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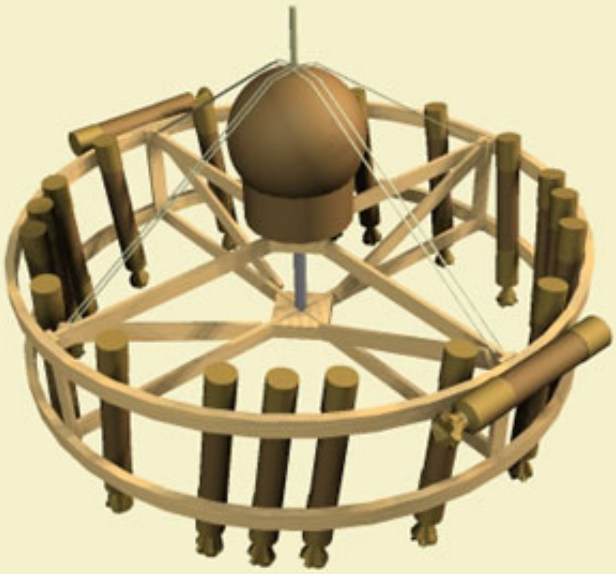
Volume 5, Issue 4

Build This...

24" Girandola w/6" Header



September, 2005 Issue

Build This:
24" Girandola

Technique:
Large Girandola Frames

Technique:
Clove Hitch Knots

Tool Tip:
String Dispenser

Autopsy:
10" Double Petal Ball Shell

Summary:

This award winning girandola uses 20 vertical drivers to lift a heavy-duty six inch double petal ball shell up several hundred feet, crowning a graceful ascent with an unexpectedly large header effect. While the frame is a respectable 2 feet in diameter, the illusion of a much larger frame is created by using a ring of 16 tethered lances that swing out on three foot long strings. For those who witnessed this beast at the 2005 PGI convention, the pictures used in this article depict the construction of the actual girandola that was used in competition, as does the companion article which shows how to build the frame.

Prerequisites: 12" Girandola, Maltese Driver Rammer, 6" Double Petal Shell

Formulas: 3/4" I.D. Vertical Driver, Winokur Silver Gerb 'C'

Materials:

- 24" double ring girandola frame weighing about 450g or less
- (20) 3/4" I.D. vertical drivers, 9 second burn time, 500g thrust
- (2) 3/4" I.D. horizontal drivers, 6 second burn time
- (2) 3/4" I.D. horizontal drivers, 9 second burn time
- (4) 5/8" I.D. silver gerbs, 9 second burn time
- (16) 3/8" I.D. green lances, 15 second burn time
- (1) 6" ball shell, 10 sec time fuse
- (12) 3 foot long internally foiled quickmatch pipes
- (40) feet of black match
- (16) strands of 3 foot long flax or hemp twine
- (48) strands of 22" long waxed linen twine
- (24) sheets of 7-1/2" x 4" wide 30 lb kraft (driver nosings)

Tools:

- Hot glue gun
- Knife
- Rubber band
- Paper hole puncher
- 5" case former
- Girandola stand
- White glue
- Foil tape

- (4) sheets of 6-3/4" x 3" wide 30 lb kraft (gerb nosings)
- (16) sheets 3" x 2-1/2" wide 30 lb kraft (lance nosings)
- (2) 4-1/2" diameter chipboard disks
- (2) 24" long x 3-1/2" wide poster board strips
- (1) 29" long x 4" wide 60 lb recycled kraft strip

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24" Girandola...

Figure 1: Completed components required to build the girandola.

Figure 2: Matching the drivers with a hooked stick of black match secured by a dab of hot glue.

Introduction

The bigger a girandola gets, the more toys it can take along for the ride. A 24" girandola can easily lift two or three pounds of payload in addition to it's own weight, which gives you a lot of options for creative effects. Not only can you increase the size or number of traditional headers fastened to the drivers, you can lift rising gerb effects, second stage mini-girandolas, parachutes, lance work attached to the frame or even separate lance work suspended below the girandola as it rises.

The girandola described here replaces the traditional driver mounted headers with one large central header. This will give you a more impressive looking header compared with the many small puffs of stars that seldom occur simultaneously using the traditional method. Keeping the header effects detached from the drivers has several advantages. A driver blow-through will not prematurely set off a header on the ground or on the way up- a defect that is often seen with the traditional method. On the flip side, thin walled star-bag type headers that are prone to accidental ignition when horizontal driver sparks work their way into the casing will not set off the underlying driver, causing it to burn backwards or from both ends (thus reducing thrust). Timing is also much easier to control with a single detached header if the effect you want is a single burst of stars that distribute equally in all directions. Trying to achieve that using multiple headers attached to the drivers relies on the unlikely combination of ramming all drivers to the exact same burn time in addition to igniting them all at the exact same time in order to achieve a uniform ring of headers that all break at the same time. Lastly, it is also less work to create one 6" shell than it is to create eight 3" shells, and the payload weight is about the same.

