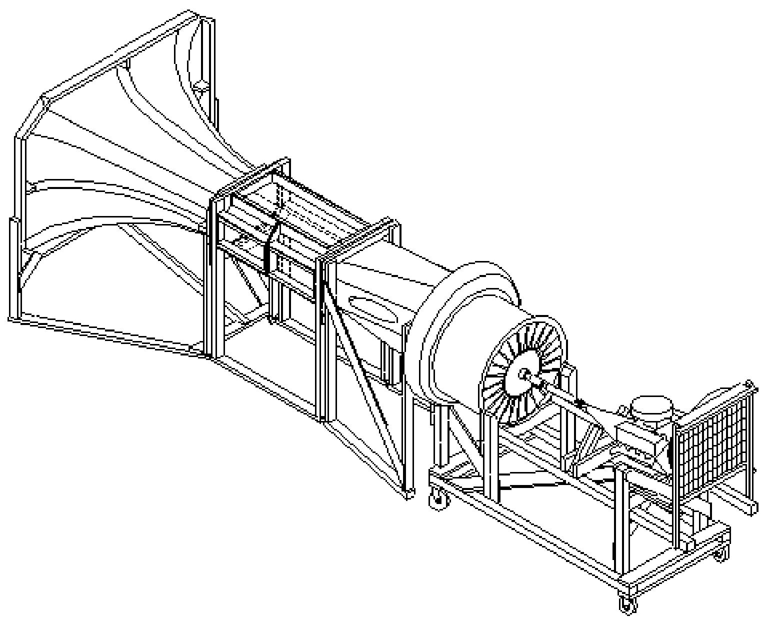
Gevers Aircraft, Inc.

P.O. Box 430
Brownsburg, IN 46112 USA
Email: geversair@iquest.net

Gevers Wind Tunnels
19” x 27” Wind Tunnel

This wind tunnel is an excellent size for educational and amateur aerodynamics as well as economical professional flow visualization experiments on small parts or models. The following describes the wind tunnel and gives advise to those who may attempt to build their own.



INTRODUCTION

After a few years of preliminary design work on the Gevers Genesis concepts, the very real need for a wind tunnel became apparent. So, in 1985, with limited resources we set out to design and build a wind tunnel to meet our specific needs.

After more than a year of creative resource management (scrounging) the small tornado maker took up residence in both bays of our garage. To our pleasant surprise the resulting quality of airflow and accuracy rival many university tunnels.

INLET BELL

The purpose of the inlet bell (entrance cone) is to allow the air to smoothly accelerate from a calm almost static condition to a high-speed flow at the test section. The entrance measures 68 inches high by 96 inches wide and along a length of 66 inches it contracts to 19 inches high by 27 inches wide. An ellipse works very well for the curvature of the walls. The shape and curvature can easily be calculated on a spreadsheet and verified by making a model out of paper.

The structure is made with a 2x4 frame, plywood walls, and plywood reinforcing ribs. To bend the plywood at the tightest portions of the curve it is best to weaken it by cutting grooves across and half way through the tension side. The tighter the curve the closer the grooves. It is important to have a smooth evenly changing curve. Another trick to bending plywood is to soak it with hot water. Cutting the reinforcing ribs out of plywood to the correct curve and attaching to the outside holds the shape. A layer of automotive fiberglass works well to seal and strengthen the joints after attaching the sides together.

A smooth surface finish is easy to achieve by covering the inside surface with 1/4 inch thick drywall. Drywall is easy to bend into a smooth curve with a little moisture and time (10-15 minutes). Lay each piece of drywall (cut to shape) onto the assembled plywood structure and screw the least curved end down first (toward the test section). Wipe the drywall with wet rags then slowly and gently force it onto the curved plywood. Keep wetting the area ahead of the bend and work toward the highly curved end. When the end is reached clamp the drywall down with a 2x4 and straps until it dries.

Joints, bumps, dips and screw heads can be rounded and smoothed with joint compound or spackle and sanded smooth. Several coats of high gloss paint (white) make the entrance smooth, easy to clean, and look very professional.

TEST SECTION

The test section is the main part of the tunnel. Its cross section can be circular, elliptical, rectangular, etc. However, curved walls make construction and use difficult. An excellent general-purpose shape is an elongated octagon. This shape has a large, flat floor and ceiling, flat walls, and 45 degree corners. The rule of thumb for size is for the height to be 70 percent of the width.

Our test section is 27 inches wide by 19 inches high by 48 inches long. It is a 2 x 4 frame lined with 1/8 inch thick plexiglass. The corners are just wide and long enough for double bulb fluorescent lights. The door is a simple removable section of half of one wall with a piece of the 45-degree corner attached. A small (4-inch diameter) hole in the plexiglass door panel is just right for reaching through during a test. A removable (flush on the inside) plug covers the hole at other times.

THE DIFFUSER SECTION

The most complex shape in the whole wind tunnel is the diffuser. It must smoothly transition from the eight sided pseudo-rectangle to the circular shape of the fan section. It must have a cone to cover the fan hub, and it must also have dividers to prevent the fans rotation from creating a vortex upstream in the test section. In addition, this particular diffuser has a unique capability. The horizontal divider has an airfoil shaped hollow passage passing through it from side to side with a plexiglass window at the tip of the cone. This allows us to insert a camera or mirror and see upstream from a viewpoint in the center of the cross section.

