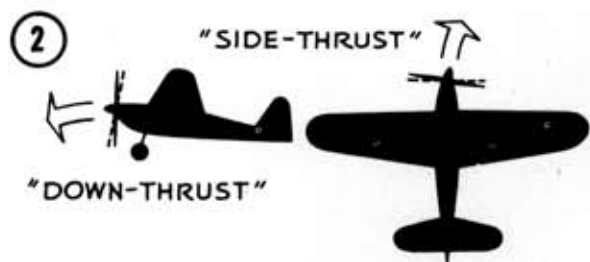
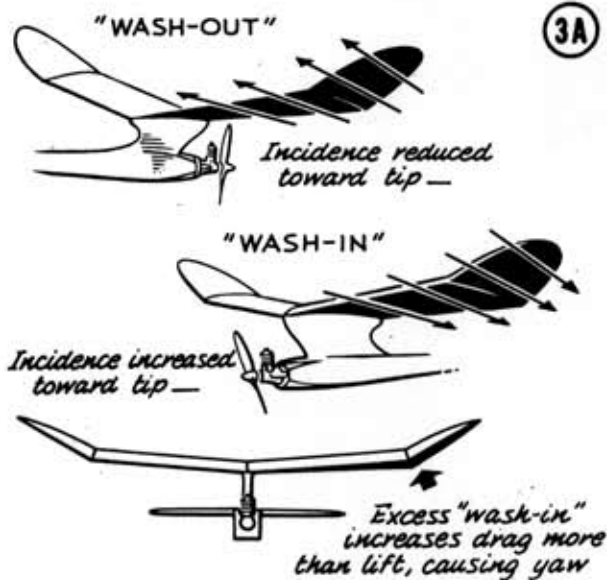


## Five Basic Adjustments

1—THRUST-LINE OFFSETS; 2—WARPS, WING AND STABILIZERS; 3—DECALAGE, CENTER-OF-GRAVITY PLACEMENT; 4—RUDDER TAB; 5—STABILIZER TILT.