In addition to a nice header, this girandola also features a unique rising ring effect that employs sixteen lances suspended on threads attached around the perimeter of the frame. When the frame is spinning at a good clip, the individual lances will visually blend into one continuous ring of light surrounding the central frame. I have been using this effective trick for years and find it surprising that it hasn't caught on more in popularity, since it is simple to achieve and can be applied to any size girandola. The effect creates the illusion of a much larger frame than what is really there, and the additional weight required to produce it is minimal. Many variations can also be made, such as double rings, color changing rings, waterfall rings etc. For this project we are just using a single green ring.

A group of four downward pointing silver gerbs are also used to give a rising tail effect. I prefer to use a no-frills black powder driver for all girandolas, since the Maltese driver rammer tool can not be used

Figure 3: Nosing the drivers after fusing.

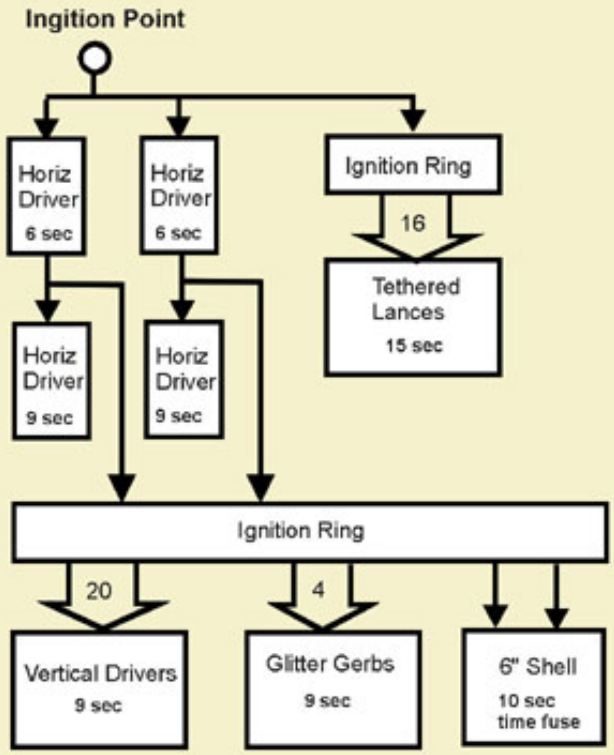
Figure 4: Dry rolling the lance tubes on a 3/8" former.

Figure 5: Tooling for securing twine into bottom of lances.

with metal dust anyway. This way I can get the driver dialed in and never mess with the formula again, then use rising gerb effects to create whatever tail effect I want.

Components

The first phase of girandola construction consists of building all the individual devices that will be attached to the frame. Sometimes this can be like building a small show, depending on the size of your girandola. The most tedious part is by far the large number of drivers that must be loaded. Figure 1 shows all the components required to build this project. Note that there are two 1-1/4" horizontal drivers in this picture, while the recommended design is to use four 3/4" horizontal drivers instead and fire them in pairs as shown in the fusing diagram below. Trying to use one pair of horizontal drivers that burn for 15 seconds tends not to generate enough thrust to get the girandola spinning good before it takes flight. The lance ring, which swings out to a radius of four feet from the center point of the frame, will add considerable resistance to rotation which requires a stronger horizontal driver than usual.



Note in the fusing diagram that the time fuse on the header shell does not take fire until the drivers fire. If the shell were to take fire at the initial ignition point, there would be a hazard to bystanders if a fusing error or defect caused the driver ring not to ignite. You don't want the shell to ignite until you know the girandola is going to fly, or at least TRY to fly!

The drivers used for this project are produced exactly as described in the Maltese Driver Rammer article. If the drivers are produced by hand ramming, they will only burn about 7 seconds. This is not long enough to get the 6" shell to a good height, but you can use an alternate payload that weighs less if you want to hand ram the drivers. Otherwise, without the driver rammer tool, you will need to

use a hydraulic press to consolidate the fuel enough to get 9 seconds of burn time.

Once the drivers are all rammed and drilled out, they are fused with a bent piece of black match as seen in Figure 2. The end of the match is hot glued to the tube wall so that it can not fall out of the hole. I prefer this method to the alternative of tamping the choke hole full of powder, which will cause a delay before the driver reaches full thrust. The method shown in Figure 2 results in instantaneous ignition of the driver, and takes fire very easily from a second piece of match tied into the final nosing. The match inserted into the choke is intentionally not directly connected to anything else, since the quickmatch fusing ring is subject to pulling forces that would potentially yank it out of the choke hole were it connected directly.

The drivers are completed by nosing with two turns of 30 lb kraft as seen in Figure 3. At this point the drivers are ready to be fastened to the frame.

Figure 6: Knotted string passed through the ramming nipple.

