Skylighter

Making a Girandola

Create Your Own Flying, Spinning Wheel

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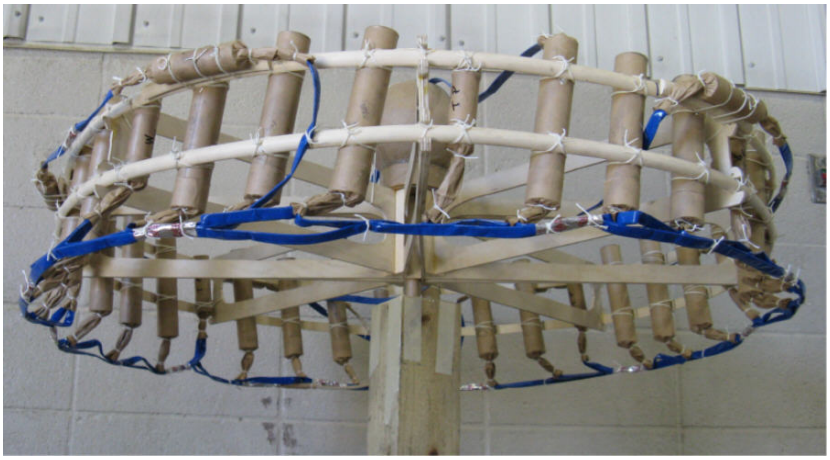
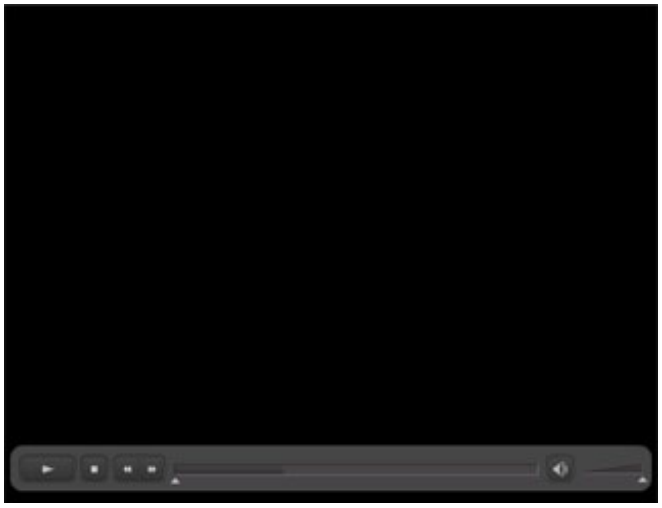
How to Make a Girandola

What is a girandola? How is the word even pronounced? (It's Italian: jee-ron'-da-la.)

You may not know the answer to one or both of those questions, but once you've seen one of these spinning, flying, fireworks wheels perform, you'll probably never forget it.



36-Inch Girandola on a Launching Post

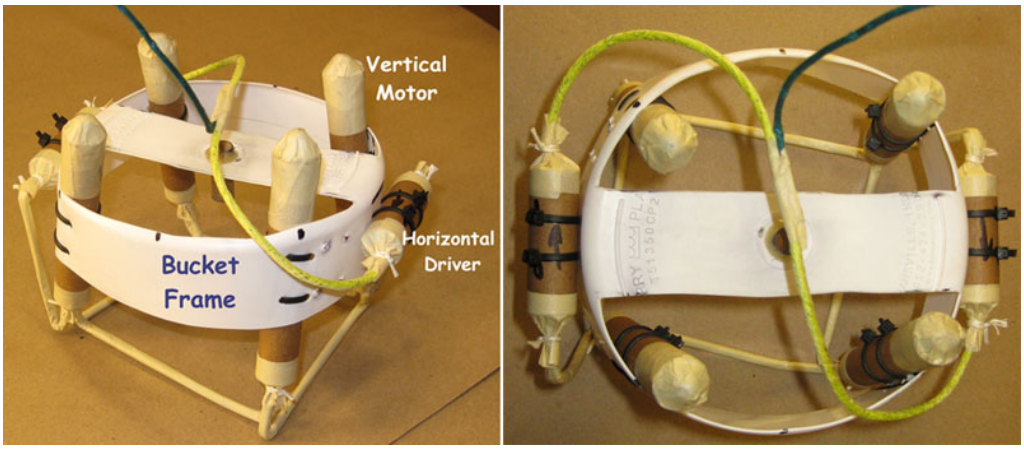


(click image to play video)

A girandola's display will typically begin with a spinning ground effect as the horizontal wheel begins to turn on its launching post under the power

of horizontal drivers. Then vertical motors ignite which cause the spinning wheel to fly skyward.

