ITSP 2012: Weekly Report 1 (6 to 11-May-2012)

Team: 1A03 Freebird. Project: Sea-Biplane.

Members: Aidren Quental, Meera Devrahi Singh, Johnson Minz.

Task 1: Study of Biplane aerodynamics

Biplane Characteristics:

From an aerodynamic standpoint, the monoplane wing is more efficient than the superposed wings of the biplane type, since the proximity of the two surfaces in the latter causes a decided loss in the total lift.

The practical advantage is the total efficiency of the complete biplane may be even greater than that of the monoplane. For the same area the structural parts of the biplane are lighter, and this advantage increases rapidly with the size of the machine.

A biplane is easier and cheaper to make than a monoplane, since the wing bracing of the former can be arranged to better advantage, the load bearing members can be simpler, and the safety factor made higher for an equal weight.

By suitable adjustments between the wings of a biplane, it is possible to obtain a very high degree of inherent longitudinal stability without incurring much loss in efficiency, an arrangement that is of course impossible with a single monoplane surface. By ''staggering," the view of the pilot is increased, and the generally smaller size of the machine permits of better maneuvering qualities for a given load.

Interference:

The choking of the air stream between the upper and lower surfaces is called interference. Lift of both wings is reduced, with the drag remaining about the same as with a single surface due to interference. This, of course, reduces the total lift-drag ratio at all except certain angles.

Interference causes a loss on the opposing faces of the wings, the pressure being reduced on the top surface of the lower wing, and on the bottom surface of the top wing.

Since the upper surface of the lower wing is under suction, it produces the greater proportion of lift. So it is natural that the lower wing lift should be reduced to a greater extent than in the upper wing, since it is only the lower surface of the top wing is affected.

At normal flight angles the upper wing carries about 55 per cent of the total load. At zero degrees incidence, the upper wing carries as high as 62 per cent of the total load, while at 12 degrees this may be reduced to 54 per cent.

Gap-Chord Ratio:

The distance between the upper and lower wings is called the “Gap”. The ratio of the gap to the wing chord greatly influences the lift. This ratio is called the "gap-chord ratio" and may vary from 0.8 to 1.0 in small machines or 1.0 to 1.2 in slow, heavy aero planes.

With the drag remaining practically constant, the lift-drag is of course affected by a change in the gap-chord ratio, this quantity being diminished at small gap ratios. Compared with a monoplane, the lift of a biplane is about 0.77 when the gap is 0.8 of the chord, and about 0.89 of the monoplane value when the gap-chord ratio is increased to 1.6.

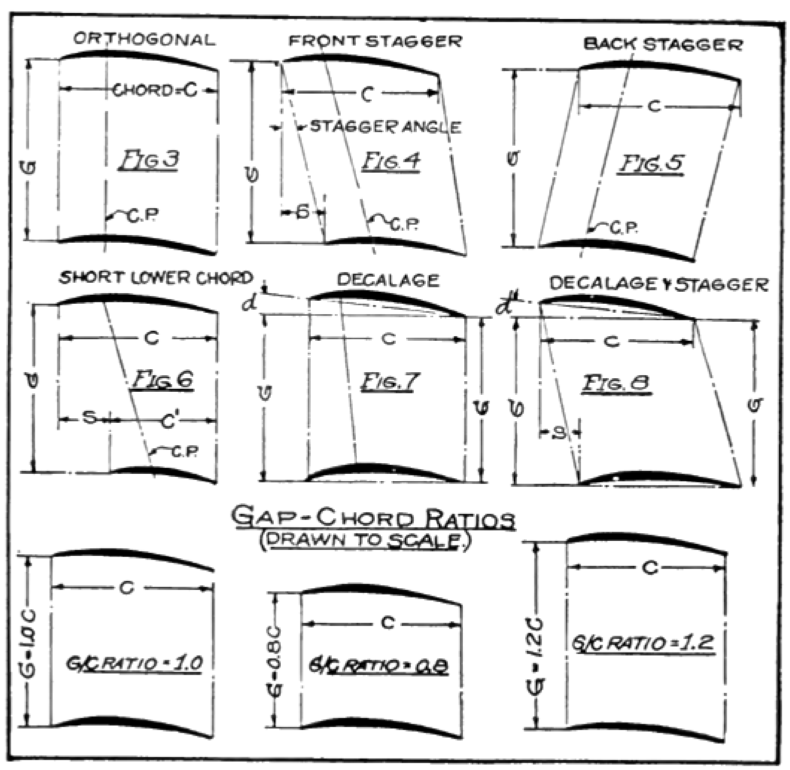
The center of pressure movement is not greatly changed with any gap-chord ratio for orthogonal biplane arrangement. The total efficiency of the aeroplane is not always increased by a large gap because of the great head resistance due to the longer struts and interplane bracing. So "gap-chord ratio" is 0.8 for fast planes and 1.0 for slow and heavy planes.

