

1970 NATS-MULTI WINNER

A-6 Intruder!

By James 'Jim' Kirkland
Part One of a Two Part
series

Continuing Model Airplane News policy of presenting the Champions and winners of the really big ones. This is a really big and so very complete, it is necessary that we run it in two parts so that our readers receive the full benefit of the total effort by this year's Nats winner. Just to read this article is a benefit!



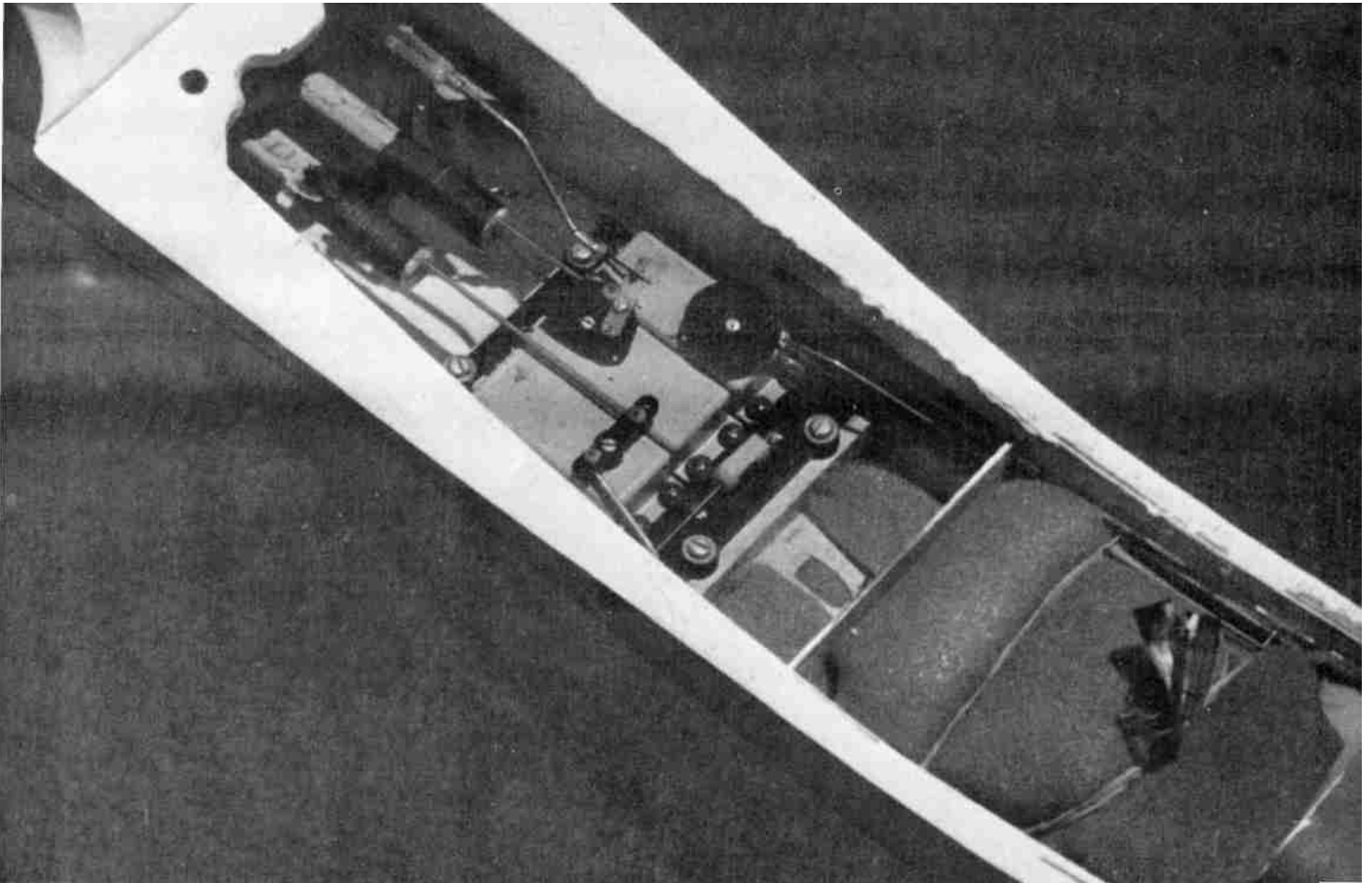
And here we have the Champ with his ever pre- up all the marbles for the second time. Jim sent smile and the tools with which he picked is one of the warmest people that we

“22.1 OBJECTIVE: To control by radio a model airplane so that various planned maneuvers may be accomplished. The criterion is the quality of performance, not the mechanism of control. RC competition shall be based on the excellence of performance of the model's maneuvers compared to similar maneuvers performed by a full size plane. Maneuvers shall be judged according to the AMA Radio Control Judges Guide.”

The above is the lead-off paragraph under Section 22, Radio Control Pattern Event Regulations, of the AMA's official rule book. Essentially unchanged since the birth of official RC competition, this is what it is all about. The reference to a model's performance similarity with that of a 'full-sized plane' has been more or less lost in subsequent years of rule changes and revisions, etc., to the Judges Guide. Today's winning RC competition designs fly with jet-like scale speeds, fly some maneuvers like a full size jet aircraft, and

fly some maneuvers that are common to only reciprocating engine, fully aerobatic aircraft. As a result our models must perform in a manner peculiar to both jet and reciprocating engine planes!

The caliber of today's competition is much tougher than it has ever been in the past, with absolute and total perfection in each and every individual maneuver being the goal of every top competitor. With the



The -guttly innards; Pro line PLUS-Io servos in a Kraft mounting tray. Receiver well protected in foam up front, flat battery pack under former F-4.

margin of victory usually measured in fractions of a point, no compromise in model design is possible. Any model design that sacrifices one or two points as a result of design deficiency or compromise is a sure-fire loser in the majority of starts!

The current trend toward perfection is not a new trend. It has been underway for over ten years and growth seems to foster more growth. Year to year progress reaches almost unbelievable proportions in engines, RC equipment and flying skills. This progress towards perfection has led us to a point where latitudes in competitive model design are very restrictive. A tricycle gear is now considered a must; wing areas have stabilized; and after the experience some flyers had with the increased lateral area flap in 1970, it is a fair assumption that lateral area, and distribution, will now be rather stabilized!

The important thing for any would-be RC pattern competitor to realize, is that this stabilization of competitive RC model design parameters resulted from competition and the competitors. Just as in any sport, those who compete are the ones who determine what is necessary to win. The difference between a competitor and an armchair analyst is that the competitor uses the rules as a basis for his reasoning, while the armchair analyst uses the results achieved by competitors as his reasoning

basis. The degree of design stability and performance we enjoy in this hobby today has resulted from the persistent model design efforts of the competitors. Those design features that contribute most to winning, resulted from competition experience and the ability to see ahead from the competition standpoint.

