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NEWSLETTER

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Add Flip-Out Fins To Your Model Rocket

By Tim Van Milligan

In Peak-of-Flight Newsletter #300 (www.ApogeeRockets.com/Education/Downloads/Newsletter300.pdf), I showed you how to add flip-out fins to your RockSim designs. But I left the details up to you on how to actually implement the construction of such designs. In this article, I thought I'd give you some ideas on how to add flip-out fins to your rockets.

Flip-out fins are mainly used in multi-stage scale model rockets, where the upper stage doesn't have fins. The Saturn V model is a perfect example of this. Incidentally, if you're wondering why real NASA rockets don't have fins, see Peak-of-Flight Newsletter #248 (www.ApogeeRockets.com/Education/Downloads/Newsletter300.pdf). It explains how the rocket is controlled using steering motors.

The other place where flip-out fins would be useful is when the rocket is launched out of a tube. There are many military applications for this, but for us as modelers, I'll just stick with scale models. It really isn't too much different to launch a rocket out of a tube, as you'll see in this article.

Figure 1: Seperation point between the first and second stages on the Saturn V.

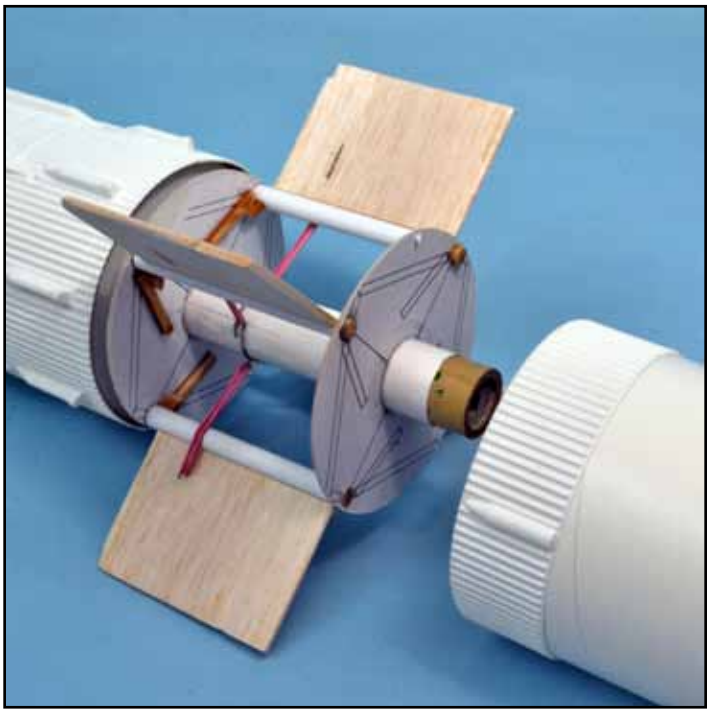

Figure 2: The fin can of the 2nd stage, with the fins in the extended position.

Method #1: Fold-out Fins

In Peak-of-Flight #300, I used the example of fins that fold radially, as shown in Figure 3. This may not be the best method for making flip-out fins, but it does work. The military uses this on many small rockets. Aerocon-Systems sells a little rocket called the FlippiFinn that utilizes surplus fin cans from military rockets, as shown in Figure 4.

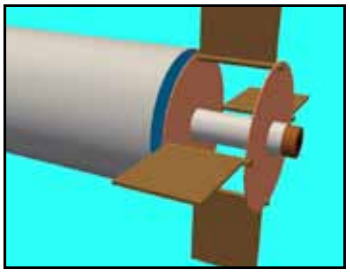

Figure 3: This is Figure 10 from Newsletter 300. Note that this matches what was created in Figure 2.

The military style rocket uses curved fins, which help increase the surface area of

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Figure 4: Fold-out Fin can from a surplus military rocket. Source http://aeroconsystems.com/cart/rockets/the-flippifin-breech-launched-model-rocket/

the fin, and make them more effective. But, as you can see from Figure 2, flat fins can also be constructed.

For something as complicated as flip out fins, you really need to plan in advance how everything is going to work. This is the type of engineering challenge that gets my blood flowing.

