COBRA

The domination of the competition scene by the sixty powered pattern ships gives way to the new breed of fast-striking, high performance forty ships epitomized by the Cobra. Designed to win, this machine is your ticket to the winner's circle.

By Jim Cooper

● For years, 60 size pattern airplanes have dominated the contest circuit. Everyone said they flew better than smaller ships, although many weren't sure why and, besides, fuel was inexpensive and supplies plentiful, so smaller airplanes weren't necessary.

Those days are now gone forever. Prices have skyrocketed. The time has come to challenge the "supposed" superiority of the 60's. Instead of scaling down the successful pattern ships of the past and designating them sport/pattern models, the time is right for a 40 powered aerobatic airplane, designed from the ground up, that will successfully compete in today's pattern contests. The Cobra is offered as just such a design concept.

Areas where a smaller pattern airplane is superior to its larger brother are immediately obvious. The cost of building and finishing materials, engines and fuel, are close to doubled for a 60 ship, when compared to an equivalent 40 size model. The problems of storage and transportation are noticeably reduced for the smaller airplane. It also pays not to overlook the difference in loss incurred after one of those inevitable "radio failures."

On the reverse side of the coin, many current 40 size designs lack smoothness in the execution of maneuvers. Some of this is due to design and can be improved, as I will discuss later, and some is due to technique. A 5 pound pattern airplane exhibits a smaller opposing force to a change of direction than does an 8 pound airplane, a fact which must be accounted for at the transmitter by avoiding quick stick movements. Control inputs must be introduced and removed smoothly. What this all means is that a flyer accustomed to 60 ships needs to fly the new 40's more than a few times to make the transition properly and to pass fair judgement on their capabilities. It isn't more difficult, just different.

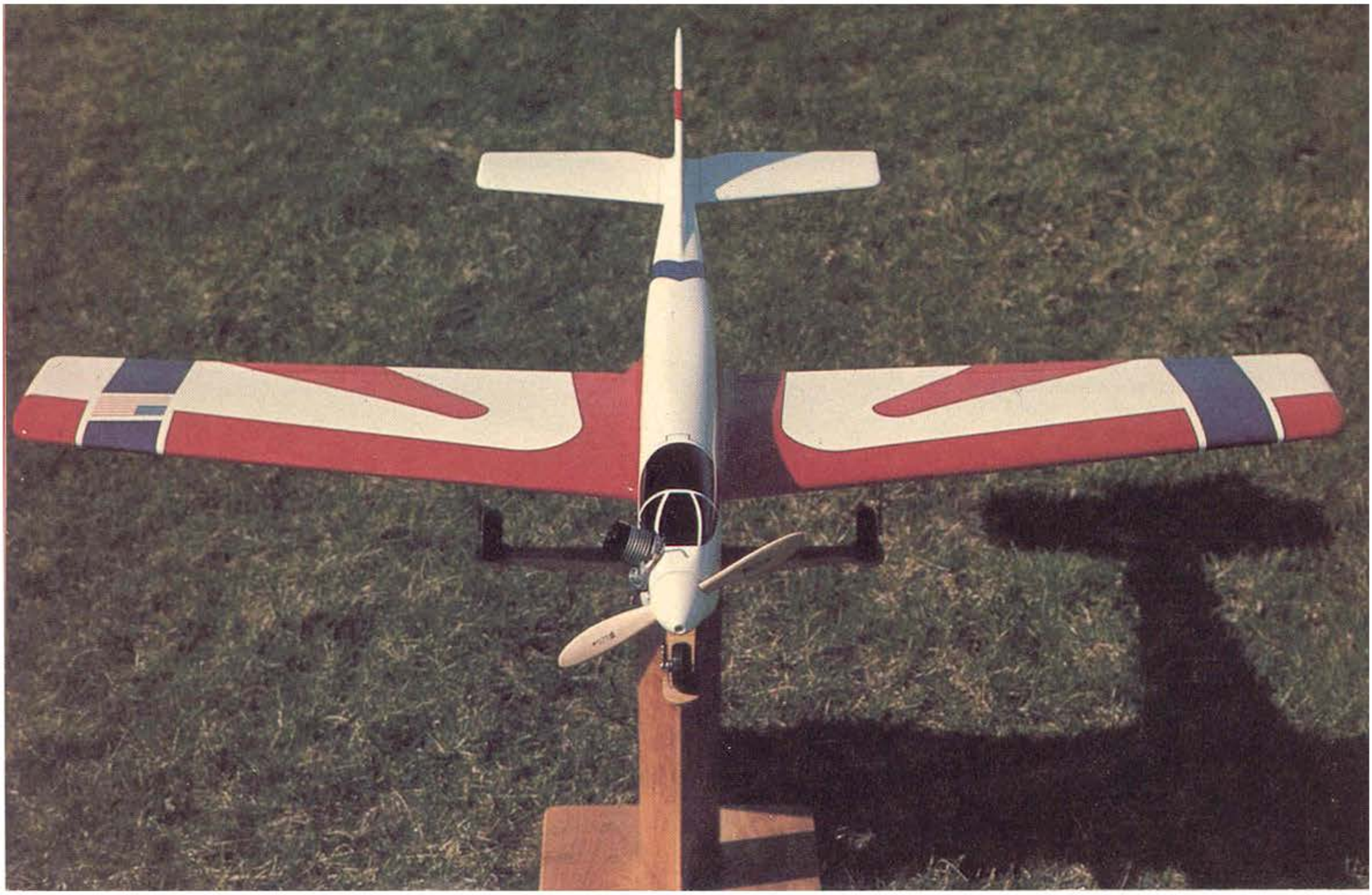
A second criticism of the 40 is that its wind penetration isn't up to par. Admittedly this is the smaller design's weakest point, but much can be done to bring the wind performance within acceptable limits. The most effective adjustment available is wing loading. For normal flying, a wing load factor of around 23 oz./ft.^{2} is ideal on a 40 ship. Using weights at the C.G., the wing loading can be increased up to 27-28 oz./ft.^{2} to increase wind penetration. Another helpful aid in conquering the wind is a good, powerful engine. One of the best on the market is the Schnuerle O.S. 40 FSR and is highly recommended for this airplane. The important thing is to not get a hang-up on wind effects. Whether we like it or not, all pattern airplanes are affected by the wind and practice in the wind, not design, will improve your score the most.