When making the tethered lances, the easiest way to attach the string is to ram it into the clay plug, as seen in Figure 7. This is done by using a special ramming base that has a 1/16" hole drilled all the way through the nipple, shown in Figure 5. A 3 foot strand of thin flax or hemp twine is knotted at one end and passed through the nipple hole so that the knotted end sticks out as seen in Figure 6. The tube is then placed over this and the clay plug is rammed on top of the string, thus locking the knot into the clay so that it can't easily pull out.

An alternate method to plugging the lance tubes is to ram small wads of glue soaked paper into the ends and letting them fully dry. A small 1/16" hole is then drilled through the paper plugs, then the string is knotted after it is passed up through the bottom of the tubes. This method is a little slower, but removes the need for any special tooling and works equally well.

Figure 7: Finished plug with nicely centered twine.

Because of the rammed plugs in the color lances, the tubes need to be a little thicker walled than usually required for a lance. The tubes shown in Figure 4 are dry rolled from sheets of recycled 60 lb kraft measuring 7" long x 3" wide, with paper grain running in the short direction. The tubes are rolled on a 3/8" diameter former, then plugged as described above. The tubes are then charged with green lance composition to a height that will result in a 15 second burn time. The tubes are then nosed with a 3" x 2-1/2" long strip of 30 lb kraft, into which a stick of black match is tied in with a clove hitch. A batch of finished lances is seen in Figure 8. The black match should only protrude beyond the nosing by about 3/4 inches.

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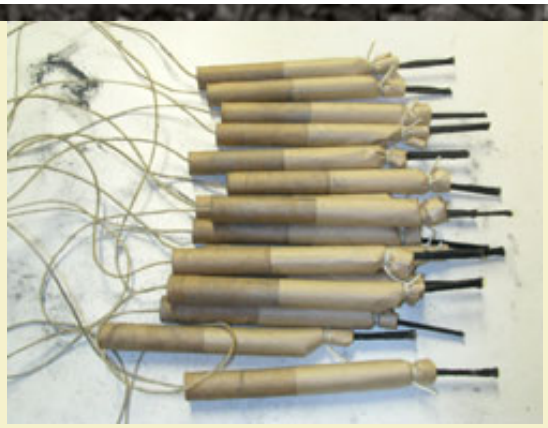

Figure 8: Completed lances ready for stringing onto the frame.

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Figure 9: Gluing the shell platform disk on top of the frame.

The horizontal drivers can be constructed the same way as the vertical ones, only it is not necessary to ram them with as much force since they will be using a slower burning composition. A mixture of ball milled meal with an additional 25% charcoal added will work well using the same driver dimensions. Extras such as titanium, ferro-titanium, steel filings, fire-fly aluminum or additional coarser charcoal can be added to taste depending on the effect you want. The first set of drivers only needs to burn about six seconds to get the frame moving and allow the lances to drop out and spin up to the same plane with the girandola. The second set is intended to burn all the way up during flight, adding significantly to the width of the rising tail. When using the lance rings, I like to avoid using bright effects such as titanium of flitter on the rising set of drivers, since too much brightness will detract from the ring effect.

The gerbs are made from 5/8" I.D. tubes that are about 3" long. They are rammed with a clay plug at one end and left unchoked at the other end. The Winokur silver gerb formula works well with no choke when suspended upside down, dropping a nice silver glitter effect with good duration and density.

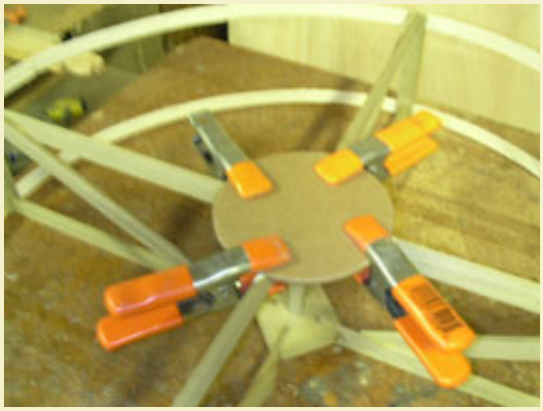

Figure 10: Using spring clamps to make sure disk is firmly planted.

The ball shell can be anything you like of course. The one used here is a paper double petal with Lancaster Yellow glitter to Dixon Gold on the outer stars and my Emerald Green on the inner petal. The construction of this shell is described here.

The charge heights in all these devices must be tested and figured out on an individual basis. I will usually retest each new batch of composition when building a new girandola, since timing is so critical here. You don't want anything left still burning by the time the shell goes off, and you don't want the ring or horizontal drivers burning out half way through the ascent either.

The duration of the vertical drivers are what will determine the time values of everything else, so measure these first and design around it. All the times given here are based on a vertical driver burn time of nine seconds. You must adjust the values accordingly for the burn time of your own drivers. Note that the shell time fuse has an extra second of delay built into it just to give everything time to extinguish, since everything never ignites at the exact same time.

