MODEL FLYING BOATS

J.A. SIZER

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MODEL FLYING BOATS

BY

J. · A. · SIZER

A.R.Ae.S., A.I.N.A.

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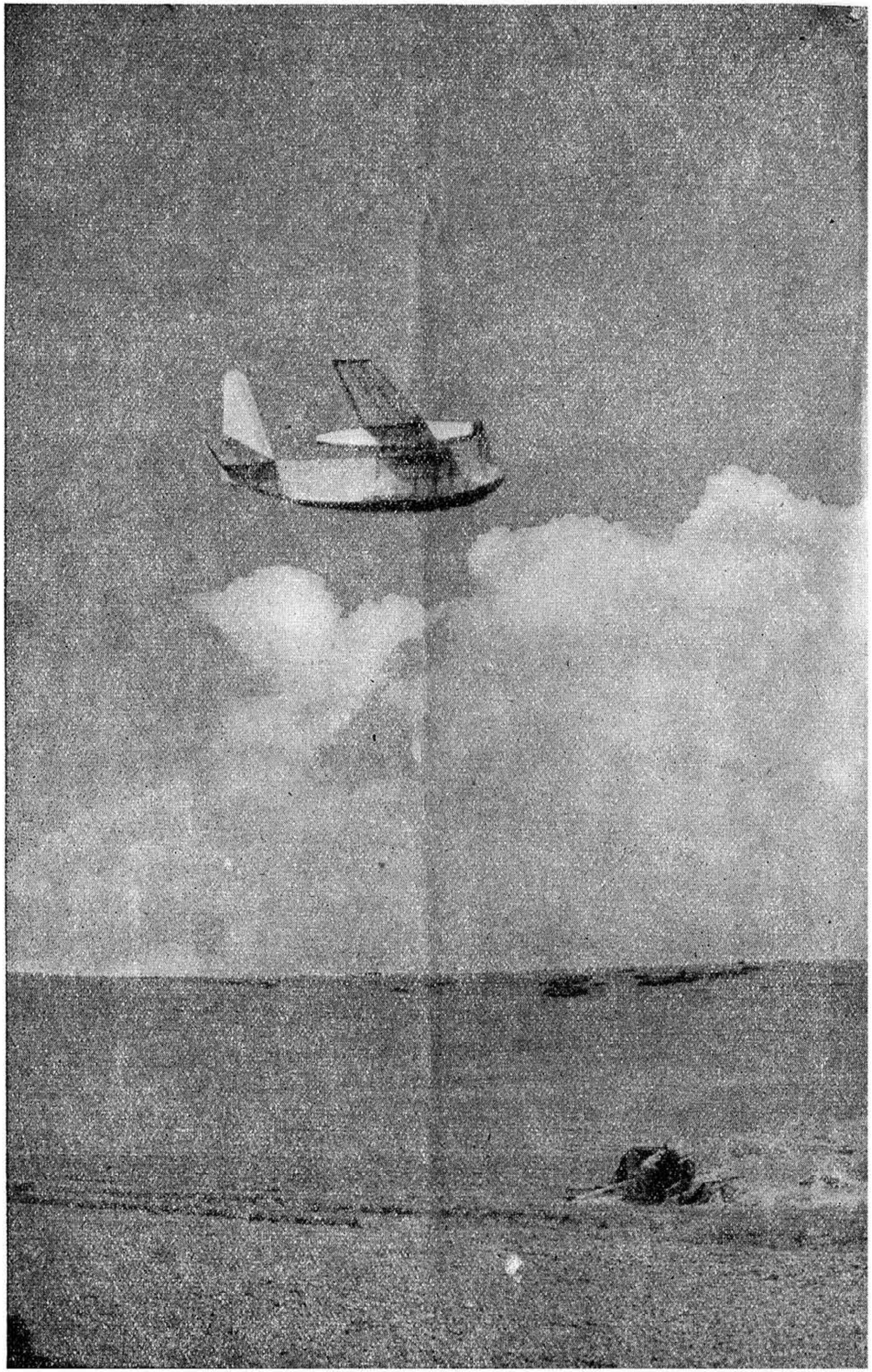


PREFACE

THESE notes are in the nature of an interim report. For two or three years now the author has been building various types of waterplane. Not all of these have been successful, but gradually success has been achieved and it has been possible to make some notes and generalizations.

It is the author's hope that greater interest may be aroused in the design, construction and operation of this type of model, and that is the reason for this little book.

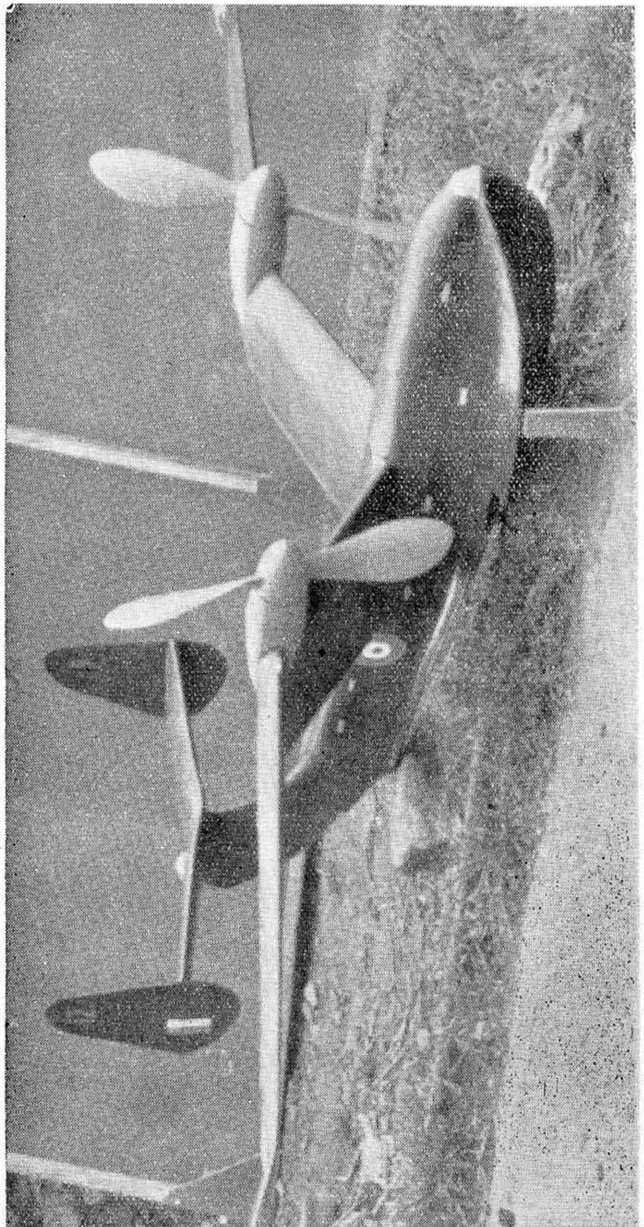
These notes are essentially practical in character and no advanced mathematics or formulae are included unless their inclusion is unavoidable. Title is "Model Flying Boats." The notes are concerned only with rubber driven models, but there seems no reason why many of the design features outlined cannot be applied with success to petrol-driven models or any other type.

Successful design of water-planes requires a basic knowledge of the principles of hydrodynamics—the science of the physical features of water and flotation—and aerodynamics. This latter subject has been fully and excellently treated by various *Harborough* publications. Although the principles of hydrodynamics may be reasonably well understood by many readers the application of this data to low speed model water-plane work still awaits experimental proof. The author has been able to go some little way in this direction.

There is still much to learn in the evolution of a successful design of model water-plane. In hardly any other field of aero-modelling are there so many unknowns and variables. This fact in itself adds tremendous incentive to the keen modeller.

J. A. S.

Farnboro',
Hants. 1943.



"The Gull." A 52½ in. span twin engined Flying Boat built by Mr. A. K. E. Gyford. Full-size detailed plans for building this excellent model are available through the AEROMODELLER Plans Service, price 4/6 post free. See further details of Plans Service on pages 46/47.

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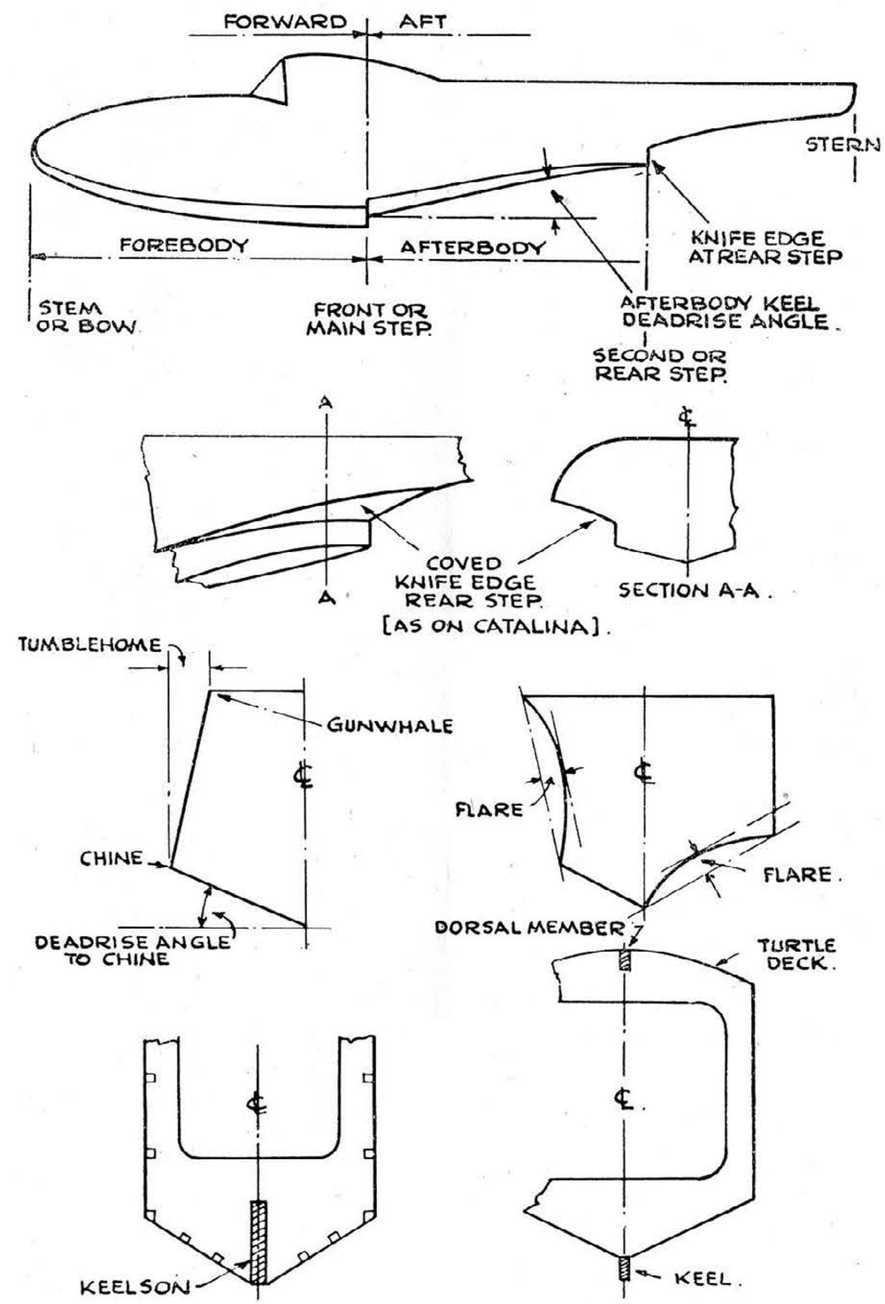
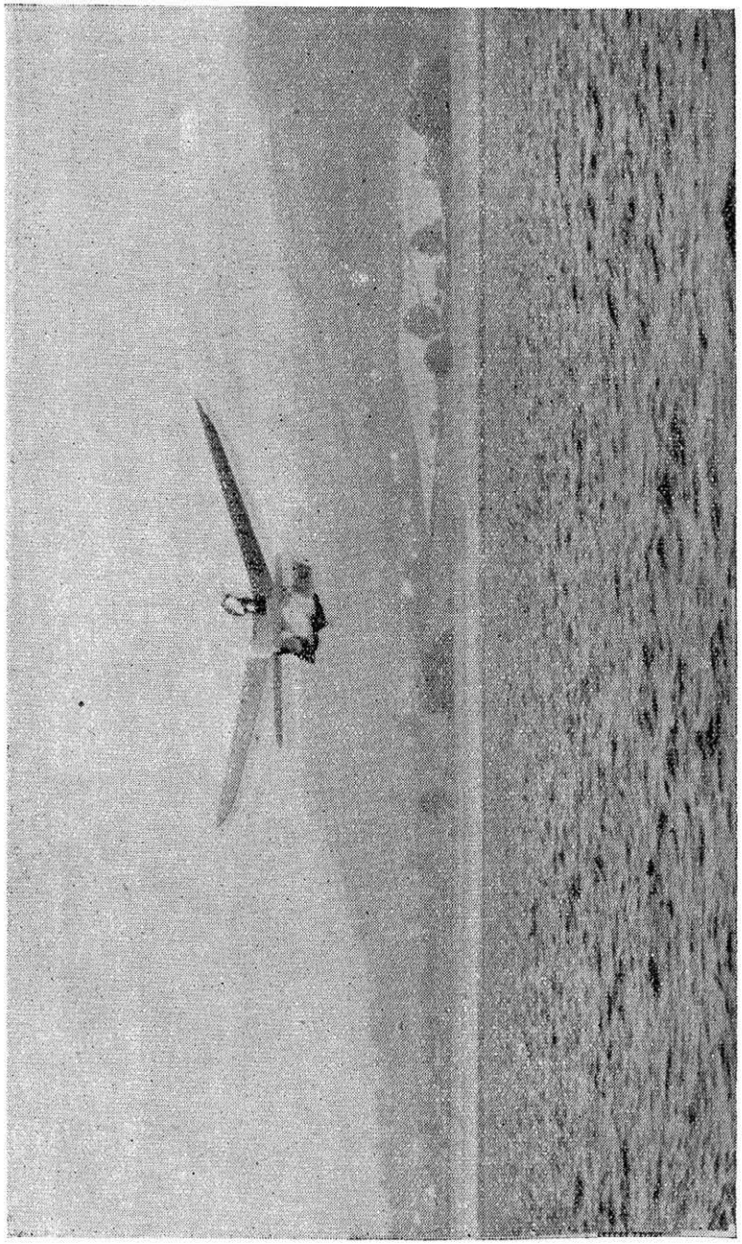
HULL NOMENCLATURE

Abaft	Nearer the stern than an object e.g. abaft the main step.
Abeam	Directly at right angles to the fore and aft line. Abreast on the beam.
Aft	Towards the stern, from amidships.
Afterbody	Hull structure aft of midships.
Athwartships	Crosswise, sideways, beamwise.

