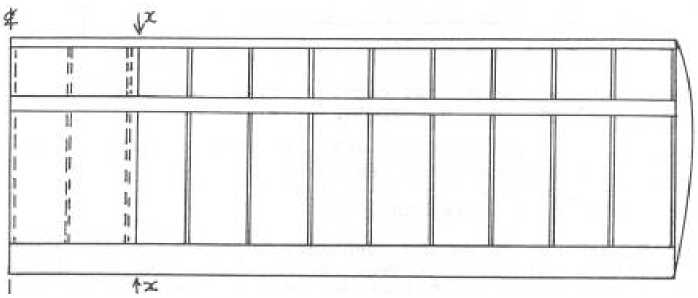
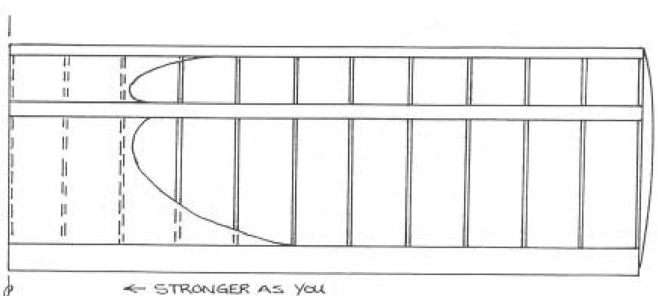
those are very soft covering materials. They give very little torsional rigidity to the structure. A strong wing is required underneath. The worst case scenario is the iron on fabrics. They are 2 to 3 times as heavy as Monokote and have less torsional rigidity. It is like covering the structure in a tent.

When sheeting a wing, the sheeting can add a lot of strength if done properly. In a simple thermal glider wing there is a big strong spar and a lot of ribs. Most gliders have the center two bays sheeted so you can put on the rubber bands. The designers stop the sheeting suddenly. That's a problem because there is something nice and strong transitioning to something that's trying to flex. If a little load is put on this wing, it breaks right on the x (see figure) . The most notorious case of this is



the performance glider design by a major west coast manufacturer. I've seen many of these planes blow up. As long as they are flying without strain on the wing, they're great. Get them into a little bit of a dive, over speed them a little, so that they start to get some torsional flutter and bang. All the load ends up at the leading edge and snaps it. The wing twists and blows off. That's usually the failure mode.

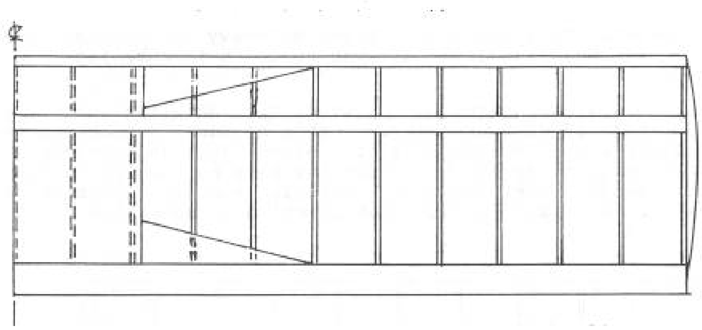
How do you solve it? You have to get around the *stress risers* by distributing the loads over the area, by cutting the sheeting to spread the loads over a couple of rib bays.



Another solution is to taper the amount of sheeting. (see figure top of next column)

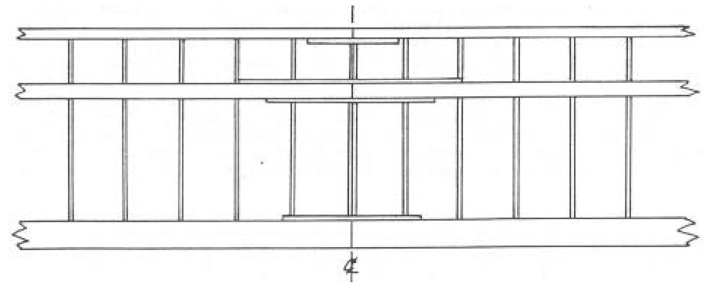
If you don't like to cut curves, straight lines are OK, just don't stop the sheeting in one spot.

If it is a full "D" tube, I'm not sure how important it is to curve the rearward sheeting. It does look nice. It also prevents that funny little "pocket" that forms in the



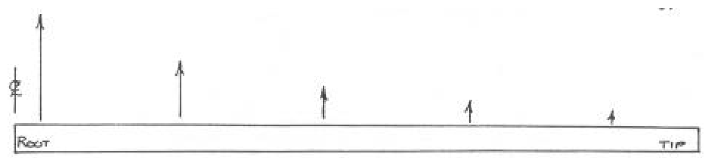
Monokote at a 90 degree corner.