Assembly

Once you have all the components shown in Figure 1 produced, you are more than half way done. It does take several hours to strap all this to a frame and fuse it together though. The frame used here is built as described here.

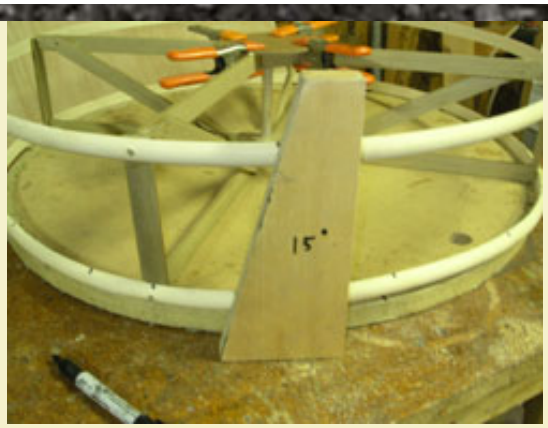

Figure 11: Using a 15 degree angle jig to mark driver connection points.

Before you start fastening drivers to the frame, a few modifications need to be made. First you will need to attach a cardboard disk to the top where the header will be attached. Glue is applied to the tops of the frame spokes, then spring clamps are used to hold down the disk as seen in Figure 10. Note in Figure 9 that a wad of paper has been stuffed in the axle hole, which prevents glue from dripping down into the tube and jamming the pin when placed on the launch pad. Note that you won't be able to use long launch pins with this girandola, since the center shell blocks the pin hole. Really you should not be using launch pins that protrude beyond the top of your frame anyway, as long pins just cause your girandola to waste valuable flight time trying to work their way off the pin. Only two or three inches of pin are all that is needed.

It is a good idea to mark your frame where the drivers will be fastened. This way you get even placement of your drivers with a consistent firing angle. If you marked the driver placement on the bottom ring as mentioned earlier then all you need to do is mark the top ring. Figure 11 shows an angle gauge that is aligned with the bottom mark to find where the top mark will be. The drivers are placed 15 degrees from vertical, thus the piece of scrap wood is cut with a 15 degree angle.

Figure 12: Drilling 3/32" holes through lower ring where tethered lances will be fastened.

Since this girandola will have a lance ring, you will need to drill a series of 3/32" holes around the lower frame ring where the strings will attach. The strings will be passed through these holes and then knotted one or two times to keep them from pulling back out. The holes should be located about an inch to the right of each driver mark, as seen in Figure 12.

The type of twine used to assemble girandolas is pretty important. The twine needs to be coated with a tacky substance such as bees wax or tar. This sticky coating helps the twine grip the driver and frame members so that everything stays tight, and also keeps the knots from slipping into a loose tie point as you work. If you do not have any waxed twine on hand, it is not too difficult to make some yourself. One method is to fix a block of wax in a vice and run each segment of twine through it back and forth several times to coat it. This can be a bit tedious when you have almost 50 pieces of twine to coat though. An alternate method is to melt some bees wax in a hot pot and drag some twine through it onto a rotating frame as when making black match. It is important to use bees wax and not candle wax, however, as the latter is not tacky and your knots will slip (which is what you are trying to avoid by using wax in the first place). A high quality waxed linen twine can also be found at PyroSupplies.com, which is the twine being used in the photos here.


Figure 13: Tying the gerbs onto the lower inside spokes of the frame.

Tar is the traditional coating for girandola string, which works even better than the wax but it is not commercially available anywhere that I have ever heard of so you have to make it. The tarred string is a little messier and trickier to make than the waxed string, so it will have to be the subject of a future article.

Start by cutting 48 segments of waxed or tarred twine that measure 22 inches long. The string dispenser described here can make short work of this task. The dispenser is placed 22 inches from a table

edge or other marker, then pull out to the marker and drop the string down on the razor to rapidly cut the segments.

It is easiest to tie the items onto the frame by placing it on a launching stick that sits about eye level. This way you can easily spin the frame as you work, and it is easy to see what you are doing. Trying to work with such a large frame while it sits on a table top would be quite difficult.

The first items to be tied to the frame are the gerbs, which are located on the lower spokes as shown in Figure 13. The sequence for tying a tube onto the frame is shown below, which is the same knot used for all drivers except for the horizontal drivers (since they don't cross perpendicular to a frame member).