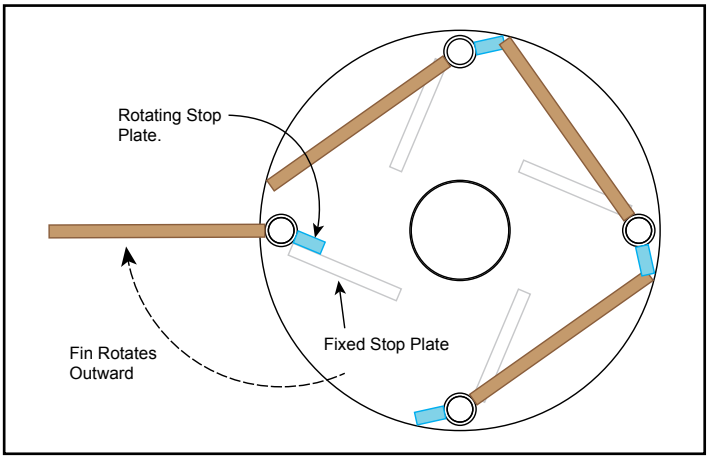

Figure 5: The stops that prevent the fins from rotating too far, were positioned using a full-size drawing.

The process starts by drawing a full-size layout of the parts. I showed the start of this in Newsletter 300, but now I had to take it a step further.

The first thing I had to find out was how far the fins would stick out once they were deployed. I needed this to put into RockSim to see if the rocket would be stable.

The next critical thing was to figure out some way to way to prevent the fins from overrotating during deployment. Obviously, you want them to be perpendicular to the body of the rocket so they stick out into the airflow as much as possible.

To stop the fins from rotating, I put little wood tabs

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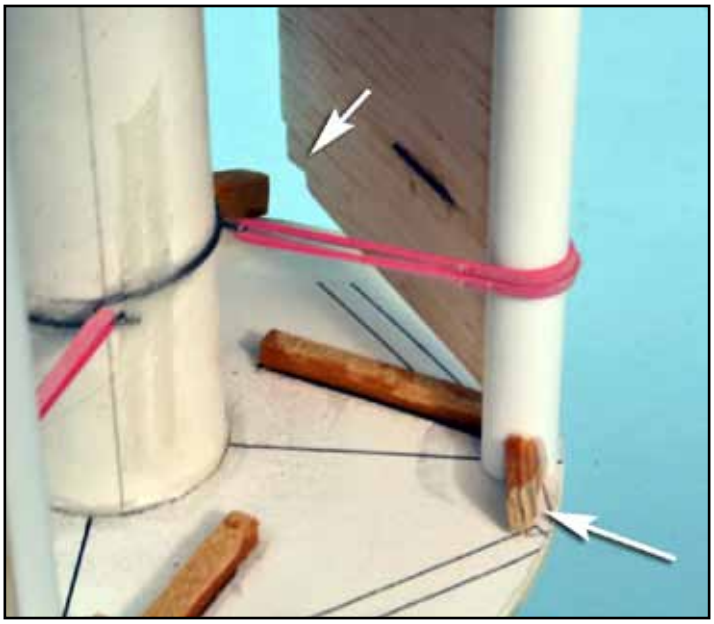
(called rotating stop plates) that would project outward from the posts. These would rotate with the fins, and strike a fixed stop-plate when the fins were in the correct deployed position. The stop-plate is longer than the little tabs, because I wanted to give a lot of glue surface to make sure they weren't snapped off by the opening force of the fins.

Making the fins and the rotating stop plate actually pivot was pretty easy. I went down to a hobby shop and found some styrene tubes that fit over a 1/4" diameter wood dowel (Figure 6). The fins and the rotating stop plate were simply glued to the styrene tubes, while the dowels that went through the tube, were glued to the centering rings.

Figure 6: A styrene tube over a wood dowel provides the pivot support for the fin.

