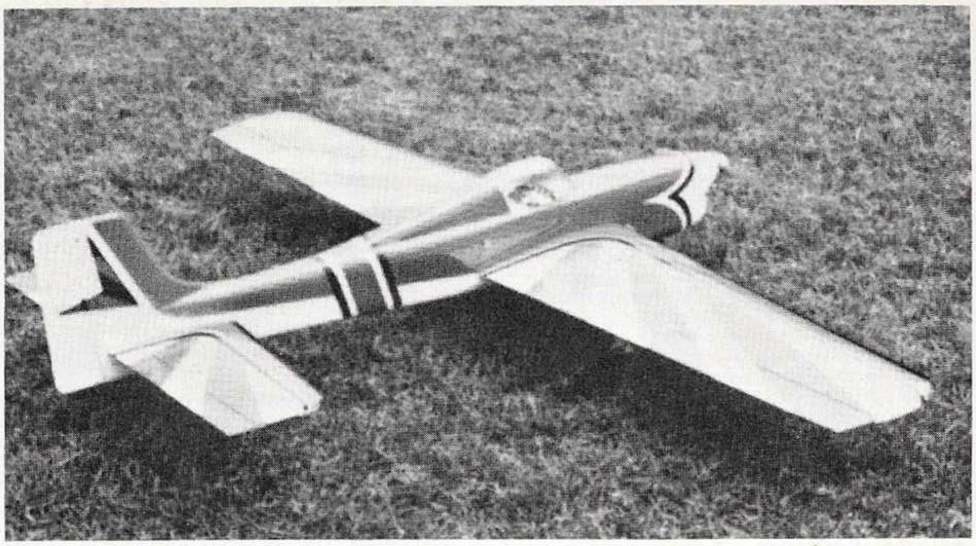
# FAKIR I

The Fakir (named after Hindu magicians) is a pattern machine with very little trickery, but capable of producing extraordinary (almost magical) results. / by Howard C. Mottin

# FAKIR I



The February ('73) issue of AAM contained the announcement of a Super Design Contest, based on the drawings of Bob Lopshire. The bottom view of the Fakir was on the cover of the Doylestown World Championship program (also on the October '71 AAM) and the top view appeared on the cover of the February '73 AAM. Using the rules for the contest as a guide, I created the idea of the Fakir-I. The contest called for the plane to be designed on paper first and then constructed according to those drawings. Finally, the rules required that the flight characteristics be demonstrated by appearing at the '73 NATS in Oshkosh.

The primary objective of my particular design approach was to create a plane that would have good flight characteristics. Many pattern aircraft are developed through a build-and-crash procedure, often encompassing several years. In this way, the bugs and design deficiencies are eliminated one by one, until an optimum craft is achieved. Because of the time restrictions imposed by the contest, this was impossible; so the next best thing was to model the plane according to existing designs of known flight quality.

The first step in the design procedure was a dimensional analysis in order to arrive at the overall configuration. Current design trends in pattern planes decree that their weight is between seven and eight lb., with wing areas of around 650 sq. in. The overall configuration of the plane was dictated by Bob Lopshire's drawing in AAM. This, then, was the basis for the design, with each component defined by experience and the state of the art analysis.

### DESIGN THEORY

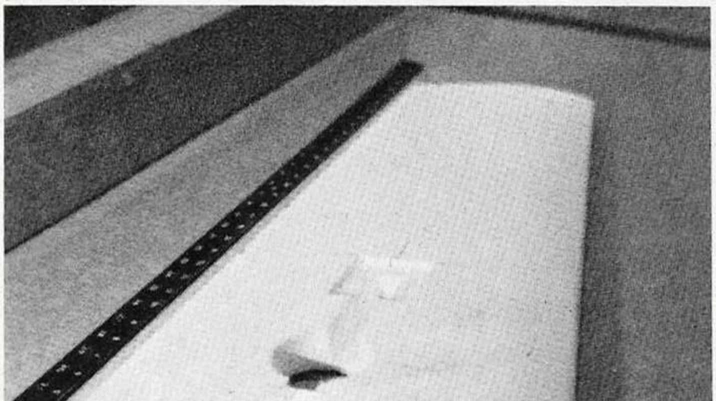
**Wing:** The wing is the most important single feature of a pattern design. A goal of seven lb. total weight and a 650 sq. in. wing area gives a wing loading of 25 oz./sq. ft. This is on the heavy side, but about standard for the top pattern design of today. The wing planform with a straight trailing edge and swept-back leading edge, is dictated by the AAM drawing. Aspect ratios have traditionally been between 5:1 and 6:1, with the higher ratio being more stable about the roll axis, and having better turn and spin recovery characteristics. A wing design I have evolved through the years has a 5.7:1 aspect ratio.