The decision to try a 40 or stay with the 60's boils down to one's personal priorities. Keep in mind, however, that for a very large percentage of contest flyers, the airplane, be it a 40 or a 60, has a flight potential equal to or greater than the flyer's ability to guide it. If you're aiming at a national title and have the money to support your habit, your choice is clear. For the other 99%, this new breed of 40 deserves your consideration. The important thing is to try it for yourself. Don't take someone else's word for it.

Design Philosophy

The Cobra was designed with several goals in mind. In order of importance they were: (1) To display competitive performance. (2) To be rugged yet simple in construction, and (3) To be economical to build. At each decision point in the design, secondary goals were considered after insuring that all performance criteria were met.

The fuselage design pivots around two main themes; first, the necessity of retractable landing gear to keep the ship as aerodynamically clean as possible, and second, the requirement for balanced side area fore and aft of the C.G. to enhance both crosswind taxiing and knife edge flight. The nose is faired smoothly, if rather bluntly, from the spinner to a maximum cross sec-



tion well forward of the C.G. where it begins a constant reduction to the tail end of the aircraft. Low speed aerodynamics show that blunt shapes have minimum drag characteristics, as exhibited by a raindrop. The canopy is purely cosmetic. A separate canopy has a severe drag penalty, considering that it is an esthetic feature.

Internally, plywood is used extensively for its high strength to weight ratio. Fuselage moments were sized by the minimum nose moment necesary to accomodate the engine, tank and retracts. By bringing the firewall down well below the thrust line, a reduction in nose gear strut length was accomplished, allowing for the shortest possible total nose moment. A tail to nose moment ratio of 1.85 was selected. Although slightly higher than many 40 designs, the long tail moment contributes significantly to smoothness of flight.