At the end of its flight, aerial effects are displayed, capping off its performance.



Here's the Turbo-Pyro Girandola

(click image to play video)

This series of effects is unique to girandolas, with ground effects progressing to rocket effects and ending with aerial effects. The girandola performs for a longer duration than most fireworks devices, with more variety than most other fireworks as well.

But, a girandola is no simple device, and fine-tuning them so that they perform well and consistently is a real challenge for the fireworker. So, it

is very satisfying when one of these “machines” is fine-tuned and performs as designed.

As a result, this Turbo Pyro project is as much of a “challenge” as it is a “how-to.” If you can get a girandola to perform well, you’ve really accomplished something, and you have displayed a multitude of fireworking skills.

Some necessary factors in a successful girandola are:

- Light weight
- Weight balance
- Stability
- Sufficient thrust

Light weight is achieved by carefully weighing each component of the girandola and reducing weight wherever possible. Weight balance is achieved by making every aspect of the girandola symmetrical, with attention to construction detail.

Stability in a girandola is achieved by spinning the machine before and during flight. This keeps the girandola stable in much the same way a spinning bicycle wheel resists changes to its position. Where sticks or fins are used to stabilize rockets, girandolas are stabilized during flight by this spinning motion.

Sufficient thrust is achieved by the installation of enough vertical motors to have the girandola fly gracefully skyward. It is this aspect of the construction we’ll address first.

Vertical Motor Thrust

A type of rocket motor that is new to the Turbo Pyro curriculum will now be introduced: the end-burning rocket motor.

End-burner motors are just like fountains in that they have no core going up into the fuel beyond the hole in the clay nozzle. Unlike fountains they use a “hot” fuel and the hole in the nozzle is smaller.

The combination of the hot fuel and the small nozzle aperture produces more thrust than the fountains did, and will enable these little end-burning motors to lift some weight when mounted on a girandola.

The slower burn, longer duration of end burners, as compared to a rocket motor with a faster burning core, also helps them lift a girandola gracefully and to a nice height.

To construct an end-burning motor, take one of the 3/8-inch ID x 3.5-inch long paper tubes and temporarily close one end of it with a piece of masking tape. Put the ram-through funnel on the other, open end of the tube.

Put a slightly rounded ¼-teaspoonful of dry clay into the tube. Hold the tape-closed end down flat on the ramming part of the combo-tool base or any other flat, solid surface. Using the solid rammer, ram a solid plug in the tube. This creates a 3/8-inch thick clay plug in the tube's end. Dump the excess clay out of the tube.

Now ram level ¼-teaspoonfuls of the black powder base mix into the tube, always using the solid rammer, until only ¼-inch of the tube remains empty.

Fill that empty space with clay and ram the clay into a solid clay bulkhead in that end of the tube. There will be a slight recess left between the clay and the end of the tube.

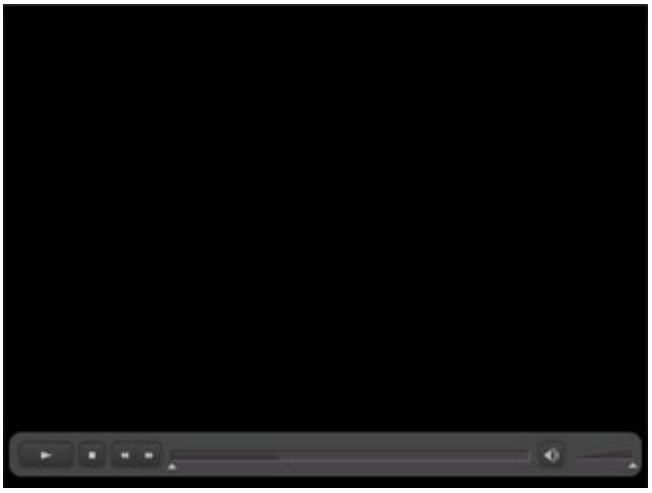
Remove the tape from the end of the paper tube. The clay will be flush with the end of the tube, and that will become the nozzle end of the motor.

Note: Do not be tempted to use the gerb spindle when ramming the nozzle of an end-burning motor. It is too wide in diameter to create enough thrust to lift the girandola.

