THE BIG! APPRENTICE

By BOB BENJAMIN. . .A classic R/C trainer, scaled up and presented for the first time. Structurally redesigned, it's perfect for a .60 four-stroke.

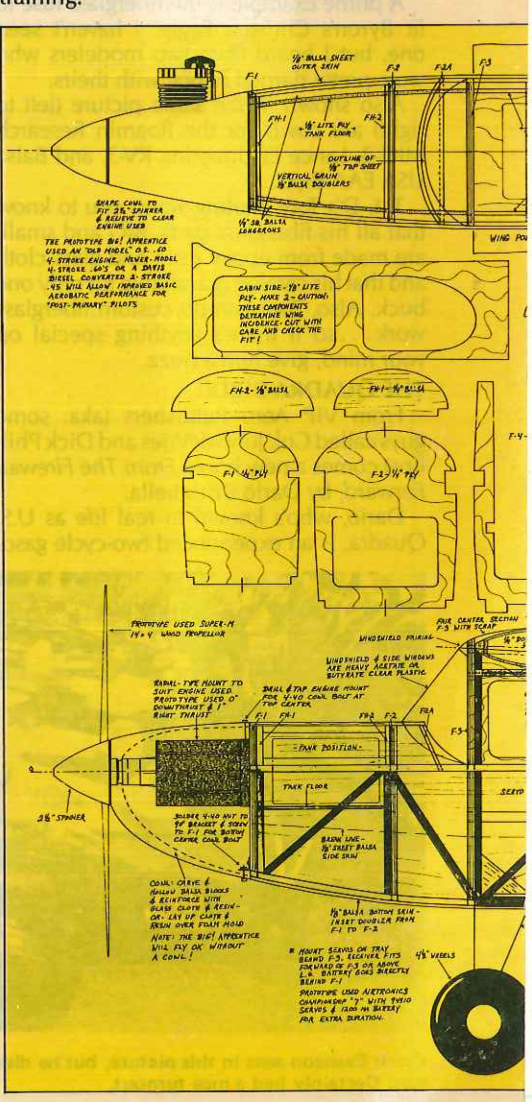
• The Big! Apprentice is an enlarged and structurally redesigned version of the original Apprentice R/C trainer designed by *Model Builder's* publisher, Bill Northrop, in 1967 and published in the May 1968 issue of *Model Airplane News* when Bill was the R/C editor of that magazine. A great many changes have occurred within our hobby since that time, but the need for good primary training airplanes to get newcomers off to a good start has not gone away. With that in mind, Bill re-introduced the Apprentice in the May, 1980 issue of *Model Builder.* The Big! Apprentice represents my effort to respond to current needs with a primary trainer developed in direct response to several recent trends in R/C that had barely begun to appear when the original Apprentice was new. On the assumption that a lot of you reading this are fairly new at the R/C flying game and in response to some controversy that has arisen recently concerning primary training models, I have gone into a lot of detail both on construction of the airplane and on the reasons the Big! Apprentice is the way it is. You experience fliers may disagree with some of what I say, but please keep in mind that what is presented here has been proven to work.

Twenty years ago the R/C hobby was in the midst of a period of transition. No doubt most all of you, from oldtimer to teenage newcomer, know that our current, state-of-the-art R/C equipment traces its lineage back to some pretty shaky beginnings. Although by the late fifties and early sixties the forerunners of today's multiple function, proportional radio systems had appeared, the majority of modelers were using simple equipment so limited in control function as to appear primitive by current standards. By the late sixties, when our hero, the Apprentice, came on the scene, there was a bewildering variety of radios around. Even though the first of the reliable proportional systems (the kind we all use today) were available, they were prohibitively expensive, with the result that most of us made do with older radios. The problem with these old rigs wasn't that they were limited in control as much as that they weren't always very reliable. There were days when making a couple of flights and taking the airplane home in one piece was considered a big deal. To complicate the issue the guys who were able to afford the really slick new radios were putting them in some equally slick pattern and racing airplanes. The natural tendency was for most modelers to want to try one of those hot-dog jobs themselves. It wasn't uncommon for a builder with little R/C experience, a radio of very limited capability and a really demanding airplane to get together for some pretty hairy (and discouraging) flying field sessions.

Enter the Apprentice. Bill recognized that what the modeler getting into R/C needed was a slow, stable airplane that would not only allow him time to sort out his newly developing reactions, but that would also fly calmly through most of the glitches and weird wiggles generated by those old radios. For the lucky ones with sophisticated radios the Apprentice was just as desirable in that it would fly through most of the weird wiggles generated by novice pilots without splattering those expensive new systems.

These days, though a lot of things have changed, we still face some of the old problems. Radio systems have reached a degree of reliability undreamed of a few decades ago and as a result, complex high performance airplanes are being flown well and repeatedly as a matter of routine. Also very much as a result of these new radios being available far more people than ever before are taking up R/C flying. Unlike in the "old days," many of these newcomers are brand new to model building and have had no prior experience at all on which to base judgments before getting that first R/C system and airplane. Taking into account the highly competitive, goal-oriented nature of our American society, it is hardly surprising that many of these newcomers end up with high performance airplanes well suited to just about anything but primary flight training.

The Big! Apprentice framed and ready for covering, with Saito .45 installed. Later, O.S. .60 four-stroke was installed, giving excellent flight performance.



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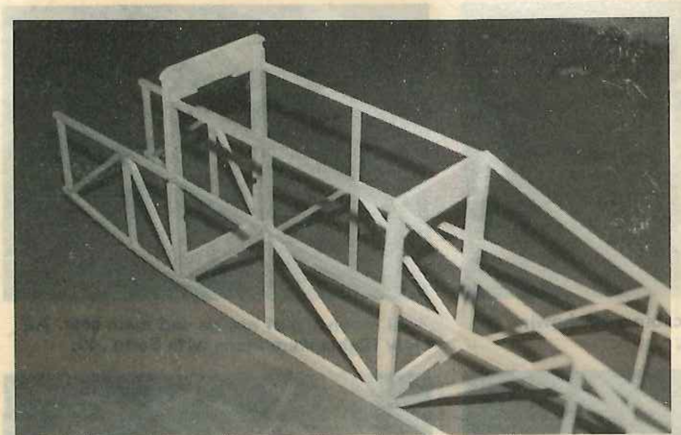
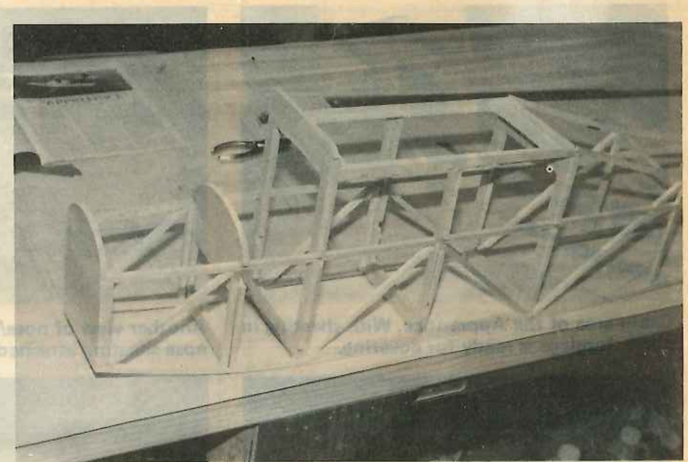


The basic fuselage box, with F-4 not installed; F-3 and F-5 are installed first. See text for details.

