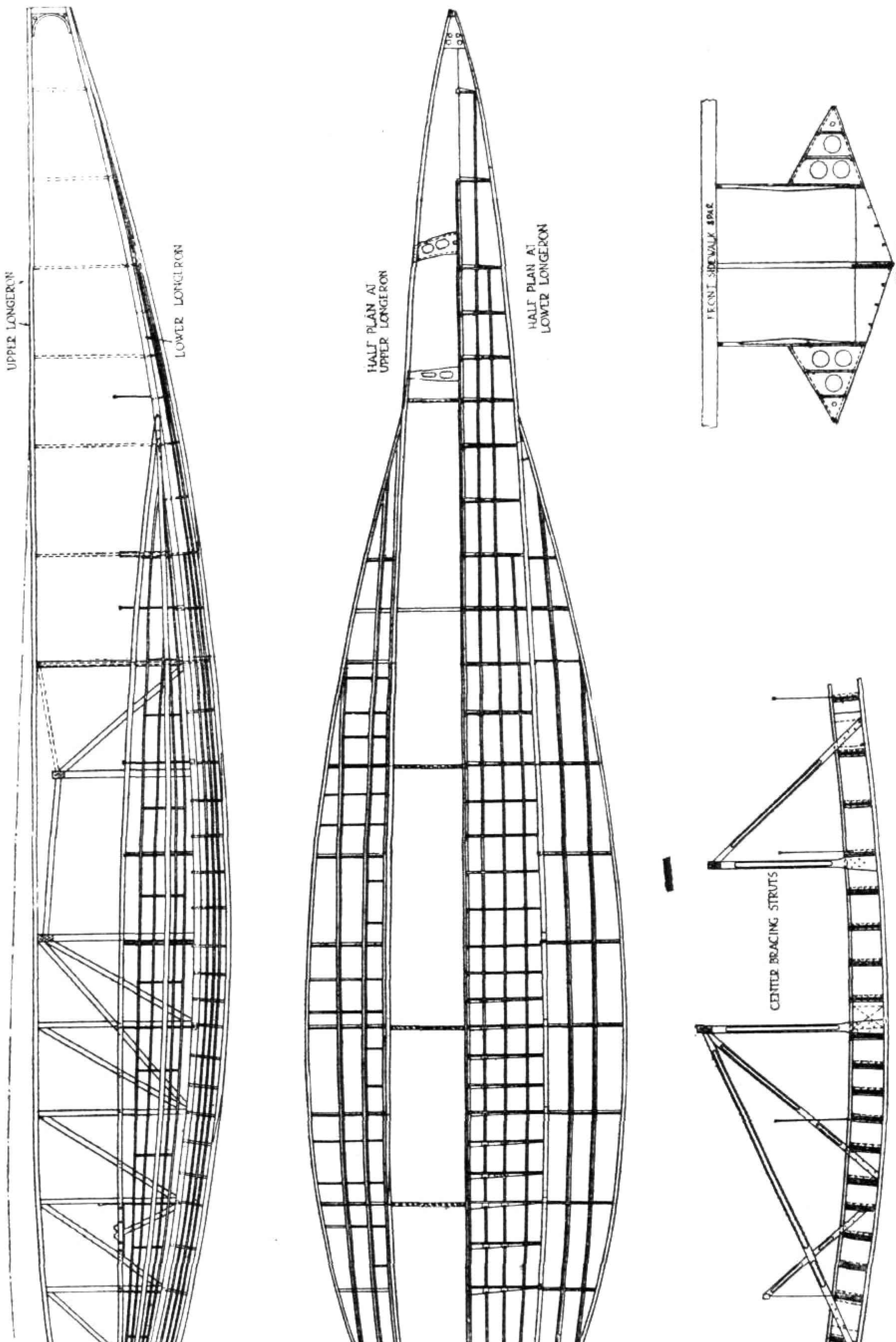
A further difference in the construction of this hull and that of similar hulls of its predecessors is to be noted. On previous models, riblets were used to connect the keel with the fin edge stringers. These riblets were about ½ in. by ½ in. ash, spaced at distances varying from 9 to 15 ins. transversely across the boat bottom. To bring their bottom surface flush with the stringers, lower *longerons* and fin edges, it was necessary to notch keel, stringers, *longerons* and fin edges that they might be set in. And it was a slow, tedious job. On this unit, the riblets are omitted, though several ash-tie strips are used to connect the keel with the fin edges. It is considered that these, together with the planking, provide transverse strength in abundance. Another feature in the construction is the extensive use of steel tubing as struts and posts in the body bracing. This is particularly noticeable in the tail, where the parts are under no great strain, and are not used for the attachment of other parts. Steel tubing is readily procured, and ready for use by simply cutting to length.