If you look at Figure 5, you'll notice there are a couple of places where the fins would interfere with the stop plates. To overcome this problem, I made the fin a little shorter then the length of the styrene tube. This way, the



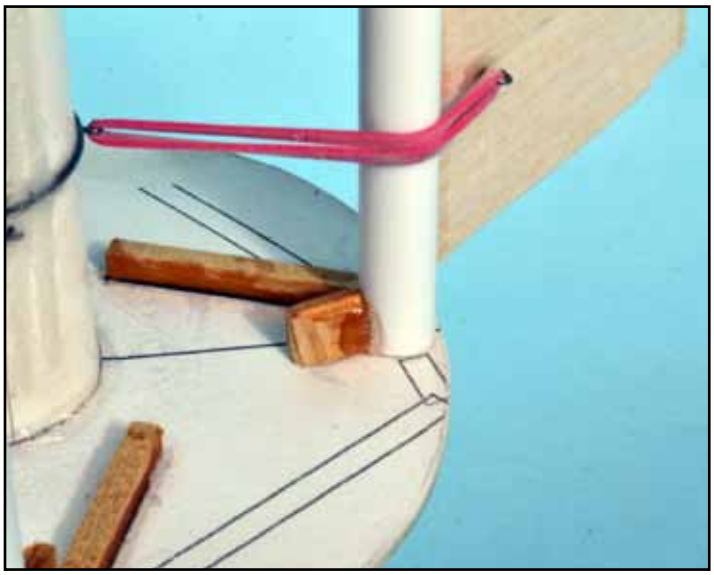


Figure 7 (Top Right): This image shows the fin and the rotating stop-plate in the stowed position. The arrow at the top shows a small cut-out I had to add on the tip of the fin so it didn't interfere with the stop plate of the fin next to it.

Figure 8 (Bottom Right): The fin is partially open. You can see the rotating stop-plate about to come into contact with the fixed stop-plate that is bonded to the centering ring.

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fin would simply swing over the fixed stop plate that was bonded to the centering ring.

The dumb thing that I forgot was that the fin also interfered with the rotating stop-plate of the fin next to it (see Figure 5). I should have cut the fins a little shorter, but I decided to simply cut a notch in the tip of the fin so that it cleared the rotating stop plate of the next fin over (as seen in Figure 7).

The last piece of the puzzle was to figure out a way to pull the fins open. The military fin cans (shown in Figure 4) use a spring. That is pretty nifty. But I decided to use a rubber band. To secure the rubber band ends, I made some small music-wire hooks. One hook was attached to the fin itself, and the other end was secured to the motor mount tube. I had to bend the leg of the hook in a curve so it would conform to the perimeter of the tube. I used this technique before, which you can see in Newsletter 243 (www.ApogeeRockets.com/Education/Downloads/Newsletter243.pdf).

To keep these hooks secured to the tube, I placed a piece of fiberglass over the top of them, which you can also see in Figure 7.

I built this fold-out fin device as a seperate fin can. To attach it to the rocket, I added two more centering rings to the front of the motor tube (Figure 10), and then glued these rings into the bottom of the upper stage tube (see Figure 2 on page 2).

The nice thing about this particular fin can is that the centering rings slip nicely into the tube of the booster stage, so the rocket is held together nicely and doesn't wobble between stages.

The one disadvantage is that the small rotating stop

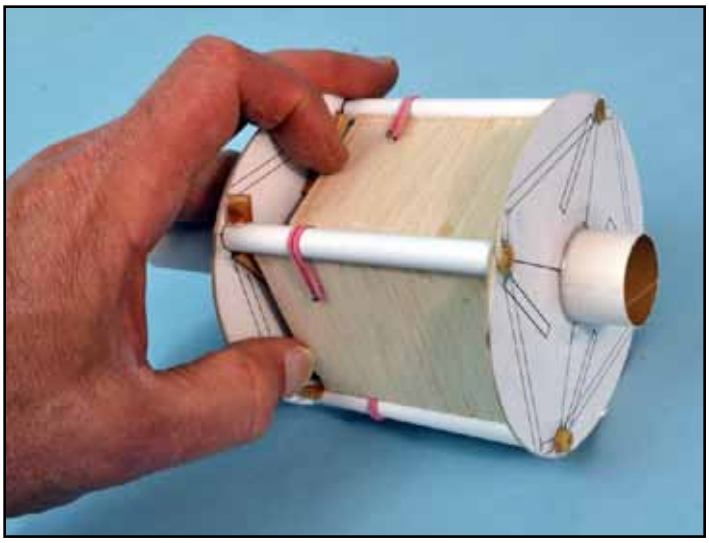

Figure 9: The fin can in the stowed position. All the rubber bands are hooked up, and as soon as you let go, they all spring open with a loud snap.