Biplane Arrangements:

When the upper wing is positioned ahead or behind the lower wing, it is called “Staggered”. A forward stagger gives better view to the pilot and a slight increase in L/D.

With a comparatively large stagger the range of the stalling angle is increased, and the lift does not fall off as rapidly after the maximum is reached as with the orthogonal type.

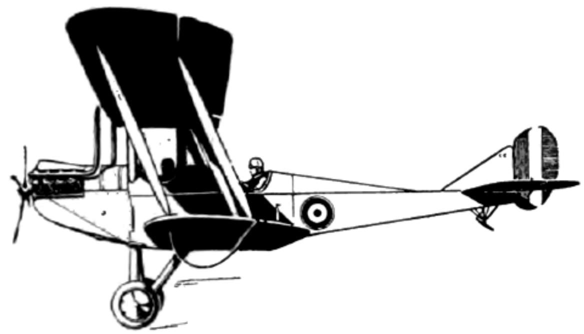
By staggering, the resistance of the interplane bracing struts is somewhat reduced, because of their inclination with the wind, although they are longer for the same gap. When the top surface was staggered forward by 1/2.5 of the chord and with a gap-chord ratio of 0.9,



Figs. 3-8. Different Biplane Arrangements, Showing Stagger and Decalage.

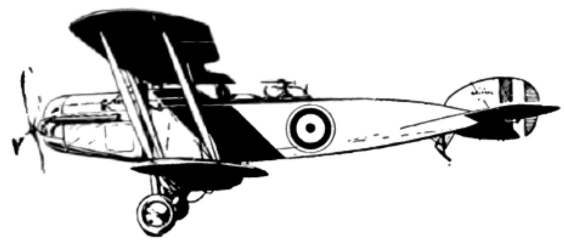
an Increase in lift of from 6 to 10 per cent was obtained. The L/D was the same as with no stagger.

The backward0.33c stagger gave about 15 per cent greater lift than the orthogonal biplane, or about 4 per cent less lift than a monoplane surface of the same area. Backward stagger would give better results than forward stagger, since the air swept down by the upper surface would pass further to the rear of the lower plane and hence would not so greatly affect the vacuum on the upper surface of the lower wing. This would, however, destroy the view of the pilot to a greater extent than any of the other arrangements.



Slow Speed, Two-Seat Biplane, with a Large Gap-Chord Ratio. The Large Gap Is Permissible in a Slow Machine, as the Strut Resistance Is Less Than the Gain in Lift-Drag Ratio Obtained by the Greater Gap. It Will Be Noted That These Wings Have a Considerable Amount of Stagger. The Position of the Bottom Wing Allows the Observer to See Almost Directly Below.

Stagger always introduces structural difficulties, makes the wings difficult to assemble and the wires are of varying lengths. A simple orthogonal cell is more compact and better from a manufacturing standpoint, as it simplifies the fittings, and to a slight extent decreases the weight. When combined with sweep back, the complication is particularly in evidence.