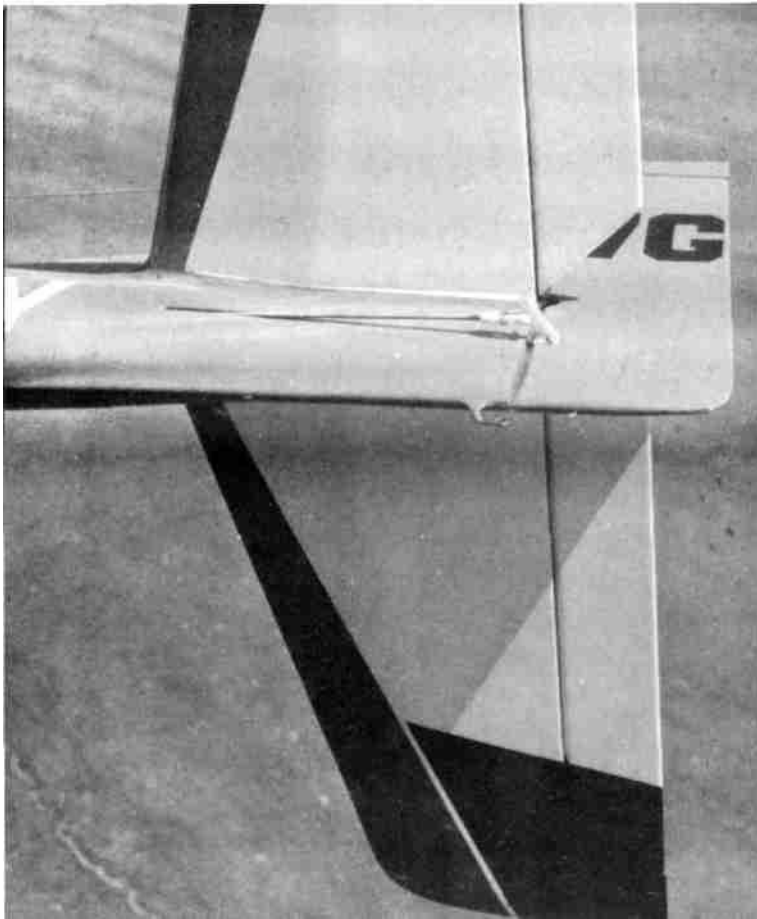
The ancestry of the A-6 Intruder rather closely 'parallels the progress of RC pattern competition over the past eight-year period. Its oldest forerunner was the Beachcomber, the 1963 Nats winner, and an exponent of the then newly emerging zero-zero force set-up, using a 15 percent symmetrical wing with a symmetrical stab. Then came the first Citrons which were the fastest pattern models in the mid-60's with a .45 cubic inch engine no less! With the advent of the big .60 engines, and jet-like speeds, came the Triton. It not only moved like a jet but resembled one too! The emphasis now was on how to retain smoothness and maneuver perfection while flying at such high speeds. The Triton won a Nats second and a place on the 1969 FAI team. Many features from the Beachcomber through the Triton are incorporated in the A-6 Intruder design. Perhaps the most significant fact is that not a single *new* design feature appears in the A-6 Intruder. Ten years of experimenting with every variable applicable to this type of model has led me down many roads to

what I consider dead ends!

The look-alike feature so prevalent in today's pattern models, is a direct reflection of the standardization reached by the top competitors in their pursuit of design perfection. With design parameters the deciding factor, it is hard to achieve much in the way of a different look. Look-alike paint jobs on two different designs can cause total confusion among the modeling public!

I prefer my designs to resemble an existing full-size aircraft. I try to achieve such an over-all appearance even though the model itself is in no way even semi-scale!

Fifteen years of experimenting with airfoils and planforms has led me to believe that aerodynamic theories applicable to full-size planes have almost no place in model wing design. The scale-effect is so prevalent in a wing with even 750 square inches of area that airflow and reactions are more a result of thickness, high-point location, and leading edge shape, than of a specific curvature of the airfoil. A thick wing will fly slower, have a lower stall speed, but with a substantial loss of effectiveness prior to reaching the actual stall point, and will slow down quickly when power is reduced. A thin wing is fast, reluctant to slow down, and normally has a very sharply defined stall point while remaining very responsive



Not a tail dragger as it would seem with tail skid, this is only for those high main gear landings and touch and goes! Note rudder pushrod. Nose section showing Lee Super Custom .61 engine, slightly recessed Sil-nose encaire muffler, homemade nose wheel drag brake & Navy markings.

right up to the stall point. A wing of a given thickness, with a rounded and blunt leading edge, will have a lower stall point than the same wing with a sharper leading edge. Also, a wing with a reflex airfoil will have a considerably lower stall point than the same wing without the reflex. Using the 33 percent point as a reference for the high-point location on a given airfoil, that airfoil will stall at a higher speed if the high point is moved further to the rear, and at a lower speed if moved further forward. A tapered wing with a constant airfoil shape will experience tip stall at a higher speed than the stalling speed of the root section due to the increase in scale-effect caused by the smaller tip section. These features of model airfoil reactions, are based on symmetrical airfoils, but would probably be mostly applicable to semi-symmetrical shapes also.

While flying airfoils from 13 to 17 percent sections, it became apparent that the 15 percent section was better suited to today's top class of competition. The 17 percent section would have to have an edge in the lower classes of competition, especially in Class A, because of its lower speed. The 13 percent wing is fast and graceful, but needs flaps to achieve any degree of realism in the landing maneuver. If heavily tapered, the 13 percent wing needs a reflex section at the tip in order to control tip stall. Hence the reason for the 15 percent section used on the Intruder.

When the Triton was first designed, early in 1967, the only really accepted way to control tip stall in taper-wing planforms, was to increase the thickness percentage of the tips. The Triton wing made use of a practice long established as the way to prevent tip stalls in the old rudder-only models without having to build in washout. This consisted of gluing triangular stock to the center-section of the wing's leading edge, thereby creating a sharp leading edge in the center of the wing, while the tips retained their rounded leading edge configuration. This method was as effective as wash-out in the rudder-only designs and a heck of a lot easier to control! These rudder-only wings were usually constant chord sections, and the change in leading-edge shape was very effective. It was reasoned that a *constant* leading edge radius in a *taper-wing* planform would have the same effect. Thus the radius of the leading edge of the smaller tip section, while being identical to the radius of the leading edge of the root v section, would be blunter and rounder because of the reduced size at the tip section. Just as additional insurance, the tip section was changed to a very slight lifting section. When the Triton wing was built in this manner the results exceeded expectations, and was as stable as any straight wing that I had ever flown. This wing never displayed *any* tip stalling tendencies! It was only natural to carry this basic wing on to the Intruder design.