Using a 3/32-inch drill bit, gently hand-twist-drill holes straight and dead center into and through the clay plugs at both ends of the motor until the drill just penetrates the base mix fuel about 1/16-inch.

Note: A typical nozzle hole in a black-powder end-burning rocket motor is calculated at ¼ of the tube ID: ¼ x 3/8 = 3/32 inch.


Making and Testing an End-Burner Girandola Motor



(click image to play video)

To test the thrust of one of these motors, tape a bamboo skewer to the motor and fly it with no heading. The motor should fly straight up, more slowly than the bottle-rockets did, with a distinctive “hissing” sound that is typical of end-burning motors.

A motor with a stick and a single-star heading should fly straight up or arc over only slightly during flight. Another way to actually measure the thrust of one of these motors is to rig up a little static test stand as in the photo below. A mechanical postage scale is tared to zero with the motor and wood-base sitting on it. The scale’s readout is monitored as the motor burns. This is most safely done by video taping the process, rather than standing right next to it watching the scale.

End-Burner Static Test

(click image to play video)

You can see from the video that the motor burned for almost 7 seconds with a consistent thrust of 2 ounces (about 57 grams).

So, how many motors does the girandola need to fly well? The little girandola we're about to make flies well with four vertical end-burner motors lifting it.

Typically, girandola designers shoot for a total-weight to total-thrust ratio of between 1:2 and 1:3, with the lower thrust of 1:2 producing a slower, more graceful flight, and the 1:3 ratio resulting in a fast, high flight.

Stability

Two horizontal drivers will spin the girandola up on its launching post before flight. This will create a nice low-level effect prior to the rising rocket effect of the vertical end-burner motors. The spinning action also creates the gyroscopic stabilization that the machine needs as it begins to fly straight up.

The two horizontal drivers are simply two short charcoal fountains, made just like the fountains in Turbo Pyro and the charcoal drivers in Turbo Pyro's wheel project.

Cut a 3/8-inch ID paper tube in half.

Mix 4.5 grams of base mix with 1 gram of 80-mesh charcoal.

After marking the "do not pass" line on the solid rammer, as in the fountain project, ram two half-tube fountains, just as in that project.

Drill a 3/32-inch passfire hole through the top clay bulkhead, the same way you did with the end-burner motors above.

Harvest some of the single strands of black-match out of the paper-wrapped fast fuse. Cut two 3/4-inch long pieces of the thin black-match. Put one piece into the passfire hole in the clay bulkhead of each horizontal driver.

Cut four 1-inch pieces of the black-match, and put two pieces into each nozzle hole of the horizontal drivers.

Make sure the black-match is pushed down all the way in the holes, so that it is in contact with the black fuel grain at the bottom of each hole.

Put masking-tape nosings on both ends of each of the horizontal drivers, just as was done with the drivers in the wheel project. Leave the nosings open for right now.

The Girandola Frame

The bottom of a 5-6-inch diameter chemical bucket makes a strong and light girandola frame, perfect for our purposes in this project.

Holding the bucket upside-down, measure 1.5-inches down from the bottom and put a mark all the way around the side of the bucket.

Cutting Bottom off of Bucket

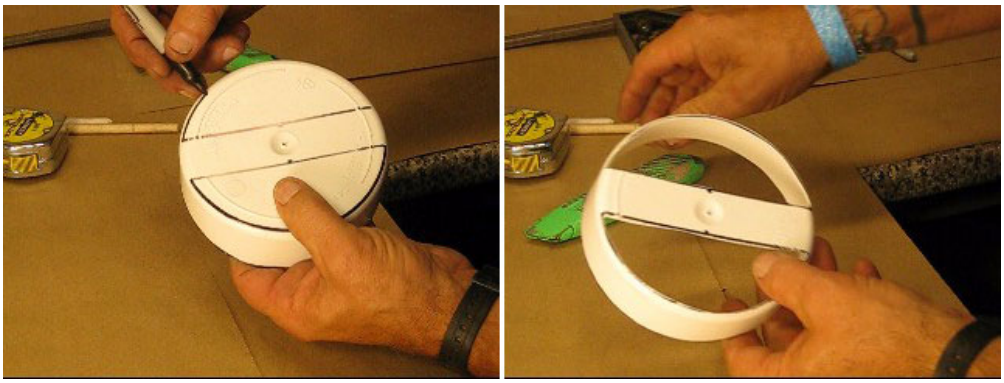
Very carefully slice this bottom section off the bucket using a razor knife, with the blade extended only 1/8-inch.