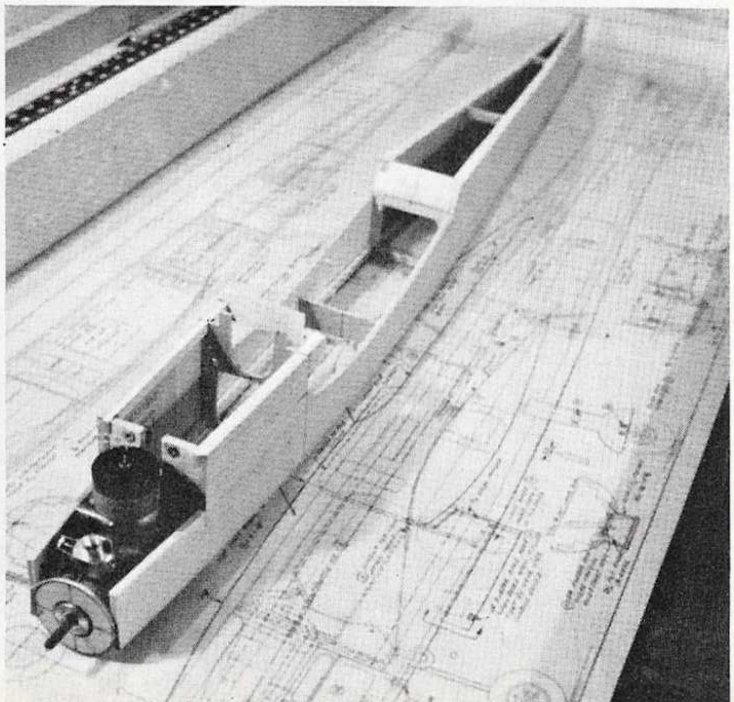
This design must incorporate inset ailerons. Using a figure of 11 percent of wing area, I arrived at an aileron area of 70 sq. in. The current trend of using torque tubes eliminates the bellcranks and pushrods in the wing, and also satisfies the contest requirement of no exposed linkages. The original design called for a 1/8" dia. torque rod, but this had too much flex, and was replaced with a Rom-Air torque rod unit.

The next important selection is that of airfoil. Through the years, hundreds of different airfoils have been tried, and many have been claimed as the optimum for RC. Currently, the symmetrical sections are the most popular, with 15 percent thickness just about the standard. Because this was to be a highly tapered wing, some method had to be employed to prevent tip stall. Dismissing wash-out, there are three common methods to prevent tip stall: (a) increase the thickness percentage at the tips; (b) maintain a constant large leading edge radius; (c) gradually change the tip to a slight lifting section. Point (b) was used in the design of this wing.

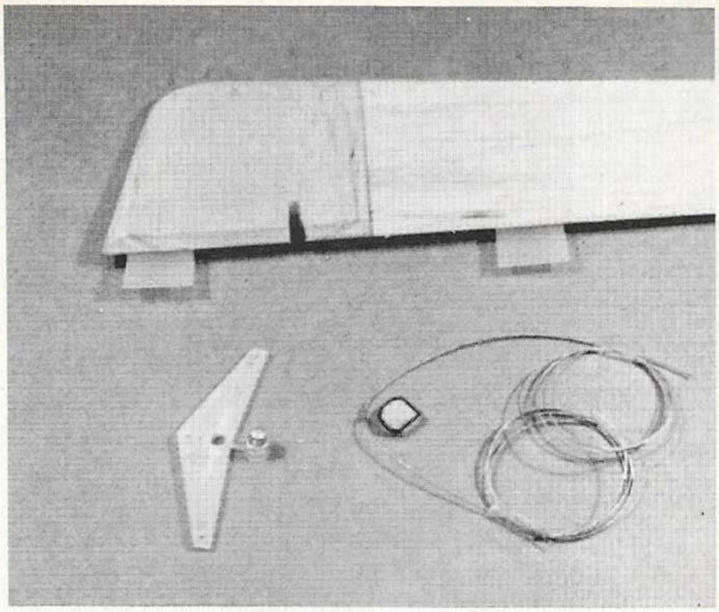
Incidence and dihedral complete the wing analysis. The 0-0 setup is the standard of today. I like to design my wing to be 1/32" lower at the trailing edge, just to insure that the wing does not end up negative. For all practical purposes, this is still a zero incidence design. The current trend is also toward zero dihedral. I prefer one in. under each tip, just for appearance's sake. With the swept-back leading edge (the sweeping giving effective dihedral), this probably figures out to be about 2°. In summary, the wing was designed to the following dimensions:

| | |
|---|---|
| Wing area | 650 sq. in. |
| Root chord | 13 in. |
| Tip chord | 8-3/8 in. |
| Wingspan | 61 in. |

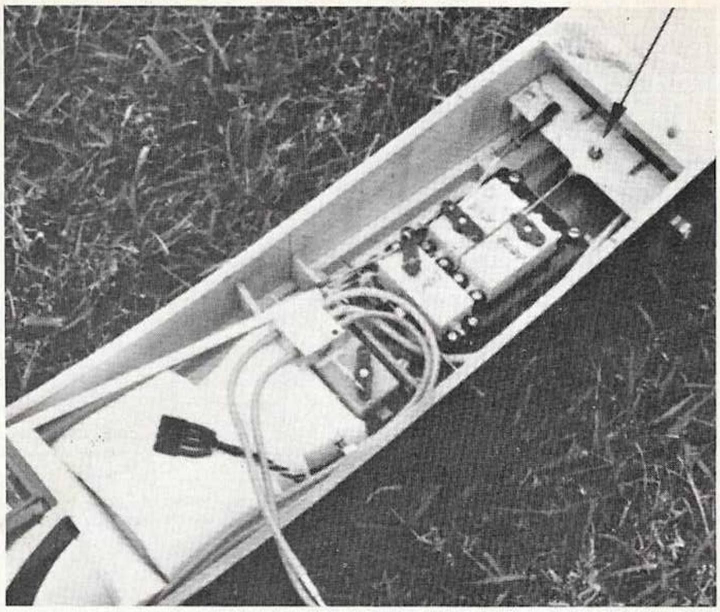




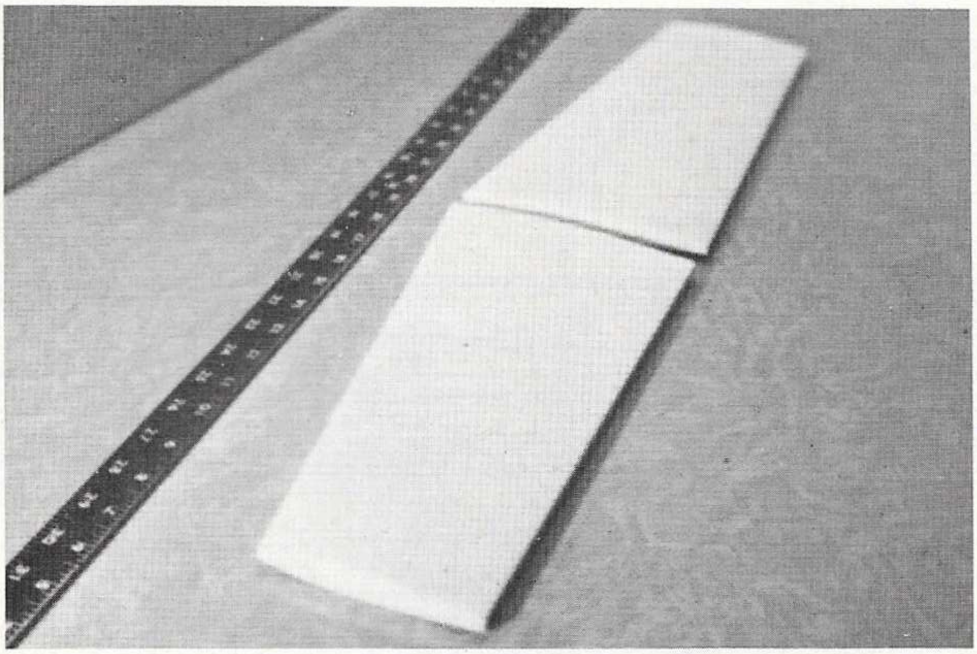
**ABOVE: Fakir's wing core ready for sheeting. Wheel wells, gear anchor plates and LG channel have all been premeasured and cut out. RIGHT: Fuse builds, like most pattern ships, inverted on the boards. All bulkheads have been fitted and the engine is aligned for proper thrust angle. Plywood template nose ring slips snugly over the engine bearing to ensure proper centering of nose cone.**