There was a change made in the planform to a straight trailing edge, with all taper in the leading edge. This was to allow the drag coefficient of the wing tips to be moved still further behind the center of gravity, thus increasing directional stability. The modified, constant chord strip ailerons were used for two reasons. First, there is no loose play between the servo and the ailerons when this type linkage is used so no flutter or sloppy centering problems. Second, this type of strip presents very little inboard drag during rolls, yet is almost as effective as barn-door types on slow speed landing approaches.

Horizontal stabilizers have bugged me almost as much as wings have, and for almost as long! There is something about the stab's small size that just yells for inattention, especially after working on a wing! The natural tendency is to build it flat and get it over with! However, after many hours of flight evaluation it became obvious that a flat stab just couldn't measure up to a symmetrical section. About all that I can say today about a flat stab is that it is adequate for horsing around!

Subsequent evaluation of various symmetrical stab sections, together with experiences with the flat sections, turned up a key fact: the leading edge shape seems to be as effective as stab thickness, or elevator cross section, in controlling elevator sensitivity. For a given stab

section, a rounded leading edge decreases elevator sensitivity around neutral, while a sharper leading edge shape increases sensitivity around neutral. Stabilizer thickness governs the elevator's sensitivity away from the neutral zone, contributes to the tail drag coefficient, and is a factor in determining the *amount* of elevator deflection requirements. The particular curvature of the airfoil did not seem to matter very much!

This determination posed a real dilemma! Why bother to jig-up and build a symmetrical airfoil stab, when the airfoil curvature apparently played so little a part in the overall performance? Well, the flat stab was out because of performance characteristics, and the only real advantage that appeared to result from the use of the airfoiled section was primarily in its thickness. So why not a thick flat stab; but how in heck to streamline such a slab! The result of such frustrations became the diamond stab section used first on the Triton, and further refined for the Intruder.

There is no intention here to claim originality in the use of a diamond stab on the Triton. Ed Kazmirski used a diamond section on the Taurus, and I suspect for the same reason that I finally selected such a section for use on the Triton. No doubt many others have used a diamond stab.

There is a degree of uniqueness in the diamond section used on the Triton and the Intruder. Going inboard from the small tip rib, each succeeding rib is an exact projection of the angles from the preceding rib, and retains the same width at the leading and trailing edges. This feature requires constant width leading and trailing edge pieces (same as a flat stab), and also allows the stab to be built upon a flat work surface in much the same manner as a flat stab. As such, no jig is required during the building process and it is as fully warp resistant as an airfoiled section.

The diamond stab has better flight characteristics than any previous airfoil stab I have used in the past! I do not know why, but the diamond stab *seems* to make a pronounced difference in the way the Triton and Intruder handle just before landing touchdown. It is as if the stab helps tremendously in holding the model off until the last instant, and then holds it just a bit longer! The phenomenon must be experienced to be fully appreciated. In flight, while performing various maneuvers, I can tell no difference between this stab and a symmetrical airfoiled section of the same thickness and with the same leading edge shape.

The amount of lateral area in a model, and its distribution, has never had much discussion outside designer circles until the 1967 and 1969 Internats, especially after the 1969 Internats when reports led the modeling public to believe that a *lot* of lateral area was now a necessity. Suddenly everyone was lateral area conscious! This sudden publicity did not change the lateral area requirements for RC pattern models

one iota from what it was before! *If* there was a rule requirement for a ten degree climbing knife edge flight for a ten second time period, *that* would change lateral area requirements. No such rule now exists and, based on the current rules' outlook, such a rule is not likely. After all, what full-scale aircraft can perform such a comparable maneuver?

Lateral area has a direct relationship with how a model reacts to the slipstream created by the propeller. If the center of lateral area is too far in front of, or behind, the center of gravity location, some weird characteristic will be noted in some maneuvers. It is impossible to trim these weird characteristics out of that particular maneuver without having something just as bad show up some place else in a different maneuver! Too much lateral area will only give the pilot ulcers when forced to compete under crosswind conditions! Too little lateral area is hard to get and still mount the engine, tank, and radio in the fuselage!

Ideally, the amount of lateral area will be about that required to house the aforementioned components in the fuselage in the conventional manner. The center of lateral area should be five to ten percent of the fuselage length *behind* the center of gravity, and concentrated as much as possible in this area. Fortunately, this is *not* a hard and fast requirement, or all competition designs would be even more similar in appearance! However, extreme deviations in distribution of lateral area can be most troublesome to the perfectionist flyer. For instance the correct amount of lateral area could be present in a design, but concentrated at the front *and* rear of the fuselage with a corresponding *correct* center of lateral area location. This arrangement can play havoc in crosswinds and in some maneuvers requiring simultaneous rolling and looping actions.. Lateral area that is massed mostly from the center of gravity rearward, causes the rudder to act like ailerons *and* rudder in some attitudes. Lateral area that is massed mostly to either side of the center of drag (usually considered as the wing location) will cause very noticeable dutch-roll characteristics.

The lateral area distribution in the Intruder fuselage and fin layout represents a degree of compromise from the ideal in order to achieve the appearance features of the Navy's A-6 Intruder. The amount of lateral area is enough to perform the required knife-edge in four-point rolls, knife edge flight, and the slow roll. Very little rudder is required in these maneuvers when speed is sufficient. Despite the small compromise, the amount and distribution of lateral area seems to be just about right in the Intruder. Some self-compensation is apparent in crosswind loops, yet the Figure M can be done with repeated success in crosswind conditions from either side.

The original Intruder was built to use the KDH retract gear system, however, only a fixed gear installation is shown on

the plans. The reason for both actions is quite basic. It was determined that retracts were an evil necessity for top level competition, so the original had retracts. Most builders probably would not want to be bothered by these monstrosities. (I hope). Those that do could select any one of the many different types available (all mount differently) and drawings for one type installation would help only a very few. Besides, if a builder wants retracts he should be able to work them into the basic model as easily as I did; which was not that easy! So if retracts are considered a must, be prepared to add a couple of weeks to the building time. While retracts do add to the performance of the model at the present state-of-the-art', they require too much maintenance to be practical for anything less than top level competition. Hopefully, the manufacturers of these units will soon overcome this major deficiency.

