*3/4 top front view.*

Ken has gone overboard again. This time with this quarter scale model of Bob Starr's 6'-6" biplane appropriately named "Bumble Bee." Yes --- it did fly!

**By Ken Willard**

*3/4 top rear view of full size Bumble Bee. Note split elevator.*

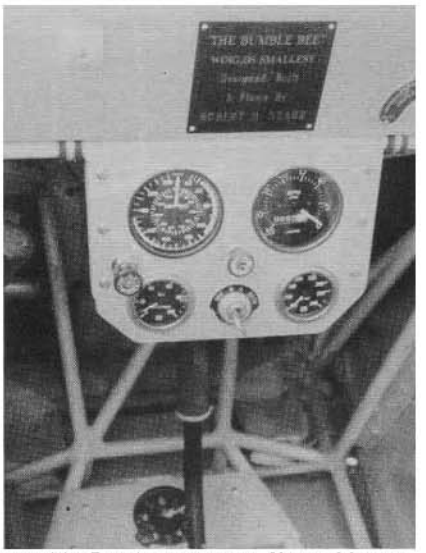
# BUMBLE BEE

*Ken Willard shown holding Quarter Scale alongside full scale.*

The full scale Bumble Bee was designed, built, and flown by Bob Starr. The objective of the design was to attain the title of the world's smallest man-carrying aircraft. That title previously belonged to Ray Stits' "Skybaby" which was flown by Bob Starr in the early 1950s.

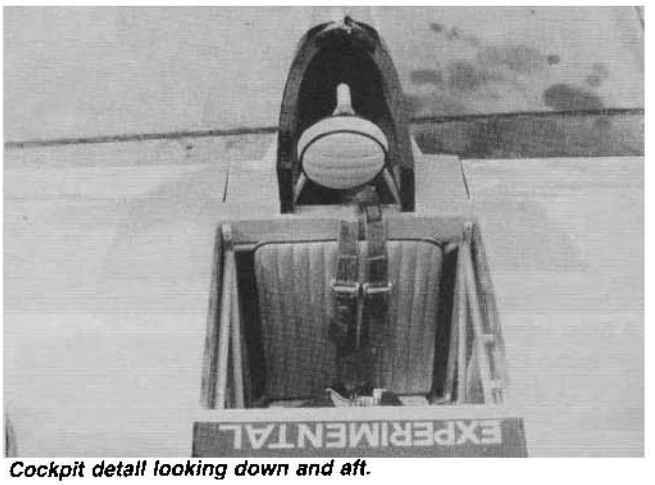
As you regular readers know, I designed and flew a Quarter Scale model of the Skybaby, after over two years of frustrating failures, and the design was published in the June 1986 issue of RCM. It was during the early flight tests of the Skybaby that I heard of the Bumble Bee's successful flights,

*Bob Starr and Ken Willard look over the Bumble Bee.*



*Bumble Bee instruments. Note altimeter on floor pad.*


*Cockpit detail looking down and forward.*



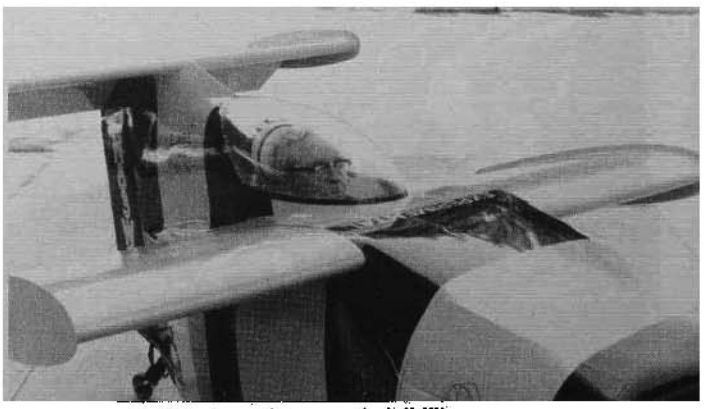

*Cockpit detail looking down and aft.*

and contacted Bob Starr in Tempe, Arizona, regarding a Quarter Scale Bumble Bee. He was enthusiastic about the project, and we spent many hours together, during which I took many photos and measurements. This construction article for building a Quarter Scale model of the Bumble Bee is the final result of all that activity. My Quarter Scale model is strictly a stand-off scale job, with no cockpit detail. I wanted to assure myself of its flyability, which turned out to be touchy but reasonable. The photos of the full scale job along with the 3-views on the plans, will assist any of you scale enthusiasts in the event you want to add more detail.