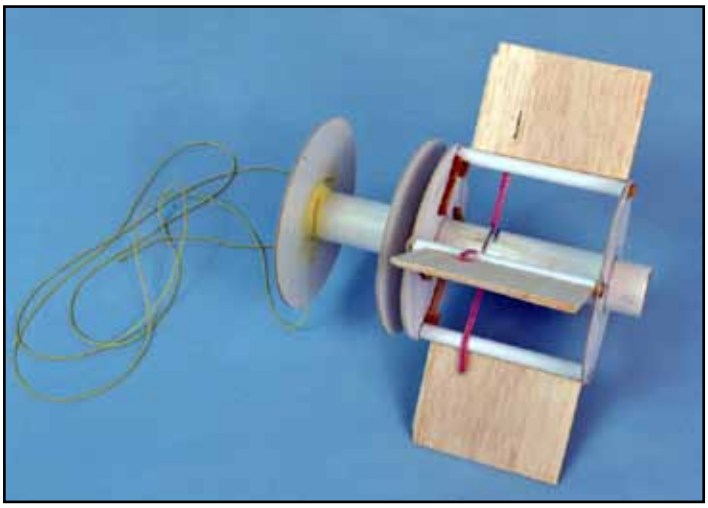

Figure 10: The completed fold-out fin can, ready to be glued into the base of the rocket.

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plates are the weak part. If the rubber bands are too tight, they are going to slam hard into the fixed stop-plates, and they could possibly snap off. So you have to make sure that they are strong, and the tension on the rubber bands is just right.

The other disadvantage is how far into the airstream the fins can protrude. The length can be made as long as you want, but the span is limited by the diameter of the body tube. This problem leads us to option 2 for flip out fins.

Method #2: Pivot Fins (Swing Aft)

When I was at NARCON in Hutchinson, Kansas in March, Bob Wingate was showing a scratch-built 2-stage Saturn V that he built with fins that pivoted in the rocket. It was so cool that I had to take some pictures of how it operated.

The neat thing about it was that the fins pivoted at the rear root edge. There are two advantages

Figure 11 (right): While I was photographing Bob Wingate's pivoting fins, Doug Guthals was taking a picture of me.

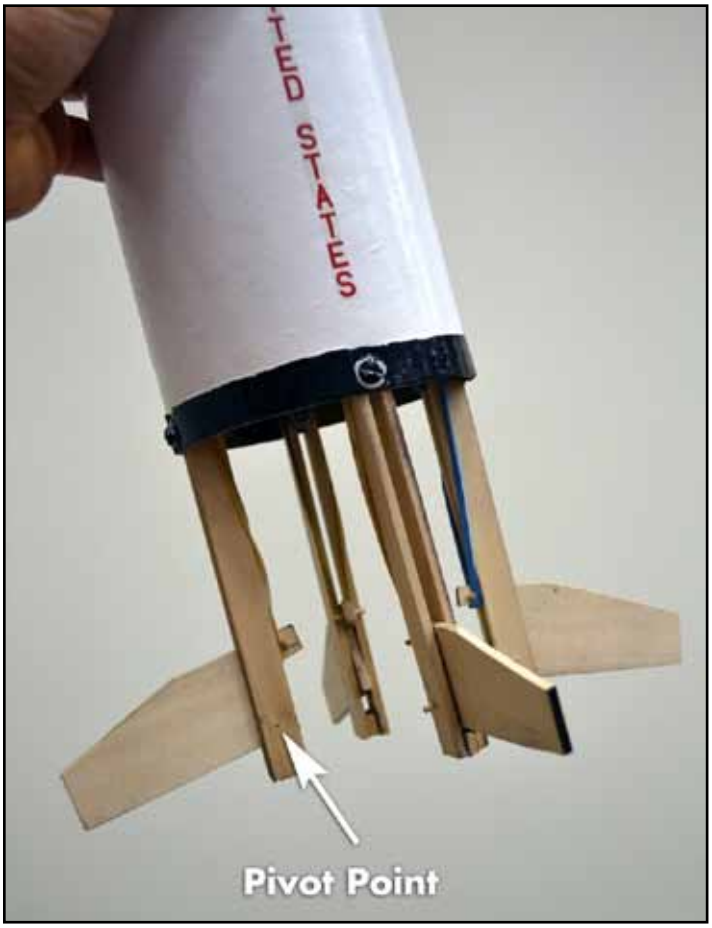

Figure 12: Close-up of deployed Pivot Fins.

to this position of the pivot point.