The sidewinder engine mount used on the Intruder is canted just slightly upwards. This makes priming through the venturi a bit easier. It also helps the Silencaire muffler to clear the side of the model *if* a long type muffler is used. If the short type Silencaire is used, as on the original, the lower right section of the nose has to be gouged away to half bury the muffler body and pipe. This was the result of an oversight when the original was built and it is a safe bet that this extra work will not be necessary on another Intruder! I will use the long Silencaire muffler!

One final word about fuel tank location before beginning construction. The centerline of the fuel tank (a 12 ounce Sullivan slant style) should be located even with, to one-quarter inch below, the level of the venturi's dead center at the fuel jet location. If the engine goes leaner when doing outside loops, lower the tank. If the engine goes richer when doing the outsides, raise the tank. The tank should have foam rubber on either side, top, and bottom to prevent fuel foaming that can result from tank vibration. Adjust the tank level to suit your particular engine.

Pre-flight checkout and flight trim procedures follow construction details. So let's get to cutting balsa!

GENERAL CONSTRUCTION NOTES

At the speeds which dominate today's pattern model performance, it is more vital than ever that accurate building and alignment practices be strictly adhered to. Anything less will only serve up a disappointment. The little extra time needed to achieve perfection, over that required to 'just build', is the difference between the zircon and the diamond!

The A-6 Intruder is relatively simple when compared with other winning designs of the current times. There is a simple jig in which to build the all-balsa wing. Foam templets can be made from the root and tip cross-sections shown on the plans if foam wings happen to be your

'thing'. The diamond stab is built on a flat surface and requires very little more effort than the inferior flat-type stab. The diamond stab will not warp and has characteristics equal to, and even superior to some symmetrical stabs. The fin is a simple balsa covered framework that is highly warp resistant. The fuselage is a rather straight box that gets its shape from the carved top and nose blocks. The Epoxy-Lite fillets serve to blend things together and gives the finished product that 'molded' look.

About the only thing that could be considered difficult about the building process would have to be the balsa block shaping and the fillet work. To ease the task of sanding, shaping, and hollowing out balsa, the following tools are very helpful: a razor plane and a spoke-shave, a large X-Acto handle, a set of gouges, and two or three sharp Y router blades. Make up three sanding blocks from three-quarter inch soft pine shelving materials, two and one-half inches wide and nine and one-eighths inches long. Take some #40, #80, and #100 grit garnet paper sheets, cut in half (crosswise), and use six thumb tacks to fasten the half sheets to the three sanding blocks. You will be pleasantly surprised at how fast these blocks can shape a balsa block. Be careful with that #40 coated block! It will not be used very much!

Wing-Jig Layout In laying out and building the temporary wing-jig, it is best to have a carpenter's level and a 36 inch straight edge available. These tools will enable you to overcome any slight irregularities in the work surface on which you plan to build the wing-jig. Accuracy is very important in cutting the wing-jig stations from the balsa sheet. Proceed carefully, with accuracy, and your finished all balsa wing will be second to no model wing ever built! The small amount of time to layout and build the wing-jig pays off in a big way for you.

After laying out the reference and station lines on the work surface, glue the WJ-1 pieces together and then to the work surface with one on either side of the center station line. Use the level chordwise across the WJ-1 pieces and shim, front or rear as necessary, to get a level bubble indication. Glue the WJ-6's in place; again use the level and shim as necessary to get the same bubble reading as at the WJ-1 stations.

Glue the remaining wing-jig stations in their proper place on the layout, using the 36 inch straight edge as a guide across front and rear station tabs in the following manner. Place station vertically over its proper location on the layout and place the straight edge from front tab on WJ-6 to front tab on WJ-1. The front tab on the intermediate station should just touch the straight edge when it is held vertically over its proper location. If not, either trim or shim until it does. Repeat across the rear tabs, correcting level of the intermediate station as described above.

When intermediate station has been properly leveled, glue into position. Repeat this procedure for all intermediate jig stations in both wing panel cradles.

Now look down the finished wing-jig from either end. The cradle formed by the individual stations in each panel should appear smooth and consistent with no station breaking the 'consistency' of the cradle. The wing-jig is now both level, true, and ready to build the wing in.

The Wing The construction of the wing is well detailed in the illustrations on the wing plan. It is recommended that a sandable white resin glue, such as Franklin's Tite-Bond or Ambroid's Se-Cur-It, be used to glue the sheet balsa together to make the wing skins. I also use white glue to do all framework gluing between W-6's. For the outboard of W-6's, I use standard Ambroid glue to minimize the weight factor in the wing tips except along the leading edge where sanding must be done after basic construction is finished.

When the wing has been completed to the point shown in Step Five of the wing plan illustrations, shape the ailerons from three-eighths inch sheet balsa. Drill hole for the aileron key wire, and cut the groove for the torque rod. Now ailerons can be slipped into place on the torque rod assembly end and taped to the wing trailing edge with masking tape. After a 72 hour curing period the wing, at this stage, should weigh from 14 to 20 ounces, depending on the density of wood used.

F-3A, the fuselage fairing block, and lower fillet sections will be added to the completed wing during the final alignment and assembly process.

The Stabilizer Refer to illustrations on the stabilizer plan to build the diamond stab.

The Fin Build the fin over the plan. Glue R-1, R-2 and R-3 together and glue in the crossmember. Cut the planking on a bias and glue it together. When dry, remove framework from plan and glue sheeting to both sides. Pin to flat surface until dry. Sand the rudder cross-section shape into rear of R-4. When fin is dry, glue R-4 to top of fine pieces R-1 and R-3. Tack glue rudder to R-4 and R-3. When dry, use a sanding block to sand fin and rudder to proper shape. Remove rudder and sand double bevel to leading edge.

The Fuselage Glue the main plywood doubler to the main fuselage sides with contact cement. Do not use a water base contact cement and be sure to make a right and left side as determined by rear push-rod exit hole locations. With doublers glued in place, use white glue to glue the spruce longerons to the top of the fuselage sides. Now glue the balsa longerons to the bottom rear of the fuselage sides. Glue in the plywood stab seat doublers, and the balsa side stiffeners between the top and bottom longeron members as shown on the plan between F-5 and F-6.

A sort of crude, but adequate jig is used to assemble the fuselage sides,

formers, bottom sheeting and bottom rear block. Take a piece of flat board about forty-four inches long and at least six inches wide. Draw a straight centerline the length of this board and use the top view of the fuselage plan to mark off former locations perpendicular to this centerline, with the back of former F-2 flush with one square-cut end of the board. The fuselage is built upside down on this jig board in the following manner:

Tack the top overhang of F-2 to the end of this jig-board, leaving clearance for the top longerons between the top of the board and bottom of the longeron notches in F-2. Use small spots of Ambroid to cement and glue the remaining formers to this jig board at their proper locations. Be sure each former is vertical over its location. Include the servo rails, the crossmember on F-5, and the balsa crossmembers at the two stations between F-5 and F-6.

