AIRCRAFT CIRCULARS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 79

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TYPE S-38 MODEL 1928

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THE SIKORSKY TWIN-ENGINED AMPHIBIAN TYPE S-38 MODEL 1928.*

The Sikorsky twin-engined amphibian type S-38 model 1928 is a nine-passenger sesquiplane powered with two Pratt and Whitney "Wasp" 410 HP. engines. With the present type of cabin, it is intended primarily for commercial transport service on routes where the ability to alight and take off from both land and water is essential for safety and convenience (Figs. 1 and 2).

The S-38 has been developed directly from the two preceding models of Sikorsky amphibians, the S-34 and S-36. The type S-34 was an experimental design of which only one was built. Five of the S-36 type were constructed, however, and put into service. A careful refinement of this design with no major changes resulted in the present type S-38. The development may be follower by inspection of S-34, S-36, and S-38, respectively.

The sesqui arrangement of the wings which was originally developed and used before the World War by Mr. Sikorsky and Mr. Breguet independently, has proved very suitable for amphibians. It combines the aerodynamic advantages of the monoplane with the structural advantages of the biplane; it places the major lifting surface well above the water; and it affords good

*Prepared by Sikorsky Manufacturing Corporation.

support for the side floats in a convenient position not too far from the hull.

In order to preserve the efficiency of the tail surfaces that results from keeping them in the slip streams and to minimize the danger of their being damaged in rough water, the tail surfaces of the S-38 are mounted high above the water and supported by two outriggers from the upper wing and two struts from the stern of the hull (Fig. 3).

The distance from the center line of the hull to the center line of the floats is 141 inches, the normal displacement of each float is 500 pounds, and the total displacement is 1400 pounds each, a combination that gives a righting moment of around four times the tipping moment at the angle of full displacement of one float when the airplane is loaded to 9900 pounds gross weight. Such a large righting moment insures seaworthiness and enables quick turns to be made when taxying on the water, with only a small angle of heel, thus adding greatly to the physical and mental comfort of the passengers.

The twin-engine arrangement assures quick maneuverability with perfect control when taxying on either land or water, or from one to the other.

By careful design of the hull and floats, the spray has been reduced to a minimum, practically none reaching the propeller or either the pilot or passenger cabin.

Provision is made to keep the airplane afloat in case the

hull or floats are damaged, by having the hull divided into six, and each float into three, water-tight compartments. These are listed below with their displacements:

1.	Bow of the hull	2400 lb.	
2.	Baggage compartment	6300 "	
3.	Below floor of cabin	2800 "	
4.	" " " "	1000 "	
5.	Passenger and pilot cabins to upper chine	11000 "	
6.	Stern of hull	3600 "	
	Total displacement of hull to upper chine		27100 lb.
7.	Total displacement of floats		2800 "
	Grand total		29900 "

$$\text{Ratio} = \frac{\text{Total displacement}}{\text{Normal displacement}} = \frac{31100}{9900} = 3.02.$$

Since with a total load of 9900 lb. the power needed for level flight is only 300 HP. of the total 820 HP., there is an exceptionally large reserve power available for take-off, climb, and for that most important safety factor, flight with one engine. Tests have shown that the S-38 will maintain level flight with one engine at a maximum speed of 90 M.P.H. with a total load of 9400 lb., which is equivalent to the full load of 9900 lb., less the gasoline for the dead engine. Directional control in single-engined flight is provided by balanced compensating rudders of

unsymmetrical section (patented). When taxying on the water with only one engine, the steering may be greatly facilitated by lowering the landing wheel on the same side as the running engine.

The cruising speed of the S-38 is 105 M.P.H. at 1600 R.P.M. and the fuel consumption at this speed is 0.37 gallon per mile. Theoretically, the most economical speed, defined as the speed at which the fuel consumption in pounds per mile is a minimum, is 90 M.P.H., and the fuel consumption .33 gallon per mile.

The ailerons, which are on the upper wing only, are of the balanced and differential type. All control mechanisms swing on ball bearings to make operation easier. The stabilizer is adjustable in the air from the pilot's cockpit.

By means of a simple manually operated hydraulic control, developed by the Sikorsky Manufacturing Corporation, the landing wheels, separately or together, can be raised in 30 seconds, and lowered in 40 seconds. If the pressure in the landing gear oil supply tank is kept at 25 lb. by the small hand pump installed as standard equipment, the landing gear will be pushed down automatically. When retracted the wheels lie horizontally against the lower surface of the lower wing projecting forward about half their diameter.