View of the pilot's and wireless operator's quarters on the F-5-L flying-boat

The central or transversal bracing unit is a complete unit in itself, and is set up as a separate assembly previous to installation in the hull. This differs from the usual construction and permits the use of templates to assure accuracy. The transverse bracing connects the hull to the wings and the hull may be said to be built around this unit. By making all transverse bracings identical, any set of F-5-L wings, engine mountings, etc., may be more readily installed. It is also to be noted that the wing spars passing through the hull are spliced at the centre. These spars, styled the sidewalk spars, as they carry a short veneer covered wing section at each side of the hull that is used as a sidewalk for the mechanics to reach the engine, may be removed when the hull is packed for shipment, permitting the use of a much smaller shipping crate.

Hull Construction Plans of the F-5-L Navy Flying Boat



THE U.S.A. NAVY F-5-L FLYING-BOAT. Drawings of the hull

The bottom planking comprises an inner and an outer skin, each of $\frac{7}{32}$-in. cedar. The inner skin is placed at right angles to the keel, differing from usual practice wherein both layers are at an acute angle to the keel. As riblets are eliminated, the right-angled inner planking tends to replace them as strength members. This inner planking is either Port Oxford or Spanish cedar in random widths of from 4 to 10 ins. The outer planking is placed at an angle of 45 deg. to the keel, the acute angle being on the aft side. All pieces are from 4 to 5 ins. wide, Spanish cedar, and are screwed to all longitudinals. The two layers of planking are secured together by brass clinch nails. Courtrai, a special fabric, is laid in marine glue between the two layers of planking, and is used extensively in rendering all joints tight. All planking is laid with a slight clearance to allow a go-and-come resulting from moisture changes.

The bottom steps are secured in place after the hull is planked. They are two layers of $\frac{7}{32}$-in. mahogany planking, fabric and marine glue between, screwed and clinch-nailed together, and secured to the hull bottom by copper rivets, being separated from it by triangular ash strips. The forward ends of these steps are scarfed and set into the hull planking, a thick brass strip being set in flush over the joint. For the rest of the hull $\frac{1}{8}$-in. three-ply waterproof veneer is used.

The top plane is built up in five sections, comprising a centre section of 13 ft. 6 ins. span (108 sq. ft.), two intermediate, 27 ft. span (216 sq. ft. each), and two outer extensions, 15 ft. 11 ins. span (95 sq. ft. each). The lower plane is in four sections, consisting of two centre sections (or sidewalks) mounted one on each side of the hull, giving the same overall span as the top centre section and having a combined area of 66 sq. ft. The balance of the lower surface consists of port and starboard wings, 30 ft. 5 ins. span (240 sq. ft.) each. Vertical "non-skid" fins are mounted above the top planes at each outermost interplane strut.