Glue the fuselage sides to F-2, applying glue to only the lower half of F-2 (upper half as it is during this inverted build-up period) and be sure that the rear of each fuselage side is in contact with the surface of the jig board. Use epoxy on this joint. The new five minute epoxy glues by Hobbypoxy and Dev-con are excellent adhesives and will speed up the building time considerably. When the joint at F-2 has thoroughly set-up, glue the sides to the lower sections of F-3, F-4, F-5, and F-6. Glue F-5A in place. Mark the location of the servo rails and balsa cross members on the top longerons but do not glue them in place yet. Glue the V-shaped balsa tail block in place.

Cut the rear bottom fuselage block from one-half inch sheet balsa, rough shape it, hollow to outline shown on side view of plans and glue in place to rear of fuselage. Add the one-quarter inch sheet balsa lower nose doubler between F-2 and F-3. Glue the triangular stock to the lower side of these doublers. Fasten the Top Flite nose gear mounting brackets and standoffs to F-2. Glue the one-quarter inch sheet balsa to bottom of fuselage between F-2 and F-3. Sand flat across bottom of the rear fuselage block until its shape is the same as shown on side view of the plan. Glue the balsa ventral fairing to the rear of the bottom fuselage block. Let this assembly thoroughly dry.

Pull tacks from that part of F-2 that overhangs the jig-board, and use a pocket knife blade to pop the spot-glued formers from the jig-board. With fuselage structure and jig-board separated, glue the fuselage sides to the upper portions of F-2, F-3, F-5, and F-6. Use a toothpick to wedge glue down into crevice as fuselage sides are pulled slightly away from these former stations. Glue the servo rails and balsa cross members in place. Glue the vertical triangular stock in place behind the upper section of F-2.

Follow the steps illustrated on the fuselage plan to shape, hollow, and attach the top fuselage block and the nose blocks.

Cut the wing-fuselage fairing block to outline shape, but to fit between F-3 and F-5B. Tack glue in place between these formers, with F-5B tack glued to F-5A. When dry, sand the bottom of the fuselage to shape (flat with rounded corners at the front between F-2 and F-3 to a near semi-circular shape just in front of the ventral fairing). Remove the wing fuselage fairing block from the fuselage proper, remove F-5B from the block, and hollow to approximately three-sixteenth inch wall thickness. Glue F-5B back in place. Glue the hardwood wing-bolt anchor-block in place between the fuselage sides and against F-5 with white glue.

Part 2

April, 1971 M.A.N.



Old Smily himself showing off the bottom of the bird against the Florida sky. In this shot you can see the retract gear and wells

Final Assembly - The performance of the finished product is very much dependent upon the accuracy achieved in the final assembly process. Therefore, painstaking care must be used, and constantly pursued in setting the wing, the stabilizer, and the fin to the fuselage. You simply cannot overcheck each step in the final assembly process!

Use two short pieces of one-quarter inch dowels to pin F-3A to F-3, placing wax paper between these two pieces. Notch the leading edge of the wing to fit over F-3 A. Shim, or trim the wing seat in the fuselage to achieve a zero incidence setting on the wing. (Top of fuselage sides are parallel to the engine thrust line and should be used as a reference for setting the wing). Measure from the rear of fuselage to the wing tips for lateral alignment of the wing. Now epoxy wing to F-3A and pin, tape, or tie wing to fuselage when it has been aligned properly and allow the epoxy to set.

Before removing wing from fuselage, drill through rear of wing and into wing-bolt anchor-blocks with a #8 drill at the location shown on the wing plan. Glue the

wedge-shaped basswood screw head leveler blocks to the bottom of the wing and center over these bolt holes. Leave enough clearance behind these leveler blocks at the wing trailing edge for F-5B. Remove wing from fuselage and twist dowel stubs from F-3 A. Drill into wing leading edge, through holes in F-3A, and glue in regular wing hold-down dowels with white glue. Use a ¼-20 tap and tap the drill holes in the wing anchor-bolt block. Use a one-quarter inch drill and, using the smaller size holes as guides, drill through the trailing edge and the leveler blocks.

Cut some one-quarter inch washers from manila folder stock to be used as shims to the wing-bolt anchor-block. Glue these shims to the anchor-block until the wing can be firmly bolted to the fuselage and retain a perfect alignment with the fuselage.

Sand one-eighth inch from the front of the wing-fuselage fairing block so that the block will fit between F-3A and F-5A. Trim the sides to fit the lower contour of wing. Bolt wing to the fuselage and glue the fairing block to the bottom of the wing. Cut small holes in the fairing block over the anchor-bolt heads and enlarge them to slightly over one-half inch diameter, and center over the anchor-bolt heads. Enlarge as necessary to receive access tubes made of poster board, masking tape, and epoxy. Epoxy these access tubes into place, fastening to the leveler blocks and to the fairing. Be careful not to foul the anchor-bolt heads with epoxy. When epoxy has cured, use a sanding block, and sand the protruding ends of the access tubes flush with the fairing block.

Use slow setting epoxy to fasten the horizontal stabilizer in place. Notch the bottom of the stab to just clear the top of F-6. Measure from the front-center of the fuselage to the stab tips for lateral alignment. The mean chord line of the stab should be in line with the top of fuselage sides. Align the stab horizontally by using the wing as a reference while standing seven or eight feet behind the model, and sighting down the centerline of the fuselage.

The fin must be perfectly in line with the fuselage center line and absolutely perpendicular to the horizontal stabilizer. The trailing edge should line up with the rear of the fuselage consisting of the V-shaped tail block, fuselage sides and ventral fairing. If, when the lower tab of R-2 is pushed into recess in the top of stab, this line-up does not occur, then R-2 must be trimmed until a proper line-up can be achieved. Epoxy the fin in place. Shape the dorsal fin and epoxy in place.

After the epoxy has set up, build up the fuselage-stab-fin fillet from Epoxy-Lite. A wet finger can form this material into a final fillet shape that will require little sanding. In fact, if you use the wet finger technique, be sure to finish shaping the fillet so that it will require little, or no, sanding. Epoxy-Lite finished in this

manner has a tougher, and a somewhat more flexible surface film, and is harder to sand.

