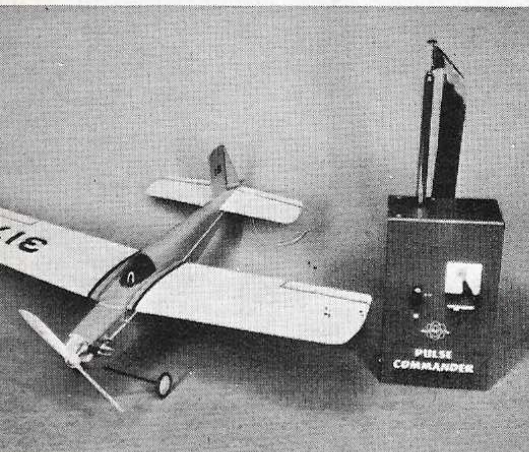




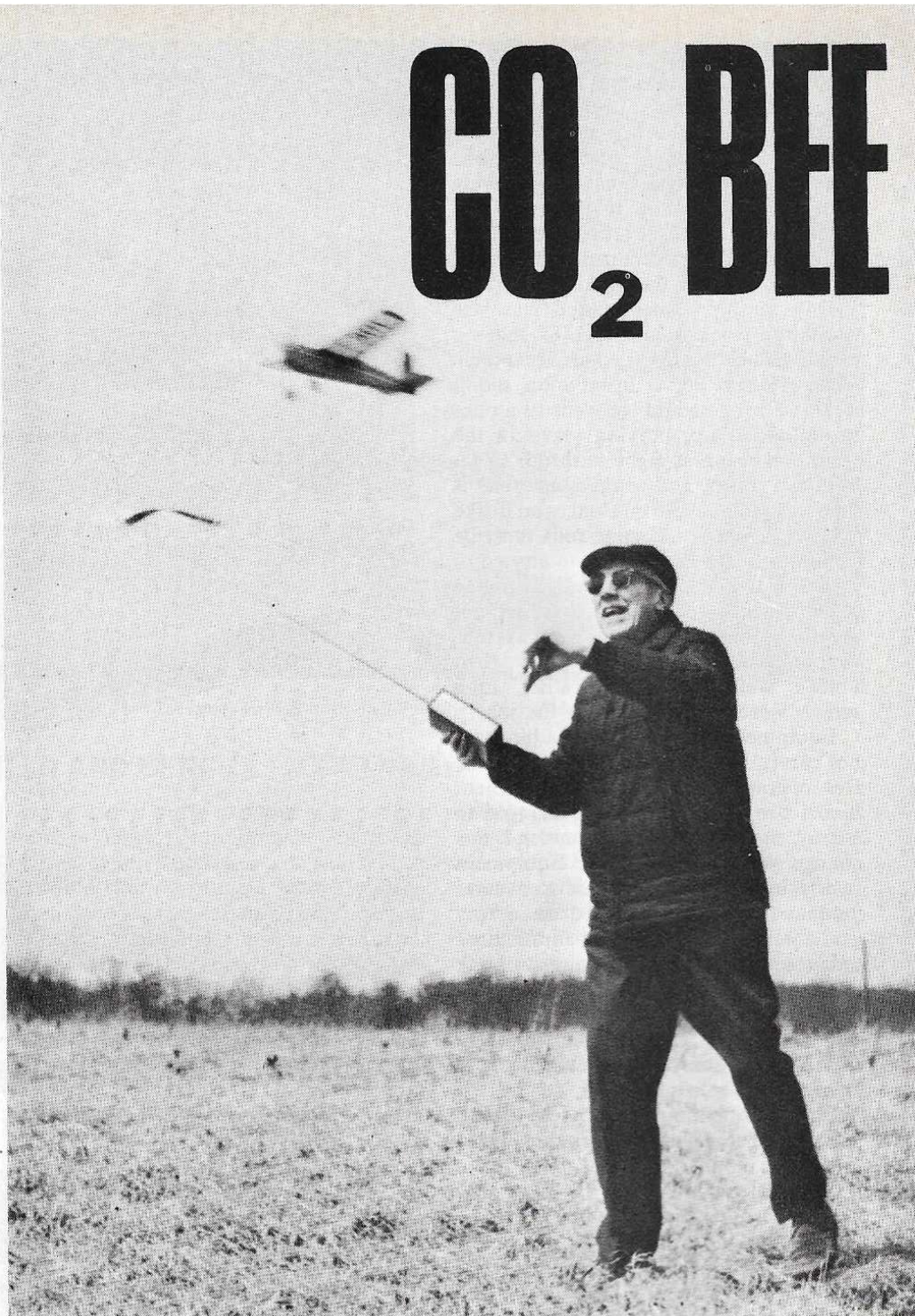
Howard McEntee and CO<sub>2</sub> Bee; plane is patterned after shoulder wing design Mac flew for years.



