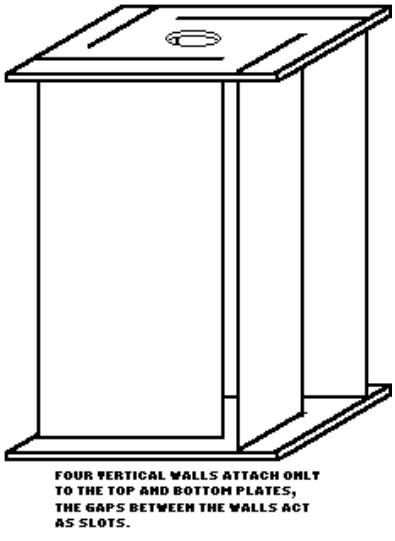
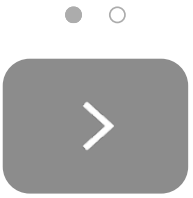
TORNADO GENERATOR BOX



Doug Smith and I put together this tornado chamber as part of a semi-permanent science museum exhibit in Boston in 1988. The main body was built from 1/4" thick plexiglas, a small 3in "boxer fan" on top of the case supplied the propulsion, and an ultrasonic humidifier supplied the white mist.

SCIENCE FAIR NOTES: If you don't need the device to last forever, you could build this out of cardboard or "gatorfoam" instead of plexiglas. Use duct tape instead of glue, and use incense sticks to make "smoke" instead of a humidifier. The bottom panel should not be cardboard, since it's a fire hazard with incense, or humidifier mist will make it soggy after awhile. If you use opaque materials, then make a big hole in one of the side panels and tape clear plastic over it to form a window. The fan creates the tornado, and the mist or incense smoke makes it visible. Instead of using an ultrasonic humidifier, you can use burning incense sticks or cones, but supply a large dish or pan on the bottom so the burning incense cannot become a fire hazard! If desired, put a small (15W) light bulb at the rear of the chamber to light up the mist tornado, and paint the inside of the chamber black to give good contrast. Try using the "12-volt micro fan" from Radio Shack, part number 273-240, and run it from a 9V battery. However, if the slots in the side of your tornado box are too wide, you'll need a more powerful fan. R. Grummer suggests using dry ice, which can sometimes be had at no cost by asking your local grocery store.

Top view of the tornado box looks like this (if the square top panel is removed) :



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||   (------ about 14" ------)
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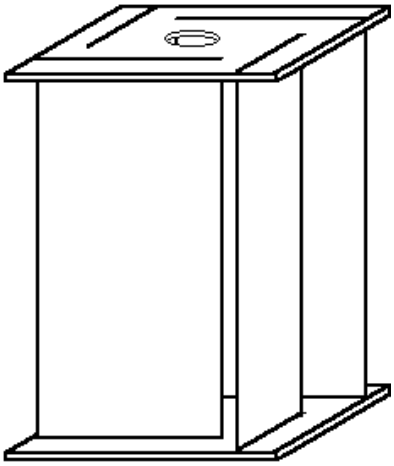
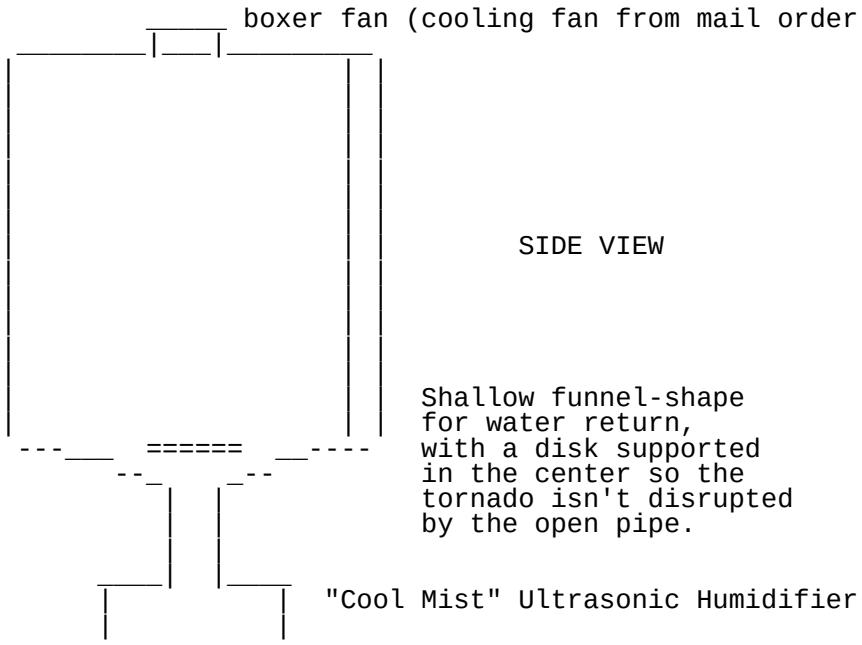
The four 14"x24" vertical panels are fastened to top and bottom square plates 18" wide, but are not fastened to each other. Gaps between the vertical panels form the slots. With 18in square top and bottom plates, and 14in walls, the slots are 1in across, and the square central chamber is 12in side. Air rushes in through the narrow slots at the four corners, then swirls inwards to form the tornado, then exits through a hole in the top. A small fan was installed in the center of the top plate (with a hole cut for the fan.)