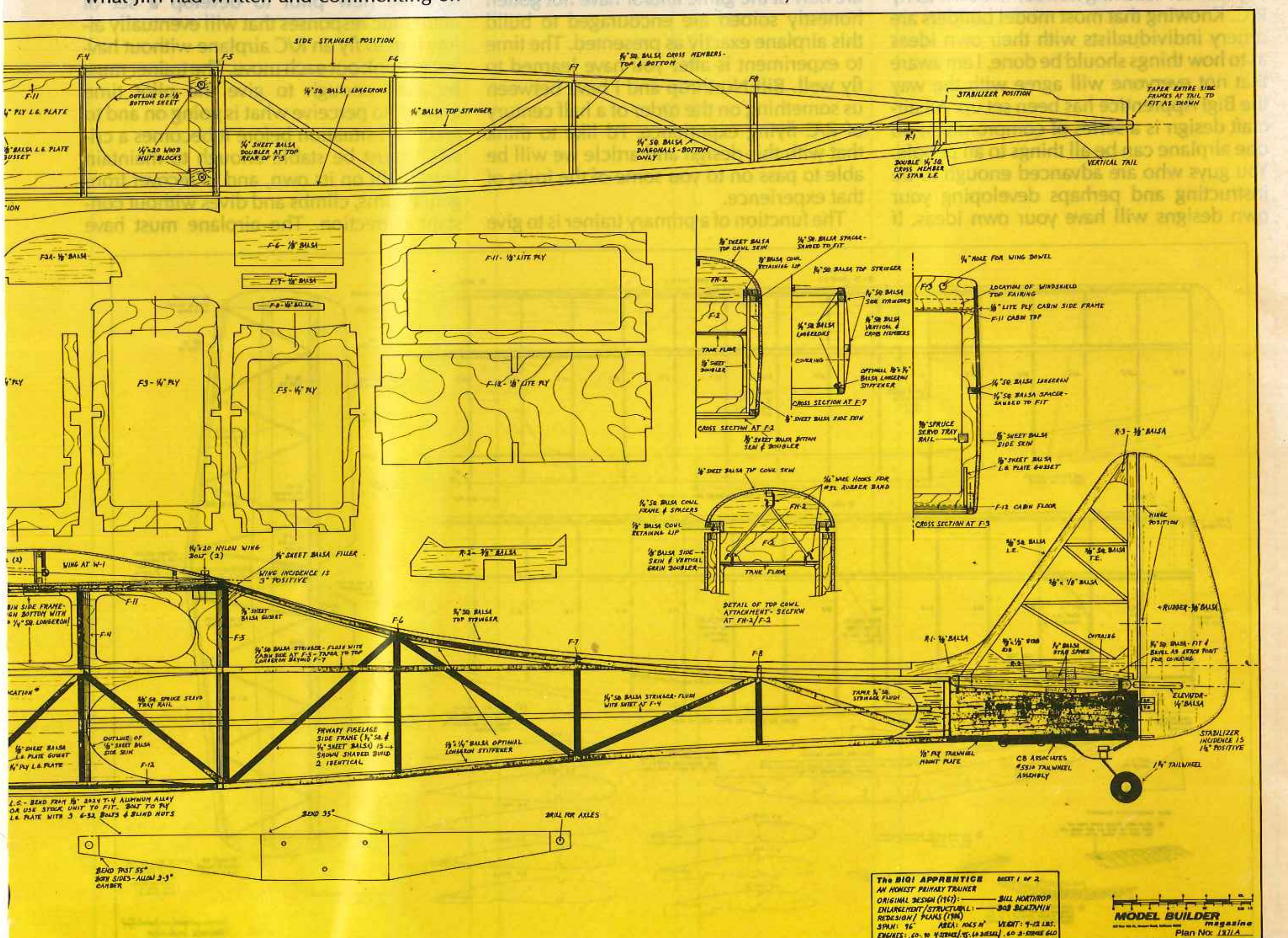


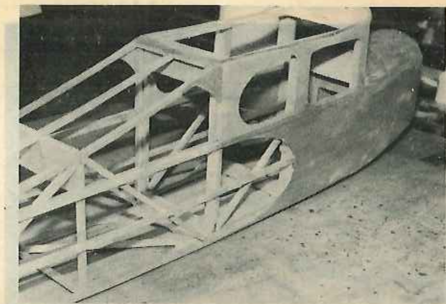
Fuselage with all the basic nose formers, and F-11 and F-12 in place.

With the appearance of the April, 1985 issue of *Model Aviation*, what has come to be referred to as the "Great Trainer Controversy" was initiated when a modeler by the name of Jim Waterman wrote a letter to the editor decrying aggressive advertising by various kit manufacturers touting relatively high performance, fast airplanes as ideal primary trainers. Jim felt that newcomers to R/C flying were being misled and proposed some alternatives to the situation as he perceived it. My own reaction was to fire off a letter to the same editor supporting what Jim had written and commenting on what I have come to call the "macho factor," which I have described as the inclination of most of us to want to be associated with high performance, speed, great challenge and the like. In R/C model airplane flying just learning basic safe flying skills turns out to be much more of a challenge than many people realize. Unfortunately there are always a few insecure characters around who confuse accepting the need to learn to fly on a forgiving trainer with lack of courage and the inability ever to fly anything more demanding. More on this later.

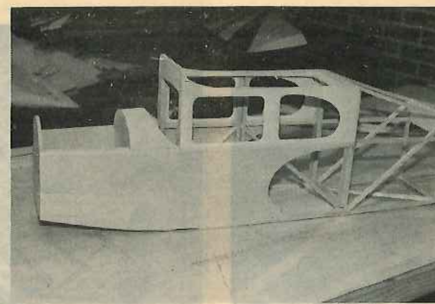
The most concrete result of my involvement with the "Great Trainer Controversy" was the decision to contact Bill and get him to agree that the Apprentice had never gotten the attention it deserved and should do very well revived in an enlarged form, in keeping with all the current interest in big models. The result is the Big! Apprentice, designed around the popular mid-size (.60) four-stroke engines, as well as the less well known Davis Diesel conversions of two stroke glow engines.

NOW LISTEN UP, ALL YOU NEWCOMERS TO R/C, AND ALL YOU GUYS WHO HAVE BEEN TRYING TO LEARN TO

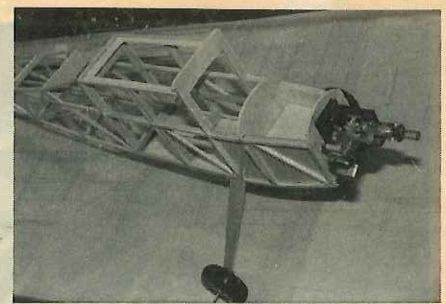




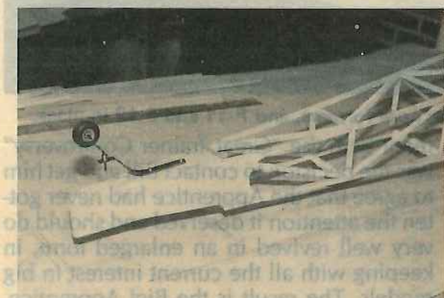
Cabin area of the Apprentice. With sheeting in place, fuselage is ready for covering.



Another view of nose/cabin area showing the nose sheeting attached.

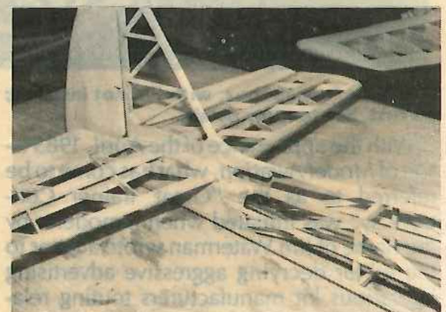


Trial mounting of engine and main gear. All early flights were made with Saito .45.



Tailwheel assembly in place for a trial mounting.

Landing gear mounting with extra ply member at left to take external stores mount, or to be used as rear mount for future float setup.

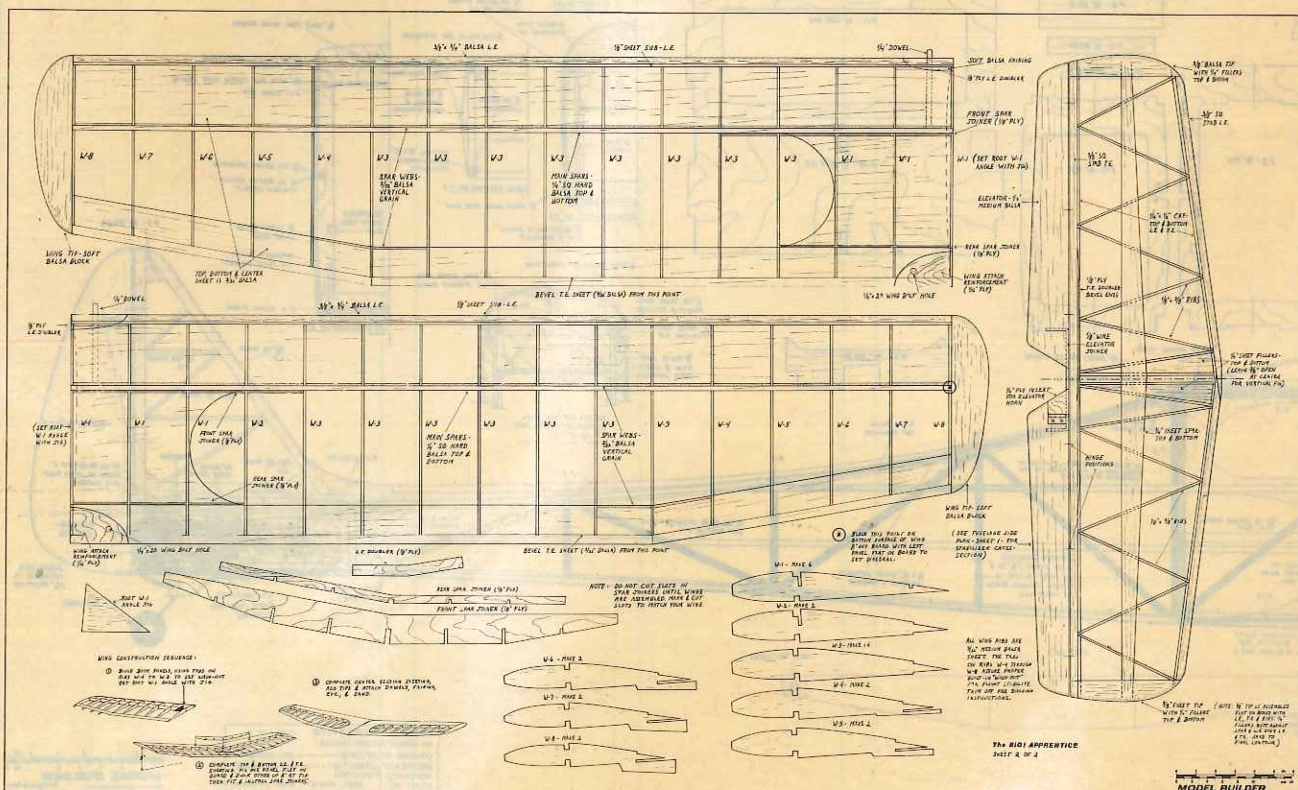


Completed tail assembly, ready for covering.

