Leonardo Aerial Screw

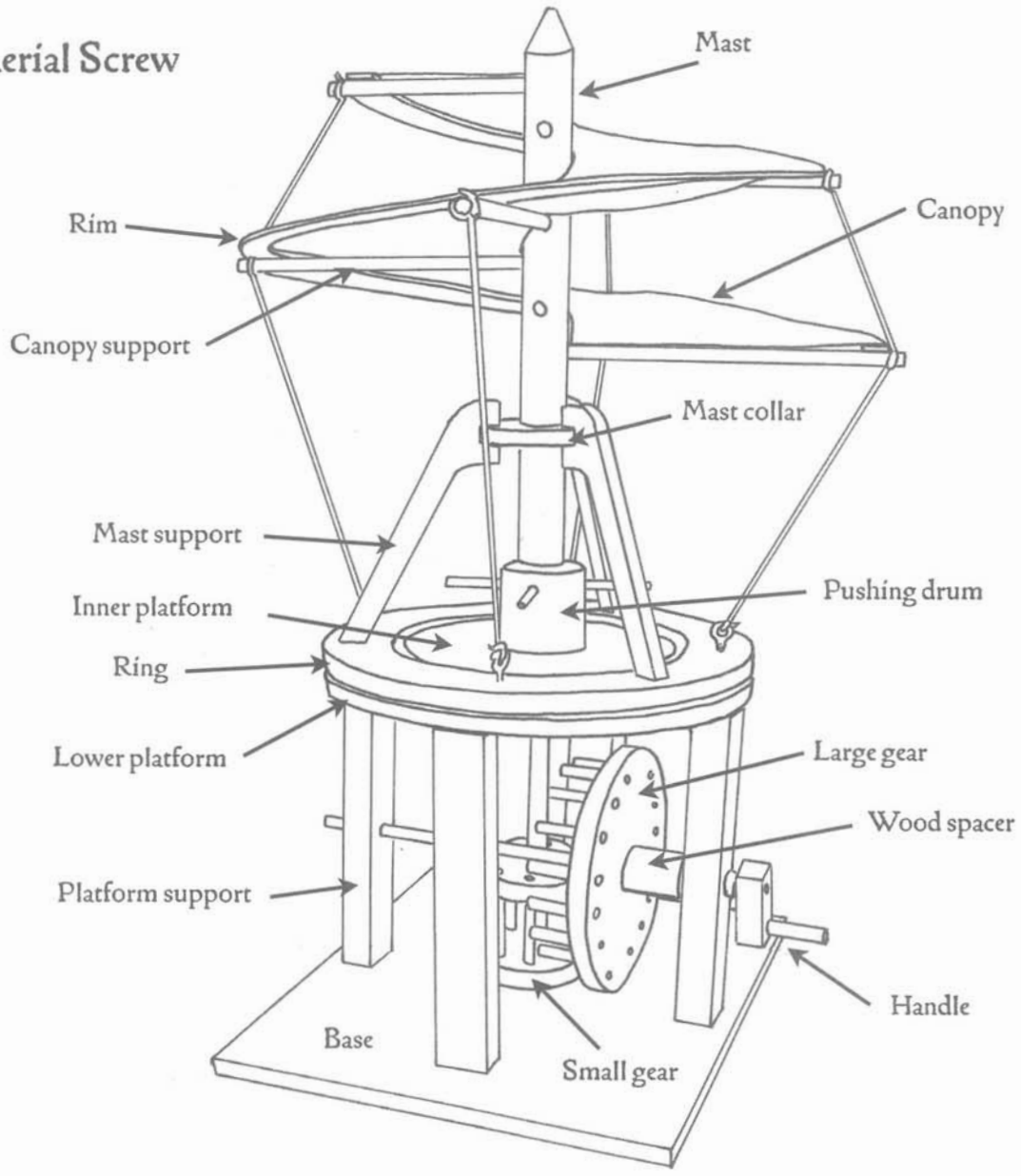
Pathfinders

Leonardo da Vinci was a prolific inventor and artist who had a keen sense of the world around him. While most of his flying machine drawings illustrated an attempt to mimic the wing movements of birds, he made one drawing of a helicopter type flying machine, which he called an aerial screw, since in his vision it would have screwed into the air.

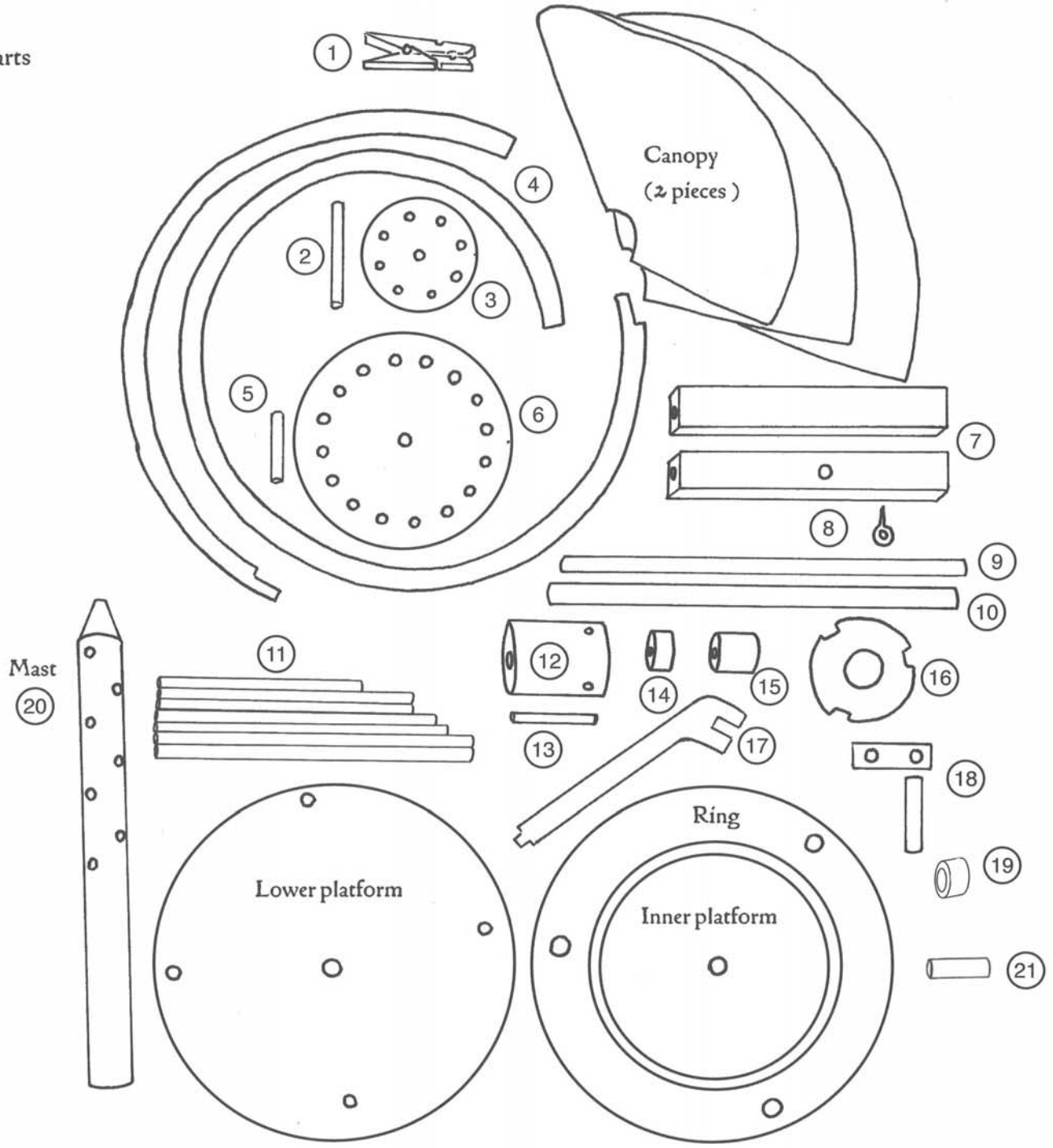
Leonardo understood that air had mass, and so it could be screwed into, hence this design. We know that there would be some technical difficulties as the rotation began, since as soon as the canopy and base lifted off, there would be nothing solid for the pilots to push against, and the rotation would stop (and gravity would take revenge). We discuss the methods it might have worked at the end of the manual, but nowhere in his notes, or other accounts of the day - do we find any information about this being tested. We understand that he was somewhat secretive in his inventions though, so he may have, and we just never found out! More about this later, let's get on with building a cool historic model!