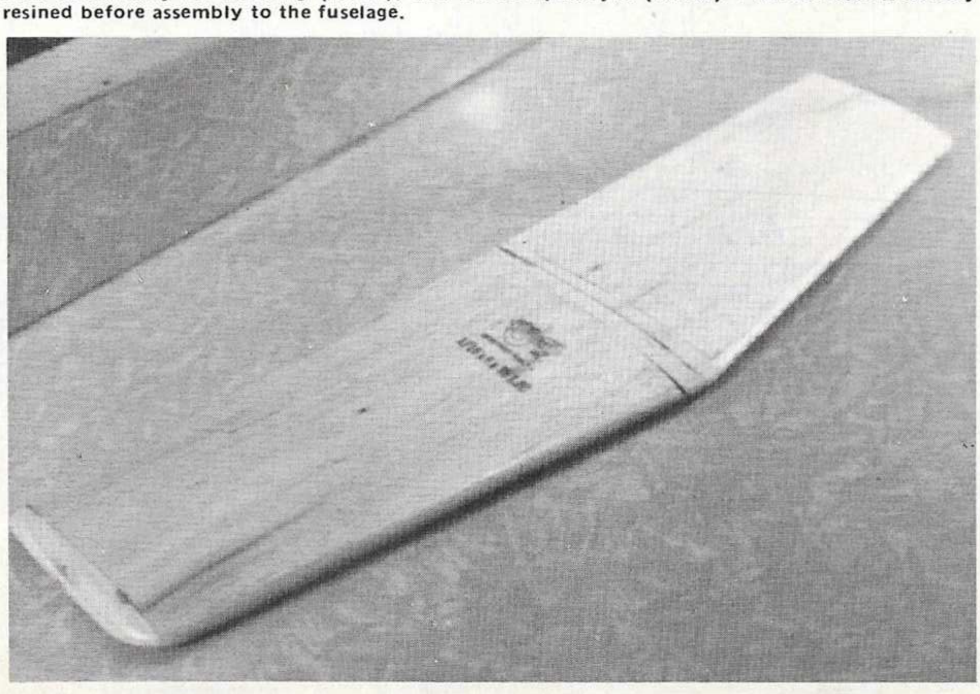
Rudder and its linkages. Note chord-wise grain of the hard balsa which forms the lower third of the rudder. ½A bellcrank and braided cable—the way they rigged linkages on antique full-sized aircraft. A very positive control setup.



The radio compartment of the Fakir is well thought out. Pneumatic actuator valve is secured to the top of the retract servo. Arrow points to nylon bellcrank on platform, to which is connected the rudder linkage.



Stab cores ready for covering (above), and the complete job (below). Finished stab is already resined before assembly to the fuselage.



| | |
|---|---|
| Aspect ratio | 5.7:1 |
| Ailerons | 70 sq. in. (11% span width) (2½ x 14") x 14") |
| Wing loading | 25 oz./sq. ft. |
| Zero incidence | |
| Slight dihedral | |

**Stabilizer:** Stabs are usually in the range of 20-25 percent of the wing area. I have always preferred the larger percentage because I think it flies better. With a 650 sq. in. wing, this figures out to be 160 sq. in. A 4-1 aspect ratio defines the plan of the stabilizer. Allowing 20 percent for the elevator gives a 1½ in. wide elevator. To match the wing shape, and AAM drawings, the stab has a swept leading edge. Since we've gone to the trouble of cutting a foam core for the wing, we might as well use one for the stab. This results in a nice airfoil shape, which most designers feel is more efficient than a flat stab. I settled on a 3/4" constant thickness stab for several reasons. One is that it is very easy to build straight on a flat table and, secondly, it is easy to align correctly when gluing to the fuselage. I suspect that it might have some aerodynamic improvements also. A Midwest metal control horn is used, and is enclosed in the fuselage, as per the AAM requirements. This also results in a very clean tail, without the drag from that wire bird cage sticking out in the wind. The stab then figures out thus:

| | |
|---|---|
| Span | 25 in. |
| Root chord | 7½ in. |
| Tip chord | 5¼ in. |
| AR | 4:1 |
| Total area | 160 sq. in. |
| Elevator area | 37 sq. in. |

