Technical Report TR-5
Building a Wind Tunnel
Estes Industries 1963

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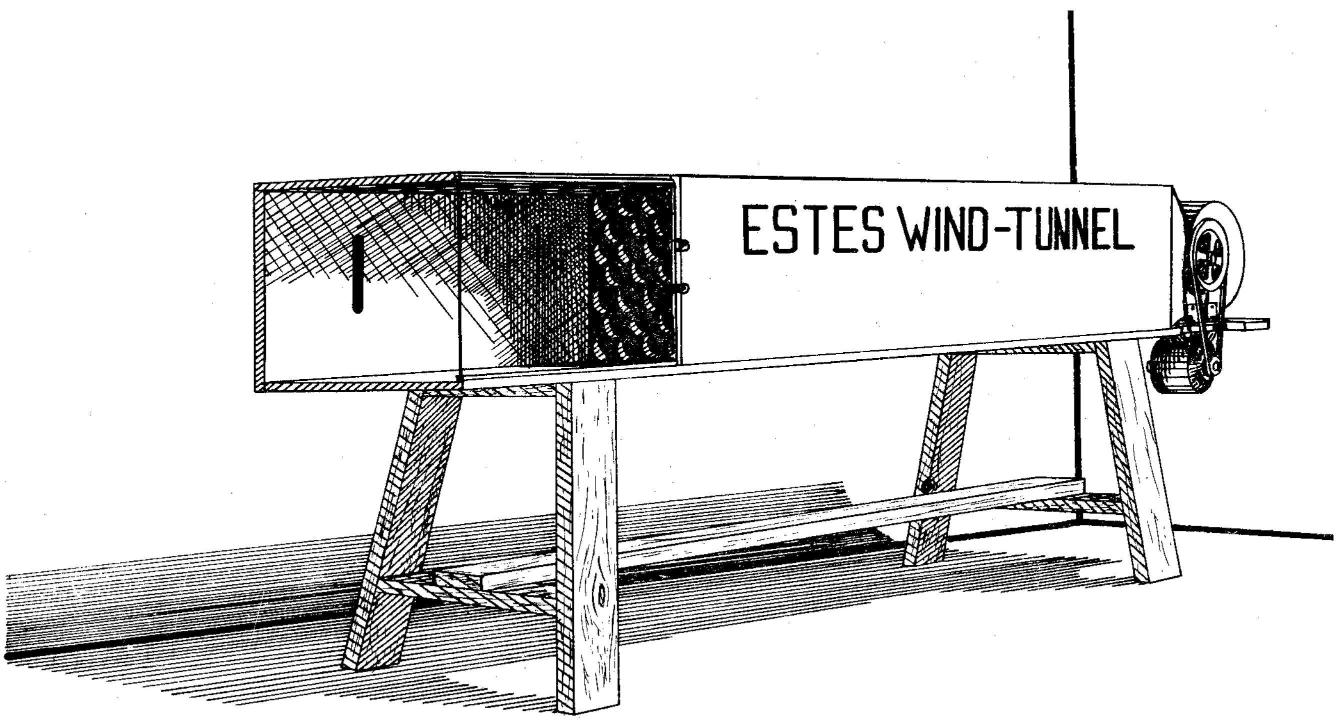
Building a Wind Tunnel