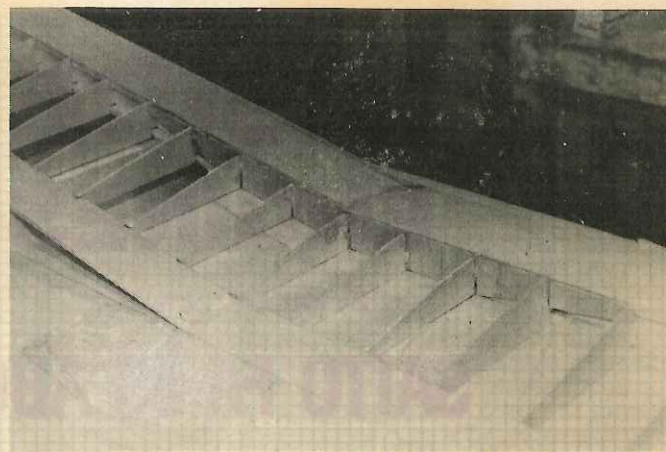
FLY FOR THREE OR FOUR YEARS! PLEASE READ THE FOLLOWING CAREFULLY:

The Big! Apprentice has been developed as our attempt at providing a really good airplane for teaching newcomers how to fly R/C. Knowing that most model builders are ornery individualists with their own ideas as to how things should be done, I am aware that not everyone will agree with the way the Big! Apprentice has been set up. All aircraft design is a series of compromises; no one airplane can be all things to all people. You guys who are advanced enough to be instructing and perhaps developing your own designs will have your own ideas. If you choose to use a Big! Apprentice for training or demo flying, please build it essentially as we have developed it and let us know how you make out. Those of you who are new at the game and/or have not gotten honestly soloed are encouraged to build this airplane exactly as presented. The time to experiment is after you have learned to fly well. Bill Northrop and I have between us something on the order of a half century of R/C flying experience. I'd like to think that with this design and article we will be able to pass on to you some of the fruits of that experience.

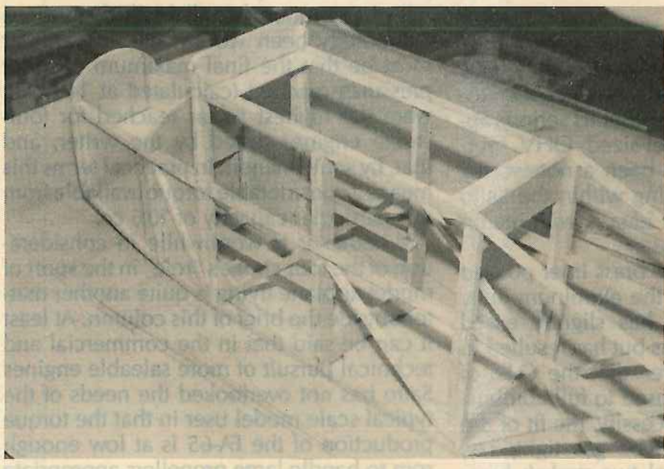
The function of a primary trainer is to give a new pilot the opportunity to learn primary flying skills. One of the prime requisites for this task is the ability of the airplane to fly slowly and stably enough to allow the new pilot to develop a set of automatic responses that will eventually allow him to fly an R/C airplane without having to think out each move. The trainer must be slow enough to give the pilot time enough to perceive what is going on and to react to a situation before it becomes a crisis. It must be stable enough to maintain level flight on its own, and to recover from gentle turns, climbs and dives without constant correction. The airplane must have



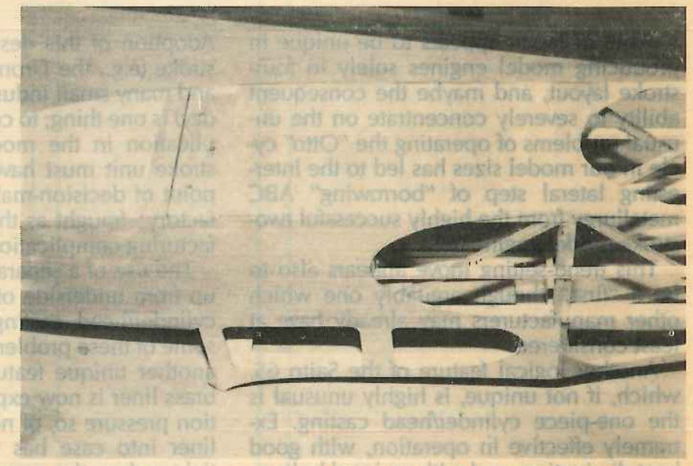
The finished tail surfaces of the Apprentice laid out on plan.



Wing center section with panels joined and spar doublers in place.



Fuselage with vertical grain nose doublers in place.



Underside all fiberglassed and ready for covering.

enough power to take off reliably and climb safely, but must not be so powerful that the new flier is forced to throttle back to avoid losing control. "You can always throttle back to learn" is an oft-repeated justification for overpowering trainers. While it is true that with a good instructor at his side a beginner can indeed cope with extra power, the throttle is usually the last thing he reaches for in a panic situation, often with the result that the airplane gets away and either is taken over by the instructor or crashes.

The next few paragraphs review the logic by which the Big! Apprentice came to be designed the way it is, in our attempt to meet the criteria I have presented. Experience has shown that, all other things being equal, "bigger is better" for trainers. Larger airplanes are easier to see when flown at safe altitudes. When properly set up they tend to fly more slowly in relation to their size than do smaller models, making orientation less of a problem. Larger airplanes are less affected by rough ground, and even more important, much less affected by rough air. Quite specifically, the prototype Big! Apprentice has been flown side-by-side with smaller trainers on windy days when the smaller trainers were bouncing around enough to make their student pilots nervous enough to stop flying. On several occasions those students were put right back in the air on the Big! Apprentice on a dual control ("Buddy Box") radio and immediately commented that the smoothness of the larger airplane allowed them to calm down and stay in control. Keep in mind as you read on that this smoothness has been achieved without sacrificing the forgiving positive stability we want our ideal trainer to have.

"Ailerons or not?" has been the focus of an ongoing controversy for some years. The great majority of full-size airplanes use separate aileron and rudder controls for a maximum of control under varying flight conditions. In the very early days of R/C flying, most models used very limited control

The author with his Big! Apprentice after first test flights.

Flight shot with no trim paint; Saito .45 powering the Apprentice for the first few test flights.

(usually "rudder only") because the radios of the day were so limited. As R/C technology advanced, "Full House" became the goal, with all the basic controls of full scale being duplicated. This arrangement, control of rudder, elevator, throttle, ailerons and some form of ground steering, is nearly universal today, but is not always the ideal set-up. Our friend the "macho factor" tends to creep in and mess things up for the new flier; because it is possible to have aileron control, it can be argued that there must be something wrong with the airplane (or flier) without it . . . not necessarily so! The most obvious need for ailerons is to ensure the ability of the airplane to perform complex precision aerobatics. Aside from the contention that a primary trainer need be capable of only elementary aerobatics, which the Big! Apprentice is, the problem caused by a trainer designed to use ailerons is that for them to work properly the airplane must have a minimum of positive stability in roll. Simply stated, this means that if such an airplane is rolled (turned) out of level flight, it will tend not to roll itself level. This is great for aerobatic flying, and an invitation to disaster for primary training. The most important determining factor as to whether an airplane will have positive stability in roll is wing dihedral. In general, if an airplane has sufficient dihedral it can be made to turn and bank well using only the rudder (no ailerons). Conversely, the dihedral will give it the tendency to roll itself back to level flight without control input from the pilot. It happens that in most cases enough dihedral to make good rudder turns and "hands-off" recovery possible also renders aileron control very sloppy. The Big! Apprentice is designed to have positive stability in roll. Adding ailerons to the existing wing would be a waste of time, as they would work poorly if at all due to the generous dihedral. Redesigning the wing to allow good aileron control would destroy some of the stability characteristics that make the airplane a good trainer in the first place.

In fairness to other designs, and designers, I must mention that it is quite possible to learn to fly R/C on an aileron equipped trainer. Aileron equipped airplanes can be made docile in a number of ways. Our contention is that for the great many beginning R/C fliers who either have no skilled instructor available or who simply insist that "I'll do it myself, thanks," the design philosophy presented with the Big! Apprentice provides the best chance of success.

Several other special features of the Big! Apprentice warrant some explanation. Along with positive stability in roll, a good trainer ought to have the same characteristic in pitch; that is, nose up/nose down motion. In this design the incidence angles of the wing and horizontal stabilizer have been laid out to provide a comfortable margin of automatic recovery from a nose down attitude without making the airplane overly sensitive to speed changes and consequently difficult to fly on windy days. All other things being equal, an airplane with more longitudinal dihedral, or greater positive incidence (leading edge raised) in the wing than in the horizontal tail will tend to recover more rapidly from a dive without control input than will an airplane with less. Conversely, too much longitudinal dihedral will cause an airplane to pitch up or "balloon" with every increase in airspeed such as is caused by recovery from a nose-down turn or by gusty winds, to the point that the airplane becomes difficult to fly smoothly. The problem of ballooning in gusts can be compounded by the flat bottomed or "undercambered" (concave) airfoils usually used on trainers because they tend to fly better at low airspeeds than do the symmetric or semi-symmetric airfoils more commonly used on aerobatic or racing airplanes. Since it is indeed desirable to have an airfoil on a training airplane with good, stable, low speed characteristics, the problem becomes that of eliminating excessive ballooning. In general, flat bottom or concave airfoils usually react more abruptly to changes in airspeed (gusts) than do airfoils which are symmetric or nearly so. One of the reasons that the Big! Apprentice is so stable in rough air is the custom "semi-flat-bottom" airfoil section Bill Northrop cooked up for the original "small" Apprentice. Flat bottomed from the spar back, it incorporates a generous upward curve under the forward portion and combines the gentle low speed stall characteristics and smooth reaction to gusty air that we want. The Big! Apprentice will, by the way, fly inverted with this airfoil when you are ready to begin learning basic aerobatics.

