A Zero-Volume Piston Launcher

by Michael Burzynski

Zero-volume piston launchers (ZVPLs), or boom-tube launchers as some of us call them, are hard to build, like other closed breech launchers. There are only a handful of people who are willing to take the time to build one, test it, and put up with the extra hassle involved in setting it up for one flight and then cleaning and storing it after the launch. This article covers the ZVPL state of the art, up to now, by telling how to build an efficient and relatively simple ZVPL. To build this successfully you will need some skill and experience with modrocs, but time and patience, more than anything else, are needed. The launcher described here is for any type of rocket based around a CMR RB-77 (i.e., egg lofter, glider, altitude) but it can be used as a guideline for other sized rockets and launchers.

Basically, to newcomers, a ZVPL is usually about 3 feet long with a complete rocket and engine sitting on the top. ZVPLs work like a piston in a car. Wires inside the launcher ignite the engine, the piston is pressurized, and then the rocket and the 3-foot launching tube shoot upward. When the launching tube runs out of piston, at about 2 ½ feet, the rocket separates from the launcher and streaks skyward — if everyghing works right (if the gods are in a good mood). (Figure 1.)

Rockets used on ZVPLs are built as one unit, unlike those for blow-through launchers, where the rocket picks up the fins on the way out. (See *Model Rocketeer*, July, 1974, "Pressurization Effect Launchers".) For this convenience, however, some ZVPLs can lose compression, in addition to being more complicated in design. Blow-through type launchers are a good second choice to the ZVPLs; they don't have moving parts and are simpler to use, but they are limited as to what kind of rocket can be fired from them and what size the launching tube can be. I don't recommend using an older type closed breech launcher, the ones made with a 6-inch cardboard tube where the rocket is put inside on a specially constructed shroud (See *Model Rocketeer*, July, 1974, "Pressurization Effect Launchers"); for most rockets these are not worth the effort, as I will attempt to explain.

ZVPLs were originially built around BT-20s. They resembled blow-through launchers, but weren't as efficient, when launching similar rockets. The ZVPLs will lose compression between the piston and the launching tube, and the rocket also has to lift the weight of the launching tubes up the launcher; with the blow-through it does not. Building a ZVPL around a ½-inch BT-5 will give almost twice the compression of ¾-inch blow-through, theoretically, and will still be ahead when the compression loss and launching tube weight is added in.