*Note: The longer the nose moment the more effective are thrust offsets.*



# How to ADJUST the Hot Free Flight

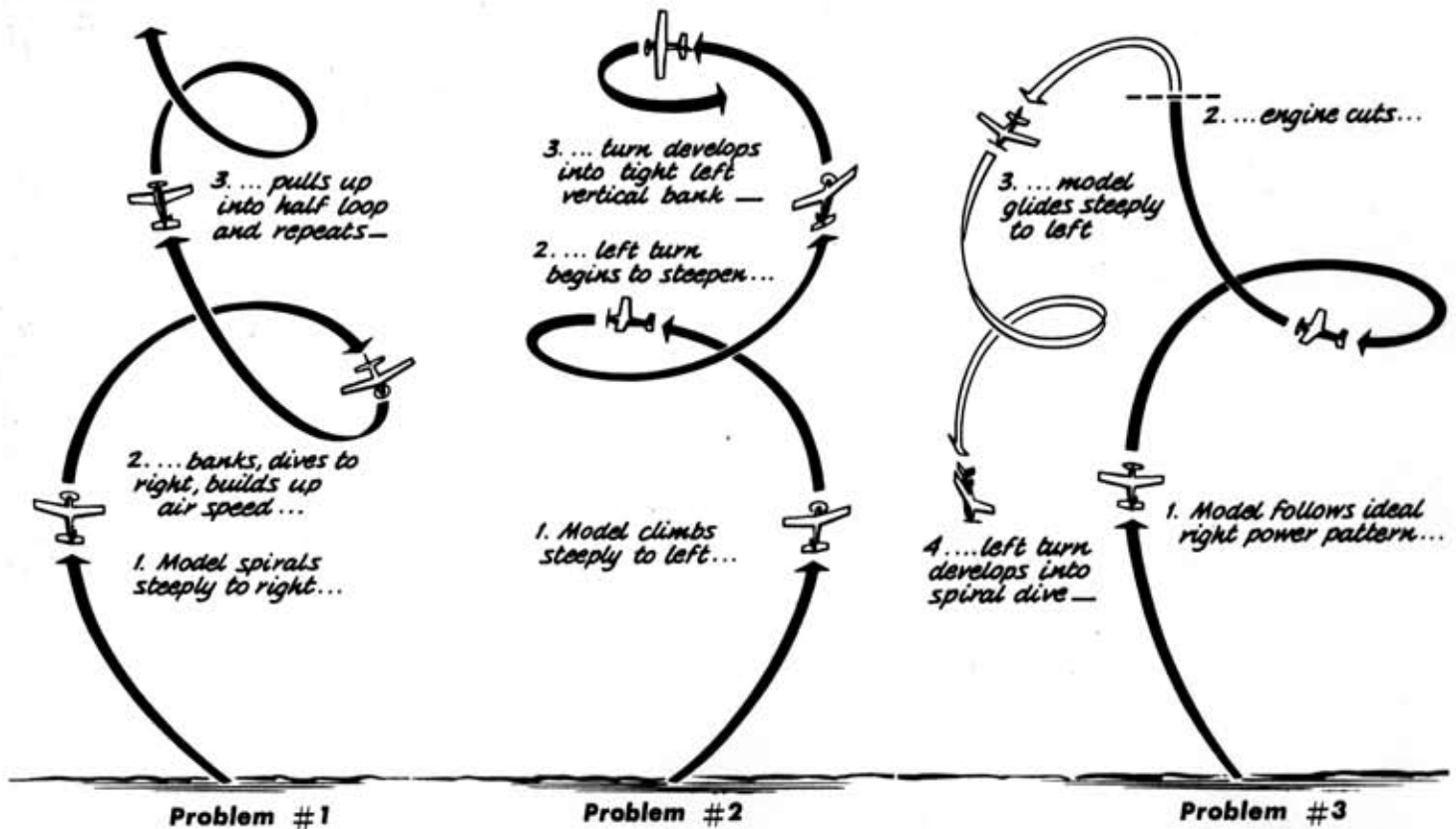
by PHIL KRAFT

**Laid end to end all the articles on adjusting would reach to Mercury. Suggestion: burn 'em! Phil really puts it on the line.**

►An understanding of aerodynamic force adjustments is basic to the success of the free-flight or radio-control modeler. While a correctly designed flying model should require a minimum of adjustment, the flight pattern of even a perfect design may be upset because of hidden structural defects or misadjustments. Conversely, even a basically bad design may turn in excellent performance if patiently and intelligently adjusted.

Perhaps in no other phase of model building are there as many widely divergent opinions as on how to adjust the contest free-flight. One expert says that it must be done in only one manner and another will say the exact opposite. Probably, both are correct for the particular design they fly, but different designs require different adjustment combinations and even different models of identical design may not require the same adjustments.

A common misconception is that all models of a basic design type must be flown in a particular pattern or direction. While it is true that certain models are designed to



fly in a definite direction and pattern, others fly equally as well either to the right or left and in different type flight patterns. There are no hard and fast rules as to adjustment combinations. Consequently, this article will attempt to define and show the effect of aerodynamic force adjustments separately and then show possible combinations to achieve the desired results. Once the modeler really understands the separate effect of each aerodynamic force adjustment, he will learn by experience to apply them in proper combinations.

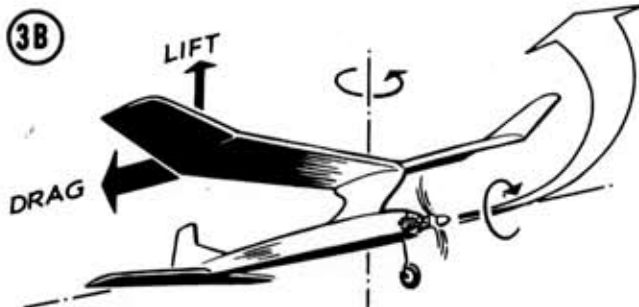
The five most important adjustments are: (1) Thrust offsets, (2) Warps of wing and stabilizer, (3) Decalage and center of gravity (CG) placement, (4) Rudder tab, and (5) Stabilizer tilt.

Thrust adjustments are of two different types: Down thrust (propeller shaft tilted at a downward angle to the model's flight path) and side thrust (propeller shaft tilted to right or left of the fuselage center line). The important

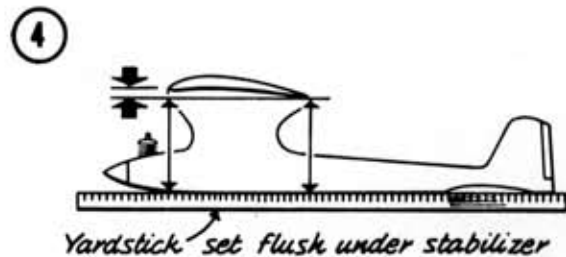
thing to remember about thrust adjustments is that their effect diminishes as the speed of the model increases. Actually, thrust offsets produce a force which is, for practical purposes, constant; while increases in flight speed produce a proportional increase in the effect of other forces.