An excellent emergency braking action is obtained with this type of landing gear when running on the ground. By operating the single throw valve, the airplane may be lowered smoothly until the keel of the hull scrapes the ground, effectively stop-

ping the airplane. The bow of the boat prevents nosing over during this emergency operation.

In the forward compartment of the hull, which is 4 ft. 6 in. long, 3 ft. 6 in. wide, and 2 ft. high, and has a capacity of 30 cu.ft., is stored the marine equipment including one 35-pound collapsible ground anchor and line and one sea anchor with oil tank. The bulkhead behind this compartment is solid but through a small hatch in the deck the equipment is accessible to one standing up in the second compartment. One end of a towing cable is spliced to a fitting on the keel well under the bow and the other end is made fast to a cleat or deck. A light line is rigged to pull up the end of the cable after it has been cast off by the tow boat.

The second compartment is 4 ft. 2 in. long, 4 ft. 10 in. wide, 3 ft. mean height, and has a capacity of 52 cu.ft. This space is provided for baggage or mail and a seat for the mechanic is folded against the forward bulkhead in case it is desired to place a passenger beside the pilot. Large hatches in the deck enable the crew to pick up a mooring or drop anchor. Since the plane of rotation of the propellers falls in the after end of the baggage compartment, no seats or vital parts of the airplane are in danger from propeller breakage.

Aft of the baggage compartment is the pilot's cabin (Figure 1) furnished with two seats, side by side, easily adjustable in height by the occupant without removing his

weight from the seat. The engine controls, stabilizer adjustment, and landing gear controls are conveniently located between the seats. At the top of a single control column, also located between the seats, an arm carrying the wheel is hinged and may be swung in front of either pilot where it automatically locks in place. Dual rudder controls are provided with a novel foot rest of the stirrup type which also serves as an adjustment for pilots of different stature.

On the dashboard the engine instruments and switches, and the landing gear pressure gauges are arranged in two columns in the center, the left column containing the instruments for the left engine and landing gear, and the right column for the right. The flight instruments are grouped in front of the left seat from which the piloting is normally done, but can, however, be read from the right seat. The instrument board is carefully lighted for night flying. Tachometers having luminous dials are set on the vertical landing gear members 20 inches from the window and level with the pilot's eyes.

The following instruments are included as standard equipment: Two oil pressure gauges, two oil temperature gauges, two tachometers, two magnetic gasoline tank gauges, two pressure gauges for hydraulic landing gear, one pressure gauge for air in landing gear oil tank, one altimeter, one air-speed indicator, one turn and bank indicator, one magnetic indicator, one Waltham

eight-day clock and two hand-operated fire extinguishers.

The noise from the exhausts has been reduced so that conversation in ordinary tones may be carried on in the cabin.

As on all recent Sikorsky airplanes, the airfoil section used on the S-38 is the G.S.-1 developed by the Sikorsky Manufacturing Corporation and well known for its efficiency.

Construction

Wings.- The entire internal structure of the wings, control surfaces and outriggers is built up of simple duralumin shapes fastened together with duralumin rivets. The spar construction with compression members, tie-rod bracing, dural covering on leading edge, and final covering of fabric is used on all Sikorsky airplanes for the following reasons (Figs. 8, 9, 10):

1. Since the stresses are carried entirely by well-defined beams and trusses, the magnitude of the stresses and the strength of the structure can be accurately computed.

2. A thorough inspection can be made at the small cost of a new fabric covering.

3. It is necessary to keep on hand only a small number of structural shapes to repair minor damages to the structure and this work can be done by relatively unskilled workmen.

Both front and rear spars of the upper wing, and the out-

riggers, are Warren trusses with extruded bulbed "T" sections for flanges connected with ties of small channel section. Web plates are added at all strut points (Fig. 5).

Of similar construction are the upper wing compression members and the stabilizer spars except that the flanges of the former consist of two angles, and of the latter, one angle.

The wing ribs are made of light duralumin channels riveted together to form a Warren truss.

The lower wing spars are single "T" sections with the leg of the T horizontal. The basic spar is reinforced quite heavily at the strut point where the bending moment is large.

All struts are tubes of streamline section.