Below are two columns showing com-

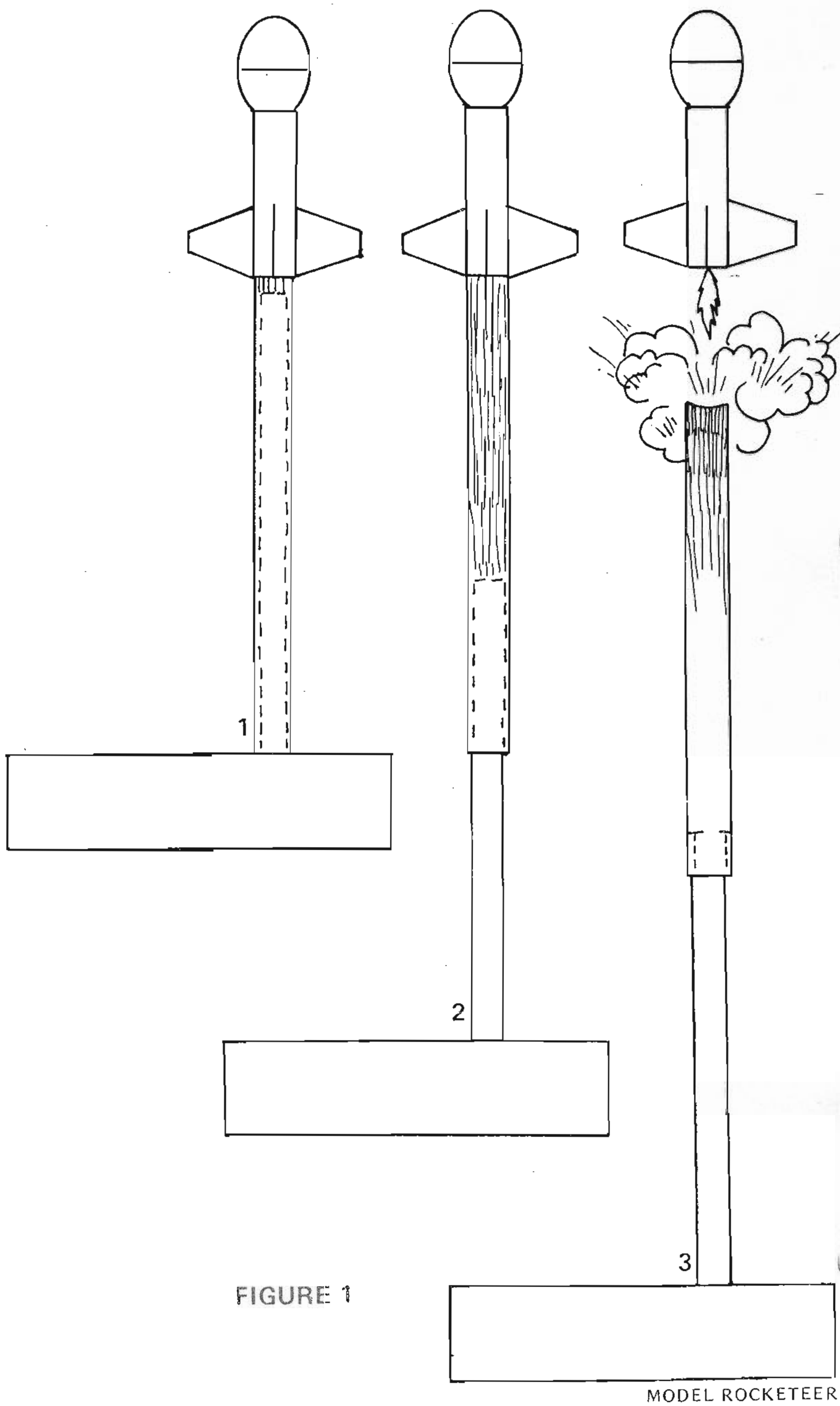
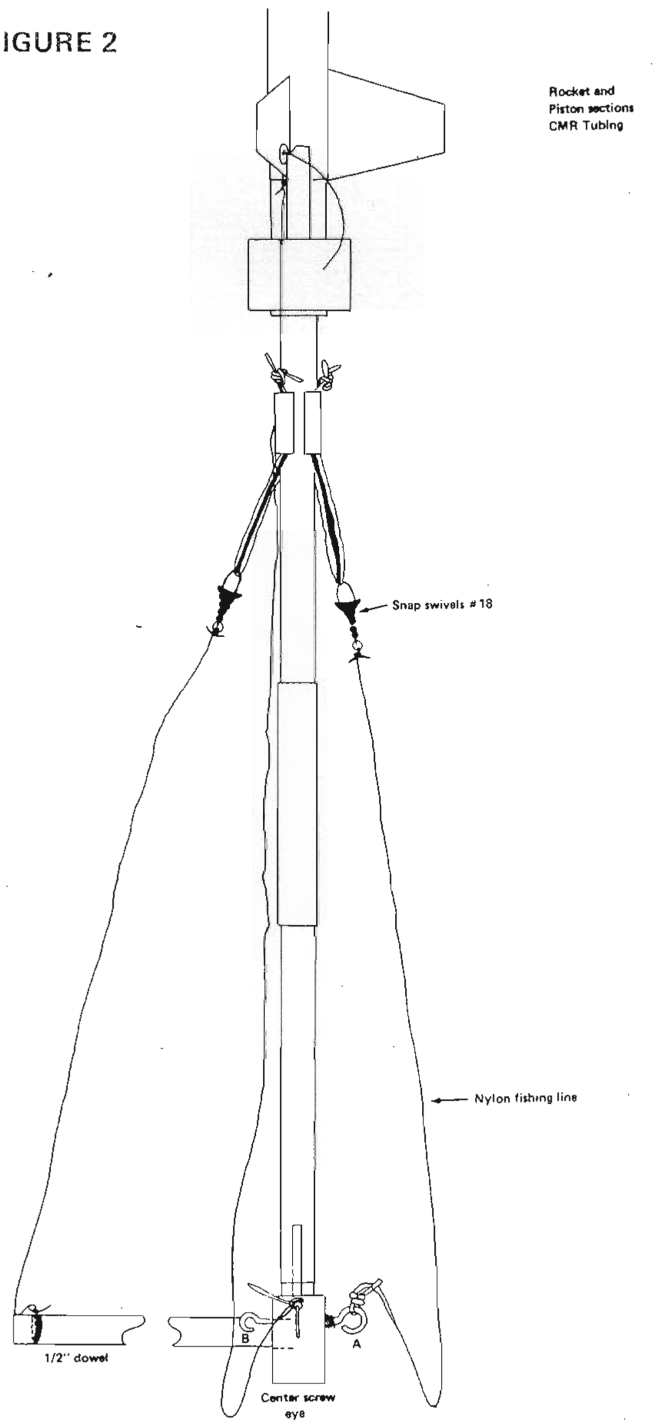


FIGURE 1

FIGURE 2



pression area of various launchers (which is the piston diameter times 36 inches, which is the average launcher length). The lower the number the higher the compression and more efficient the launcher. The second column has launching tube or shroud weight and compression loss figured in.