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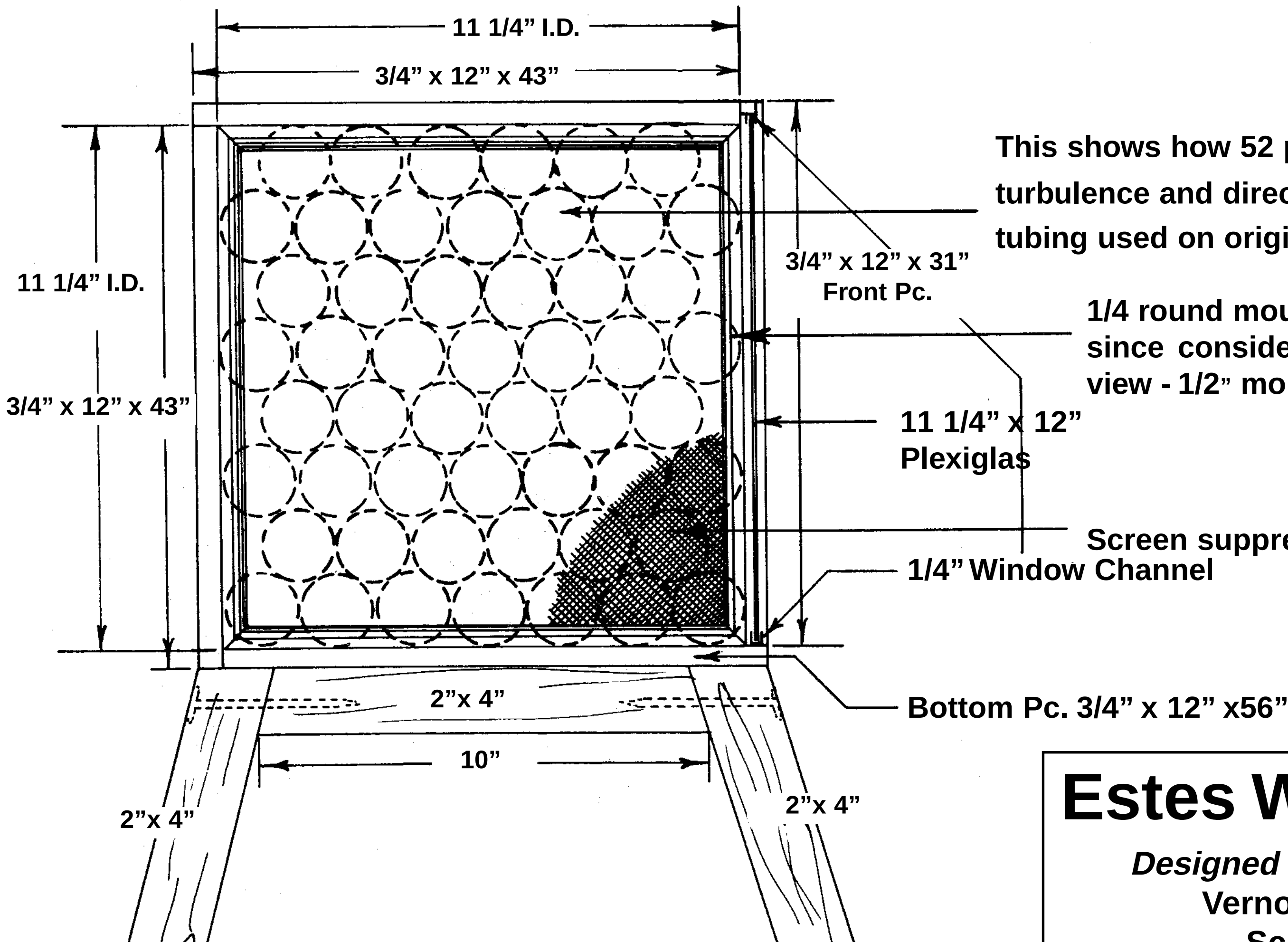
OBSERVATION - END VIEW



Approximate wind velocity
22 feet per second.