Warning: There is probably no easier way to cut yourself than when cutting plastic with a razor knife. Unfortunately there's also no better way to cut this bucket to make the girandola frame. Be very careful when performing this task. Keep your fingers and hands out of the way in case the knife slips. Don't let kids perform this task.

Now, using something that is 1-inch wide, such as a carpenter's square, measure over from the center of the bucket bottom 1/2-inch and make a dot there. Line one edge of the one-inch wide ruler up on that dot, so the ruler is centered on the bucket bottom, and mark two lines where the edges of the ruler are, as shown below.

Marking 1-Inch-Wide "Spoke"

Mark around the bottom edge of the tub as shown, and cut the sections out with your knife. Once again, be very careful.



Marking and Cutting "D" Shaped Openings in Bucket Bottom

Cut a 1-inch section of one of the sparkler tubes, if you have any left, or a section out of a soft-drink straw. Mark a hole, the same diameter as the small tube, in the center of the bucket bottom, and carefully cut the hole out with the knife.

Hot-glue the tube section into the bottom of the bucket with most of the tube's length inside the bucket as shown below. While the glue is still warm, straighten the tube to make sure it is perpendicular to the bottom of the bucket.

Hot-Gluing Tube into Hole in Girandola Frame

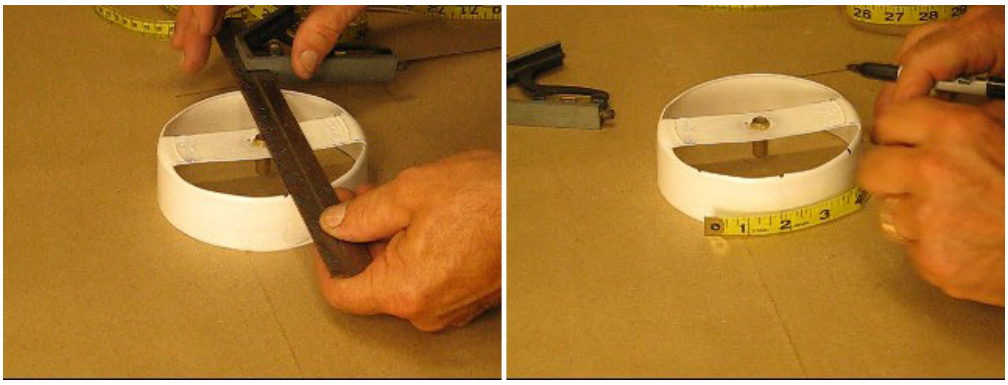
(click image to play video)

Assembling the Girandola

You already have the 2 horizontal drivers as described above.

Make 4 vertical end-burner motors and add single-star headings to each one, the same was as in the stinger-missiles project.

Now, you can lay out the locations of each of the vertical lifting motors. Hold a straight edge at 90 degrees to the frame's spoke, crossing the center of the frame. Mark each side of the frame where the centerline crosses it.



Measuring and Marking Vertical Motor Locations

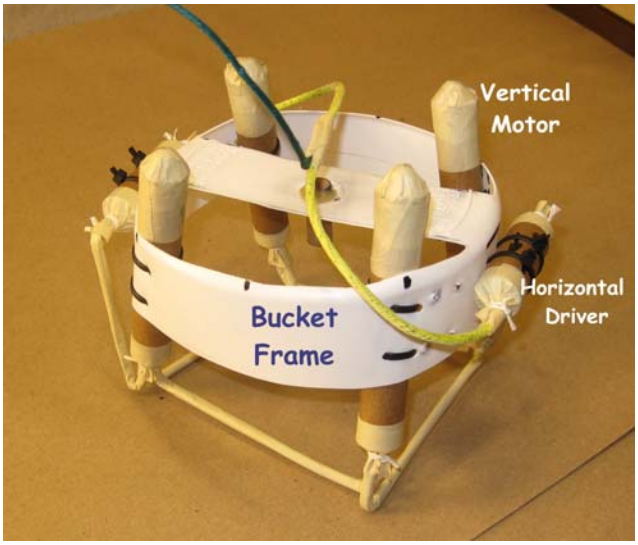
For the next part, you'll need a cloth or other flexible tape measure. From one of those centerline marks you just made, measure 2 inches (or 1/8 of the bucket's circumference if your bucket is a different size than the one used here) around the frame and make another mark. This is where one vertical motor will be located.