**Fuselage:** Most fuselages are designed rather arbitrarily around the equipment they must contain. The general shape of this fuselage is already determined by the AAM drawing. There is still quite a bit of latitude as to what moments to use in the dimensions of the fuselage. The nose length is determined by the engine, fuel tank and nose gear retract unit. This usually turns out to be around 10 in. but, for this design, it was reduced to 9¼ in. for two rea-

# FAKIR I

sons: (1) the shorter nose lessens the effects of engine torque in certain maneuvers; (2) the swept wing would further increase the adverse effects of a long nose. A standard 48-in. sheet of balsa for the fuselage side permits you to lay out the rest of the fuselage according to the following formula:

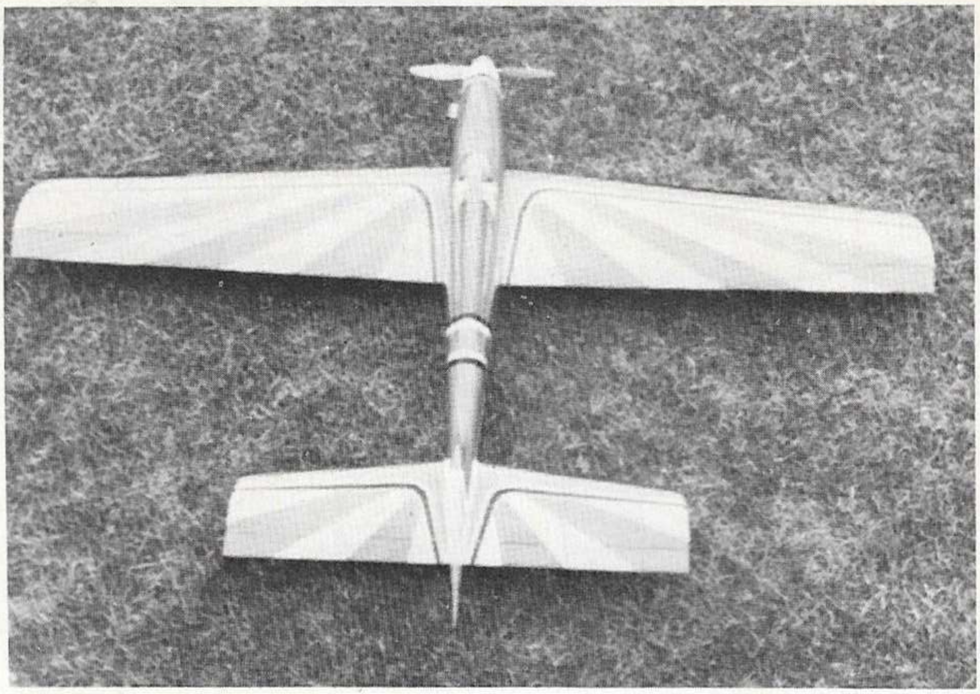
| | |
|---|---|
| Nose | 9¼ in. |
| Wing chord | 12¾ in. |
| Stab chord | 7½ in. |
| Tail | 17 in. |
| Rudder | 3½ in. |
| Total | 50 in. |

This arrangement gives a tail moment arm of 27 in. which is close to a 2:1 ratio. This is a very good force arrangement. The placement of the wing is critical in this situation, in order to allow room for the fuel tank and the retracted nose wheel. The wing chord centerline was placed 1¾ in. below the thrust line for this reason. The bottom part of the fuselage was extended back, past the leading edge of the wing, to enclose the wheel well. This will also serve as a key for locking the front of the wing securely in place.