When putting in dihedral braces, don't make them all the same length. Make them all different lengths so that they're not concentrating all the stress on one part, (or in one line).

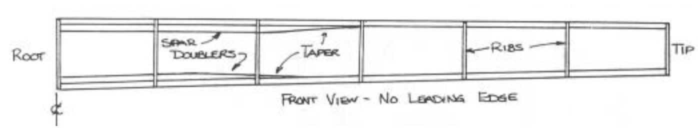


If the plane is not in need of a fully sheeted airfoil, but you are concerned about loads, you can make a tapered spar. It's a lot or work, but you might want it.

Think about the loads on a wing. The tip is supporting itself and providing lift. The next panel is providing lift and also supporting itself, and the tip. The next is lifting and also supporting the end two panels and so on, until you get to the center section which is providing lift and supporting the whole rest of the wing.



If you think about the load on the wing, the spar doesn't need to be as strong at the tip as at the center. Tapering the spar is a pain and it doesn't save much weight. If you have an extremely strong wing and want to use a "D" tube and cap strips, scarf in spar doublers for 2 or 3

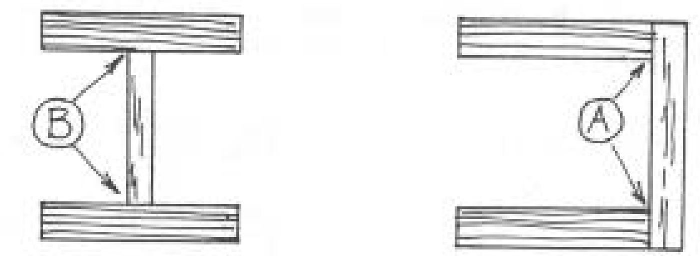


rib bays out. Taper the end to transfer the strength gently to the outer spar material at the tip. It only has to be 2 or 3 rib bays. The center section will be a little bit stronger, especially around the landing gear. That is where a lot of load is provided from landing. On most of my big airplanes and pattern airplanes, this is the spar system I use. If the upper and lower spars are 1/8" x

3/8" spruce then the doublers are 1/8" X 3/8" also.

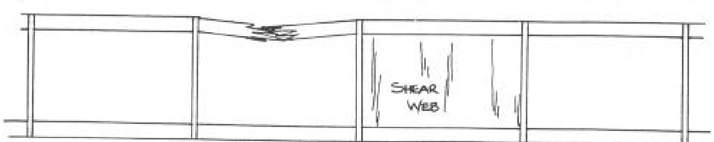
Spars:

For the best bending conditions, keep the spars thin and wide, as a cap. If you put shear webs against the face of the spar, the glue joint at "A" is in shear and



glue is not very strong in shear. There is not a lot of gluing surface. A good shear web in-between the spars is stronger, because the joint at "B" is not in shear and the glue is just there to hold it in place - not really much load on it.

If you don't have shear webs, the bottom spar doesn't fail under load. The top spar fails "out" or "in" . By putting the shear web in-between you control the breaking, to some degree.

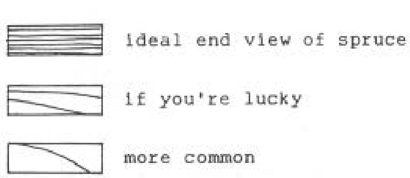


FRONT VIEW – NO LEADING EDGE

If there is one place to spend more time on craftsmanship than anywhere else, it's on making shear webbing. If it doesn't fit, pitch it and make another. It's only sheet balsa. It only takes a few minutes.

If you want to increase the spar size, you have a choice between thicker and wider, remember wide and thin is better.

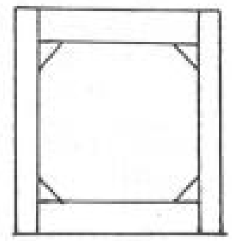
There is a caveat. Spruce, that is bought in the hobby shops, is a faint memory of what we used to get. Balsa has gotten bad; spruce is worse. The good stuff is difficult to find and cut. If you can't find any, you are better off going to a square piece. You at least have some chance of the grain going in the right direction. The grain in the end of good spruce looks like a leaf spring



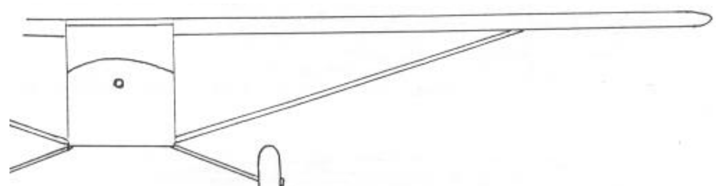
If you find shear webbing bothersome to glue between the spars, with square spars, gluing to the face is better than with flat spars. The gluing area is that much larger. The shearing effect is spread over much more of the glue joint. You can get away with it.

