SETTING UP A BIPLANE -

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This article was originally published in the Jan '90 issue of <u>Airflow</u>,newsletter of the Glastonbury Modelers in CT. It's a "must read" for any clubster that's planning to build a biplane. The information it contains is invaluable - Editor.

To some modelers, the biplane is the epitome of airborne aesthetics. Still, some of this same flock shy away from building them, considering them too complex in final assembly, and too mysterious in flight trim. That's all propwash! In this article we will cover the theory of two wings, and the advantages. Part II will show us the design and assembly of a model, while the third and final part will deal with flight trim.

The theory of using two wings on full-size planes is that they offer the best solution for a strong and light weight for a given area. If different angles of incidence are used for each wing, stability is gained. Let's look a bit closer at this last point.

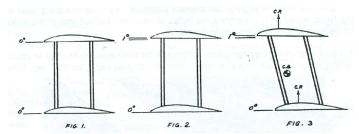


Fig. 1 depicts biplane wings at a like angle of incidence. When the plane climbs too steeply, both wings will see the same angle of attack and stall simultaneously. This complete loss of lift will cause the nose to drop abruptly, and there will be a considerable loss of altitude before recovery.

Fig. 2 shows a biplane cellule with the top wing at a greater angle of incidence than the bottom wing. At a high angle of attack the top wing will stall first. This will cause only a partial loss of lift and the plane will mush into a recovery of flight with little loss of altitude. Presto! Automatic stability has been built into the aircraft. This--angular difference in incidence between wings is called "decalage."

Fig. 3 depicts a biplane with 1 degree of decalage and positive stagger. The arrow off the top surface of each wing indicates the center of pressure, which is nothing more than the point where all the lift created by that wing balances. You could call it the center of lift (C.G.). The C.G. is also shown falling where it should for a biplane, between the lift centers of the two wings. In this configuration even greater automatic stability is gained, because when the top wing stalls first (and it will, due to the decalage) lift loss is forward of the C.G. while the bottom wing is still lifting with its center of lift aft of the C.G. The plane will actually "snap out" into level flight with no loss of altitude at all.

(PFFT Ed. Note: The logic of this may not be all that clear — what actually happens is that with the CL of the lower wing being behind the CG, the lower wing will cause the nose to drop sufficiently to allow the top wing to start flying again.)

What has the stabilizer been doing through all this? In Fig. 1 it has been doing all the work and it will need to be large in area, be it a full-size airplane or a model. In Fig. 2 it is doing some work, and in a model a scale area will probably do if it is not too miniscule. In Fig. 3 the stabilizer is not working hard at all, and a scale size is big enough in a model.

Next, do you think the drag off all those struts and wires reduces performance? Sure, that's why the FAC gives a bonus for biplanes. But the penalty is not as bad as you may think, and here's why ...

Because a bipe has a lighter wing loading than a monoplane. Usually, it does not need to fly as fast in order to climb. Drag increases by the square of the speed, so a biplane with a given drag area that flies at 15 mph suffers only a 12% drag penalty over a monoplane with half the drag area that flies at 20 mph! Glide duration of the two types is similar. The monoplane glide, however, is faster and flatter than that of the bipe, whose nose is down more, but moving slower due to the extra drag.

O.K. bipesters, having digested the reasoning behind using two wings, we can go on to drawing up a plan or re-drawing a kit plan to incorporate the decalage and other features to build a good flying biplane.

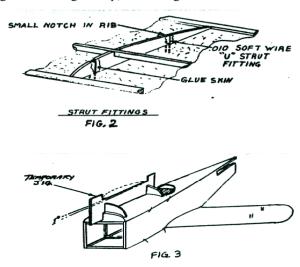
First off, it is a good idea to use a "real" airfoil, not just one off a French curve or old Megow plan. Pick one thinner than a Clark "Y." You don't need the strength of a deep spar ala a monoplane, one wing braces the other on a bipe. An airfoil that has worked well is the Rhode St. Genese 26 shown in figure 1. It has a very sharp leading edge to reduce drag. Yes, I know

that wings with sharp leading edges are subject to abrupt stalls, but our decalage will take care of that.



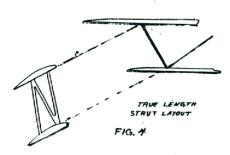
Make a template of your chosen airfoil for top and bottom wings and trace them onto your plan so that you have no more than 1/2 degree of decalage. Incidence creates drag. We need it for decalage, but do not overdo it. To help you in drawing ... 1 degree = 1/64 inch rise in a one inch distance.

Design the wings for one-piece construction. Build them flat, with no wash-in or wash-out. Also, incorporate the strut tie-in system illustrated in figure 2 using soft wire. This tie-in system allows a temporary fitting of the top wing to check alignment. Use glued up, it is strong as a bull!



Design the aft end of the fuselage so there is space to change the horizontal stabilizer incidence. If your model's top wing is strut mounted to the fuselage (these are termed cabane struts), design and build a temporary pylon to position the wing above the fuselage. You might want to design in stops on this jig so everything "nests" into position as shown in figure 3. Just tack glue this jig in position on top of the fuselage. You'll probably destroy it to remove it. Above all, be sure you get the incidence angle the way you want it.

