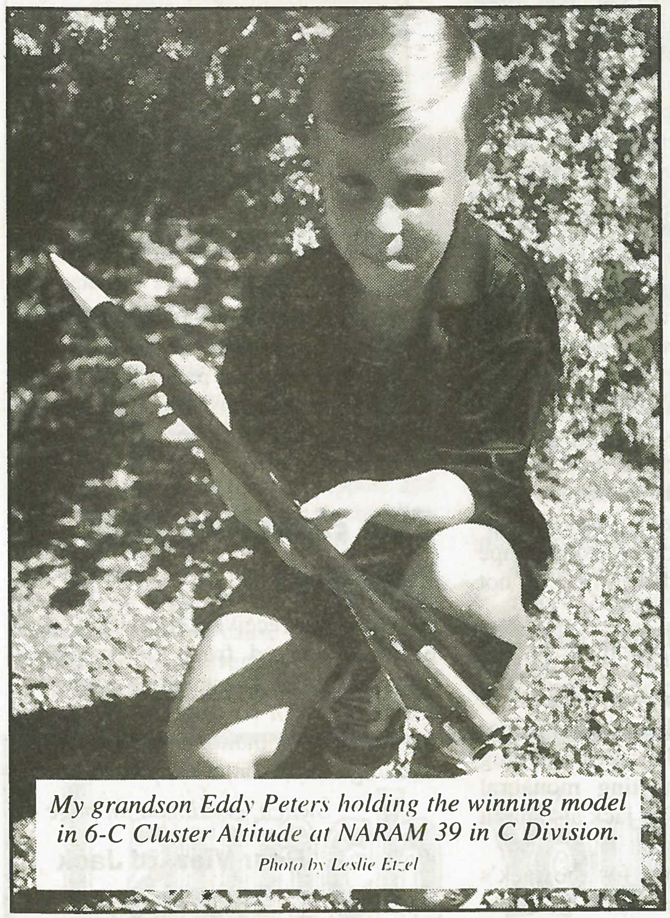
Building for Six-C Engine

CLUSTER ALTITUDE



My grandson Eddy Peters holding the winning model in 6-C Cluster Altitude at NARAM 39 in C Division.

Photo by Leslie Etzel

by Wally Etzel, NAR 50638

The Superstition Spacemodeling Society has been flying the cluster altitude events since they were first proposed. During this time I have observed those characteristics that are common to the winners, usually not me. I had tended toward long models to reduce weight required in the nose, and to build minimum weight models. The winning models were usually just the opposite, with short bodies and whatever weight was required in the nose to make them stable. So, not being one who ignores the writing on the wall, I set out to design a six-C Cluster model that could win.

The first and probably the biggest decision was whether to use a central motor with five around it or use a three motor core with three external pods. The former offers the best use of the motors with only one used to eject the recovery device. However, all the layouts that I made of this configuration led me to conclude that the effective diameter at the aft end would be large, and I never did figure out how to put three fins, equally spaced, on three of five pods!

I had used the three-and-three configuration before so I was comfortable with that approach, but some changes had to be made to reduce the base drag. I thought that offsetting the inboard motor cluster from the outboard motor cluster might result in an effect similar to a boat tail.

The final design task was to integrate the outboard motor pods and fins. The start of the fin is made coincident with the tip of the motor tube fairing so there are only three perturbations to the air flow instead of six. Also, the projected area of the motor pod is included as part of the fin area. Many people told me the fins are too small, but when you include the pod, the fin area is quite generous. You will see that motor retention is provided for all motors since returning the model with motors intact is a major requirement for this event.

CONSTRUCTION

Start by CA'ing two of the inboard motor tubes together, on a flat surface. When cured, add the third tube. Use CA here because epoxy will soften when it gets hot. Put three 3/8-inch diameter dowels or brass tubes (they are straighter) into the motor tubes and put a rubber band around the dowels at what will be the aft end. Slide the body tube over the dowels at the other end, up to the motor tubes. Mark the motor tubes where they meet the body tube. Use a small aluminum angle to project the marks down the motor tubes, then cut off the excess motor tube and cut the 1/2-inch slots that engage the body tube. The inboard pod assembly should slide smoothly, snug (but not tight) into the body tube and should look like the Aft End View on the plan.