The strength of an "I" beam is linear to the strength of the caps, but it is the square of the distance between them. Get as much of the good stuff as far out as possible. BUT the wider the spar, the harder it is to find good wood for them. It's worthwhile, any time you are in a hobby shop, to check out the spruce rack and if you find any good stuff, even if you don't need it, BUY IT! The same holds true for 1/16" balsa. There just isn't enough out there to rely on getting it when you need it.

Box spars are used when you don't want to sheet the wing. You use wide spar caps and full webs front and back. This approximates a tube and that is rigid. A "D" tube is bigger and stiffer. On real airplanes it is used to avoid a "D" tube, (fabric covering). For models, you are better off with the "D" tube.



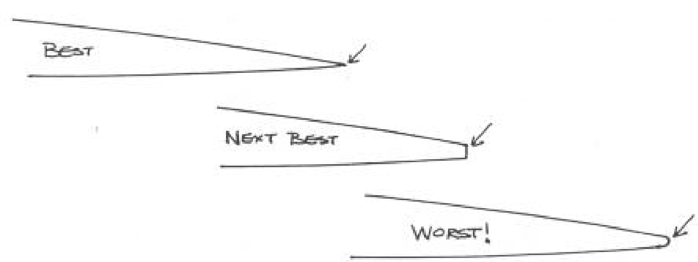
A note on struts: If a wing has struts, (i.e. a Cub), it's always a good idea to make them functional.



This creates a triangle and the strut is under tension.

A note on trailing edges:

NACA research has shown that the perfect trailing edge is a razor sharp trailing edge. The NACA research also showed the next best was a square trailing edge, as much as 3/16" on a 12" section. The worst is a rounded off section, the way most models are done!



Foam Wings:

Foam wings can be very, very strong but are also often very heavy. It has nothing to do with the materials. It is the glue. People cut the core and bond the sheeting, and that's OK. When they put on the leading and trailing edges, instead of sanding the core smooth, so that a thin film of glue works, they gouge it and slap on about an ounce of epoxy and stick it on. They cut a big hole for the bellcrank and mount it on 1/4" ply, and use a pool of epoxy as a cure-all for their sins. THAT'S where all the weight in a foam wing comes from, adding all the other things. A carefully made foam wing, with balsa sheeting, can be as light as a built up aerobatic wing. If you are dealing with a light, floater type wing, it's senseless, but things like F5B gliders have to use foam. I believe that you couldn’t build a wing strong enough with conventional construction.

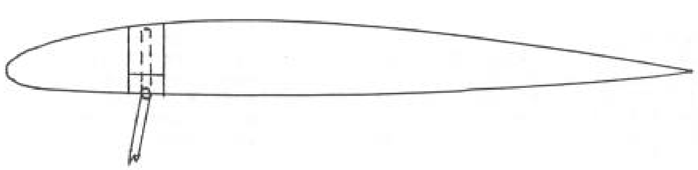
My little ducted fan uses a foam wing, 260 sq. in., with 1/16" sheet and weighs about 4 oz., which is about as light as a conventional wing could be and as strong. It just a matter of taking care to keep the amount of glue to just what is needed.

The foam is really the shear web. It's basically keeping the sheeting apart. The sheeting is the spar and the foam is just keeping it from going anywhere. The bond must be good, to stop the sheeting from popping loose. A spar is usually counterproductive, as it creates a stress riser. That means the sheeting fails near the spar. It also needs shear webbing which negates the purpose of using the foam in the first place, namely to try to minimize the internal structure.
(Going to glass or carbon fibre could be another five hour discussion.)

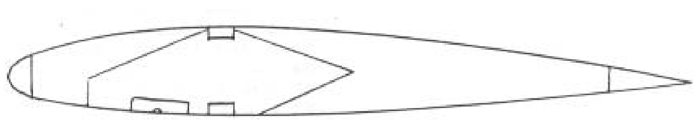
Foam wings can be used with electrics. I do it all the time, especially with high performance airplanes. You do have to be careful where you add weight.   The leading and trailing edges can be made from the softest material you can find. The skin is the strength. You do have to be careful. If you are the sort of person who takes the wing and throws it into the back of the car and the tool box rubs up against it on the way home and you put a good healthy crease in it - guess where it fails? That sheeting is the spar and if you damage it, you've got problems.