We suggest some nice renaissance music, and a healthy snack of local, organic, fruit or nuts to keep you going!

Aerial Screw



Parts



Parts (number of pieces)

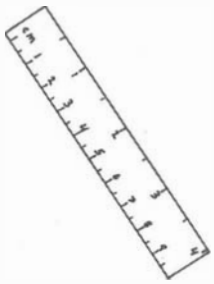
1. Clothespins (5)
2. 4 cm gear dowels (8)
3. Small gear plate (2)
4. Canopy rim (2)
5. 2.5 cm gear dowels (16)
6. Large gear
7. Platform supports (4)
8. Screw eyes (4)
9. 17 cm crankshaft
10. Main drive shaft (**thicker**!)
11. Canopy supports (7)
12. Pushing drum
13. 3.5 cm dowels for drum (4)
14. Main shaft drive holder
15. Crankshaft spacer
16. Mast collar
17. Mast support (3)
18. 3 cm handle (3 cm dowel)
19. Plastic spacer
20. Mast
21. 1.5 cm dowels (8)

Not shown:
Base, string, sandpaper.

Canopy Support Dowels:
1 at 8.5 cm
2 at 10.5 cm
1 at 11.5 cm
1 at 12 cm
2 at 13 cm

Assemble these items:

glue



ruler

scissors

healthy snack!

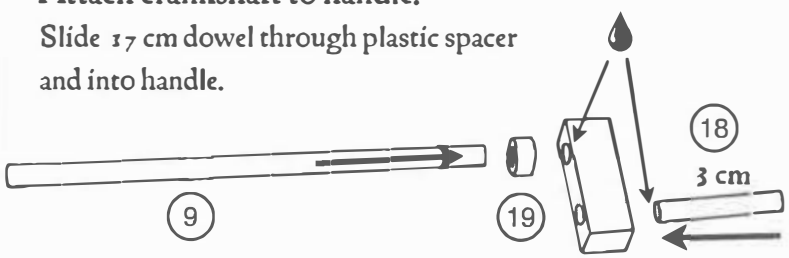
Note!

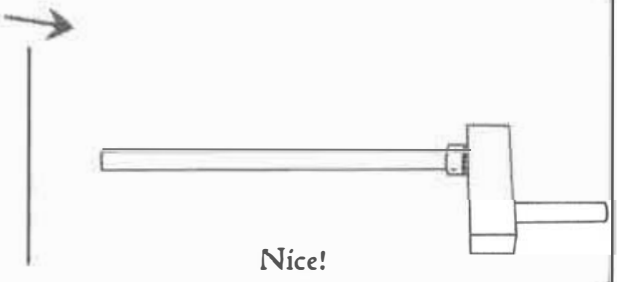
= Add glue to the area indicated

1 Glue these pieces together and let dry!

Attach crankshaft to handle.

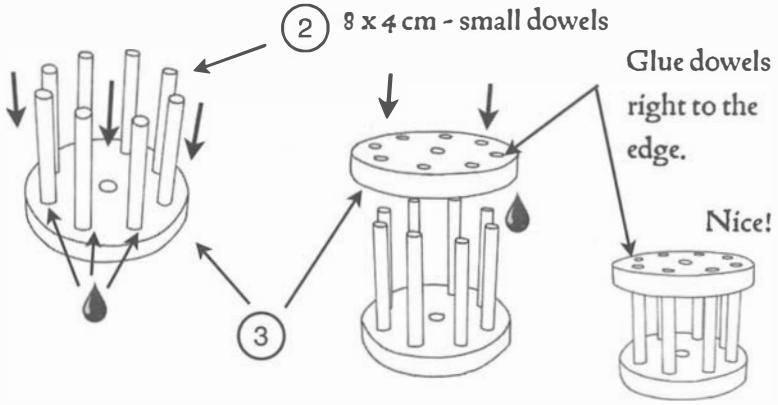
Slide 17 cm dowel through plastic spacer and into handle.





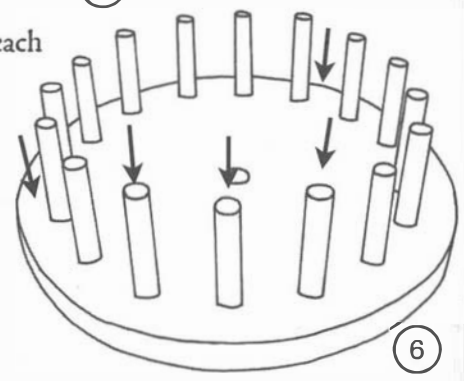
Nice!

Make the small gear



Large gear (5) 16 x 2.5 cm small dowels

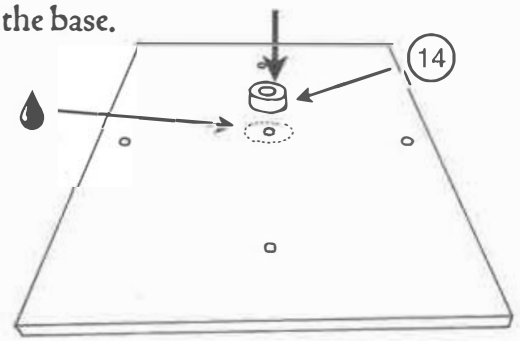
Glue each one!



Check to make sure they are nice and straight!
Once nicely lined up - let glue dry!

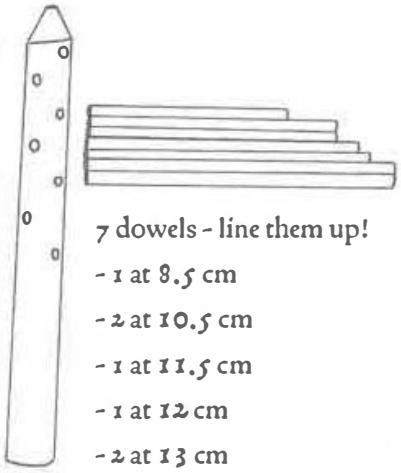
Glue drive shaft holder to the base.

Center the holder perfectly over the center hole.



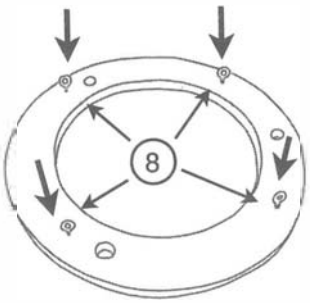
Let all these items dry for about 20 minutes.

2 Assemble the pieces for the upper platform and mast.

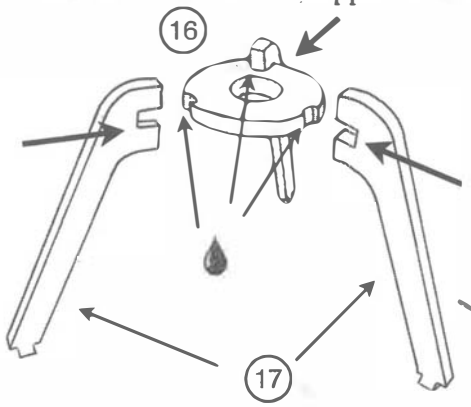


7 dowels - line them up!
- 1 at 8.5 cm
- 2 at 10.5 cm
- 1 at 11.5 cm
- 1 at 12 cm
- 2 at 13 cm

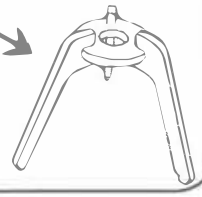
Screw eyes into the 4 starter holes on one side of the outer ring.



Glue the collar and mast supports in the grooves.