Measure two inches from the centerline mark in the other direction and make another mark for the second motor's location. Now turn your frame around and make the same marks on the other side. You should end up with 3 marks on each side of the frame. Ignoring the center mark on each side, the two outermost marks on each side are where the vertical motors will be located.

Once all your marks are made, you will have 4 motor locations, which are evenly spaced around the frame. Notice they are intentionally placed away from the spoke-end locations. The spoke-ends are where the horizontal drivers will be attached.

Extend the motor location marks to the top-inside of the frame. Now, here's the critical part. The motors, once they're attached, must be at a slight angle, about 5-10 degrees. Do not attach the motors so that they are vertical. If they are vertical, the girandola will not spin as it rises.

Now, look closely at this picture. This is how your vertical drivers are supposed to be mounted—on an angle.



Vertical Motors Mounted at An Angle

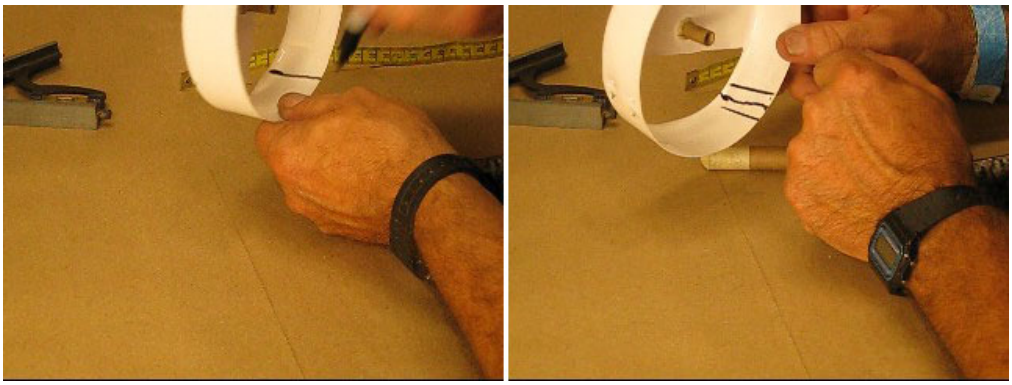
So, here's how to get that angle. Best if you read this section first, and check the photos below to make sure you understand before starting.

How to get the correct angle: First, make a mark on the inside top of the frame, right where each of your existing motor marks are. What you want to do is use this mark to begin a line down the inside of the frame to the bottom. Make that line hit a spot at the bottom edge, about 1/8-inch to the right of the mark at the top. And that's how you get the angle.

When you finish drawing that line, it should be slightly slanted, and "leaning" the left. That's the angled centerline, indicating where your motor will be mounted. Repeat this for each of other 3 the motor mount positions. Eyeball check and make sure that all of these motor mount centerlines are slanted in the same direction and at the same angle.

Now, hold a motor centered on one of the alignment marks and mark the frame where the sides of the motor will be. We'll call these the "side lines". Mark the sidelines for all 4 vertical motors. The side lines should be parallel to the motor mount centerlines.

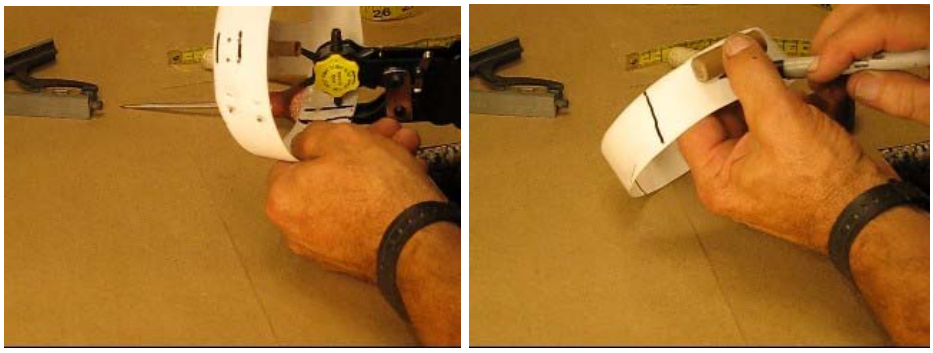
Remember that you must attach the vertical motors at an angle in order to cause them to continue the girandola's spinning (started by the horizontal drivers) as the device rises into the air.