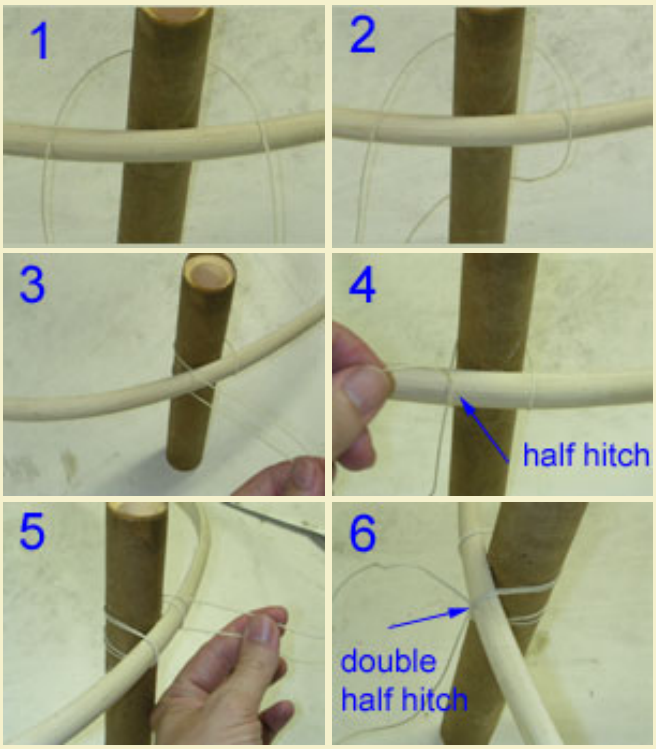


Figure 14: Temporarily holding the top end of a driver using a rubber band while the bottom end is tied.


Figure 15: Tying on horizontal drivers after all vertical drivers are attached.

Next attach vertical drivers at the 16 points that were marked on the frame. It helps to temporarily hold the top of the driver to the upper ring using a rubber band while tying the bottom end, as seen in Figure 14. The rubber band is then removed to tie the top end. After the first 16 drivers are attached, add one more driver between two existing drivers in each quadrant of the frame. When expanding the driver count beyond 16, you always have to add them in pairs at opposite sides of the frame in order to keep it balanced. Thus the driver configurations must increase in multiples of two, from 16 to 18 to 20 etc.

The last items to tie on are the horizontal drivers, which are also done in pairs on opposite sides of the frame to keep things balanced. Be sure that the direction of thrust for the horizontal drivers matches the direction of rotation that will be generated from the vertical drivers, as seen in Figure 15. Getting these backwards will result in a girandola that actually slows its horizontal rotation and could even stop rotating altogether during mid flight!

Figure 16: Frame is set upside down for fusing of drivers and gerbs.

Once everything is tied onto the frame, it is removed from the stand and placed upside down on a table for the fusing process, as seen in Figure 16.

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Figure 17: Placing loose clove hitch ties around each driver to be nosed.

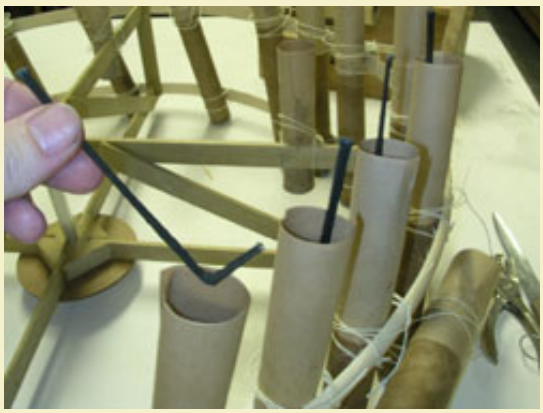


Figure 18: Inserting sticks of black match with a hooked end into each vertical driver.

Fusing

In preparation for tying off all the nosings (28 in this case), I find it saves a lot of time to pre-tie some loose fitting clove hitch knots and slide them over each casing as seen in Figure 17. The clove hitch is first tied around two or three of your fingers, then slipped off and cut free. When you are ready to tie of the nosings, simply slide the pre-tied knot in place and pull the two strings. This way you can tie all the knots one after the other in rapid succession instead of trying to fish string in and around each driver one at a time.

The first items to fuse are the ring of 20 drivers, which are fused with a single hooked stick of high quality black match cut to a length that will give you about an inch of bare match above the nosing paper. The black match is hooked on the end going into the driver, as seen in Figure 18. This helps prevent the sticks from being pulled out from violent lurches that the ignition ring may undergo as the hot gases race through it. This match needs to be a good quality seven or eight strand construction with a solid coating of BP into the core, since it will get bent up a bit while feeding the ends into the ignition ring. Simply insert a stick into each driver and then cinch the nosing paper around it using the pre-tied clove hitch knots.

Once all the vertical drivers are matched, it is time to make the ignition ring that fuses them all together. This is made with several pipes of hand-rolled 3/8" I.D. pipe that has been internally foiled as described here. The foil is to protect the drivers from accidental ignition by sparks from the horizontal drivers or even sparks from other fireworks at the launch site. Failure to heed this step can lead to problems more often than you might think. I've never had things fire out of sequence even once since I started using this type of fire resistant pipe.

Begin by bending an empty stick of pipe around the drivers and marking where the fuse points will be, as seen in Figure 19. Make sure the end of the pipe starts between two drivers when doing this, since it takes multiple pipes to make the full ring and you want the joints to fall between the drivers instead of right over them.