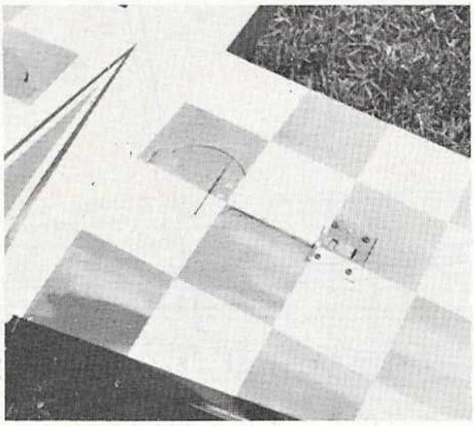
With an inverted cowled engine, cooling could be a problem. Rather than just stick the engine cylinder in a large cavity in the interior of the cowl and hope for the best, a pressure system of cooling was used. This worked well in control line, and should work in RC, too. The cowl interior is formed to force air through the cylinder fins, and exits through a hole in the fuselage bottom under the retract unit, ahead of the wheel doors.

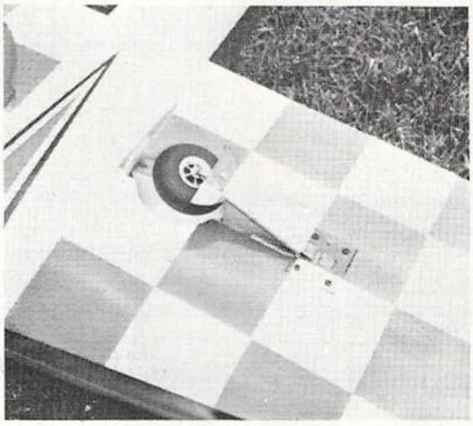
The fuel tank will be located above the nose gear and, because of this high location, will require the use of a pressure feed system. The easiest method is to use muffler pressure to maintain a constant head. This is a low pressure system, but it is enough to give a good constant engine run throughout the flight. The remaining point to be designed into the fuselage is the fin and rudder. Most of the current top designs use a 25 sq. in. rudder, and about a 30 sq. in. fin. This gives good yaw stability and enough control for the Figure M and spin maneuvers. To maintain a good profile configuration, the final design figured out to be a 34 sq. in. fin and a 25 sq. in. rudder. Normal RC design practice dictates that the CG should be located at one-third of the mean aerodynamic chord. From practical experience, this can vary from 30 to 40 percent of the chord. This CG range is shown on the fuselage profile drawing as a point to shoot for. The final weight of the plane is 7 lb. 2 oz., and the CG came out at 33 percent.

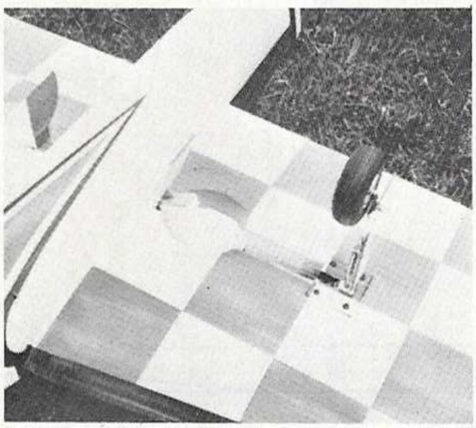
Two prime features make this design unique: a completely cowled engine, and wheel doors covering the retracted landing gear. The cowled engine caused some concern because of the tendency of these large bore RC engines to overheat. Hot humid days and mufflers seem

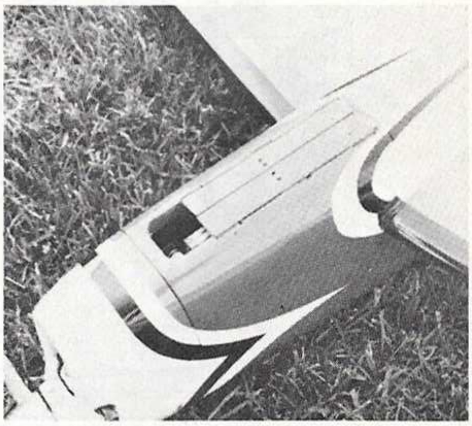


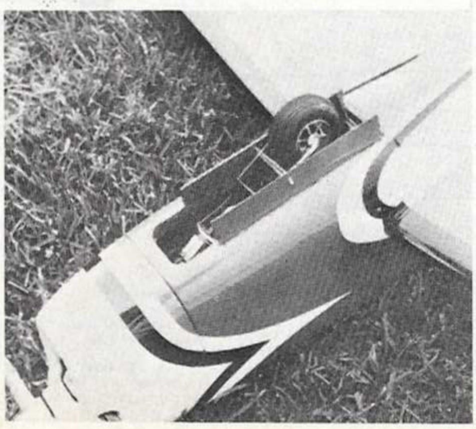
Top view of the Fakir I shows its low drag fuselage and pleasing moments. Short nose moment is more obvious here.