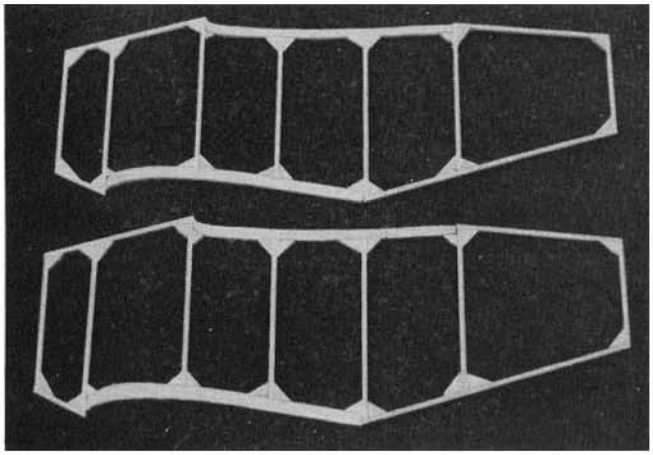
The full story of the Bumble Bee and the Skybaby is a totally fascinating tale of two men and their professional relationship, which is so engrossing that it will have to wait to be told at another time --- perhaps in another magazine, since it really has nothing to do with radio control models. However, if you R/C enthusiasts indicate enough interest in an article about full scale airplanes, we might tell the story in RCM at a later date.

I get a certain sense of deja vu in publishing the Quarter Scale Bumble Bee. Just as in the case of the Skybaby,

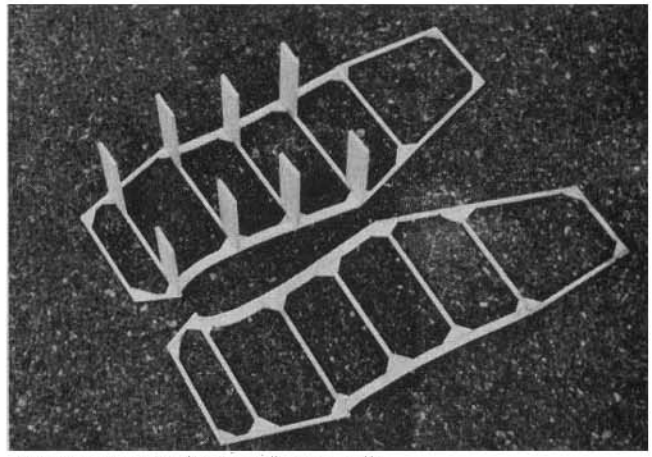
*Ken sits in cockpit. Room enough for a 200 pounder, 5' 9" tall.*



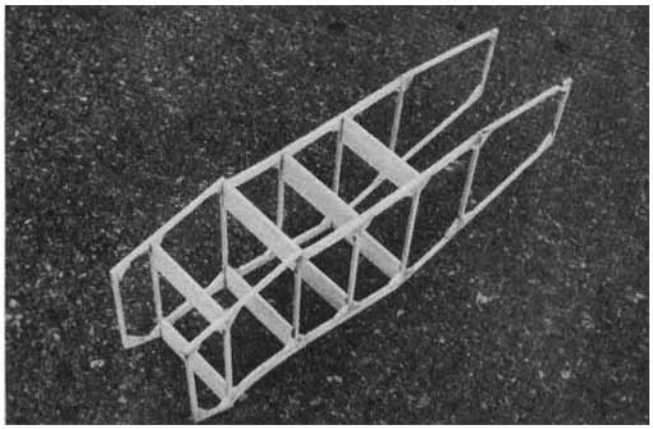
*Canopy locked in place gives good visibility.*



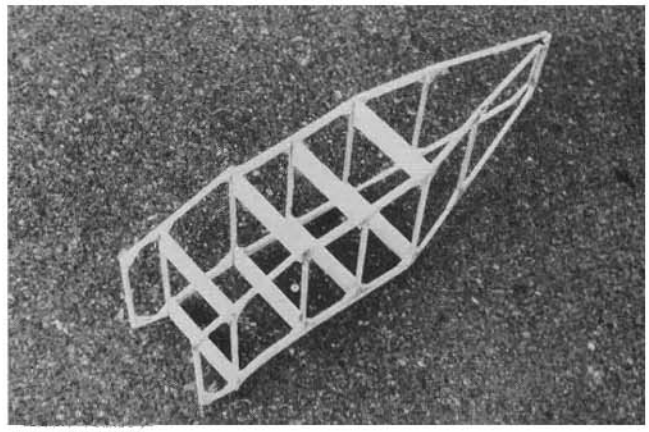
1. Fuselage side trusses.



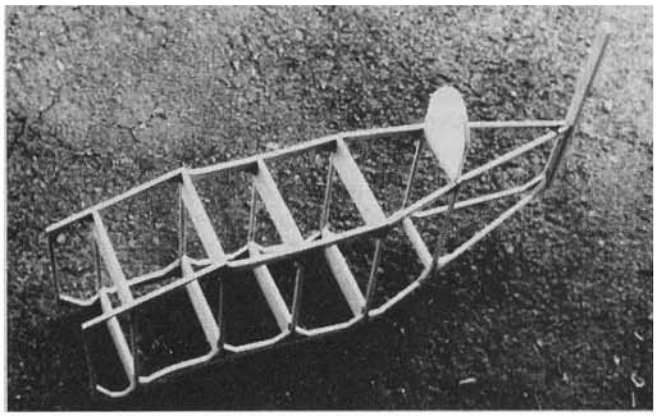
2. Cross pieces attached to one side.