A High Speed, Two-Seat Fighting Biplane, with a Small Gap-Chord Ratio. In This Case, the Strut Resistance Would Be Greater Than the Aerodynamic Gain of the Wings with a Greater Gap Chord Ratio. The Gunner Is Located in the Rear Seat, and Behind the Trailing Edge of the Lower Wings. He Has a Clear Field to the Rear and Over the Top Wing.

Influence of Camber:

The amount of air swept down by the upper wing is largely determined by the curvature of the under surface of the upper wing. By decreasing, or flattening out the curvature of this surface, the velocity is increased in a horizontal direction and reduced in a vertical direction, so that the lower wing is less affected.

The upper surface of the upper wing is not influenced by interference. It should be noted at this point that air in striking a convex surface is increased in horizontal speed while the reverse is true of the lower concave surface. If the under surface of the upper wing were made convex, the down trend of the air would be still further reduced, and the loss on the lower wing reduced in proportion.

Increasing the camber on the upper surface of the lower wing increases its horizontal velocity and hence affects the upper wing to a less extent, but as the upper wing loss is comparatively slight, the camber increase below is not of great consequence.

Effects of Decalage:

When the upper wing incidence is increased in regard to that of the lower wing, or is given decalage, the stability is increased with a slight increase in the power or drag. This angle must be accompanied by stagger to obtain stability, the angle ranging from 2 to 4°.

With a decalage of 2.5°, and a stagger of half the chord, a high degree of stability is attained with a loss in the lift-drag of from 4 to 6 percent. The lift and the range of the stalling angle are both increased, the former by about 3 percent, while the latter is nearly double.

By increasing the decalage to 4°, the lift-drag is still 4 percent less than with the orthogonal cell, but the range of the stalling angle is nearly tripled. The 4° decalage is very stable and is suitable for training machines or for amateurs.

Without regard to the stability, and only with the idea of a greater L/D in mind, it has been usual in several European machines to adopt a ''negative" decalage, that is, to increase the angle of the lower wing in regard to the upper chord. With the top chord horizontal, a negative decalage of 4° would make the incidence of the lower wing equal to 4°. This has not been generally found advantageous in model tests, but in full size machines there is a considerable increase in the L/D ratio. The greater incidence of the lower wing also improves the lift of this surface and thus requires less surface area for obtaining the same total lift, especially when top wing is staggered forward. Incidence of top wing of Nieuport = 1°. Lower wing is set at 3°.

Varying Incidence:

The angle of incidence is reduced from the center of the wing to the tip. A decrease in angle toward the tips has much the same effect as an increase in aspect ratio; that is, it decreases the lateral flow and end leakage.

It also has an effect in aiding the lateral stability because there is less lift at the tips, and hence they are less affected by side gusts. "Washedout" incidence is an aid to longitudinal stability, as the center of pressure at the tips is moved further back than at the center of the wing, and therefore the C. P. is distributed over a longer distance fore and aft than it would be with a uniform angle of incidence.

Overhanging Wing Tips:

The upper wing is given a much greater span than the lower. The overhanging tips may slightly increase the efficiency of the biplane by reducing interference at the ends, it makes the span unduly long and difficult to brace at the end. Ailerons are more effective when mounted on the upper overhang.

The ailerons are generally placed on upper wings, only while with equal or nearly equal spans, they are placed top and bottom. The overhanging section and the ailerons form a single detachable unit as a general rule. With nearly equal spans, the upper and lower ailerons are generally interconnected with a small strut in such a way that they act together. Small fast planes have any overhang since the object of these machines is to make them as small and compact as possible.