	1	2
Closed-Breech 6"	216	225
Blow-Through ¾"	27	27
ZVPL ¾"	27	36
ZVPL ½"	18	23

If you believe this, a few ideas should be obvious. If a launcher you plan to build has a large compression area, such as 220, you can actually lose altitude. These big launchers take a longer time to fill with exhaust gas and pressurize. The rocket will try to move out faster than the exhaust gases can fill up the tube, but the rocket would be pulling a vacuum if it tries, so it doesn't accelerate any faster than the time this takes. Likewise, building a launcher over 3 feet long is unnecessary. Large closed-breech launchers of this type would only be good for heavier rockets, where higher compression launchers would push the rocket off the pad at a higher speed than the engine can accelerate the payload. On the other hand, you can design a launcher with an even lower compression area than I have mentioned, providing you can find ¼-inch or smaller aluminum tubing that will work, and then take into account sonic booms and time warp factors. A ZVPL½ is capable of cracking an egg at *liftoff* if it is not properly cushioned. A Robin Egglofter using a Prangroc design (See *Model Rocketeer*, March, 1974) will lift off perfectly from a ZVPL½, fast and with no tipoff; a heavier rocket would be better off with a ZVPL¾.

SPECIAL RULES FOR BUILDING AND FLYING

1. Do not mix CMR and Estes body tubes on the rocket and piston sections (Figure 2); they won't fit together when the engine is installed. Use CMR tubes for these parts. Estes tubes are great and I recommend them for the launching tubes.
2. Sand the wax off the body tubes before gluing.
3. Keep the launching tubes light in weight.
4. Clamp the launcher to the rack with metal C-clamps, instead of putting it on the ground. This means you'll have to get assigned one of the end rails, 1 or 6.
5. Use plastic tape to protect the igniter wire tubes from the exhaust gases. If these tubes get dirty on the inside you will have continuity problems. If you can design a better way to clip the igniter wire, use it.

PARTS LIST

#	Qty	Item	Size	Available from:
1	1	Aluminum tubing	½" O.D. by 3'	Hardware or
2	1	hardwood piece	¾" thick, 12" by 1½" (roughly)	lumber store
3	3	screw eyes		
4	2	BT-5	18" each	Estes
5	2	5-20 centering rings (engine blocks or carefully cut engine casings can also be used)		
6	1	RB-52	6"	
7	1	RB-52	1" slit lengthwise	CMR
8	1	RB-74	5"	
9	1	¼" balsa	1½" by 1½"	
10	1	1/64" model aircraft plywood or strong 1/16" balsa	¼" by 1½"	
11	1	1/16" balsa	1" by ¼"	Hobby store
12	1	⅛" dowel	2"	
13	2	1/16" brass tubing	2" each	
14	1	music (piano) wire	.020" by 4"	
15	1	¼" dowel	1"	
16	1	twin lead wire	5 feet	
17	1	straight pin		Burzynski's
18	2	snap swivels		Auto Parts
19		woven nylon fishing line	25 lb. test	
20	3	screw eyes		

ALSO

Soldering iron and solder
5-minute epoxy
(where it's called for)
White glue or Titebond
(everywhere else)
Needle nose pliers
Plastic electrical tape
C-clamps

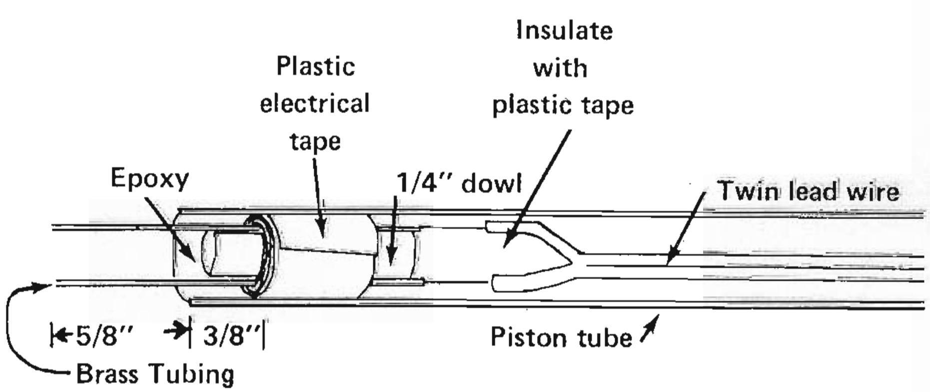
PROCEDURE

Drill a ½" hole through launcher base (part #2). Push piston tube (#1) into ½" hole; it should fit tightly enough so that you have to force it into the hole and it will not move after it is pushed in. If you don't think it's going to be tight enough, it will be up to you to devise some glue and/or screw to make it strong enough to stand up to launch.

Solder twin lead wire (#16) to brass tubes (#13).