The Big! Apprentice has been designed to use a conventional (tailwheel) landing gear, rather than the nosewheel arrangement used on most other primary trainers. While tailwheel airplanes have gained a reputation for being more difficult than tri-gear types to take off and land, this isn't always necessarily true. Both setups have advantages and drawbacks. Tailwheel setups can be overly prone to nosing over and breaking props, and can be subject to ground looping (uncontrolled swerving, often in full circles). The advantages are that tailwheel installations are lighter, create less drag in the air, are usually easier to install, and put no appreciable load on the rudder servo either in normal operation or in a crash. Nosewheel arrangements are virtually immune to noseovers and, if properly set up, can be very docile on the ground. Their drawbacks are that if incorrectly installed, they can be just as nasty as "taildraggers" to take off. Nosewheel installations are heavier and cause more drag. In anything but a very well executed landing the entire nosewheel assembly, along with the firewall and/or engine mount to which it is attached, takes a terrible beating. Worse, unless very carefully set up, the nosewheel installation can literally wreck the rudder servo used to drive it.

The Big! Apprentice is designed to optimize the good points of the tailwheel arrangement. Noseovers just aren't a problem. The combination of a long tail moment, careful placement of the main landing gear, and toe-in of the main wheels, described in detail later, makes the airplane as easy as a nosewheel model to take off. Along with this, all the problems of tri-gear installation and maintenance have been eliminated.

One other factor was given a lot of thought in the development of the Big! Apprentice. A lot of us are becoming increasingly aware of the noise of our engines as perceived by non-modelers. Four-stroke engines are gaining wide acceptance partly because they nearly always create both less noise and less objectionable noise than do their two-stroke counterparts. They also work extremely well in many applications, one of which is flying large, slow airplanes efficiently. Another excellent choice for this model would be a Davis Diesel conversion of a two-stroke glow engine; these share the advantages of low noise level, surprisingly good fuel economy, and excellent performance on big props that are generally credited only to the four-strokers. Check out the Davis ads and write for more information if you think you'd like to learn more. Whatever engine you use, don't overpower the airplane! Any of the current crop of four-stroke .60s will fly the Big! Apprentice well, as will a Davis Diesel conversion in the .45 range. A good bet for newcomers living at lower elevations is the older model ("open rocker") O.S. .60. Not as hot as the later generations of four-strokers, a lot of these are lying around unused, waiting to be picked up at good prices. I'm using one on the prototype, running on Red Max four-stroke fuel, with excellent results. If you live at a higher elevation where density altitude is a problem, you will need a hotter engine. As a point of interest, the prototype was initially flown on a Saito .45. While that excellent engine did fly the airplane, there just wasn't enough margin for safety and the decision was made to specify a .60 as the optimum power plant. For those of you with more experience who might want to build the Big! Apprentice as a fun flyer or even as a demo ship for airshows, I have no qualms about recommending a four-stroke .80 or .90, or a Davis Dieselized .60. The airframe will handle the power with no problem. A Saito .90 twin installation would be a thing of beauty; if any of you try that, you're under orders to send us a picture care of *MB*!

A word to those of you who honestly do feel uneasy about building a three-control airplane (one without ailerons). Have you been convinced that "rudder" airplanes are somehow not quite with it? Has someone told you that you will "outgrown" a non-aileron trainer immediately and be stuck with a useless model? Are you concerned about the impression you might make showing up at the field with an easy-to-fly primary trainer? Think about this. Which is more impressive: showing up at the field month after month with a "hot dog" airplane you can't fly without help, or which you are constantly crashing, or showing up with a good trainer which, after a few weekends, you can confidently take off and land at will and take home in one piece? Anyone who would actually deride you for building a good trainer is no real friend, anyway. As for the "outgrowing," don't worry! I personally have a number of fast, flashy fully aerobatic airplanes which I very much enjoy flying. Being able to handle these ships well doesn't mean that I don't enjoy the prototype Big! Apprentice. There are times when it is the only ship I bring out, just to enjoy a leisurely hour or so of cruising around, shooting touch-and-goes, and doing a few big lazy loops and hammerheads after a full work day.

LET'S GET ON WITH THE CONSTRUCTION

The Big! Apprentice takes a little more building than some of the other trainers currently available either as kits or in plan form. The slight extra complexity is more than justified by the extreme toughness of the airplane. There is enough redundancy in the structure to allow you to tip the model over, or smash through a bush short of the runway, and go right on flying. If you have done any "traditional" built up construction before, you should have no trouble with the Big! Apprentice. If you are brand new to model building, or if this will be your first plans-built model, enlist the aid of a more experienced modeler whose judgment in building and flying you trust and have him check your work as you progress. I'm assuming that a lot of you building this airplane will indeed be a little short on experience, so a lot of steps and techniques that would be automatic for an old timer will be laid out for you in detail.

BEFORE BUILDING

A rigid, accurate building surface is essential. If you don't already have a good building board, you can make a good start by using a "B" grade (blemished) door from your local builders' supply. While you're there, get a sheet of Celotex or similar soft composition board to match the door. The door provides an accurate, FLAT surface; the Celotex, which is laid over it, provides a soft surface into which you can stick pins. Make sure you have enough room to work. The 96-inch wing on this airplane gets very big once you get both panels joined and is very easy to damage running into things when you have to move it around. You'll need the usual modeling hand tools; pliers, screwdrivers, and wrenches to fit your hardware, a supply of fresh razor or Uber Skiver blades, and plenty of good quality aluminum oxide paper (not ordinary flint or garnet "sandpaper"). Access to a good miniature jigsaw, such as the Sears or Dremel, will be a great help in cutting the various plywood parts. You'll need some kind of a drill; a hand held 1/4-inch electric job will work fine. If you're serious about this model airplane business you might want to check out the imported miniature drill presses showing up for under $100. I bought one recently and am well pleased with it.

Examine the bill of materials at the end of the article and arrange to have as much of the stuff you will need as possible on hand when you start work. You won't need the radio at first, but having all the other hardware, including the engine and mount, will save a lot of backtracking.

I used the several grades of Hot Stuff cyanoacrylate adhesive exclusively in construction of the prototype Big! Apprentice and recommend it without reservation. Please forget any old wives' tales you may have heard about cyanoacrylate adhesives' not being strong enough for heavy structure. It just ain't so! If you aren't comfortable with the super glues, an aliphatic resin glue such as Titebond will work well, but at the expense of having to allow for drying time.

Cover your plans with some sort of clear plastic material to prevent their becoming a part of your airplane. Clear plastic wrap works well for me, although a tendency to stick to glued joints bothers some people. Clear MonoKote backing, if you have access to some, has been reported to work very well. Don't use waxed paper, as the wax is dissolved by some adhesives and can weaken joints.

BUILDING THE WING

Begin construction by cutting all the wing ribs from 3/32 sheet balsa. Assuming you had a good variety of wood to choose from when you bought material, you will want to select for the ribs the stiffest ("B" or "C" grain) wood with the speckled appearance for the ribs. Save the lighter colored, more flexible ("A" grain) wood for the wing sheeting. As so many of the ribs are different, the best way to make them is simply to trace them out and cut them individually. To avoid cutting up your plans, I'd suggest that you trace through the rib patterns onto light card stock using carbon paper. Cut out the card stock patterns and trace onto your wood using a fine ballpoint pen. If you cut on the resulting line, your ribs will be slightly oversize. Stack all the ribs together in sets by number (all W-3s together, etc.) using short lengths of 1/4 sq. spar stock in the spar notches to align them, and take advantage of the oversize cut you made by block sanding all the sets lightly so that all ribs of a given number match.

Extend the lines marking the center ribs ahead of and behind the leading and trailing edges, where the center section sheet structure will cover up the rib locations on the plan. You can build both panels simultaneously, or one at a time as you wish. Cut the lower trailing edge (T.E.) sheet pieces for the inboard panels (from the root W-1 to the outer W-3) from the lighter 3/32 sheet balsa you set aside for sheeting, and pin them in place on the plan. Cut and fit the bottom center section sheet from the back edge of the 1/4 sq. spar to the T.E. and glue it in place. Pin the 1/4 sq. balsa lower spar in position over the plan, shimming it up off the surface with scraps of 3/32 sheet. The lower leading edge sheet will later fit into this gap you are providing. Fit all ribs W-1 through W-3 in place, excluding the last W-3 which forms the junction between the inboard and the outer (tapered) panel. Glue all the ribs in place, using the root W-1 angle jig made from the pattern provided to set the root W-1 at an angle with the top edge leaning toward the tip. Set all the other ribs at 90 degrees to the board using a square to align them.

Cut the outer panel lower T.E. sheets to size from 3/32 balsa. Assemble and glue ribs W-4 through W-8 to the lower 1/4 sq. spar, aligning as you did the inner ribs. Notice that the alignment tabs built into these ribs will raise the trailing edge of each progressively higher from W-4 to W-8. This automatically builds a twist called "washout" into the wing which will prevent stalling of the wingtip at very low airspeeds, and is in part responsible for the docile handling characteristics of this airplane. These tabs will be trimmed off flush with the bottom sheet after the wing is complete.

Fit the outer panel lower T.E. sheet into place in the slots in the outer ribs. The sheet would fit snugly against the inner panel T.E. which is flat on the building board and twist smoothly upward from that joint to W-8. Trim as needed to get a good fit; when it's right, glue the sheet in place. Now glue the last W-3 in place, square to the board. Fit and glue the upper 1/4 sq. spar. Cut the sub leading edge (L.E.) from 1/8 sheet balsa, allowing enough material so that you will be able to block sand the edges to follow the tip and bottom curvature of the ribs as viewed from the side. This will allow the top and bottom L.E. sheeting to fit flush against the sub L.E. when it is added. Glue the sub L.E. in place, making sure that it is aligned correctly. Once the adhesive has set, bevel the top and bottom edge as just described. Now cut and glue in place the 3/32 sheet balsa vertical grain spar webbing between all the ribs and against the front edges of the top and bottom 1/4 sq. spars. Don't let the spar webs project beyond the outer edges of the spars, or it will interfere with the L.E. sheet to be added later. Take your time and make the spar webbing fit. A lot of the strength designed into this wing depends upon accuracy in this part of the wing assembly. Make sure you cut the pieces so that the grain of the wood is vertical; that is, at right angles to the spars.