Down-thrust is an effective means of eliminating stalls and smoothing out the flight pattern of relatively low-powered aircraft such as radio-controlled and rubber-powered models. Such aircraft slow down as their climb steepens, and as their speed decreases the force of down-thrust becomes increasingly effective to pull the nose down to regain flying speed before a stall occurs.

Many designers of the high-powered contest free-flight build up to 10 degrees down-thrust into their models for two reasons. First, down-thrust helps to produce safe stable VTO take-offs. Second, it helps to prevent looping and, because its effect diminishes with speed, it leaves a safe margin for recovery should (Continued on next page)



Example: Right-turning model  
"Wash-in" in right wing causes yaw to right about vertical axis... but model resists banking due to lift on inner wing which works on model's longitudinal axis —



"Decalage" varies from 0° to 5°, is difference between wing and stabilizer angles... average is 1/32" to 3/64" per inch chord —

## How to ADJUST Hot Free Flight

Continued from preceding page

the model pick up an unusual amount of speed. However, down-thrust is not a substitute for proper decalage and CG placement.

While down-thrust results in a loss in thrust efficiency, the loss is relatively small and more than compensated for by the gain in stability.

Side thrust is an excellent means of providing a transitional balance between high- and low-speed trim. As a general rule it should not be used for purely directional trim. To illustrate, suppose a model has a strong spiral dive tendency to the right. If enough left thrust is added, the model may fly straight or even turn to the left until it picks up speed. Then the force or forces producing the right spiral dive in the first place may take over and again the model will spiral dive to the right. To repeat, side thrust is effective as a low-speed turning force and, therefore, usually should be used in conjunction with other adjustments to provide a balance between high and low speed trim.

Warped surfaces have a strong effect on the flight characteristics of an aircraft and are often used to obtain a desired flight pattern.

Wash-in of a surface occurs when the surface is twisted so that the leading edge gradually becomes higher than the trailing edge from root to tip. Wash-out is the opposite. Wash-in increases the lift of a surface but any increase in lift is accompanied by a corresponding and often greater increase in drag. The exact opposite is true of wash-out. Of course, wash-in increases effective decalage; wash-out decreases it.

Wash-out is commonly used to improve the stall characteristics of a wing and to reduce tip drag. High pressure air underneath a wing tends to spill over into the low pressure air on top at the wing tip. The resulting turbulence causes the tips to stall before the center area of the wing. By washing-out the wing tips a wing can be made to stall evenly from root to tip. When this is done, the aircraft does not stall as violently and stability is improved.

It is the combination of increased lift and drag that makes wash-in of a wing panel useful in achieving the desired climb pattern. Consider a free-flight aircraft with wash-in in the right wing panel. The increased lift of the panel tends to roll the model around its longitudinal axis to the left. The increased drag of the washed-in right panel tends to turn the model to the right. Therefore, in a right spiral climb the model actually rolls to the left as it turns to the right producing the ideal vertical rolling corkscrew type of climb pattern.

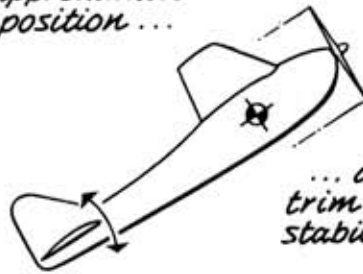
Wash-in or wash-out of a stabilizer panel has effect similar to wash-in or wash-out of corresponding wing panel with two important differences. Wash-in of a stabilizer panel decreases effective decalage while wash-in of a wing panel increases it. A washed-in stabilizer will tend to roll the model the same as wash-in in the corresponding wing panel but the drag of stabilizer wash-in is much less effective as a turning force. At low speeds wing wash-in produces more drag than lift and a model will tend to turn in the glide direction of the washed-in panel.

Decalage and center of gravity placement must be discussed together as they are interdependent.

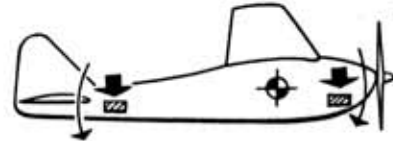
Decalage is the angular difference between the wing and stabilizer. To measure this in a model, place a straight edge parallel to the stabilizer chord line and extending along the fuselage underneath the wing. Measure from the straight edge to the leading and trailing edge of the wing. The amount that the wing leading edge is higher than the trailing edge is expressed as decalage.