Center of Pressure Calculation:

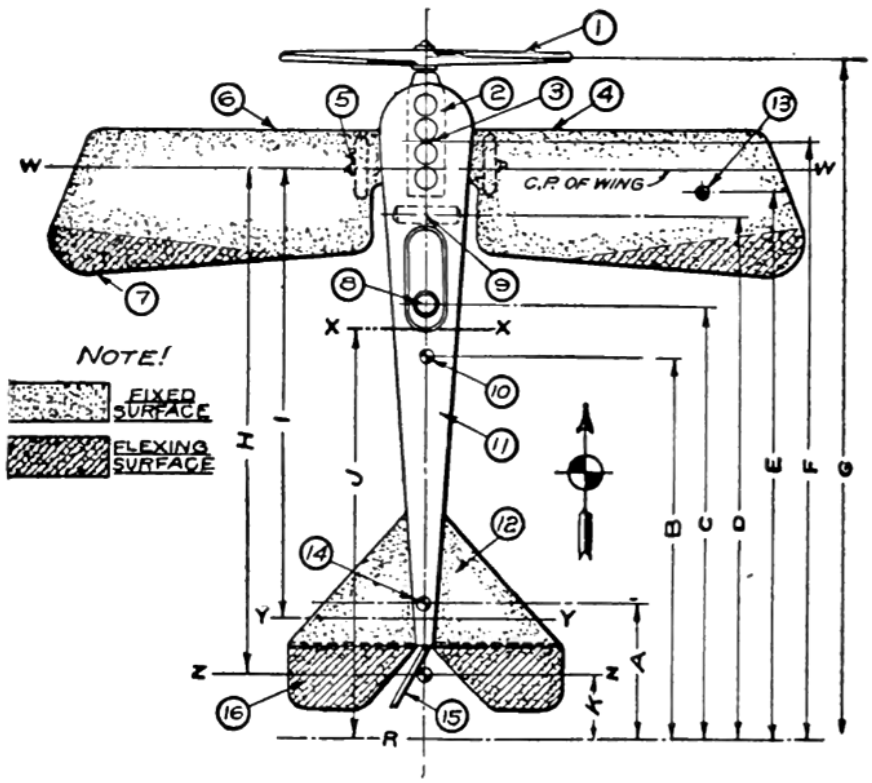


Figure shows the method of calculating the center of gravity. The reference line R is shown below the elevators and is drawn parallel to the center of pressure line W-W, the latter line being assumed to pass through the center of gravity.

The weight of each item is multiplied by the distance of its center of gravity from the line R, these products are added, and the sum is then divided by the total weight of the machine. The result of this division gives the distance of the center of gravity from the line R.

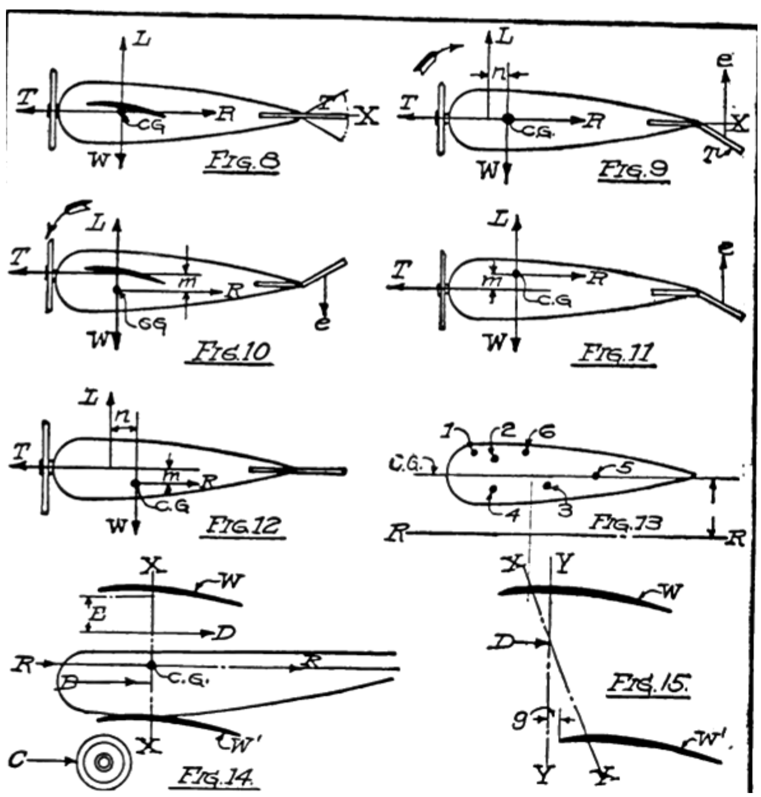
Thus, if the center of gravity of the body (11) is located at (10), then the product of the body weight multiplied by the distance B will give the moment of the body about the line R. The weight of the motor (2) multiplied by the distance F gives the moment of the motor about R, and so on through the list of items. The distance of the center of gravity (or center of pressure) from the reference line R is given by (H + K).