Epoxy brass tubes into piston tube (#1). The exposed electrical parts must be covered to prevent an electrical short. The easiest way to do all of this is to tape the brass tubes on opposite sides of a ¼" dowel (#15), leaving 1" of the tubes opened, and taping the open wires and tubes that go inside the piston tube with plastic tape for electrical insulation. Anyway, look at Figure 3. With all this tape built up, the brass tubes should fit snugly against the sides of the piston tube and keep the exposed sections of brass from shorting with the aluminum piston tube. Put

FIGURE 3



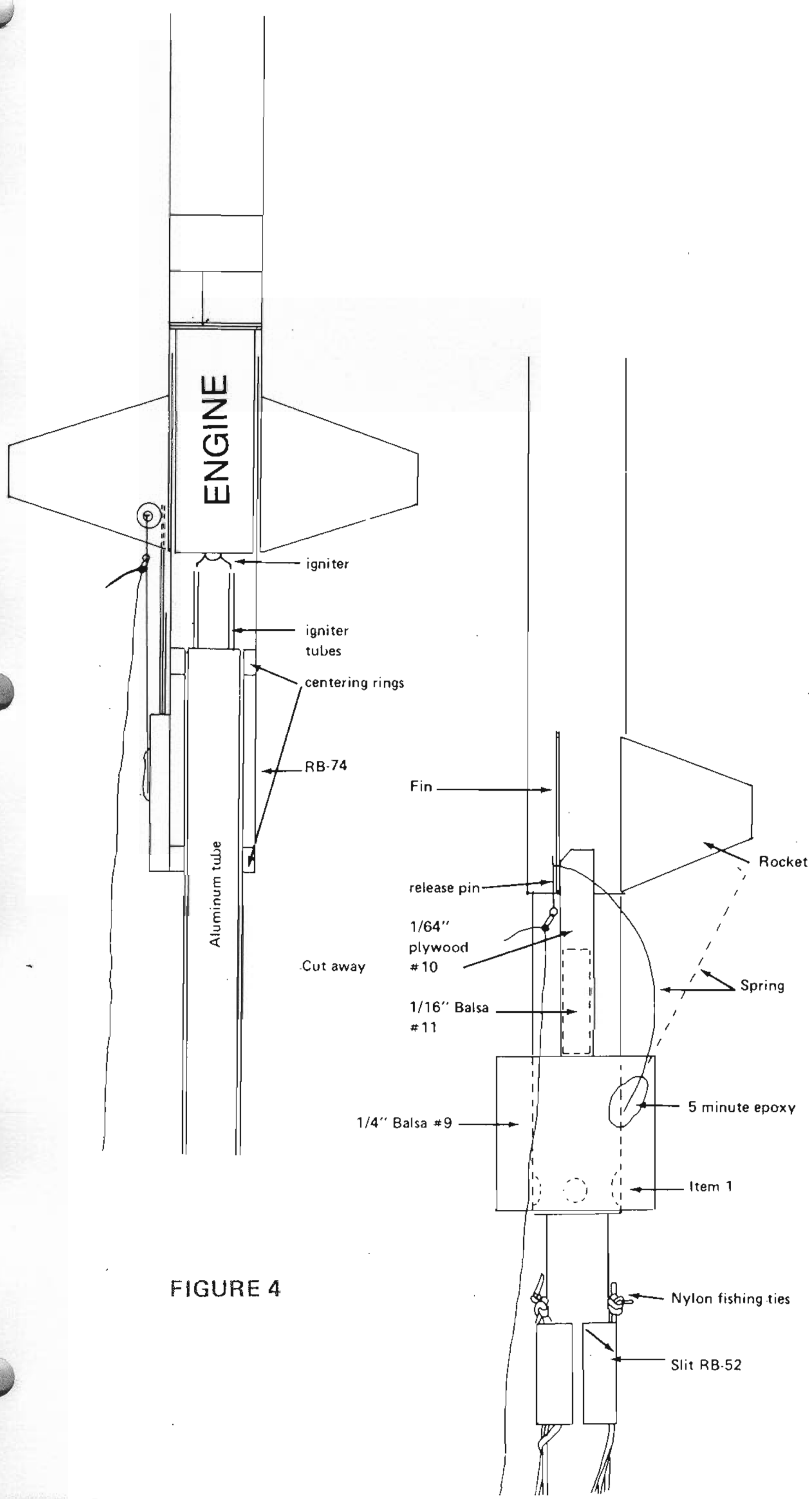


FIGURE 4

the wire and the tubes inside the piston tube. Mix up a generous amount of 5-minute epoxy; fill up the end of the piston tube with the epoxy; cup your fingers around the brass tubes and the piston tube, where all the sticky epoxy is; and turn the whole thing upside down for 5 minutes. When it has dried, sand smooth any excess that spilled over the sides.

Glue the 2 BT-5s (#4) together. The RB-52 (#6) is used as a coupler, but it's a little too big for this, so it's necessary to slit the RB-52 lengthwise and remove a ⅛" strip, or slit and overlap the ends. When gluing them together take care not to let the glue seep inside the tubes and make sure the tubes line up straight before the glue dries.

Glue centering rings (#5) to the BT-5 (#4). Be careful not to crimp the tube. (Figure 4.)

Glue on the RB-74 (#8). If you cut holes in the bottom where the centering rings are, more glue can be applied there and the RB-74 will have a stronger bond. (Figure 4, item 1.)

