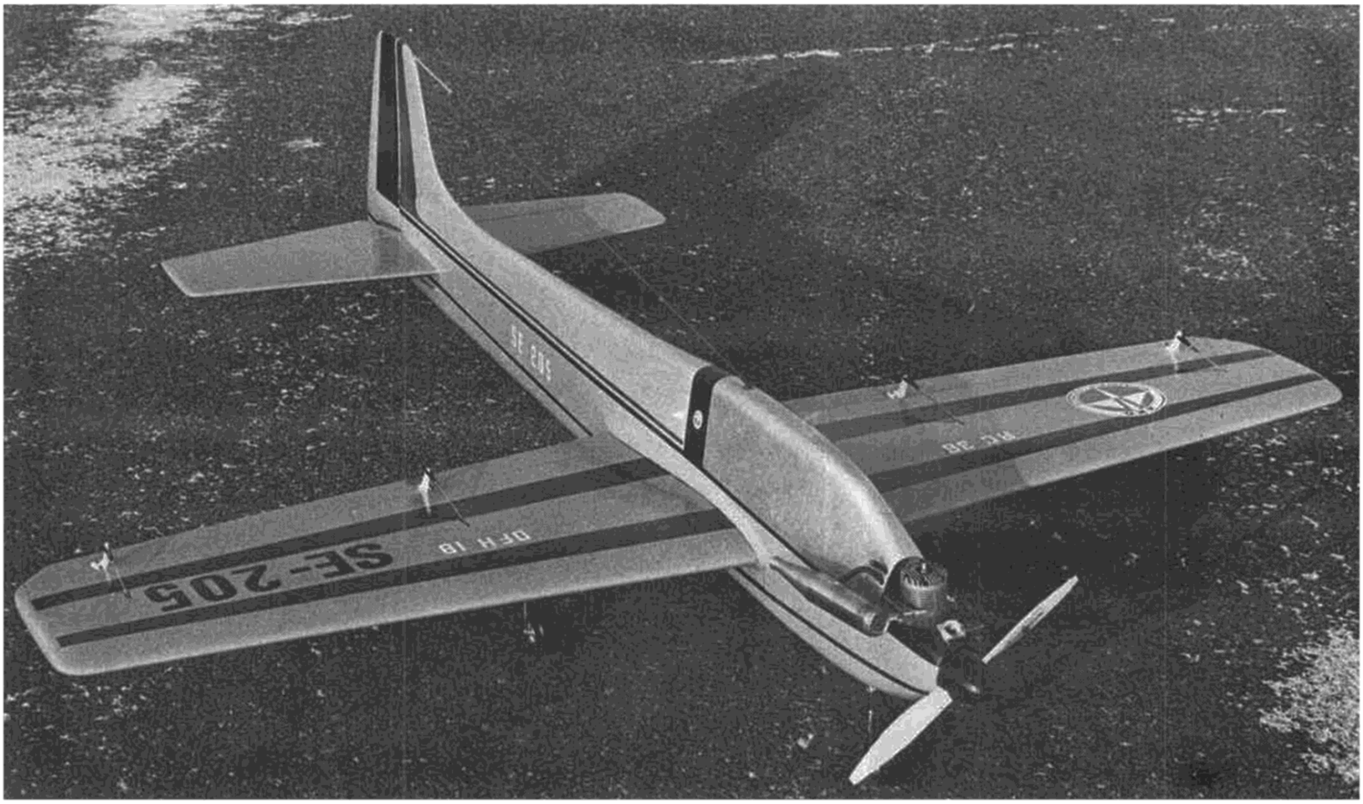


• DEN FLYGANDE HYVELBANKEN (DFH) 18 •

By BENGT LUNDSTROM . . . No molded fiberglas fuselage, no foam core wings . . . just a top-notch pattern ship built out of exotic balsa and ply. It placed a very credible 23rd at the 1975 World Championships.

• The name for this model is "DFH 18", or in full, "Den Flygande Hyvelbanken 18". In English it is "The Flying Carpenter's Bench 18". It sounds like something square and dull and so it was with the first 5 in the series. Some evil tongues invented the name and as I couldn't fight the name I adopted it for the coming models.

This dull design evolved into DFH 18. I used similar models at the world championships in Italy, 1973, placing 33rd, and in Switzerland, 1975, placing 23rd, with variations in size and so on.

THE DESIGN

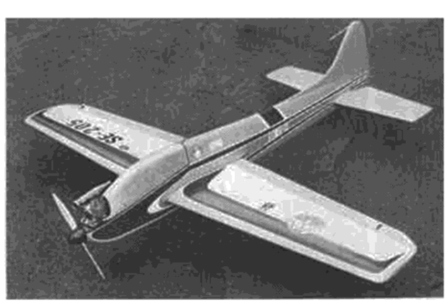
The first design goal has been to make a "clean" plane with as little inter-action or deviation as possible when applying aileron, rudder, elevator, upright or inverted, or when applying full throttle from idle. This means to me a mid-wing design with symmetrical airfoils and a 0^{o}-0^{o} set-up. It is only the fin that can't be made symmetrical. To counteract the rolling action when applying rudder, there is some dihedral. To make it smooth and stable, a quite long tail is used. The fuselage is longer than the wing.

The second goal has been to make it possible to fly quite slow in rolls . . . not losing height in knife-edge and at the same time, keeping the fuselage axis as much as possible in line with the rotational axis. This goal is met by a very high-speed fuselage. In Switzerland, it was not needed, as several top flyers were not penalized when making 7-8 second top speed rolls. This far exceeded the rule book's statement of 4-6 second rolls within a 90^{o} sector and with the normal flying distance of 50-100 meters. I think the judge's policy must change, and in the meantime you can try to make knife-edge loopings. I have made it, but be careful!

Many consider it best to slow down the plane by using the thick airfoils. I consider it wrong, as it won't help in knife-edge, which the highsided fuselage does. I also like thin airfoils to speed up the plane in the round manuvers, where there are no problems with the 90^{o} sector.