The wing airfoil selection was based on leading edge sharpness, maximum thickness percentage and chord location of maximum thickness. To insure good stall characteristics, a fairly blunt "high volume" airfoil was selected. By designing a wing with a 15 percent root and a 16.5 percent tip with a constant radius leading edge, the effective leading edge sharpness increases towards the root. This causes the wing to stall sooner at the root than the tip, eliminating a nasty snap roll on those slow landings. The chord location of maximum thickness is well back from the leading edge to insure laminar flow over the entire wing. The wing area was set higher than average to provide an initially low wing loading. The sweep was designed into the wing for effective, positive dihedral, upright or inverted, to improve tracking in the round maneuvers. The remaining dihedral necessary to roll stabilize the aircraft is indicated on the plans. It must be emphasized that the right amount of dihedral is a function of each particular airplane. Although the figure indicated is the best place to begin, the best dihedral can only be determined for each airplane through experimentation.

The wing location, with respect to the fuselage, is a compromise of positioning the wing close to the thrust line, yet retaining adequate space in the fuselage for radio installation. The Cobra wing is one inch below the thrust line. This location, coupled with the deep forward fuselage, results in a spacious belly pan under the wing. Using an access hatch allows mounting an inverted aileron and landing gear servo (definitely recommended for Goldberg retract units). This set-up gives a straight route for the nose gear retraction link which can be easily removed at the servo for wing removal. The aileron horns can be adjusted through the back of the belly pan.

Because of the smoothness problem with smaller pattern designs, a flying stab has been employed in place of the conventional elevator. The thick airfoil also provides smooth, positive response while allowing for zero trim drag. The fin and rudder are also quite thick to keep the center of drag behind the C.G. for good directional stability and, again, smoother maneuvers.

Construction

In keeping with one of the original objectives of this project, the construction of the Cobra involves a fundamental knowledge of the basic building techniques used on current pattern-type aircraft. The airplane is standard balsa and foam with plywood formers and doublers in the fuselage. General building procedures apply and will not be covered here. I will, however, review the sequence used, and any tips that may prove helpful.

Build the wing first. Use extra care in forming the core and tip templates and aligning them on the foam block. Anything less than a true wing is totally useless for competition flying. Sheet and joint the panels in the usual manner. Ailerons are of the standard strip variety, but remember that the control horns go **down** on the Cobra. Also, achieve a no-gap fit between the wing and aileron at the hinge line. Air leaking through the gap from the high pressure under surface of the wing to the low pressure on top can make true round maneuvers nearly impossible to do. Don't worry about the belly pan with formers F-2A and F-3B at this time.

The flying stab should be tackled next. I machined my own mechanism from a block of Delrin, but the commercial units are as good and may save you some time. The two critical points on any flying-type surface are (1) a no-slop system must be achieved, and (2) the correct location for the surface's pivot location must be determined and strictly adhered to. The "no-slop" arrangement only requires that care be taken in fabrication (if you build your own) and installation. Item number (2) however, requires some knowledge of aerodynamics. A lifting surface, such as a stab, has a location through which the lifting forces act, called the center of pressure, Cp. This point occurs at the intersection of the mean aerodynamic chord (MAC) and the 1/4 chord line. If you decide to design your own stab, be sure to calculate the MAC correctly. Get the proper method from a good book on aerodynamics. The chord section that includes the Cp is the reference chord and all pivot location calculations are made with respect to it. Theoretically, if the pivot for the stab were located at the 25% location of the reference chord, only frictional forces would have to be overcome to change stab trim. However, because this system is unloaded, it is also unstable. A small vibration is undamped and could lead to flutter which can easily destroy the stab and, consequently, the airplane. By moving the pivot point aft of the 25% location, the moment caused by the force at the Cp loads the mechanism and damps out unwanted oscillations. Naturally, if the pivot location is moved too far aft, the force required to control the stab becomes more than the servo can handle. Because the stab airfoil on the Cobra was selected for its stable Cp through large changes in angle of attack (25% is only an approximation for most airfoil sections), a pivot location at 29% of the reference chord was selected. A safe bet for most airfoils is 33%, although this places a slightly higher load on the servo.