Once the first pipe is marked, use a paper hole puncher to cut half circles where the marks are, as depicted in Figure 20. Then you will need to flatten out the pipe and insert two sticks of good quality black match down its full length. One stick would probably work if you have good match, but two makes for better insurance. Two sticks of match are used for all the piped connections throughout the construction of this device.

Figure 19: Marking insert points on empty match pipe where drivers will connect.

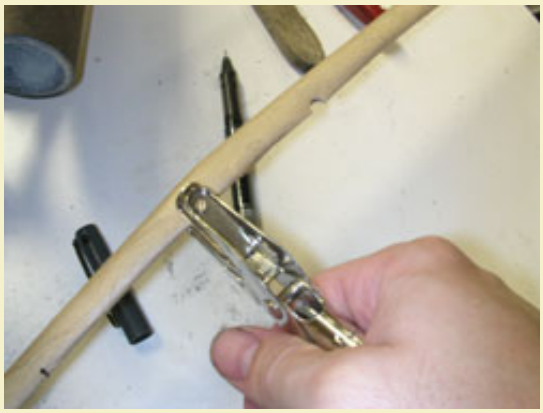


Figure 20: Using a paper hole puncher to open the pipe at the marked connection points.

Figure 21: Inserting the driver match into the punched fused pipe.

Once the first segment of pipe is prepared, bend it back into a curve and work it into position by feeding the match stick from each driver into its corresponding hole. You may need to enlarge the hole with the tip of a pencil if the match has a hard time fitting inside. Figure 21 shows the first section of pipe put in place. Note that both ends fall between drivers, thus keeping the joints in a place that won't interfere with anything. When joining the next piece of pipe onto the end of the previous one, you will need to crimp the end of one piece and insert it inside the other. A piece of foil tape can then be used to secure around the joint so that they don't slide apart.

Figure 22 shows the completed ignition ring for the drivers, which takes about two and a half sticks of three foot match pipe to make. The next step is to foil over each fuse junction, as seen in Figure 23. A piece of foil tape is draped over the junction between the driver and the ignition ring, which helps protect any exposed black match from stray sparks that could set the ring off too early. Figure 23 shows the folding pattern for the foil in three stages on three different drivers. The foil tape makes these junctions quite a bit sturdier, such that you can actually rest the completed girandola on it's ignition ring without crushing or crumpling any of these fuse junctions.

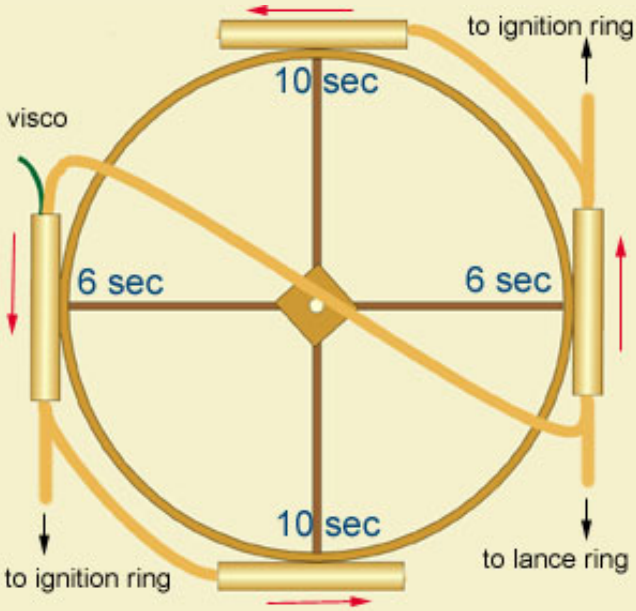
It helps to think of your network of quickmatch pipes and junctions as a plumbing system. For a brief second, these pipes will be under pressure with heated gas flowing through them just like water flows through pipes. The gas runs faster than the actual flame front burning on the fuse, and it is the gas that actually ignites everything. The stronger the pipes are, the longer they will be able to contain the pressure without bursting, thus the longer your effects will be exposed to the hot gases they need for ignition. Keeping the pipes free of crimps and blockages also helps increase the speed and efficiency of ignition. Thus you don't want to tie off the nosings around single match strands too overly tight, otherwise you create a fire block. For multiple match strands this is not as much of an issue because there will always be an air gap between the strands for gas to get into. The foiled junctions over the drivers are like T-joints in a plumbing system, and their resistance to fire and pressure help insure that hot gasses are quickly transmitted through tiny gaps around the tie-off points.

With the main ignition ring complete, you can now begin tying the remaining items into it. Each of the four glitter gerbs need to be tied into the ignition ring. This can be done by punching a hole into the side of the ring using an awl, then using a pencil tip to enlarge the hole to the size shown in Figure 24. Here we see a tie-in point for one of the gerbs, showing a short stick of bare match being inserted into the ignition ring. This junction should be foiled over with one or two turns of foil tape to protect any exposed black match from sparks. The opposite end of this connection pipe has a short stick of bare match protruding as well, which is bent into a hook and inserted into one of the gerbs. One opposing set of gerbs can have the nosing tied off, while the other set will need to have an additional pipe running up to the 6" shell so it should be left untied until later.