To build the wing fillet, first pin a piece of wax paper covered balsa to the rear of F-5B with approximately one inch overhang on either side, and along the wing trailing edge. This overhang should be trimmed to the concave shape of the lower wing fillet, and will act as a backstop for the build-up of the fillet.

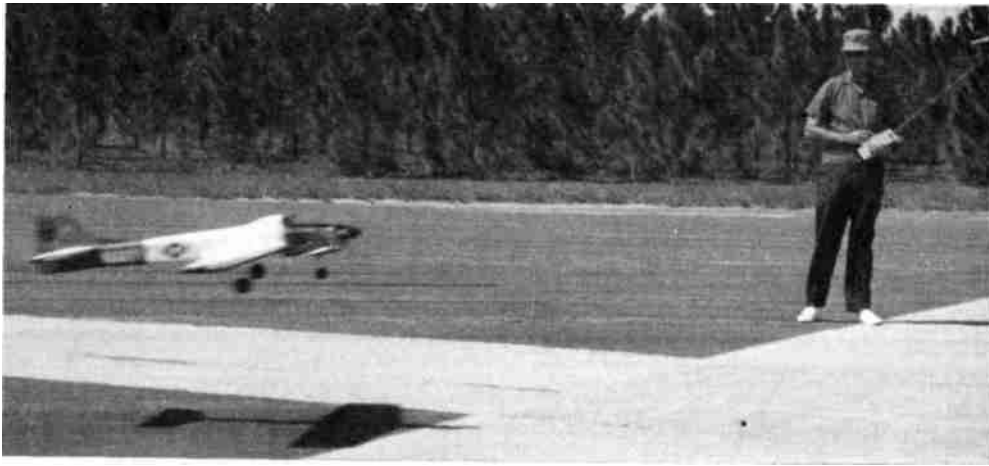
Using the wet finger technique buildup this lower wing fillet to the lines shown on side and top view of plans. Let this Epoxy-Lite fillet cure until hard. Bolt the wing to the fuselage with wax paper between them and extending about two inches from each wing panel past the fuselage sides. While holding FF-2 pieces to conform to wing shape, and against the fuselage sides, run a bead of five minute epoxy along the FF-2-fuselage seam. Hold in place until the epoxy sets. Epoxy FF-1's to fuselage sides and in line with trailing edge of wing. Lay a bead of five minute epoxy over the near butt-joint between FF-1's and FF-2's. Be sure the wax paper between the wing and fuselage extends from the dowels at F-3A to a point past the lower fillet line on F-5B. Apply Epoxy-Lite material to upper and rear areas of wing-fuselage joint to complete the wing fillet. Let Epoxy-Lite cure thoroughly.

At this point I use various sizes of dowels and small blocks to sand all fillets and the entire model to the shape that I want the finished model to have. I then go over the entire model with 120 or 150 grit garnet paper to make certain that it is smooth and ready to receive the finish.

Covering and Finishing - There must be as many ways, and combinations of materials, to finish a model as there are modelers! A few people have reached what they consider to be a Utopian level in-so-far as their personal preferences are concerned. Others are still searching and having their problems with peeling, cracking, bubbling, warping, and other phenomena too numerous and varied to categorize! I went this route, and while I do not consider my present method Utopian, I do feel it is the most consistent and predictable. It should be, as it has been around longer than any of the newer methods. Primarily, I use silk and dope! I suppose personal experience accounts most for the consistency and predictability, but this method is hard to beat for a true workbench modeler. It requires sandpaper and some patience, but the results are good looking, durable, fuel-proof, non-cracking, easy to clean, and easy to repair if the need arises!

I do not claim results for myself that the true perfectionists can get with silk and dope, but the following is a relatively fast way to complete a model using this method.

First, the bare wood is given three coats of clear dope. (Stick with the same brand of dope from start to finish.) Use 120 garnet paper lightly after each coat is



One tail-low spot landing coming up. Spot in this case a yellow X denoting that field is closed.

dry to the touch. The wood should have a sheen and be slick to the touch at this point.

I cover the fuselage with one piece of silk. Fold the silk lengthwise, slit and notch the fold at one end to clear the fin and stabilizer. Lay the silk along the top of the fuselage with the front of the slit against the front of the dorsal fin. Wet a kitchen sponge, wring it partially, and wipe the silk smooth along the top centerline of the fuselage. Use a one-half inch wide brush and brush dope through the silk along this centerline from front to rear of fuselage. Now use the wet sponge to wipe the silk down and around one side of the fuselage, doping only in the concave fillet areas. Slit if necessary around the rear of the wing fillet, and cover the resulting bare area with a scrap later. Continue wiping silk around the fuselage until it overlaps the bottom centerline. Dope along this line, cutting off excess silk with a sharp razor blade before the dope dries. Cut away excess at wing opening, leaving approximately one to three-quarters of an inch for lapping underneath. Repeat for other side of fuselage. Make slits in overhang areas at wing opening, engine opening, and at front of fuselage. Dope these tabs down.

Cover the stabilizer, fin, rudder, elevators, and ailerons with Japanese tissue. Use thinner to stick the tissue to the wood, rubbing the wrinkles out as you go. It helps to iron the tissue first if it has many wrinkles. This tissue will not follow a compound curve, so slitting is necessary about the tips and in the fillet areas.

I prefer to use Skyloft, a nylon fiber material marketed by Southern RC Products, Pecan Street, Citronelle, Alabama, to cover the wing. It resembles Jap tissue, or lightweight silkspan, and is light in weight, super tough, and fills very easily during the clear doping process (provided you do not sand up the nylon fibers!) It follows a compound curve easily when wet, and it must be applied *wet!* Use four pieces to cover the wing and keep all lap joints on the bottom surface of the wing. If you use silk, apply it with a wet

sponge as described in covering the fuselage.

When covering has been completed, clear doping time has arrived! Apply two coats to the entire model and when dry to the touch, sand with 120 grit garnet paper. Get as rough as necessary to get the surface 'bump' free. If it is necessary to cut any fibers, do it during this first sanding! Now apply two more coats of clear dope to the fuselage and wing. Apply one coat of clear and one coat of your primary color to all areas covered in Japanese tissue. Use 120 grit garnet paper and sand again, but try not to cut any more fibers this time around. The final two coats of brushed fill-coats should be of your primary color, and only one coat is applied to the areas covered in Jap tissue. Now use 320 wet or dry sandpaper, (use it dry) and go over the entire model. It should now be slick to the touch in all areas. If not, work these individual areas out until they are slick and appear so when held up to the light.