Glue the two fishing line ties underneath the slit RB-52 (#7). Tie them any way you can as long as you end up with two loops about six inches around for each side. The knots are glued just above the RB-52; the line then runs underneath the RB-52 and out the bottom side, where the loops hang down. Equal length is not important for the 2 sides.

Glue dowel stop to bottom of launching tube (#12).

The fishing lines that are used to stop the launching tube are attached at the ends of a 3-foot dowel in the pictures. For simplicity, however, metal screw eyes positioned where the dowel would go through should be used. The dowel outrigger was used to spin the rocket before it cleared the tower. It works straight just as well.

Screw in all three screw eyes (#20). Cut two 6" lengths of fishing line (#19). Tie one end of each to one of the screw eyes on the side (a and b on Figure 2).

The next step is to measure the correct length of stop line, the 6-foot lengths of fishing line tied to the screw eyes above. Install the launching tube over the piston. Slide the launching tube up until the bottom of the launching tube is four inches from the top of the piston. (You'll have to mark off four inches beforehand.) This is the point where the stop line will stop the launching tube. Tape the launching tube here, and it becomes easy to measure the correct length of fishing line. Attach the snap end of the snap swivels to the fishing line ties first; then tie the stop lines to the other ends, adding a little tension to the first side, which will make the launching tube lean to that side. Apply equal tension to the other side to straighten it back out. When this is finished, the launching tubes can be moved up the piston, and the fishing lines should become tight and stop the launching tube at the same time (whereas one of the lines could be too short and cause the launching tube to lean off to one side at liftoff).

The release pin (#17) is done in much the same manner. Shape the straight pin into the screw eye shape; then tie a 6-foot length of fishing line to the pin. The other end is tied to the center screw eye on the base of the launcher with enough length to pull the release pin out 2 inches before the stop lines stop the launching tube, thus freeing the rocket slightly ahead of time. This can be accomplished easiest by trial and error. (Figure 5.)

Glue spring plate (#9) to the RB-74 on the launching tube. (Figure 4.)

Glue on fin stop assembly (#10 and 11). This part is necessary to prevent the rocket from turning after the spring is hooked up. (Figure 4.)

Bend the loop in the spring wire (#14) as shown in Figures 5 and 6. It must be large enough to let the release pin slip through easily. If, however, the finished loop will not fit easily through the hole in your rocket fin, which is made of CMR plastic with a 3/32" hole through the center, the hole can be bored out with an X-Acto knife.

Epoxy the spring in place. (Figure 4.)

When the launcher is finished and dried, make a few dry runs with an engine installed in the rocket. Put the rocket on the launching tube, stick the spring through the fin, and attach the pin. Pull the rocket upwards. The release pin should come out, the spring should spring away, the launching tube should stop, and the rocket should separate fairly easily, in that order.

ROCKETS

Rockets for this particular launcher are built around RB-77, with the only difference being the engine, as in other ZVPLs, and the hole in the fin.

Simply drilling a 3/32" hole through the fin would probably work, but if you plan to use the rocket many times it is better to reinforce it with plastic. Take a .02" polystyrene sheet (from CMR), drill a 3/32" hole through it, and then punch it out with a paper hole punch. Don't use the hole puncher on the fin. If you use plywood or plastic fins you can skip the plastic. If you want to use a glider, or if your rocket won't seem to match up with the hole through the fin, the plastic can be glued to the body tubes directly or underneath the fin. This is easier to understand once you've built one and it doesn't fit.

The engine is usually secured by an engine block and a large amount of tape at the top of the engine casing to get a friction fit with the large tube. Another more complicated method, shown in Figure 7, involves gluing an engine block (BT-20) to the engine and installing the engine through the top of the rocket. I'm not going to describe it in detail. I figure if you're smart enough to figure this out, you're probably capable of building it