THE FAN AND ENGINE SECTION

The choice of the fan was the easy part – we found it in the junk. This particular fan is from a farm grain dryer. There is quite a variety and seems to be quite a few available if you know who to ask at the local farm co-op or put an add in a farm magazine. Of course you could always buy a new one. To find a manufacturer check the Thomas Register under ‘fans’ at the library.

The one we found is 38 inches in diameter and has 14 cast aluminum, adjustable pitch blades and had its own shroud. At 120 mph through the test section the flow is about 38,000 cubic feet per minute.

The engine is also recycled. It is a 351 cubic inch Cleveland V-8 out of our old Ford. One-fourth the power would be adequate but, again, it was available and at the right price. The engine, transmission, radiator, speedometer, engine gages and shifter are all stock items. The driveshaft was shortened, and the throttle is an aircraft type push-pull cable with a fine adjust capability. Fortunately we had an automatic transmission. A clutch would be more difficult to operate. The only custom part was the fan shaft. Any machine shop can make that for you.

The structure is made from 4 x 4 wooden posts bolted together. Use bolts, not nails! Nails will vibrate loose. As with most of the lumber, these were leftovers from other projects. This makes the wind tunnel a close relative of our new deck and remodeled bathroom.

At the time it was built the only place we had to put it was our two-car garage. Obviously, to put a 25-foot long device in a 20-foot room something has to give. The wind tunnel consists of a stationary half and a movable half. The moveable half holds the fan and powerplant. The stationary half consists of – the inlet bell, test section, and diffuser, all of which are firmly bolted together. The fan/engine section is on wheels (2 fixed & 2 castoring wheels) so it can be rolled around for storage.

The movable feature created a problem that soon turned into an advantage. How to seal the separation between the fan and diffuser? We made a giant, soft ‘O’ ring out of a tractor tire inner tube. This not only sealed the junction it also isolated the engine vibrations so they would not be transmitted to the test section.

MODEL MOUNTS

Having an accurate angle of attack indicator on the mounting pylon is important. This job turned out to be easier than expected. With a large circular scale and a vernier on a pointer arm we can repeatably get .05 degree accuracy (much more than needed). The model mount (stinger) goes through a slot in the test section floor and wraps around to the outside of the side wall were it is attached to the pointer pivot. An optional mount goes straight through the side wall at the pointer pivot. As the pointer is moved the model rotates and the angle is read at the tip of the pointer arm.

Force measurement scales were not used on this small wind tunnel. We use it mainly for flow visualization. The scales used on our 5’ x 7’ tunnel could easily be adapted here if necessary (see the scales information under the description of the Gevers 5’ x 7’ wind tunnel).

FLOW VISUALIZATION

The real beauty and usefulness of this wind tunnel is in flow visualization. Ten minutes of moving a piece of yarn on a stick around your own ‘flying’ model is worth weeks of reading about the dynamics of airflow. Reading everything available on the subject is still required but the theories make much more sense when you can see and feel the force and flow.

A small rod with a string glued to the end is to an aerodynamicist what an X-ray machine is to a doctor. You can ‘see’ what otherwise can’t be seen. Other useful tools are tufts of thread attached to the model surface, oil or paint drops dabbed on a glossy white model surface, and of course, smoke.

Be careful since most petroleum smoke is toxic. Corvis oil (used in air shows) is one alternative. To generate smoke I used a small diameter metal tube and electrically heated it while pumping oil through it. As the oil went up the tube it burned and smoked out the other end. Be careful of electrical shock and starting a fire.

SPEED MEASUREMENT

Airspeed measurement is pretty simple. I made a total pressure measuring tube (a tube pointed up stream with a square cut end) and a static pressure measuring tube (a tube with the end blocked and rounded with holes around the sides). The total pressure tube is connected (via flexible plastic tubing) to the bottom end of an inclined manometer. The static pressure tube is similarly attached to the top end. The manometer is inclined at 11 degrees up from horizontal to maximize accuracy. Of course, you could use a standard aircraft pitot tube.

One set of tubes is permanently mounted in the test section for reference flow velocity. An alternate, portable, tube can be used to check the velocity at any point in the test section. I checked the velocity profile across the test section with this tube and found that the velocity is constant to within an inch of the walls. These measurements were verified with an industrial velometer.

SOUND AND SAFETY

The sound level is not bad at all. The fan is not nearly as noisy in the wind tunnel as it was in the grain dryer. The back pressure and turbulence is now much less. The sound pressure level is roughly 80 db at the exit. This is well below the OSHA level for an eight hour per day exposure. And although I see the neighbors pull back their drapes when we make a run, we’ve not heard any complaints.

Safety needs to be addressed in several areas. Personal safety around the tunnel fan, drive shaft, engine fan, and engine exhaust is of prime importance. The engine exhaust is directed away from the working area with flexible exhaust tubing.

Also build strong models that won’t be torn loose and sucked through the fan. Using a screen in front of the fan is a tough choice. Even a course screen greatly affects the efficiency. Our grain dryer fan had the original heavy expanded metal screen that cut the airspeed down by about 10 percent.

CONCLUSION

This tunnel has been used to model several aspects of our airplane design, an industrial ventilation system, and an RC model with quite satisfying results. Of great value is the heightened understanding of the aerodynamics associated with a design. A small tunnel like this can give you a feel and appreciation for some aerodynamic principles that just can’t be gained from textbooks alone.

If any of you should happen to build a wind tunnel in your garage be prepared to find people standing in your driveway scratching their heads and being known in the neighborhood as the people with the “thing” in their garage.