Wing Mounted Landing Gear

The landing gear is another area where a lot of kits and magazine articles put in an inordinate amount of weight and no strength. The wing mounted trunnion block is typically made of 3/4" solid maple, while the vertical block is too often pine or spruce. All the load is in that vertical block. The big block is just there to stop the wire from sliding back and forth on the wing.

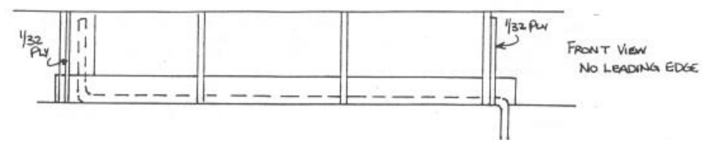


If you want to do a trunnion block set up use 1/32" ply laminated to the rib and notched to the spars. The



block, instead of maple, can be made of 3/32" ply with say 1/8" x 1/4" spruce fore and aft to stop the wire moving.

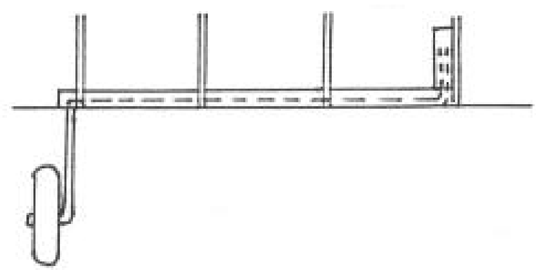
At the other end is where all the forces are going to concentrate. When you come in for a landing, the wire flexes back. The vertical block is trying to rotate out the front of the wing. If you are going to use maple anywhere, use it there.



If you insist on using spruce, don't put the grain vertical, put it horizontal, so that the wire can't split the grain. The grain should run front to back on the wing and the hole for the wire goes up through this. This vertical piece is glued to the ply rib doubler on the inner end. That' where all the strength in the airplane is, at that one joint. The rest is going along only to prevent the wheel from wandering.

Retracts:

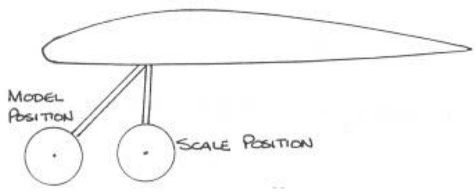
It is possible to put retracts on electrics. I have 3 or 4 now. In general, the problem is not the weight of the retracts.



With fixed landing gear you have a torsion bar, a piece of wood and plywood to support it, the wire and the wheel. You want to make it into a retract. You've still got the wheel, most of the wire, some ply facing on the ribs to distribute load. You don't have those two pieces of torsion block on a retract, instead you've got the retract unit. These are pretty light. You've got a servo in the middle to run the retracts and you've got a slight difference of weight in the retracts themselves. To give you an example, the retracts on my 40 size Spitfire cost me 3.5 ounces.

The problem with retracts is not the weight factor. Real airplanes take off from grass or pavement. In proportion, we take off from hay fields. To make most scale airplanes work, the landing gear is pushed forward so that the bending action, that the gear goes through on landing, doesn't cause the plane to land on its nose.

That gave me fits with my Mew Gull. I tried a scale

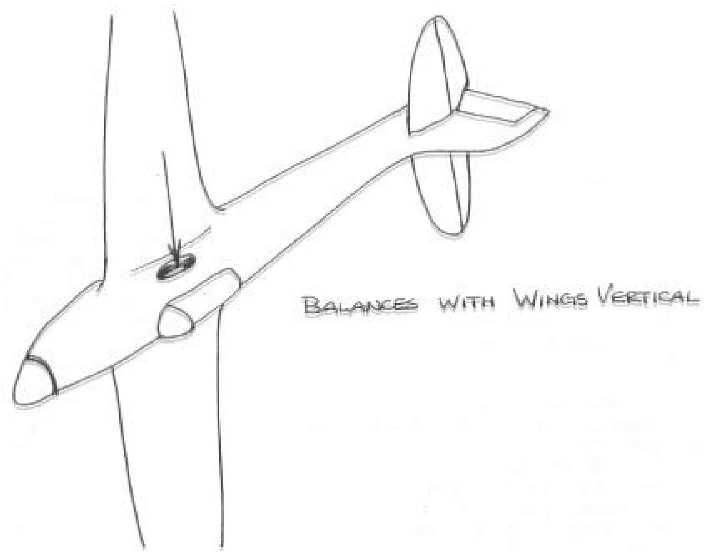


landing gear location and no matter how careful I was, no matter how much I flared, every time I came in, right up on its nose instantaneously. I don't think there was even any roll. I even put flaps on it to try to slow it down to see if I could come in to land better. I was trying to get away with a scale landing gear location. It wasn't even retracts.