Beam	Maximum width of hull on load water line.
Beam Coefficient ..	A coefficient used for expressing beam in relation to all-up weight. In full-scale practice has symbol C_{Δ}, equal to $\dfrac{W}{63.4 \times b^3}$.
Beam loading ..	In model work, all up weight in ozs., divided by beam in inches.
Bows	Nose or front sections of a hull or float.
Buoyancy	The measure of flotation of a floating body.
Buttock-lines ..	Vertical sections of a hull body plan taken longitudinally.
Centre of Buoyancy	The point through which the forces of Buoyancy act. Also called the "centre of flotation." Abbreviation C.B.
Chine	The intersection of the planing bottom with the hull side.
Deadrise	An angle in the planing bottom below the water-line.
Dorsal	The top central longitudinal member, above the keel, below the deck.
Drogue	A cone-shaped bag of canvas or other similar material used to aid manoeuverability on the water.
Flare	The outswept curvature of the hull or float side from chine to Gunwhale, or the sweep inward of the planing bottom from keel to chine.
Freeboard	Vertical distance between waterline and Gunwhale.
Keel	Central external member at the bottom of the hull or float, on the C/L.
Keelson	Central internal member at the bottom of the hull or float on the C/L.
Offsets	Table of dimensions of widths, depths, heights etc. on lines plan.
Port	The left-hand side looking forward.
Starboard	The right-hand side looking forward.
Tumble-home ..	The inwards slope of the hull side towards the C/L above the chine.



· HULL NOMENCLATURE ·



One of Dr. Forster's flying boats in flight. A fine pcture of this machine just about to take off is printed in the centre pages of this book.

MODEL FLYING BOATS

Physical Features of Water.

The density of sea-water is 64 lb. per cubic ft. ; the density of fresh water is 62.4245 lb. per cubic ft. Sea-water is 800 times heavier than air, fresh water 780 times. That is one reason why more power is required to achieve take-off in water-plane models than in land types. Relative density of water is 1.00 at 4° C. (39.1° F.). Water has high viscosity and tends to stick to anything moved through it. Turn your bath-tap on and hold a spoon under or in the stream. The flow of water will follow the contour of the spoon. The greater the speed of flow, the greater the suction. This consideration must be borne in mind as one of the factors affecting the shape of the underwater surfaces of the water-plane's hull or floats.

The suction effect must be broken down in some way, and this is done by providing steps in the hull bottom, or it can be achieved by introducing a layer or stream of air between the planing bottom and the surface. Another method consists of a sharp change of section analagous to a step.

Flotation.

All floating vessels displace their own weight in water. That means to say that if a floating vessel weighs 62.5 lb. it will displace one cubic foot of water (fresh) which also weighs 62.5 lb. The volume of displaced water is exactly equal to the volume of the vessel up to the water-line. An upward thrust, keeping the vessel afloat, is acting on the vessel equal to the total weight of the vessel, and we call this the "Force of Buoyancy".

This force acting through the Centre of Buoyancy, need not always act through the Centre of Gravity, although in some cases it does so. When a vessel is floating freely, the Centre of Buoyancy (C.B.) lies on the same vertical line, though not necessarily in the same horizontal plane.

Longitudinal Trim.

If the buoyancy of a model hull is greater *ahead* of the C.G. (i.e. if there is greater hull volume ahead of the C.G.) the model will sit on the water stern low (called "Trimmed by the stern") due to the clockwise moment of the Force of Buoyancy acting through C.B.

Trim by the nose is the reverse of these conditions. It is thought advantageous to have slight trim by the nose, as then when planing, the planing forces on the underwater-forebody rotate the model to trim by the stern. Trimming moment is *positive* when the model is trimmed by the stern and *negative* when trimmed by the nose.

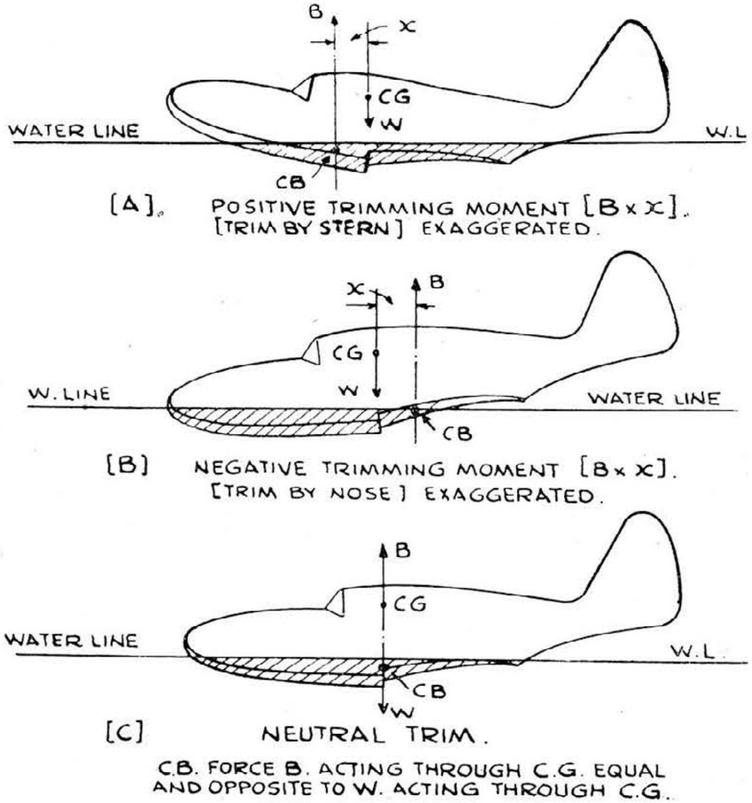
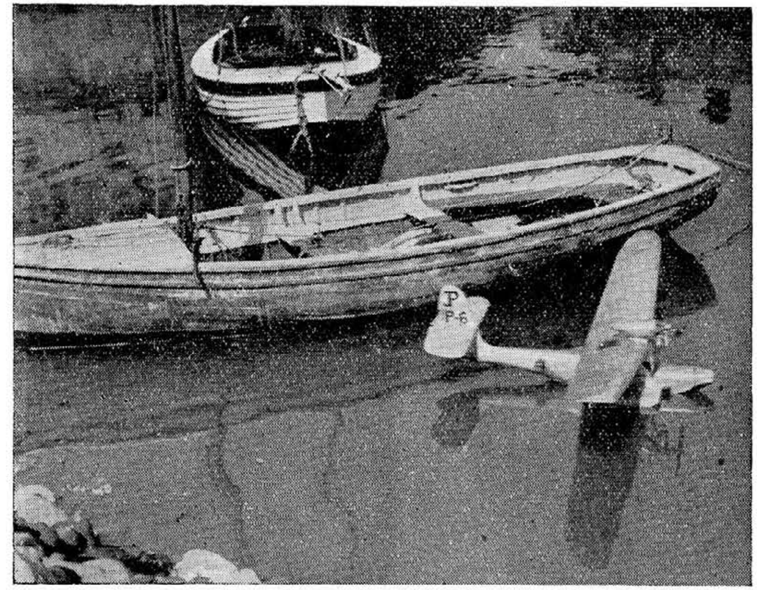


FIG. 1. TRIMMING.

Positive, negative, and neutral trim at rest are shown in Fig. 1. (A) in Fig. 1 indicates that the hull shown has obviously been designed with very "mean" or small afterbody volume. (B) with too great afterbody volume, and (C) has both fore and after-bodies of equal volume. In actual practice, good results seem to be obtained with about 2° trim by the stern, which means to say that the W.L. (water-line) is rising towards the tail. Fig. 2 shows the at-rest water-line position



A further view of Dr. Forster's boat at rest on the water. Points of interest are the sponsons, high tail unit, and beautifully graceful appearance of the model as a whole.

and wing-setting of a typical water-plane. The wings had an angle of attack of 4° at rest, but when planing, the model, due to planing forces on the forebody, rotated to trim by the stern giving about 6° wing incidence.

Lateral Stability.

Fig. 3 shows the three basic conditions of Static Stability. These are Stable, Unstable and Neutral. (A) is the Stable condition to be found in ship and surface vessels of con-

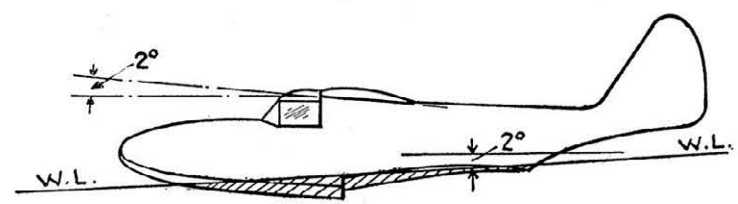


FIG. 2. TRIM AND WING SETTING.

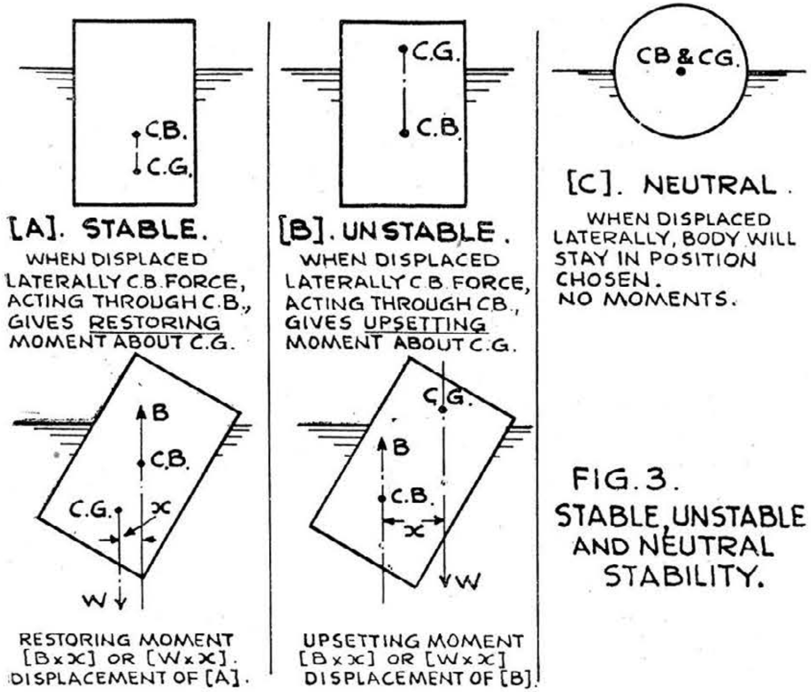


FIG. 3. STABLE, UNSTABLE AND NEUTRAL STABILITY.

ventional design. (B) is the Unstable condition to be found in almost all flying boats and water-planes generally. (C) is the Neutral condition to be found in, say, a rubber ball or similar floating object having its Buoyancy force acting through the Centre of Gravity in any condition or displacement laterally. In (A) it can be visualised that when the body is displaced through a given angle laterally the C.G. and C.B. forces act *favourably* to restore the body to its original state of rest. In (B) any displacement laterally through an angle (however small) will be *aggravated* by the moment of C.B. forces about the C.G., until the C.G. reaches a position similar to that shown in (A). In (C), neutral stability is indicated. It will be apparent that no matter how this body is displaced laterally, it will just stay there. It is the condition (B) which is, unfortunately, the state of affairs we are concerned with in model water-plane design. To overcome the instability, which results from having airscrews and motors, wings, tail, etc., clear of the water, provision has to be made

for some sort of aid to be given the model, to keep it upright. In the models used for tank tests in the Froude tank at the N.P.L. and at other research establishments, hulls are supported on recording beams and generally, no wing floats are fitted.

Metacentric Height.