First, the span of the fin can be made pretty long, so the fins can project far out into the airstream. This makes them much more effective, and therefore the rocket should be very stable.

The second advantage is that the airflow actually helps

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open the fins. Since they pivot forward into the tube, as they slip open, they are designed to swing backward. The drag on the fins cased by the air will actually push them, and help deploy them. Even if a rubber band should fail, there is a chance that the fin could deploy on its own.

In this design, each of the fins are held between two long, flat sticks. The sticks have to be made of hard-wood, since they need to be rigid. The longer the sticks are, the longer the fins can be (which increases the span of the fins once they are deployed).

In Bob's rocket, he had screws securing the forward ends of the sticks to the inside of the body tube. But I can't see any reason why they couldn't be just glued along the inside of the tube. The advantage of that is that it would remove the screw-head that protrudes on the outside of the rocket (creating extra drag).

The forward ends of these wood strips are also used as the anchors for the rubber bands that pull the fins open. Bob simply laid the rubber bands over the tops of the strips. The other end of the rubber band was wrapped around a post that was built into a tab (that was similar to a through-the-wall tab) on the fin. The tab extends from the leading edge of the fin. The short post is inserted into this tab. The post also serves as a stop, to prevent the fin from over-rotating.

Figure 13 (right): The pivot fins in a partially open position so you can see how they rotate downward as the rocket stages separate.

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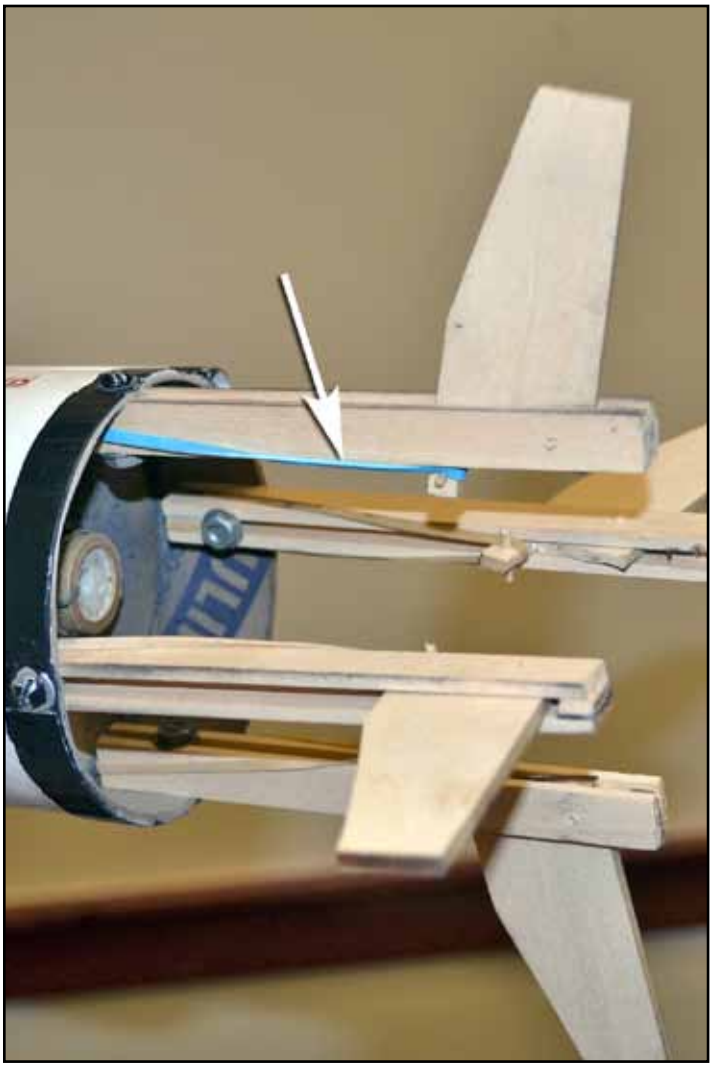

Figure 14: A rubber band, hooked over a tab on a tab on the root edge of the fin, helps deploy the fins. The forward part of the rubber band is placed over the front of the sticks that support the fins.