At this point, a decision must be made. The inboard pod assembly can be CA'd to the full length body tube, or the aft 4 inches of the body tube can be cut off and attached to the pod. The latter method allows better access for attaching the inboard pod and generally easier construction of the aft end. The rest of the body tube is then attached later using a tube coupler. There is no great penalty since the coupler is very near

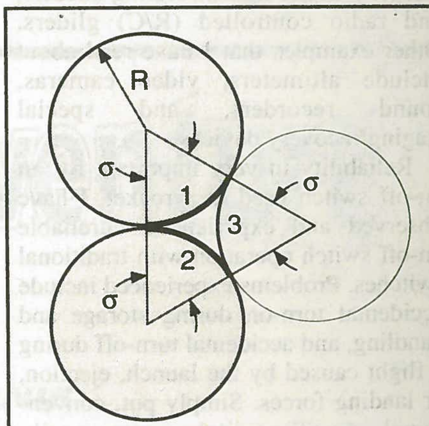


Figure 1. Why fillets are needed.

Arc 1 = Arc 2 = Arc 3 = Rσ

If the fillet (Arc 3) is not there, then the length of the surface exposed to the rushing air is Arc 1 + Arc 2 = 2 Rσ.

With the fillet (Arc 3) in place, the length of the surface exposed to the air is Rσ, one-half of the length without the fillet!

This example is simplified in that all radii and angles are the same, but a generous fillet will always result in less surface area.

the CG. Whichever way you do it, now is the time to glue in the pod. Keep everything straight and provide generous fillets for strength. Fill the three areas in the body tube to prevent leakage of ejection pressure (see the Aft End View).

The inboard engine pod installation is completed with the installation of the thrust rings and half-moon bulkheads. Thrust rings are cut from the dummy motor tubes supplied with kits for spacing thrust rings, motor hooks, etc. The thrust rings are all 1/2-inch long. Pressure bulkheads are made from the center disks left over from cardstock BT-20 centering rings. As you can see, I never throw anything away!

Trim a thrust ring to fit into the motor tube where it overhangs the body tube and CA it in place flush with the aft end of the body tube. Slide a bulkhead into the body tube and mark the area to be cut off to provide a passage in to the body tube. When the bulkhead fits correctly, glue it in place. Provide generous fillets around the forward side of the bulkhead for strength and coat the aft side with epoxy or wood glue to provide some heat protection.

Install the second (true) thrust ring against the rear of the bulkhead, and one motor tube is complete. Repeat the procedures for the other two inboard motor tubes.

The final task on the inboard pod is installation of the motor retainer. The motor retainer is a one inch length of 1/8 inch brass tube, tapped for a 4-40 screw. The brass tube is CA'd into the center hole of the pod, between the three motor tubes. The motors are held in place with a 1-1/4 inch long machine screw with a large washer under the head.

The outboard motor tubes can be built up before attaching them to the model. Install the aft (true) thrust ring first and punch two exhaust holes centered in the thrust ring and on opposite sides of the motor tube using a hand punch. Install the bulkhead and forward ring. Slot the forward end of the motor tube back to the bulkhead for the fin. Be sure that the line connecting the slots is perpendicular to the line connecting the centers of the vent holes.

Attach a motor clip to the motor tube in line with one of the vent holes. CA the motor tube to two inboard motor tubes and the body tube in the location indicated in Section A-A on the plan. Be sure the line adjoining the two slots in the front of the motor tube is perpendicular to the body tube.

Repeat the procedure for the remaining two outboard motor tubes. Cut out three fins per the outline in Section A-A, taper to the tip, round the leading edge, taper trailing edge to a sharp edge, and CA the fin in place. Keep them straight!

Nose cones for the motor pods are made by rolling a pieces of bond paper into a cones of appropriate size. Tape the large end of the rolled paper to maintain the cone shape, saturate it with CA, and let it cure overnight.

Cut the cone for an outboard pod in half and fit the halves to the pod on each side of a fin. Use wood glue to attach the nose cones, and make sure that there are good fillets of glue where the cones meet the motor tubes so these areas can be rounded off during final sanding without losing the joints.

Cut smaller sections from a rolled paper cone to make the transitions for the inboard motor tubes.

Figure 2. Igniters with extension wires attached.