Power Plant

The two Pratt & Whitney "Wasps" are located symmetrically about the center line, 126 inches apart, and are hung 32 inches below the upper wing. The mountings are built of angles riveted and bolted together in the form of a pyramid with the mounting ring at its base, and weigh only 25 pounds each. The supporting streamline struts are attached to the ring and the apex of the pyramid. The nacelle is carefully streamlined with dural cowling.

Inertia starters are installed as standard equipment. Both engines are cranked from the side nearest the hull where there is good footing for the mechanics.

Metal propellers are used.

The power unit may be quickly dismounted for overhauling.

In case more power than is given by the two "Wasps" is desired, they may be replaced by two "Hornets" or "Cyclones" without any change in the structure.

Fuel System

From experience with different gasoline systems and location of tanks on previous airplanes, it was found to be best from every point of view, to put the gasoline tanks in the center section of the upper wing and to use gravity flow entirely. The bracing in the two center panels of the drag truss consists of dural sheet on the bottom with the gasoline tanks resting on it. Rigid dural "T" sections across the top of the tanks hold them firmly in place. The two wing tanks and the two float tanks hold 100 gallons each, making a total of 400 gallons. Large diameter dump valves operated from the pilot's cabin are fitted in each wing tank. A special compound insoluble in gasoline or benzol keeps tight the seams of the riveted duralumin tanks. The oil tanks, which are of similar construction, are located in the upper wing and have a capacity of 12 gallons each. All tanks are reinforced inside and fitted with large sumps and drain cocks.

Landing Gear (Figure 6)

The landing gear members are steel tubes heat-treated to 125,000 lb./sq.in. In designing, the loads required by the Department of Commerce were used, and for additional safety the margin of safety was kept above 25%.

The vertical landing gear members which connect the outer end of the axles to the engine mountings, contain the entire shock absorbing and retracting unit as shown in Figure 6. A combination of Oleo action and spring compression absorbs the shock while the spring alone supports the airplane in taxying.

The tail skid consists of a central tube containing a small Oleo shock absorber and two helical springs on either side of it, fore and aft.

Hull and Floats

The hull is 30 ft. long with 62 ft. beam, which is increased at the bottom to 82 in. by large sponsons. The bottom is built with a 17 degree Vee at the step.

Composite construction is used, the frameowrk being of oak and ash with joints reinforced by duralumin and the skin of Alclad noncorrosive duralumin sheet (Fig. 7). This type of construction makes the hull fully as strong as an all-metal hull and more easily repaired.

The floats are similar to the hull in form and construction.

Dimensions

Span	71 ft. 8 in.
Length, over-all	40 " 3 "
Height	13 " 10 "
Width of tread	9 " 8-1/4 in.
Span, upper wing	71 " 8 in.
" , lower "	36 " 0 "
Chord, upper wing	100 "
" , lower "	59 "
Dihedral, upper wing	0°
" , lower "	1°
Gap	95.3 in.
Stagger	4.5°
Area, upper wing (including 42.2 sq.ft. for ailerons)	574 sq.ft.
Area, lower wing	146 "
Total wing area	720 "
Area, stabilizer	44 "
" , elevator	26 "
" , fins	15 "
" , rudders	20 "

Weights
Dead Load

Structure

Wing group	1332 lb.	
Tail "	169 "	
Body "	2311 "	
		3812 lb.
Power plant		1856 "
Fixed equipment		207 "
Weight empty		5875 "

Useful Load – 3300 lb.

Crew (2)	340 lb.	
Equipment	125 "	
Gas for 5 hr. at 18 gal. per hr.	1080 "	
Oil – 16 gallons	125 "	
		1670 lb.
9 passengers	1530 "	
Baggage	100 "	
		1630 "
Useful load		3300 "
Gross weight		9200 "

Useful Load – 400 lb. range 500 miles

Crew (2)	340 lb.	
Equipment	125 "	
Gas for 5 hr. at 12 gal. per hr.	1080 "	
Oil, 16 gal.	125 "	
		1670 lb.

Carried over -		1670 lb.
9 passengers	1530 lb.	
Baggage & Mail	800 "	
Pay load		2330 lb.
Useful load		4000 "
Gross weight		9900 "

Useful Load - 4000 lb. range 750 miles

Crew (2)	340 lb.	
Equipment	125 "	
Gas for 7½ hr. at 18 gal. per hr. per engine	1620 "	
Oil - 24 gallons	185 "	2270 lb.
9 passengers	1530 lb.	
Baggage	200 "	1730 lb.
Useful load		4000 "
Gross weight		9900 "

Performances

Gross weight	9200 lb.	9900 lb.
High speed	128 M.P.H.**	124.5 M.P.H.**
Stalling speed	52½ M.P.H.	55 "
Cruising speed at sea level at 1650 R.P.M.	112 M.P.H.	110 "
Initial climb	940 ft./min.**	880 ft./min.*
Climb in 10 min.	7650 ft.**	7250 ft.**

Performances (Cont.)