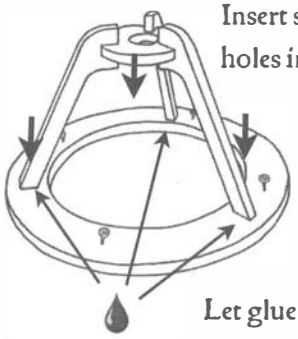


Nice!



3 Assemble mast support

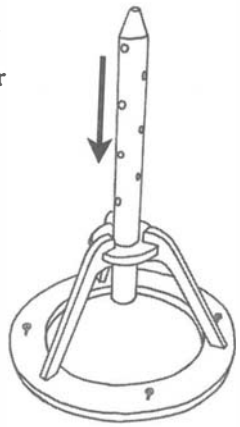
Insert support into holes in outer ring.

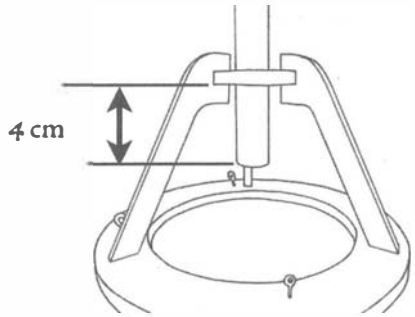


Let glue dry!

Gently push mast through the collar so the bottom of the mast is 4 cm below the collar.

No glue, this is pressure fit for now!

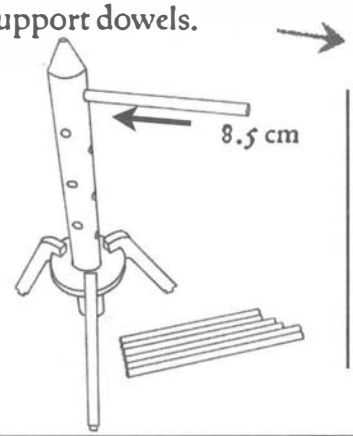


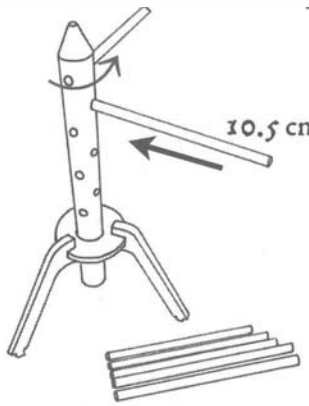


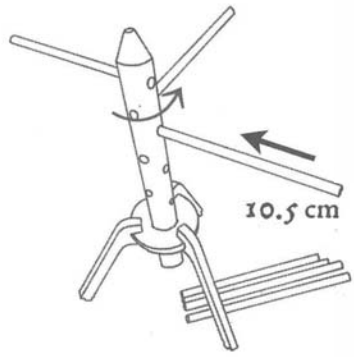
We removed the round base in the drawings below to remove clutter!

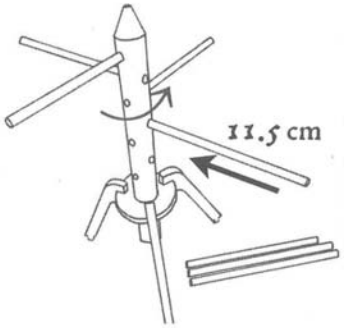
4 Insert canopy support dowels.

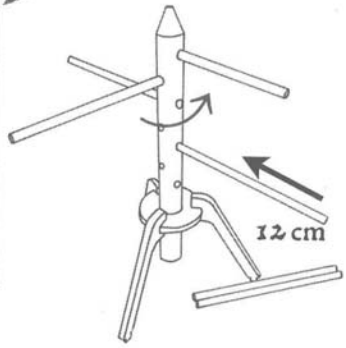
Start at the top, and insert - smallest to longest - as you turn the mast counter clockwise. Push the dowel right to the edge.
No need for glue!
(if they are loose, you can add a small drop!)

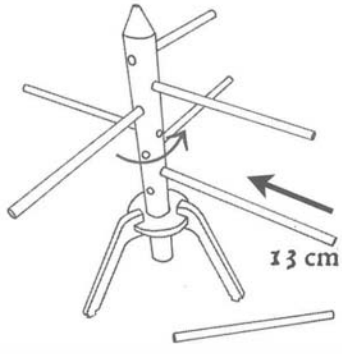


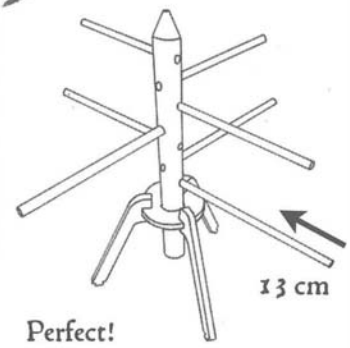










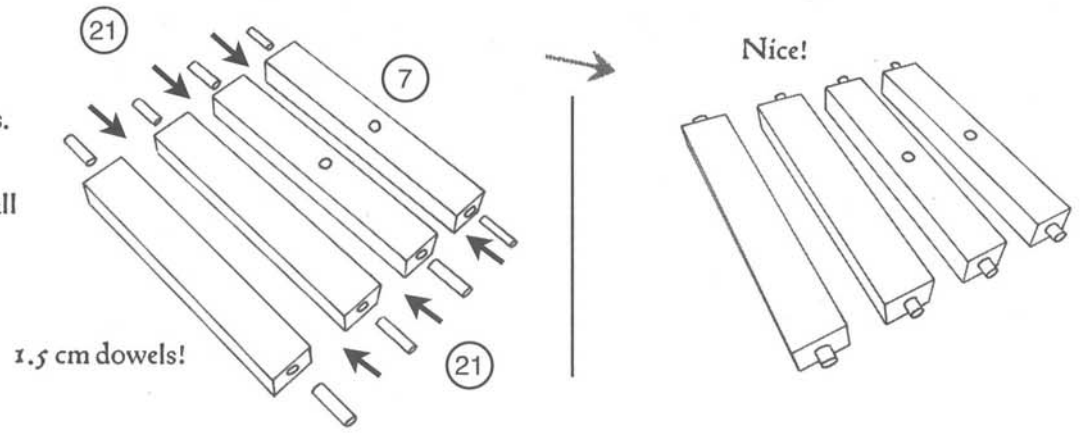


Perfect!

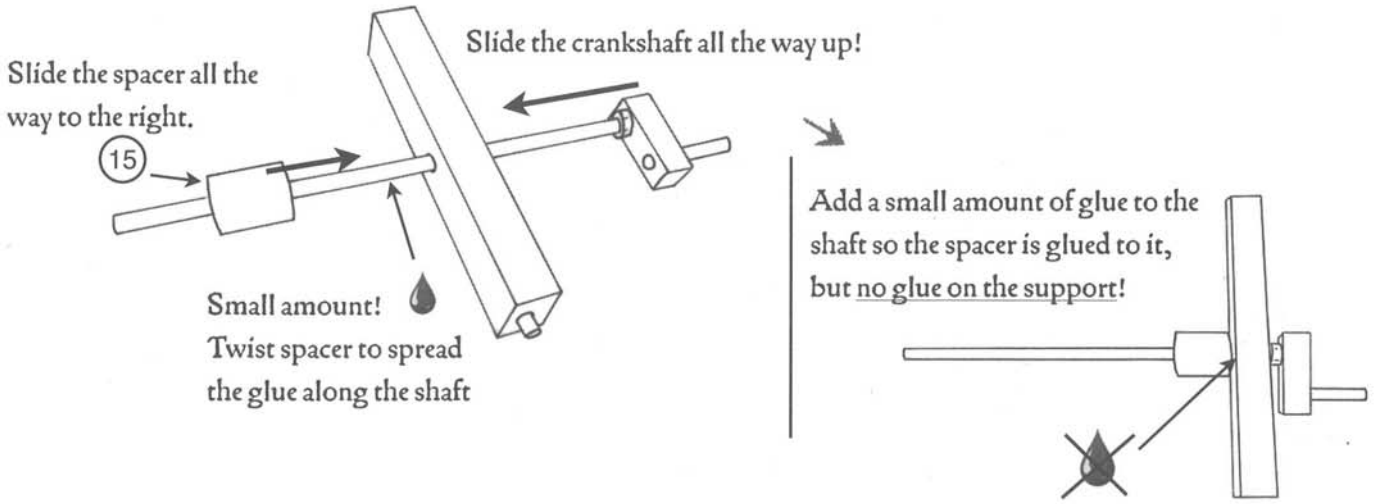
5 Assemble the base.