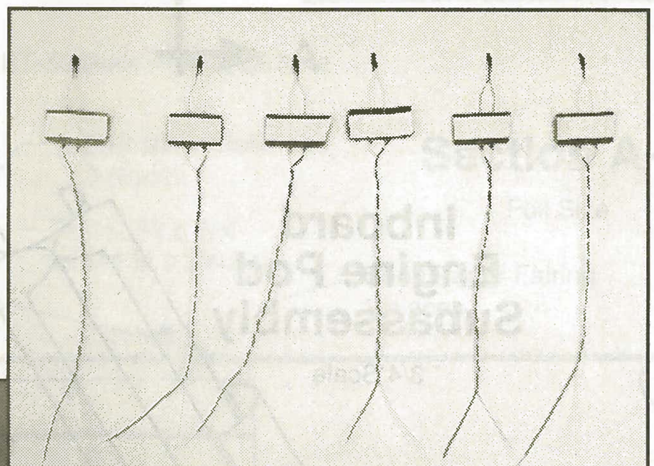


Figure 1 shows why fillets are required. Two types of fillets are used on this model: typical epoxy fillets are used where the fin meets the motor tube and nose cone, and bond paper fillets are used where motor tubes and fairings meet the body tube. The latter fillets are made by cutting long triangles of bond paper. Then, starting with the apex of the triangle at the junction of an outboard motor tube and an inboard motor tube, work forward bridging between the outboard tube and the inboard fairing. Stop at the point where the paper is also tangent to the body tube. Cut another triangle of bond paper and this time start at the tip of the outboard nose cone with the apex of the triangle. Work back from the tip of the cone bridging from the cone to the body tube. Continue until this fillet meets and just overlaps the previous fillet.

There should now be a smooth transition from the tip of the outboard cone back to the inboard fairing, then up to the junction of the inboard and outboard tubes. If it is rough in spots don't worry;

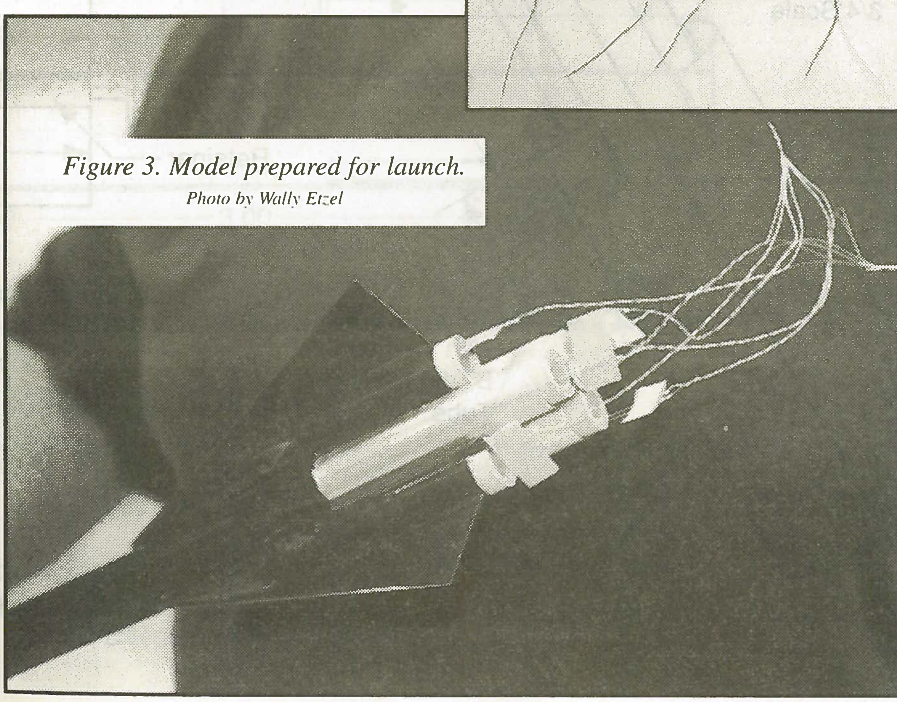
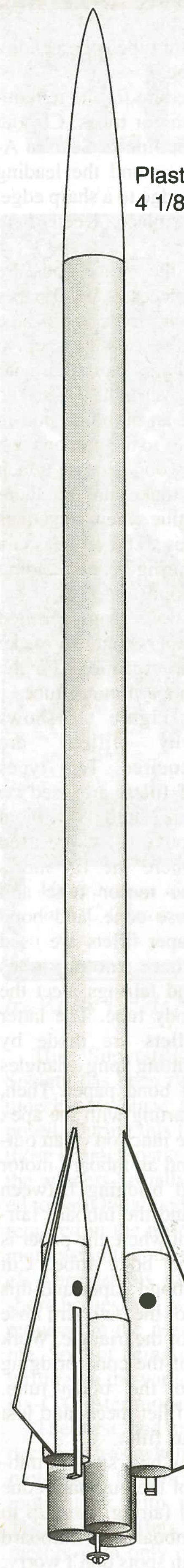