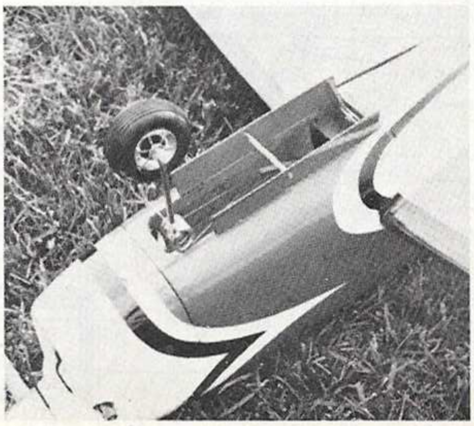












## FAKIR I

to aggravate this condition. This concern proved unfounded as the engine has performed beautifully in all weather, and no overheating problems have occurred. One condition that must be avoided is that of overpriming the engine before starting because, in the inverted position, a hydraulic lock can develop and serious damage could result. A wire clip is fastened to the glow plug and extends out the bottom of the fuselage for starting.

The model wheel doors proved to be the most perplexing problem. At first, it was thought that the nose gear doors would not be any problem because of the clam shell arrangement. Merely let the gear pull the doors closed as it retracts, and that's solved. It seems simple enough, except for one slight problem. The strut is off to one side and, as it contacts the spring, it twists, thus causing the wheel to turn and hang up the doors. This problem was solved by adding a wire to the other side of the wheel, creating equal tension on both sides to keep the wheel straight.

The main gears were built just as designed and worked very well. Minor adjustments to obtain the proper clearances and spring tensions took a good deal of time. The wheel doors do work well, when in adjustment, and the appearance of the model with folding doors is second to none.

The main gears were built just as designed and worked very well. Minor adjustments to obtain the proper clearances and spring tensions took a good deal of time. The wheel doors do work well, when in adjustment, and the appearance of the model with folding doors is second to none.

In retrospect, it appears that the best approach would be to use an auxiliary power system to actuate the doors. The modeler must weigh the effort involved (setting up the door system and keeping them working properly) against the option of simply retracting the gear into open holes. A few years ago, it was totally fixed gear planes; then retracts became the order of the day. Now, perhaps, full working doors will achieve 100 percent reliability and become common place.

### CONSTRUCTION

The drawings are more than self-explanatory. Only a few highlights will be touched upon. The fuselage crutch is best constructed inverted over the plans. This will result in a true shape and thus avoid a lot of flying problems. The plan is built with a 0-0 incidence setup. The top of the crutch is a convenient reference line to set up the wing and stab on a parallel line. The engine thrust line should be checked before gluing in the firewall. The Tatone mount has a built-in downthrust angle (the newer ones do not) which, in this case, would result in up thrust. This can be corrected by either milling the mount square, or shimming the mount to maintain the zero offset.

The wing, stab and fin cores are covered with 1/16" balsa, using the core blocks as a jig. The wing is covered with a one-piece skin constructed from smaller sheets, as shown on the plans. Epoxy and cellophane tape have proved to be the best combination for joining the sheets (resin gluing makes a more sandable seam). A convenient method of wrapping the leading edge, without the necessity of wetting it, is to use a strip of Coverite. A two-in. strip of Coverite is ironed to the centerline of the wing skin. It has been found impossible to crack the skin, even when bending around the tightest radius. After covering the cores, the Coverite can be merely pulled off, or left in place to be covered with the finish.

All the wheel doors are constructed by epoxy-laminating two pieces of 1/32" plywood. The hinges are sandwiched in between during assembly. This results in a very warp-free piece of plywood, much better than a single piece of 1/16" plywood.