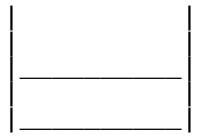
If one wall is made of clear plexiglas, then you can see inside. Or use wood, but cut a large viewing hole in one side and cover it with stretched plastic wrap. Paint the interior black to make the tornado easily visible. The entire device can be any size, keeping the scale of the slots about the same of course: with a 12" square inner chamber, the slots end up being about 1" across. The total height is up to you. My device was about 2ft. tall. If you make yours lots taller, you either need to use a fairly strong fan, or you need to make the width of the slots smaller.



The top plate of the version I built was a flat panel with a 2" hole in the center, with a high speed 120volt AC 3" box fan screwed over the hole. Fan air direction was aimed out of the box of course. This type of fan is available at surplus electronics outlets, and I think Radio Shack carries one version.

In order that it stand up to many weeks of wetness, I made the bottom of mine from a heat-formed plexi sheet, formed into a shallow funnel shape in an oven, w/crude frame to hold the edge, and a piece of ABS pipe used temporarily to punch the "funnel" shape into the hot, soft sheet. A hole was cut at the bottom of the funnel shape, and the edge of the hole was glued to a short piece of ABS sewer pipe. A perforated plexi disk covers the funnel mouth and provides the flat surface that the tornado needs in order to form properly. The ABS pipe led down into an ultrasonic humidifier which provided the marker-mist and made the vortex visible.



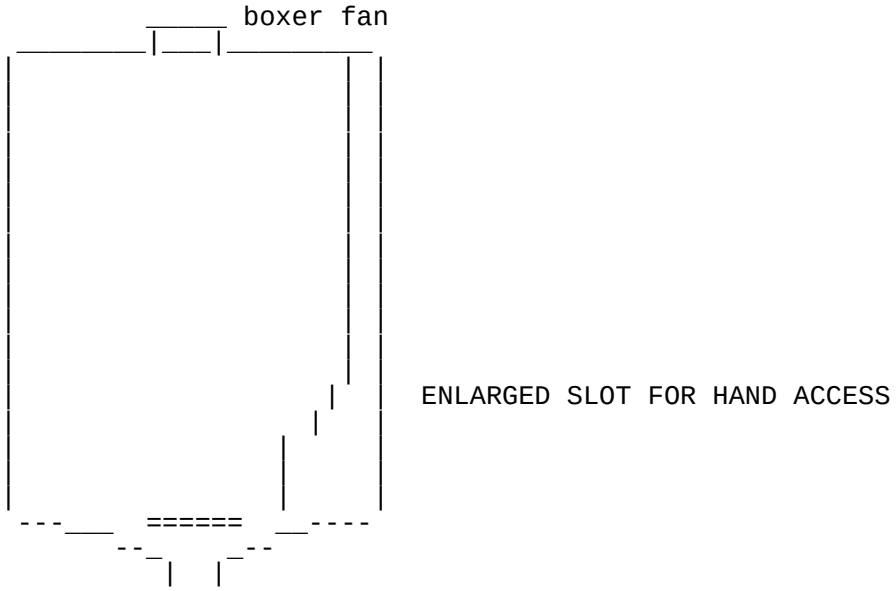


Ultrasonic humidifiers normally emit a blast of mist rather than a slow flow. To eliminate the blast, I plugged the little air-jet aperture down inside the humidifier's mist compartment with a plexiglas block, with a few small holes drilled to point downwards. (Pools of water develop everywhere inside the humidifier, so properly angled air holes in the small plexiglas plug are needed to prevent water buildup from filling the air holes.) When the holes are the right size, dense white mist fills the humidifer and pours out the top like a white fluid. The quick version: crimp some aluminum foil over the air-jet aperature inside the humidifier, wrap rubber bands around it to hold it in place, then stab it with a pencil point to make small holes in the foil. See the "Touch the clouds" exhibit article for more info on humidifiers.