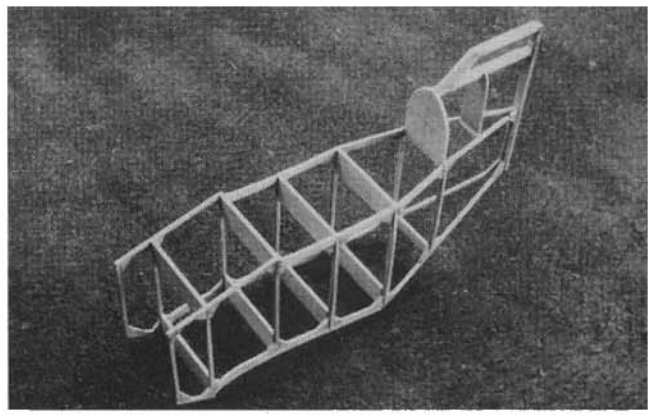
3. Sides joined.



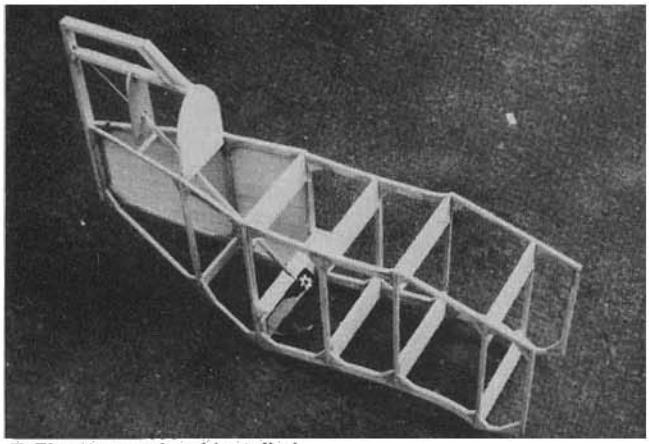
4. Tail joined.



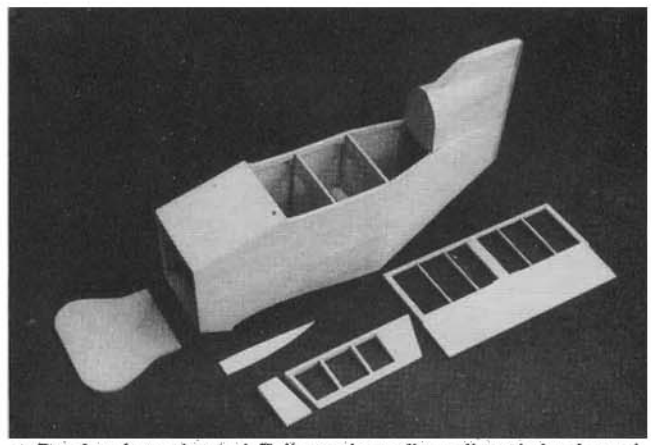
5. Tailpost and canopy backing installed.



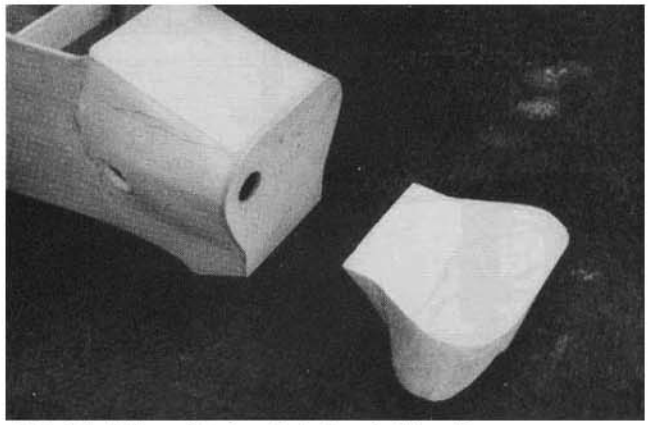
6. Vertical fin structure added.