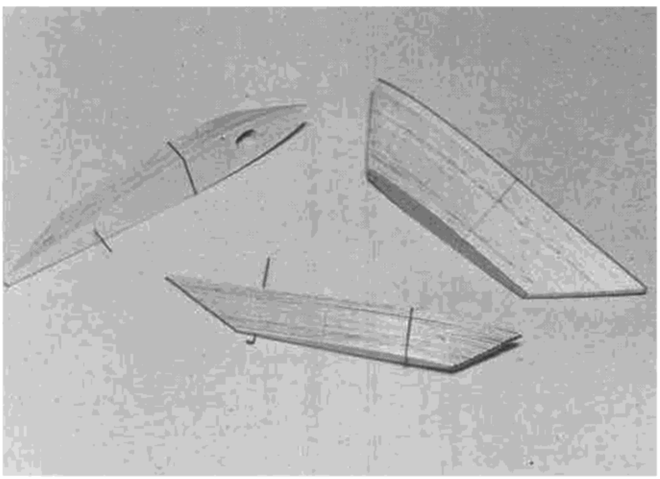
One other probably distant excuse is that the very roomy canopy can hide a big muffler. I think the engines will evolve like to day's powerful 2.5cc engines, with rear facing exhausts. To reduce the noise, we also need a rear intake to put a muffler on the carburetor.

The third noise producer is the propeller. The trend today to make slow-revving, 15cc engines can reduce the propeller noise. But otherwise, this idea seems ridiculous. We have models today

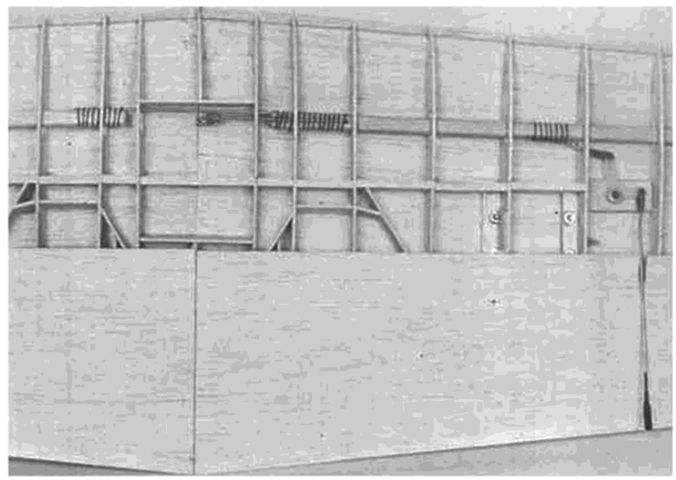


Just in case you thought this design fell together in one evening, here are only three of the predecessors, all showing variations of the progressive aileron deflection system which Bengt talks about in the text.

Profile view shows proper set-up of landing gear, giving slight positive angle to wing as plane sits on ground. This assures a smooth, jumpless takeoff. High fuselage profile permits sustained, even climbing knife-edge flight.



Ribs are sandwich-cut. The rear 1/3 of the airfoil is straight, permitting construction on a flat surface. No spars are used.



The sparless wing gains its strength from the proper adhesion of all structural parts to the wing skin. Note wood pushrod and linkage.

which are too big, too fast, too noisy, and which even kill people. And this makes very big airfields necessary. With a 15cc engine, the planes will be still bigger, and what contest flyer can resist using some of the 5cc's to get more power? I find it better, to reduce the engine size to 2.5-6cc (by FAI rule), but that seems to be very, very far away. Already we can fly a decent aerobatic program with as small as a Tee Dee .049, which is quieter without muffler than today's 10cc engines with muffler.

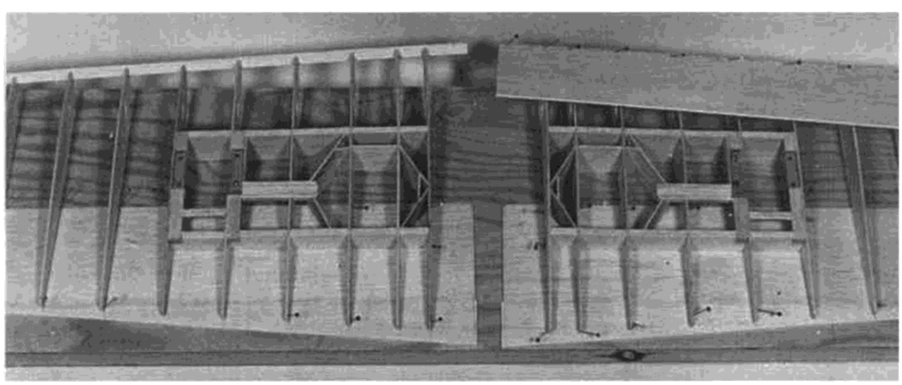
The third design goal has been to make a plane with a good control margin in critical positions . . . for example, losing speed and making a roll, as on the top of an Immelman. In Bern, most top flyers avoided this problem by rolling before the first half loop was finished *(Cliff Weirick put us on to this trick way back in 1967! wcn)*, again with no penalty. I also want the control response to be the same at high and low speed. All of this is made by:

A. Using thin wing, stabilizer, and fin airfoils.

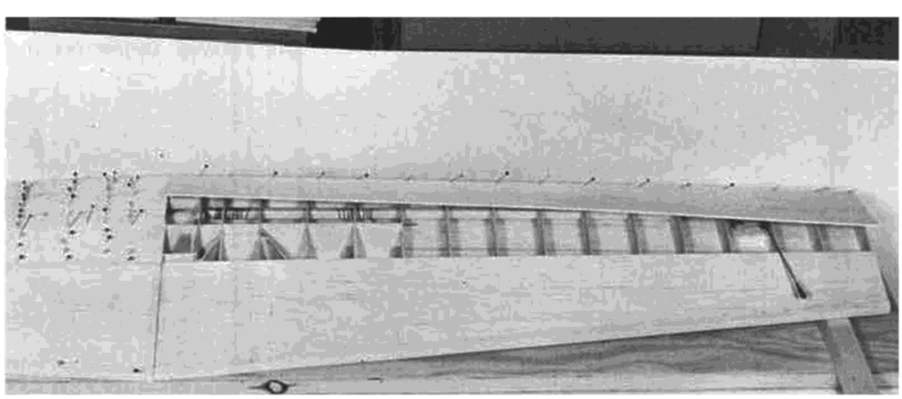
B. Using balsa to get a modest weight, which also enables an unusually long tail moment.