When making all the adjoining connections into the ignition ring, it is important to pay attention to the direction of rotation the girandola will take. The pipe should run in the direction of the airflow rather than against it, otherwise you create a spark trap between the two pipes

where a spark could blast it's way between the pipes where no protective tape exists. Such a spark could find it's way into the bare match at the junction and send the girandola flying ahead of schedule!

Figure 22: The completed ring takes two three separate pipe segments to complete.



The diagram above shows how the horizontal drivers should be fused together. The first pair ignite along with the lance ring. It will take about a second for the lances to burn off their nosing so that they can drop down, after which the drivers will spin them around until they rise up to the same level as the frame they are attached to. After six seconds, the second set of horizontal drivers are ignited from the back end of the first set of drivers. At this time the main ignition ring will also take fire and the girandola will lift off. The second set of horizontal drivers will continue for the full duration of flight, burning out just before the header explodes.

Figure 23: Taping off connection points with foil tape.

Note that the long piece of quickmatch that runs across the frame should be routed through the center of the frame, not below or above it. This insures that it does not cover the launch pin hole and accidentally get in the way.

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Figure 24: Inserting connections for fusing one of four gerbs.

Figure 25: The hooked stick of blackmatch protruding from the quickmatch is inserted into one of the gerbs and tied off.

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Figure 26: Rolling half of a Maltese style canister to use for a ball shell holding fixture.

Figure 27: The completed shell mounting fixture.

Attaching the Header

At this point you have a solid girandola capable of lifting up to three pounds of effects to a respectable height. The less weight you add onto it then the higher it will fly of course, but the 3 lb limit will still get it up to the standard height. Adding nothing at all would probably allow it to go to a pretty spectacular height.

To attach the six inch ball shell at the center, you will need to make a cup-like holding fixture, seen in Figure 27. This is rolled on a 5" case former using the Maltese style of canister shell construction. That is, two turns of pasted poster board inside of two turns of recycled kraft, then pleated down over an end disk using a knife to cut 1-1/2" long tabs at the end. The cup walls should be 2" tall after it is completed.

After the cup dries, use a knife to slot some 1/2" tabs all around the edge, then flare them out as seen in Figure 28. This cup is secured to the center platform on top of the frame using hot glue, also seen in Figure 28.

The six inch shell built for the header needs to have a time fuse that burns one second longer than your vertical driver duration, which is 10 seconds in this case. That is quite a long time fuse, measuring 4" between cross match holes when using standard Chinese time fuse that burns about 2.5 seconds per inch. There will be at least 2 inches of time fuse sticking out from the shell.

The shell is hot glued into the holding cup with the time fuse pointing upwards, as seen in Figure 29. The tabs are bent slightly outward prior to applying the hot glue so that it will conform to the curved shell wall. If you were using a canister shell, you could omit the holding cup and just glue the shell directly to the center disk on the frame.

The header shell is pretty safe from centrifugal forces as long as it is mounted dead center on the frame. Anyone who remembers standing dead center on a rapidly moving merry-go-round as a kid knows that there isn't much force at that location. But get even a little off center and you find yourself on the verge of becoming a playground statistic! To help insure your shell doesn't suffer the same fate, twine is used to secure it further. The twine runs through holes drilled through the frame spokes near the ends, then loops back and ties off on the time fuse. While one long piece could be used to tie off all four supports, it is easier to use two separate pieces to tie two sets of two. Start by securing one end to the time fuse using a clove hitch, then loop through one frame member back up to the time fuse again. Pull the twine tight and wrap it around the time fuse a few more times to keep the tension, then loop to the opposite side of the

Figure 28: The rim of the shell fixture is slotted and flared out prior to attaching with hot glue.

Figure 29: Hot glue is used to secure the 6" ball shell into the holding fixture.

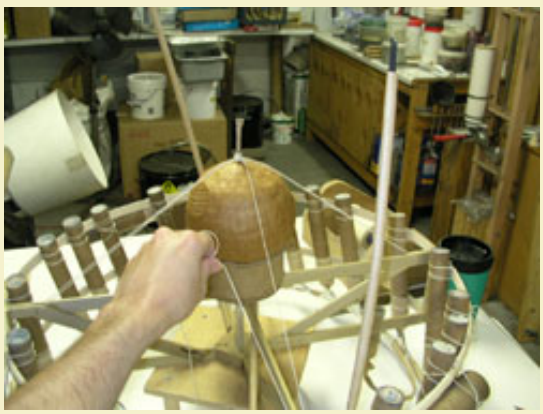

Figure 30: Twine running through the frame members is wrapped around the shell's time fuse for extra reinforcement.

frame. The twine is brought back to the time fuse again, looped around a few times and then tied off with a final clove hitch. The other set of supports are tied in the same way.