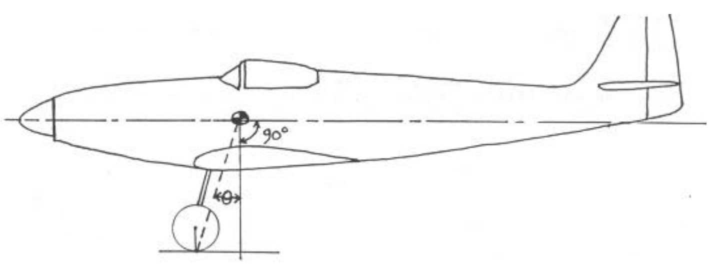
What I did was to make a new set of wheel pants and cant them forward. If you see my plane you'll notice that the center line of the wheel isn't anywhere near the center line of the wheel pant. That's the only way I got it to land.

How to get the retract unit back up into the hole in the wing is usually a problem because when the wheel returns into the wing it is at quite an angle. If you're going to go off and play with retracts make absolutely sure you know where the wheel is supposed to be.

To figure out where to put the wheel requires the vertical center of gravity. To find this, (unfortunately the airplane needs to be virtually complete), take the whole airplane and find where you have to hold the airplane with the wings vertical to balance it.



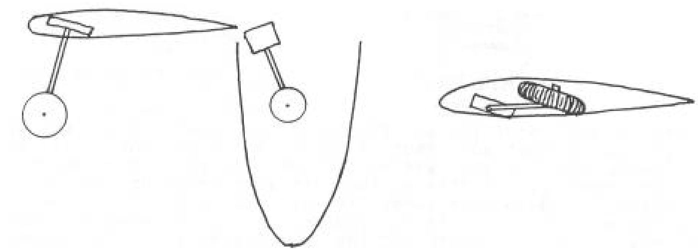
Once you have that point, draw a picture of the airplane in flying stance (see figure) and drop a line



down through the vertical center of gravity. This is the magic angle. Wherever the wheel contacts the ground is the point we are concerned with.

If you are flying off pavement, and you are only flying off pavement, you can get away with 5-10 degrees. That's what most scale airplanes are set up for. If grass, it's more like 15-20 degrees. If you're flying off a hay field, it's up around 25-30%. A lot of airplanes get into trouble if the gear is too far back even on take off. The airplane's sitting there, you add a little throttle, the nose goes down so full elevator is applied. The airplane somehow walks away. In order to keep the plane from going over, it requires holding full power and full elevator. Guess what? The airplane floats off the ground in full stall, snap rolls and goes in. It never got into flying stance. It causes a lot of crashes because the gear is so far back that you are having to balance the airplane.

In general, with 40-60 size airplanes, you can probably put in retracts with no trouble because you can play with the geometry to get the gear up and down.



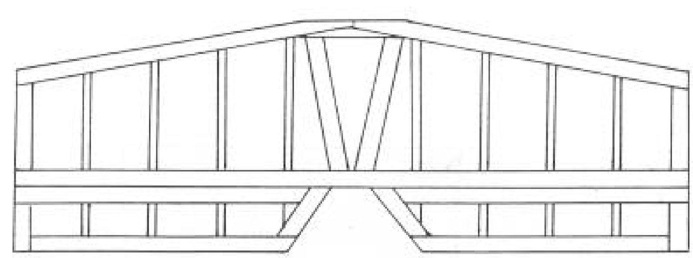
With 15 size and smaller, it's probably not such a good idea. You are dealing with a wheel so small in proportion to the grass that they have to be awfully far forward and therefore difficult to get off the ground.

In order to get the wheels to retract back and up, it's an intricate set of geometry. You end up having to tilt the retracts forward and out.

Retracts are really nice if you really have to have them. You'll spend a lot of time getting take offs and landings down right. Sometimes it adds so much trouble that you don't like the airplane.

Tail Surfaces

Remember I said that tail surfaces are over built? When not dealing with a scale airplane, with specific rib locations, it's a classic case of where triangulated structures add a tremendous amount of strength for the same weight.



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