Insert the 8 - 1.5 cm dowels into the ends of the platform supports.

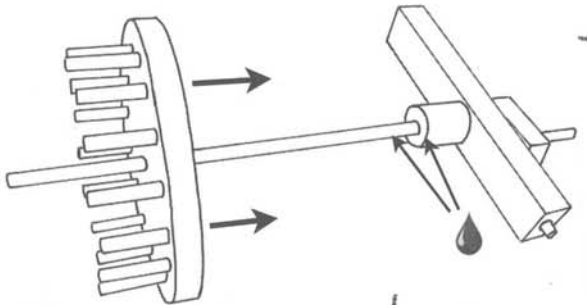
If the dowels are loose, add a small drop of glue.



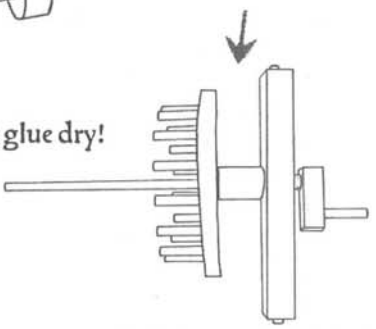
Insert the crankshaft (from step 1) through a support, and add the crankshaft spacer.



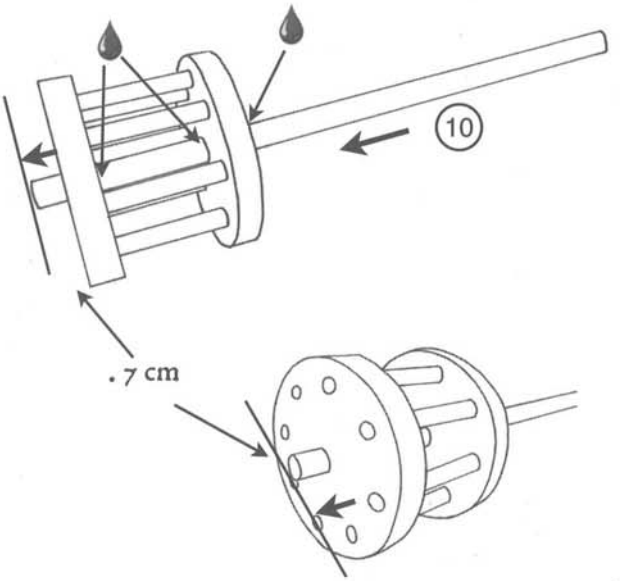
Add glue to the dowel and the edge of the spacer and slide up the large gear to the spacer.



Great - let the glue dry!



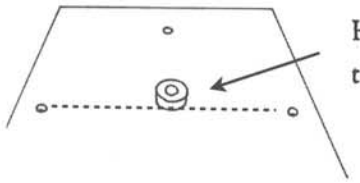
Insert and glue the 17 cm thicker dowel (main shaft) into the small gear.



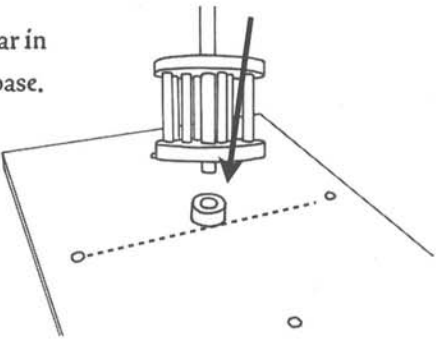
NOTE:
The dowel should be .7 cm from the bottom of the gear.

6 Assemble the base - continued!

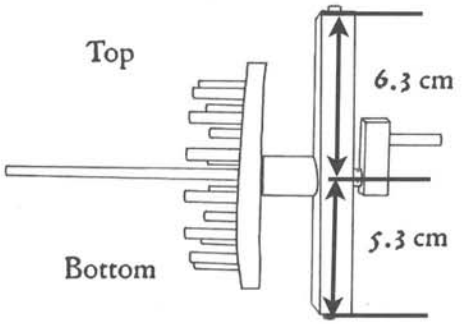
Lay out the base so the holder is as shown - It is not in the center!



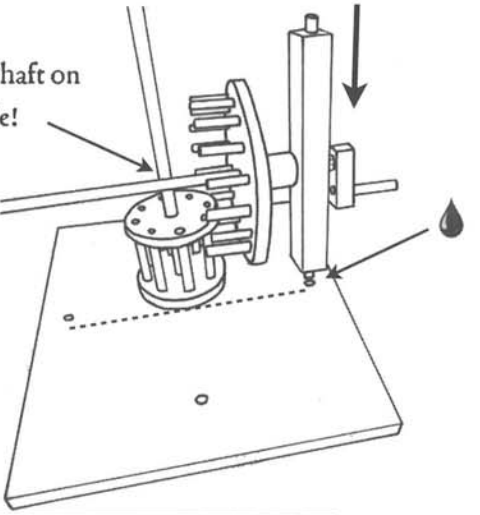
Insert the small gear in the holder on the base.



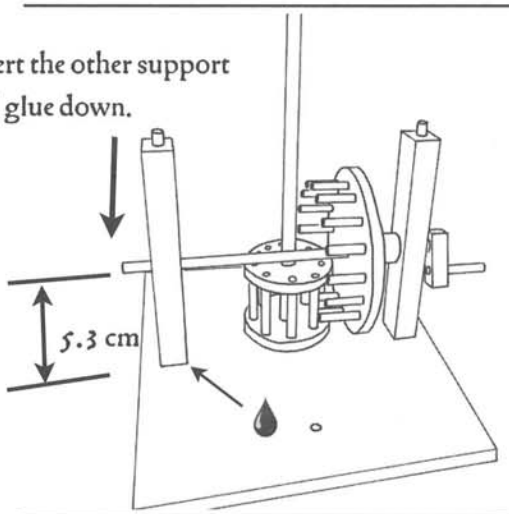
Note: The two supports are oriented with the smaller distance at the bottom!



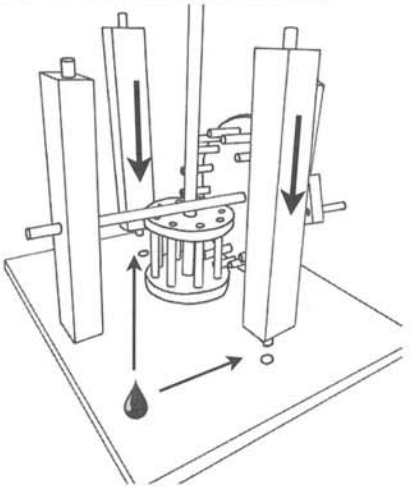
Insert the support and mesh the large gear with it.



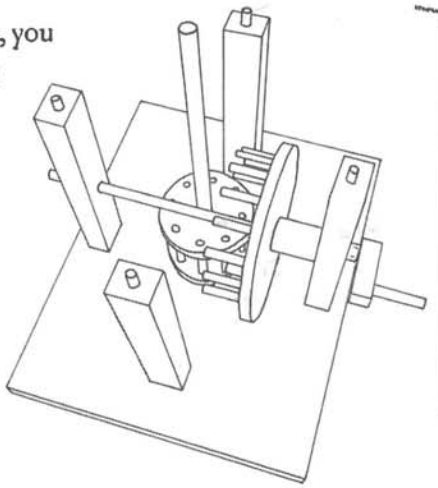
Insert the other support and glue down.