For the purpose of this article, the CG may be considered as the point at which (Continued on page 54)

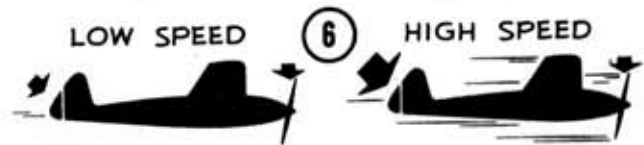
1. With decalage and C.G. in approximate position ...



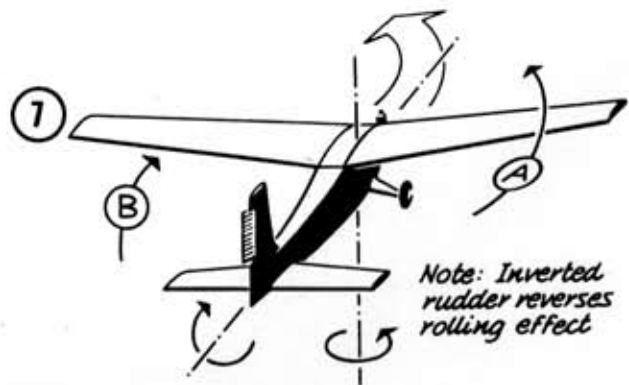
... adjust power trim by shimming stabilizer angle—



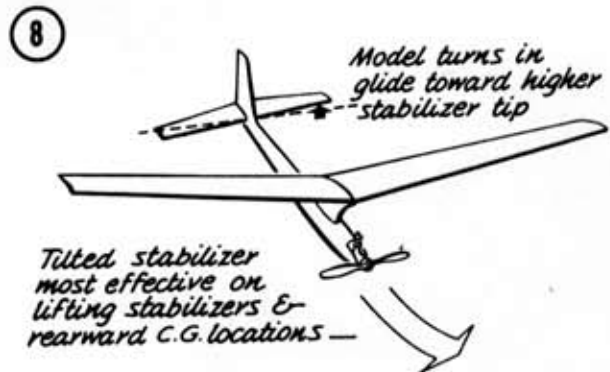
2. For glide, trim C.G. position to gain lowest sinking speed



1. Thrust adjustments do not gain effectiveness as speed increases.  
2. Tab adjustments gain effectiveness proportionally as speed increases.



Rudder tab offset has two effects:  
A = Makes model yaw about vertical axis, and  
B = Makes model tend to roll about longitudinal axis, unless tab area is centered on axis.



## How to Adjust Hot Free Flight

(Continued from page 18)

the model balances when supported close to the wing root.

The amount of decalage necessary and the CG placement are dependent on the design of the aircraft. Generally, models with non-lifting stabilizers balance from 25% to 40% of the wing chord aft of the wing leading edge. With lifting stabilizers the CG usually lies 50% to 85% aft, although with large stabs and long moment arms the CG may extend aft of the trailing edge of the wing.

The amount of decalage necessary varies widely with the type of model and may be from zero to 5 degrees or more. Generally, with lifting stabilizers, the greater the thickness of the stabilizer airfoil in relation to the wing airfoil, the more decalage is required.

The important thing to remember about decalage and CG placement is that if one is wrong you cannot correct the difficulty by changing the other. The most common mistake is to try to correct a stalling glide caused by the CG too far aft by decreasing decalage.

The proper technique is to follow the plans of the model as to CG placement and decalage to start with. Then hand glide to determine if the glide is reasonably flat with no stalling characteristics. When adjusting the contest free-flight, don't worry about final glide trim until the desired power pattern is achieved. Adjust climb by shimming at the leading or trailing edge of the stab. As long as the model pulls out of the stall quickly when the engine cuts, decalage may be decreased by shimming up the front of the stabilizer as necessary to eliminate looping tendencies. If, however, the model's recovery is slow from a stall, do not attempt to eliminate looping tendencies by further reducing decalage. Once the power pattern is set, the CG position should be varied to produce the lowest sinking speed. If the model stalls or mushes, add weight to the nose; if the glide is too fast add weight to the rear of the fuselage. It has been assumed in the foregoing that the glide trim was not too far off because wide changes in CG placement also affect climb trim and recovery.

Used properly, a rudder tab is virtually indispensable to proper adjustment of the flying model. However, particularly on the hot free-flight it must be used with care and discretion. Rudder tabs should be small and stiff enough so they are not easily bumped from their settings. On a class "C" free-flight a tab  $\frac{1}{2}$ " by  $1\frac{1}{4}$ " is amply large and should be moved only a fraction of an inch at a time.