Cut, fit and glue the upper 3/32 T.E. sheet to both the inner and outer panels, then add the vertical grain webbing against the front of the T.E. sheet between the two outer W-3s and out to W-4. Do not add the top center section sheeting forward of the T.E. yet. Fit and glue the top L.E. sheet in place. If you do not have 48-inch sheet stock, you can make a butt splice in the sheet centered over any one of the ribs. The sheet should fit over the 1/4 sq. top spar, butting solidly against the lip on each rib, and extend slightly forward of the sub L.E. Make sure that the L.E. sheet fits securely against all the ribs, the spar, and the sub L.E. True up the structure with your sanding block as necessary to get a good fit. Don't be afraid to take off a little wood here and there if necessary.

Remove the wing panels from the plan and turn them over. Block the left panel in place upside down and level over the right plan and vice versa, and pin each panel in place so that it rests securely on the building board where the top L.E. sheet attaches to the top spar. It is important that the wing panels lie flat at this stage; be certain that you do not allow them to develop any kind of twist, other than that which is built into the outer panel by the tabs on ribs W-4 through W-8. Double check that the lower edge of the sub L.E. has been sanded to the correct contour, then fit and glue the lower 3/32 L.E. sheet just as you did the upper. Sand the front surface of the sub L.E. and the edges of the top and bottom sheets flush and add the 3/8 x 3/4 L.E.

Remove the panels from the board and turn them right side up again. If necessary block sand the lower surfaces smooth so that both panels rest flat on the board. Block sand each root smooth, blending the root W-1 rib and all the various sheet and the L.E. together. Trim away 1/8 inch at the front of each root W-1 where it meets the sub L.E., then slip the 1/8-inch ply L.E. doubler in place in each panel in turn to check that it fits correctly. To join the wing panels, pin either one flat on the building board. The opposite panel will be joined to it at the root and blocked up at the tip, and so must be entirely over the building board in order to be measured. If your board is not long enough, you can let part of the panel which is to lie flat hang out over one end, making sure that it is fastened down securely. Fit and block in place the panel which is to be raised off the board. The bottom surface of the lower 1/4 sq. spar at rib W-8 must be 8 inches off the surface of the building board. Sand the root ribs W-1 as necessary to get them to fit together snugly. Cut the front and rear spar doublers from 1/8-inch aircraft plywood (not Lite Ply!). Mark the locations for the rib cutouts, but do not make the cuts until you have checked the marks against the actual rib locations on your wing. This way you can adjust for the minor inaccuracies that creep into the best of building jobs and fit the spar doublers precisely. Make the rib slot cutouts, then fit both spar doublers precisely. Make the rib slot cutouts, then fit both spar doublers in place without glue and check that both panels fit squarely together with one panel flat on the board and the other raised exactly 8 inches (10 degrees) at the tip. Trim or sand as necessary to get a good fit, making sure that one panel does not sweep forward or backward as viewed from above. Check the alignment along both the L.E. and the spar with a long straightedge to make certain you are not building in any sweep. When everything fits and lines up correctly, remove the spar doublers and using a slow setting adhesive such as Special T or Titebond, glue the panels together at W-1, slipping the 1/8-inch ply L.E. doubler in place against the back side of the sub L.E. as you assemble both panels. Re-insert and glue the spar doublers, then double check all alignments, making certain that you have the correct dihedral angle, that there is no sweep forward or back, and that the bottom edges of the center section sheeting at both W-1 ribs are securely against the building board. When everything is right, give the entire assembly a good spray of Hot Shot accelerator if you are using Hot Stuff. If you are using Titebond or a similar glue, go away and leave the entire assembly undisturbed overnight.

When all the adhesives in the center section dihedral joints have set, add the remaining top 3/32 sheet. Remove the wing from the board. Trim off all the tabs on the outer panel ribs so that the bottom edge of each rib is a straight line from the T.E. to the spar. Block sand the outer faces of ribs W-8 smooth. Rough carve two wingtips from the lightest balsa blocks you can find, glue the rough shaped tips in place, and then block sand them to final shape. Continue sanding the entire wing, blending all sheet edges together. Shape the L.E. to the cross section shown on the fuselage side drawing and be certain that the T.E. sheets meet in an edge about 1/8-inch thick. Round this edge; do not try to sand it sharp. Add the 1/16-inch ply reinforcement at the top rear of the center section where the wing tiedown bolts will rest. Fill any cracks or low spots with scrap wood glued in place and sand smooth. When the entire wing is correctly contoured, sand the entire surface satin smooth with extra fine production paper. When contouring the wing, do not hold back on sanding for fear of taking off too much wood; if you pay attention to what you are doing that will not happen. By far the most common error among new builders is failing to take off enough material when finished sanding.

The horizontal tail structure follows the design of the original "small" Apprentice almost exactly. In those days the "diamond" airfoil was quite popular for lots of applications, among them C/L combat wings and R/C tails. We tried it and found that it works as well on the Big! Apprentice as it did on the earlier version. Start building the thing by laying out on the plan the 3/8 sq. balsa L.E. and T.E. Pick medium weight, relatively stiff wood for these pieces. Very soft wood won't do, as the tail depends on the edges for a lot of strength, but watch the weight, which can make a big difference this far back on a long-tailed airplane. Carefully strip out an appropriate amount of 3/8-inch wide stock from a sheet of 3/32 medium weight balsa; from this cut, fit and glue the "ribs" between the L.E. and T.E. Notice that most of the ends will need to be cut at an angle to fit properly; make these cuts as accurately as possible. Cut the tips from soft 3/8-inch sheet balsa, noting that the tip extends back to and butts against the 3/8 sq. T.E., but that the L.E. stops short of and butts against the inside of the tip. Cut and taper the 1/8 ply T.E. center doubler, then trim away the 3/8 x 1/8 ribs where necessary and glue the doubler in place.

When the adhesive you are using has set, block sand the upper surface so that the edges of all the parts meet flush. Cut the tapered top and bottom spars (both are identical) from medium to light 1/4 sheet balsa and glue the top spar in place over the ribs and tip pieces. Notice that the spar extends all the way to the outside edge of the tip. Add the L.E. and T.E. caps, which are 1/16 x 1/2 sheet balsa, glued flush with the outside edges of the stab so that the inside edges project in 1/16 inch and cover the joints between the L.E. and T.E. and the ribs. Cut pieces of light 1/4 sheet balsa with the grain running spanwise to cover the center section. The center sheet rests on top of the ribs and butts against the 1/4-inch spar and the 1/16-inch edge caps. This looks strange, but the sheet will later be sanded to a smoothly faired section. Fill in the tips with 1/4 sheet in the same way; the filler pieces completely cover the portions of the 3/8 sheet tip not covered by the spar and the 1/16 sheet caps. Note: when sheeting the center section, don't forget to leave the 3/8-inch wide area between the two center ribs open to receive the vertical tail base R-2 during later assembly.

Remove the stab assembly from the board, turn it over, sand the entire lower surface true and repeat all the steps you just completed on the upper surface. The stab is symmetrical; the top and bottom surfaces are identical. When all the adhesive has set, use your sanding block and first true up the outline, using the plan as a guide, then taper the 1/4 sheet at the tips and center to blend smoothly from the spar into the outer surfaces of the L.E. and T.E. caps. Look at the stab cross section on the fuselage side view drawing to see what it should look like. When this is done, round the entire L.E. and T.E., round all corners, and taper the outer edges of the main spars toward the L.E. and T.E. so that the covering will lie smooth and not show two abrupt ridges at the edges of the spars. Note that the covering will not touch any of the ribs, but bridges the areas from the edges of the spars to the L.E. and T.E. Sand the entire stab smooth with fine production paper. Cut the elevator halves from medium weight 1/4-inch sheet balsa. Inset a piece of 1/8-inch plywood in the area shown to serve as a strong mounting base for the elevator horn. (Insetting means that you carefully cut away balsa to a depth equal to the thickness of the ply and glue the plywood in place with its surface flush with that of the balsa.) It doesn't really matter which side of the airplane the elevator horn goes on, as long as it is opposite the rudder horn to prevent possible jamming. It will, however, have to be on the bottom. Think out your control installation before you inset the ply. Bend an elevator joiner from 1/8-inch music wire and drill a hole in each elevator half and recess a slot in the inboard end of each leading edge so that the wire is inset completely into the elevator. Doublecheck with the elevator halves over the plan that the joiner wire fits correctly with both elevator pieces in the correct relation to each other, then glue the joiner wire in place. When the adhesive has set, remove the elevator from the board and block sand all edges around, then sand the entire elevator smooth with fine grit paper.

Build the vertical tail by laying out the 3/8 sq. L.E. and T.E., using the same criteria for wood as you did for the stabilizer. Cut R-1, R-2 and R-3 from 3/8 sheet balsa. Use the separate pattern on the center of the plan for R-2, noting that it will extend down through the center of the stabilizer during assembly. Fit and glue R-1, R-2 and R-3 and add the 3/8 x 1/8 balsa ribs. Remove the assembly from the board, block sand it smooth, then round all edges except at the bottom of R-2 and at the front of R-1 where the fuselage top stringer will later blend in. Cut the rudder from 3/8 sheet balsa and inset a piece of 1/8 ply for the rudder horn just as you did with the elevator. Round all edges and sand smooth as with the rest of the tail surfaces.