The cool thing is that the rubber band also acts as a little bumper that prevents the fin from hitting too hard and splitting when the fin pops open (see Figure 14).

The downside of this design is that it takes up more vertical room in the rocket. If you compare the image in Figure 15 to the one in Figure 2, you may notice that the separation plane is further forward on the rocket.

Figure 15: The fins take up a bit more room in the rocket, so the separation point moves forward.

On the upside, this design allows you to move the motor further forward in the rocket, as can be seen in Figure 14. This moves the CG further forward in the rocket, making it more stable.

Another method of making hidden fins is similar to this method. But instead of the fins swinging aft, they are swung forward.

Method #3: Pivot Fins (Swing Forward)

This design came out of the December 1976 issue of the Model Rocketeer (the old name of the NAR's bi-monthly newsletter.)

The article, by Gary Cole, entitled: "Multi-Staging the

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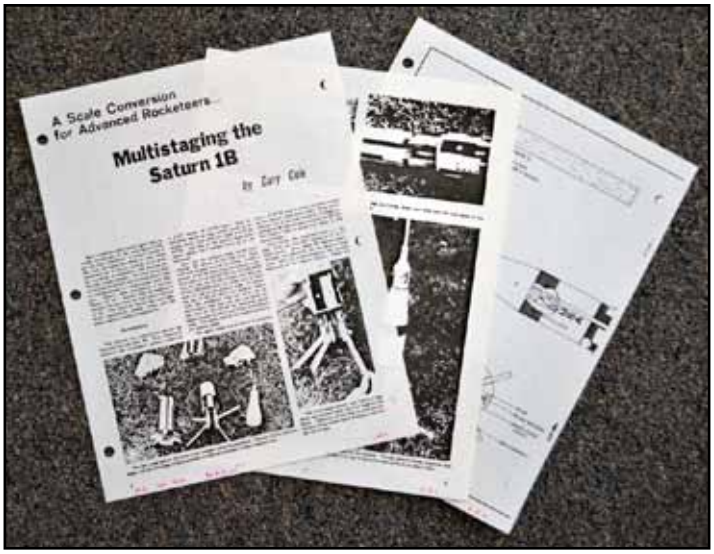

***Figure 16: Plans for swing-forward fins were found in the December 1976 issue of the* Model Rocketeer.**

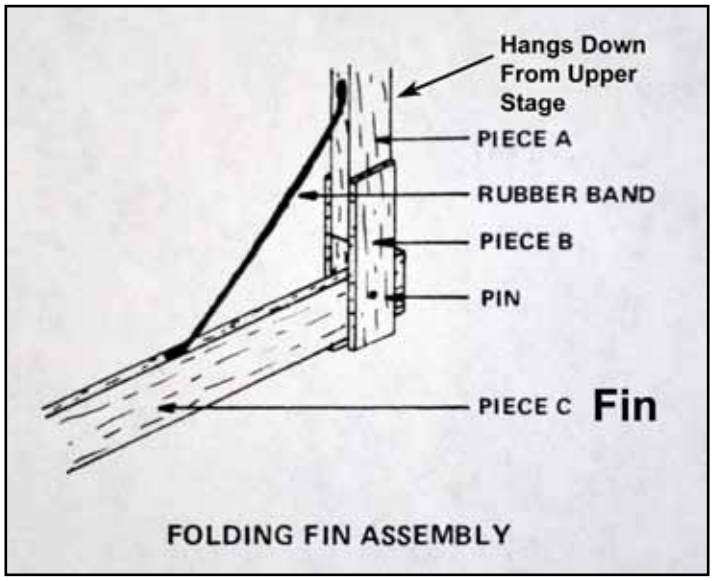

Figure 17:The hinge mechanism for swing-forward fins.

Saturn 1B" had detailed plans for swing forward fins (see Figures 16 and 17).

Now the Saturn 1B is a lot harder to stage, because the bottom portion of the rocket is made from nine different tubes. There is just not a lot of room in those tubes to make the fins have a lot of area. So even though the mechanism looks a lot like the swing-aft fins shown previously, they need to be skinnier on the Saturn 1B. In the plans, the fins look more like dowels than they do flat plate.