If your model has vertical interplane struts, simply build them using the side view of your layout. However, if the interplane struts are canted, you'll have to project a true view as shown in figure 4. (PFFT Editor: You might also check the article "Landing Gear, Finding True Length" in the website pensacolafreeflight.org articles index) Canted cabane struts should be laid out and built in like manner. As a matter of fact, you may want to try laying out true views of all your struts, building them, and assembling the wings without going through the trouble of making that pylon.

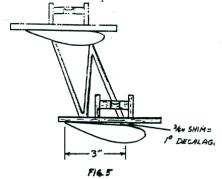


No matter which method you use, the top wing should be mounted temporarily at first by squeezing the ends of the wire loops against the struts with needle nose pliers. If things look pretty well lined up by eye-balling, smear some Duco cement on the strut/wire area and let it dry. If you have to break the joint loose later for re-alignment, use a drop of acetone brushed on the glue skin and a pointed blade to pry it loose. Now, I know all of this is no piece of cake. You have to align that wing

from the front, top, and side. It takes time, patience, delicate handling, and sometimes doing it over again until it's right. The incidence angle should never be compromised.

To be sure of that incidence angle, and the decalage, arrange a temporary jig of books, blocks, or whatever, to hold your model inverted. Place a small, lightweight level on the bottom surface of the lower wing near the root and shim the aft part of the fuselage up or down to center the bubble. Check the entire span of the lower wing with the level. If you have done your work well, there should be no variation in the level reading.

Now, put the level on the bottom surface of the top wing (figure 5). If you have built in incidence, the bubble should move toward the trailing edge. Check the entire span thus. If there is some run-out, adjust the length of the nearest strut to true up the wings. Next, you can position the stabilizer. Tack glue either the leading edge or the trailing edge, and pack the other with thin balsa shims to level its bottom surface in the same plane as the bottom surface of the lower wing.



Once you are satisfied with the wing assembly you can final glue the struts and wire fittings. As soon as the rigging threads are wrapped and glued around these joints you will have a very strong biplane whose wings will survive many a mishap. Do not final glue the stabilizer at this time. We may want to adjust it during our trim flights.

Now our new two-winger is almost ready for testing. We have our 1/2 to 1 degree of decalage along the entire span, and the horizontal stabilizer is in the same plane as the bottom surface of the lower Wing. Before glide testing, add ballast to bring the balance point (CG) to 30% chord for a bipe with no stagger, and 50% chord for a bipe with positive stagger. These are the starting places. They may need change later.

Find a soft place, tall grass, snow, etc. Beds are far too small. To test glide any model effectively, pick a spot on the ground about 12 feet in front of you (upwind, of course - wind is blowing in your face), and launch the model at that spot at a good rate of speed. Don't be hesitant. You can do more damage if you don't give your ship the flying speed it needs. Adjust the amount of ballast until the model **flies straight to that spot on the ground without stalling or flattening out**. It should exhibit some buoyancy, however.

Now that you have the ship gliding at its glide speed, start launching it harder and faster - still toward that spot on the ground - to see how it will behave as it approaches its speed under power. If the nose lifts up, or tucks under, rebalance and test again.

Once satisfied with the glide, put in plenty of down thrust (around 8 degrees) and some right thrust as well, of course. We will discuss only trim for pitch stability from here on, assuming the test pilot can handle torque and yaw trim simultaneously. You are less apt to damage the model by flving it into the ground because of excess down thrust, than a series of stalls into the ground due to insufficient down thrust. Put in at least 300: turns for the first flight. If the ship gets nose high after launch you don't want the motor to quit and have her stall into the ground. With enough turns in the model she can recover, climb again, and gain altitude before the motor quits. At least now she will have a chance to set up a glide, and come in for a landing instead of "sliding in" tail first.

If you have done your work well up to this point, you should not encounter any extreme instability problems. Make corrections to the powered part of the flight by changing the thrust line. If the glide exhibits "mush", move the balance point to compensate. Sometimes you may need to alter the thrust line again to compensate for the shift in balance.

Let's say you have your crate flying pretty stably now, but darn it ... it needed a heck of a lot of down thrust, and it does not seem to go anywhere, yet the glide is good. This trait tells you the airplane is "dirty" aerodynamically. To clean it up, loosen the leading edge of the horizontal stab and shim it up about 1/64". Now start the whole test cycle again. You should be able to remove some nose ballast and down thrust. You may even have to add another shim to the L.E. of the stab,

even more. Only flight testing can tell you this. If your glides become long shallow dives with a long time needed for recovery, or any other nasty traits show up. like spiral dives, you have gone too far in your clean up effort. Take out that last shim you added to the leading edge of the stabilizer.

In short, if you keep the decal age between 1/2 and 1 degree, it is simply a matter of optimizing the balance point, thrust line, and tail plane incidence to arrive at an aerodynamically clean and stable biplane. Stability is achievable without gaining aerodynamic cleanliness, but you will not get good performance.