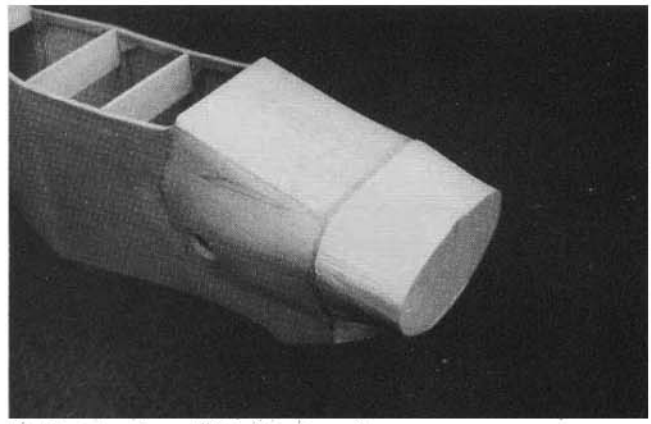
7. Elevator pushrod installed.



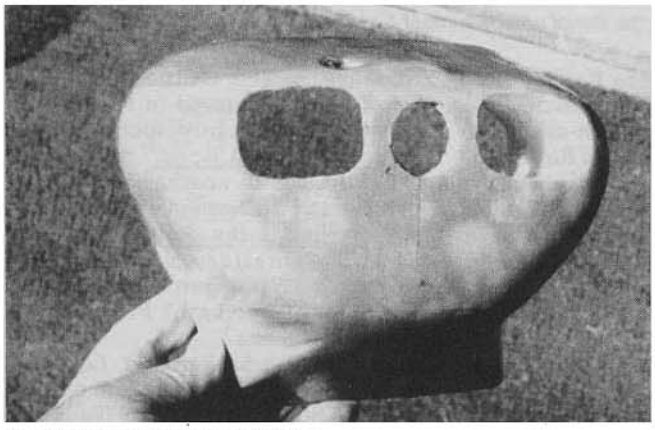
8. Box fuselage sheeted. Tail members, firewall, and cheek cowl template shown.



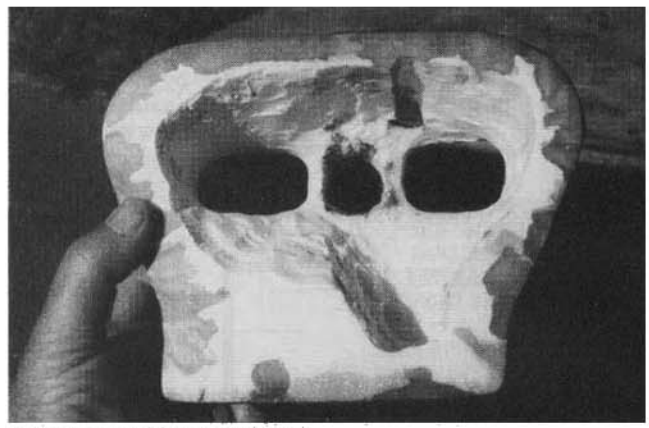
*9. Detail of firewall exhaust duct and side exit.*



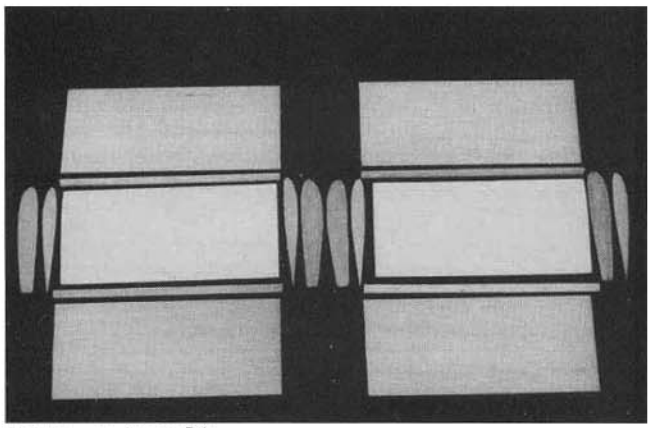
*10. Rough cut cowl fitted to firewall.*