Estes Wind Tunnel

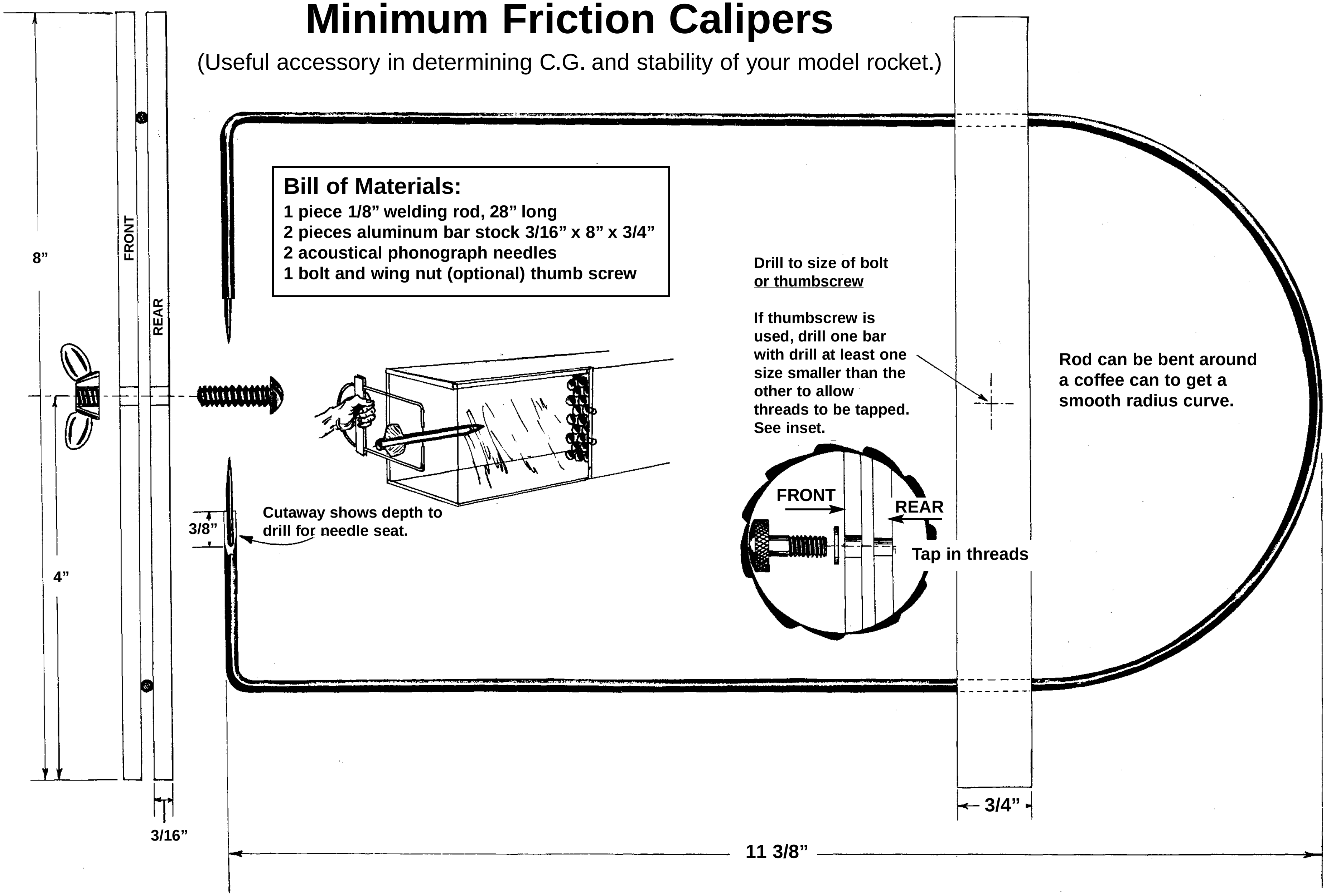
Designed and developed by
Vernon Estes 1961
Scale: 3” = 1’