FIGURE 5

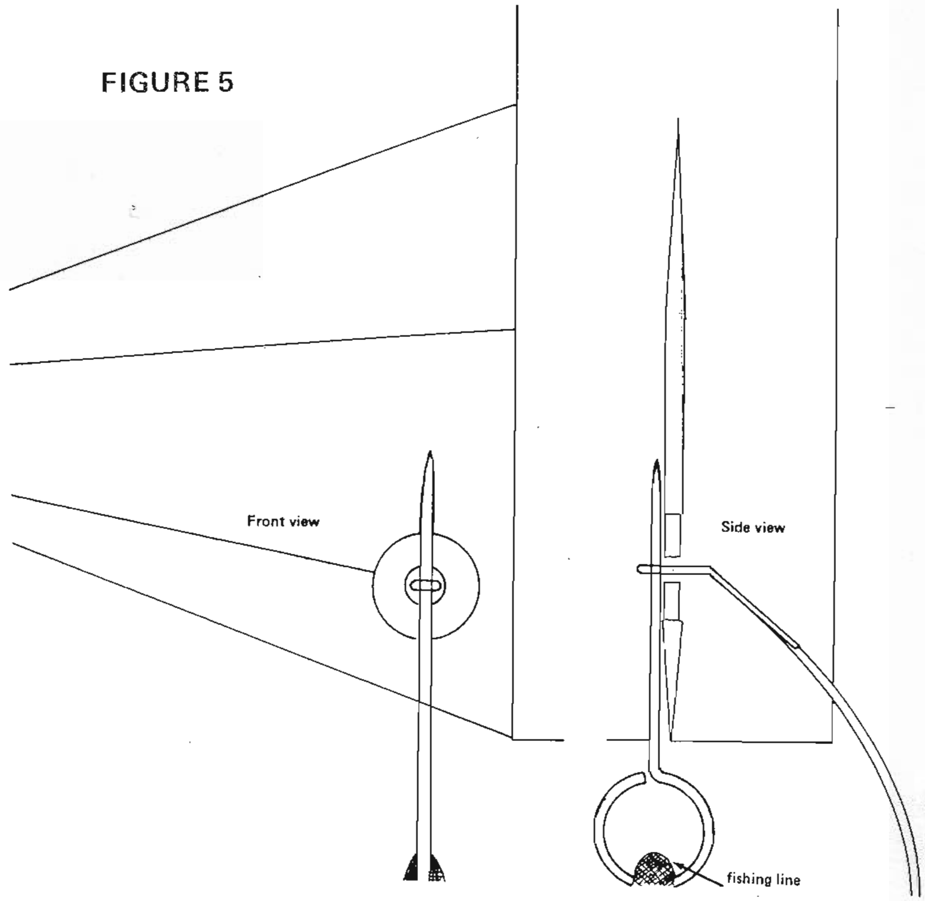


FIGURE 6

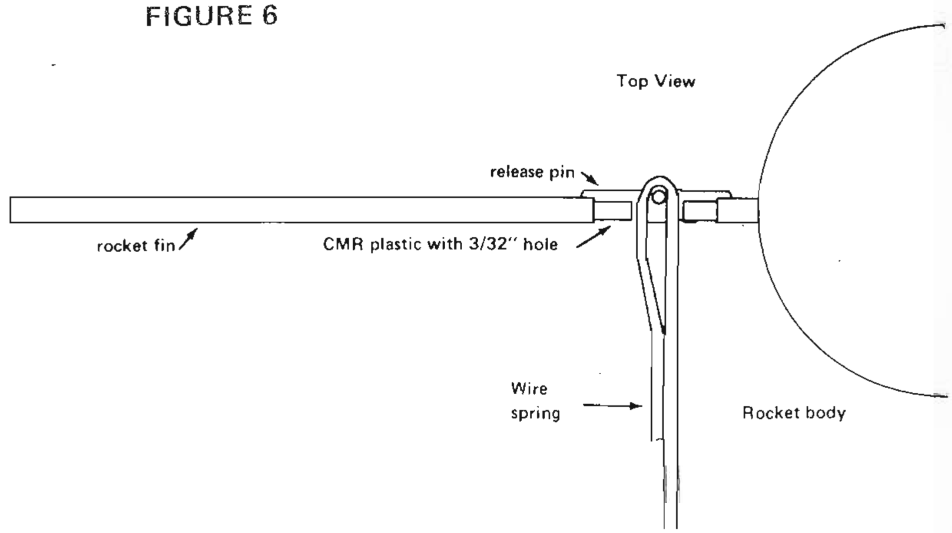
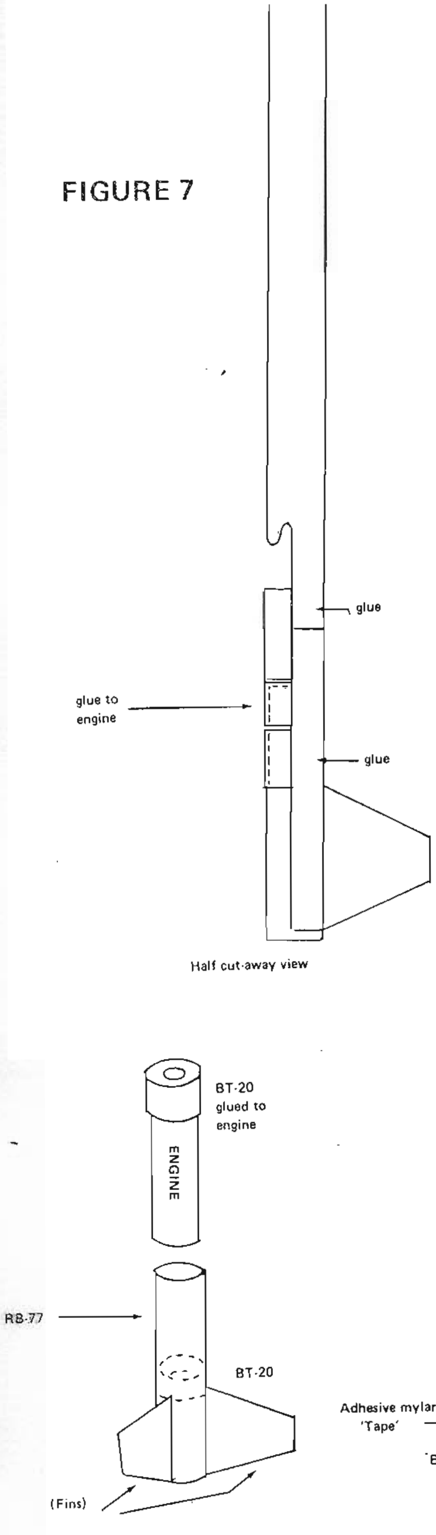