The size of lateral stability aids such as floats, sponsons, etc. depends on the weight of the model, the metacentric height (*see* Fig. 4) and the type and position of the float or sponson. Fig. 4 shows how metacentric height is determined. A typical hull is shown heeled over through an angle of $\theta°$. The water-line has changed from W.L. to W^1L^1. Assuming that displacement remains constant and that the C.G. is unaffected by the lateral rotation (i.e. there are no movable weights in the hull to slide to one side or the other), then the volume of shaded wedge $W.S.W.^1$ = volume of shaded wedge $L^1.S.L.$ As g (the Centre of Gravity of the *emerged* wedge) moves to position g^1 (the Centre of Gravity of *immersed* wedge) the C.B. moves from position B to B^1, while the C.G. remains at G. The weight of the model, W, acts downwards through G while the buoyancy (equal to W) acts upward through B^1, thus forming a couple $W \times G.Z.$ The moment of this couple

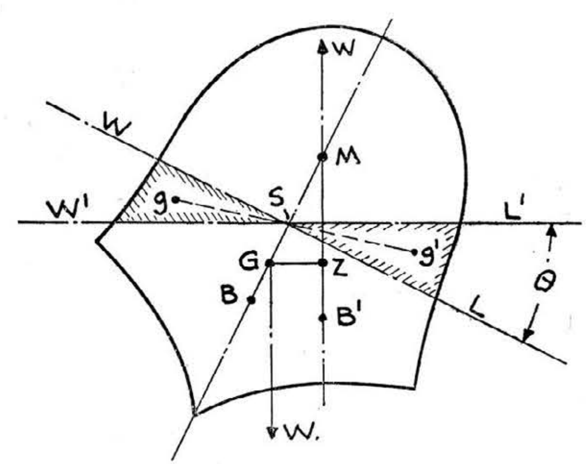


FIG. 4. METACENTRIC HEIGHT.

is called the "Moment of Statical Stability" for a given angle of inclination. The term "Transverse Metacentre" is used to define the point of intersection M, between the vertical centre line of the hull, and the vertical line through B^1 in the inclined position.

The model's underwater form and its displacement determine the position of M. The distance of G from M is known as the "Metacentric Height" and is *negative* in the case of almost all water-planes, i.e. M is *below* G, and the model is laterally unstable. *Positive* metacentric height, i.e. when M is *above* G is attained in almost all ships. *Neutral* metacentric height is attained when M is coincident with G.

Size of Wing Floats.

In full size flying boat design the following formula or variations of it is used to determine the size of wing tip floats—

$$R.W. \quad (h + \sqrt[3]{W}) \sin \theta \text{ lb. ft.}$$

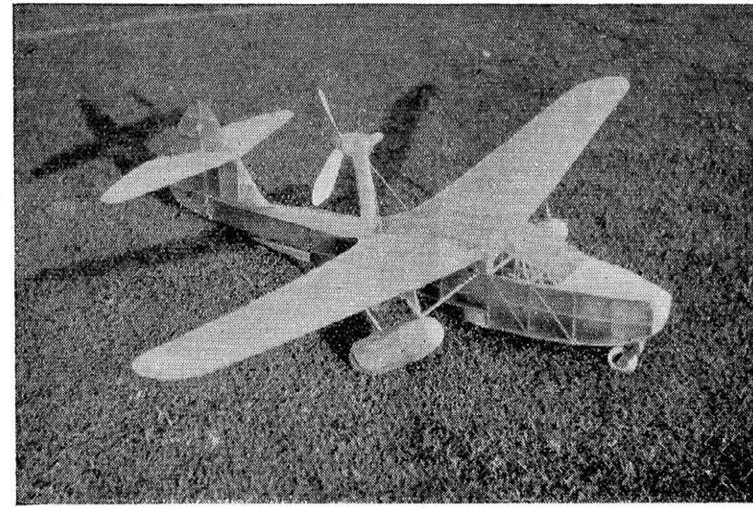
where W = all up weight of machine in lb.

h = negative metacentric height of hull in upright condition, in feet.

θ = angle of heel or roll to submerge completely a wing float (if θ is less than 7°, the value $\theta = 7°$ is to be used in the above formulae).

R = a coefficient depending on the value of W, determined from the considerations of the all up weight of the aircraft.

It has appeared to the author that for rubber-driven flying boats a simpler method of arriving at wing tip float sizes can be used. Since it is impractical, from a take-off and general operating point of view, to have wing floats placed at any great distance from the centre line of the model, inboard floats placed at 1/3 of the semi-span from the hull side have been found to give good results on two successful models. The tendency for a float to "dig-in" due to the torque of the motors, is still there of course, but the moment of the drag due to increased draught of the float so loaded (by torque) is reduced, and before it has time to become serious, the model is airborne. Reference should be made later in these notes



A three-quarter view of Mr. H. J. Towner's model of the Spencer-Larsen amphibian. Note the three-bladed airscrew. Plans for building a 68" wing span flying model of this amphibian are available through the AEROMODELLER *Plans Service.* *See pages* 46–47.

to some possible rearrangements of basic design to give enhanced water performance.

The volume of the float should, we believe, be determined by associating it with the type of hull used, and the displacement of the hull. Considerable experiment is called for in this direction, as very little information, if any, is available on the correlated volumes of hull and floats. We can, therefore, only present to readers the results obtained so far from two successful models.

Satisfactory righting moment can be obtained from floats having a displacement of one-tenth to one-twelfth of the hull displacement, and placed along the wing to give a satisfactory righting moment without creating serious swing during take-off.

It is possible to make the hull of sufficient beam to dispense with the need for aids to lateral stability, but our experience has been that unless excessive beam is resorted to, wing tips will come in for a ducking in any gusts of other than zephyr intensity. When a good layout of side floats has been achieved, dihedral can be reduced to that used in conventional model design. If it is obvious that the floats have insufficient righting moment, the cause may be due to one of four things, or a combination of them, as follows :—

1. Too much dihedral.
2. Float volume insufficient.
3. Float distance from centre line of hull not great enough (insufficient righting moment).
4. Punctured float.

If the model, at rest, submerges a float to what appears to be a severe degree, either the float should be moved outboard along the wing, or its volume increased. If, in gusts, a wing float is submerged, the float righting moment should be increased (volume × distance from hull centre line) or the wing dihedral reduced. Fig. 5 shows how gusts, acting on the model, may capsize it laterally. No model waterplane can hope to cater for severe gusts, nor can really accurate assessment of the force applied in an upsetting moment be obtained. However, by patient experiment and intelligent observations, good results can be achieved.

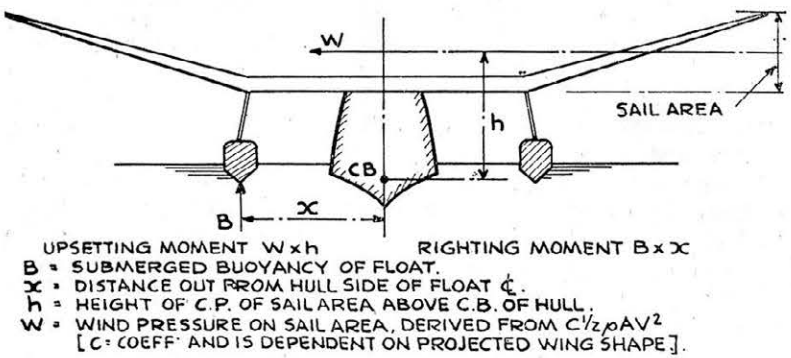


FIG. 5. GUST UPSETTING FORCES.

In full size aircraft it is usual to mount floats so that the bottoms of the floats are clear of the water when the hull vertical centre line is vertical (i.e. a line drawn through the C.B. and C.G. is vertical). The clearance allowed, depends upon the size and duties of the aircraft. In model work however, it is well to have both floats *just* touching the water, as then a swing is minimised on the first burst of power. Floats should not have flat bottoms, especially if covered with tissue. The water will pull the bottoms out in a very few flights, and

whatever material is used, the drag of flat bottoms will be greater. Steps are not necessary in wing floats, but the stern should terminate in a vertical knife edge.

Float volume will be sufficient for a model of about 10 oz. all-up weight if the conditions in Fig. 6 are met. This takes into account normal gust upsetting forces but it is only related to a certain type of hull design and arrangement.

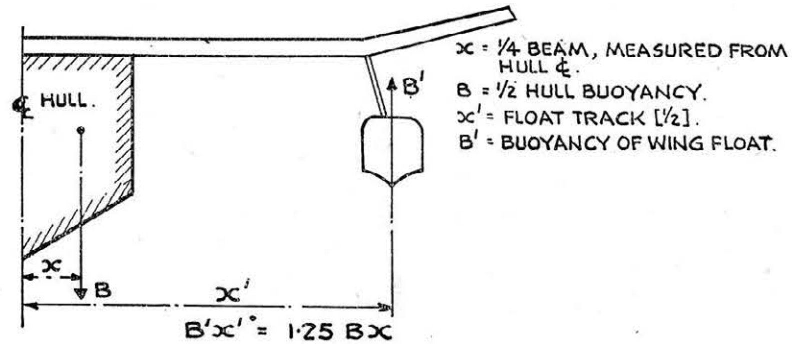


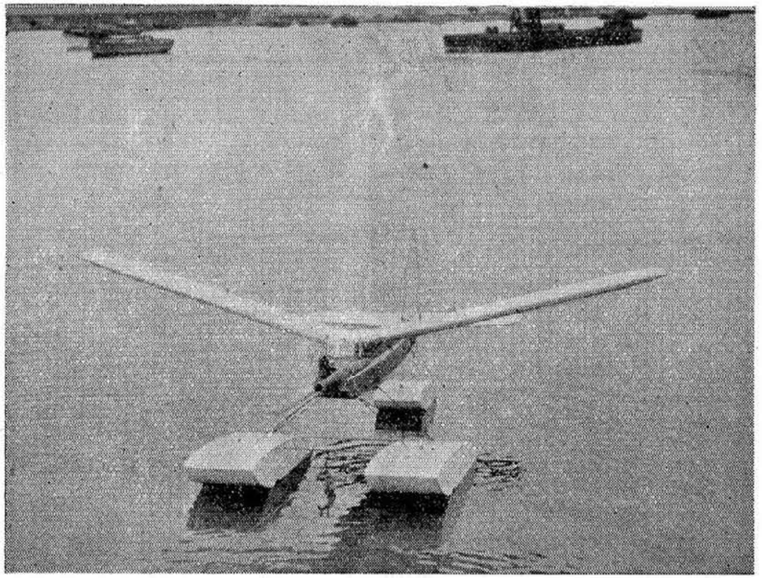
FIG. 6. INBOARD WING FLOAT VOLUME.

Choice of Hull.

Before we can choose the type of hull to be used in a model flying boat we must consider the functions performed by the hull. A hull must give low air drag and low water drag. It must be light, yet strong enough to withstand reasonably rough treatment. It must plane well and not be "dirty" running—that is, make a lot of waves and spray. It must be long enough on the water line to provide longitudinal stability, yet not too long to prevent it trimming by the stern to get on to the step when planing. It must be wide enough in beam to obviate too great a draught. It should have watertight compartments or sub-divisions up to the water-line, in case the planing bottom is punctured.

Low Air and Water Drag.

The requirements here are the same as for any model as regards air drag. Since the factors involved in the design of low drag fuselages have been fully covered by various articles in the *Aeromodeller* and in the various *Harborough Publications*, we will not dwell on them here. However, the flying boat model is penalized in the air because of the addition



In this photo is shown a petrol engine driven seaplane designed by Lt.-Col. C. E. Bowden.

of features required to make the hull water-worthy. Steps are necessary except in grossly over-powered models. To enhance its water performance, a hull generally features "dead-rise" angle to the chine, which causes still more air resistance. Furthermore, to prevent the tail unit from receiving continual duckings, it has to be kept well up above the water line, which is not a good thing from air resistance points of view. Fig. 7 shows the variations from a streamline shape, of a typical model hull. The value of the drag coefficient for a hull of this type has not been established as yet for a model waterplane hull, but has been arrived at for tank models of full-size flying boats as compared with a full-size streamline shape. The coefficients are 0.0038 for the streamline envelope (with a fineness ratio of 7 to 1) and 0.0052 for a model of a flying boat hull at a Reynolds Number of 6×10^6.

Factors bearing directly on model water-plane hull air drag are the length-to-beam ratio, the depth-to-beam ratio, the number of steps, depth of steps, and the angles of deadrise (chine and after-body keel). The length-to-beam ratio should

be between 5 and 9. If this is exceeded it will affect air drag adversely, as well as resulting in an unsatisfactory hull profile if the requirements of best waterline length are to be met. The depth-to-beam ratio should not be greater than 2, but to obtain a reasonable hull cross-section this ratio is generally greater than 1. A good average value is 1.5. With regard to the number of steps, one will be sufficient if the model has a small value of beam-loading combined with low power-loading and low wing-loading.

It should not be necessary to employ more than two-steps in the planing bottom of the hull. The number of steps and their location depends upon the arrangement of hull volumes and the type of hull used. The location of the main-step depends upon the height of the centre line of thrust above the centre of water drag, the height of the C.G. above the centre of water drag, and the position of the C.B. The *amount* of thrust also bears upon the location of the main step, as also does amount of forebody volume available. These questions are dealt with in greater detail later.