The shallow funnel-shape allows the water which builds up in the bottom of the tornado chamber to run back into the humidifier, rather than pooling up in the bottom of the chamber and growing algae. Over the heat-formed funnel I placed a 6" dia. perforated plexiglas disk with 1/8" legs around the edge. The legs raise up the circular plate so water can run past the edge, but the slot is narrow enough that debris from museum visitors won't end up in the humidifier water. The perforations in this flat plate were closely-spaced 1/4" holes made in a large circle, and the mist from the humidifier exits through these holes. It is important to provide a central, flat, unperforated surface for the vortex to "work against", and therefore this plate has an unperforated center, with a circle of holes about 3" dia. to feed mist into the vortex from around its perimeter.

I found that the tornado is hard to see against a light background, so I made the two back walls opaque black, the bottom funnel and plate black, and two front walls transparent, then I lighted the whole thing heavily from the top and from slightly behind. If I had to do it over again, I might try installing a flourescent tube running the length of the box. This tube would need to be in the rear from the viewpoint of users, but with some sort of light shields added, so it illuminates the mist column from behind, but doesn't shine directly in the user's eyes.

To allow people to stick their hands inside, I cut the vertical slot in the front of the box larger at the bottom, as shown below. This distorts the vortex, but allows "hands on" access. If you use a tiny, weak fan, you probably should skip this part, since the large hole will divert air from the vertical slots and prevent the vortex from forming.



And last, I built a small electronic controller which allowed users to vary the fan speed by pushing and holding a "faster" and "slower" button. (Speed control knobs tend to get wrecked pretty fast in an exhibits environment, while pinball machine flipper-buttons are long-lasting.) As the fan runs faster and faster, the tornado suddenly undergoes transition to turbulence, changing from an onion-layered smoke column into a whirling turbulent cloud. To preserve the contents of the water tank, the controller would disable the humidifier if none of the buttons were pushed for about two minutes. Once the mist had started, there was one last button which allowed the user to turn the mist off and on, and even to make "pulses" of mist which would travel upwards in the vortex.

The speed of the fan and the size of the slots must be adjusted correctly in order to create a robust vortex. I used a handheld incense stick to inject smoke into the air so I could see if the vortex was working. If your fan is too powerful, the vortex will be turbulent and won't create beautiful complicated "onion layers" of laminar flow in the smoke pattern. The fan's air stream can be slowed by partially blocking its exit with cardboard and duct tape. If the side slots of the main chamber are too large and the fan too weak, the vortex will form very slowly and will vanish at the slightest disturbance. If this occurs, either move the chamber walls to make the side slots smaller, or find a more powerful fan.

Forever on my "wish list" was to install a scanned laser beam "sheet-of- light" generator. This would allow visual cross-sections of the mist to be created. Simply aiming a handheld laser through the rear slot of the chamber and waving the beam rapidly back and forth through the mist caused momentary but spectacular "wind tunnel" turbulence patterns to appear, but I never went any further with this. Shielding the beam would be an issue, since to be efficient, the illumination must be directed through the mist column from behind, and towards (but not hitting) the users' eyes.

Other ideas for variations: a sculptor in New York converted an entire room into a tornado chamber. He/she provided a large exhaust fan in the center of the ceiling, then arranged a large circle of vertical pipes into the shape of a skeletal cylinder, with the center of the cylinder pattern aligned with the ceiling fan. These pipes extended from floor to ceiling, and each pipe presumably contained its own fan, and a series of holes or slots running one along side of the pipe. The pipe slots blew air sideways so all the air in the room rotated slowly, and the central fan pulled air towards the center of the circle. The large "cylinder" of pipes acts as the walls of the chamber and provides tangential air jets, so any air which flows towards the center of the room is forced to spiral inwards. A powerful vortex forms in the center of the room, extending from floor to ceiling. A big pile of leaves, shredded plastic, etc. completes the exhibit.

The Exploratorium museum in San Francisco contains one large, famous example of a tornado generator chamber. (www.exploratorium.org) Only two walls are provided, the walls being made of huge curved sheets of plexiglas, with a fan in the ceiling of the exhibit. Ultrasonic humidifiers provide mist in the floor of the exhibit. Children can walk into the device and interrupt the spinning mist vortex.

Also see HOMEMADE HURRICANE, the one from World Book that inspired me as a kid. That's on Bizarre Stuff you can make in your kitchen.

LINKS:

- Wirbelrohr Ranke-Hilsch vortex tube

HOMEMADE HURRICANE

- Smoke-ring Launcher, shoot ring-shaped tornadoes across the room, or construct a stench-gun. Silent but deadly!
- Tornado in a bubble
- Detailed Plans for 4-foot tornado machine
- Teaching Tornado educational device
- Fire Tornado machine (vid)
- SRL Flame Hurricane, fire tornado driven by jet engines
- 4ft Tornado Generator (complete plans)
- Stormchaser Dave's Tornado Machine
- Tornado Simulator from Tornadoproject
- Huge man-made tornadoes from Reelefx Inc

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http://amasci.com/amateur/tornbox.html
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