Veteran R/Cers will recognize Co<sub>2</sub> Bee's ancestry as author's well known "Kickin' Duck" Nats ship.

## By HOWARD McENTEE

• Long before the CO<sub>2</sub> plane described in the August, 1970 issue was flying, plans were being mulled over for an R/C plane driven by the tiny Brown Jr. CO<sub>2</sub> powerplant. Experience gained with the pusher gave an idea of lengths of engine run, props to use, etc. When actual design on the R/C plane began, there were several facts of life to be faced; first, the complete powerplant would weigh around ½ oz., with two CO<sub>2</sub> tanks and a commercial nylon prop. Second, the complete radio installation would weigh about ¾ oz. This total weight of necessities could only be trimmed slightly; one could carve a wood prop to save some weight, and the radio slide switch (by World Engines, R/C Craft) could be replaced with dress snaps. Probably a lighter battery holder might be devised. However, the decision was to "go deluxe" all the way, hoping to keep the airframe weight reasonably low. The latter is just about impossible for *this* builder—there's always the urge to beef that part up a bit—and make this section a little stronger. Final plane weight totals 2.8 oz. Far better would be 2½ oz. and if one could keep it down to 2¼ oz., the plane could fly far longer (because the



Away she goes; Ace Commander Tx, Albin Rx and Bentert actuator are fitted in the mini-fuse-

lage. Plane has demonstrated fine flight characteristics including ROG; can do RO maneuvers.

motor could be slowed down to conserve fuel).

The glide turned out to be quite good, though on the fast side; engine has plenty of power to pull the craft along in a steep climb, but this eats CO<sub>2</sub> in a hurry. At this writing, best flight has been a big one min., three sec.! It's felt that one of the keys to better performance is a more suitable propeller; Top Flite's 5¼/4 does a good job, though, and it can be had most anywhere. Much of our test flying has been done in cool weather. CO<sub>2</sub> works much better on hot summer days, so it seems possible flight time can be extended somewhat.

Design is simple and there are no startling tricks; final plane looks quite a

bit like a line of shoulder wing R/C planes we've been flying for years; a somewhat 'Mooneyish' shape was utilized for rudder and stab, to alter appearance a bit. The sweptback nose gear is fairly effective in preventing noseovers, should plane touch down in a steeper than normal glide. Actually, it often lands with the engine still turning at low speed, which gives a very flat glide and really "greased" landings. Trike LG was ruled out due to increased weight. However, with the LG as shown, ROG takeoffs are beautiful and there is seldom a ground loop.

Wingtips were given 1/16" washout—probably fortunate in view of the plane weight. Flight is very stable, and