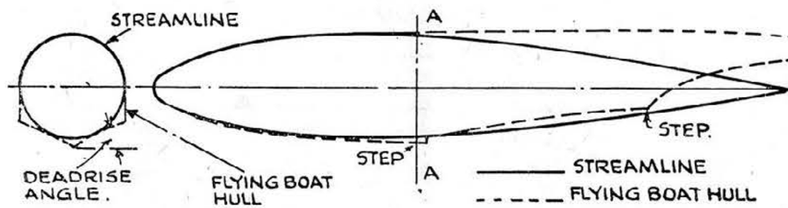


FIG. 7. STREAMLINE ENVELOPE & FLYING BOAT HULL

The second step is more efficient, both in the air and on the water, if made in the form of a vertical knife-edge, because in that form it acts as a keel when the model is trimmed by the stern, just before getting on the step, thus assisting the model in running straight. There are, also, various arrangements of the mainstep in plan-form. Some of these are indicated in Fig. 8. It is doubtful whether the structural complications attending the use of the horizontally vee-ed step are worth the gains in steadier running on the water when on the step, and the slightly lower air drag, as compared with the normal transverse step. The semicircular and semi-elliptical step are quite good—especially the latter—from all points of view except that of construction. But for any new-comer to the sport of water planing, the straight unvee-ed step will give all the satisfaction required.

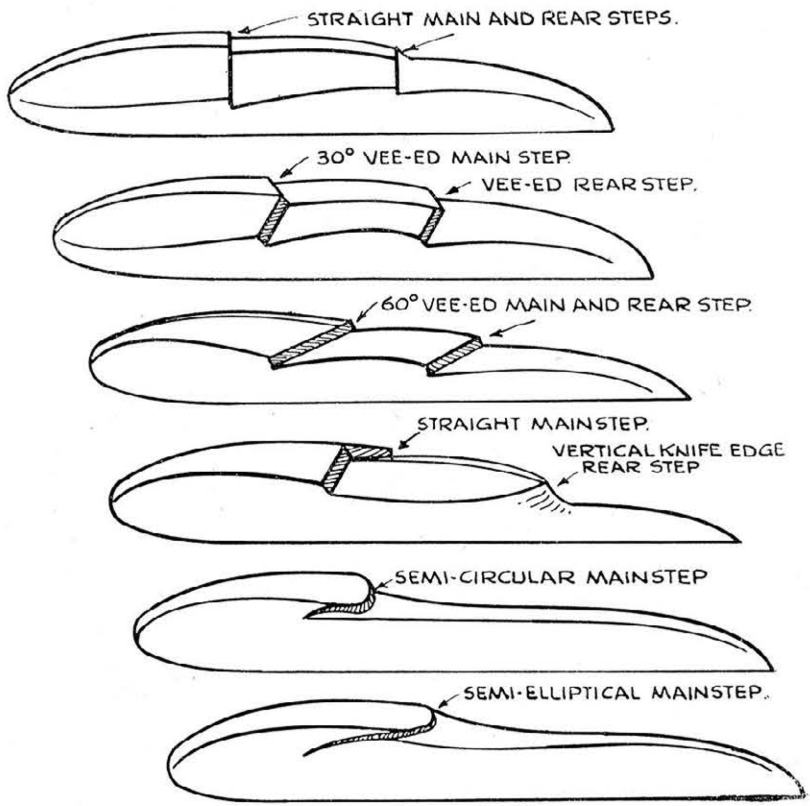


FIG. 8. STEP ARRANGEMENTS.

Incidentally, the idea of using steps in the bottom of a planing surface is due to—whom do you think?—a parson! In 1872 the Rev. C. M. Ramus, who lived at Playden near Rye, in Sussex, developed a hydroplane described as "being formed by two wedge-shaped bodies, one abaft the other." The essential feature of the design was the introduction of what are now commonly known as "steps." The wedge-shaped fore-and-aft bodies tended to lift the boat out of the water on an even keel. Sir John I. Thornicroft showed great interest in the scheme, and developed a variation of the Rev. Ramus's design in 1877.

Step-depth is usually associated with beam and beam-loading, as well as being allied to the deadrise angle of the

afterbody keel. If this angle is fairly pronounced (or large) say, more than 10°, the step depth may be reduced slightly.

In our experiments we have found a step depth of $\frac{1}{12}$th of the beam, (with a beam loading of 3.3 ozs. per inch) combined with an angle of afterbody keel deadrise of 7° to give satisfactory results. The angle of deadrise to the chine is usually made about 15°. From take-off considerations alone, a value of 0°—that is a *flat* planing bottom is best, but this section is liable to run erratically because it is devoid of the "keel effect" endowed by the provision of deadrise angle to the chines. Further, the "flatty" invariably bounces on alighting, with possibly disastrous results. But for small models up to about 8 ozs., the structural complications involved in embodying deadrise in the planing bottom are hardly justified, and thus a flat bottom will provide good results.

Where deadrise angle to the chine is embodied, it should never be more than 22° as values in excess of this cause increased air drag without materially improving water performance. A good average value lies somewhere between 15° and 20°. The junction between the planing bottom and the side of the hull should be clean-cut at the chine (*see* fig. 9A). This prevents water running up from the planing bottom, and clinging to the sides of the hull, as it does if the chines are rounded (*see* fig. 9C). In general, wherever any surface discontinuity appears in the planing bottom it should finish *abruptly* otherwise the suction properties of water are not broken up. Look at any full-size flying boat and observe how this is borne out.

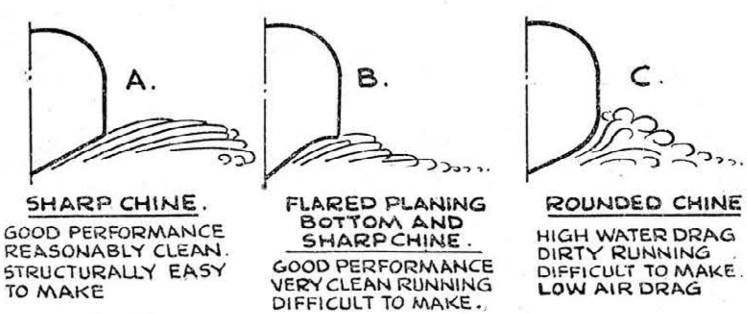
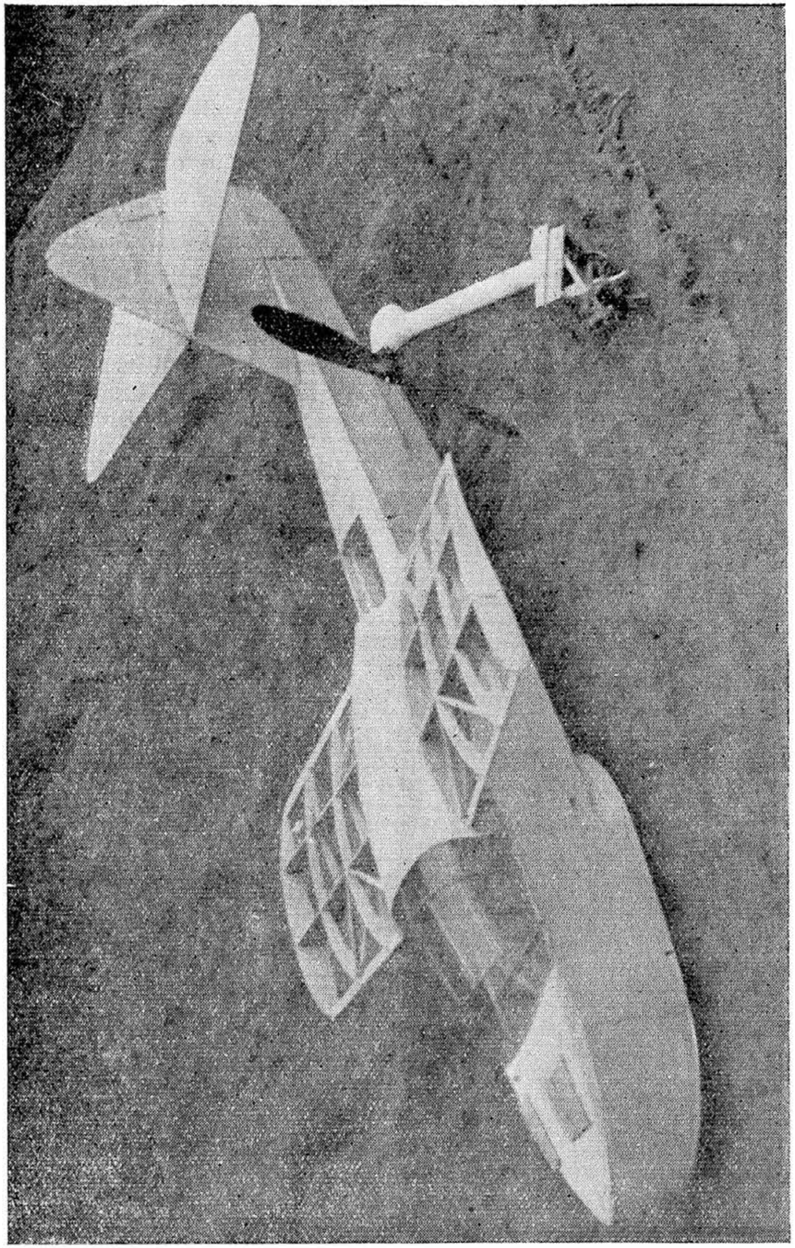


FIG.9. CHINE FEATURES.



The Spencer-Larsen amphibian, designed by Mr. H. J. Towners. Another photograph of this model, showing a three-bladed airscrew fitted, is on page 15.

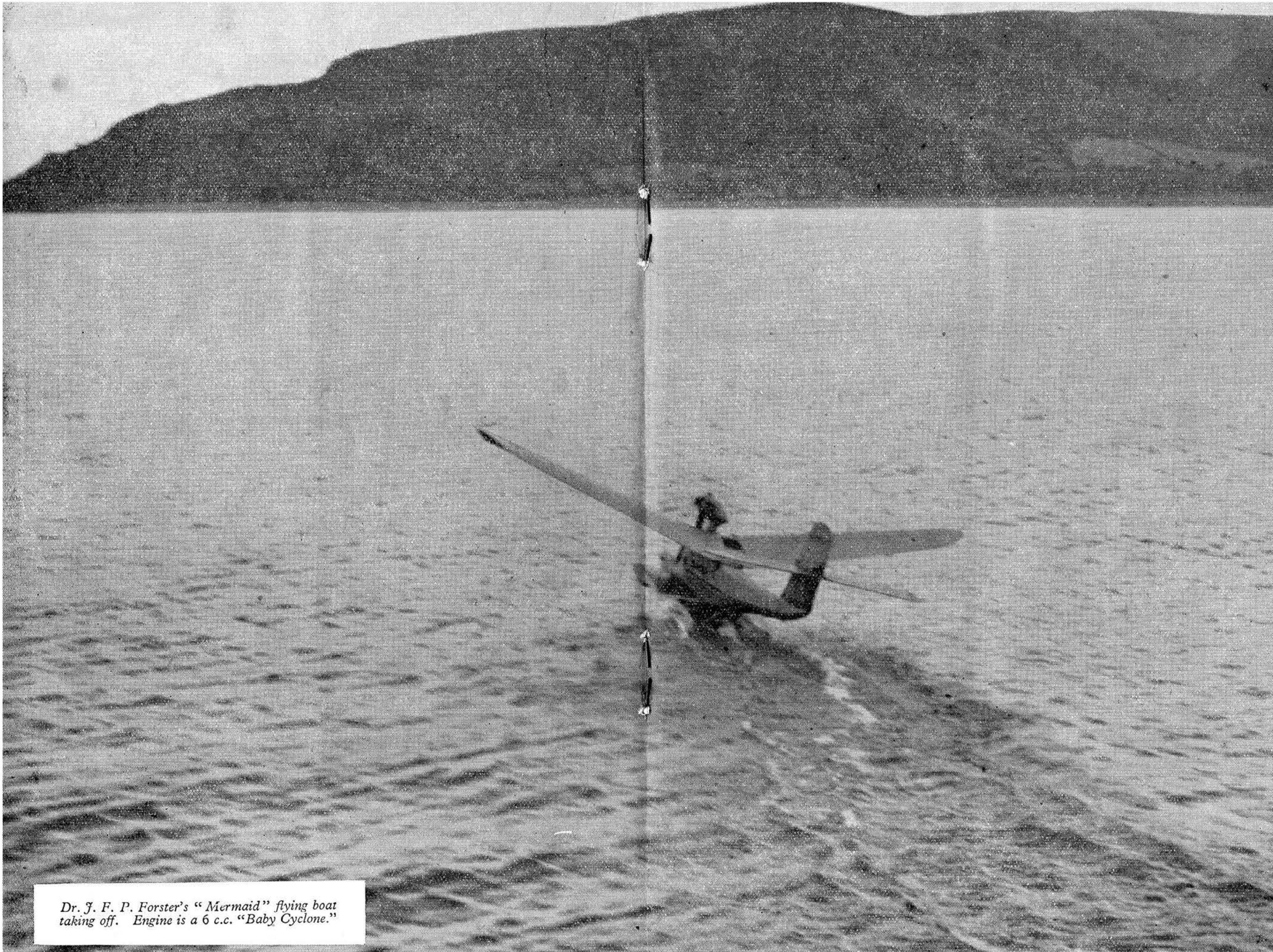
Strength and Lightness.