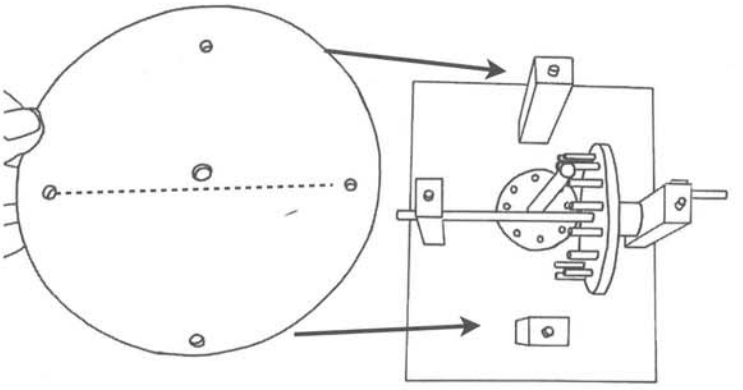
Glue the other two supports down!



Looks great, you are a master!



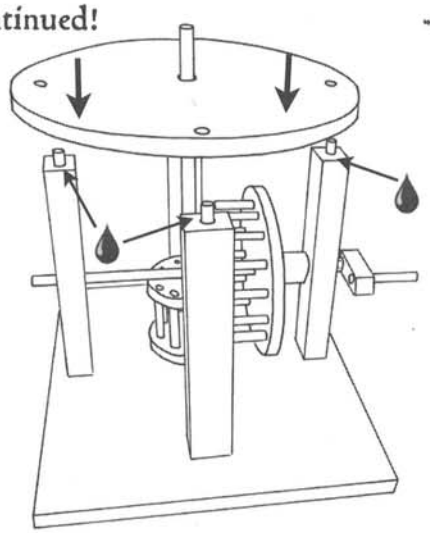
Line up the lower platform as shown, center hole to one side.



7 The base - continued!

Glue the platform on the supports.

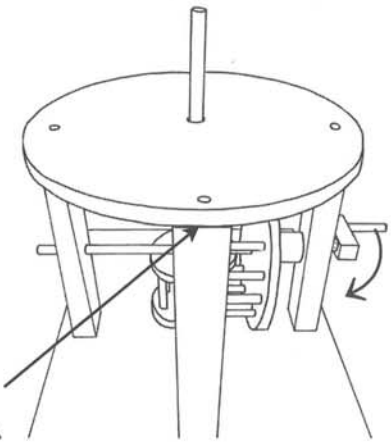
Make sure it is aligned correctly first, then add the glue!



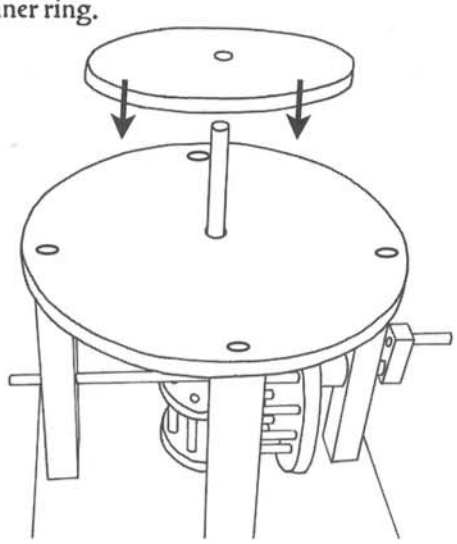
Glue into place and gently test the crankshaft.

It turns Counterclockwise!

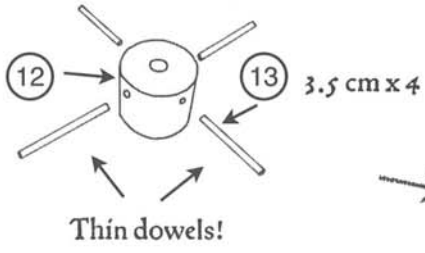
This support is close to the edge.



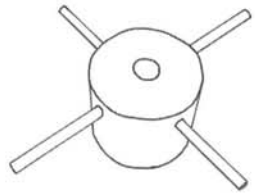
Add the inner ring.



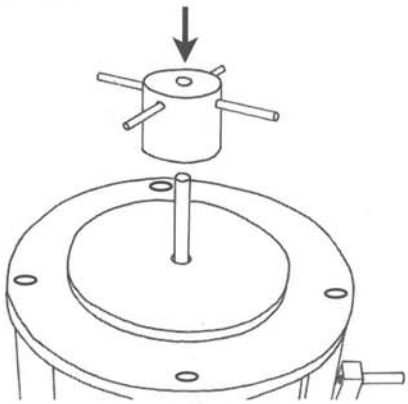
Assemble the pushing drum.



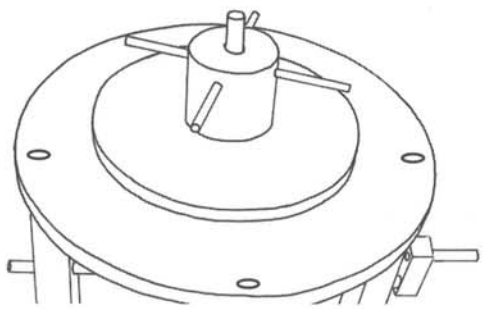
Easy!



Add the drum.



Nice, this doesn't need to be glued.

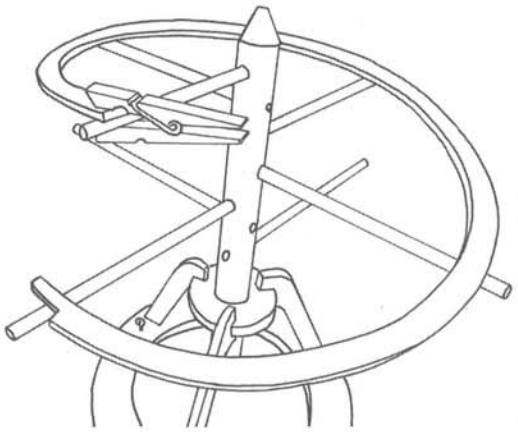


Snack time!

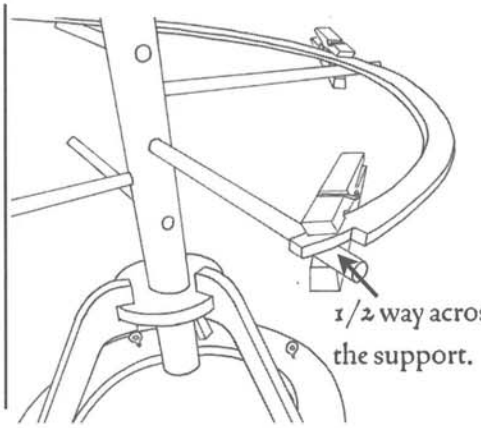
Test the crankshaft. If it binds, gently sand and round the ends of the pegs on the large gear.
If you look carefully at Leonardo's drawing, it seems he thought there should be rungs for the men to push against on the inner ring. You can draw a few on if you wish! We like the natural look though.

8 Glue on the canopy rim.

With the small clothespins, line up the upper rim on the canopy supports. This will take some practice to get it just right, so take your time!



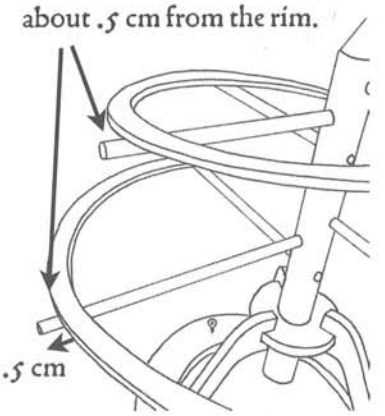
Use the larger rim



Line it up and clamp

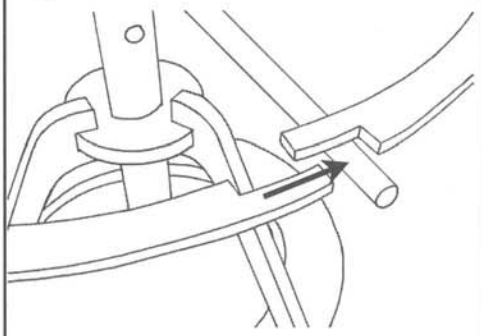
Important!