The location of the C. G. can be changed by shifting the weights of the motor, passenger, or other easily moved items. In any case, the C. G. should lie near the center of pressure.

Tail Lever Arms:

The effective damping moment exerted by the fixed stabilizer surface (12) will be the product of its area by the distance (I), measured from the center of pressure of the wing to the center of pressure of the stabilizer. The lever arm of the elevator is the distance (H) measured from the centers of pressure as before.

Resultant Forces and Moments in Flight:



The aeroplane is in equilibrium when all of the forces pass through a common center, as shown by Fig. 8. In this figure the lift (L), the weight (W), the line of propeller thrust (T), and the resistance (R) all pass through the center of gravity shown by the black dot C. G. There are no moments and hence no correction is needed from the elevator (T).

In Fig. 9, the thrust and resistance pass through the center of gravity as before, but the center of lift (L) does not pass through the center of gravity, the distance between the two being indicated by (n). This cause a moment, the length of the lever arm (n) being effective in giving a right-hand rotation to the body. If horizontal flight is to be had this must be resisted by the upward elevator force (E).

In Fig. 10, the lift passes through the center of gravity, but the line of resistance lies below it by the amount (m). The thrust (T) tends to rotate the machine in a left-handed direction. The elevator must exert a downward force (e) to resist the moment caused by (m). This is a bad disposition of forces, as the machine would tend to stall or tail-dive should the propeller thrust cease for even an instant. The stability of Figs. 8 and 9 would not be affected by the propeller thrust, as it passes through the C. G. in both cases. In Fig. 11, the center line of thrust is below the line of resistance (R), so that the thrust tends to hold the nose up. Should the motor fail in this case, the nose would drop and the machine would start on its gliding angle and pick up speed.

In Fig. 12 none of the forces intersect at a common point, the lift and weight forming a right-handed couple, while the thrust (T) and the resistance (R) form a left-handed couple that opposes the couple set up by the weight and lift forces. If the thrust-resistance couple can be made equal to the lift-weight couple, the aeroplane will be in equilibrium and will need no assistance from the elevator. As the weights in the aeroplane are all located at different heights, it is necessary to obtain the center of gravity of all the loads in a vertical plane as well as horizontally.

Thus in Fig. 13 the line C. G. is the center of gravity of the engine weight (1), the wing weight (2), the pilot's weight (3), the chassis weight (4), the fuselage weight (5), and the fuel tank weight (6). The line C. G is the effective center of all these loads, and is calculated by taking the products of the weights by the distance from a reference line such as R-R. The center of resistance is the effective center of all the resistance producing items such as the wings, body, struts, chassis, etc.

The method employed in obtaining the center of resistance is shown by Fig. 14, the center line of resistance R-R being the resultant of the wing resistance (D), the body resistance (B), and the chassis resistance (C). It will be noted that the wing resistance of biplane wings (W-W) does not lay midway between the wings but rather closer to the upper wing, as shown by (E). This is due to the upper wing performing the greater part of the lift.