Cut slits for the nylon hinges and cut hinges for all surfaces. Epoxy all hinges into the main surfaces using five minute epoxy. Push pins in until they touch nylon, clip off with diagonal wire cutters, push in until flush with finish, and use the butt end of a small drill bit to push the ends below the finish surface. Careful, don't let the point penetrate the finish on the opposite side! Fill holes over pins with spots of white glue. Now push control surfaces onto hinges, first filling the slit in the surface, and coating the tip end of the hinge, with slow setting epoxy. Push surface up against the other surfaces's flat-faced trailing edge and pin as described above. Use medical Q-tips, dampened with alcohol, and toothpicks, to remove all excess epoxy in the V-shaped groove between the control surface and the main surface. When hinging the ailerons use a piece of PVC bag (almost all model parts are packaged in this type of bag) between the protruding end of the torque rod and the trailing edge of the wing. Push aileron into place and pull, and tape the PVC strip tightly around the V-shaped leading edge of the aileron. Be sure to clear all excess

epoxy away from the torque rod where it enters the bearing tube next to the end of the aileron.

Now cut and fit the Debolt CL-4 canopy to fit into place on top of the fuselage. With the canopy held in place, mark around it with a felt-tip pen. Remove the canopy and mask one-quarter inch below and outside this line. Brush on four *thin* coats of whatever color you wish to use under the canopy, and add whatever you wish in the way of cockpit details. Remove masking tape from around the canopy paint area and glue the canopy in place with Aero-Gloss C-77 cement. To keep peace in the family, *ask the wife* for about twenty-inches of narrow (three-eighths wide) hemming tape. Now apply masking tape around the upper section of the canopy so that the lower edge of the tape is *below* the point where your final paint line will be. Use C-77 cement and glue the hemming tape around the base of the canopy, half or less on the canopy, the remainder on the fuselage. Rub two coats of C-77 into the hemming tape fabric and sand when dry. Repeat this procedure until the tape, and resulting canopy fillet, is smooth to the touch. Remove masking tape from the canopy, remask to your final paint line. Sand away the ridge left when original masking tape was removed.

Now for the final finish, spray on two coats of your primary color, mask as required; seal tape edges with clear dope, and spray on two or three coats of your trim color. Remove masking tape.

If a spray gun is not available, thin the dope to approximately 65-35 proportions (65% dope, 35% thinner) and use a soft bristle brush to apply three coats of the primary color, and three or four coats of trim color. Unmask, add decals, wax, and you are ready to install the radio and perform the pre-flight checkout.

If a spray gun was used to apply the final finish, apply decals after removing the trim masking. Test decal material's compatibility with clear dope on a test board. If clear dope caused decals to wrinkle, brush one coat of a decal protector, or fuel proofer, over them. When dry, test again with clear dope. When all decals and markings are compatible with clear dope, spray one coat of clear over entire model. When dry, wet sand model with 400 wet or dry sandpaper. Cut ridges at trim edges down smooth to the touch, lightly sanding the remainder of model. (Sand *very* lightly over the decals.) Now mix retarding thinner and clear dope to fifty-fifty proportions and spray a light wet-coat to the entire model. This will bring the colors out, bright and glossy. When dry, wax the model.

This type of finishing and covering adds approximately eight to nine ounces to the total weight of the model. Not very much, yet a good durable finish, with a minimum of sanding and no rubbing. I think you will find the finished product worth the little extra effort required.

Pre-Flight Checkout - Install fuel tank, engine, prop, spinner, landing gear and the radio. First, check ground angle. The wing mean chord line should be parallel to the ground when the model is at rest. Check the center of gravity location as shown on the plans and adjust until it falls *exactly* on this point. (Fuel tank empty.) Now balance the model along the fuselage centerline, adding weight to the lighter left wing tip until a perfect lateral balance is achieved.

Turn on the radio and set the transmitter controls and trims, at neutral. Adjust the clevis at the control surfaces until each surface is in line with its reference surface (R-4 for rudder, stab tip and aileron fill-pieces for the elevators and ailerons respectively). Now check the deflection angles for each control surface. Adjust for each control surface until the deflection angle matches that shown on the plan for that particular surface. Adjust the throttle linkage so that full servo throw moves the throttle from full open to the idle position *without* hitting a stop at *either* end.

I have used every kind of brake system that has appeared on the model scene over the past ten years. All have their particular advantages and peculiar traits of operation and maintenance. I have found that a simple nose wheel drag brake, that operates in conjunction with full down elevator control, is the most positive and trouble-free. Under existing rules it is totally adequate for competitive purposes on most flying sites.

Flight Trim - This can be a rather frustrating experience for the novice, and is a necessary chore if any flyer is to realize the full potential of any model design. Probably more erroneous conclusions have been reached about a particular model because of inconsistent and improper flight trimming than for any other reason. Until a flyer can properly flight trim a model for competition flying it would have to be considered an impossibility for that person to properly analyze the performance characteristics of any given model or design.

To begin with, the model must be constructed as accurately as possible. Any deviations from such basics as thrust and decalage settings during construction will have to be corrected during the flight trimming process. Results from such practices are usually at least unsightly, or else require considerable effort to camouflage. So initial efforts to get these basics correct will be most beneficial during the flight trimming process.

Warpings that result from hasty building practices are much worse than those that may result from covering and doping. Built-in warpings, twists, and misalignments are practically impossible to correct. Slight warpings (usually to control surfaces in a model of this type) caused from covering and doping can usually be corrected by steaming the surface and twisting the warp out. Needless to say, any warp will only

serve to aggravate the flight trimming process, and may even make it impossible to properly trim the model if severe enough.

It is possible to flight trim a model of excellent design, built to absolute accuracy, to fly like a real dog. Only a model with superior design features, plus proper flight trimming, can result in a model with superior *flight* characteristics.

Do not dismay. While all of the above has a direct bearing on trimming a model for flight, not many models have ever been built to such standards. In fact, not very many have ever been trimmed out to perfection, not even by the experts! A combination of model design, flight trim, flying skill, and equipment reliability and accuracy, all combine with a bit of lady luck, to produce a winner. So proper flight trim is only part of the expert's bag of tricks, and this can be mastered to the degree necessary to materially increase the enjoyment of flying by any RCer. Only experience can lead to a satisfactory degree of perfection, but experience can best be gained while working with a pattern of basic techniques. I have found the following step by step procedure to work well with any type of model, using every step in trimming a model such as the Intruder, and only those applicable for the less complicated models.

1. Trim for hands-off upright level flight while using full engine power. Normally, only elevator and aileron trim is required.