The main point to remember about rudder tab adjustments is that their effect increases proportionably with flight speed. This is just the opposite of thrust adjustments, and consequently, it is by the use of tab and thrust off sets that the flight pattern of a model may be balanced between low and high speed trim.

Tab offsets also produce leverage effects tending to roll the model as well as turn it. This effect is very noticeable on some designs. As an example, the Spacer uses an underslung fin which causes it to have a strong right turn tendency. This is counteracted by offsetting the rudder tab to the left. Since the tab is below the longitudinal axis of the model, it exerts a leverage tending to roll the aircraft to the left. As the model climbs to the right under power, this left tab leverage tends to keep the model climbing without dropping the inside or right wing panel and, consequently, helps produce a very desirable climb pattern

To sum up the use of rudder tab, its effectiveness increases radically with flight speed. Fast models are very sensitive to the slightest tab movement. Use the rudder tab for minor directional trim or as necessary in combination with other adjustments.

The easiest method of achieving proper glide turn is by tilting the stab as stabilizer tilt has little directional effect on power flight. This adjustment is effective on models with lifting stabilizers and rearward CG position. The model will turn in the glide towards the high stabilizer tip. Most models tend to turn naturally in the glide so use stabilizer tilt to tighten the model's natural glide turn to the desired amount.

The preceding has described the adjustments most commonly used to obtain the desired flight pattern. To illustrate possible adjustment combinations we will flight test several hypothetical models. However, before test flying, all models should be carefully checked and prepared.

Wing and stabilizer surfaces have several weeks curing time during which warps are removed by heating the surfaces and twisting opposite, to the warp. If possible, let the surfaces sit in the hot sun for several days and periodically check to see that warps removed do not come back.

It is difficult and sometimes impractical to remove all warps. Some warping can be tolerated so long as its effect is neutralized by other warps. As an example, wash-out of one stabilizer is all right if the other panel is washed-out in a similar manner. The main consideration is that any warps that do occur don't work against the model's desired flight pattern. Watch out particularly for wash-out of the wing and stabilizer panels inside the model's power circle or wash-in of the outside surfaces. Slight wash-in of the wing panel inside the power circle is usually desirable and many designs specify it. Don't attempt to fly a model if the preceding conditions can't be met. If necessary build new surfaces.

The wing and stabilizer should be carefully aligned perpendicular to the fuselage and keyed in place to prevent accidental shifting. Wing and stabilizer keys should allow absolutely no shifting of the surfaces. The fin should be aligned parallel to the fuselage or offset as specified. The angular difference between the wing and stabilizer (decalage) should be carefully checked as previously described. It's safest to start with a slight excess of decalage and shim it out as test flights indicate. If the design does not specify the exact amount of decalage;  $1/32$ " to  $3/64$ " per inch of wing chord is usually ample.

Balance the model by suspending it by the finger tips as close as possible to the wing root. If it doesn't balance as shown on the plans, add weight to the nose or tail until it does. Under no circumstances should an attempt be made to fly an improperly balanced model, no matter how much weight must be added to achieve proper balance. A good way to add weight to the nose is to melt lead into the engine's crankcase cover. If the model can't be balanced without adding a large amount of weight, lengthen the nose or build a lighter stab (consistent with adequate rigidity). Excessively long nose moments make adjusting difficult so keep the stabilizer light. If it is necessary to add weight to the rear, cut a hole through the stabilizer platform and fill with clay as required. To complete the pre-flight check, measure carefully to see that the engine has the prescribed offsets.

In all the preceding, no sloppiness or half-way measures can be tolerated. At best, the hot contest free-flight is a very delicate balance of many opposing forces and it takes very little to upset the balance.

The model's surfaces should be securely strapped in place with rubber bands. It might be well to mention that when in doubt as to how many bands are required to hold a surface in place, always put more than would seem necessary. Don't worry about the effects of tightly strapped surfaces in case of a crack-up. Actually, the advantages of "pop-off" surfaces are highly over-rated anyway.

Hand gliding is the first step in test flying. This should be done in absolutely calm weather, as it is virtually impossible to tell anything in the wind. Hand gliding will show up serious errors in trim but don't waste time trying to obtain the flattest possible hand glide as it doesn't mean much and many have to be changed as a result of power tests anyway. Just check to see that the glide is reasonably flat with no pronounced turning tendency.