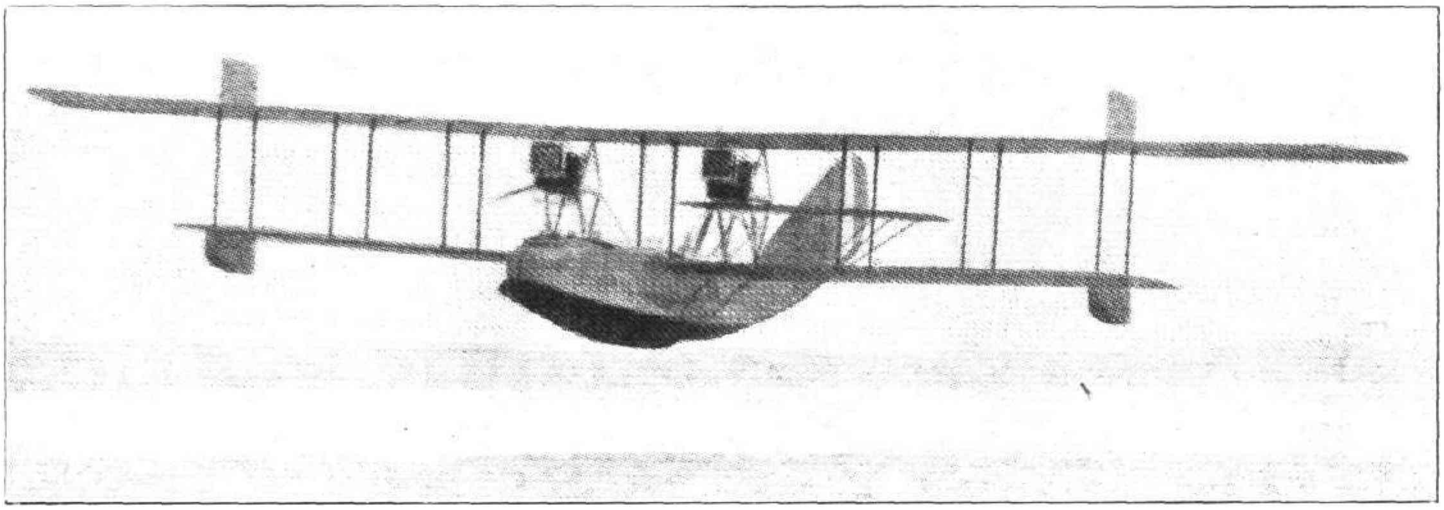
An extended technical description of the panel, strut and tail construction could be expanded to many volumes. But the outstanding features of these are laminated spars, simple strap type wing and strut fittings and laminated uniform section struts.

At one time laminated or spliced spars were not in favour, but the shortage of long spruce necessitated the use of laminated and spliced spars, and it is found that the laminated spar is better than the unlaminated one. Outside of the economy of material, the ease of drying pieces of small cross section and the resulting dependability of built-up spars more than off-sets any additional expense in manufacturing. Two types of laminated spars are used—the two-piece and the three-piece. The former is simply two pieces placed back to back, and glued together. The two halves are of equal thickness, and are lightened as was the solid spar except at splice positions. Scarfed splices are used, and staggered in the two halves. The two-piece is used in the following places: all front spars (except engine section), horizontal stabiliser spars, and rear *aileron* spars. The three-piece spar comprises a thin piece sandwiched between two thicker outside pieces, glued together, and lightened similar to the solid spar, except at splices. This construction is used in the sidewalk and engine section, or for rear spars. Of the two types, the two-piece is considered stronger, and hence the above distinction of their use.

The idea of using strap fittings and the elimination of forgings and machined fittings extends to the strut and wing fittings. Here also mild carbon steel is used, cut from flat patterns and bent to shape. The base wing fitting is a U-strap, bent around and bolted to the spar. From it lugs are bent for interwing wiring, and the interplane side has a cloverleaf extension for the attachment of the struts and wire terminals. These are reinforced by washer plates to provide bearing for the bolts. Roughly, the spars are secured to the strut ends by a bolt passing through the central cloverleaf and the strut end, and the usual strut socket is eliminated. In detail, the strut end is squared down, drilled to mate with the central cloverleaf hole, and a steel tube fitted in the end to give greater bearing and prevent the strut end from being crushed when the through-bolt is tightened. The through-bolt has a standard eye head, permitting the attachment for the drift and anti-drift wires, where a single wire is used. When double drift wires are used, the through-bolts holding the flying and landing wire clevises are made with an eye. Bearing for the strut ends on the spar is secured by means of a thin bearing plate between the strut and the spar.