BUILDING THE FUSELAGE

The fuselage is built in the "traditional" manner, which is based on two identical side frames built over the plan, then removed and joined with the various formers and cross members. The side frames are built entirely of 1/4-inch sq. balsa and 1/4-inch sheet balsa. The 1/4 sq. stock in this case should be the hardest you can find. You can if you prefer substitute spruce for balsa for the longerons. Even using 48-inch stock, it will be necessary to splice the lower longeron. Splice the material at an angle, with the joint at least 1 inch long and locate the splice next to the 1/4 sq. lower longeron doubler between F-3 and F-5. Cut and fit all the 1/4 sq. side frame pieces using the shaded portion of the fuselage side drawing as a guide. The shaded areas exactly match the structure to be built. Cut, fit and glue the 1/4 sheet filler pieces at the tail, using lightweight wood. When the adhesive has set, remove all pins and block sand the upper surface of the side frame completely smooth, then cover it with an extra piece of whatever material you are using to protect the plans. Re-attach the side frame to the plan, lining it up carefully, and build the second side directly over it, making an exact duplicate. When the adhesive has set, remove both sides from the plan and block sand both sides of each perfectly flat.

Cut all F- parts from the stock indicated on the templates. A small jigsaw will do the best job on the plywood parts. If you don't have one, taking the time to visit a friend who has will be easier in the end than trying to hog them out by hand with a coping saw. There are several things to be aware of when cutting the fuselage parts. Cut as accurately as you can, as proper fuselage alignment depends in part on a good cutting job. Don't be afraid to open up a notch during assembly if necessary to fit a longeron; not all stock is cut exactly as specified and your cutting, like mine, may not always be perfect. Work at it and make it fit right! Because of inaccuracies which may creep in, I'd suggest that you cut F-11 and F-12 1/32 inch oversize and be prepared to sand them to an accurate fit during assembly. A pattern has not been provided for the tank floor; as there can be so much variation in dimension by this point in assmbly, it is easier for you to make your own pattern from card stock when you are ready for it. The cutouts in formers F-2 through F-5 are made oversize where the 1/4 sq. diagonals fit. If you want to cut the slots undersize and hand fit them it's OK, but not necessary.

Pin the fuselage side frames vertically in position over the fuselage top view. Note that the top view does not show as much information as the side view; it is provided in large part to serve as an alignment guide for the assembly you are doing now. Assemble formers F-3, F-4 and F-5 in position, double checking that they are square with the side frames and that the side frames are perpendicular to the board. Note that the side frames are parallel to each other between F-3 and F-5. Glue all joints between the side frames and these three formers, checking again that all joints are square. Check from above, from both sides, and from the front and rear. Work at it and get it right! As soon as the adhesive has set, remove the assembly from the board, fit and glue F-12 at the bottom of the cabin area, replace the fuselage on the plan, and add F-11 at the top. These parts will help hold the basic assembly square while you complete the rest of the fuselage. PAY ATTENTION to alignment at this stage. A twisted fuselage, or a wing or tail attachment that is out of line, will leave you with an airplane that can never be adjusted for consistent flight performance.

Keeping the fuselage assembly pinned squarely to the top view plan, draw the sides together at the front end and assemble and glue F-2 in place, being certain that it is tightly in position against the 1/4 sq. uprights of the side frames and exactly perpendicular to the centerline on the plan. Follow F-2 with F-1, again being uncompromising with alignment. F-1 is perpendicular to the centerline as seen from above and to the board as seen from the side. There are not built-in thrust offsets. Add the bottom 1/4 sq. balsa crossmembers and the top formers F-7 through F-9, working from F-7 back toward the tail. Keep the side frames aligned over the plan. Bevel the inside of the side frames at the tail before adding the last few sets of crossmembers. I find it is easier to do this with the sides partially assembled, making it simpler to see just how much wood must be removed. When the side frames fit correctly with a tailpost joing 3/8 inch wide, fit and glue the remainder of the crossmembers and join the sides at the tailpost. Fit and glue the 1/4 sheet balsa filler behind F-5 and between the top longerons. Add the 1/4 sq. balsa diagonal braces on the bottom behind F—5 and the 1/8 ply tailwheel assembly mounting plate between the bottom longerons at the tail. Cut and install the 1/4 ply landing gear (L.G.) plate against the rear of F-3 and between the bottom longerons. Add the 1/4 sq. balsa longeron doublers to the outside edge of the center longerons from F-5 forward to F-1. These must be sanded flush with the outside edges of the formers to allow 1/8 sheet skin to fit smoothly against them as well as against the formers. Add the 1/8 balsa L.G. plate gussets. Make sure the grain of these pieces runs as indicated on the plan. The gussets glue to the back side of F-3, to the top of F-12, and against the inside edges of the 1/4 sq. diagonals. If you choose to add them, cut, fit and glue the 1/8 x 1/4 balsa diagonal reinforcements along the inside edges of the top and bottom longerons behind F-5. If you intend to use a doped fabric covering, you may want to consider fitting these individual lengths of doubler between the formers and uprights to reduce the possibility of extreme shrinkage of the covering causing a slight bow in the longerons.

Fit and glue in place the vertical grain 1/8-inch sheet balsa nose doublers between F-1 and F-2 and between F-2 and F-3. This doubler sheet lies flush with the top of the upper longeron and with the bottom of the lower longeron, and against the inside of the 1/4 sq. diagonals in the side frame. Cut, fit and glue in place a tank compartment floor of 1/8 Lite Ply. This lies parallel to the upper longeron and flush with the top of the cutout in F-2. Add F-2A at the angle indicated on the side view. Cut and install the 3/8 sq. spruce servo tray rails in the cutouts on the inside of F-3 and F-4.

If you are making your own landing gear, cut and bend it to shape now, including a few degrees of camber in the lower portions where the axles are mounted. (Camber means that the wheels, as viewed from the front, will be angled with the tops a bit further from the fuselage than the bottoms.) Also bend in about one degree of toe-in, so that the wheels as viewed from above will have the front edges closer to the fuselage than the rear edges. The camber keeps the wheels riding squarely while bearing the full weight of the airplane, and the toe-in helps reduce the tendency of the airplane to swing to one side, or ground loop, during takeoff and landing. If you are using an off-the-shelf landing gear, I suggest that you modify it with the adjustments just described. Mark and drill the center section of your gear for three 6-32 volts, then transfer these marks to the L.G. mounting plate, being certain that the gear is absolutely square on the fuselage. Drill the L.G. mounting plate, countersink the inside surface to accept blind mounting nuts, and bolt the gear in place to seat the blind nuts.

If necessary, mark, drill, and tap holes in your engine mount to fit the engine you are using. Adjust the position of the engine on the mount to insure that the location of the propeller matches the position shown on the plan as closely as possible. Some combinations of engine and mount may make matching the exact F-1 to propeller distance impossible; get it as close as you can.

Mark a horizontal centerline across the outside of F-1 by drawing a line connecting the top edges of the top longerons where they project through to the face of the former. Establish and mark a vertical centerline by measuring at this horizontal line and at the bottom of F-1. Check that the vertical line is perpendicular to the horizontal. Now, with the engine removed from the mount (and with all traces of engine oil, which might interfere with subsequent finishing, cleaned off), center the mount on F-1. Most commercial mounts incorporate molded-in centering marks for just this purpose. Mark and drill mounting holes for 6-32 bolts and countersink the back of F-1 for blind nuts. If you are using a four-stroke engine in the .60 to .65 range, a diesel .45, or a two stroke glow in the same range, I recommend that you incorporate one degree of right thrust offset, as viewed from above. This will prevent a swing to the left as you open the throttle to take off, or when going from idle to high power in the air. The best device to build in your offset is a prepared shim, available in various degrees of offset at better hobby shops. Alternatively you can make a shim by feathering a sheet of plywood of the appropriate thickness (about 3/64 inch, or by using a pair of washers under the two left mounting bolts. If you are using a larger engine I assume that you have some experience and know what you are doing; I'd suggest a little more side thrust. Do not build any downthrust in for engines in the recommended size range. The angular arrangement of the wing and stab builds in an "implied" downthrust of one-and one-half degrees, and this has proven to be ideal on the prototype. Screw the mount to F-1 to seat the blind nuts and leave it there for now.

Fit FH-1 and FH-2 in place, cutting out the center of FH-1 as necessary to clear the blind nuts on the inside of F-1. Build up the cowl starting with three 1/4 sq. balsa spacers at the top center and at each edge, then add additional 1/4 sq. spacers inside the two lower pieces. Trim these flush with the inside edge of the 1/8 sheet vertical grain nose doubler. Add a piece of 1/8 sheet balsa on the inside edge of each spacer so that each fit snugly against the nose doubler and serves as a lip to keep the cowl from sliding from side to side. Make sure these 1/8 sheet parts are glued only to the cowl and not the the nose itself! Now remove and set aside the cowl, engine mount and landing gear.

Install the 1/8 lite ply cabin sides. Be absolutely certain that both cabin sides match each other. Double check against the plan to see that when the bottom edge of the cabin side is aligned with the top edge of the center longeron, the top (curved) edge matches the curve shown on the plan. These pieces determine the angle of incidence of the wing, which is one of the most important measurements in the entire airplane. Make sure you get it right! Glue the cabin sides in place, checking again that the bottom edges match the top edges of the longerons, and that the front edge of each side is flush with the front surface of F-3. The top edge of each cabin side should fit against the lip at the top of F-3; trim this area to fit if necessary. Check the fuselage side drawing and the cross section drawing of F-3 to clarify the way the cabin sides fit.