Unlike the fuselage of the durating landplane model, the hull of a model waterplane does not appear to have been used to hold the power unit. Most experimenters have all their work cut out to achieve satisfactory performance on the water and in the air, and consequently have had to back-pedal in the development of practical hull-borne motors. In the Scutfly Mk. II an attempt is being made to mount the rubber motor in the hull. In general, however, no loads are taken by the hull except those transmitted by the aero-structure and the loads of handling, take-off and alighting. Therefore, the structure requires no great strength except up to the water-line. The keel should be a substantial member to obviate twist. On this backbone depends the truth and fairness of the hull lines lengthwise.

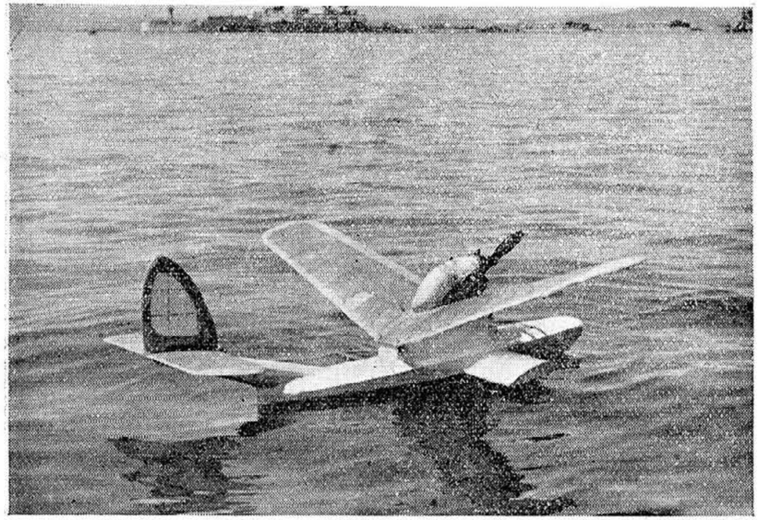
It has been found that tissue, no matter how well doped and varnished, tends to "pant" when used on the planing bottom. It is an essential requirement for efficient planing, that surfaces must be stiff, otherwise a fair proportion of power is spent in forcing the water to work on the planing bottom deflection. In full size practice some elasticity in the planing bottom is required in order to absorb alighting shocks. In view of the above therefore, the planing bottom—especially the forebody—up to the waterline should be covered with $\frac{1}{32}$nd Sheet Balsa, and the frames and stringers should be close together so that large unsupported panels are eliminated. Frames should be no more than than $1\frac{1}{2}''$ apart (station to station) and stringers no more than $\frac{1}{2}''$. In most other respects standard aero-modelling practice may be adhered to. The chine member should be strong because one nearly always finds oneself holding the model somewhere along this member. Its handiness for gripping corresponds to the bottom longeron of the land plane model!

Length on the Waterline.

From the results of our experiments, we feel that the waterline should be parallel to the hull datum. No harm is done if up to about 2° tail down trim (trim by the stern) is allowed. This was, in fact, the position on the Seagull Mk. I. Having the waterline parallel to the hull datum means that there must be the same hull volume ahead of the C.G. as there is hull volume aft of the C.G. This means that, at rest, the model is not trimmed by either the nose or the stern, but is stable.



Dr. J. F. P. Forster's "Mermaid" flying boat taking off. Engine is a 6 c.c. "Baby Cyclone."



A fine photograph of a 6 c.c. engine flying boat built by Lt.-Col. Bowden. Note the length of water-line for longitudinal stability on the water, and the sponsons.

one. Both are bad. From our experiments we have found that a compromise, making the beam about 0.70 of the hull depth gives good results. With a reasonable value of beam loading this gives a draught of about 0.1 times the hull depth which, combined with a deadrise angle of about 15° brings the load water line just at the chine. Here is the guiding principle :—a wide hull will give insufficient draught ; a narrow hull will give too much draught. Some typical hull sections, together with notes on their air and water performance features are shown in Fig. 13.

Further Notes on Hull Design.

The location of the steps is very important. In full size flying boats, British practice is shown in Fig. 14A and American practice in Fig. 14B. We need not adhere to these criteria, but they are a useful guide. Most petrol-engined model water planes—and rubber powered ones also—have the front or main step well ahead of the C.G. It is noticeable that these models are deficient in forebody volume. If plenty of volume is provided ahead of the C.G., a step position as shown in Fig. 14C is quite satisfactory. The distance from the bow

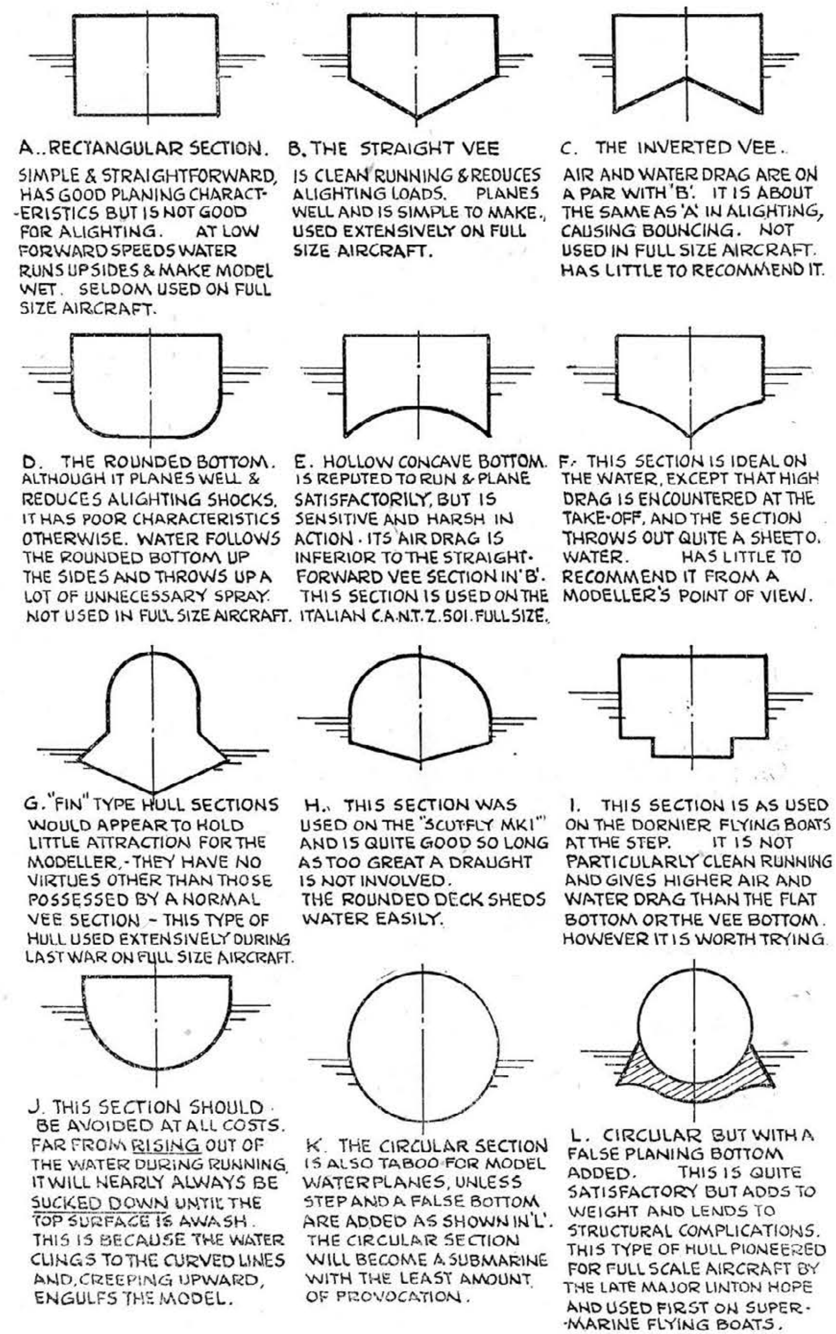


FIG. 13. HULL SECTIONS.

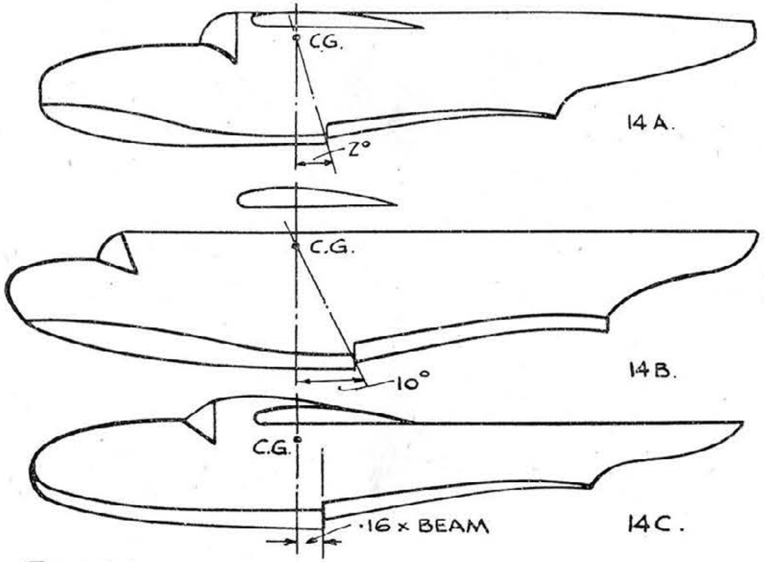
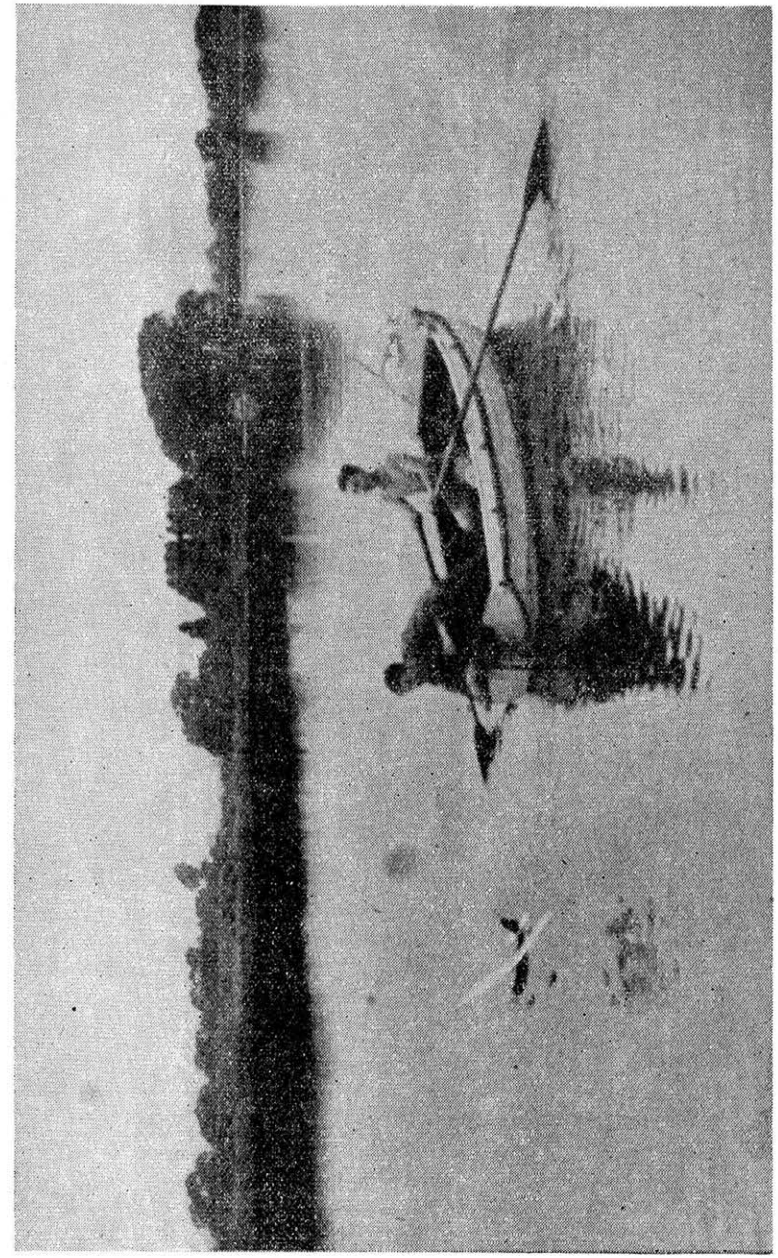


FIG. 14. STEP LOCATION.

or stern to the main step should be about 2.5 times the beam. On page 19 of these notes it was stated that the rear step should be of the vertical knife-edge form. The lower corner of the knife-edge should be about .75 times the forebody length, from the main step. These proportions are indicated in Fig. 15. A water plane model should have at least .75 times the beam for freeboard, to obviate shipping water in ruffled conditions.

Water-tight Compartments.