It was observed that considerable time was lost in shaping the tapered streamline section struts, and furthermore, these being in two-piece construction, required thick material that was difficult to obtain. Hence, a three-piece uniform section strut was chosen. As stated, this strut is three-piece, and all the lightening is done in the central portion. In the rough it is a flat board, the length and width of the strut, with a series of oval holes cut out of the central portion on a vertical spindle shaper. The check pieces are then glued on each side, and the strut rough-machine planed to a streamline section. It is then finished to the desired section by hand.

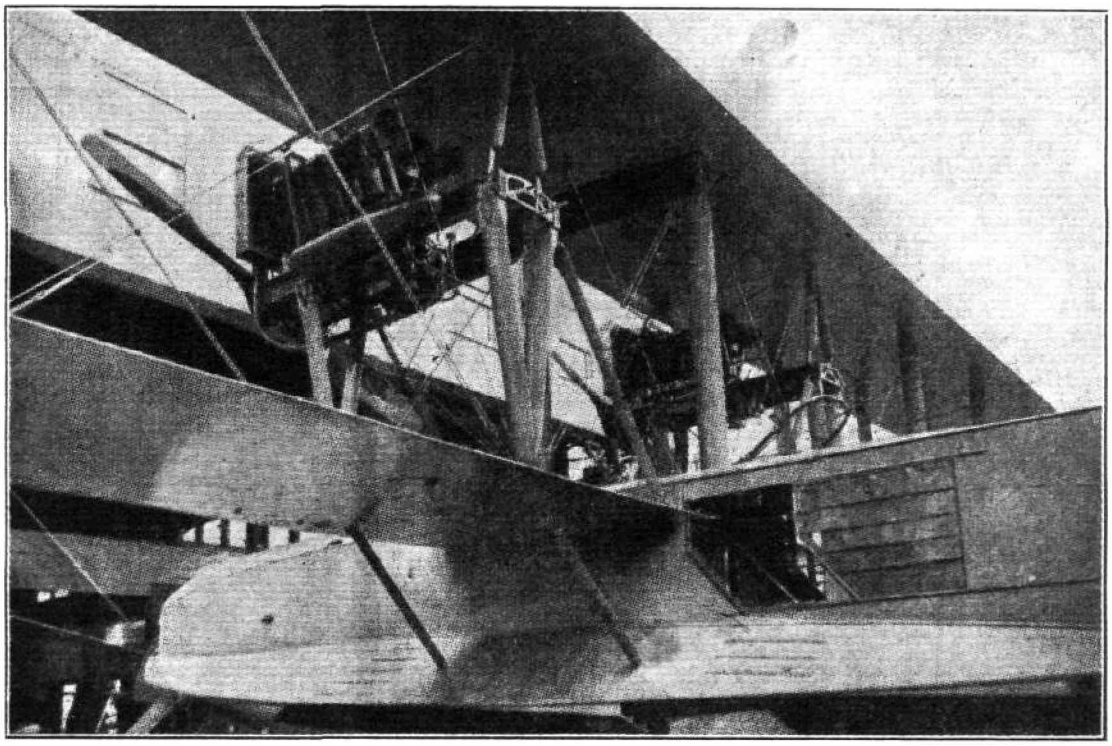
Two Liberty engines comprise the power plant. These engines are identical with the engines used by the Army, with the exception of the pistons, which pistons are given more clearance, so that the compression pressure is reduced. The result is a slight reduction in maximum horse-power, but greater engine life. This is advantageous because in seaplane service long patrols place a premium on dependability and a seaplane does not habitually frequent high altitudes or require the maximum available horse-power.