C. Using very wide ailerons and elevators.

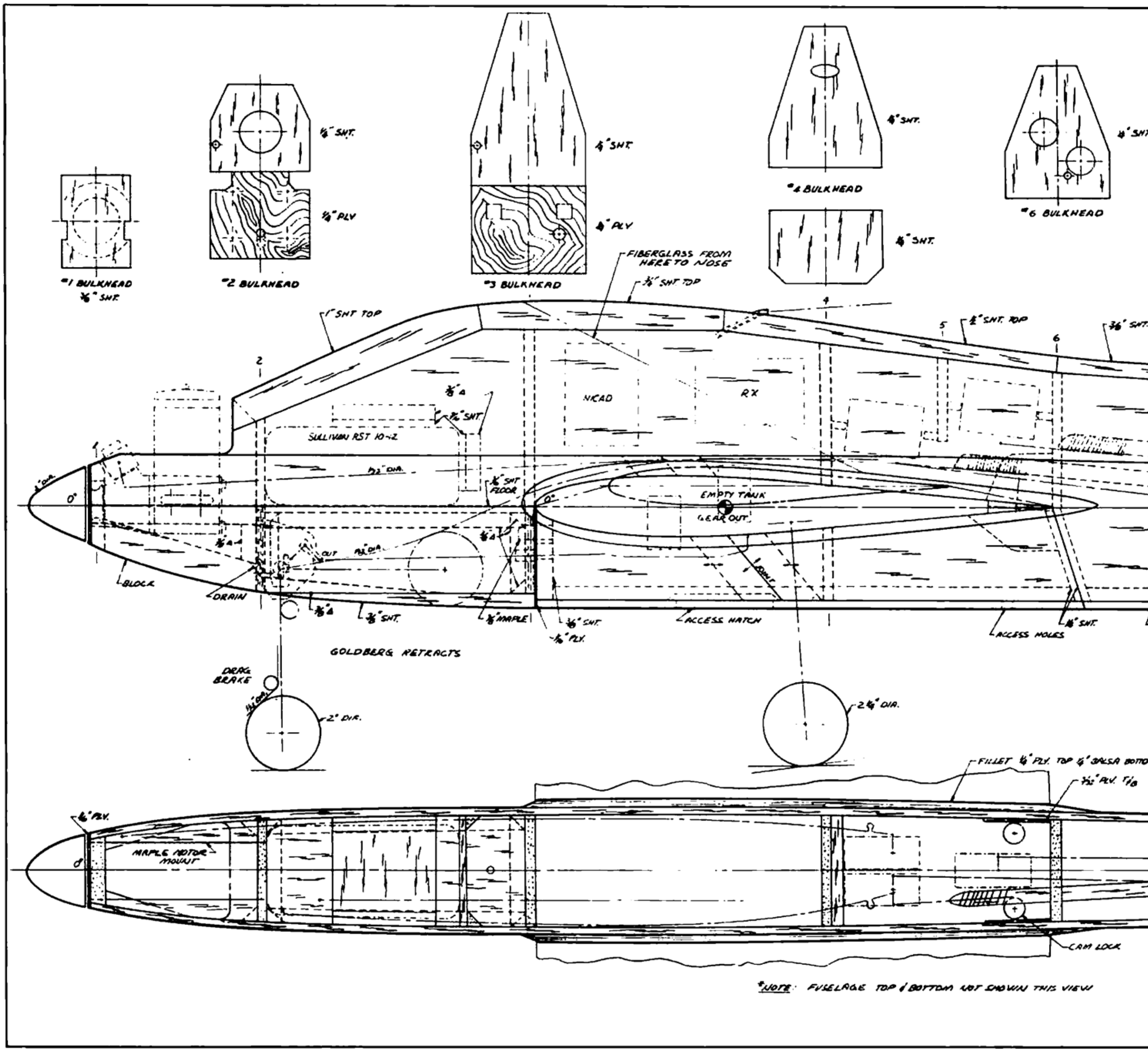
D. Using more effective ailerons by



At earlier stage of construction than in photo above, ribs are shown glued to flat partion of sheeting which is pinned to building surface. Webbing boxes in the landing gear area.



With all internals installed, wing is butt-joined at center, with required dihedral blocking. Joint is later reinforced with glass cloth and resin. Retract bays are cleaned out after top sheeting.



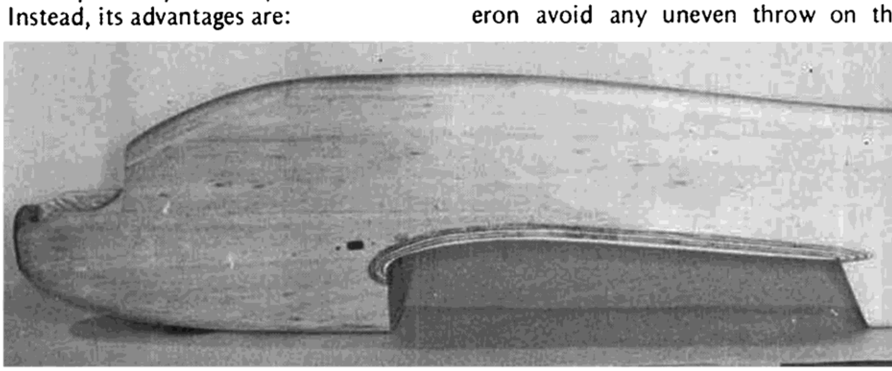
giving them more throw at the tips than at the root.

These warping ailerons are what catches most eyes. The funny thing is that they do not improve what people think they are for . . . making high speed rolls. There you don't need any more speed as you have power in excess. Instead, its advantages are:

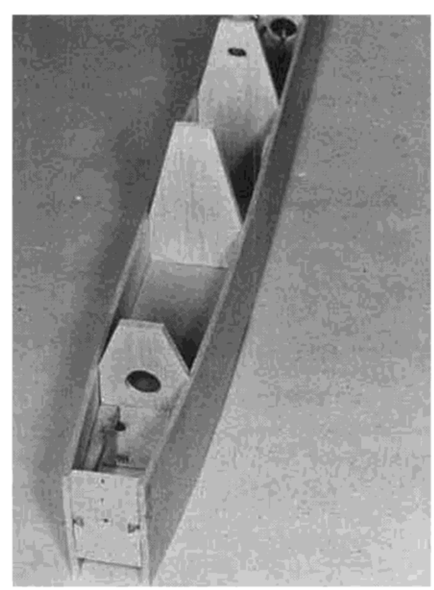
A. In combination with the wide ailerons you do not lose controls at slow speed, when the ailerons on other planes just die.