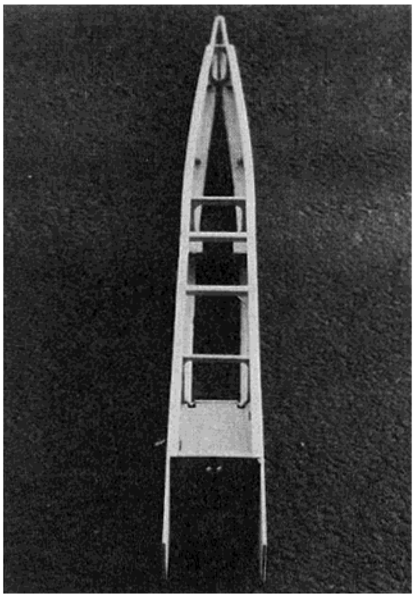
A sheeted foam stab is probably the easiest construction method to adapt to the flying stab mechanism. Begin by joining the **unsheeted** foam cores, then add the trailing edge strip. With the foam cores resting in the bottom half of their blocks, use a hot wire to cut a 5/16" wide slot for the pivot tube and a 1/8" wide slot for the actuator tube. Be sure the slots are properly located. At the same time, make a cut-out in the center section for the horn and bearing assembly. Epoxy a full length 5/16" brass tube centered vertically in the pivot slot and a full length 1/8" brass tube centered vertically in the actuator slot. Take care not to epoxy the actuator tube to the foam inboard of the stab separation lines (this portion will be cut free later). Fill in the top and bottom of the slots with balsa spars as shown and sand to the foam contour. Again, don't glue balsa inboard of the separation line on the