The F-5-L flying-boat in flight

In the main, the engine mounting differs only slightly from the mounting of the Liberty engines in the Curtiss H-12 and H-16 seaplanes. Horizontal laminated engine bearers are carried on wooden V-struts over each main wing hinge fitting, and are attached to the upper panel by tubular A-struts. The radiator is carried on a bracket at the front, and the oil supply in streamlined tanks at each side of the bearers. However, in details, the F-5-L mounting is simplified and made a better production-proposition. The first step was the elimination of drop forgings. Strap fittings built up and brazed together are used for attachment of bearers to V-braces, and the upper attachment of the A-brace to the engine section is also a strap fitting. This attachment is strong and simple. The ends of the tube are first fitted with a tubular sleeve, and then formed to a U-section. In addition to the simplicity of construction, this end is extremely rigid. The A-braces are attached to the spar fitting through a universal joint bearing plate. This is also a built-up fitting. The forward A-brace is bowed to clear the engine cylinders, and the halves are tied together by a cross-tube and through bolt. This brace must be removed before the engine can be taken from the plane, and the removable cross-tube and through bolt permit this to be done. Differing from previous construction, the engine bearers are carried forward so that a straight radiator bracket may be used. Previously, the bearers were cut off by the front engine flange and arched brackets used. However, the straight bracket is simpler to construct, and is possible on Liberty installations.

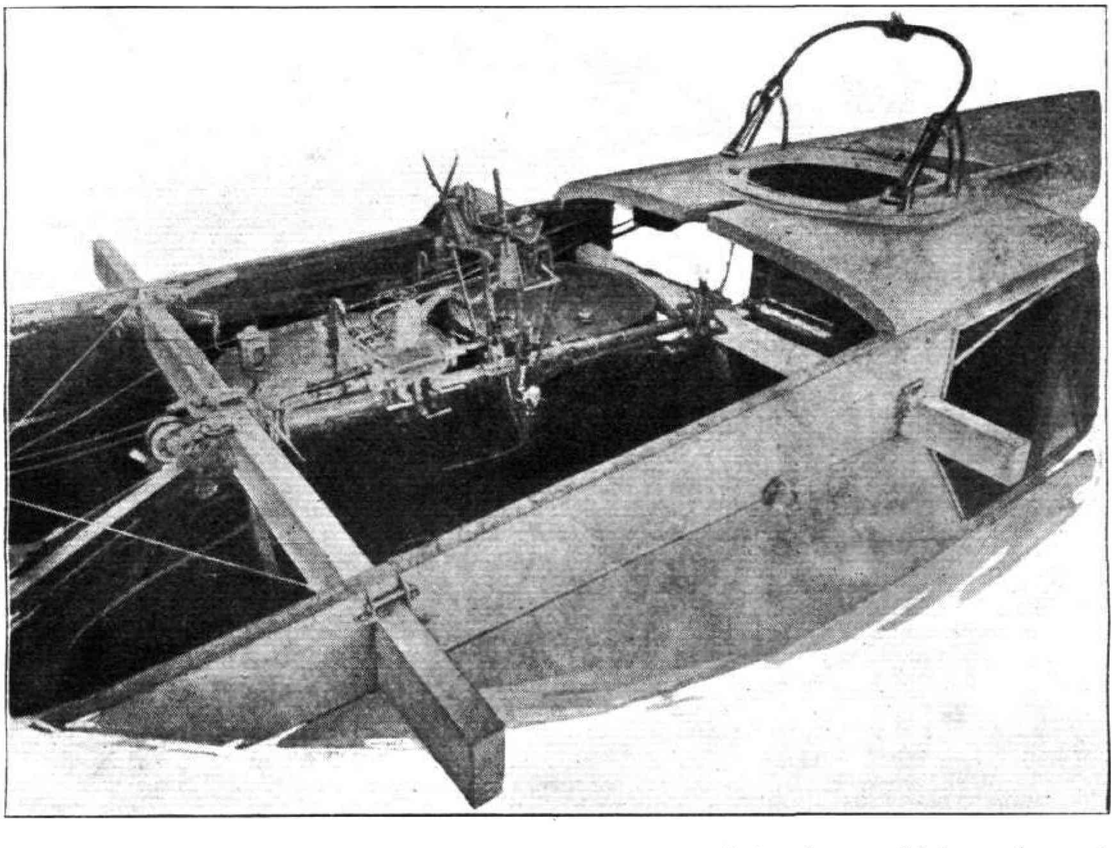
In an installation of this nature, it is, of course, impossible to start the engines by hand cranking on the propeller.



