Notes on Seaplane Design.

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THE development of seaplanes has followed very closely and continuously the development of the aeroplane and its engine While there was an apparent lag of some three years between the Wright aeroplane of 1908 and the first Curtiss seaplane of 1911, the intervening period was devoted to persistent experimenting I am not familiar with European experiments during this period, but our first attempt at a seaplane was made with the "June Bug," built by Glenn Curtiss with the late Mr and Mrs Alexander Graham Bell (Aerial Experiment Association) In 1909 Curtiss fitted the "June Bug" with twin floats of boat-like shape The machine did not leave the water although the float system looks somewhat orthodox even to-day The floats would not plane, and, furthermore, there was no margin of power

Realising that the power was inadequate, Curtiss, with a resourcefulness that marks the inventor, abandoned his twin floats in favour of an Indian canoe as a single float to get the minimum resistance to propulsion The Indian canoe has graceful and easy lines and is easy to drive at moderate speeds Curtiss's 1909 Gordon Bennett Cup winner had ample power, and, with the canoe added as a float, he succeeded in leaving the water in 1910, but crashed badly in landing The light canoe construction was obviously unsuitable to withstand the shock of landing at high speed This partial success pointed the way, and to avoid loss of time during the winter months, Curtiss established a camp at San Diego, in California, where certain naval officers joined him to receive instruction in flying and to assist in the development of a practical naval seaplane From this association, there was born the modern seaplane, and also that collaboration between Curtiss and the Navy which has had such happy results in the fourteen years that have passed since that time

The experiments of the winter of 1910-11 were most fruitful On January 28th, 1911, Curtiss flew from and alighted on the water, using floats of wing section On February 17th, he alighted alongside U S S "Pennsylvania" and was hoisted aboard , was then hoisted out and got under way and flew back to his camp on North Island For this experiment, he had a flat-bottomed, box-type float which proved relatively very successful

We must remember that these early experiments were tentative, and many suggestions were tried which, with our present knowledge, we should consider *a priori* as unsound But we are engineers and not inventors, and perhaps somewhat too conservative in feeling However, it seemed clear then, that a seaplane float

https://doi.org/10.1017/S2976693100000727 Published online by Cambridge University Press

should not be boat-shaped, but box-shaped, with a flat planing bottom In order to have aerodynamic control at starting the rear edge of the box float could not be too far aft The rear edge, cut off square, acted as a step The early box floats suffered, therefore, from deficient flotation aft, and the tail was prone to drop into the water They also were inclined to porpoise when planing, due to the flat bottom, and it was soon found important to delay planing until aerodynamic control was obtained from speed

Not distressed by these obvious defects in the first seaplane, Curtiss proceeded to make his seaplane amphibious In July, 1911, the " Triad " was demonstrated both on water and on land

It is of interest to note, at this time, the landing of a Curtiss land-type aeroplane on an extemporised flying deck with sand-bag arresting gear, on the U S S " Pennyslvania " (November, 1911)

The defects of the flotation system were nevertheless realised, in spite of the success of this first machine, and during the summer of 1912 Curtiss fitted a seaplane with a long float, making our first flying boat To permit planing, the flat bottom of the boat had a knuckle amidship, which was replaced by a step, substantially as we know it to-day

The development up to this time had been largely concerned with the central-float type, and involved provision of lateral stability by means of wing floats These were at first simple cylinders under the wing tips fitted with paddles to force them to leave the water as speed was acquired

For smooth water, such floats were effective enough, but in rough water the wing floats were apt to be torn loose Also the flat-bottomed, main float was far from satisfactory in rough water

The engineering phase of our seaplane development I consider to have commenced with Naval Constructor H C Richardson's work in 1912 He ran a comprehensive series of tests in the Experimental Model Basin, Washington, on models of seaplane floats, and showed clearly the effect of the form of the float on its water performance The tank brought out the advantages of Vee-bottom, long easy form with a single step and correct rise of after body The best tank models were tried full-scale, and proved that at corresponding speeds the tanks tests gave a correct indication of full-scale performance

Since 1912 all of our floats have been based on tank experiments, and progress since then has been consistent The general form of long float was evolved by Richardson in 1912-13, and, in the succeeding years, has come to be typical of American seaplanes It has, however, been modified from time to time as conditions of service became more severe

The practical conclusions from our experience may be summarised briefly as follows —

(*a*) The original single-float type with improved wing-tip floats has been found more rugged than the twin-float type for use in the flying school, gives better protection to the propeller from spray, is cheaper in first cost and in maintenance, and is more suitable for catapulting It is not suitable for high-powered seaplanes of short span (*b*) The twin-float type has been found suitable for high-powered machines, for torpedo-carrying, and for rough-sea work

(*c*) The small flying boat has been found dangerous for school work as compared with the tractor type on floats The flying-boat type is necessary for very large machines when the twin-float design becomes structurally weak and heavy

(*d*) The normal twin-floats should have at least 90 per cent excess buoyancy, although 80 per cent is enough for harbour work, or even less for the single-float type

(*e*) Our normal float has a beam about 13 to 14 the length, and a depth 75 of the beam The centre of buoyancy is 06 L ahead of the step The Vee-bottom is 15° for low-powered machines and 25° for high-speed, high-powered types The step depth is one-twelfth the beam

(*f*) The necessary beam of flying boats is approximately expressed by $B = 4\ 5\ \sqrt[3]{W}$ This gives about 100 lbs per inch width for a 10,000-lb machine For a single-float type, I use $B = 2\ 78\ \sqrt[3]{W}$, and for twin floats, $B = 4\ \sqrt[3]{W}$

(*g*) The stability on the water of a float seaplane should be satisfactory if the lateral metacentric height is equal to the longitudinal metacentric height and exceeds $G\,M = 1\ 4\ \sqrt[3]{W}$ For single-float types and flying boats, the righting moment due to submerging a wing-tip float should be double the upsetting moment due to the tilt of the centre of gravity

These are quite arbitrary rules, based on experience, which I have found useful for preliminary design When a seaplane has only a slight margin of power one must provide a relatively broader float, and when the stalling speed is very high, the float must be relatively narrow with a sharper Vee-bottom to prevent porpoising and to delay planing

I trust these empirical rules may be of interest, if not of use, to members of the Institution of Aeronautical Engineers