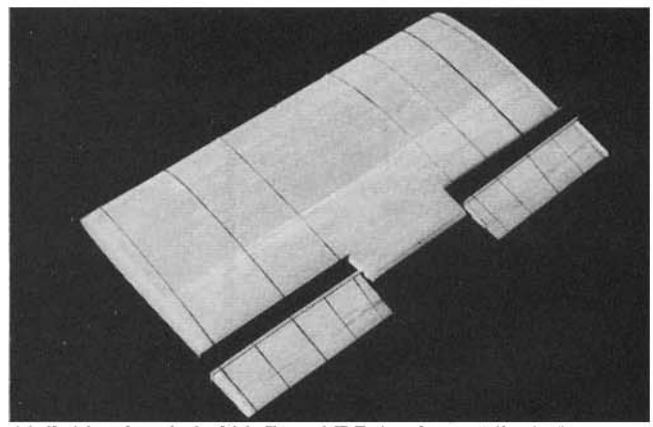
*11. Finished foam cowl exterior.*



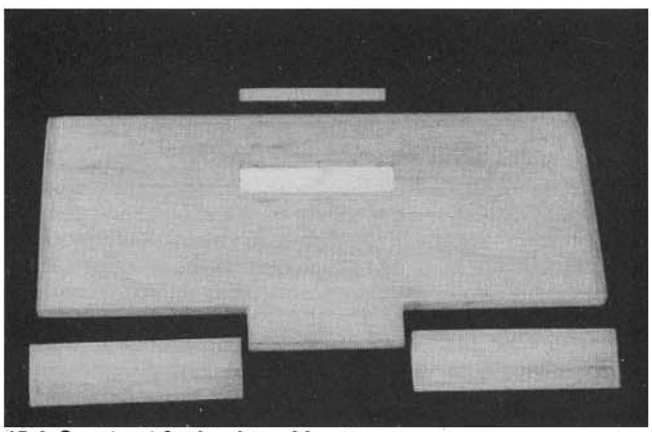
*12. Foam cowl interior cut out.*



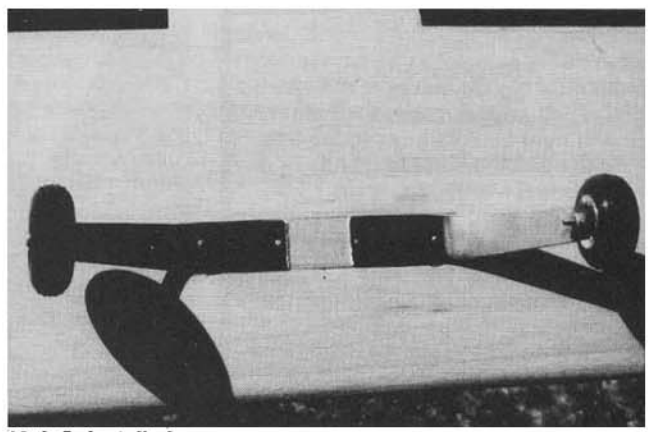
*13. Wing components.*



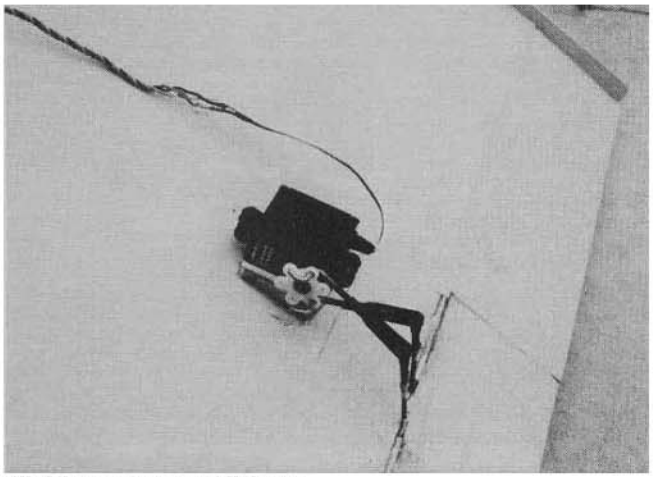
*14. Rubber bands hold L.E. and T.E. in place while drying.*