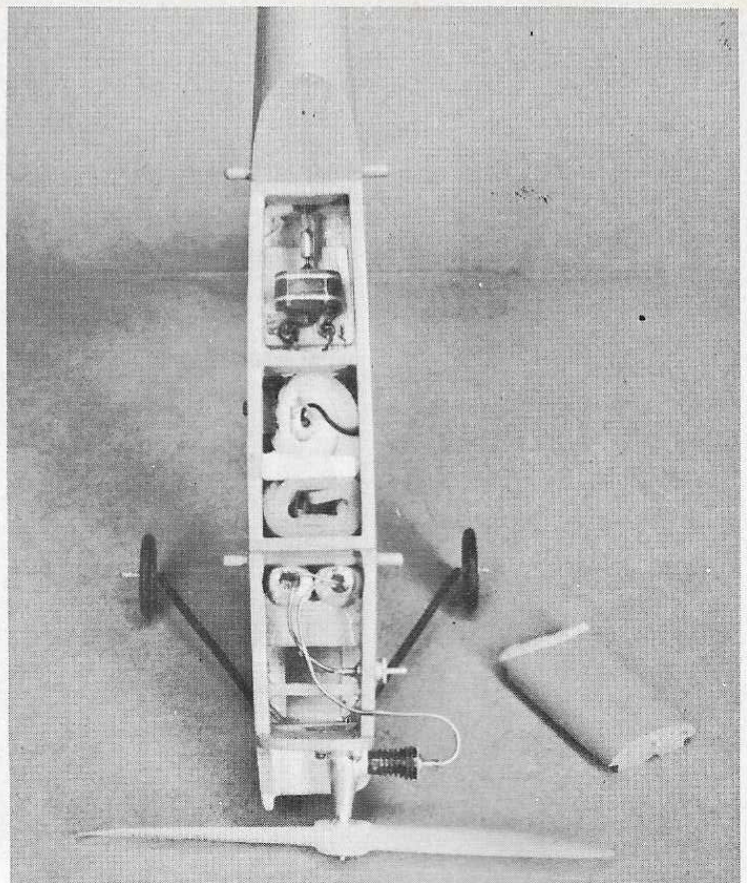
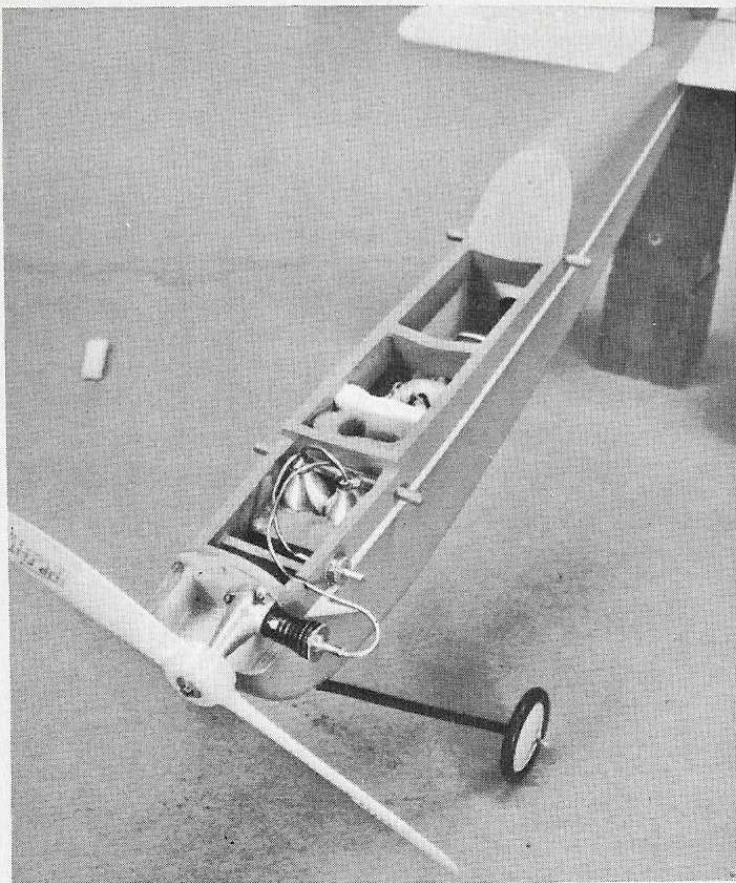
if downthrust is correct, plane seldom stalls. Wing area (not including section over fuselage) is about 60 sq. in. and span is 19½" (latter rather unusual figure resulted when we panicked upon noting the rapid weight rise, while building the fuselage and installing equipment! The wing was built last, and as an emergency measure, spacing between all ribs was increased 1/8" to lengthen span—wonder if full-size plane builders ever resort to such scientific design measures?!).

Since it's improbable that novices will tackle a plane like this, we won't go too deeply into construction. Fuselage sides are of medium 1/32" balsa, with the doublers held on by a thin coating of

sprayed contact cement. 1/16" thick balsa triplers, triangular 1/8" strips from tail to former 1 (1/32" thick fillers are needed under these, from ends of doubler sheeting to tail) and upper edge gluing strips are stuck in place before assembling sides. Join sides with formers 1 and 3, and rear of sides with small balsa block. Add firewall (note this has a slant both to right and downward) and former 2; be sure to cut holes in 2 and 3 before assembly. The soft balsa top tail block is cemented only at extreme forward and rear ends; it is partially hollowed out before assembly, mainly to make it easier to cut away so stab and fin may be installed. Forward edge of this block

should also be cut so the 1/32" turtledeck sheeting will fit flush. Now add formers 4 and 5, vertical strips at former 4 and stab LE, then 1/16" x 1/8" and four 1/16" sq. strips between former 4 and top tail block (latter five strips keep sheeting from sinking down with age, and giving a sort of 'starved dog' look to the turtledeck).