Marking Where the Center and Sides of a Vertical Motor Will Be

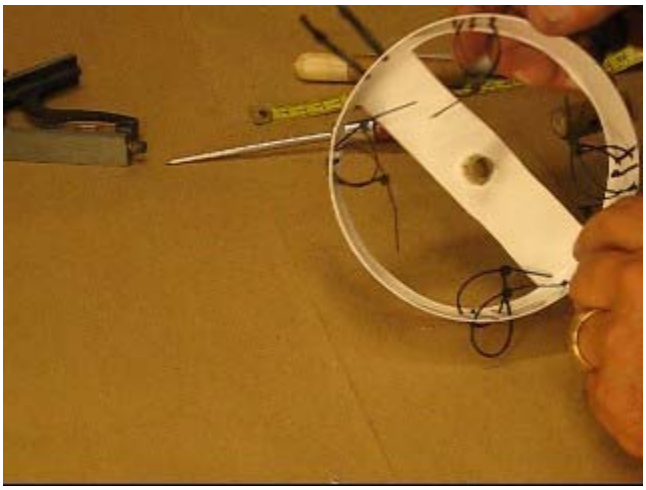
Using a hole-punch or an awl, punch a pair of small holes as shown in the photos below on each of the eight side lines for the vertical motors.

Once you have all the vertical motor holes punched, repeat the whole marking and punching process where the horizontal drivers will be located on the sides of the frame at the ends of the two spokes.



Punching Attachment Holes for Vertical and Horizontal Drivers

Now, install two cable ties for each driver. Leave them loose enough to slide the drivers into them as they are attached. See photo below.

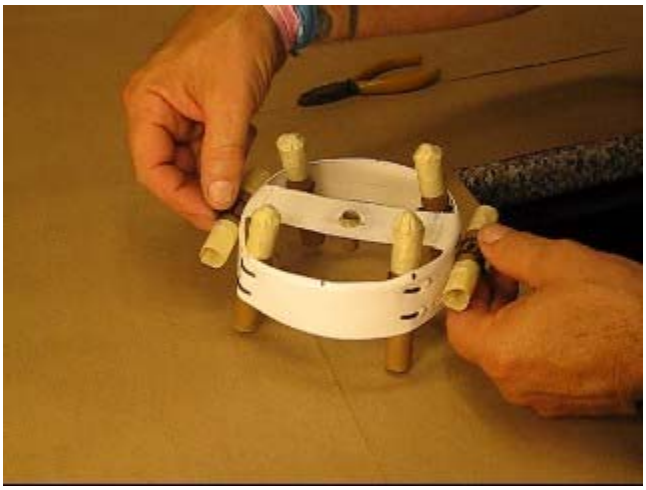


Installing Cable-Ties at Motor Attachment Points

(click image to play video)

Install the four vertical motors (not nosed on the bottoms yet), centered on the angled vertical motor centerlines with the star-headings pointing up ("up" is toward the center spoke). Tighten each cable tie. Once the ties are good and tight, clip off the excess tie ends.

Install the two horizontal drivers (with nosings on both ends), centered on the frame at the ends of the spokes, with the nozzle-ends of the drivers pointing toward the left. Tighten and clip the wire-ties.

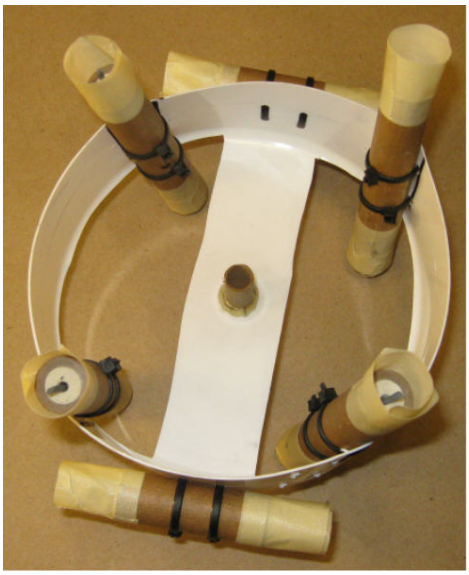


Vertical and Horizontal Drivers Installed on Girandola Frame

(click image to play video)

Note: To perform successfully, the direction of thrust from the horizontal drivers must be pushing the girandola frame in the same direction that the angled vertical motors are leaning once they ignite. Visualize the direction the vertical motors will be "twisting" the frame during flight, and verify that the thrust from the horizontal motors is turning the machine in that same direction.

Turn the girandola upside-down. Put a ¾-inch piece of the thin black-match into each nozzle hole of the vertical motors. Install masking tape nosings on the motors now, too. Leave the nosings open, as shown.