Being made up of wood, the water plane model will not sink. But it is a good thing to have the hull divided into water-tight compartments; this not only strengthens the hull, but helps one to locate a leak quickly. For instance, if no water-tight sub-division is resorted to, water will collect round about the main step in the bilge. This gives no indication as to where the leak is—whether towards the stern or bow. The compartments are simply made. Build up the frames, up to the water line, with $\frac{1}{32}$ water-proofed balsa sheet (*see* fig. 16).



A model float plane having just left the water. Note that the launching has been away from the boat and not alongside.

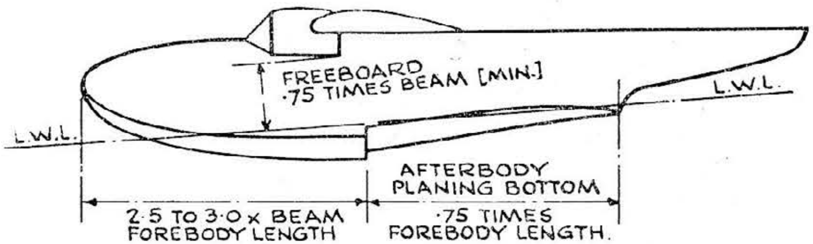


FIG. 15. FOREBODY, AFTERBODY AND FREEBOARD.

Hull Decking.

The top of the hull in front of, and behind, the cabin should be in a gentle curve, from the Dorsal member to the Gunwhale. This sheds water easily and assists in keeping the model dry inside. A flat decking will collect pools of water and give trouble at the seams. The curved decking is known as a "Turtle-deck" and is shown in the diagram of nomenclature at the front of this book.

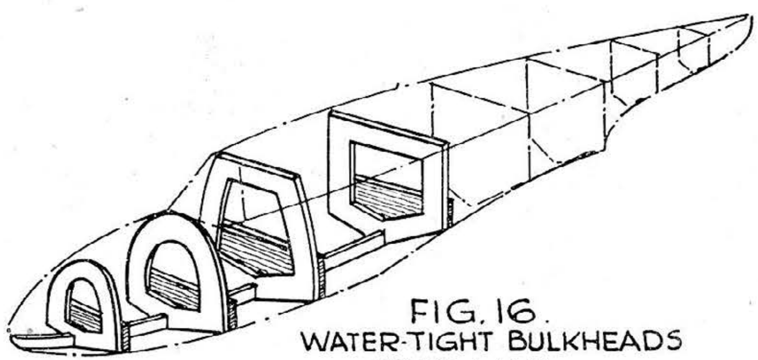
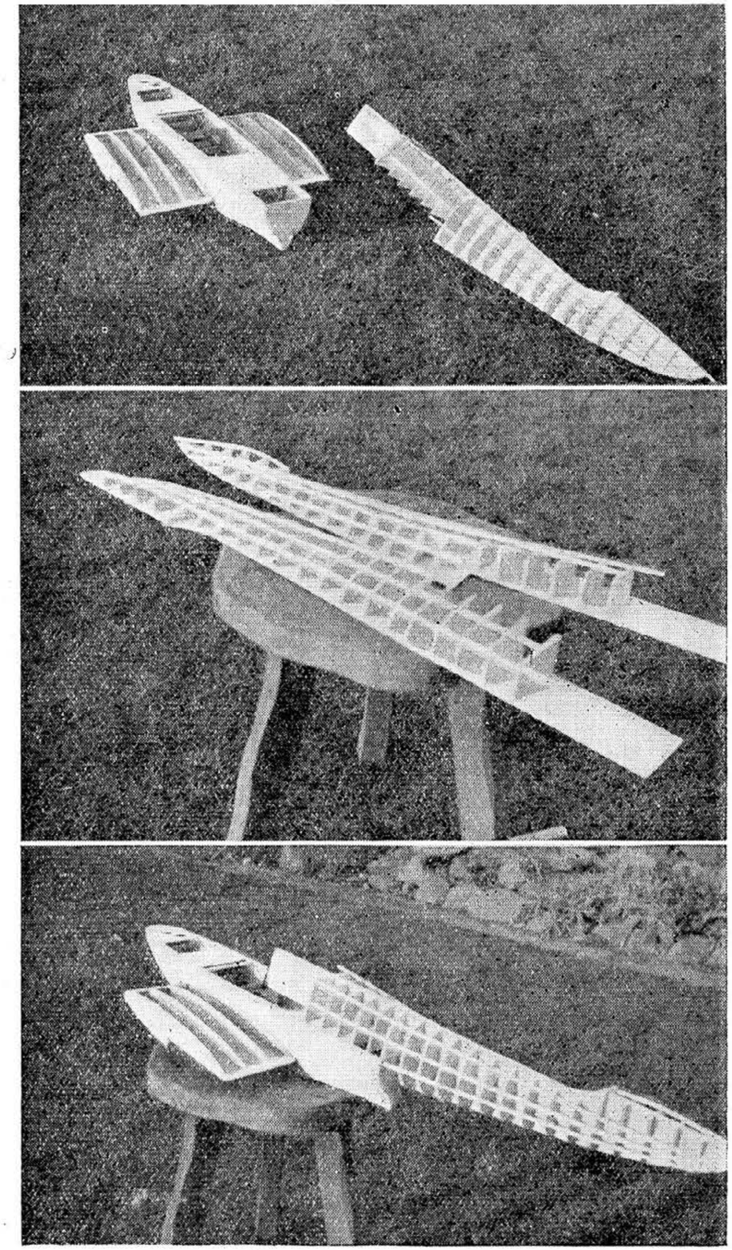


FIG. 16.
WATER-TIGHT BULKHEADS
UP TO L.W.L.

Hull Lines.

A complete explanation of hull lines and the technique of arriving at them would involve a protracted voyage into the oceans of Naval Architecture. For the present purpose therefore, a broad outline will suffice. The "lines" of a hull are usually found on the side elevation and plan view. The "body plan" is really an end elevation of the sections of the hull at each station, arranged on a common centre line (*see* Fig. 17). Water lines (as distinct from *Load* Water Lines) are



In these photographs are shown the construction of a flying boat hull designed by Dr. J. F. P. Forster

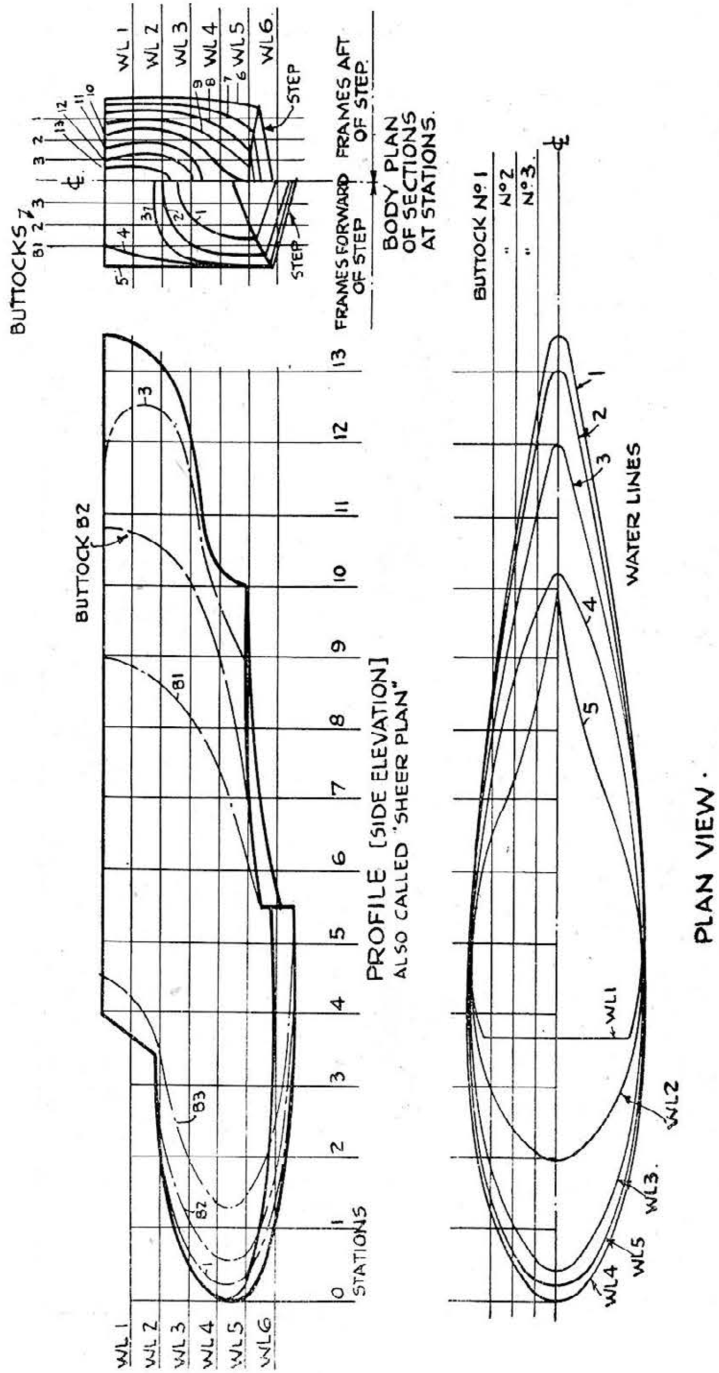


FIG. 17. HULL LINES.

horizontal lines on the *body plan*. They are referenced as WL.1, WL.2, WL.3 . . . . etc. They are used to obtain the "faired" lines of the plan view of the hull. The distance from the centre line of the body plan to the point where the appropriate WL. cuts the sections on the body plan is transferred to the appropriate station marked on the plan view of the hull. All these points, when joined up, should make a "fair" line—that is, there should be no kinks. If there are, then the section on the body plan is not correct and should be altered as indicated by the fair line arrived at in the plan view of the hull. Each water line is placed on the plan view of the hull, in turn, starting, generally, with the WL.1. Each section is altered as and when the plan of the water line shows this to be necessary.

"Buttocks" or "Buttock Lines" are *vertical* lines drawn on the body plan. By means of these, a further check is made on the truth of the sections on the body plan. Whereas WL's govern *widths*, buttocks are concerned with *heights*. Their function is otherwise precisely the same as the water lines, except that they are transferred to the *side* elevation (or profile) of the hull, from the body plan. If the foregoing has been grasped, little trouble should be experienced in laying out the lines of a model hull or float.

Firstly, of course, one has to *assume* a side elevation (or profile), and plan, and one or two (generally mid-ship, bow, and stern) sections. From thereon it is a trial and error process, but after a little practice one becomes instinctively adept.

Finding the Load Water Line.

In order to obtain the correct setting of wing tip floats or sponsons, the tail unit, and other components, it is necessary to have some idea of where the water line at full load—i.e. with rubber etc.—will be. First of all, make an estimate of the weight of the model. Next, draw the side elevation (profile) and body plan ; you will also need the plan view to ensure that the body plan is correct (*see* para. 40). On the profile mark in the stations. These should preferably be about $1\frac{1}{2}''$ apart, but because *stations* are so close together, it does not follow that *frames* should be placed at every station. The stations should be equally spaced. This is important. Next, place in the C.G. of the model. Some guesswork is needed here, but if you have built one or two models before, and read the *Aeromodeller* regularly, you should not be far out !

44. Now mark any *reasonable* load water line A.B. (*see* fig. 18). The point at which this cuts the bottom of the hull (or float in the case of a twin-float water-plane) is called neutral, so, taking the next ordinate, project the point at which the line A–B cuts the ordinate above the bottom of the hull (at X) to the body plan and draw a line X_1—X_2. This is really a projection of the load water line, at that section, to the body plan at that section. Now find the area of the section of the body plan below the recently projected line. This represents the submerged area of the hull (or float) at

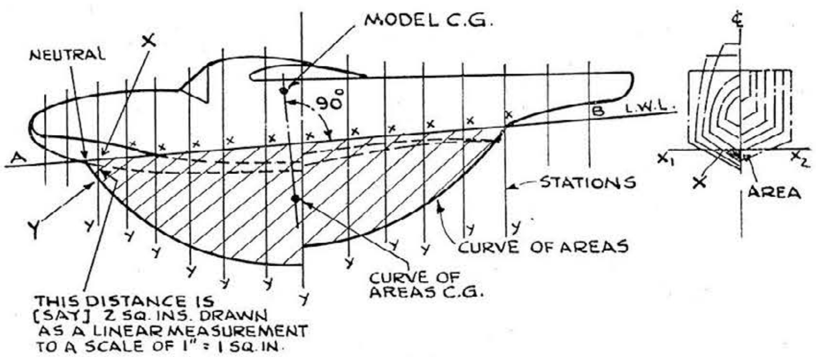
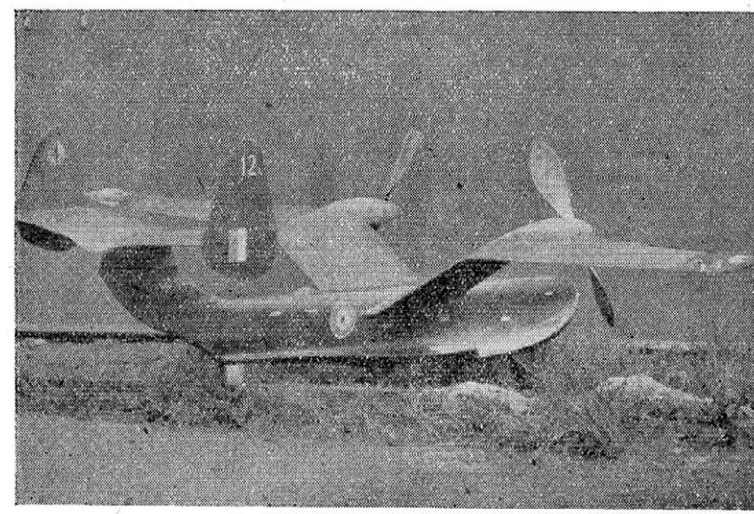


FIG. 18. FINDING LOAD WATER-LINE.