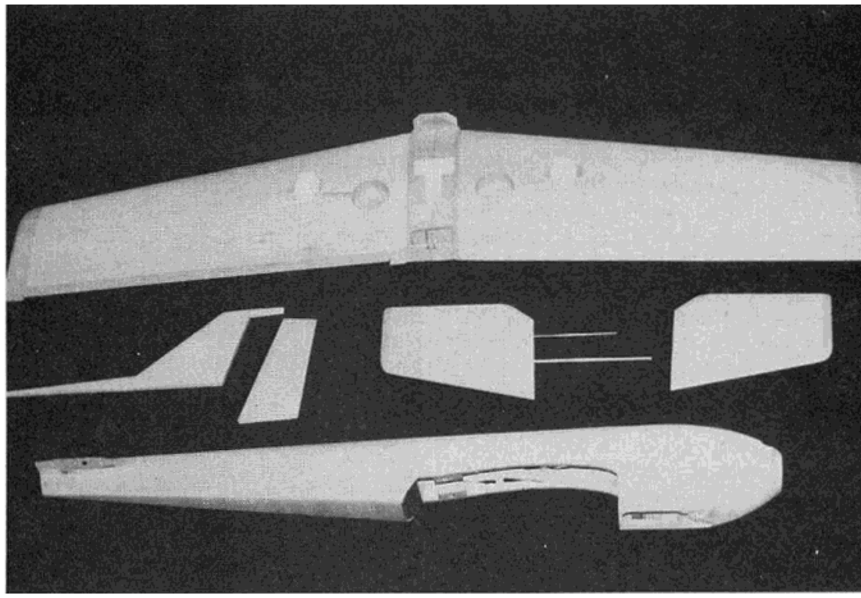
COBRA

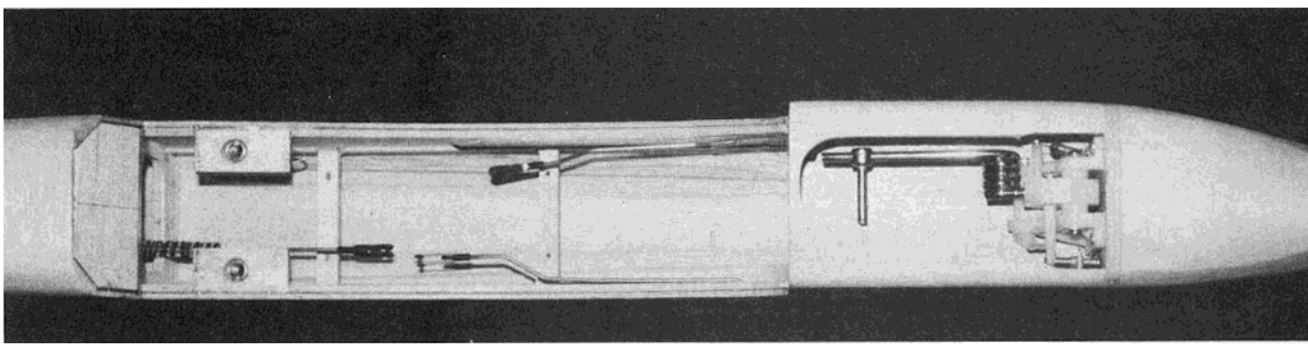
Designed By: Jim Cooper

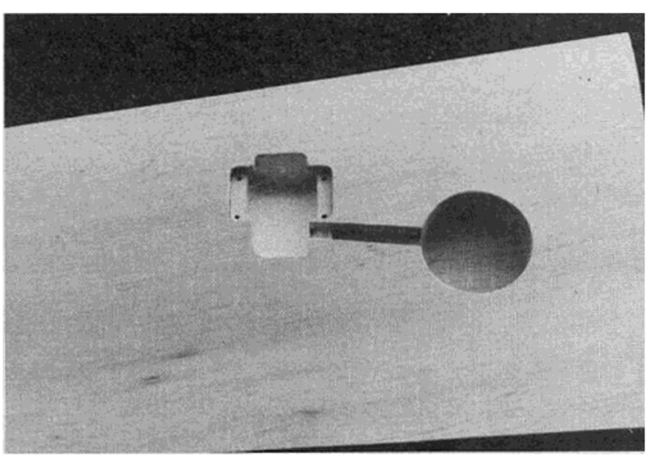
TYPE AIRCRAFT
Pattern
WINGSPAN
54 Inches
WING CHORD
Root 11" — Tip 7½"
TOTAL WING AREA
500 Square Inches
WING LOCATION
Semi Mid-Wing
AIRFOIL
Mod. NACA 64^2A015 (15.5%)
WING PLANFORM
Tapered, Swept
DIHEDRAL, EACH TIP
3/4 Inch
O.A. FUSELAGE LENGTH
46½ Inches
RADIO COMPARTMENT AREA
(L) 10" X (W) 2½" X (H) 2"
STABILIZER SPAN
20 Inches
STABILIZER CHORD (incl. elev.)
6¼" Average
STABILIZER AREA
120 Square Inches
STAB AIRFOIL SECTION
Mod. NACA 64^2A015 (10%)
STABILIZER LOCATION
Top Of Fuselage
VERTICAL FIN HEIGHT
5½ Inches
VERTICAL FIN WIDTH (incl. rudder)
7½" Average
REC. ENGINE SIZE
.40 — .46 Cubic Inch
FUEL TANK SIZE
8 Ounce
LANDING GEAR
Tricycle (Goldberg Retracts)
REC. NO. OF CHANNELS
5
CONTROL FUNCTIONS
Rud., Elev., Throt., Ail., Retr.
BASIC MATERIALS USED IN CONSTRUCTION

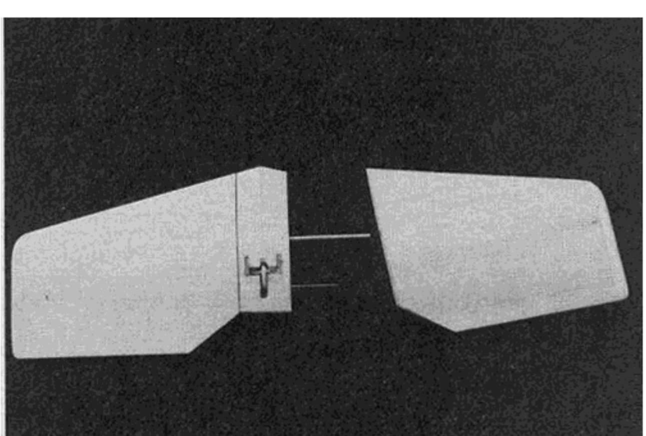
Fuselage	Balsa & Ply
Wing	Balsa & Foam
Empennage	Balsa & Foam
Weight Ready-To-Fly	87 Oz.
Wing Loading	25 Oz./Sq. Ft.