Detail view of the F-5-L flying-boat, showing the engines and rear " cabin "

For this reason a rear hand starter, comprising a reduction gear and clutch engaging the crankshaft is used. One man can readily turn the engine over, though two are generally used. As stated, the oil tanks are streamlined, cylindrical, and mounted at each side of the engine bearers. The total capacity per engine is 17 galls., and the two tanks are connected by a manifold, the division simply being constructional. In later planes the side oil tanks are being superseded by one streamlined tank mounted between the engine-bearers and behind the engines. This serves to clean the installation up to a marked extent. A long-distance thermometer bulb is installed in the oil return line, and the gauge is mounted in the mechanics' compartment by the tanks. The oil-pressure gauge is installed on the pilots' instrument-board. A water thermometer gauge likewise is in the mechanics' cockpit. This location of the thermometers is because engine temperatures are of enough importance to demand quite frequent attention.

The petrol supply is carried in five tanks placed amidships in the hull. There are two large cylindrical vertical tanks, one fore and aft horizontal tank, and two transverse horizontal tanks. The latter two were originally consolidated, but the single tank could not be removed without taking the plane to pieces. All have a total capacity of approximately 498 galls. As these tanks are below carburettor level, a header or gravity tank is necessary. This is located in the upper wing, between the two engines, and carries about 20 galls. The petrol is pumped from the hull by a double-barrelled windmill pump, and forced into the gravity tank sump. From the sump leads are taken to the two engines, and the surplus over this amount flows through small holes in the sump sides into the gravity tank. When the gravity tank becomes full, an overflow pipe carries the excess back through a sight box into one of the tanks. This overflow serves to show the mechanic that petrol is being pumped, and that the gravity tank is full. The construction of the gravity sump is noteworthy. It will be noted that the base of the sump is somewhat below the bottom of the tank, and that the two are only connected through small holes at the sump sides. Hence if the gravity tank be shot away, the supply of petrol pumped may be shut down to the amount used, with the base of the sump alone serving as a header tank. A semi-rotary hand pump is used to fill the gravity tank when the windmill pumps are inoperative. This pump is an English design, and a similar pump is also used for bilge water.



The petrol tanks and windmill pumps on the F-5-L flying-boat, which are located in the centre of the hull

The leads from all the supply tanks are consolidated into one manifold, and by regulating the valves petrol may be pumped from any tank into the gravity tank. However, it all returns into the starboard forward vertical tank, and in flight petrol is pumped alternately from this tank and each of the other tanks in rotation. It is necessary to pump from the tanks in rotation in order to trim ship, and a separate manifold would be necessary to return the overflow petrol to any tank. It is to be noted that the manifold incorporates a filler-valve piped to a union at the hull sides. This serves for the attachment of a pipe-line from a supply boat or tank that the seaplane tanks may be filled by petrol under pressure. Though this method of filling is not much used, it is stated all the tanks may be filled thus in a few minutes, whereas the funnel and measure method takes from a half to one hour.