Cut a soft piece of 1/32" sheet a bit oversize for turtledeck covering, wet it and bend to shape. Hold it until dry with tiny pins (we use some that look just like common straight pins, but are only 7/16" long and .020" thick—ideal for such delicate work!). When dry, trim to final size and cement in place.



Installation of Brown CO<sub>2</sub> engine; note two tanks; engine has potential. It isn't that there's much room, just everything is small! Neat placement.

## CO<sub>2</sub> BEE

Fit actuator mount in place; this rests atop triangular strips, is beveled underneath to match them. Also, glue in tail skid; latter must hug fuselage inner sides, to allow passage of torque rod. Bend and cement landing gear wire in place. This wire goes flush against rear of the firewall, and against fuselage sides. We used epoxy here, and also for the triangular strips that brace this area—only use of this strong but rather heavy cement in the whole plane. Stab and fin may go on next; former rests on top edge of the fuselage sides; the top block is cut away so it can slide in place. A slit is cut in the top of the block for the fin, which rests on and is cemented to stab upper surface.

Add 3/4" x 1/4" high braces in the tank compartment. Note that fuselage edge is undercut between firewall and former 1 for 1/8" thick bottom sheeting; latter goes on cross grain, may be formed to shape wet, cemented when dry. From former 1 to tail, 1/32" sheet is used with grain fore and aft.

A block of firm balsa is cut to fit between sides, forward of the firewall, cemented in place. Wing dowels may go in now, then you can fit in the CO<sub>2</sub> tanks; cut side strips in tank compartment to allow tanks to touch bottom sheeting. Cut upper tank brace but don't put tanks in yet. Make a 3/16" diameter hole for the filler body, drill holes to match those on engine crankcase.

Cut hole for the switch, but don't

mount it until finish has been applied. A hardwood dowel about 5/64" diameter was used for the torque rod. If you don't have this size, sand a piece of 3/32" stock used to hold wing rubbers down. Forward end of torque rod is attached to the actuator by a short length of soft fuel tubing, actuator shaft must be cut to 3/8" length. Over the end solder a 3/16" length of 1/16" OD brass tubing, and over this the same length of 1/16" ID tubing. Clamp needle-nose pliers (or other heatsink) between tubing and actuator rear bearing, while soldering. The actuator is bound and cemented to 1/8" thick mounting plate; two leads go to small eyelets at forward end of this plate. Tubing on actuator shaft must be rounded at rear, then assembly may be cemented in place. Actually, it might be better to wait until the plane is completed, and you can see if weight shifting is required for balance; plans show actuator position on the prototype plane (no weight was required fore or aft to attain indicated balance point).

Wing airfoil is definitely "zip-zip," actually similar to a thinned Clark Y. The ribs shown on plan are just a guide, should be trimmed to fit. Rigs used here were all based upon rib #1 (before latter was cut down to accept the 1/32" top sheeting); each succeeding rib was made with a shade less camber, after being cut to proper length. This builder has a dislike for very "fat" wingtips,

so the tip shape (#7) was made somewhat lower than rib 6. The TE spar tapers in width to the tip; LE spar is retained at full width and height out to rib #6; height is tapered a bit down to the tip. TE and LE spars on plan, install all ribs except #1. Make right and left halves, then join spars with proper dihedral and with 1/16" washout at the tips. Add TE and LE joiners (note that these pieces must be cut down 1/32", as must ribs 1 and 2), then center rib #1. When dry, add 1/16" x 1/8" top spar; this should be of rather hard balsa, since it is under compression. It functions mainly to prevent the wing from assuming "elliptical dihedral" when covering is tightened and doped! Add center sheeting (goes on top of wing only).

Turtledeck extension at rear of wing upper surface is built right in place; while the plans specify 1/32" sheeting, we fudged a bit here. Very soft 1/16" sheeting was used, with formers cut so sheeting rear edges were a bit wider and higher than the fuselage turtledeck. When all cement was dry, these extra-wide edges were sanded until they matched the fuselage turtledeck perfectly. Canopy was vacuum-formed over a well-filled sheet balsa form, on a Mattel "Vac-U-Form" machine. These units work beautifully, are ideal for making thin plastic parts—canopies, cowls, wheel pants, etc.—within their size limits. Maximum canopy size, for

## CO<sub>2</sub> Bee

example, is about 3¾" long.