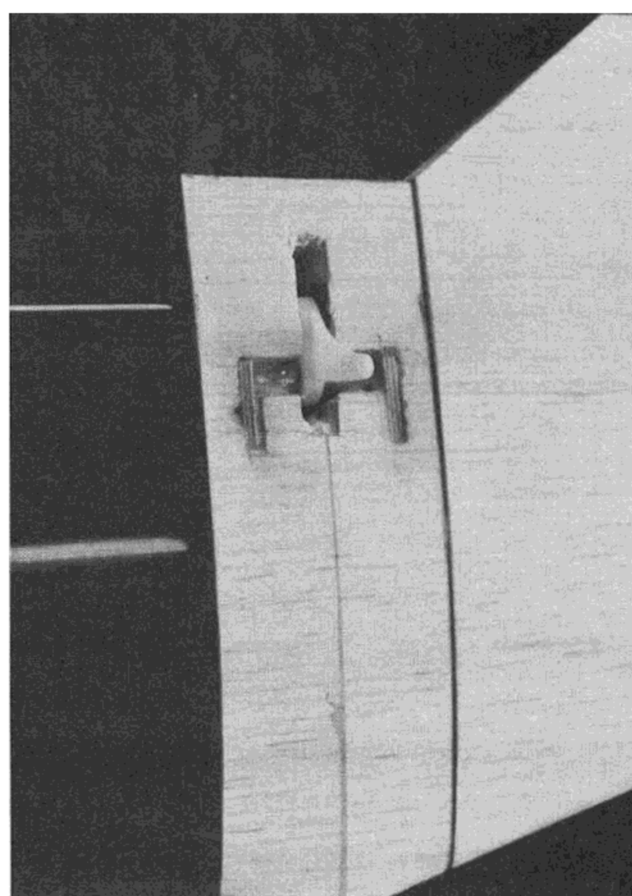










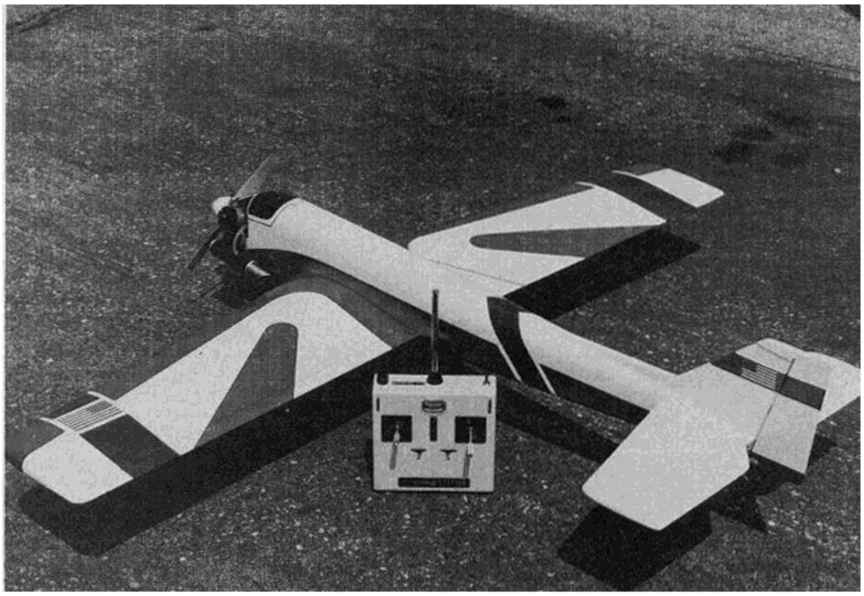


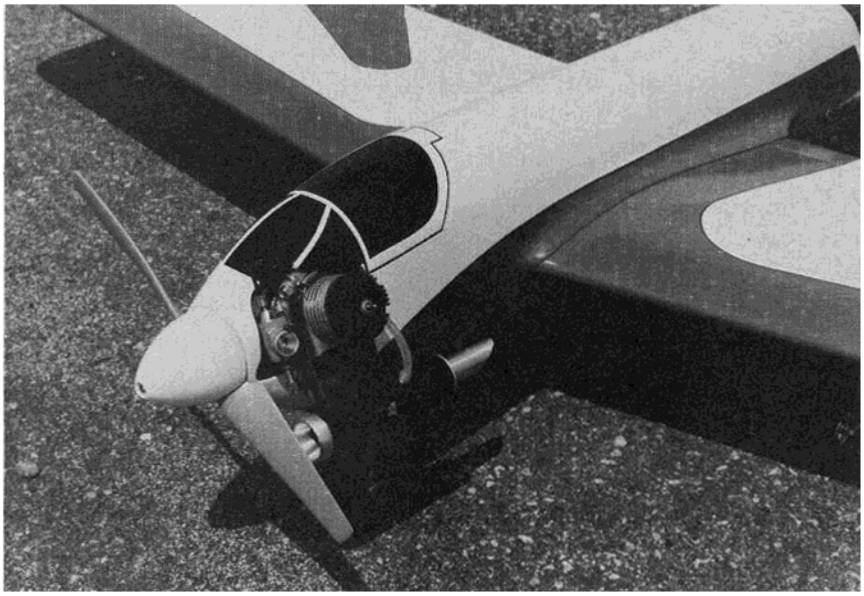
actuator tube. Now, sheet the stab bottom, add the small trailing edge ribs, sheet the top, add the leading edge and tip blocks and sand everything to shape. After carefully indicating the separation lines on the sheeted surface, cut the panel into three sections with a band saw. The two flying surfaces now contain tubes that precisely align them to the center section. Cap the four exposed ends that were just cut with 1/64" plywood and cut clearance holes for the pivot tube and 3/32" actuator wire. The clearance hole in the center section for the actuator wire will be a slot from top to bottom to allow for the required surface movement. Remove just enough sheeting from the bottom of the center section to install the horn bearing assembly in the foam. I used plywood end blocks with 5/16" brass tubes epoxied to them to provide a pivot for the horn and its 1/4" brass tube axle. To assemble the stab, a full length of 1/4" brass tube slides through the bearing tube in the