B. They are very distinct in response, which is good in an 8-point roll, for example.

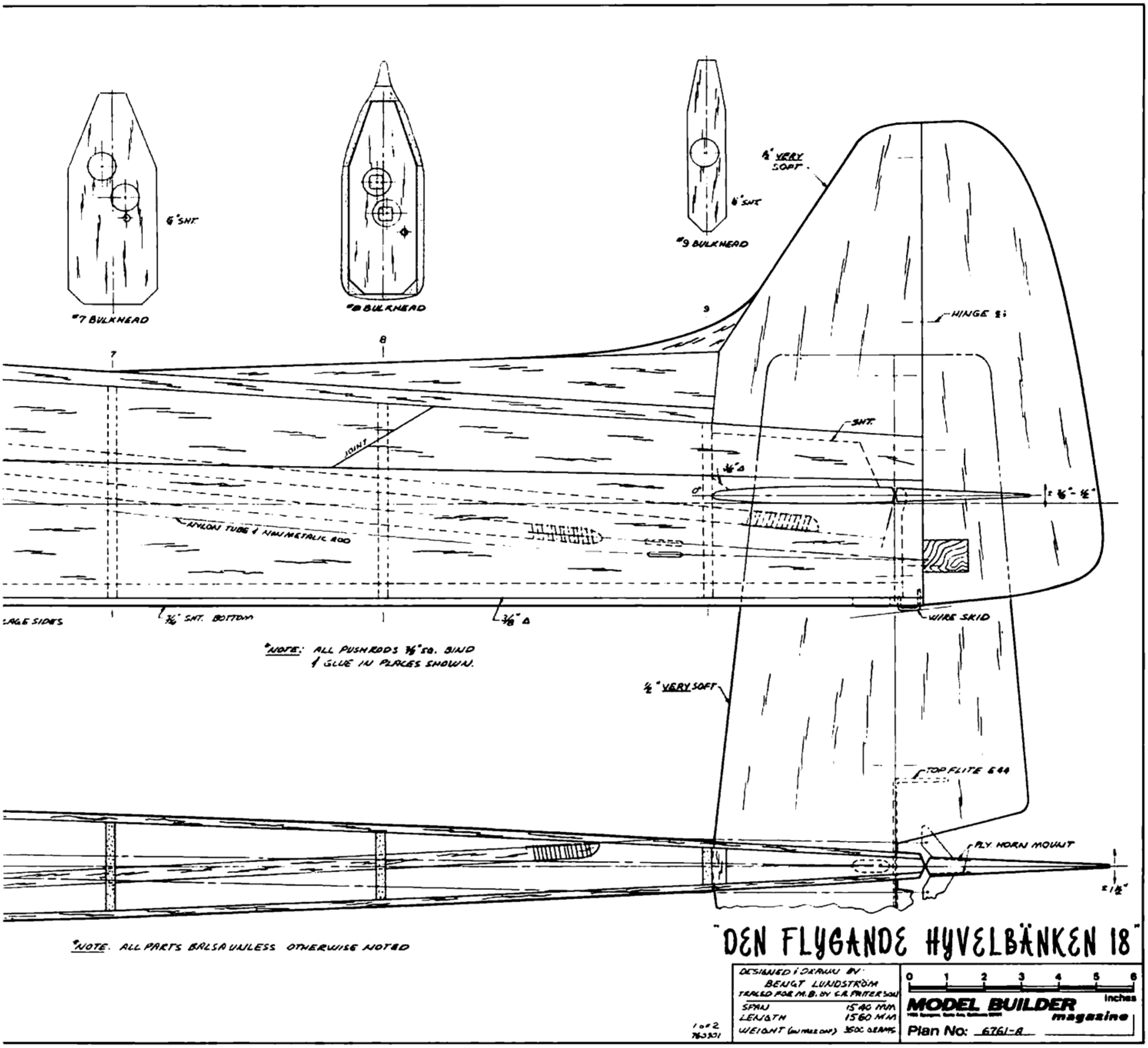
C. The two control rods on each aileron avoid any uneven throw on the



All sheet balsa fuselage has no doublers, gets its strength from careful gluing of skin to all structural parts. Upper wing fillet is shaped from 1/4 inch ply. Nose area is glass and resin reinforced.



Basic fuselage is sheet sides and bulkheads. Matching of side wood is important.



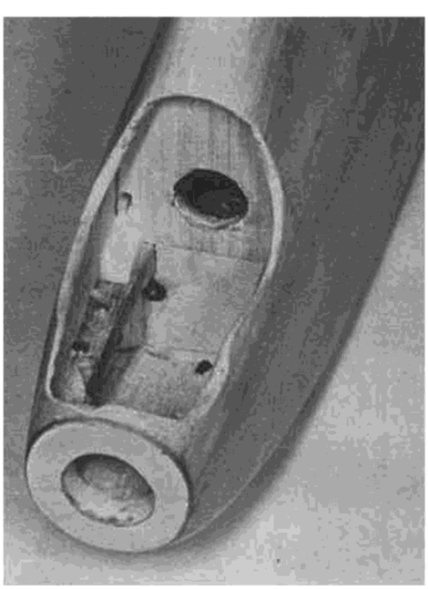
FULL SIZE PLANS AVAILABLE – SEE PAGE 94

two ailerons. It has surprised me to find how much a minor differential can influence the rolls.

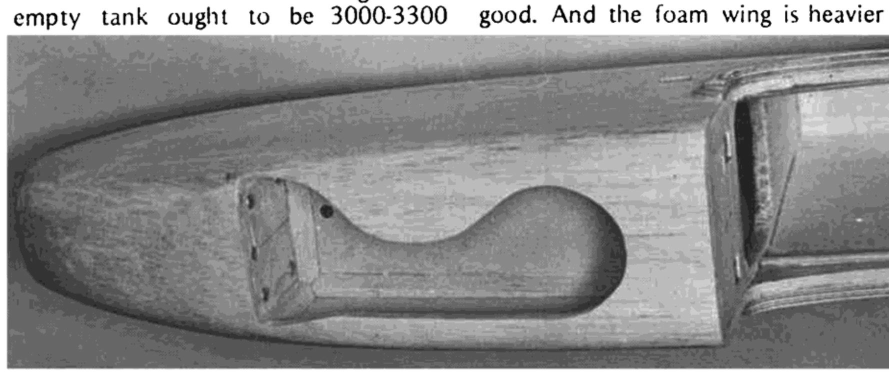
D. You won't have aileron flutter.