Cut out hatch cover from soft balsa, and cut a matching piece from the same material which is fastened to the top forward surface of wing. Hatch is partially hollowed inside, to clear the CO<sub>2</sub> piping, is held by a dowel in a hole in the firewall; wing extension holds the hatch rear edge down firmly.

With rudder hinging installed, you are ready to fit the torque rod; forward end is supported by the actuator shaft. Wire at the rod rear end is supported in a short length of 1/16" OD brass tubing, soldered to a piece of .010 shim brass cemented to the tail block. Slip torque rod through hole in tail block (hole must be large enough to allow passage of rod and fuel tubing on its forward end) and shove tubing carefully onto the actuator shaft. Pin shim brass sheet to the tail block with brass tube bearing on the wire, and solder bearing to shim stock. This sets it at the correct angle. When actuator has been cemented in place (apply cement only to top edges of actuator mount plate—you can then remove the actuator at a future date, if necessary, by simply softening this cement) torque rod may be slipped on shaft, and tail bearing cemented on firmly.

Rudder must be absolutely free on its hinging—there just is no power to waste in the tiny Bentert actuator! Likewise, there must be NO binding in tail torque rod bearing, or between the upturned wire and hairpin attached to rudder. A bit of slop at the latter sliding joint is far better than any binding!

You are now ready for final model finishing. Cover wing with light model tissue in the color you prefer. Use nitrate dope for cement, spray very lightly with water when dry. Wing should be pinned to dihedral blocks (with washout as specified) during this step, and after each application of dope. A coat of thinned clear nitrate was applied over water-shrunk paper. To get more color in the covering, we tried a trick noticed in the club paper "Flying Scale News & Views" (edited by Fernando Ramos; for North American Rockwell Corp. Flightmasters). These modelers are very active in Rubber Flying Scale, naturally seek lightest possible weight, but realism of finish. Suggestion was simply to add some "Floquil" model railroad paint to nitrate dope, since this paint is very heavily pigmented. Our dope was airplane (full size) type and very thick. It was thinned about 50% and 12 drops of castor oil were added to each four fluid oz., to prevent excessive paper tightening on wing, and later brittleness of wood surfaces. To one oz. of dope-oil-thinner mixture we added 1/2 eyedropper of Floquil; stirred well, it dissolves completely, and does add ample color to the dope—probably with little weight gain. Depending upon colors chosen, you may need more or less of the Floquil, so do a little experimenting.

All wood parts received a coat of thinned clear dope (including wing framework before papering) with light sanding to remove fuzziness. Two coats of color were applied to wing paper, and to all wood surfaces. This doesn't impart much gloss—but it doesn't increase weight much either! And of course, there is no need for

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"fuel-proofing." Area around the CO<sub>2</sub> tanks was given several heavy coats of clear dope; tanks frost up after being filled completed, and hopefully this dope will keep melted frost from soaking into surrounding wood. An extra coat or two of dope is advisable in the engine compartment. While there is no fuel problem, engine does spit out most of the lube oil applied to it. Sticky MonoKote, decals and black self-adhesive tape complete the finishing process. From our building figures, it appears that all doping, plus paper on the wing, and the finish details (including canopy) added about .25 oz.—another place weight could be cut down, if you don't mind an unfinished model!

Now you can cement the switch in place, install rudder permanently and put in power plant. For latter, you must do most of the tube bending before installation. The engines normally come with just one

tank but two are necessary (and three would be even better!). Tanks are connected "in series," per sketch. Each tank cap must have two holes, and a #59 drill is about right. None of these screwed parts need be more than finger-tight as the O-rings do the sealing. Always remove the O-rings before soldering the tank caps (a T-pin with point slightly blunted, and then bent at right angles to the shank makes a good O-ring-remover).

Tube to the filler valve may have to be shortened; we unsoldered the tube to this valve (remove outer cap and nipple first) so valve body could be pushed through the 3/16" hole, then tube was resoldered. After this, the brass valve body was well cemented in place; don't lose the tiny rubber plug that's inside the aluminum piece, when you unscrew latter.