In locating the center of resistance, the resistance forces are treated exactly like the weights in the C. G. determination. Each force is multiplied by its distance from a horizontal reference line, and the sum of the products is divided by the total resistance. As shown, the center of resistance R-R passes through the center of gravity C. G. The center of pressure line X-X also contains the center of resistance. A staggered biplane cell is shown by Fig. 15, the center of pressure of the upper and lower wings being connected by the line X-X as before. The center of resistance of the pair is shown at (D), where it is closer to the upper wing than to the lower. A vertical line Y-Y dropped through the center of resistance gives the location of the center of lift. As shown, the center of lift is brought forward by the stagger until it is a distance (g) in front of the leading edge of the lower wing. The center of lift and the center of resistance both lie on a line connecting the center of pressure of the upper and lower wings.

Calculation of Control Surfaces:

It is almost impossible to give a hard and fast rule for the calculation of the control surfaces. The area of the ailerons and tail surfaces depends upon the degree of stability of the main wings, upon the moment of inertia of the complete machine, and upon the turning moments. If the wings are swept back or set with a stagger decalage arrangement, they will require less tail than an orthogonal cell. All of these quantities have to be worked out differently for every individual case.

Aileron Calculations:

The ailerons may be used only on the upper wing (2 ailerons), or they may be used on both the upper and lower wings. When only two are used on the upper wing it is usually the practice to have considerable overhang. When the wings are of equal length either two or four ailerons may be used. Roughly, the ailerons are about one-quarter of the wing span in length. With a long span, a given aileron area will be more effective because of its greater lever arm.

If a = area of ailerons, and A = total wing area in square feet, with S = wing span in feet, the aileron area becomes: $a = 3.2A/S$. It should be borne in mind that this happens only to an aeroplane having two ailerons on the upper wing, since a four-aileron type usually has about 50 per cent more aileron area for the same wing area and wing span.

For, example, let the wing span be 40 feet and the area of the wings be 440 square feet, then the aileron area will be: $a = 3.2A/S = 3.2 \times 440/40 = 35.2$ square feet. If four ailerons were employed, two on the upper and two on the lower wing, the area would be increased to $1.5 \times 35.2 = 52.8$ square feet. In cases where the upper and lower spans are not equal, take the average span—that is, one-half the sum of the two spans.

Stabilizer and Elevator Calculations:

These surfaces should properly be calculated from the values of the upsetting couples and moments of inertia, but a rough rule can be given that will approximate the area.

If a' = combined area of stabilizer and elevator in square feet; L = distance from C. P. of wings to the C. P. of tail surface; A = Area of wings in square feet, and C = chord of wings in feet, then, $a' = 0.51AC/L$. Assuming our area as 430 square feet, the chord as 5.7 feet, and the lever arm as 20 feet, then, $a' = 0.51AC/L = 0.51 \times 430 \times 5.7/20 = 62.5$ square feet, the combined area of the elevators and stabilizer.

The relation between the elevator and stabilizer area is not a fixed quantity, but machines having a stabilizer about 20 per cent greater than the elevator give good results.

Negative Stabilizers:

A considerable amount of inherent longitudinal stability is obtained by placing the stabilizing surface at a slight negative angle with the wings. This angle generally varies from —2° to —6°. At small angles of wing incidence the negative angle of the tail will be at a maximum, and acting down will oppose further diving and tend to head the machine up. At large wing angles, the tail will be depressed so far that the tail angle will become positive instead of negative, and thus the lift on the tail will oppose the wings and will force the machine to a smaller angle of incidence. The negative angle can thus be adjusted to give longitudinal stability within the ordinary range of flight angles.

Stabilizer Shapes and Aspect Ratio:

Measured at the rear hinged joint, the span or width of the stabilizer is about 1/3 the wing span for fast planes and about 1/4 the wing span for the larger planes. Nearly all modern machines have non-lifting tails, or tails so modified that they are nearly non-lifting.

Since flat plates give the greatest lift with a small aspect ratio, and hence are most effective when running over the ground at low speeds, the stabilizers and elevators are of comparatively low aspect. In general, an aspect ratio of 3 is a good value for the stabilizer. Vertical rudders generally have an aspect ratio of 1, and hence are even more effective per unit area than the stabilizers. This is particularly necessary in ground running.