FIGURE 7



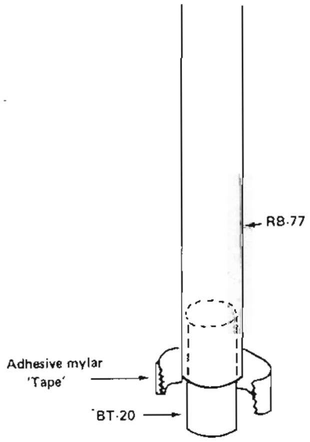
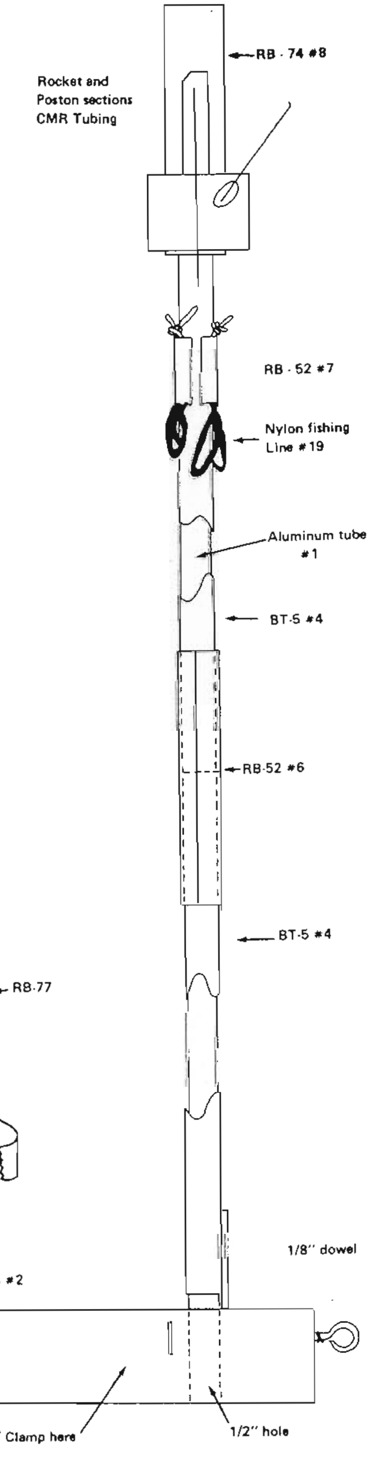


FIGURE 8



too. Be sure to use heat resistant glue, as white glue will melt, then run, and then harden again, gluing the engine permanently in the rocket. So get out the all-night epoxy and hold your nose. The shock cord is made of heavy thread similar to the stuff used on shoes. The upper half of the shock cord should be elastic. The thread is tied through the body tube as in Figure 8. This permits the engine and the upper engine block to pass without much resistance. I highly recommend test flying this first.

EARLY ZVPLs

The original ZVPLs were similar to the cutaway drawing in Figure 9. The engine block at the bottom of the launching tube was to stop the launching tube when it reached the lower piston ring. The launching tubes were a few inches shorter. Notice the bottom end is two inches off the base, so the launching tube would slide down past the piston rings. This facilitated installing the igniter and cleaning the rings after launch.

The first problem we discovered with the ZVPL was that the rockets weren't staying on the launcher long enough. In other words, the rocket would leave the launching tube after it had gone less than a foot up the piston; then the rocket would stagger up and tip off. We tried to counteract this by taping the rocket to the launching tube with small pieces of used tape, which would hold the rocket on longer and then break off. If too much tape was used, however, the launcher would shoot up, and then bust in a few places. Luckily the rocket would usually fly upward and away from the spectators carrying with it the smoldering launching tube, leaving the launcher useless for the next event.

Your ZVPL can be made for other sized engines by replacing the RB-74 on the launching tubes with an appropriate engine tube (e.g. RB-90). Remember that using this launcher for an RB-52 rocket is not worthwhile unless the launching tube and piston are about ¼ inch in diameter.

ZVPLs were mostly a NOVAAR project. Howard Kuhn came up with the original idea. Ross Iwamoto thought up the igniter tubes and Dan Meyer suggested the aluminum piston.

NOTE: Recently at NARAM-17 in Orlando, Florida, the author using this launcher along with the Prangroc egglofter built according to figure 8, placed first in eggloft with 311 meters.