center section and a 3/32" music wire is passed through the center section and the horn jaws. Stab panels are then epoxied to the 1/4" pivot tube and music wire on either side of the center section. A thin Teflon washer on the 1/4" pivot tube will reduce friction at the separation line. For now, however, leave the stab panels off until after the finishing process. You'll be amazed at how much easier it is to finish a fuselage with the stab panels detached.

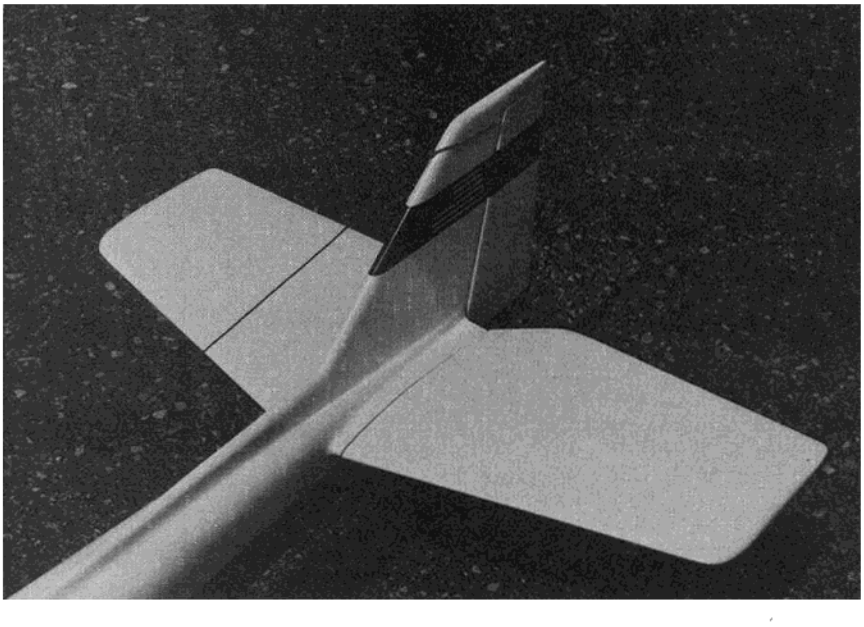
The fuselage has been designed so that it can be assembled on a flat board to insure accuracy. Begin by assembling two fuselage sides. Glue all the bracing, doublers and triplers to the sides, using the formers to help locate them. Leave the belly pan sides attached to the main fuselage sides since the belly pan will be cut away after the final shaping of the fuselage. The completed fuselage sides, formers and fuel compartment floor are now joined, inverted on a flat building board to insure good alignment. Do not include F-2A and F-3B in the assembly. Sheet the fuselage bottom and remove the building board.