Vertical Rudders:

The calculation of the vertical rudders must take the moment of inertia and yawing moments into effect, and this is rather a complicated calculation for the beginner. As an approximation, the area of the rudder can be taken from 9 to 12 square feet for machines of about 40 feet span, and from 5 to 8 square feet for fast planes.

Wing Stability:

Under wing sections, the subject of the center of pressure movement has already been dealt with. The variation of the center of pressure with the angle of incidence tends to destroy longitudinal stability since the center of pressure does not at all times pass through the center of gravity. On some wings, the camber is such that the variation in the position of the center of pressure is very little, and hence these are known as stable wings. A reflex curve in the trailing edge of a wing reduces the center of pressure movement, and swept back wings are also used as an aid in securing longitudinal stability. Introducing stagger and decalage into a biplane pair can be made to produce almost perfect static longitudinal stability. It should be noted that stability obtained by wing and camber arrangements is static only, and requires damping surfaces to obtain dynamic stability.

Float design: (Source http://flyinglindy.homestead.com/skisandfloats.html)

RC model taking off and landing on water gives more realism and enjoyment of flight. Two basic types of floats used in aircraft are "V" and flat bottom floats. The step and size of both of them are the same. The "V" bottom floats are complicated in construction but gives realistic looks.

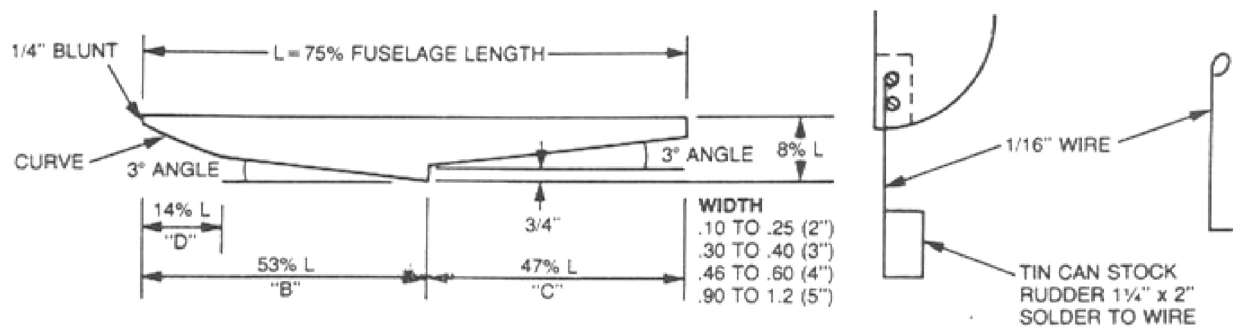
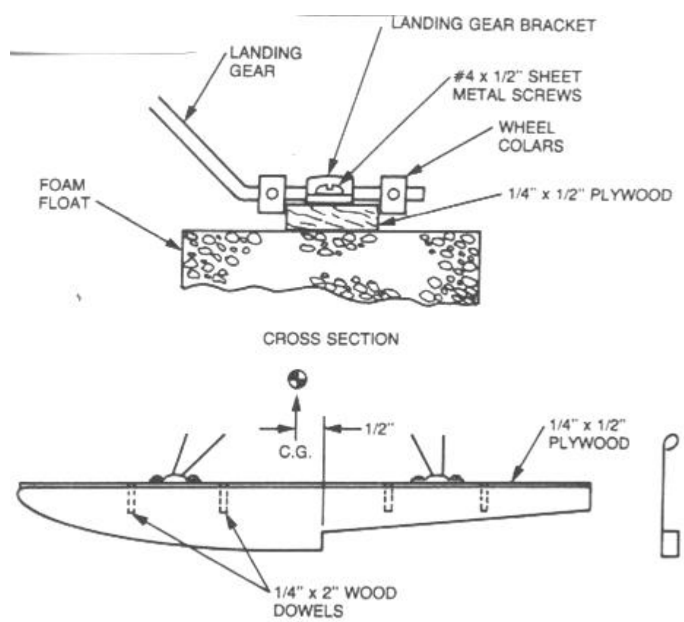