Add the 1/8 balsa fuselage side sheet, fitting the top edge of the sheet flush with the top of the center longeron ahead of F-3, flush against the bottom edge of the cabin sides, and flush with the front of F-1. Trim the curve in the rear of the cabin area to match the plan. A break line is shown midway between the longerons; use separate pieces of sheet joined at this line to match the break in the contour of the formers. Inset a piece of 1/8 sheet balsa with the grain running across the fuselage between F-1 and F-2 to reinforce the area where the battery will be installed. This should lie flush with the outside of the lower longerons. Now block sand the bottom of the fuselage smooth, removing all bumps and projections, and cover the bottom with 1/8 sheet balsa, cross grain, all the way to the rear of the cabin area. Leave an area equal to the width of your landing gear unsheeted over the ply L.G. mounting plate, and cut the rear edge of the bottom sheet to match the curve shown on the fuselage top view drawing. Slip the top cowl back in place and cover the cowl framework with 1/8 sheet balsa, fitting the rear edge of the sheet as closely as possible to the rear edge of FH-2. Note that the sheet extends forward over the top of F-1 and lies flush with the face of that former. Remove the cowl and complete the outer fuselage sheeting by adding the 1/8 balsa sheet between F-2 and F-2A, trimming the rear edge to match the curve shown on the drawings. Add the 1/8 sheet balsa gussets at the top rear of F-5, being sure to align the grain as shown.

Add the 1/4 sq. balsa stringer over the center longeron from the rear edge of the side sheeting at F-5 to a point just aft of F-7 where the center longeron and the curved upper longeron meet. This stringer is sanded flush with the cabin side sheet and tapered flush with the top longeron behind F-7. The center 1/4 sq. balsa side stringer meets the side sheeting flush at F-4 and is tapered to blend into the 1/4-inch tail filler piece at the stabilizer L.E.

Using the scrap 1/4-inch balsa sheet, cut, fit and glue doublers inside the cabin sides above F-11. These should fit tightly against F-11, F-3, F-5 and the cabin sides, and be sanded to match the top contour of the cabin sides. They will provide a surface against which the wing will be mounted.

Make up the tailwheel assembly you are going to use and set it in position on the tailwheel assembly mounting plate with the fuselage resting upside down. Mark and drill holes for the mounting screws and screw the tailwheel assembly in place. If blind nuts are provided, this will seat them in place; if not, fix the nuts you have using Special T and accelerator, or epoxy glue, then remove the tailwheel assembly.

Double check that the top edges of the tail filler pieces that form the mounting surface for the horizontal stabilizer are cut at the angle indicated on the plan. This angle is as important as the incidence angle of the wing. Get it right! Trim and sand as necessary to get a snug fit between the stab and the tail fillers, maintaining the correct incidence angle. When you are satisfied that this is correct, pin the stab in place with the fuselage fixed to the plan over the top view drawing and square the stab so that the T.E. is perpendicular to the fuselage centerline. Mark the bottom of the stab center section along the tail fillers on both sides so you can keep the stab aligned, then sight from the front and rear to align the stab parallel to the work board. When the fit is as good as you can get it, remove the stab, glue it, replace on your alignment marks and double check from all directions.

Fit the vertical tail in place, making sure that the R-2 slips between the center ribs of the stab and seats against the top stab spar, and that the bottom of R-1 rests against the two 1/4 sq. cross members at the stab L.E. Use a square to insure that the vertical tail is perpendicular to the horizontal when viewed from the rear. When the fit is correct, glue the vertical tail in place. Cut and fit fabric attach strips from 1/4 sq. balsa; these rest on the top surface of the stab and lie directly over the longeron, tapering to blend flush with the vertical tail at the T.E. These strips provide a surface to which the covering of the vertical tail and top rear fuselage surface will attach. Now add the 1/4 sq. balsa top stringer, which rests flush with the top of the 1/4 sheet balsa filler behind F-5 and blends into R-1 against the lip provided. You may choose to use spruce for this stringer to resist bowing under the tension of a doped covering.

Now go over the entire fuselage with a sanding block and blend all sheeting edges smoothly together. The nose covering should be slightly rounded over the bottom longeron and blend smoothing into the side stringers and cabin sides. The bottom sheet should be smoothly tapered flush with the bottom longerons as shown in the fuselage side view. Slip the top cowl in place and sand it flush with the fixed top sheeting behind the F-2 and with the side sheeting. Gently round the edges of the top and bottom longerons behind the cabin area. Sand all structure flush with the face of F-1.

Measure and mark a center point on the tops of F-3 and F-5. Measure and mark a corresponding centerline on the top center wing sheet. Measure in from the outer top edge of each W-8 to be sure your mark is actually at the center of the wing. Locate and drill two 1/4-inch holes for the 1/4 x 20 wood nuts for the wing mounting bolts at the rear of F-11; the wood nuts will go on the lower surface of F-11 against the front side of F-5. The exact spacing is not critical, as you will match the hold down bolt holes in the wing to the position of the nuts. Set the wing in place with the fuselage resting securely on the building board and align it as closely as possible on the wing seat formed by the cabin sides and the 1/4 sheet fillers, with the L.E. firmly against F-3. You will probably have to sand the seating surface to get the wing to fit properly. Keep in mind that it is important to maintain the incidence angle built into the cabin side pieces. I would suggest that you get one of the incidence meter devices on the market and use it in accordance with the directions provided. The wing should be set at a positive incidence of three degrees relative to the line established by the top of the center longeron between F-3 and F-5. When the wing is seated at the proper incidence, position the airplane on the work surface so you can sight from the front and establish that each wingtip is an equal distance off the board. Adjust the wing seat without disturbing the incidence until you get it right. Now find a straight piece of wood, or other material that won't stretch, long enough to reach from the top of the vertical tail to either wingtip. Pin one end of it to the top of the vertical tail at the exact center of the T.E. so that it is free to pivot to either side, swing it to one wingtip, and mark it exactly where it meets the intersection of the inboard edge of W-8 and the back edge of the 1/4 sq. top spar. Taking care not to disturb anything else, swing the "measuring stick" to the opposite wing tip and see whether the mark you made lines up with the junction of W-8 and the spar on that side. Adjust until it fits! This process, by the way, is called "trammeling," and can and should be used whenever indicated to align the flying surfaces of any airplane you build. I suspect that you may have to work back and forth a few times to get your wing to fit just right. Take the time to do it. You'd be surprised how many of the airplanes you see at the field have not been correctly aligned using this or a similar method and which as a result will never be well enough adjusted to fly consistently. It's tough enough to try to learn to fly on an airplane that isn't adjusted true and square; when you move on to aerobatics, scale or whatever other higher performance stuff interests you, you're just about wasting your time if you haven't learned the basic techniques of setting up an airplane accurately.

When the wing is seated correctly, mark the bottom sheeting along the top edge of both cabin sides so you can confirm at a glance that the wing is in position, and temporarily pin the wing firmly in position. Thread the wing mounting bolts upward through the wood nuts from inside the cabin until they press against the lower center section sheeting hard enough to make a mark. Remove the wing, drill pilot holes on those marks with a 5/32 drill, and replace the wing to check for accuracy of alignment of the holes. Mark as necessary to correct alignment, remove the wing again, and open up the holes to accept the 1/4 x 20 bolts. Cut two 3/4-inch diameter circles of 1/8 lite ply and drill out the centers so the wing bolts slip through them, then bevel the ply rings so they lie flat on the 1/16 ply reinforcement over the bolt holes and provide a square surface for the wing bolt heads to seat against. Glue these wing bolt seats in place, then bolt the wing separately in place, double checking that the wing has not shifted out of position. Now mark a line on the front of F-3 in line with the front edge of the L.E. as viewed from the side. Measure and mark a point on either side of center corresponding to the location of the wing attachment dowels as shown on the wing plan and drill straight back through F-3 with a 1/4-inch bit, completely through the L.E., sub L.E. and spar webbing. Prepare two lengths of 1/4-inch dowel long enough to slide into the holes all the way back to rest against the front spar doubler and protrude about 1/2 inch from the front of the wing. Fit these in place, gluing generously, then replace the wing on the fuselage by slipping the dowels into the holes in F-3, then screwing the bolts in place at the T.E. Now that the tough part is done, make the windshield top fairing out of soft scrap balsa and glue it in place at the top of F-3, recessing to clear the wing dowels. Sand the fairing to shape, taking into acount the eventual angle at which the windshield will meet as indicated by the fuselage side drawing. Make a fairing from soft balsa scrap for the forward portion of the wing center section; this will be flush with the top of F-3 and fair smoothly back into the top sheet near the top spar. Remove the wing and set it aside; you are finished with it until it is time to cover and paint.

Fit the hinges you are going to use and temporarily install the rudder and elevator on them. I suggest that you use a heavy-duty-type hinge which can be disassembled after installation. This way the hinges can be securely mounted in the structure and pinned if you see fit, and the control surfaces removed to allow a proper job of covering and finishing. Mark the positions of the control horns on the plywood mounting plates inset into the rudder and elevator, making sure both that you get the horns on the correct side of each surface and that you line up the holes in each horn to be exactly in line with the eventual pivot axis of the hinges. Mark and drill holes for the screws supplied with your horns and mount them temporarily. Re-mount the landing gear, tailwheel assembly and engine mount with the engine in place. Temporarily install your battery pack and receiver, packing them in foam just as though this were a final installation. This will both insure that they will fit as planned and also keep them from flopping around and getting hurt while you work. Mount your switch and external charging connection if you have one on the cabin side just below the center longeron, on the side opposite the exhaust. Make a servo tray from 1/8 plywood or, if you can find one to fit, use a commercial tray. Mount three servos in line across the tray, using the instructions and servo mounting hardware that came with your radio. Temporarily slip the tank in place and drill and route all your fuel line connections. Determine the best route for the throttle connection and at the same time decide which servo can best be connected to the rudder and to the elevator. There are so many types of control connections available that I'm not going to describe all the options. Use what the experienced flyers in your area have the best success with and install with care in accordance with the directions provided with the hardware. Connect all controls as though you were about to fly the airplane; all must work freely without any hint of binding. Be absolutely certain that each control can be run to its extreme without causing its servo to stall. Servo stall is the condition where the servo continues to try to run, and can be heard buzzing, when the control surface or throttle has been moved as far as it will go. This is especially critical with the throttle. Although you can't do a final adjustment until it is time to run the engine, be sure that the servo moves the throttle through its entire range of motion; experiment with different combinations of throttle arm and servo output hole positions to get a full range of motion without allowing the throttle to hit the open or idle stop while the servo is still trying to move. All this work is critically necessary, as servo stall while you are flying can run down your airborne battery with frightening speed. I'll make one specific comment on control hardware. On a Big! Apprentice using a four-stroke .60 or equivalent engine, control clevis hardware based on 2-56 threaded rod is fully adequate. Should you be using an engine in the .90 range, I suggest that you go to 4-40 hardware.