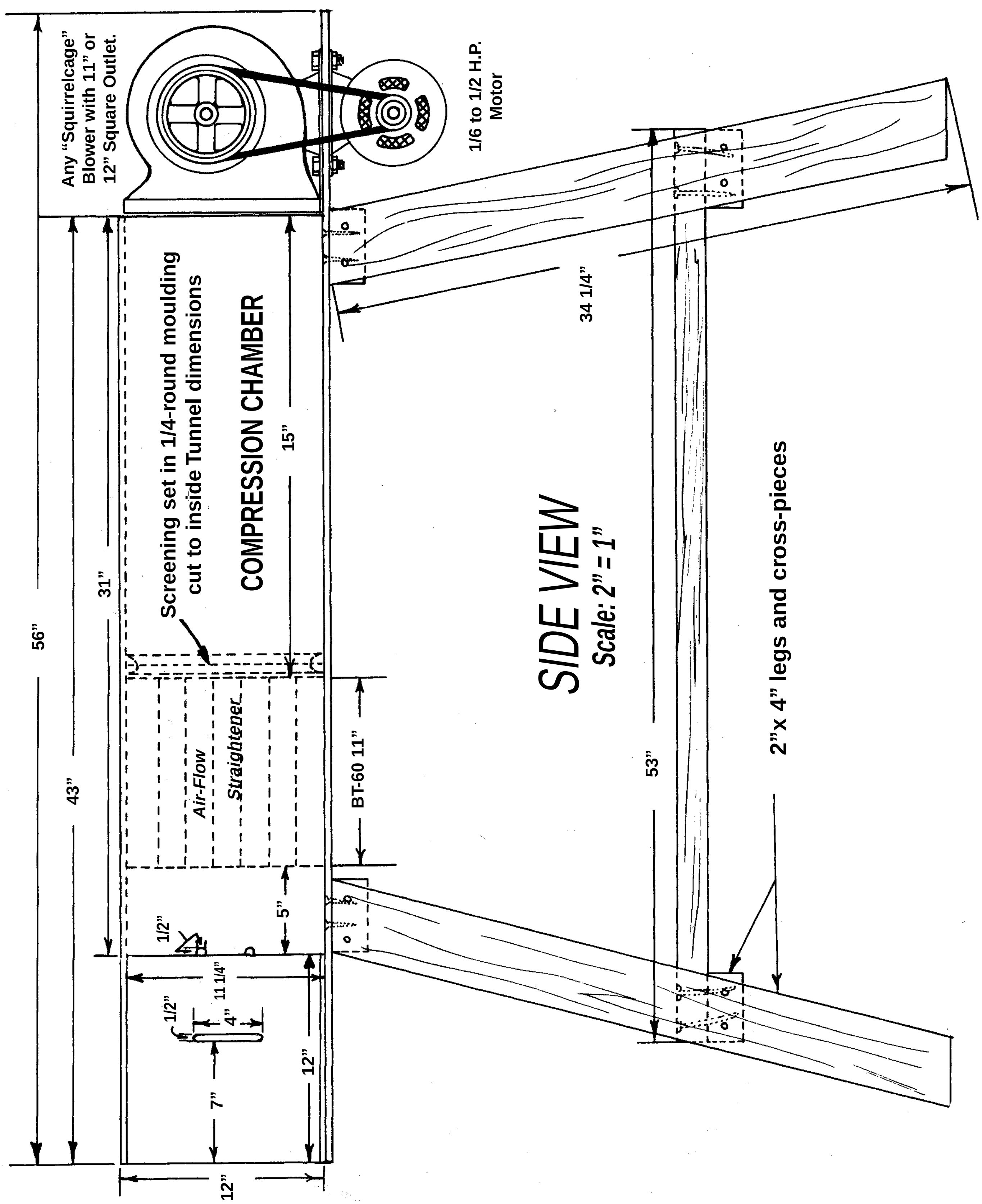
Minimum Friction Calipers

(Useful accessory in determining C.G. and stability of your model rocket.)

Bill of Materials:

1 piece 1/8" welding rod, 28" long
2 pieces aluminum bar stock 3/16" x 8" x 3/4"
2 acoustical phonograph needles
1 bolt and wing nut (optional) thumb screw





Any "Squirrelcage" Blower with 11" or 12" Square Outlet.
1/6 to 1/2 H.P. Motor
56"
43"
31"
15"
Screening set in 1/4-round moulding cut to inside Tunnel dimensions
COMPRESSION CHAMBER
34 1/4"
SIDE VIEW
Scale: 2" = 1"
Air-Flow
Straightener
BT-60 11"
53"
2"x 4" legs and cross-pieces
5"
1/2"
11 1/4"
1/2"
4"
7"
12"
12"

Wind Tunnel Assembly Instructions

The Estes Wind Tunnel was designed especially for checking the stability of model rockets, and can be easily built by the modeler with moderate experience in woodworking. Modifications in this wind tunnel design allow the use of materials the rocketeer already has on hand should not hurt its performance to any great extent.