FIGURE 1
BASIC FLOAT DESIGN

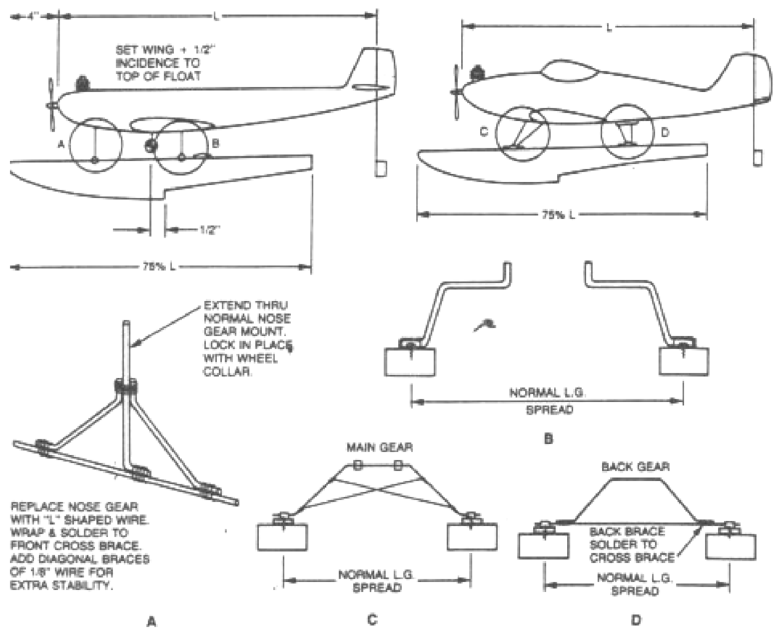
The length of the float should be 75 – 80% of total length of the aircraft, i.e. from propeller to rudder tip. The step of the float should exactly position at the balance point of the aircraft or not more than ½" aft balance point. So it is necessary to find the balance point that is optimum for flying without floats before designing the floats.

53% of float length should be forward of the step and 47% after the step. The aircraft has a tendency to pitch nose down under power and swamp float and then the aircraft. So the float should extend 1" or 2" ahead of the propeller.

The nose and tail upsweep angle should as low as possible 3°. The aft upsweep angle can be 3° - 5°. A higher aft sweep angle allows the aircraft to break the water suction easily, but the aircraft will ride lower on water.

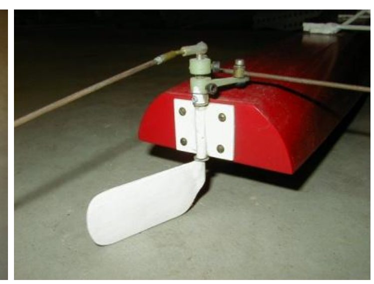


The width of the float is based on the total weight it has to carry, i.e. the sum of weight of aircraft and floats.



The floats are made by carving them out of blocks of Styrofoam using templates and hot wire cutter. Wood dowels 2" deep must be fixed on to the top of the floats. Otherwise the floats may break off on a hard water landing.

The aircraft wing should be at 2° positive incidence compared to float line. The adhesion between float and water is 100 times more than the adhesion of tire and solid ground. The positive incidence will help the aircraft to break this adhesion and lift off effortlessly.



It is important to have water rudders to steer the aircraft while moving on water. This can be a flat piece of 2" X 1"attatched to the aft of the float or rudder. The water rudders should not be active while flying at high speeds over water. Because any slight movement in water rudder may cause the aircraft to turn violently. This is dangerous during takeoff and landing. So water rudders should be engaged only at the time of taxiing over water.