Essential to successful test flying is an engine that will run smoothly and consistently at low speed. Use a low-nitro fuel and sometimes a hotter plug than for full-power operation. Plugging the engine's venturi with scrap balsa is necessary on some engines while others run well at low speed without restriction.

Don't attempt to fly unless the engine is running properly. If it quits soon after launching, you will have at best to change a prop. If it leans in to full power, you may be in for more serious trouble. Some builders put the prop on backwards and this is a good safety precaution so long as you remember to reduce power considerably when the prop is put on forwards. There is a big difference in thrust and sometimes flight characteristics between prop on backwards and then forwards.

Test flights should be made with an engine run of about seven seconds. Shorter runs don't prove much and may not get the model high enough to recover from the stall when the engine cuts. Longer runs give the model too much time to get into trouble.

From this point on no definite testing procedure can be described as this will depend on the individual model. However, we can describe certain hypothetical flight problems and their possible cure.

After launching, the model climbs steeply in a right spiral. Increased power results in a steeper climb and as the model starts into a right turn it dives sharply to the right then regains speed and up again into another diving half loop. The problem seems to be that as soon as the model starts to turn, it drops the right wing and dives until speed is built up again to repeat the climb and dive. Usually a sure cure for this is to wash-in the wing panel inside the power turn (in this case the right panel). Now the model climbs steeply and as it starts to turn, the wing wash-in lifts the right wing and it circles up smoothly. However, the circle required to keep the model from looping is rather tight. Stall recovery seems very fast so before increasing power we'll shim out some decalage by inserting a  $1/32$ " sheet wedge underneath the front of the stab. Another flight and the pattern looks fine so we'll increase engine power again. Look out! The model has whipped into a sharp right banking turn and after picking up speed climbed straight up and started to turn to the left. Another few seconds engine run and it might have dived into the left. Time to sit down, calm our nerves and think the problem out. Obviously the increased power has induced a bad right turn until it picks up speed and then the darn thing wants to dive in to the left. The wing wash-in has corrected one problem at lower power but is partially responsible for this new problem at higher power. We need to provide the proper transition between high and low speed trim.

Since thrust is effective at low speed, we shim a few degrees left thrust into the engine to eliminate the sharp initial right banking turn. Because rudder tab becomes increasingly effective with flight speed, we bend the rudder tab slightly to the right to correct the high speed left turn tendency. A bit of juggling of left thrust and right tab and now she climbs smoothly in a right spiral. However, the model still is wasting too much time in too tight a spiral. Since recovery is still fast we can shim up the front of the stab. Another  $1/32"$  to widen out the power pattern. Now full power and up she goes like a rocket. A little too much right spiral for optimum climb so we bend the tab very slightly to the left. Now that everything is in the groove the shims are cemented in place and the motor mounting bolts checked for tightness.

Now we'll test another hypothetical model of different design. After launching under medium power the model climbs out steeply and then circles smoothly in a climbing left spiral. We increase power and the model almost loops but rolls nicely and then spirals a bit tightly to the left. We can't shim out decalage because the stall recovery is a bit slow already so we add a few degrees down thrust. Now she climbs out at about the right angle but the left spiral seems to tighten a bit towards the end of the motor run. The motor is revved up a bit more and the model moves straight out and up and starts its left spiral climb. But the spiral gets tighter and tighter till the model is screaming around in a vertical left bank. We can't apply left tab because it's flying too straight vertically and would loop. Again we use the combination of thrust and tab. Left thrust is added to start the model into its left climb pattern sooner. Right tab is added because as the model's speed increases, this will prevent it from tightening into the sharp left spiral. A little experimenting with right tab and left thrust and we have the proper left spiral but still too tight a spiral is needed to prevent looping. As we can't shim out decalage, more down thrust is the only solution and finally the model grooves up as it should.

In our third hypothetical model full power performance is perfect but, if the model recovers poorly when the engine stops, it spirals dives badly in the glide to the left opposite the right spiral climb. Under normal recovery everything is all right. Since we cannot depend on a perfect transition from climb to glide every-time, we must correct the dangerous spiral recovery. Slight left thrust and right tab are added and now it recovers from a stall without a bad left spiral dive.

The preceding examples illustrate how side thrust, down thrust, wing wash, decalage, and balance might be used in adjusting. These are, of course, but three examples and do not cover all possible difficulties or solutions. However, the general principles outlined can be intelligently applied to other problems and with patience and practice, adjusting will cease to be a problem.