To give you some idea, I'll just list some of the options I chose for the prototype Big! Apprentice. As mentioned earlier, my engine is the older model "open rocker" O.S. .60 four-stroke on a filled fiberglass Hayes mount, running exclusively on Red Max four-stroke fuel. The tank is an 8-ounce Sullivan square type. Control connections are Gold-N-Rod to the rudder and elevator and cable-in-tube to the throttle. Cover and finish is 3/4-ounce fiberglass cloth with polyester resin, Sig Koverall attached and sealed with Randolph (full-scale) nitrate clear dope, and K&B Superpoxy final finish. This cover and finish system is what I have been using exclusively for the past several years with excellent results. The radio is one of my several Airtronics Championship 7 systems, which I can recommend unreservedly. I used the heavier model 94510 servos; while you don't need "giant" servos for this airplane because of its low speed range, I do recommend that you use servos with ball bearing output shafts. I used a 1200 ma. battery, not because of heavy current drain, but because the airplane is often used for prolonged training sessions and at "Open House" events, and I need the extra duration.

When all control connections are completed and everything works to your satisfaction, you can make up the engine cowl. I suggest that you do this after the engine installation, including all fuel line and throttle connections, has been completed so that you can make certain the inside of the cowl clears all moving parts. The cowl on the prototype was carved from glued-up soft balsa blocks and faired into the 2-1/2-inch spinner and F-1, with suitable holes to clear the engine, and then hollowed to about 1/4-inch wall thickness overall. It was reinforced with a layer of two-ounce fiberglass cloth and two coats of polyester resin before being given the same finish as the rest of the airplane. If you have had some model building experience in the past, I suggest that you not hesitate to tackle the cowl, as it adds materially to the appearance of the Big! Apprentice. However, if you are new at the game and don't want to take on the carving job, rest assured that the prototype has been flown quite safely with the cowl removed. Other than a bit more drag which resulted in a tendency to slow down faster when the throttle was pulled back, the airplane never knew the difference. At the present there is no fiberglass or plastic cowl available. If any of you guys out there who make custom cowls are listening, you might want to consider adding the Big! Apprentice to your list. Get in touch with Bill Northrop on that one.

With the cowl either made or dismissed, remove all hardware from the airplane, set it aside in a safe place away from sanding dust and paint, and go over the entire airframe again with the sanding block to remove any persistent lumps and bumps, then re-sand by hand with very fine grit paper. Mount your hinges now if you are using a type that will allow you to disassemble the control surfaces for covering. Make a windshield pattern from heavy paper, transfer it to heavy clear plastic, and cut and fit the windshield. I prefer to mount the windshield after covering, but prior to final finishing, and protect it with several layers of masking tape so that the finish can be extended over the outer 1/8 inch or so giving a much more finished appearance to the job. The best adhesive I have found for the job is Super T, put on heavily enough to form a fillet and then shot with Hot Shot accelerator. Any "fogging" from cyanoacrylate fumes can be removed easily by wiping the affected area lightly with a cloth moistened with a light petroleum-based oil (3-in-1 or similar). The fogging will not reappear. On my airplane I added 3/4-ounce fiberglass cloth on the entire fuselage from F-1 to F-5 and on the entire sheeted center section of the wing. This was attached with a single coat of polyester finishing resin; either Sig or K&B works well. The inside of the tank compartment was also given a coat of resin. If the cured resin is block sanded down to the top of the fiberglass cloth weave so that no excess material buildup is left, the weight gain is on the order of several ounces, but the gain in strength is tremendous. You make the choice. I do strongly urge that if you choose not to fiberglass the entire front end, you do add a 4-inch wide strip of glass cloth to the wing center section, top and bottom. I will add at this point that I feel strongly enough about the advantages of fiberglassing in the manner just described that I would not even consider building an airplane without doing it.

There are so many covering and finishing systems on the market today that I can't make a hard and fast recommendation as to which is best for a new builder. You already know what my preferences are. I cannot honestly recommend that you use any of the iron-on plastic film coverings. Although there is sufficient strength built into the structure of the Big! Apprentice, any additional rigidity that would be gained by using a properly shrunk fabric covering is lost when using plastic. Moreover, on other than the lightest of models, plastics don't have nearly the resistance to puncturing of the fabric coverings. I would suggest that the easiest system that will combine the characteristics of durability with rapid application would be to use a synthetic fabric such as Solartex or Coverite with a couple of light coats of nitrate clear dope and a final finish either of epoxy or one of the popular spray can-type paints. I do specifically recommend nitrate clear over butyrate, as it both sticks to synthetic fabric better and provides a much more compatible base for epoxy and enamel-type paints than does butyrate. If you are using a good quality paint for final finish the fact that nitrate is not resistant to glow fuel is of no consequence.

Attach the windshield if you have not done so before finishing, and add the side windows using the same material you used for the windshield. There is adequate gluing area on the inside of the cabin side frames in the window areas to get a strong glue joint using Super T; let a small bead from between the plastic and the outside edge of the side frame and shoot with accelerator. Re-install all of your control linkages, landing gear, tailwheel, engine and tank. Hook up all fuel line connections, remembering to include a fuel filter between the tank and the engine. Put the radio back in the airplane and test to insure that everything works as it should. Install your propeller and spinner if you are using one and bolt the wing in place, using some 1/16 inch thick adhesive-back wing seating tape on the top surfaces of the wing mount area to cushion the wing and prevent vibration. Determine the balance point of the airplane. This is done in ready-to-fly condition, with the tank empty. Check your balance in the shop, on the bench out of the wind, not at the field where you can't get out of the wind and will be tempted to "give it a try, anyway" before you have gotten the balance right. The balance point indicated on the plan is 4-1/4 inches back from the L.E. (33-1/3%) The prototype has been extensively tested with the balance at this point and I can see no reason to deviate from it. Add weight if necessary to either the nose or the tail until the airplane will hang level when suspended on the fuselage bottom or from the wingtips exactly at the location indicated. Add whatever weight is necessary to get the airplane balanced correctly! I know that it can seem difficult to add what appears to be a ton of lead to the nose of a new airplane to get the balance set up right. DO IT! Believe me, trying to fly a new airplane with a rearward balance point (tail heavy), is about the same as sending it out on a kamikaze mission. If you are a new pilot, you're in even worse trouble. Don't even think about trying to fly until that balance is exactly where the plan says it has to be.

The last tasks before flying include a careful checkout for warps in the wing and tail surfaces. Except for the built-in washout in the outer wing panels, you can tolerate no twists in any of the flight surfaces. Remove any you find by twisting the offending surface opposite to the warp over heat and holding it there until cool. It is sometimes necessary to do this several times over a period of a few days to get the surface to stay straight. Before you think about going to the field, give your batteries a full 24-hour charge and if possible, test run your engine to establish that you are getting full top end power and a safe idle. The airplane should not move on a close-cut grass surface at idle. You DID break in your engine according to the manufacturer's instructions before putting it in the airplane, didn't you? make an appointment with your check pilot/instructor and hope for good weather at the flying field. If you are a new pilot, I'm sure you're smart enough not to try to test fly a new airplane by yourself.

Test flying and that old nemesis of beginners, self-taught flight instruction, which is unfortunately sometimes unavoidable, is an involved enough subject to warrant a couple more complete articles. As I'm sure Bill thinks I've used up most of this issue already, I'm going to leave you on your own now.. If interest warrants I'll offer here and now to write something for future issues to help you guys who have no choice but to do your own testing and teach yourselves to fly.

BILL OF MATERIALS

BALSA:	
3/8" x 3/4" x 48" medium	2
1/4" sq. x 48" hard	22
3/8" sq. x 36" medium	3
3/32" x 4" x 36" med/soft	13
1/8"x 3" x 36" med/soft	7
1/16" x 3" x 36" hard	1
3/32" x 4" x 36" hard	6
1/4" x 3" x 36" med/soft	5
3/8" x 3" x 36" medium	1
2" x 2" x 24" soft block	1
5" x 5" x 6" soft block	1
SPRUCE	
1/4" sq. x 48"	6
LITE PLY:	
1/8" x 12" x 24"	1
AIRCRAFT PLY:	
1/8" x 6" x 24"	1
1/4" x 12" x 24"	1
DOWEL:	
1/4" x 36"	1
OTHER:	

.60 four-stroke engine or equivalent with mount and hardware, 8 ounce or larger tank and fuel line, tempered alloy landing gear per spec, 4-1/2" wheels with retainers and axles, CB #5510 tailwheel assembly or equivalent and 1-1/4" wheel, 2 large control horns, 9 heavy hinges, 2-1/4 x 20 wing bolts and wood nuts or equivalent, control connection/pushrods of choice, covering material of choice (4 yards approx.), finishing material of choice, radio system with minimum 3-channel capability. •