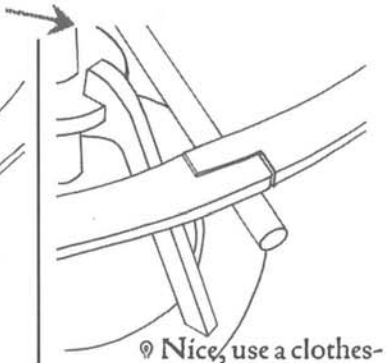
Each support sticks out about .5 cm from the rim.



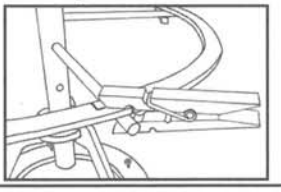
Check for alignment

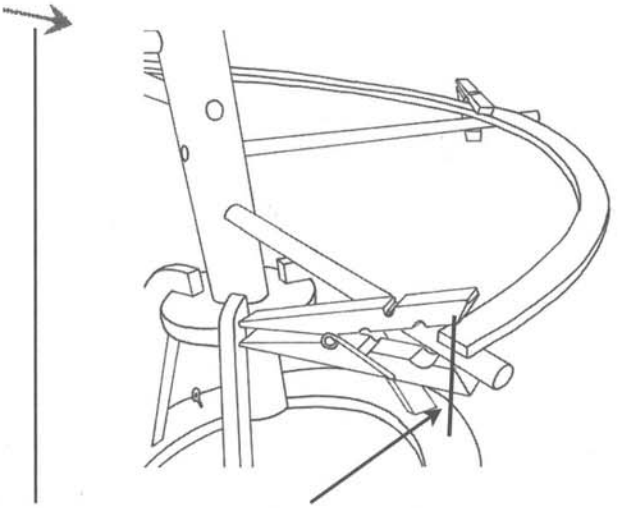
Add the lower rim. Line up the grooves!





Nice, use a clothes-pin to hold it on.

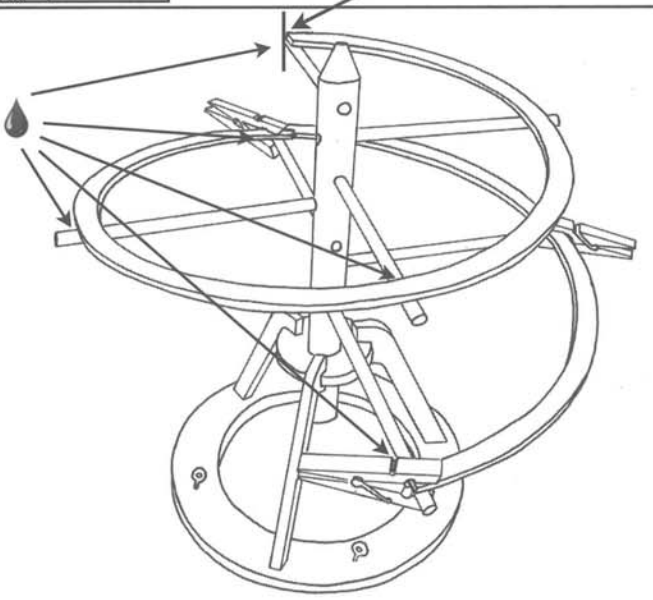




Top and bottom rim ends line up with the edge of the support.

Once it is nicely lined up, add glue and clamp down. Start with the top rim and work down. It might take a bit of patience to get it just the way you want it!

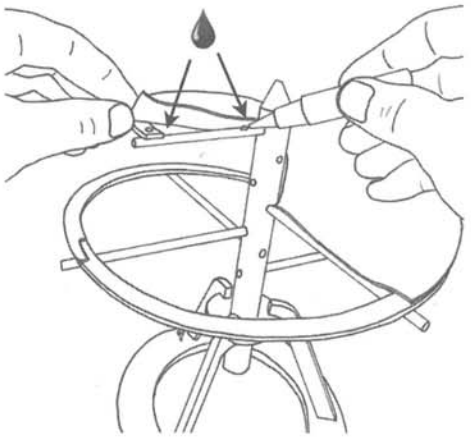
Make sure the support bars extend about .5 cm - this way you can tie the string to them. The distance doesn't have to be exact - it can vary a bit!



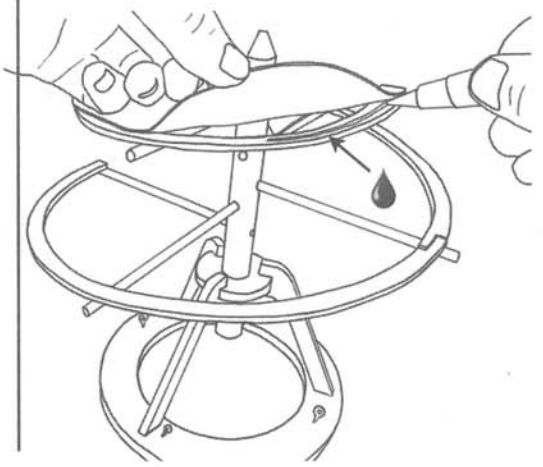
Let dry!

9 **Canopy time.** Align the canopy before you glue it down!

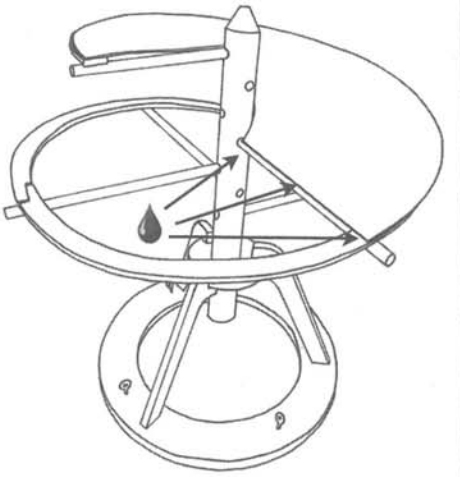
Find the two cloth canopies and lay the small one on the top rim.
Add a small drop of glue to the rim, and the inside end of the support.



Gently apply a thin line of glue to the rim, smooth with your finger, and line up the edge of the canopy with the rim all the way down.

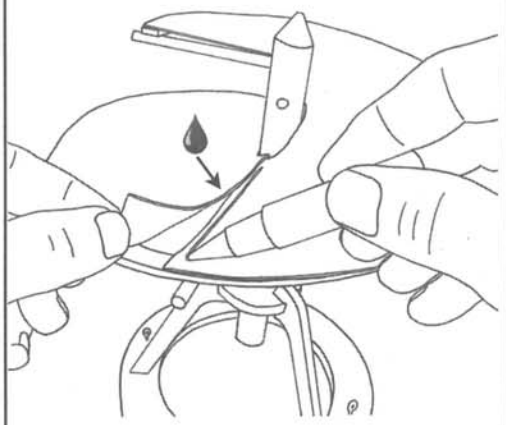


Apply glue to the bottom support and glue the canopy to the bar. Adjust so the canopy is aligned with the rim - you can use the mini clothespins to hold it!

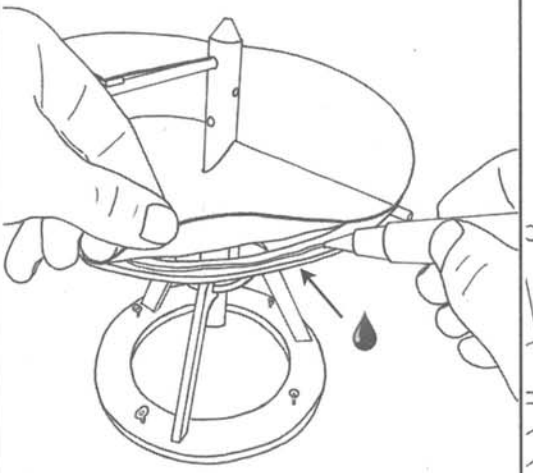


Let dry!