Engine can be bound in place with fine copper wire. Don't apply cement until you

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road trade. If you break a screw, end left in the crankshaft can probably be rotated out with a sharp scriber point. The "perfect" props for these engines haven't been discovered yet, and this is an ideal field for experimentation. As noted earlier, we feel props are a key to longer airtime with this plane; we'd be most interested to hear from builders who discover better ones for CO<sub>2</sub> Bee.

Battery holder used here is shown on plans. It is simply a plastic pill bottle with screw top, cut down to required length, and fitted with terminals. Silver-oxide cells will give a surprising number of flights—probably at least a hundred. They do not require much rest between uses, as do normal dry cells.

Switch, receiver, battery holder are wired together first, with two leads left for the actuator; these leads are run through a hole in former 2 and soldered to eyelets on actuator plate. These eyelets make a convenient spot for checking battery voltage; with transmitter and receiver operating, move control stick for longest pulses (push the trim lever in same direction) and apply prods from a meter of perhaps 0-5V range to eyelets. Approximately full battery voltage may be read here. Discard cells when they drop to around 2.5V under this load. These cells may be had in boxes of six from mail order electronics houses, for about \$2.; they are Eveready S76, or equivalent.

Receiver is simply well wrapped in foam and tucked into forward open area, with battery holder similarly installed. Antenna goes through a hole in fuselage bottom, runs back to the tail skid where it is held by tape, and the end—about 5" worth—hangs free. To get actuator to move in the correct direction with the control stick, we had to reverse two outer leads on the Ace Commander stick pot; remove leads, measure pot resistance with stick at center, then loosen pot nut and rotate pot body until you read the same resistance the opposite way around, then resolder wires in reverse.

Usual radio system checks must be made—check for range on ground, tune up receiver to transmitter frequency, make sure rudder is centered with stick at neutral, also that there is no binding whatever over full rudder actuator range. Then you can try glide tests (over the proverbial long grass—if you can find any!). CG position is shown on plans; slight trim changes can be accomplished with elevator trim tab. We found glide surprisingly flat and quite fast. First flights should be made with a minimum tank filling—fill with cartridge holder nozzle pointing upward. You will need to turn the engine cylinder down (screw it into the crankcase) until you get pretty close to full engine power. If you turn it too far engine will emit a sort of sputtering sound—back off a bit. Later

you will doubtless find you can reduce power from maximum a bit. As checked on a Heathkit tachometer, our prop turns at about 8,000 rpm during the first power burst, with a full CO<sub>2</sub> charge.

With engine running close to maximum throttle, you really need quite warm weather to get best results for maximum fuel charge (accomplished with cartridge holder nozzle pointing downward). With all this gas going through the system, there is more "refrigeration" effect, and the engine tends to sputter and spew out flecks of "dry ice" before it gets going properly. Temperatures of 70° or over are fine; good—though much shorter—flights can be had at 55°. Running the engine wide open eats up fuel in a hurry. You probably won't get more than two or possibly three maximum tank fillings per cartridge. Standard cartridge price seems to be around \$.25 each (you need the so-called 8.5 gram cartridges for the Brown Jr. cartridge holder). Check the discount stores though. We found one locally that has at this writing, at least, cartridges at 10 for \$.99. A real bargain.

For this use, a larger cartridge would be ideal—and the engine maker is looking into this matter. Two tanks we use seem to take about .1 oz. of CO<sub>2</sub> or a bit over. A tank holding 2-3 oz. would be ideal, and would easily slip into a pocket.

This little plane and its powerplant opens up a whole new field of R/C flying—indoors (large gyms), school, recreation fields, in populous areas where glow engines are banned, etc. Hope you have as much fun with it as we have already had! ■

have flown the plane, to see if more down or right thrust is needed. If there is any excess tubing to engine, coil it around near the cylinder head outside fuselage.

To use the Top Flite prop you'll need a bushing, made per sketch. If you don't have a lathe don't despair—Bill Brown tells us the nylon piece at the end of the filler nozzle will serve nicely—they may be obtained from the factory.

Nylon props (all we've used so far) work well and their rather flexible blades help prevent prop screw breakage. However, they are relatively heavy and their very rugged hubs can lead to screw bending or breakage in a nose-down "landing." You'll need longer screws than those that normally come with the engine (factory can now supply two screw lengths). At least 7/16" length is required for specified props; these 0-80 screws may be had at hobby shops catering to the model rail-

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