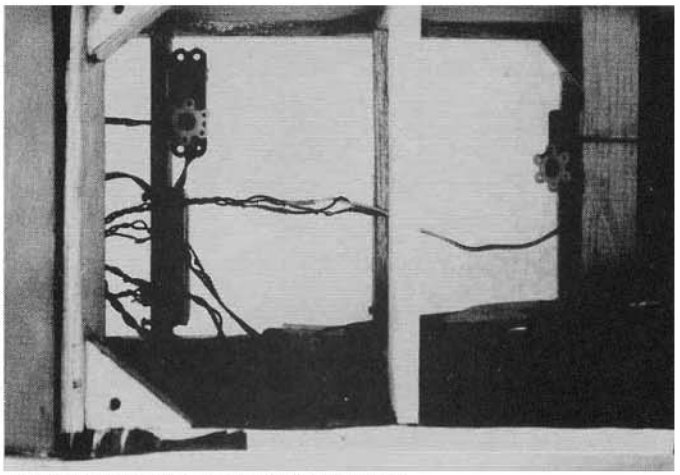
*15. L.G. cut out for hardwood brace.*



*16. L.G. installed.*



*17. Aileron servo and linkage.*



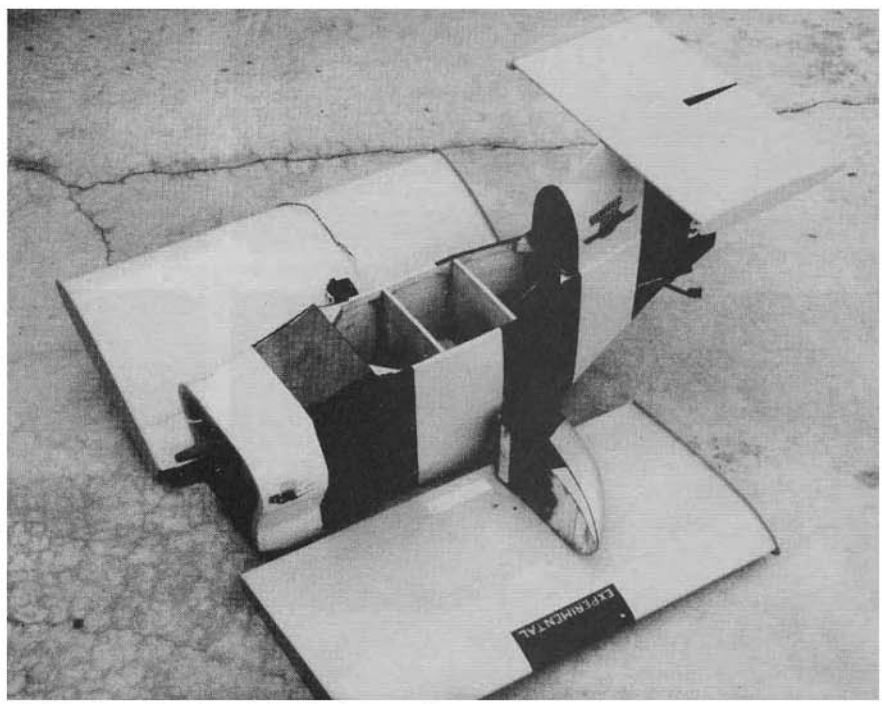
*18. Small servos almost lost in fuselage.*

**BUMBLE BEE**
**Designed By:**
Ken Willard
**TYPE AIRCRAFT**
Stand-Off 1/4 "Giant" Scale
**WINGSPAN**
19½ Inches
**WING CHORD**
10 Inches
**TOTAL WING AREA**
390 Sq. In.
**WING LOCATION**
Shoulder Wing Biplane
**AIRFOIL**
NACA 23012
**WING PLANFORM**
Constant Chord
**DIHEDRAL EACH TIP**
None
**OVERALL FUSELAGE LENGTH**
28 Inches
**RADIO COMPARTMENT SIZE**
(L) 6½" x (W) 4½" x (H) 6½"
**STABILIZER SPAN**
13 Inches
**STABILIZER CHORD (incl. elev.)**
7 Inches
**STABILIZER AREA**
91 Sq. In.
**STAB AIRFOIL SECTION**
Flat
**STABILIZER LOCATION**
T-Tail
**VERTICAL FIN HEIGHT**
10 Inches
**VERTICAL FIN WIDTH (incl. rud.)**
9½ Inches (Max.)
**REC. ENGINE SIZE**
.25 w/10 x 4 prop
**FUEL TANK SIZE**
4 Oz.
**LANDING GEAR**
Conventional
**REC. NO. OF CHANNELS**
4
**CONTROL FUNCTIONS**
Rud., Elev., Ail., Throt.
**BASIC MATERIALS USED IN CONSTRUCTION**
Fuselage ..... Balsa, Ply & Foam
Wing ..... Foamcore, Balsa, & Ply
Empennage ..... Balsa & Ply
**Wt. Ready To Fly ..... (3 Lbs. 6 Oz.)**
**Wing Loading ..... 20 Oz./Sq. Ft.**

by the time I'd flown the Bumble Bee, another airplane laid claim to the title of world's smallest man-carrying airplane. Don Stits, who is Ray's son, designed and built a small airplane named the "Baby Bird." The Baby Bird has a wingspan of six feet, three inches, compared to the six foot, six inch span of the Bumble Bee. However, the Baby Bird is eleven feet long, compared to the Bumble Bee length of nine feet, four inches, and there are other differences. The Bumble Bee has flown at altitudes of 3000 feet, circling the airport, while the Baby Bird has only made short straight line flights at 15 to 25 feet above a runway. The Baby Bird is also limited to a 140 pound pilot. Another difference is that the Baby Bird is a high wing monoplane. In any event, Baby Bird's claim to the title, as it appears in the Guiness Book of Records, is recognized in the British edition, and is "in dispute" in the American edition.

It all leads to another interesting point --- to be discussed at some other time. What is the definition of the "world's smallest man-carrying aircraft?" Wingspan? Wing area? Wingspan plus length? Plus height? See what I mean?

So much for background. Let's get on with the construction of the Quarter Scale Bumble Bee. To begin with, let me say that it is a lot easier to build than the Skybaby, primarily because of the "truss and box" structure of the fuselage, and the rectangular wings which lend themselves to foam core techniques. So does the cowl and the cockpit canopy simulation. True, there are



*19. All covered and ready for final assembly.*

some tricky little details, but this is not an airplane for a beginner. By studying the plans and construction photos, any competent builder should have no trouble with the structure. Let's start with the fuselage.