Figure 3. Model prepared for launch.
Photo by Wally Etzel

Six-C Cluster Altitude

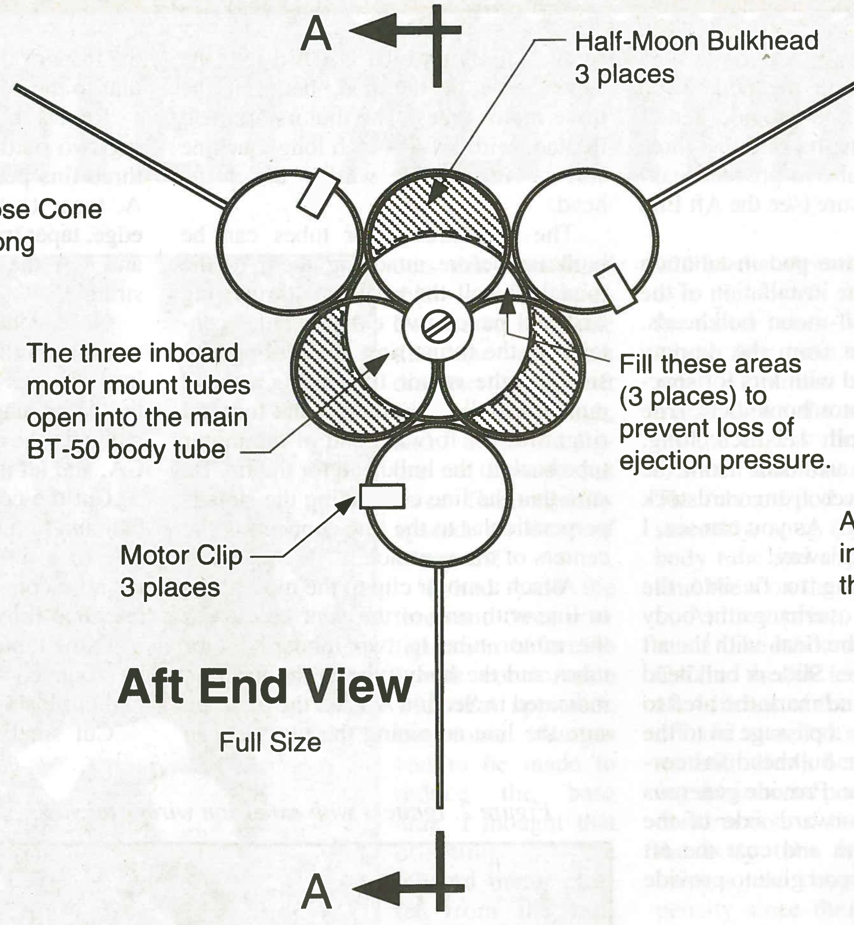
by Wally Etzel, NAR 50638

First Place, C Division, NARAM-39: *716 meters*



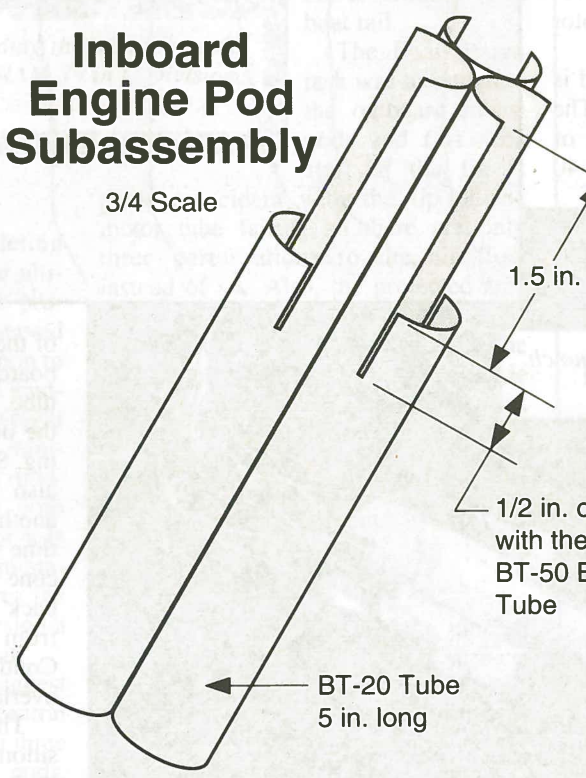
Aft End View

Full Size



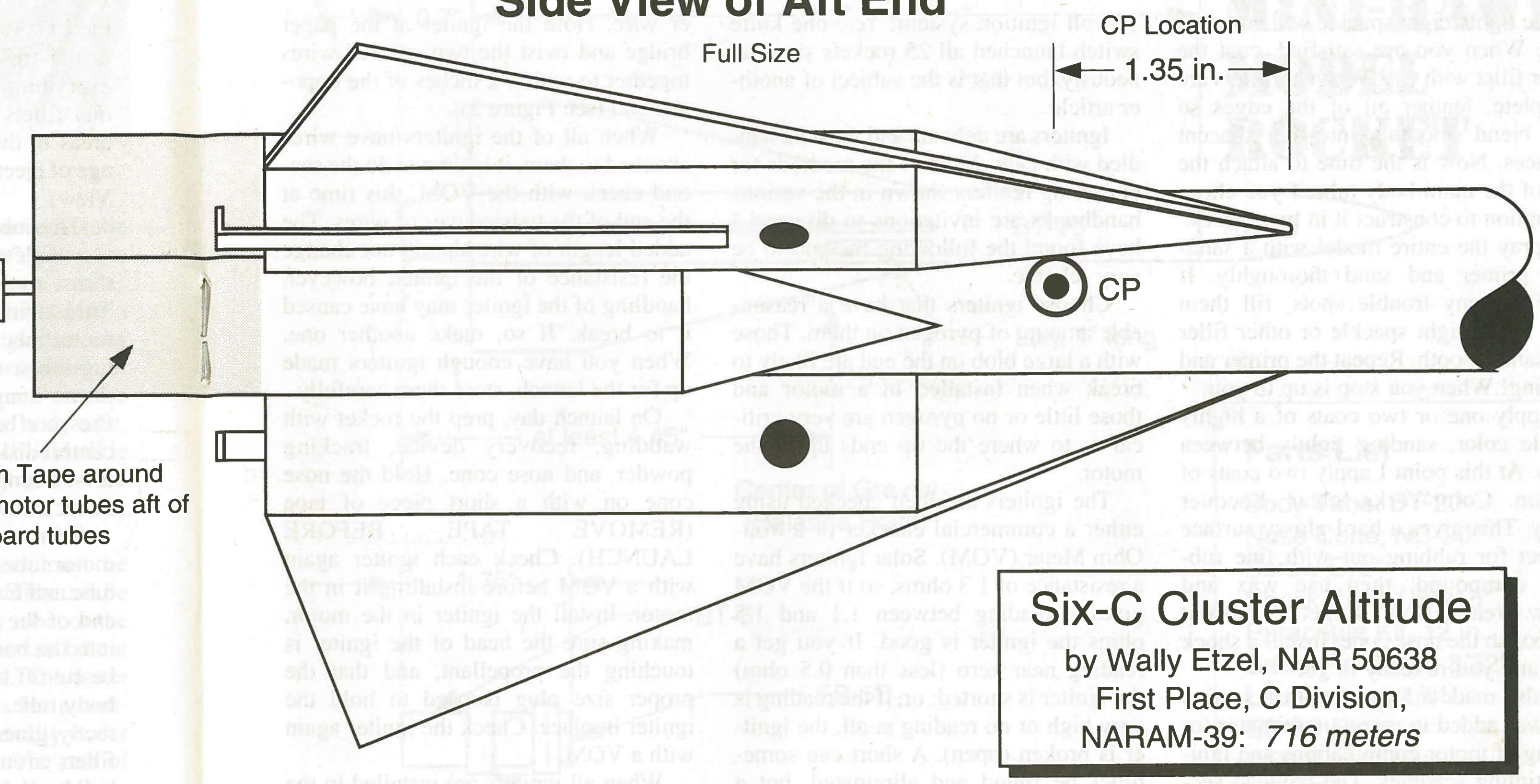
Inboard Engine Pod Subassembly

3/4 Scale



Side View of Aft End

Full Size

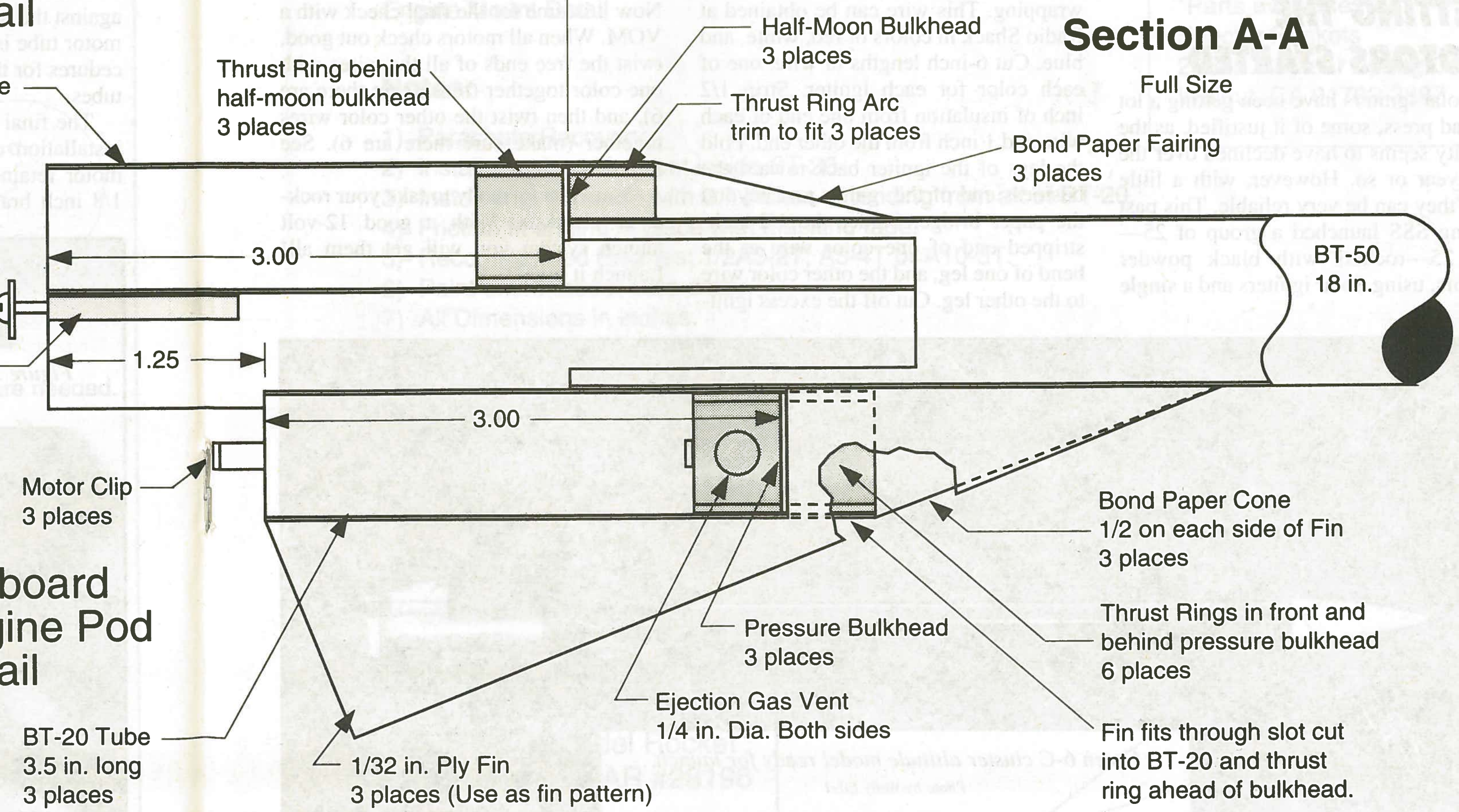


Inboard Engine Pod Detail

Section A-A

Full Size

Outboard Engine Pod Detail



a little lightweight spackle will cure that later. When you are satisfied, coat the paper fillet with CA. When all fillets are complete, feather all of the edges so they blend smoothly into the adjacent surfaces. Now is the time to attach the rest of the main body tube if you chose the option to construct it in two pieces.

Spray the entire model with a sandable primer and sand thoroughly. If there are any trouble spots, fill them with lightweight spackle or other filler and sand smooth. Repeat the primer and sanding! When you stop is up to you.

Apply one or two coats of a highly visible color, sanding lightly between coats. At this point I apply two coats of Krylon ColorWorks clear Lacquer Spray. This gives a hard glossy surface perfect for rubbing out with fine rubbing compound, then use wax and elbow grease. Don't forget to rub out and polish the nose cone. Install a shock cord and you're ready to go.