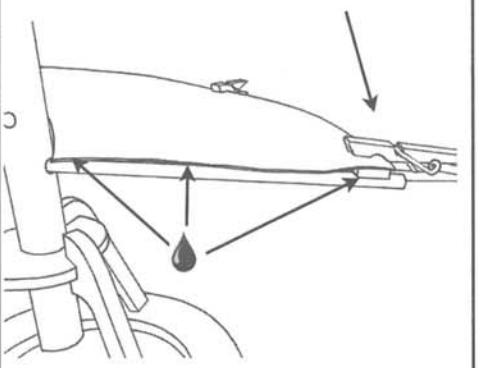
Lay the second canopy so it overlaps slightly. Adjust so it lies nicely on the rim. Add a thin line of glue to the top edge.



Line up the edge and apply a thin line of glue along the rim.



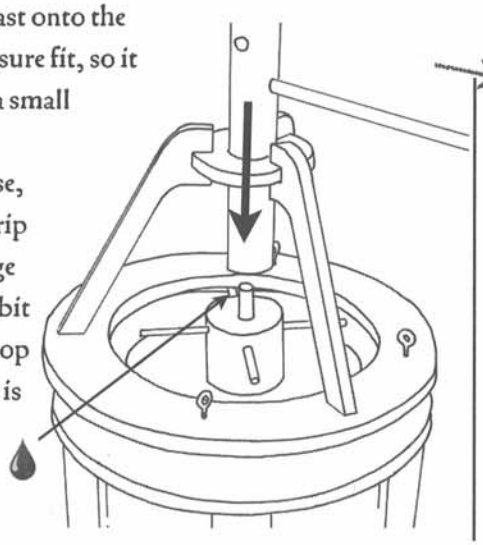
Apply glue to the bottom support and glue the canopy to the bar. Adjust so the canopy is aligned with the rim - you can use the mini clothespins to hold it!



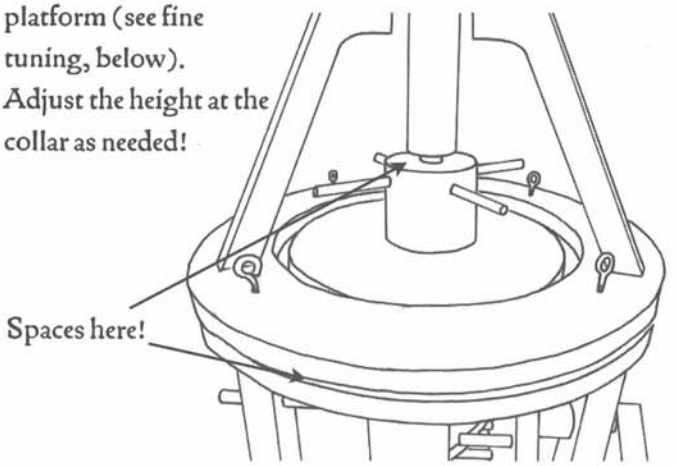
NOTE:
The cloth won't be flat and smooth- it will have some floppiness to it (but not the same floppiness as a rabbit's ears). If it overhangs the wood rim, carefully cut it with scissors.
Don't be afraid to trace the canopy onto some flowery or plaid pattern material and use that instead of the white - for that crazy look!

10 Add the canopy to the base

Carefully press the mast onto the drive shaft. It is a pressure fit, so it will only push down a small amount.
If the hole is a bit loose, just tear off a small strip of paper from the edge of this manual, add a bit of glue, and lay it on top of the drive shaft so it is tight (add a bit more glue!).
Too tight? -use the sandpaper!

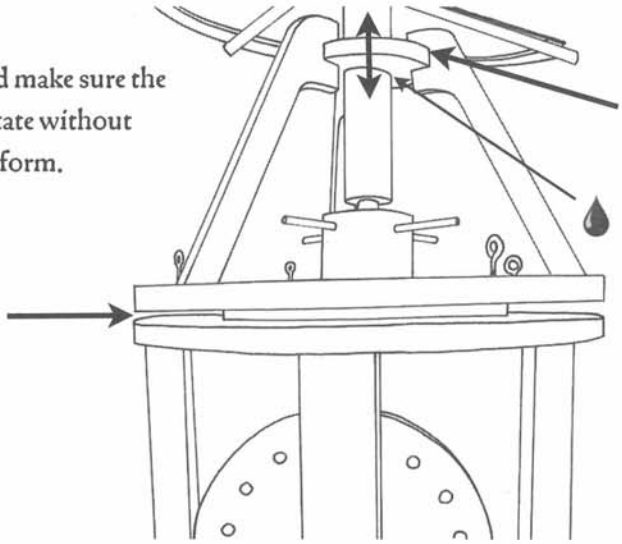


The outer ring should be in the air, and not rub on the lower platform (see fine tuning, below).
Adjust the height at the collar as needed!



Fine tuning

Gently turn the handle and make sure the upper canopy and ring rotate without rubbing on the lower platform.



Gently slide the collar up or down to move the ring up or down as needed.

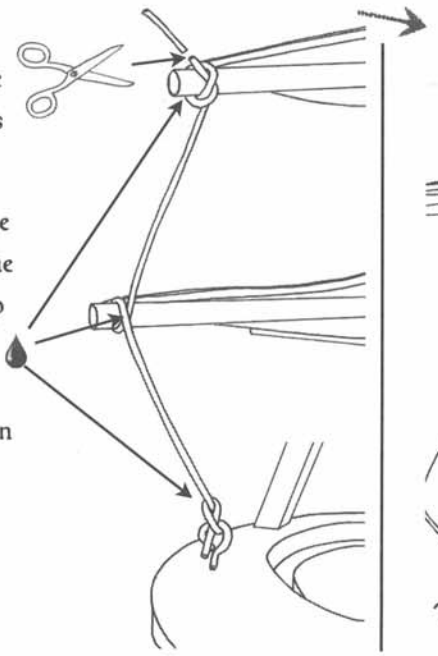
Once perfect, add a small drop of glue to the bottom and top edge of the collar to hold it in place.

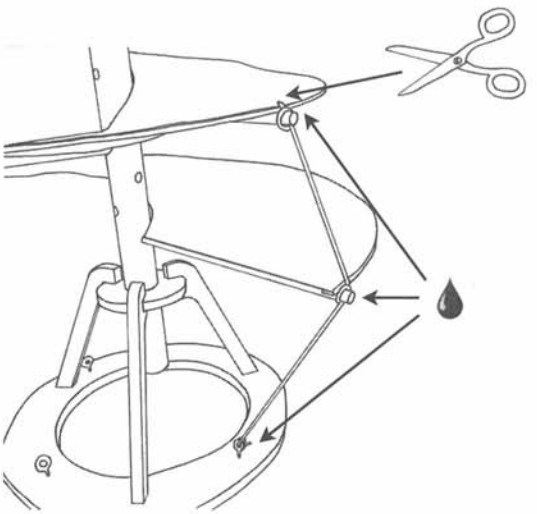
11 The String.

You can remove the upper structure to add the string if you wish (unless you glued it on).

Take the 4 strings and tie them to the screw eyes, then one wrap around the bar and an overhand knot on the top bar.

Add a drop of glue to each place then trim the string.



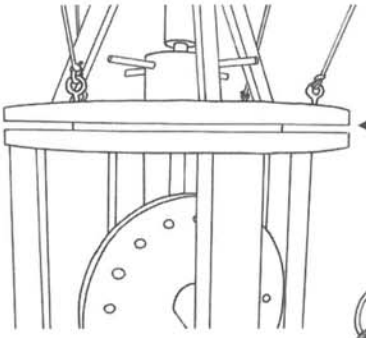


Tie them all on and then you are ready to spin!

12 String, continued...

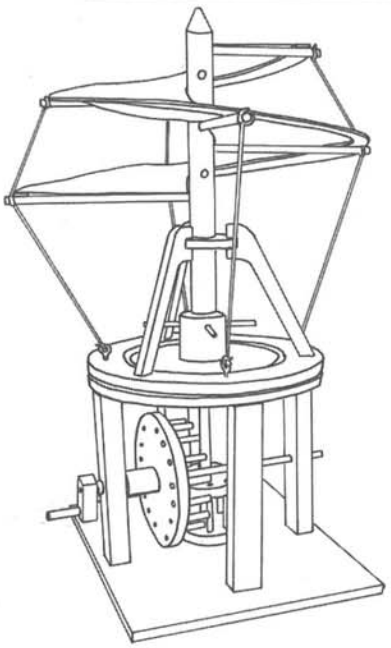
Looks great!