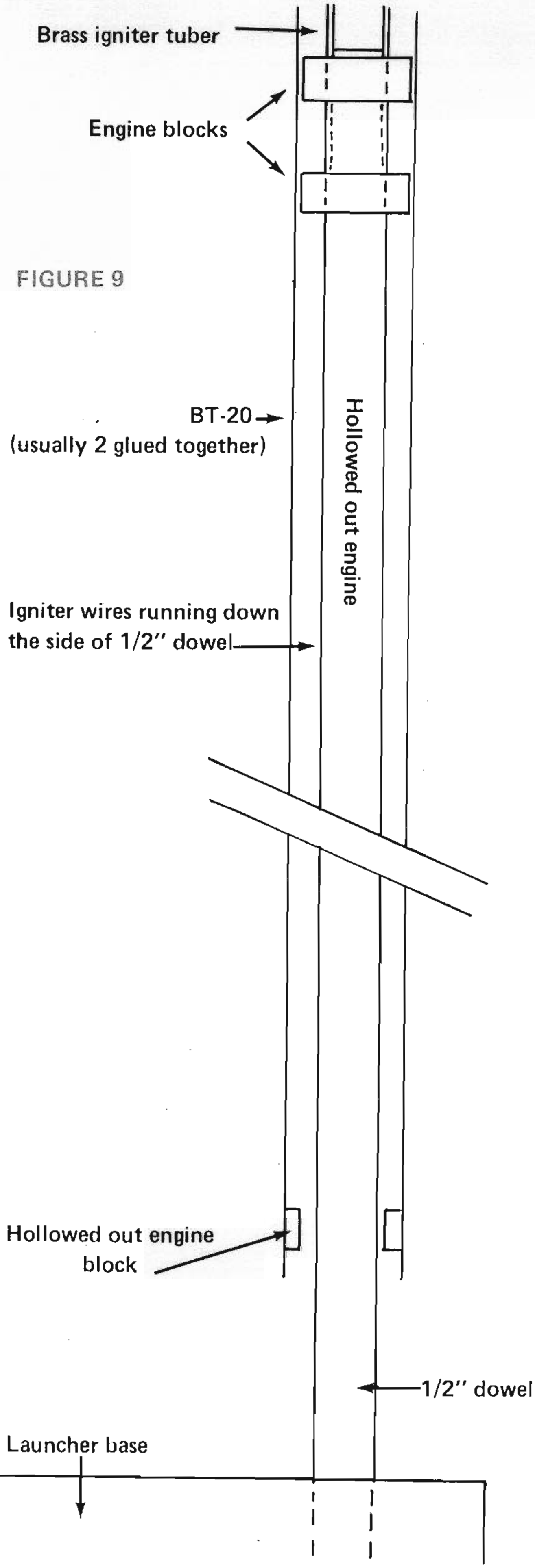


FIGURE 9

A Note from the Technical Editor

It has been a busy summer for me, and I apologize for letting any correspondence go unanswered. I have been at the Jet Propulsion Lab in California for the summer, except for the Apollo-Soyuz mission (15-25 July). I thought you might be interested in some of the details, so here goes.

Apollo-Soyuz

As you know, the joint American-Soviet space mission went well, with the successful docking of the American Apollo craft with the Soviet Soyuz in orbit. Did you know that the Soviets simultaneously had a crew in orbit in their space station, the Salyut?

The project that I work on at Goddard is the Applications Technology Satellite (ATS-6). You've probably read some of Howard Galloway's articles on ATS-6, which is a big TV relay station in the sky, in past issues of the *Model Rocketeer*. By the way, Howard is alive and well in India, coordinating the use of ATS-6 to beam television broadcasts to remote villages. I've already sent him some model rockets.

Anyway, the ATS-6 spacecraft was chosen to relay television from Apollo to the ground, due to ATS-6's unique vantage point 22,300 miles above East Africa. From its stationary point, ATS-6 could see the Apollo craft about 45 to 50 minutes out of each 100-minute orbit. This gave considerably more coverage than any ground station, which can see the Apollo for only 10 minutes or so at a time. The TV that you saw of the docking, the interior of the spacecraft, etc., was relayed through ATS-6. We effectively became a tracking station in support of Houston.

Right before the Apollo-Soyuz mission, the ATS-6 spacecraft suffered a circuitry failure in the attitude control subsystem that jeopardized our ability to support. I was quickly called back to Goddard, and the problem was solved by a reprogramming of the ATS-6 onboard computer.

During manned missions, Goddard backs up the Houston Control Center, in case Houston's computers go down. In addition, all the data from various tracking stations all over the world (and ATS-6) are routed through NASCOM at Goddard, the NASA communications network.

MJS-77

I have been involved with a project at the Jet Propulsion Laboratory in Pasadena called MJS-77, Mariner-Jupiter Saturn, due to be launched in 1977.

Its prime mission is close-up observation of the planets Jupiter and Saturn, and all (22) of their satellites. This project is an extension of the continuing study of the outer planets by JPL.