Dowel-type fins do work as fins, but they are not as effective in keeping the model stable, because they work on the drag-force principle, instead of the lift-force like a normal fin. See Peak-of-Flight Newsletter #314.

The swing-forward type fins have an advantage though. The mechanism can be made a lot shorter than the swing-aft fins (see figure 14). The fin doesn't need any support structure except at the very front edge. What this means is that the rocket will be lighter-weight with the swing-forward fins compared to the swing-aft fins.

The biggest downside of the swing-forward fins is that

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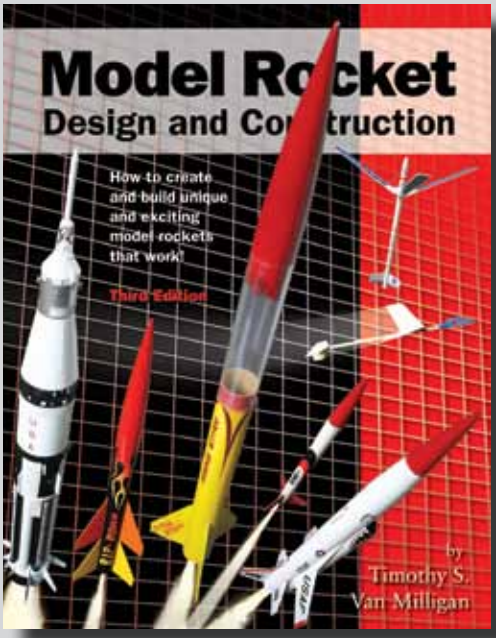

Model Rocket Design and Construction

By Timothy S. Van Milligan

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the fins also have to fight against drag as they deploy. The airflow is trying to push the fins back, while the rubber bands are trying to pull them forward. While the rocket is traveling fast, this will have a tendency to prevent the fins from splaying open all the way, thereby reducing their effectiveness even further. But as the rocket slows down, they will become a little more effective as the rubber bands are able to pull them all the way open.

Other Designs for Flip-Out Fins

I've covered three different types of flip-out fins in this artlcle. But don't think that is the end of it. There are a lot more. In fact, if you've got a design that you'd like to share, please send it my way. I love these types of designs.

About The Author:

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. Before he started writing articles and books about rocketry, he worked on the Delta II rocket that launched satellites into orbit. He has a B.S. in Aeronautical Engineering from Embry-Riddle Aeronautical University in Daytona Beach, Florida, and has worked toward a M.S. in Space Technology from the Florida Institute of Technology in Melbourne, Florida. Currently, he is the owner of Apogee Components (http://www.apogeerockets.com) and the curator of the rocketry education web site: http://www.apogeerockets.com/education/. He is also the author of the books: *"Model Rocket Design and Construction," "69 Simple Science Fair Projects with Model Rockets: Aeronautics"* and publisher of a FREE e-zine newsletter about model rockets. You can subscribe to the e-zine at the Apogee Components web site or by sending an e-mail to: ezine@apogeerockets.com with "SUBSCRIBE" as the subject line of the message.

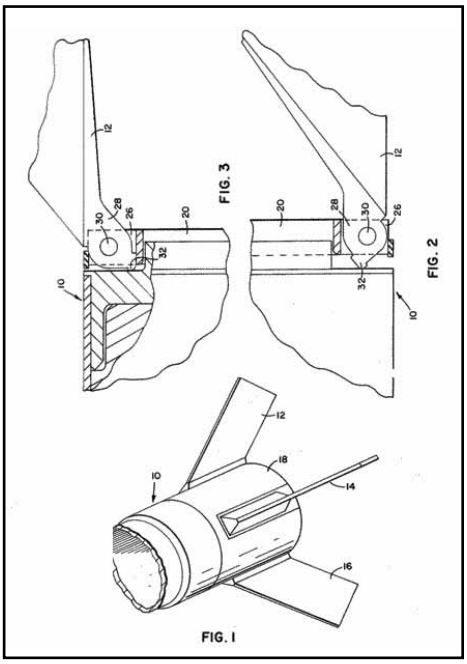

Figure 18: There are many designs for flip-out fins, like this one from a U.S. Patent.