## CONSTRUCTION

**Fuselage:**

Look carefully at photos one through eleven. Photos one through five show the assembly of a simple box structure. Photo number six shows the addition of the vertical fin structure and the slightly curved additions to the uprights at stations four, five, and six, which prevent "oilcanning."

Note photo seven carefully. It shows the installation of the elevator servo on the triangular crosspiece, with the pushrod angling up to the elevator horn location on the T-tail. It is important that this installation be made at this time, before the rest of the sheeting is installed, so the routing of the pushrod can be established and provided for.

Photo number eight shows the completed sheeted box, and it also includes the firewall, the template for the cheek cowl fairing, plus the basic tail assembly. Note that the sheeting of the underside forward of the leading edge of the wing cradle is 3/16" balsa.

Photo number nine shows a detail of the forward portion of the fuselage, with the rough cut cowl alongside. Note the hole in the firewall, which is just behind the engine cylinder when installed. It is the entry to a cooling duct which exits on the side of the fuselage where the hole can be seen. This is one of the tricky parts of the model. The carved, soft balsa fairings which are added to the side of the box fuselage are solid and carved to shape. To create the cooling duct, it has to be gouged out of the side, and then lined with a cylinder made by rolling a sheet of 1/64" plywood into a tube and inserting it in the gouged out hole, then epoxied in place and trimmed to fit the firewall and the side. Also epoxy the inner surface of the rolled tube so that it will be impervious to the exhaust residue which will pass through it.

Making the cowl is a matter of builder's preference. I "carved" mine out of blue foam, using the hand-held cutting wire of a Great American Foam Machine. With a cardboard template which fit the firewall, and another one which roughly fit the nose shape (see Photo #10) the block is cut out and then carved to final shape, sanded, covered with .6 oz. fiberglass and treated with epoxy resin (see Photo #11). Probably one of the more tedious chores in the whole building process. If you have a Formicator instead of a Great American Foam Machine, you can make a plug and draw several cowls. Otherwise, I guess it's a matter of balsa block shaping. The inside only has to be gouged out enough to clear the engine and mount (see Photo #12).

Next, come some of the details of the fuselage. Again, check the plans.

The lower wing is held in its cradle with three 10-32 nylon mounting bolts, two forward, which insert into hardwood corner braces on the fuselage, and one at the rear center, which fits into a tapped hole in the 3/16" plywood crosspiece.

The upper wing is held down with two nylon bolts through the corner braces at the forward edge of the cradle, and by inserting the trailing edge of the wing underneath the half inch crosspiece as shown on the plans. If you don't trust this set-up, you can add corner braces and use nylon bolts. I have found the crosspiece more than adequate for airloads, and it also reduced the amount of damage sustained when I inadvertently cartwheeled the model on landing. Yes, it's touchy.

For the sake of expediency, as well as simple and rapid building, I chose to simulate the cockpit canopy, using a shaped block of blue foam, covered with .6 oz. fiberglass and epoxy resin, then painted silver, black, and yellow in conformance with the full scale. This simple structure is held in place with two strips of velcro.

You may want to make a more detailed cockpit. The plans and photos show those details, just in case.

The four ounce tank is mounted right behind the firewall, resting against the firewall and on a 3/8" crosspiece. Wrap it in thin foam padding to reduce the tendency for foaming of the fuel due to vibration. Secure it from falling away backwards either by stretching a rubber band from the bottom brace to the top crosspiece, or adding another crosspiece once the tank is in place.

To help keep the model as light as possible, I used the small Airtronics Micro receiver and servos. Note also that I like to live dangerously (according to some modelers) and simply mount the servos with servo tape. There's so much room in this fuselage that many variations of servo mountings are possible. The one I show is easy, quick, and easy to get at for maintenance if needed. It's not the only way --- just my way of KISS --- keep it simple, stupid.

The last little detail worth mentioning specifically is that portion of the vertical fin aft of the tailpost and above the rudder. It is built up with sheet sides, so the elevator horn can operate inside of it. Actually, on the full scale Bumble Bee, that part of the fin extends up and between the separate elevators. Again, for simplicity, I chose to make the elevator in one piece, and trail the fin downwards aft of the hinge line so the elevator can move freely up and down. So it ain't precision scale. Picky, picky. It looks okay.

**Tail Surfaces:**

*(Editor's Note: The plans show a different installation of the control horn and pushrod. You'll note on the plans, the pushrod comes out the right side and connects with the elevator horn which is offset to the right instead of enclosed. When plans were done, Bob Sweitzer considered this method simpler and we agree.)*

The plans and photos show these surfaces in enough detail without going into it here. Rudder hinge locations are shown, but the elevator hinge is the well-known MonoKote strip. Note on the profile view how the leading edge of the elevator is slanted aft at the bottom to allow downward travel. The 1/16" plywood tip plates are added last. I painted them a matching yellow rather than covering them with MonoKote. Oh, yes, I almost forgot. Mount the horizontal stab and elevator assembly, complete with horn, before installing the fin extension aft of the tailpost, for obvious reasons.