Black-Match and Masking-Tape Nosings Installed on Vertical Motors

Now it's time to install the fusing on the girandola, which is the final step in its construction prior to flight. Here's how the fusing works.

A very fast-burning fuse will attach all the nozzle ends of the vertical motors to each other for simultaneous ignition, and the passfire ends of the horizontal drivers down to those vertical motor nozzles. When those horizontal drivers finish burning, they will pass fire down to the vertical motors, ignite them, and initiate the skyward flight of the machine.

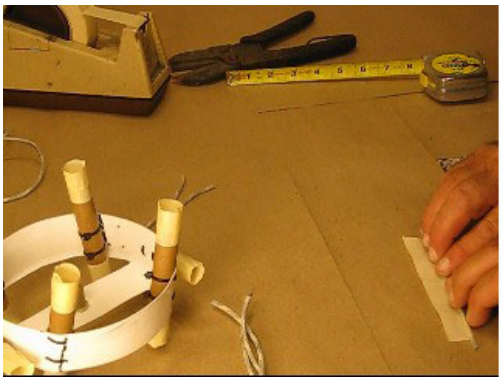
This fast ignition fuse is made by simply wrapping lengths of the paper-wrapped super fast-fuse with masking tape.

The distance between the ends of the vertical motors is 3.75 inches. You'll need another inch at each end to bend down into the motor nosings; so you cut four pieces of fast-fuse 5.75 inches long.

Similarly, two 4.5 inch pieces of fast-fuse are needed to join the passfire ends of the horizontal drivers down to the ends of the vertical motors.

Wrap those pieces of fuse in lengths of masking tape, leaving ½ inch of the fuse bare at each end.

Then tear the paper wrapping off of those bare ends to expose the three strands of black match at each end.



Wrapping Fast-Fuse with Masking Tape with Bare ½-Inch Ends

(click image to play video)

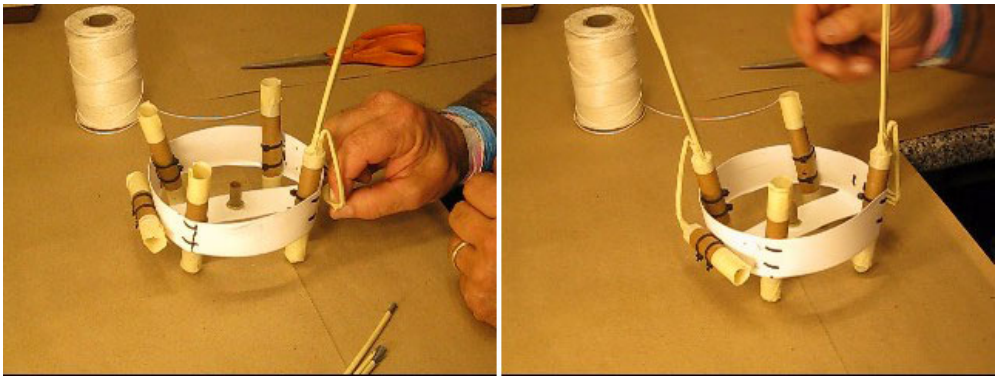
Starting with one of the horizontal drivers, install the fuse on the girandola. Stick one of the short (4.5 inch) pieces of tape-wrapped fuse into the passfire end (the end away from the nozzle) of one of the horizontal drivers. Crimp the tape around the fuse to hold it in place.

Then bend that fuse up so that it comes up to the nozzle end of the nearest vertical motor. Bend the fuse over and insert it into the nozzle end of that motor's tape nosing.

You see how it will work, right? The horizontal driver will burn, and right before it burns out, will then pass fire to the vertical motor.

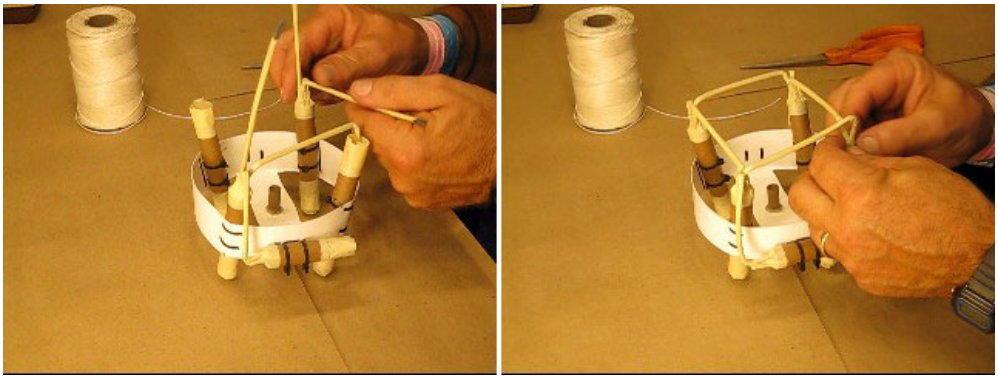
Now take two of the long (5.75 inches) pieces of fuse and stick the ends of those down into that motor's nosing as well, and crimp the tape around those three fuse ends.