The flying stab center section is now installed. Determine which horn hole gives a trailing edge movement of about ±1/2" when attached to a medium length arm on your servo. This will allow for some fine tuning at the servo without having to cut into the tail of your airplane. The elevator movement is sized by the stall-spin requirement and varies slightly from aircraft to aircraft. Once the correct hole is determined, attach the pushrod and glue the stab center section in place with the pushrod located in the fuselage. It's a good idea to solder the control horn clevis to the pushrod end to keep it from unscrewing during the remaining construction. Complete the fuselage by gluing the top formers (F-2B, F-3A, and F-5) in place, the 5/16" top sheeting strips, canopy block, nose block, tail filler block and fin. Shape and hollow where necessary.

Cut the belly pan loose just aft of F-2 and in front of F-3C. Adjust the wing saddle for







.... proper alignment, then tape the wing to the fuselage. With the wing in place, epoxy F-2A and F-3B to the wing, taking care not to epoxy the wing to the fuselage. After installing a hatch in the belly pan floor through which both the retract and aileron servos can be installed and serviced, glue the belly pan to the wing and formers F-2A and F-3B. Cut the necessary access holes for the wing bolts and the assembly is complete.

Add wing and tail fairings using your favorite materials. Keep them light and don't leave them off.

Radio and engine installations are routine with the exception of the inverted aileron and retract servos as I have previously noted. The only difficulty you may encounter in equipment installation is that of a nose wheel steering pushrod because of the high wing and low nose gear. This problem was quite effectively solved by Bob Knoll, in his Yankee article in AAM dated Sept. '74. His system works very well and I recommend it highly.

Generally speaking, the most important, single aspect in the construction of any pattern airplane is correct alignment. The Cobra is no exception. Each flying surface must be free of any warps or irregularities and aligned precisely with the fuselage. The fuselage, itself, must be straight and present a solid, true structure for surface attachment. Don't accept anything less for your airplane or it will never fly with its full potential. Nor, for that matter, will you.

Another important factor to watch is the weight. Both total weight and weight distribution. The prototype Cobra weighs in at 5½ pounds ready-to-fly. With the proper selection of wood, good gluing techniques, and a reasonably light finish, 5½ pounds shouldn't be hard to achieve, but attention must be paid to detail. A light airplane is achieved through hundreds of small weight savings throughout the construction sequence.

Proper weight distribution merely implies that the farther away from the C.G. one gets, the lighter the structure should become. This is particularly true along the span of the wing. Good rolling maneuvers are impossible if the wing tips are too heavy. Mass in a wing tip is hard to start rolling and, once rolling, difficult to stop quickly.

Finish

The original Cobra was covered with silkspan. Dope and baby powder were used to fill the silkspan, followed by one coat of grey automotive primer. The color coats can be any of a number of products, however, Hobbypoxy was used on this airplane. If you use this finishing method, be very sure that the dope is thoroughly dried and sanded before proceeding with any other finishing material. Whatever finish you decide upon — keep it light! Several thin coats are far superior to a few thick ones.

Flying

Because the Cobra was designed to fly much better than I do, help was sought in evaluating its flying qualities. I'm lucky to live in the same community with Don Lowe, and his help was solicited in the flight evaluation. After several shakedown flights and initially setting the control to my satisfaction, I asked Don to put it through its paces. The pleased smile he had on his face while flying the Cobra said it all. The only adjustment he felt necessary was an increase in the elevator throw.

As I've implied earlier in this article, no airplane will make you a better flyer. Only practice can do that. Too many times, would-be pattern flyers will attend a contest, then rush to the nearest hobby shop to buy a kit of the winning design. Hours of practice cannot be packaged along with the balsa in an airplane kit. The most anyone can ask of any design is an honest response to control inputs. The Cobra is just such an airplane. An airplane that will do exactly what you transmit to it. Whether or not the end result is a contest-winning performance is up to you. □

From RCModeler Aug. 1976