**Wings:**

Photos thirteen through sixteen show the sequence in constructing the two foam wings. All the parts are shown in photo fourteen. The upper wing and lower wing are first made alike. Cut out the wing cores, using templates made from the profile of the wing section. Cover the cores with 1/16" balsa, using the adhesive of your choice (I used Dave Brown's "sorghum"). Adding the leading edge and trailing edge stock and sand to fit. Then the ailerons are cut out on the lower wing, with a trailing strip to the wing mating to the leading strip on the aileron. Again, the leading strip on the aileron is slanted downward and aft to provide clearance for downward travel. The hinge is the MonoKote strip type. Tip plates are attached after the wings are covered.

Photo sixteen shows the Halco gear, split and mounted on the hardwood brace (I used basswood) which has been imbedded in the wing.

**Landing Gear:**

The plans and photos show enough detail to cover this aspect of the construction. One thing I did was to cut out round MonoKote inserts which I put over the wheel hubs so they'd look more like the full scale job.

**Engine Installation:**

No problem. Simply a glass filled mount which fits the O.S. Max .25, bolted to the firewall. Keep the bolt length such that they don't protrude

beyond the plane of the backside of the firewall. Otherwise they might dig into the tank.

**Radio Installation:**

As I mentioned previously, there is a lot of room in the model for various installations. Once again, though, the installation of the aileron servo takes a little doing. Note on the side view how the servo is mounted to a base with servo tape, with the top of the base slanted up and back so the pushrods point uniformly to the attachment at the top of the aileron torque rod arm. Also note that the connections of the pushrods to the servo wheel are not diametrically opposed, but slightly offset in order to yield differential travel --- more up movement than down.

To help achieve the proper center of balance, the 250 mA battery pack is located under the tank and just aft of the firewall. Location of the receiver depends on how ther model balances. I put mine alongside of the throttle servo, mounted to the crosspiece at station three with double stick mounting tape. The receiver is very light, and the tape holds it easily.

**Flying:**

The Bumble Bee, either full scale or quarter scale, is not an easy airplane to fly, Bob Starr said it best --- "It's reasonably controllable."

The response to the rudder is very fast. Therefore, the rudder travel has to be very small --- about 1/4" in either direction.

The elevator is a bit easier to handle. Set the travel to be about 1/2" in either direction.

Ailerons are responsive, but the differential travel seems to make them relatively tame. About 3/8" up travel --- with the opposite aileron moving about 3/16" down --- gives a good response. Fast, yes --- but it is always better to have a little too much control than not enough. I had the problem of not enough aileron action with the Skybaby, resulting in overcontrol added with rudder and a subsequent crash. I avoided that with the Bumble Bee.

A look at the location of the C.G. relative to the placement of the wheels shows why my take-offs and landings are very delicate. Nose-ups are easy to come by unless you are ready for the tendency. You might ask why the gear isn't further forward. Answer --- it increases the possibility of ground loops significantly. A compromise is needed on a short coupled airplane. In fact, some observers have commented that the Bumble Bee looks more like a triple tandem triplane than a staggerwing biplane --- and in a way, they are right.

Take-offs are much easier if you have about a six mile an hour headwind. With just a tad of right rudder, you can decrease the left turn tendency at the start, and when the model is up and running, neutralize rudder and use aileron. A bit of up elevator just as the model starts rolling will keep the model from nosing up, but don't overdo it, or the model will take off too soon and snap.

I give you all these warnings, not to scare you but in the hope that you'll know what to look for and be ready. Once you've got the hang of it, take-offs aren't all that bad.

Landings? Make sure that your engine runs reliably at low speed. As you come in on final, try to set the model at a nice, easy sink rate, with the nose just a bit high, and the engine about one quarter throttle. Then, as it sinks towards the runway, leave the engine speed alone and raise the nose very slightly until the model is in a "three point" attitude. This should be done when the model is about two or three feet up. It will then sink slowly on the runway, and as soon as the wheels and tail wheel are on the ground, throttle back to idle.

If, when making your final approach, it looks like you will overshoot, go around! Do not throttle back to idle; the glide rate is too sensitive, and you'll probably drop on the runway only to nose over, or cartwheel, or both. I know --- I learned the hard way. No need for you to do it.

The Bumble Bee model is relatively easy to build, with only a couple of tricky steps. It is not easy to fly, but if you use the right technique, it is, as Bob Starr says, "reasonably controllable," and will give you a sense of satisfaction and achievement. A "kneeknocker?" Yes. A challenge? Yes. But do you want to fly "goats" all the time?

Accept the challenge — you'll be glad you did. □

**From RCModeler Apr. 1988**