BUILDING OF THE MODELS

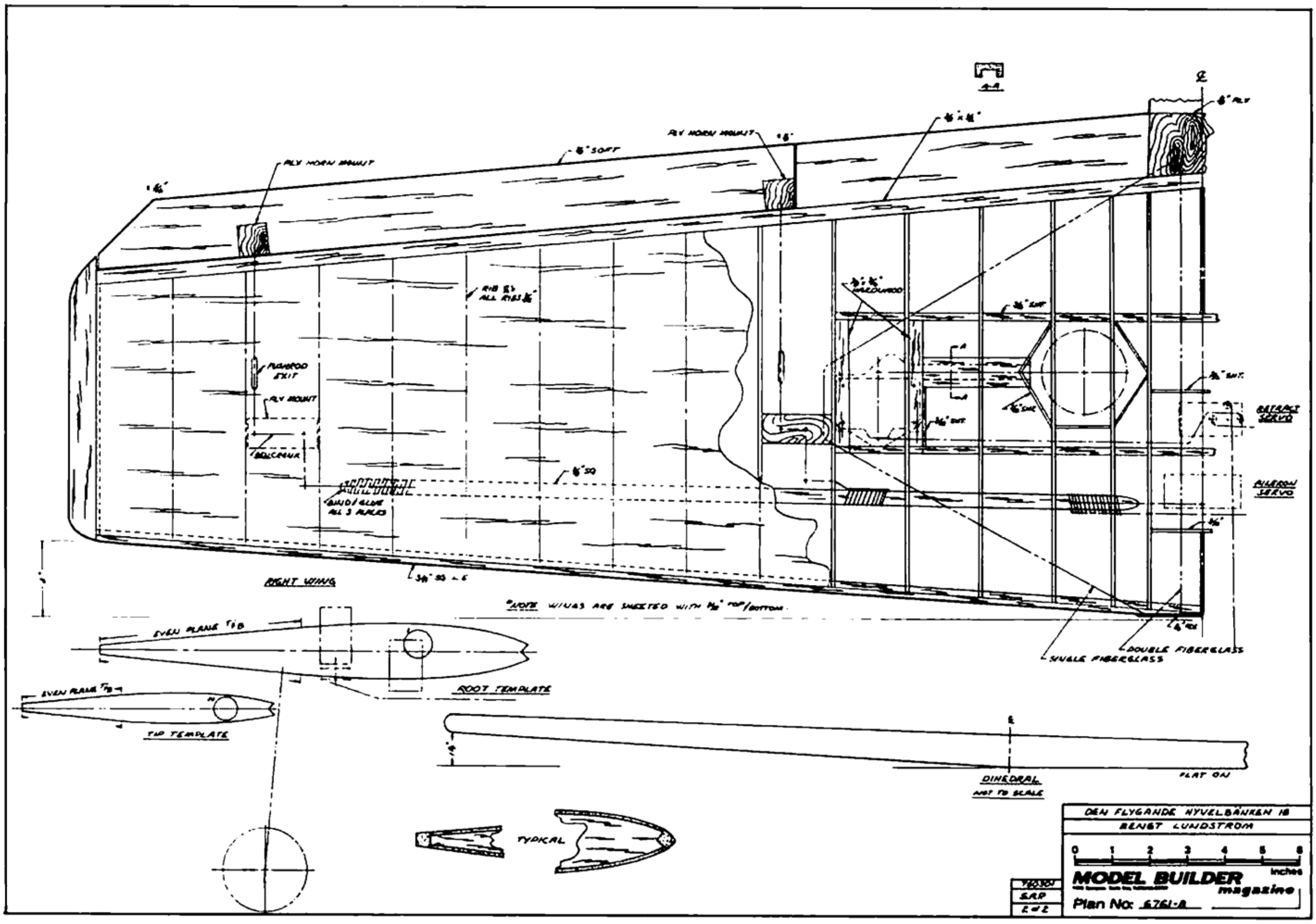
This model must be built light, particularly at the tail, to avoid a lot of lead in the front. The total weight with empty tank ought to be 3000-3300 grams (28.35 grams per ounce). If you think you will build it heavier, or will use a particularly light engine, please move the wing back a 1/2 inch. And if you will use a fiberglass fuselage and foam wing and stabilizer, move the wing back at least 1 inch. But this will shorten the tail moment, which is no good. And the foam wing is heavier at



Engine compartment is snug but accessible. Wood-constructed pattern ship rare today.



Nose gear retract bay, designed for Goldberg system. Note triangle section reinforcing in corners. Ship is built like proverbial brick outhouse, yet is lighter than many contemporaries.



FULL SIZE PLANS AVAILABLE — SEE PAGE 94

the tips, which makes the aileron response a little more mushy.

The way the plane is built may startle some people. There are no doublers in the fuselage, you find very short wooden engine mounts, and there are no wing spars. My latest 6 models have been built like this, and with no problems. The important thing is to make a strong skin to which all high forces are directed, by gluing to it . . . for example, the engine hardwood mounts. Make this skin of Hobby-Poxy 2, with fiberglass cloth (0.6-0.8 grams/DM2) as indicated on the drawing.

The photos come from several models, and there are minor differences. I have tried to pick the best from them all to make the "DFH 18."

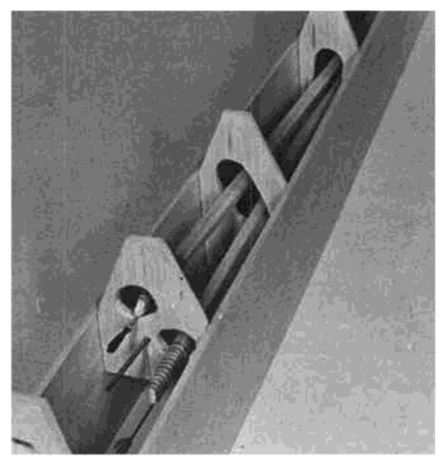
THE WING

The chosen airfoil has one very critical feature. The rear third of it is completely flat from the corner to the wing tip, as seen on the drawing. If you have a straight and even building board, you can just pin down the ribs on the rear part of the sheet skin. When making the rib packs, mark the front point of the straight portion as a help to line up the ribs.

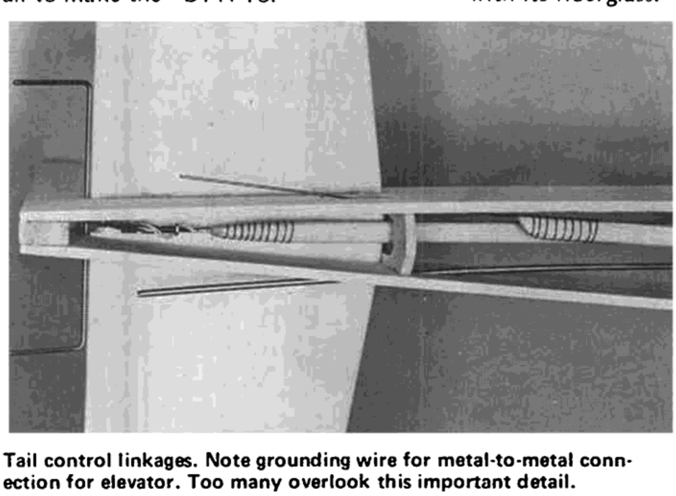
You *must* follow this sequence:

A. Start by building each wing half upside down on the rear flat portion.

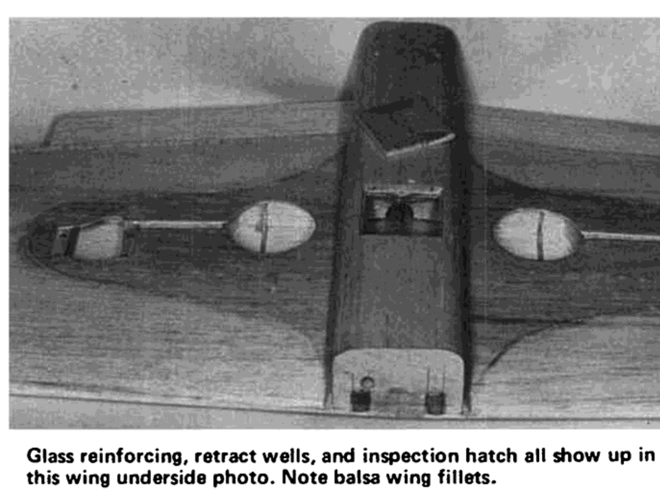
B. Fit all retract details, including the 3/16 spacers; which are a must. Also make thin spacers to be able to glue the retract hardwood mounts to the skin, with its fiberglass.



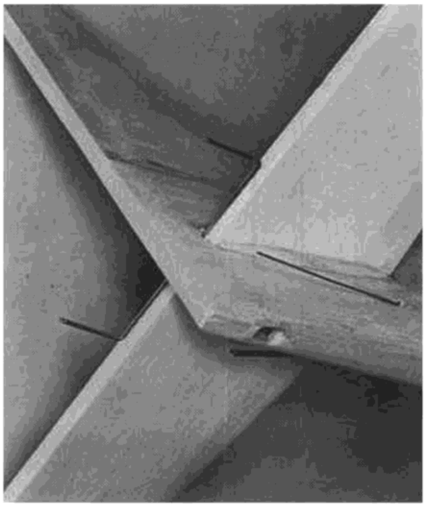
Fuselage aft of wing, showing pushrod installation. Nyrod is rudder return line . . no slop.



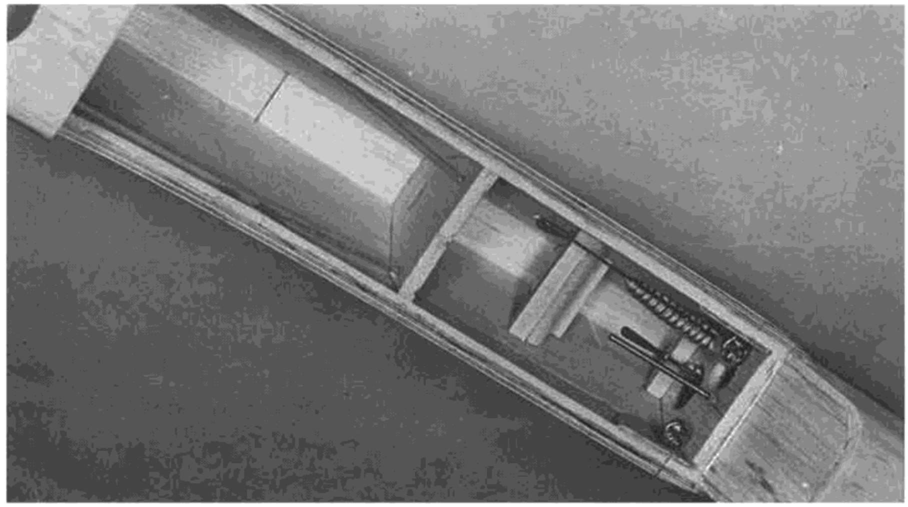
Tail control linkages. Note grounding wire for metal-to-metal connection for elevator. Too many overlook this important detail.



Glass reinforcing, retract wells, and inspection hatch all show up in this wing underside photo. Note balsa wing fillets.



Tail section prior to attaching control surfaces. Note elevator linkage inspection hole.



Radio compartment prior to installation. Longest rod and tube are for rudder. Elevator rod almost hidden. Note Dzus fasteners for wing, and tubes for throttle and nose wheel linkage wire.

C. Fit all sheets to the wing bottom.

D. Remove the wing halves from the board and fit the rear "spars."

E. Prepare to join the two halves and make the long push rod.

F. Join the wing halves with the correct "dihederal block" of 1-1/2 inches when the other wing half is lying flat on the building board. The push rod must be there.

G. Make all the details for the 90° cranks.

H. Complete the sheeting of the wing upper sides.

I. Cut the retract bays and make the servo compartments.

J. Put the fiberglass and epoxy reinforcement on the wing.

K. Make and install the push rods for the retracts.

THE FUSELAGE

Again, avoid all unnecessary weight at the tail.

A. Make the two vertical fuselage sides of equal hardness, all bulkheads, and the tail surfaces.

B. Make a sub-assembly of the bulkheads 1 and 2, and the hardwood engine bearers.

C. Glue the fuselage sides to the sub-assembled front and the fin. This *must* be done with a symmetrical curvature. If not, break it up and glue it again!

D. Fit the rest of the bulkheads, including the two balsa pushrods and the tube, which must be installed now. Note that it may be wise with some radios to fit a ground wire to avoid electrical noise at the elevator linkage.

E. Fit the bottom triangular longerons and the rear bottom sheet.

F. Make the retract bay.

G. Fit the bottom engine bay blocks.

H. Complete the tank compartment.

I. Fit the upper fuselage sides and the top blocks.

J. Cut out the wing "holes" and the bellypan. Glue the plywood reinforcement above the wing and apply the fiberglass with HobbyPoxy 2.