Service ceiling	20,100 ft.	19,400 ft.**
Take-off time in still air from land	8 sec.	10 sec.*
Take-off time from water	11 "	16 "

* Department of Commerce test.

** Official test at Anacostia, D.C. Naval Air Station.

Note.- All performance data was obtained from flight tests. (The setting of propellers remained the same during all test.)

Fig.1

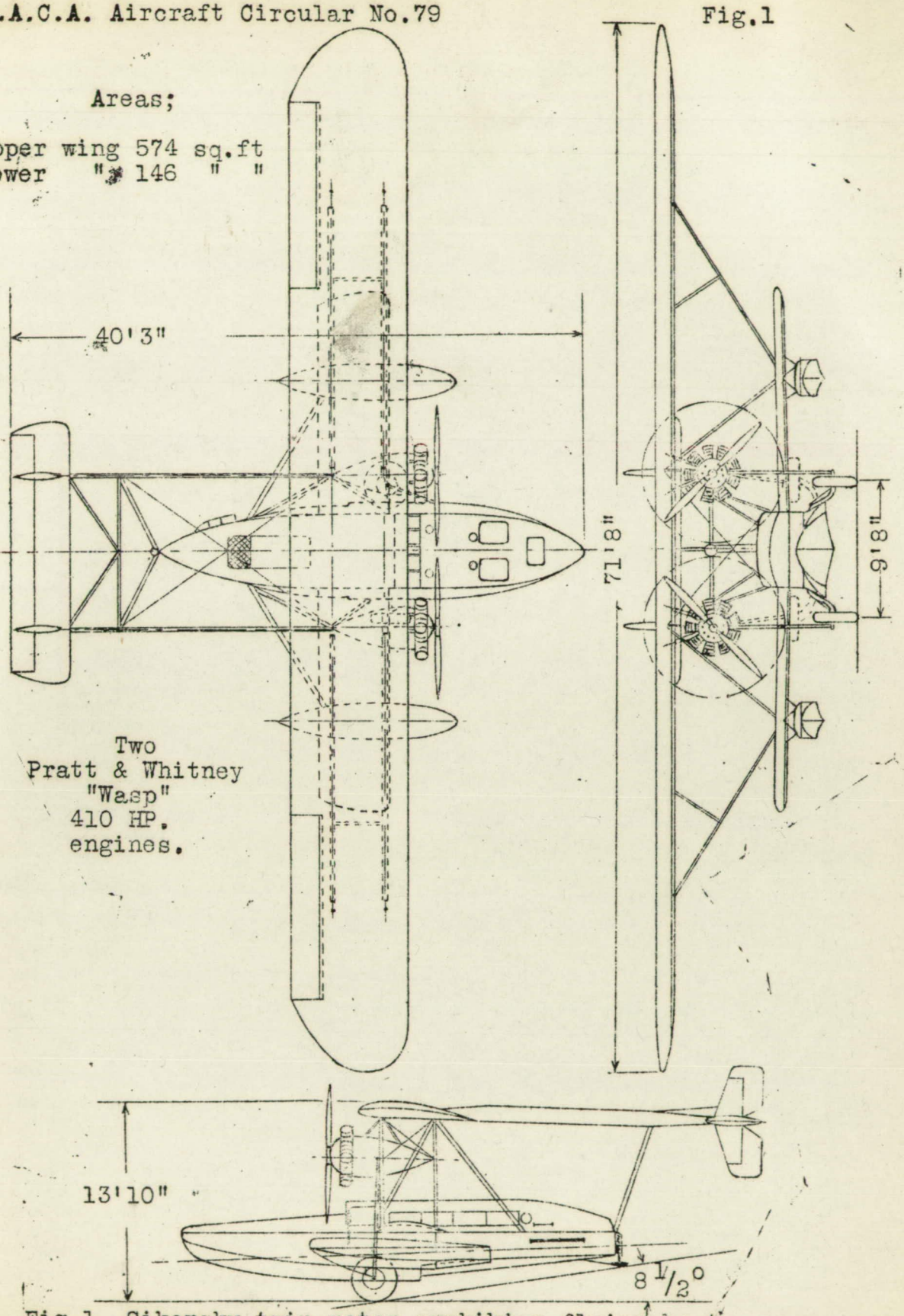

Fig.1 Sikorsky twin-motor amphibian flying boat Model 1928.