The blower used in this wind tunnel is a standard furnace blower, and it should be possible to obtain one from your local plumbing-heating contractor for a reasonable price if you specify a used one and tell him what you are going to use it for. The motor can be almost any 1/6 to 1/2 horsepower, 115 volt unit. The ratio of the sizes of the pulleys will depend on the output speed and power of the motor and the rated speed of the blower.

The first step in assembly is to cut out the front, back, top, and bottom pieces from 3/4” plywood. These pieces should be cut out carefully so they will match up properly when attached to each other. Sand the four pieces on all sides and then nail them together to form the tunnel body as shown in the plans. Use 6d finishing nails and apply white glue to the joint before pressing the wood together and nailing. Support the tunnel body during this operation to insure that it remains perfectly square.

Paint the inside and outside of the tunnel with enamel paint. Be especially careful to give the inside of the tunnel a smooth finish to reduce turbulence and give a more even air flow.

Nail four pieces of quarter round moulding into the tunnel to form the rear (blower end) frame for the screen as shown in the plans. Press the screen into position and nail the other four pieces of molding into place to form the front frame. (The screen should be nailed to place without any moulding if minimum turbulence is desired).

Cut and drill the bottom piece to match the mounting holes of the blower and the motor. Be sure that the holes are drilled to position the blower firmly against the rear of the tunnel. The blower should be adjusted so the flow is as even as possible.

Cut, miter, and sand the 2 x 4 pieces for the tunnel stand. Nail the stand together using 16d nails. Nail the stand and the tunnel together, then paint the stand.

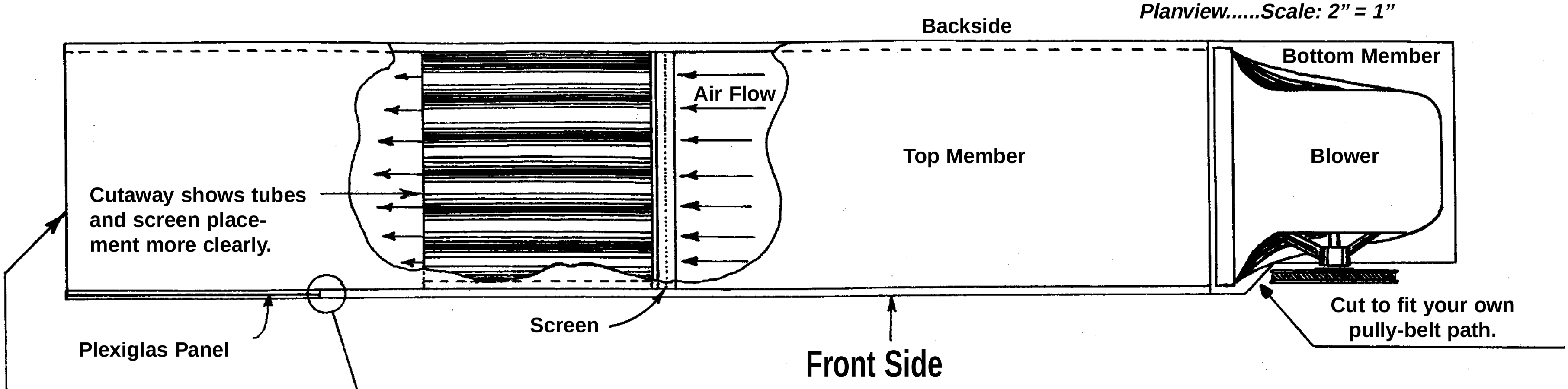
Mount the blower, motor, and belt at the rear of the tunnel. The exact mounting procedure will vary with the type of motor and blower. Make sure the belt has a firm grip against the pulleys on both blower and motor.