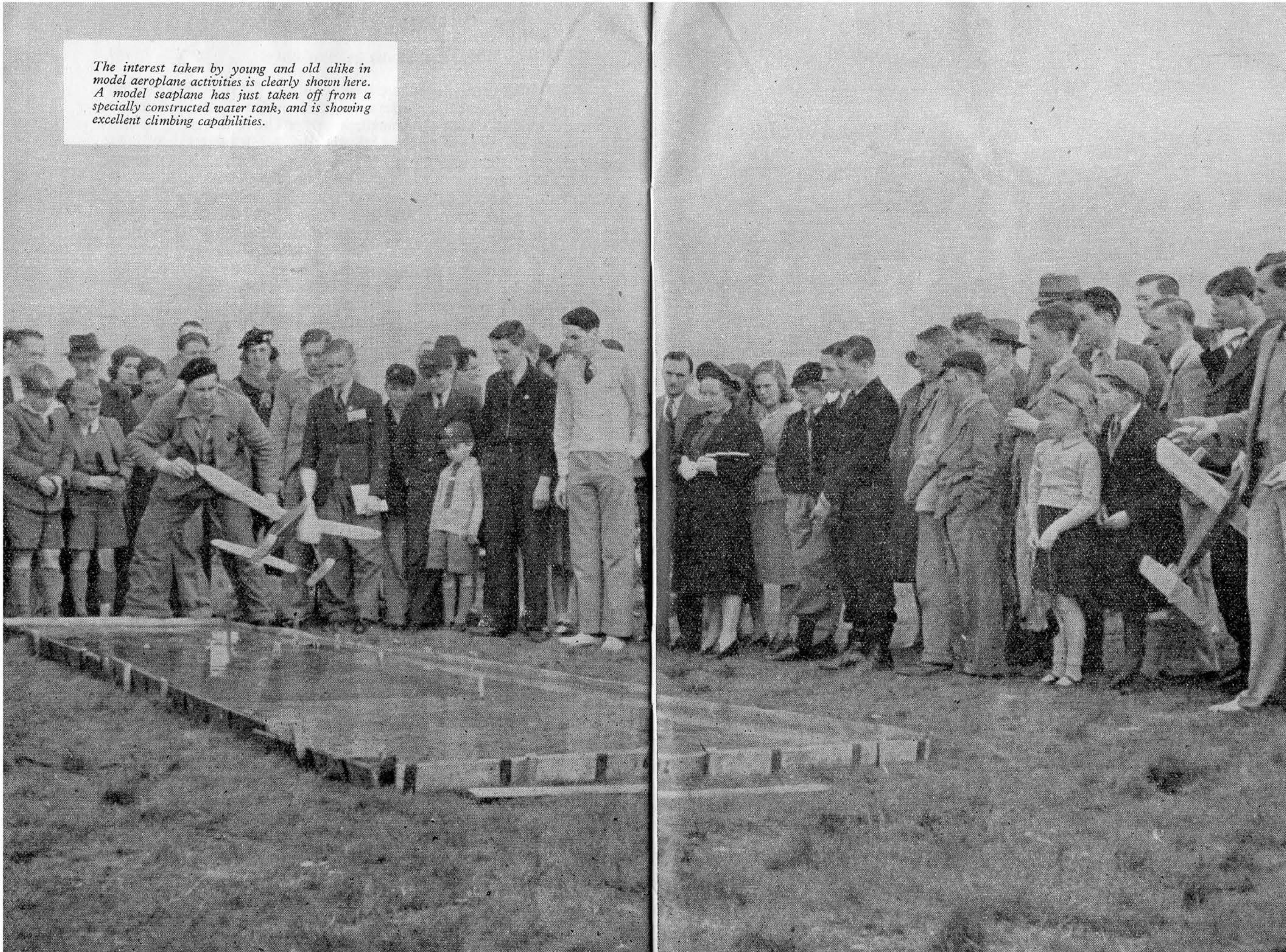
that section. Suppose the total submerged area of this section is found to be 2 sq. ins. In the case of a model flying boat hull, this area would remain at 2 sq. ins., but in the case of a twin-float water plane this area would have to be *doubled*, to obtain the submerged area of two floats. Square measure must now be brought to linear measure. This is done by choosing a scale of, say, 1″=1 sq. in. Mark this area at a distance along the ordinate from X downward to Y. This procedure must be carried out on all ordinates cut by the L.W.L. Join all the points Y, and the curve obtained is known as the "Curve of Areas". Next find the C.G. of the area bounded by the L.W.L. and the curve of areas, and mark this C.G. on the drawing. The C.G. may be found by taking moments about the load water line of each segment of area (this will give the distance of C. of A. C.G. below L.W.L.), and by taking moments of each segment about an axis at X, projected,

(this will give the distance of C. of A. C.G. behind neutral point). Where these lines meet, there is the C. of A. Another method is to cut out the shape of the Curve of Areas, in stiff card, and determine the C.G. by suspension method. Whichever method is resorted to, mark the C.G. of the C. of A. clearly on your drawing. Then, if the load water line A–B is the correct one, a line drawn at right angles to the L.W.L., and passing through the C.G. of the model should also, when produced, pass through the curve of areas C.G. If it does not do so, the load water line is incorrect, and must be tried in another position. The procedure must then be repeated. It will be found that two or three trials are necessary before a correct load water line is obtained. It is worth bearing in mind that if the fore-and-aft inclination is over 3° to the hull datum, a new set of sections should be drawn at right angles to the load water line, otherwise results are likely to be erroneous.

When a load water line has been found which fulfils the above conditions, a check may be made as follows. Calculate the area of the figure bounded by the curve of areas and load water line, and, correcting for the scale taken, multiply



A three-quarter rear view of Mr. Gyford's "Gull" flying boat. The model shows beautifully clean lines.



The interest taken by young and old alike in model aeroplane activities is clearly shown here. A model seaplane has just taken off from a specially constructed water tank, and is showing excellent climbing capabilities.

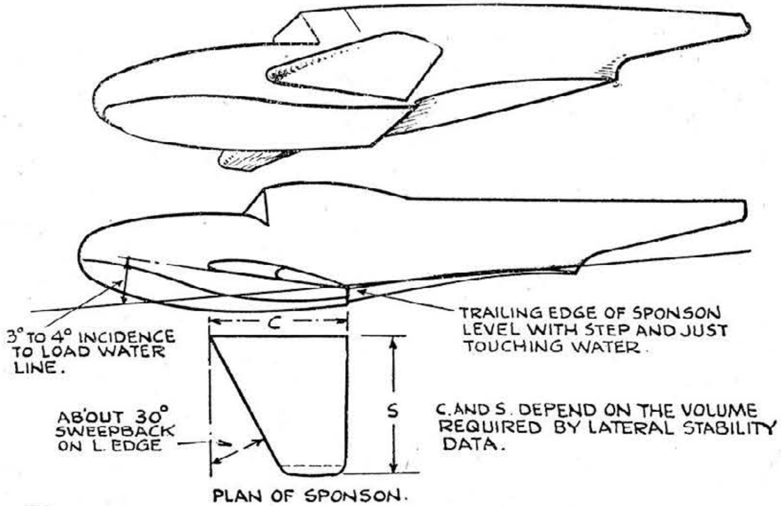


FIG. 19. LOCATION OF SPONSONS.

the results of the density of water (62.5 lb./cu.ft.). This will give the *weight* of water displaced, which should of course be equal to the weight of the model. The volume of a complete hull or float can be arrived at in a similar manner. The area of the curve of areas may be arrived by applying Simpson's first rule or by using the much quicker Planimeter.

Sponsons.

Sponsons have been used on successful petrol-engine water-plane models. There is much to justify their use but they are also open to criticism. In the first place, sponsons (or stubs, sea wings. The Germans call them "Stumeln") are resorted to because wing floats tend to dig in and swing the model round when take-off is attempted. As a cure for this vice, they are perhaps worth while. If a twin-motor layout is used in rubber powered models, a few more turns on one motor, or a slight amount of off-thrust, will cure any swing tendency.

Sponsons must be placed at just the right height above the water line. If they are too high the righting moment suffers, and when it *is* applied it is harsh, as the inertia of the model is brought up with a jerk. If they are too low, they cause great drag at take-off. It is possible for them to "take-it-green",

with the result that they will keep the model on the water for good.

Both Doctor J. F. P. Forster and Lt.-Col. Bowden have resorted to "steps" in the stub undersurface. In effect, they have simply *increased the beam of the hull locally*. The air drag of such stepped sponsons must be of a high order. When planning, incidentally, tank tests prove that the influence of the sponson waves upon the hull wave-pattern sets up high water drag at and around the hump speed. Sponsons are about 5% heavier as compared with wing floats.

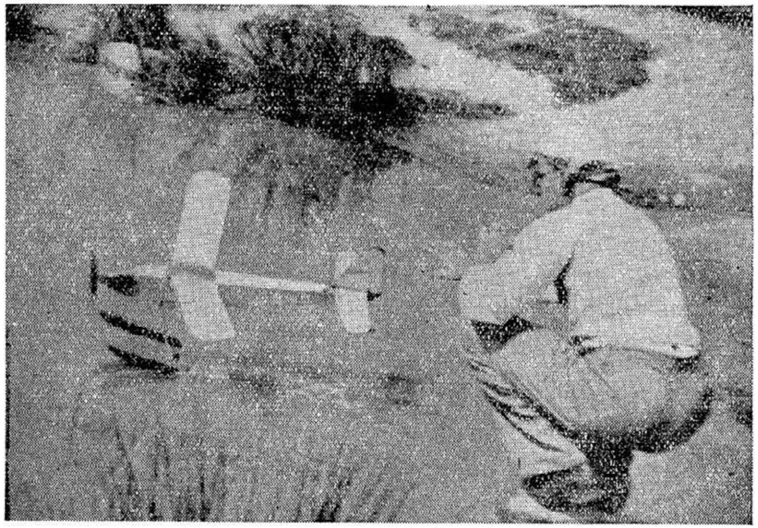
Sponsons are of course much more robust, and a model will be, in general, more suitable for open water operation, if fitted with stubs or sponsons. A guide to the correct setting for sponsons is given in fig. 19. The leading edge of the sponson should have sweep back in order to reduce water drag.

Tail Unit Design.

We have found a single central fin having an area of about 20% of, the wing area to be satisfactory. This rather large figure is demanded by considerations of "sailing" so that the model always turns into wind when adrift. It is also required because a hull always seems to come out shorter than a duration model fuselage. Twin fins are not good on water planes, especially if twin engines are used. They get in the way and are liable to get very wet in gusty weather. The tailplane should preferably be mounted at least 2x the beam above the load water line, if trouble through water and spray are to be avoided. Also, in this position, combined with a wing position as in the "Scutfly Mk. I" and the "Seagull Mk.I", the tailplane functions in a less disturbed stream of air. Being close to the mainplane, this is an important consideration.

Wing Design.

Wings should be robustly built because if they come in for a ducking—which happens with shocking frequency—water will make an appalling mess of a flimsy structure. Where wing tip floats attach, the structure should be stiffened. Wings need to be torsionally stiff, even *without* the covering. After an afternoon's sport the covering is usually past taking any torsion loads. Otherwise there are few special points to be covered in wing design.



Model sea planes can be flown off quite small ponds, as they do not require the same length of take-off run as flying boats. The large photograph on pages 38–39 shows how a "water way" can be improvised in the middle of a field.

Protective Finishes.

Before covering a water plane model, give the structure two coats of Banana oil; this not only "stiffens" it up but also waterproofs it. We have found joints breaking because water seeped through the covering and caused the balsa to swell. All joints must be well made and any point below the water line should receive special attention. Covering should be secured by doping. Apply two coats of dope and then use high-gloss varnish. If a tissue planing bottom is used, cover it with two layers of tissue doping before the second layer is applied.

Test the hull for water tightness by leaving it in water overnight. Propeller shafts should be well lubricated. All metal fittings, wires etc., should be greased, preferably with lanoline.

Operational Notes.

Any reasonable stretch of obstacle-free water will serve as an operating base for model water planes. Avoid the use of weed-ridden stretches however, and unless your crew and yourself are good swimmers avoid using deep water, unless you have a boat. We are fortunate in having a lake from which to fly our models. It is only three feet deep and has a sand bottom. Nevertheless, we find a boat most useful and necessary. We use a twin-float affair and this has proved ideal. The technique of launching which we have adopted is as follows. One of the crew stays on the bank with the model. He launches the model from the edge of the water in the general direction of the other chap on the pontoon. When the model alights, the pontooner paddles over and manoeuvres the pontoon so that the model goes between the pontoon's floats. The model is prevented from passing right between the floats, by its wing span. The pontoon is then paddled shore-wards. The final approach is made very gingerly so that the model is not crushed between the landing stage and the pontoon. This business is shown in fig. 20. If a boat is used it should have small freeboard, so that one is not too high above the water for launching. Always launch the model *away* from the boat, not parallel to it. After each flight, or between each series of flights, examine the model for signs of soakage, and for the condition of the covering. If the rubber is exposed, as it is on most of our models, a good supply of lubricant should be carried. Water washes the skeins dry of lubricant. You cannot prevent this.