K. Make the servo compartment and install the cam locks.

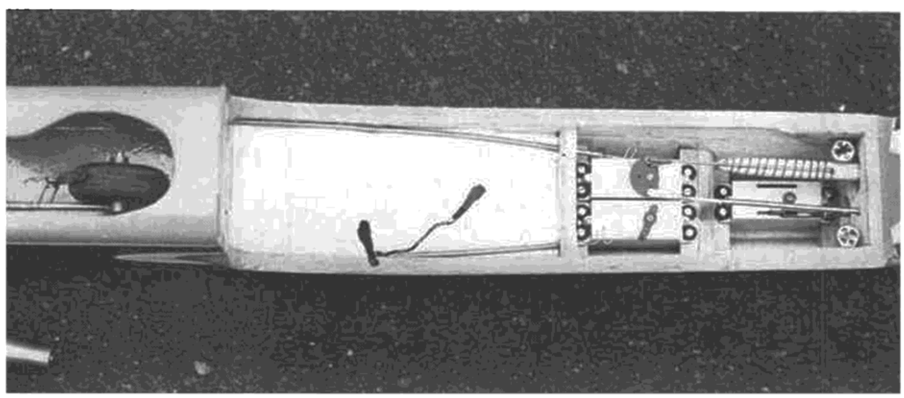
L. Fit the belly pan to the wing and mount all the details shown on photos 21 and 22.

M. Make the ailerons, elevators, and the rudder.

FINISHING

I use nitrocellulose car paint, and over on that, clear polyurethane. In the engine and tank surroundings, I use clear epoxy.

Continued on page 84



Radio installation completed. Note nose-wheel drag-brake, connectors for retract and aileron servos, and kinks in throttle and nose wheel steering control wires. Very neat office.

Underside of completed DFH-18, showing Goldberg retracts extended. Hatch is for access to retract servo. Note inner aileron horn pads.

The end! Note dual rudder linkages which eliminate slop, also wire skid to protect rudder during nose-high landings, identification tag.

DFH-18 . . . . . . *Continued from page 15*

With this, I end up with a total weight of 3100-3300 grams (empty tank) and the shown center of gravity. If you are afraid that your plane will be tail heavy, I suggest that you apply Monokote, or similar, to the stabilizer and the fin in place of the paint. This saves a lot of weight, but makes a soft surface.

WEIGHT INDICATIONS

For a model with cellulose paint and clear polyurethane.

A. Sanded, including HobbyPoxy 2, ready to be painted.

Fuselage . . . . 600 grams
Rudder . . . . 25 grams
Elevators . . . . for two 25 grams
Wing, including belly pan 550 grams
Ailerons . . . . for two 15 grams

B. Painted, all details mounted including ailerons, rudder, elevators, retracts and wheels. No R/C gear or engine.

Fuselage . . . . 1100 grams
Wing . . . . 920 grams

C. Including R/C gear and engine.

Fuselage, empty tank . . 2150 grams
Wing . . . . 1050 grams
Total weight, empty tank 3200 grams
Fuel . . . . 300 grams
Take off weight . . . . . . 3500 grams

D. Surfaces Wing Area . . . 45 DM$_2$
Stabilizer Area . . . . 15.5 DM$_2$
Total area . . . . 57.5 DM$_2$

E. Surface loading
3500 / 57.5 = 61 grams/DM$_2$

Surface loading, max return 75 grams/DM$_2$

F. Max permitted take off weight 75 x 57.5=4300 grams

FLIGHT TRIM

Adjust the nose gear length to a little nose-up attitude. This improves the take-off very much, with the penalty of a little more risk of getting bouncy landings. Don't forget the nose wheel drag brake.

Check the center of gravity and adjust if necessary. If the CG is too far back, the plane will be unstable when flying slow before landing, but on the other hand, it needs less corrections in rolls and round maneuvers. It is also easier to "stop" the model at the spin entry and the spin is easier to have. Experiment and make your own choice.

Check that one wing is not heavier than the other. If so, balance by putting lead in the light wing tip. You will probably have to make more corrections later on, when flight testing, as the two wing halves are sure to be different and, for example, seldom have the same area. And only 2-3 grams out of balance in a tip is easily felt as out-of-trim.

Check the aileron, rudder and elevator throw to be as indicated on the drawing. Later on, try to flex with as little throw as possible, to get a smoother flight.

Now make your first flight. If you have trouble retracting the long landing gear, it might help with 2-3° "nose-in" for the main wheels. Just before entering the bays, the wheel have a 4° angle of incidence against the air. This angle tries to force the wheels out. The "nose in" also helps a little to avoid ground loops.

First check the upright and inverted loop radii to be about equal, and as big as possible with full elevator throw. For safety reasons, always make the first inverted loop upwards. If you fly the plane nose-heavy, you may need more down than up, which can be had by drilling your own hole on the rotating servo disk, a little towards the tail. On the other hand, the linear racks give less sensitivity around neutral, which is good . . . but there is usually more play.

One very common problem is that the wing does not stay horizontal in the loops and bunts (outside loops). Mostly the problem can be traced to wing halves being out of balance. Sometimes it is interconnected to an engine being angled to the right or left, which together with dihedral and/or a big distance between engine axis and wing, may give a roll if they are not matched to each other.

If the above variables are properly matched, an engine angled to the right or left ought to give only a sideways movement with the wings horizontal all the time in round manuvers. The reactions are sometimes very confusing, but midwing designs are much easier to correct, as they have less interaction.

Try these methods:

A. Fly straight and level and note if one wing drops. Then fly inverted and note is the same wing drops, if so it is too heavy. If the other wing drops, you have just too much aileron trim. You can only find a severe unbalance this way.

B. A little more sensitive method is to fly straight and level and give full up to get a vertical climb. If this climb is inclined to one side, the same wing tip is too heavy.

C. A far more sensitive way is to make several bunts. If the plane slowly rolls to the right, it is possible to correct this by applying right aileron trim. But this is no solution as it gives other problems. Instead, you will probably have to put 3 to 5 grams in the left wing tip. This text has to be made on a calm day.

D. If all is confusing, just put lead in one wing tip and observe what happens. You ought to be 50% sure that it is the right side. The problem is how much lead.

Always remember that contrary to what most people say, even a very warpy and unbalanced plane can be made to fly clean and nice if you just work hard and try different ways.

Now adjust the aileron throw to give 3 rolls in 5-6 seconds.

Next try a spin. I say "try" because one drawback with low wing-loading and as little throw as possible on the control surfaces is that it may be difficult to make a spin.

A. With idling engine, reduce speed by giving more and more up elevator all the time with the same altitude until the plane "stops" in the air with full up elevator.

B. Then give full right rudder.

C. After a 1/4 turn, give full right aileron.

I am well aware that this spin entry is not what is considered the "right" one by many. To the confusion of others, even the Head Judge at Bern 1975 demanded a climbing entry instead of a level one, which is more difficult and even impossible with some models. I consider that this climbing spin entry idea relates from the fact that some model and full scale planes cannot "stop" after a straight and level entry, they just move the nose slowly downward. Also, many flyers at Bern didn't care what the Head Judge wanted. I had a feeling that many of the judges didn't care either.