Fig.2 View of the Sikorsky S-38 amphibian with two Wasp engines

Fig.3 Tail surfaces of the Sikorsky S-38 amphibian

Fig.4 Interior of cabin of the Sikorsky S-38 amphibian

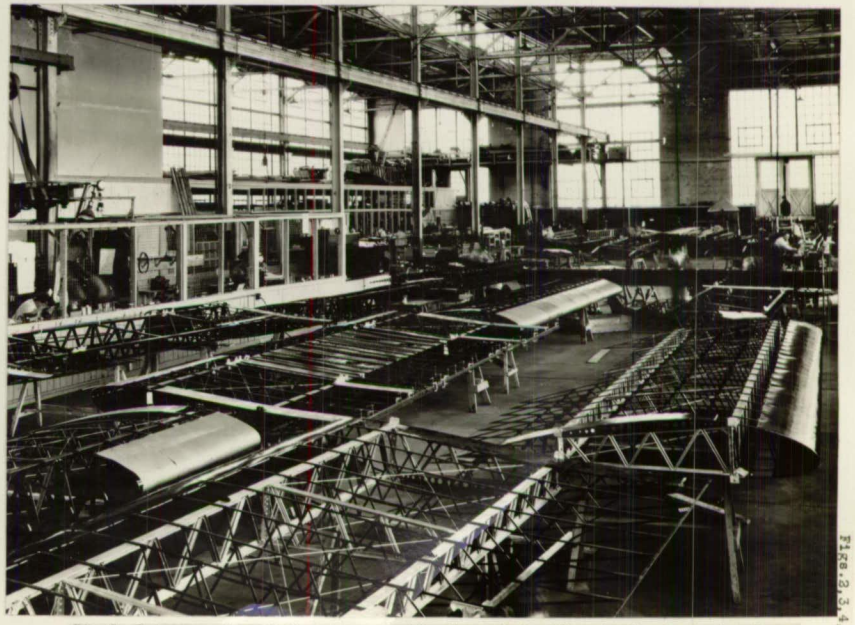

Fig.5 Interior view of the wing assembly shop of the Sikorsky Manufacturing Corp.