Now, go to the second horizontal driver, and repeat this process on the second horizontal driver's passfire end. When you finish, both horizontal drivers will be fused to their nearest vertical drivers as you can see below.



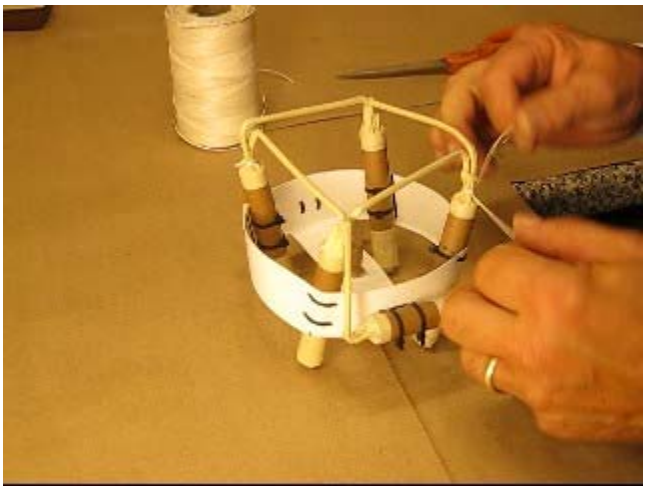
Passfire Fuse Attached from Horizontal Drivers to Vertical Motors

You now have two vertical motors, each with two pieces of fuse sticking out of their nozzle-ends. Bend these four pieces of fuse to the adjacent motor ends. Then, push them down into the nosings, crimping the tape tightly around them. When you finish, you should have a "ring" of fuse connecting the nozzle-ends of all the vertical drivers, as shown below.



Joining Vertical Motor Fuses to Each Other in a "Ring"

Tie clove-hitch knots around each nosing with thin string to tightly secure the fuses in place.



Tying Nosings with String and Clove-Hitch Knots

Now, flip the girandola over so that it's right side up (vertical motor nozzles pointing down). Join the two nozzle-ends of the horizontal drivers with a piece of yellow fast-Visco fuse bent into an S. Crimp the tape nosings and tie them as was done with the other ones.

Tape a piece of green ignition-Visco fuse so that it is attached to the yellow fast-Visco at its dead center. Just use masking tape to attach the two fuses to each other side-by-side, for surefire ignition.

Fast-Visco Fuse and Green Ignition-Visco Fuse Installed on Girandola

(click image to play video)

Here's how the ignition sequence works in your girandola:

The green ignition-Visco fuse is lit

It burns and passes fire to the center of the yellow fast-Visco fuse

The yellow fast-Visco fuse burns and ignites both horizontal drivers simultaneously

The horizontal drivers burn and then pass fire down to the bottom, nozzle ends of the vertical motors

The vertical motors burn as the machine rises into the air, and then pass fire to the star headings

The headings ignite and display

All of this presumes, of course, that we performed each task in the girandola's construction process meticulously, and that the Pyro-Gods are smiling on us.

Launching the Girandola

A 1-inch diameter wood dowel, with a piece of ¼-inch dowel in the end of it, makes a nice launching post for the girandola.

Drill a ¼-inch hole straight into the end of the dowel, about an inch deep. Then insert a 3-inch piece of the ¼-inch dowel, tapping it securely into the hole.

This leaves about 2 inches of the thin dowel pin sticking out, onto which you place the girandola for launching.

The launching post can be duct-taped to a metal stake in the ground to provide a firm and secure launching platform.

Put the girandola on the post and spin it to make sure it turns freely prior to ignition and launching.

Girandola Launching Post

(click image to play video)

And there you have it, a really creative and challenging project, which will put all your fireworking skills to the test.

There's really nothing quite like watching one of these babies fly.

Here's a slightly larger model, made with a 5-gallon bucket frame and more complex stages, in flight. You can work your way up to constructing something like this.

(click to play video)