I also made a 5-inch payload section that was added to carry an altimeter for testing of motor combinations and ignition timing schemes. The payload section was not used on competition launches.

GETTING THE MOTORS STARTED

Solar igniters have been getting a lot of bad press, some of it justified, as the quality seems to have declined over the last year or so. However, with a little care they can be very reliable. This past Spring SSS launched a group of 25—yes 25—rockets with black powder motors, using Solar igniters and a single 12-volt ignition system! Yes, one knife switch launched all 25 rockets simultaneously, but that is the subject of another article.

Igniters are delicate and must be handled with care. Most of the methods for clustering igniters shown in the various handbooks are invitations to disaster! I have found the following method to be very reliable.

Choose igniters that have a reasonable amount of pyrogen on them. Those with a large blob on the end are likely to break when installed in a motor and those little or no pyrogen are very critical as to where the tip ends up in the motor.

The igniters are then checked using either a commercial checker or a Volt-Ohm Meter (VOM). Solar igniters have a resistance of 1.3 ohms, so if the VOM gives a reading between 1.1 and 1.5 ohms the igniter is good. If you get a reading near zero (less than 0.5 ohm) the igniter is shorted; or, if the reading is very high or no reading at all, the igniter is broken (open). A short can sometimes be found and eliminated, but a broken igniter is history.

For the next step, you will need two colors of the type of wire made for wire-wrapping. This wire can be obtained at Radio Shack in colors of red, white, and blue. Cut 6-inch lengths of wire, one of each color for each igniter. Strip 1/2 inch of insulation from one end of each wire and 1 inch from the other end. Fold the legs of the igniter back toward the business end of the igniter just beyond the paper bridge. Solder the 1/2-inch-stripped end of one color wire at the bend of one leg, and the other color wire to the other leg. Cut off the excess igniter wire. Hold the igniter at the paper bridge and twist the two colored wires together to within 2 inches of the opposite end (see Figure 2).

When all of the igniters have wires attached to them, it is time to do the second check with the VOM, this time at the end of the twisted pair of wires. The added length of wire should not change the resistance of the igniter, however, handling of the igniter may have caused it to break. If so, make another one. When you have enough igniters made up for the launch, store them carefully.

On launch day, prep the rocket with wadding, recovery device, tracking powder, and nose cone. Hold the nose cone on with a short piece of tape (REMOVE TAPE BEFORE LAUNCH). Check each igniter again with a VOM before installing it in the motor. Install the igniter in the motor, making sure the head of the igniter is touching the propellant, and that the proper size plug is used to hold the igniter in place. Check the igniter again with a VOM.

When all igniters are installed in the motors and checked, the motors are then loaded into the rocket in their proper locations (double check the locations). Now it is time for the final check with a VOM. When all motors check out good, twist the free ends of all the wires with one color together (make sure there are 6), and then twist the other color wires together (make sure there are 6). See Figure 3.

You are now ready to take your rocket to check-in. With a good 12-volt launch system you will get them all! Launch it high!!

Green 6-C cluster altitude model ready for launch.
Photo by Wally Etzel