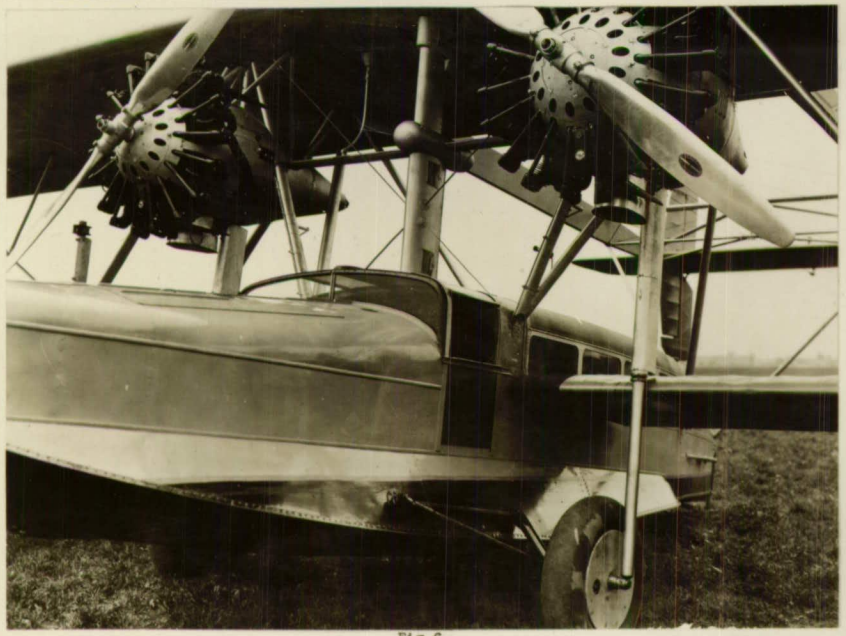

Fig.6

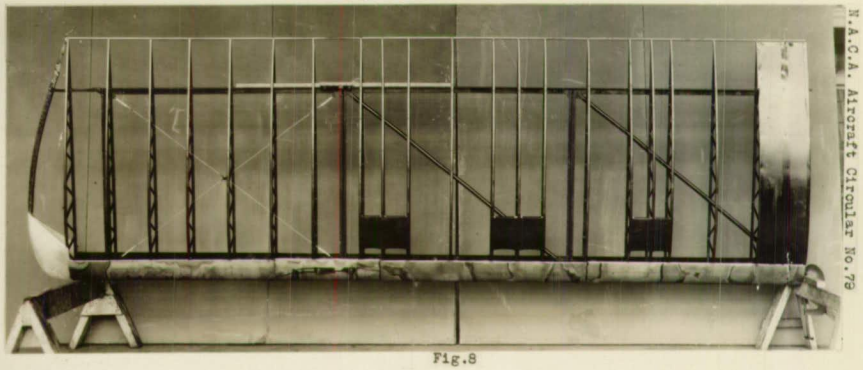

Fig.8

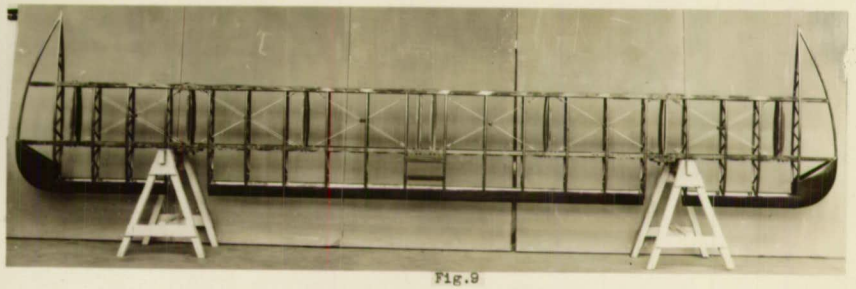

Fig.9

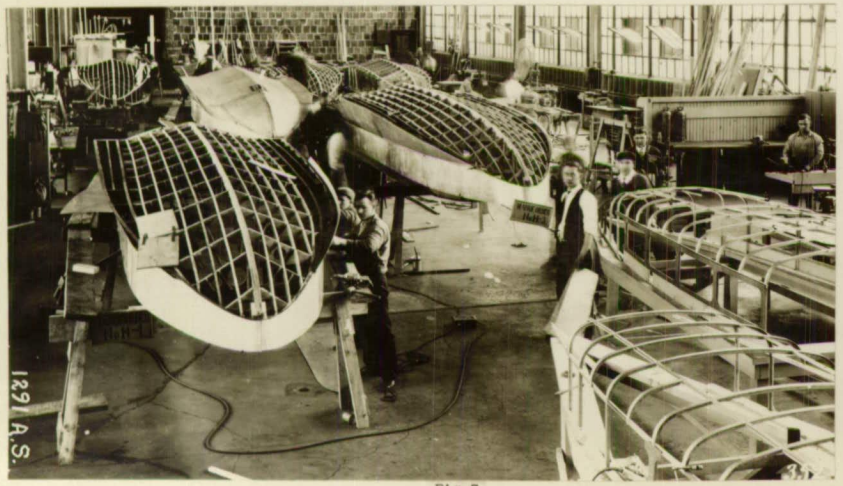

Fig.7

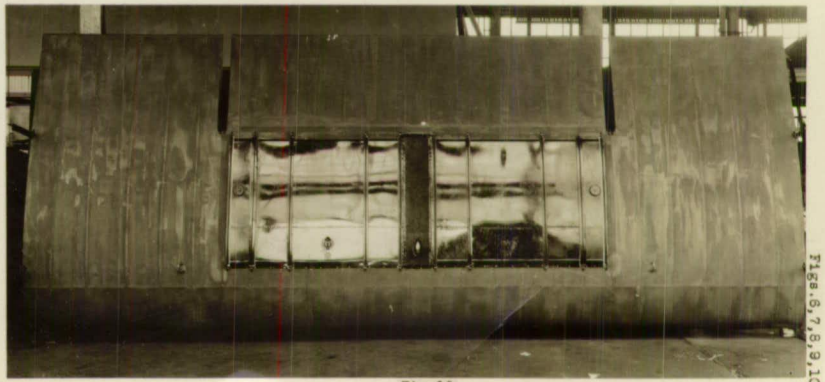

Fig.10