Place the canopy back on the base (if you took it off).



Did we mention a space here?

Finished your snack? Now is a good time!



You should now be ready to start the spinning!

When you spin the canopy you will notice a slight breeze underneath as the canopy pushes the air down - this would be the way that Leonardo thought it would work; the screw-like boring into the air, pushing the air down, would propel the canopy, and base - along with the pushing workers into the air.

If you want the top structure permanently attached, then remove it from the main shaft, add a drop of glue to the mast (in the hole) and replace. If the drive shaft dowel is a bit loose, then place a small bit of paper on the dowel and push the mast over it, that should make it snug. Experiment! - if you don't glue the canopy on, you can make helicopter propellors (from paper or foam core), remove the top structure and attach them to the spinning shaft and see what happens!

Fine tune the helicopter by making sure the outer ring is not rubbing on the platform, by moving the collar up the mast if needed and adding a bit of glue.

A little about Leonardo da Vinci and the Aerial Screw

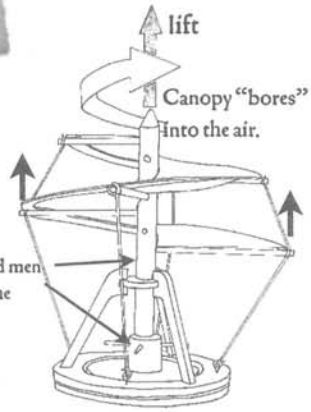
Leonardo made only one drawing of this machine, and had few comments about it in his notes. Researchers have written much more about it since then, and you can find links to that on our web site www.pathfindersdesign.net. We don't have room here to fully expand on all aspects of this design and what he was thinking, but we will consider a few questions and points.

He wrote: "I think if this screw instrument is well made, that means made from linen starched (to block its pores) and is turned rapidly, then said screw will find its female in the air and climb upwards."

His notes suggested that the helical structure (canopy) would be 4.8 meters in diameter, and that the outer ring be made with thick iron wire. He also noted that a small paper model could be made to test to see if it works. Pretty sparse actually, and it didn't explain all of what he did know about the ability of air to be compressed or of its fluid nature. While scholars think this drawing is dated in the 1482 to 1483 range, he must have been aware of the Archimedes screw (invented by Archimedes of Syracuse in the 3rd century BC) which he did draw in other notebooks, and that invention may have inspired him to consider that if a screw can lift up water, then flipped over and made bigger, it may be possible to push air down, lifting the object attached to it. Leonardo's inventive mind was well suited to improving on designs already made, and turning over an Archimedes screw and applying it to another area would seem typical of his genius. We will never know the influences that past scientific inventions had upon him, or even if he knew about them (there were Chinese spinning wing toys from much earlier times), but it appears he was beginning to understand aerodynamics in a rudimentary form, and applying it seriously to ways of getting off the ground with human propulsion , although it is clear he didn't understand the premise of lift over a wing airfoil. We know he was very interested in flight, and while most of his flying machines were based on the moving wing (his Ornithopter designs), this one stands out for its uniqueness and astonishing "out-of-place-ness" - compared to what others at the time were doing in the areas of flight.

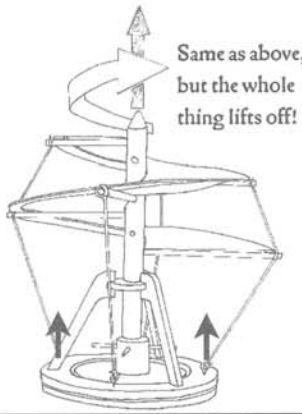
While we consider this the precursor to the modern helicopter in terms of the notion of air being compressed with a spinning circular thing, it really does not use the same premise of "lift" as a modern wing, or helicopter blades use (which is really a wing that spins, creating lift (see below). There is an interesting article by Dylan Connelly " A study of Leonardo da Vinci's Inventions: the Aerial Screw" - worth looking up online, (there is also a link at our .net web site). If you like Leonardo's drawings of machines, the book Leonardo da Vinci's Machines by Marco Cianchi is excellent.

How would the Aerial Screw have worked?



Inner base is pushed with feet, men stay in the same place, and the canopy without the mast or the men, lifts up.

There are two theories.
In one possibility, the pilots would have stood on the inner platform and pushed the handles on the pushing drum. This drum would have been attached firmly to the mast and lower base (a base under the one they were standing on). The pilots hold onto the drum and push with their feet on the rungs of the inner platform, facing the left . This would set the base and outer ring in motion, and the canopy structure that is attached to it. Once moving fast enough the canopy would bore into the air and the canopy would lift off. The top canopy would slide off the mast in this case (meaning the canopy is not attached to the mast as we have it here, and would stand on its own). Where our collar is tight, the collar in this case would be loose and slide up the mast.
This has good potential, if the structure could be turned fast enough, but then the inner platform they are standing on would have to release somehow, to allow the canopy to rise without them. It would then slow down and return to Earth.



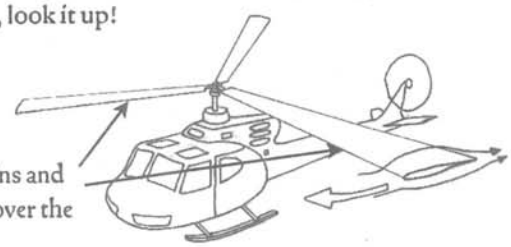
Drum is attached to mast and the angled structure. The men run counterclockwise around the mast.

In the other case, the men would face the opposite direction and would actually move around the mast. The drum would attach to the mast and outer ring. As the canopy got going fast enough it would lift off.

Then of course it would fail since there would be nothing solid for the men to push against, and with no steering ability, it would tilt over and fall down, with ensuing scrapes and bruises.

How does that compare with a modern helicopter?

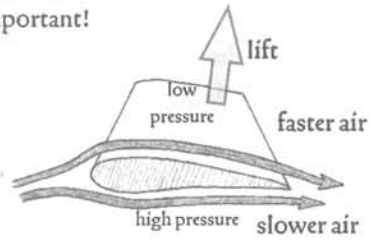
Helicopters work with the lift that is generated as the air flows over the airfoil on the rotors (blades). The shape of the blade (and all airplane wings) has an airfoil shape - like a bird's wing. The air splits as it moves over the wing , and the air flowing over the top moves faster, as it bends around the wing. This creates a low pressure area, with the pressure on the bottom of the wing being higher, and since high pressure likes to get to the low pressure, it pushes up on the wing, giving lift to the wing (blade). This lift is what lifts helicopters, airplanes, and makes windsurfers and sailboats move forward. There are other forces acting on flying machines too, look it up!



The blade spins and creates wind over the airfoil.

The wind flow creates a low pressure area on top , which lifts the blade (and anything attached to it!).
Leonardo's Helicopter did not use this type of lift since the canopy did not have an airfoil shape.

The shape of the wing is important!



Yes - we were confused too, so don't worry too much about the technical details, Leonardo was an "ideas" man in this invention and what we find intriguing about this drawing is how different it was from everything else at the time. His ingenuity is an inspiration to all of us to look at things differently, to dare to dream. For every working invention, there are prototypes and drawings that never got off the ground. Use this kit as an inspiration to think big and get out there and invent new and cool things that may someday inspire others to reach lofty goals!
If you are interested in inventions, make sure you check out James Burke, and his Connections series, where he follows the interplay of how one discovery leads to other, seemingly unrelated inventions and discoveries. The finest documentaries on inventions ever made!

Helicopter/Aerial Screw © Derek Wulff, Pathfinders Design and Technology, 2011.
Original design by Leonardo da Vinci (really, we're not making this up!).
Kit designed in Canada by Pathfinders, cover art and design: Anna Lewis.
Questions, comments? contact us at: www.pathfindersdesign.com
Made in Taiwan by SabMatt Corp.

Check out the other Leonardo kits!