Always carry a fairly large sponge—a flat one—and a soft cloth, with you when operating water planes. The model

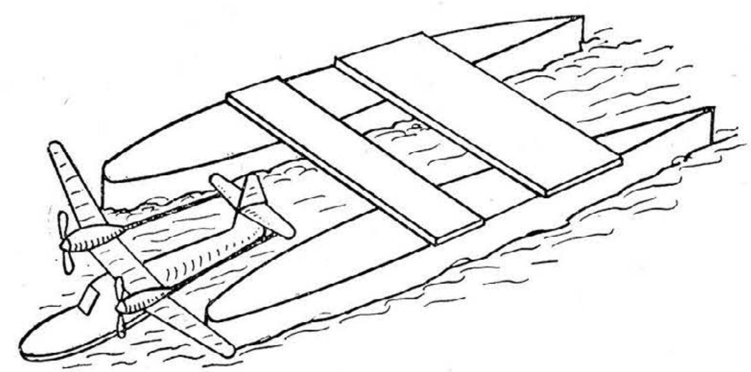
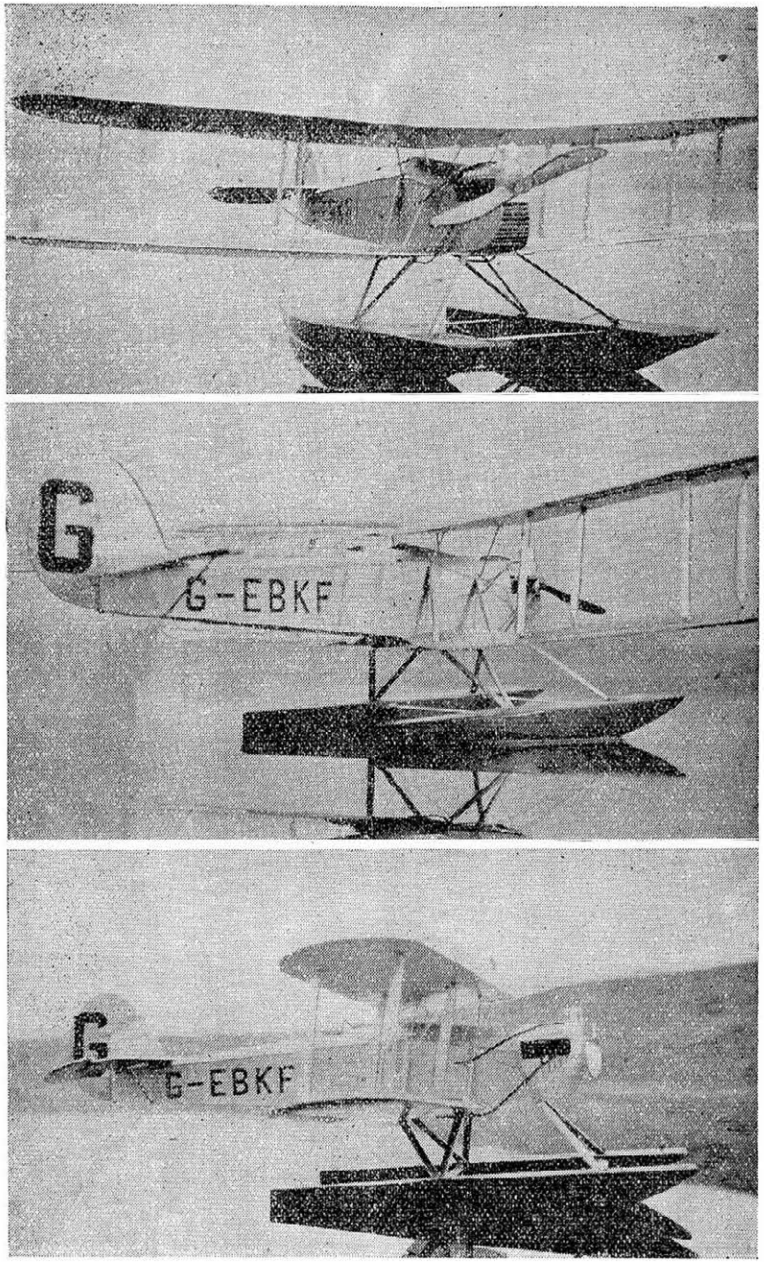


FIG. 20. PONTOON AND MODEL.



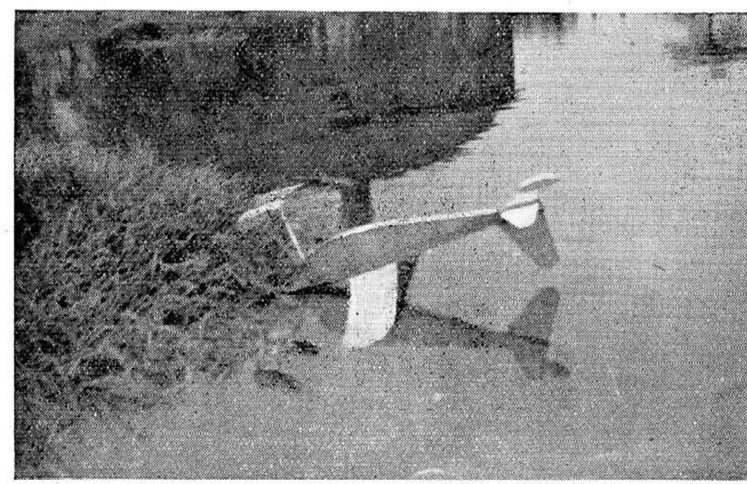
A beautifully made non-flying scale model built by Mr. E. J. Riding.

should be wiped as dry as possible with sponge and cloth after every few flights, and before any repairs are undertaken.

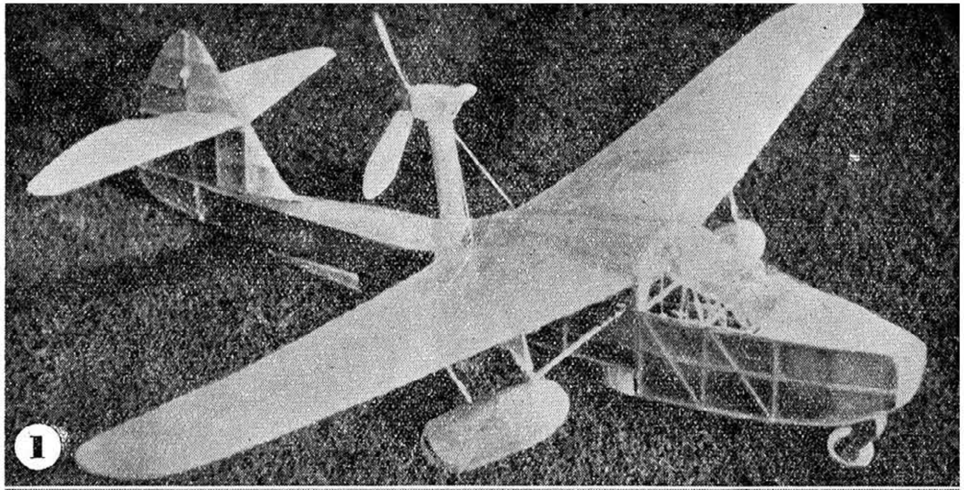
Conclusion.

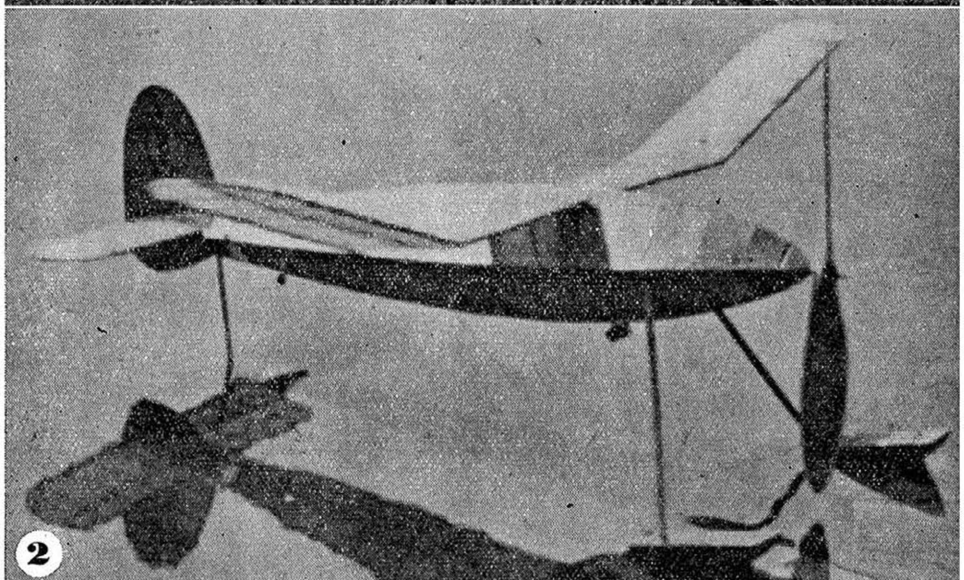
These notes have been made because we found a new avenue of interest when we decided to construct a model water plane. There are gaps in the notes which can only be filled as our knowledge develops. We hoped to arouse some interest in this fascinating branch of aero-modelling, and if we have achieved this, we hope readers will make known their successes and failures so that all may benefit. We have been grateful to Lt.Col. Bowden and Dr. J. F. P. Forster for their contributions to the art of model water planing, and to others who have helped us in our own experiments from time to time. Perhaps it is our enthusiasm, but we feel that no other field of aero-modelling presents such opportunities for originality and development as does the model water-plane, whether twin-floated or single-hulled. We have a comprehensive development programme ahead of us and hope to record its unfolding as we progress.

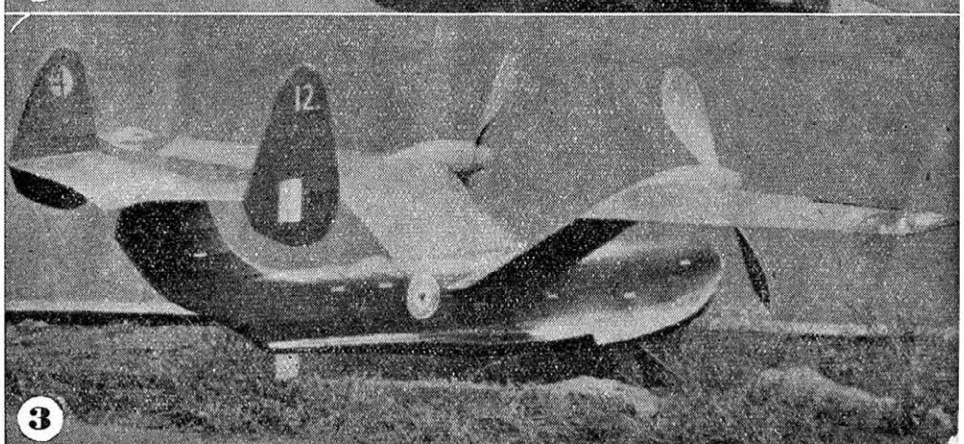
There seems no reason why more competitions should not be held to encourage people in model water planes. To this end we heartily endorse Lt. Col. Bowden's words and shall be pleased to co-operate with anyone organising such contests.

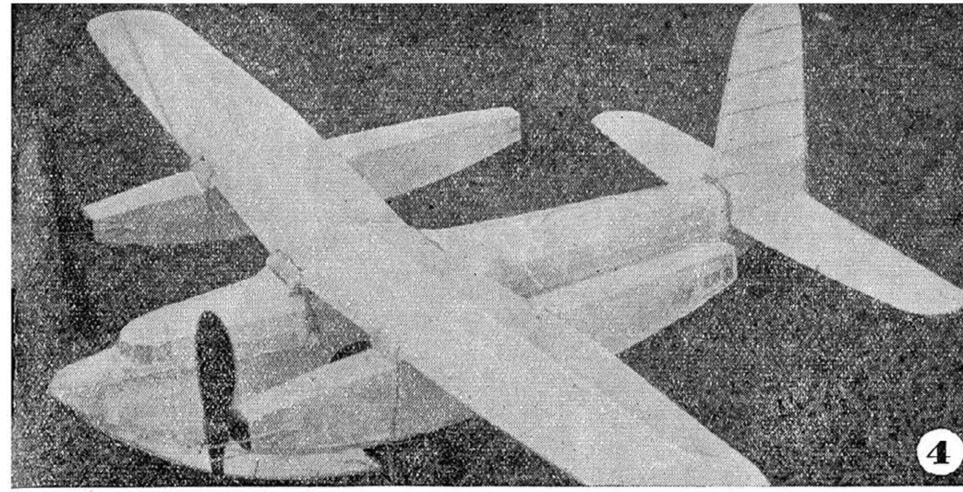


"Journey's end!"









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