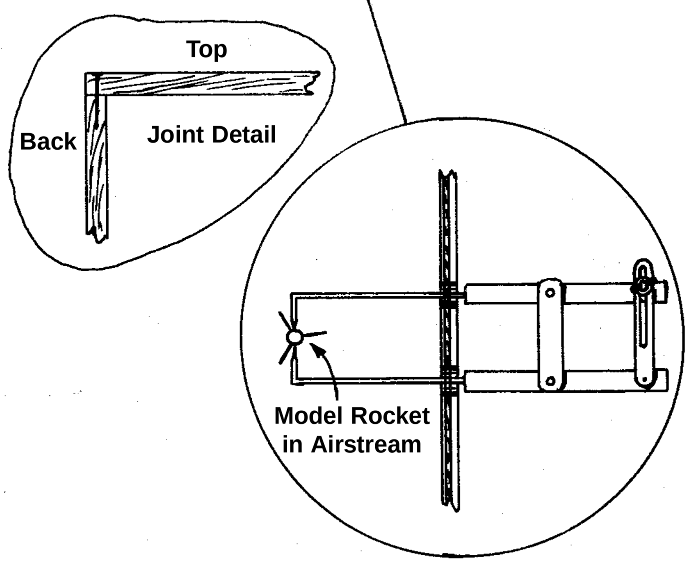
Put the flow straightener tubes in place in the tunnel. These tubes should have a thin wall, and either metal tubing or BT-60 may be used. When all tubes are in place the assembly should make a tight press fit inside the tunnel body. (There are several other possibilities for the flow straightener. It may, for example, be made from heavy posterboard arranged to form a rectangular grid.)

Make a belt guard to keep fingers out of the moving parts of the wind tunnel. This guard should be designed to fit the pulleys and belt used on your wind tunnel, and may be made from sheet metal, cardboard, plywood, or other materials which may be available. Attach the aluminum window channel at the front of the tunnel. Slide the plexiglas window into place and the wind tunnel is completed.

Top View

Planview......Scale: 2" = 1"





Use of low-friction pivot-points is shown here, protruding through the slots adjacent to plexiglas *"Window"*

Bill of Materials:

1 - 3/4" x 12" x 31" ....Front Side Member
2 - 3/4" x 12" x 43"..................Top Member and Back Side Member
1 - 3/4" x 12" x 56"..................Bottom Member
1 - 11 1/4" x 11 1/4" ....Standard Wire Screen, 8 mesh
8 - 1/2" x 11 1/4"......................Quarter-round molding for frame on screen
52 - 11" Section.......................B-T 60 Tubing
1 - 11 1/4" x 12" x 1/4"............Plexiglas Sheet
2 - 1/4" x 12"............................Aluminum Window Channel
2 - 2" x 4" x 10".......................Top Leg-Land
2 - 2" x 4" x 19 3/4".................Leg Cross-Brace
4 - 2" x 4" x 37 1/4".................Leg
1 - 2" x 4" x 53".......................Longitudinal Leg-Brace
Misc. Nails - Woodscrews - Blower and Motor-Mounting Bolts
1 - Squirrelcage Blower with 11" or 12" Outlet
1 - 110 V. Electric Motor, 1/6 to 1/2 H.P.

Open End Permits Test of Larger Models…
But, results may be inconclusive due to "Outside Air" mixing into straight flow, causing turbulence at varying distances from tunnel-end.
Suggest nose of vehicle under test be placed well into tunnel.

PLEASE NOTE:
Though this unit is ideal for stability tests, it is not recommended for checking drag. Flow-velocity is too low at 22 feet per second.

Testing Rockets for Stability

DETERMINING CENTER OF GRAVITY

The first step in checking the stability of a model rocket is to locate its center of gravity. As you know from reading the technical report on rocket stability, the center of gravity is the balance point of the rocket and the point about which the rocket will rotate in the air.