### FINISHING

The model was finished by the K&B "Ultimate Finish" method. All the surfaces are given two coats of resin, followed by sanding with 150 paper after each coat. A coat of primer is then sprayed on and, after curing, is wet sanded with 320. The entire plane is then sprayed with two coats of white Superpoxy. After 24 hours, the plane is wet sanded with 400 paper to a super smooth surface.

Then all the trim is masked off, using black electrical tape (try Scotch Fine Line Masking Tape from the automotive store—Ed.), cut in 3/16" wide strips. The open areas are covered with newspaper and masking tape. Then the trim is sprayed on. After 24 hr., all the masking tape is removed, and the plane is once again wet sanded with 600 paper *very carefully*. The plane is then sprayed with a couple of coats of clear, one after another, until a super smooth surface results. No polishing or rubbing out is necessary with this method, as the resulting surface is like glass.

### FLYING

The foregoing finishing procedure took over two weeks to accomplish, and a bit of apprehension set in as to whether the bird should be flown, or merely hung on the wall as a Toledo-type creation. However, we decided to install the radio and hardware in order to go ahead with the flight testing. As part of the initial design procedure, a projected weight and CG table had been prepared. Now the completed plane was checked against this. The weight was within two oz.; CG was within 1/4" (well within tolerances). The dry weight of the completed plane is seven lb. It could be increased to eight lb. and still be acceptable.

A last minute check of everything was made before going out to the flying field for the first crucial test flight. It was a typical day for a first flight; wind gusted up to 30 mph, but the sky was bright and sunny. (It's always best to test fly on a windy day, because usually there isn't anyone around to see your mistakes.) After a couple of throttle checks and a little taxiing around, the nose was pointed into the wind, and off into the wild blue yonder. The plane was a delightful surprise to fly. It was very smooth, and the elevator response was just perfect. However, a couple of minutes into the flight, a disheartening sound, familiar to all pylon pilots, was heard: the unmistakable hum associated with aileron flutter. A low altitude pass was initiated and, sure enough, the ailerons could be observed bouncing up and down like a vibrating reed. A hasty landing was executed. Then, back to the old building board.

A quick overnight repair consisted of replacing the 1/8" dia. music wire torque rods with some Rom-Air torque tubes. The ailerons felt solid now, so it was back to the flying field. The next day's weather was a duplicate of the first, with the wind velocity perhaps even a little higher. Again a takeoff was commenced, and a series of high speed passes confirmed that the aileron flutter problem had been solved. The trimming procedure was then begun. The first step was a check of the control response. The elevator and rudder checked out, but the ailerons were a touch fast. A minor adjustment at the horns corrected this. Normally, the plane would be trimmed for straight and level flight as part of this step. This was unnecessary, as the plane literally flew off the drawing board with perfect straight flight. A few flight patterns were performed to show up any deficiencies, but none were found. This plane was capable of flying in a Pattern contest just as built.

The Fakir-I is extremely smooth in the air, probably due to its clean aerodynamics. The elevator response is very soft, making loops, landings and takeoffs a joy to perform. The rudder action affects only the yaw direction. Its application at the knife-edge points of the four point roll holds the plane in the correct attitude, and doesn't cause any adverse roll. The wing appears to have a very gradual stall. The model will maintain a nice nose-high landing attitude, without any tendency to drop a wing tip. In the spin entry, the plane will pull up into a stall and then drop straight down into the spin—the way it's supposed to be done. The plane can be throttled down and walked-in for a landing.

## ADDITIONS

Two weeks before the NATS, I changed the wheel door mechanisms from the rubber springs to wire coil springs. This system is a vast improvement over anything I had seen to date, and guarantees 100 percent operation and reliability. The system works as follows: with the door open, the spring is geometrically at a right angle to the door and opposes any force tending to close the door. Upon retracting, the wheel hits the spring from the side, pulling the door closed. Everyone who saw this system at the NATS commented on its simplicity and foolproof operation.

Editor's Note: The Fakir-I has done well on the contest trail. The most significant award was a twin victory at Pontiac, Michigan, where the plane won the design contest and took first in C Expert.

**See Bruce Lund's Fakir II, the runner-up in the Super Design Contest, on page 49 of this issue. Hints and ideas from other contest entrants appear in this month's Model Techniques section.**