If you have trouble getting a spin, first try to reduce the idle and increase the rudder throw as much as possible. It is for this and the resulting big neutral play that the two control rods to the rudder are used.

If you still have problems, move the rudder trim to full left on the transmitter with neutral on rudder. Then when entering the spin, move the trim knob to full right to get more throw. You can do the same with elevator trim but then move the trim back during the spin exit.

Another way is to use reduced throw normally for rudder, elevator, or even aileron, and then full throw for spin. To have it on rudder may be the best because you can use it full on "figure M" also and have reduced throw in rolls.

The engine axis 0°-0° set-up ought to be the right one. Adjustment may be needed if:

A. The plane moves sideways to the left with horizontal wing in round manuvers. Then give the engine axis a right inclination.

B. It drops the nose applying idle from full power. Then angle the engine axis a little down.

One problem which is surprisingly little discussed is the behavior in knife-edge flight. There are two unwanted reactions when flying straight and level in knife-edge:

A. A roll to upright or inverted position when you apply rudder. This effect is quite easy to counteract by giving more or less aileron, as there seldom is any interconnection. If it is too irritating, the problem can be cured by increasing the dihedral if the model rolls to inverted, or decreasing if it is the other way. It is only if the reaction is different depending upon what wing is down that there is not any simple solution.

B. Much worse is the phenomenon that the plane "turns" toward either the "fin"(=up) or the "wheels" (=down) . . . and that this behavior is worse with more rudder to hold the plane level.

What does the flyer do when he makes a slow roll to the right? In Bern, most top flyers started with something that is not in the rule book and they were obviously not downgraded. They raised the nose slightly before rolling to minimize the need for corrections later on. But if we suppose that you will not do something so bad, this ought to happen:

A. During the first 90° roll you will give more and more left rudder. Probably a little up in the beginning to keep the fuselage level.

B. From 90° to 180° (inverted) you will slowly neutralize rudder and start giving a little down.

C. From 180° to 270° you will apply more and more right rudder and neutralize elevator.

D. From 270°-360° you will neutralize rudder and if you need, you might even give a little up elevator, which is neutralized when finishing the roll.

What has happened to the control surfaces?

A. Aileron: constant . . . I hope. No problem.

B. Rudder: Left (90°), neutral (80°), right (270°) and neutral (360°). In low speed, or with insufficient fuselage side area, you need more rudder. Otherwise it is quite uncomplicated.

C. Elevator: A little up (0-90°), neutral (90°), more and more down to max at 180°, neutral (270°), perhaps a little up (270-360°), neutral (360°). This is more complicated. You could minimize the need for elevator correction, for example, by moving the center of gravity backwards.

What happens if you have a "down" elevator interconnection (to the "wheels") when giving rudder in knife edge? Only look at the elevator:

A. 0-90°, up elevator

B. 90-135°, elevator gradually to neutral

C. 135-180°, elevator gradually to "max" down

D. 180-225°, elevator gradually to neutral

E. 225-270°, elevator gradually to "up"

F. 270-360°, gradually from up to neutral.

This seems to be very complicated!

What happens with an "up" elevator interconnection (to the "fin")? Again, only look at the elevator:

A. 0-90°, perhaps nothing, as you will have a little up automatically.

B. 90-180°, more and more down elevator.

C. 180-270°, less and less down elevator.

D. 270-360°, again perhaps, nothing as you will have a little up elevator effect.

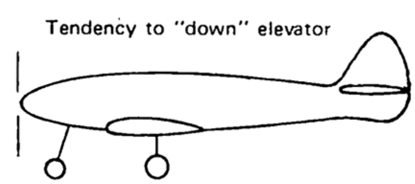
This seems to be much better!

However, this "up" elevator effect will usually be far too much. So the best choice seems to be neutral to a very slight up elevator (to the "fin") interconnection.

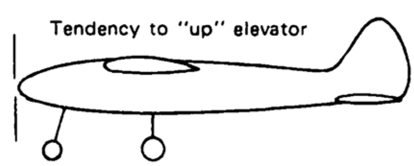
How do today's models behave? The funny thing is that it is much more common with a "down" elevator interconnection than an "up". The terrible thing is that models built alike can behave differently, with no obvious explanation. In my own experiments I have only been able to observe tendencies and I have very few cures to the problems.

What are the tendencies?

A "standard" low wing model with a high placed stabilizer used to go towards the wheels ("down") or it is sometimes quite neutral.



A mid or high wind model with a low placed stabilizer used to go towards "up" elevator.



These observations make one guess that it may have something to do with a turbulence originating from the wing root and which increases when applying rudder. If the plane doesn't have the same tencency depending upon which wing is down, it might be due to an effect from the spiraling propeller slip stream.

How can this interconnection be avoided? The two obvious measures are:

A. Move the stabilizer away from the wing turbulence . . . upwards or downwards at least 2 to 3 inches, depending upon the fuselage length.

B. The other way is to place the stabilizer with equal turbulence on both the upper and the lower surface. This would mean in line with the wing. This would probably also mean a more horizontal roll axis in a snap or very fast roll. The worst stabilizer position ought to be a 1/2 to 2 inches above or below the wing. If you are unlucky you might need the crazy positioning of one stab side placed higher than the other!

C. Move the center of gravity. If a model flies straight and level, the wing lifts the model's weight, one G. If we roll to knife edge, this ability to life one G ought to be at least partly translated to horizontal and some tendency to move towards the "fin" (up) ought to be there.

If the CG is moved far forward, you have normally to fly with more "up". When the one G disappears in knife-edge, the plane ought to move a little more towards the "fin" (up). A move of the CG backwards would then create a tendency to move towards the "wheel" (down).

This way you can change the tendency only slightly.

D. Create another turbulence on the fuselage side at a wanted height to give the desired stabilizer influence as "A" above. A sidemounted engine or muffler might work as such a turbulator. Even in this case the influence is surprisingly marginal, but it is always safer to have both fuselage sides alike with smooth wing fillets.

E. A longer tail may help to get a more even turbulence on both sides of the stabilizer, as the turbulence spreads at a longer distance from the wing. But if the stab not until now will enter the turbulence, it will be worse with a longer tail.

F. Make yourself a "black" electronic box similar to Ken Gustafsson's, here in Sweden. It gives the proper amount of elevator compensation when rudder is applied on his "Mach 1".

Most of this discussion is based upon the assumption that a turbulence is created affecting the stabilizer. But I have never seen it and do not know. Someone interested ought to investigate it with the help of a wind tunnel.

In the mean time I keep to a high speed midwing design like the DFH 18.

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