The time fuse is then cross matched and fitted with a bucket tied on above the support twine. This bucket will receive two passfire pipes that tie into one of the gerbs. The dual fusing is for symmetry and redundancy. It is a good idea to foil over the top of the bucket after the two passfire pipes are tied in, otherwise it becomes a spark trap. I prefer to foil the side of the bucket as well, since it is a thin walled paper tube that can be easily penetrated by fast moving sparks.

Installing the Lance Ring

The lance ring is the last effect to be attached, since the strings would get in the way when installing the other components. It highly recommended to work with the girandola on the launch stand for this step, since this allows the strings to hang down out of the way. The string from each of the 16 lances is passed through the holes drilled in the lower ring, then double knotted at the end so that it can't pull back through. If the holes are too big to reliably keep the knots from pulling through, you can just tie the strings off around the frame.

Once all the lances are dangling down from the frame, you are ready to install another ignition ring that will pass fire to them all at once. This is a band of double matched pipe that wraps around the lower ring, into which each of the lances will be inserted.

Making the ignition ring for the lances is pretty similar to the ring made for the drivers. An empty segment of match pipe is bent around the frame and marked at intervals where the lances will be inserted. The pipe is then removed and a paper hole puncher is again used to perforate the pipe. Two sticks of black match are inserted into the pipe and it is finally tied off to the frame using a series of clove hitch knots spaced at intervals as needed. Figure 32 shows the fluted pipe after it has been tied to the frame. It is difficult to see the string from the hanging lances in this picture, but if you look real closely you can see that they are there.

Attaching the lances is a simple matter of sticking the bare match from the lance into the punched holes, as seen in Figure33. This will orient the lance sideways on the frame, with the string making a loop from the frame to the end of the lance. Note that the lance should be inserted so that the ignition point will be facing the direction of travel as the frame rotates. Spark traps aren't as much of an issue in this case since the lances are among the first things to ignite, but it is just good practice to always eliminate spark traps on rotating wheels where crevices exposed to down-wind sparks can expose bare match to unwanted ignitions.

A piece of foil tape is placed over the connection point of each lance in order to prevent accidental ignition from other sparks that may be present at the shoot site. The lance is then secured to the frame with a clove hitch that wraps around the nosing paper. The lances must not be secured by tying anything around the lance tube itself, since they need to be free to drop down once the nosing paper burns away.

Figure 31: A bucket is tied to the shell's time fuse and matched with dual leaders connected to the main ignition train.

Figure 32: A ring of matched pipe is tied to the lower ring. Note the holes pre-punched where the lance fuses will connect.

Figure 34 shows how the lanes pack together behind one another. While it is possible to fit more than 16 lances on the frame, entanglements become more likely as the number increases. When two adjacent lances become wrapped around each other after dropping down, they tend to burn as one point of light instead of two, and will be located closer to the frame than the other lances. This detracts from the ring effect by causing a deformity in the symmetry.

Entanglements are less likely if the frame is spinning fairly fast before the lances break loose, as they will tend to fly outward instead of dropping downward. A delayed ignition of the lances can be achieved intentionally by adding a segment of time fuse into the leader that ignites the lance ring. You just have to remember to decrease the burn time of your lances by an equivalent amount if using this delay method.

Launch Notes

This size girandola can weigh between seven and twelve pounds, depending on how densely the drivers are loaded and how much payload you put on it. Due to this heavy weight, it is a good idea to fit your launch stick with a support platform as described here. The launch pin should not have a sloppy fit into the girandolas axle, but it should not bind when lifted on or off either. The pin only needs to stick up above the support platform by about two inches, so disregard any myths you may have heard about overly long launch pin requirements for girandolas.

When staking out your launch stick, be sure that there are no support braces or support wires located closer than four feet from the bottom of the girandola, otherwise the lances could become entangled on these supports when they drop down.

Care must be taken when transporting the girandola to and from the launch stick or in and out of transport crates, since the strings can easily get hung up on things and yank out a lance. It is best to drape the string loops up over the top of the drivers until the girandola is ready to fly. Then prior to launch, make sure each of the strings for the hangs down in a clean loop that does not criss-cross the other strings or get hung up on the frame somewhere.

With 45 ignition points, 6 separate timing groups and over 30 feet of fusing, it always amazes me that these things manage to work at all, not to mention perform as designed. But even when things don't go as expected, something entertaining almost always happens when you set fire to this much pyro strapped to a single frame!

Figure 33: Inserting one of the 16 lances into the ignition ring. Note the dual strands of black match inside the pipe.

Figure 34: Side mounted lances are tied off and foiled over to protect the connection points.

Figure 35: The finished girandola showing the dangling lance strings the way they should look prior to launch.

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