2. Trim for inverted straight flying, using only down elevator to maintain altitude. If the model has a persistent turning tendency in a given direction, trim rudder in the same direction as the turn until no turning tendency is present while flying inverted. If rudder trim was required, retrim ailerons for hands-off upright level flight. Repeat inverted straight flight trim, etc., until model flies straight, level, and true both upright and inverted. (Hands-off upright and only a slight down elevator required when inverted.) If a lot of down elevator is required to maintain altitude when inverted, check center of gravity location, decalage, and thrust settings. Correct if necessary, and repeat Steps One and Two.

3. Trim for glide condition. Fly by upright and level with full power. Cut power to full idle. Model should continue on a straight line, with no tendency to suddenly balloon or dive. As speed decreases the nose should gradually drop, but only a slight amount of up elevator should be required to maintain a constant speed and rate of decent in the glide. If ballooning or diving occurs when power is abruptly cut to idle, then a vertical (up or down) thrust angle change is required. If a lot of up elevator is required to maintain the glide, then center of gravity, or incidence settings should be checked and corrected. If changes are needed, retrim as outlined in Steps One and Two.

These three steps constitute the basic flight trim and must be achieved before proceeding further. Most major changes have now been completed with respect to center of gravity, decalage, and vertical thrust settings. If any changes are made to these three basics in later trimming processes, then Steps One, Two, and Three should be repeated and verified as remaining correct.

If the model is to be used in competition, or if the flyer has any interest in aerobatics, the flight trimming process must be continued if full potential is to be reached. So the next requirement in the flight trimming process is to set the deflection angles for the elevator, ailerons and rudder. Two factors are used to govern our efforts in setting up these deflection angles.

First is the need to achieve maximum benefit from the human reflex system, wherein the reflex action requirements are as even as possible on all axis of control. I choose to call this a 'balanced-feel' of control where model response is the same in either direction about a given axis. In other words no control has a more sensitive response in one direction than the other. This 'balanced-feel' should also apply to the response sensitivity between controls for all three axis, particularly between elevator and ailerons. In other words, we do not want a soft feel on the elevator and supersensitive ailerons, or vice versa.

The second factor in determining deflection angle limits is maneuvering requirements about each axis of control. This is determined by either individual preference for the sport flyer, or the current rule book for competition flyers. Each control must have sufficient deflection available to perform the most demanding maneuver which uses that particular control as the primary means of achieving the desired flight reaction.

The Elevator: The requirements of the spin maneuvers are the primary factor in setting up the elevator deflection limits. The elevator must be able to put the model into a stalled condition and hold it in a stalled condition for the duration of a spin. This is true for both upright and inverted spins, and reversals, if such maneuvers are required. Incidentally, you do not release the elevator command in a reverse spin maneuver until the spinning action has been completed in both directions!

The elevator deflection angle for most designs is approximately fifteen degrees, but may be as little as ten degrees, or as much as twenty degrees. Since limited elevator sensitivity is important for smooth execution of most all maneuvers, the deflection angles should be set as low as possible, but with an equal amount to either side of neutral.

When split type elevators, such as on the A-6 Intruder, are used it is most important that the trailing edges of the two elevator halves be in perfect alignment. Any attempt to flight trim a competition

RC model by *misaligning* the elevator halves could best be compared to trying to correct an automobile's steering discrepancy by misaligning the rear wheels! The results would probably be similar also!

The Rudder: Any rudder deflection beyond about thirty-five degrees does not do much more than apply air-brakes! If the rudder will not do what it is supposed to do with thirty-five degrees of deflection, it needs more area! The amount of deflection is determined by how much is needed to do a dead straight hammer-head stall, to either right or left, with no wind present. Any more than this will turn the spin into a real tail twister!

The Ailerons: Both the double immelmann and the three rolls are used to determine the amount of aileron deflection. For me, this works out to be about four seconds required for the three rolls. At this point I try to achieve a 'balanced-feel' between the ailerons and the elevator by either slightly increasing, or slightly decreasing.

It is now necessary to adjust for proper aileron differential. I have found it easiest to determine if the differential is correct by doing a split S from a long, straight-away climb-out. If, following a left 180 degree roll, the heading has veered to the left, there was too much differential. If the veer was to the right, there was not enough.

Loop Tracking: This is probably the biggest bugaboo of all! No wind and stable air are both a must if experience is lacking, and a definite help in any case. Inexperience could also use a helper to verify what happens and jot down this information for analysis during the relaxing periods between flights!

To trim for loop tracking requires that both inside and outside loops be flown with the model heading straight away from the pilot. Try inside loops first and use no command other than elevator to complete one loop on any given pass. Note which direction the model turned, right or left, and if a turn did occur, which wing went toward the *outer* perimeter of the loop. Now do an outside loop, using only elevator command, and note turn direction and wing deflection. At this point, you are interested only in whether a wing *did* deflect in both inside and outside loops, and if it did, was it the same wing panel in both type loops. If the same wing panel moved outward in *both* inside and outside loops, then that panel is heavier, and weight must be added to the lighter panel's tip.

If the same heading change occurs at the *beginning* of both insides and outsides, the rudder should be trimmed to correct this heading swerve. If a change in rudder trim is necessary, the ailerons will probably need re-trimming also. If the same heading change occurs primarily as you approach the *top* of the insides and outsides, the problem is more likely engine thrust setting than rudder trim. In this case, right or left thrust must be added by

shimming the engine mount.

If, after following the above steps, the model will track while doing insides, but will not track as well while doing outsides, raise both ailerons two turns at the control clevis. Depending on the degree of improvement, or aggravation, of the outside tracking tendency, either raise the ailerons more, or less, or change to lowered ailerons, as the results dictate. Continue this process until the model will track properly during only *one* inside loop and only *one* outside loop. If it will track through one loop, it will track through three, unless the flyer, the slipstream from the preceding loop, or wind conditions causes the model to veer. For these reasons, it is only rarely that three perfect loops can be done using only elevator commands.

There you have the basic techniques that I have used successfully for fifteen years to flight trim my RC models. The loop-tracking procedures may seem oversimplified as there are usually two or three different adjustments to make. Trying to analyze those first loops may be frustrating! Just remember to first learn to recognize a heavy wing and correct for this. Then recognize turning tendencies, whether caused by rudder or thrust, and correct the causing factor. Finally, after correcting the wing balance and the turning tendencies as much as possible, play around with raising and lowering the ailerons to find the best setting for loop-tracking. Only experience will teach you to recognize the primary culprit early in the trimming process. I still find an advantage in having someone around to help if a model turns out to be particularly difficult to trim!

Flight trim can either make or break a model for you. Proper flight trim can give anyone a winning edge in competition, or just plain satisfaction in fun flying. It is as much a part of this hobby as any other part and, while some things can be bought, flight trimming must be learned! See you in the winner's circle.