First locate the approximate center of gravity by balancing the rocket on a finger. Then set the rocket on a flat surface, spread the jaws of the calipers apart, and put them into position on the rocket in the area located previously. The two points of the calipers should be on directly opposite points on the body. Pick up the rocket with the calipers. If the nose of the rocket points down, set the rocket down and move the calipers ahead slightly. If the tail of the rocket points down, move the calipers rearward slightly. Continue this until the rocket balances perfectly. This balance point is the center of gravity. The center of gravity is always determined with a loaded engine in place in the rocket. A string and soda straw may also be used to balance and hold the rocket. For details on this system, see technical report TR-1 on Rocket Stability.

CHECKING FOR STABILITY

When the rocket has been balanced correctly, turn on the wind tunnel, and holding the calipers vertically as in the illustration on the previous page, insert the rocket nose first into the wind tunnel. If the rocket remains pointing nose first into the tunnel with nothing but the calipers touching it, it is stable. The string and soda straw (see TR-1) may be used in place of the calipers.

It still remains to determine just how stable the rocket may be. It is not enough if the rocket remains pointed into the wind when aimed in that direction, it must also be able to recover and point back into the proper direction when a rotating force such as an off-center engine or a side gust of wind interferes with the rocket's flight. Also, a heavier rocket must be more stable than a light rocket, since the heavier rocket is going slower when it leaves the launch rod and gets less corrective force from its fins at the lower speed.

Any model rocket must be able to "recover" and point back into the wind when it is pointed 5 degrees out of line. A good general rule to follow is to require an additional five degrees of recovery for every ounce of rocket weight. When we put the rocket into the wind tunnel's air stream we want to see how far out of line we can point it and still have it swing back into line. The greater the angle from which the rocket can recover, the better it will fly. A one-ounce rocket which barely recovers from 5 degrees out of line is only marginally stable, while one which can recover from 20 degrees or more is stable enough to fly under almost all conceivable conditions.

FINDING THE CENTER OF PRESSURE

A more accurate measure of stability can be made by locating the center of pressure (see technical report TR-1 on Rocket Stability). This is done best by marking the center of gravity on the rocket body, moving the calipers rearward on the body slightly, and placing the rocket back in the wind tunnel air stream to see if the rocket will still point into the wind. The calipers are moved backwards until the point at which the rocket no longer will point into the wind, but begins to rotate freely in the air stream is located. This point is the center of pressure, and should be marked on the rocket body.

The rocket's center of pressure should be at least 1/2 the diameter of the rocket body behind the center of gravity for proper stability. The diameter of the rocket is called its caliber, and it is common to talk about the stability of the rocket in terms of calibers. Thus a model which has its center of pressure 1/2 caliber behind the center of gravity is said to have 1/2 caliber stability.

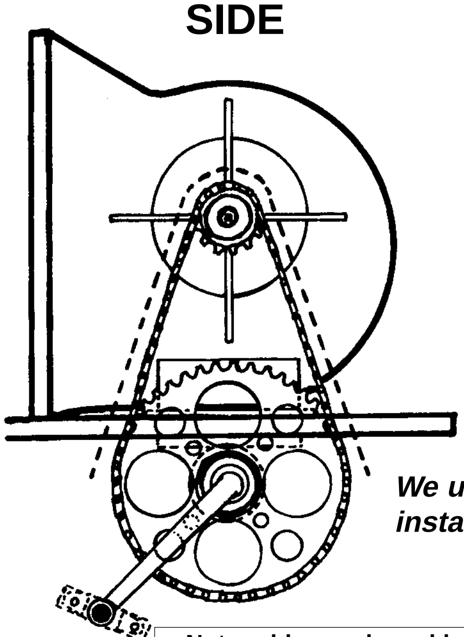
CHECKING MULTI - STAGE ROCKETS

The procedures outlined above are also used in determining the stability of multi-stage rockets. However, some extra steps must be taken with such a model. A multi-stage rocket must be checked in all the shapes in which it will fly. Thus, a two-stage rocket is checked with both stages joined together and then the upper stage is checked alone.

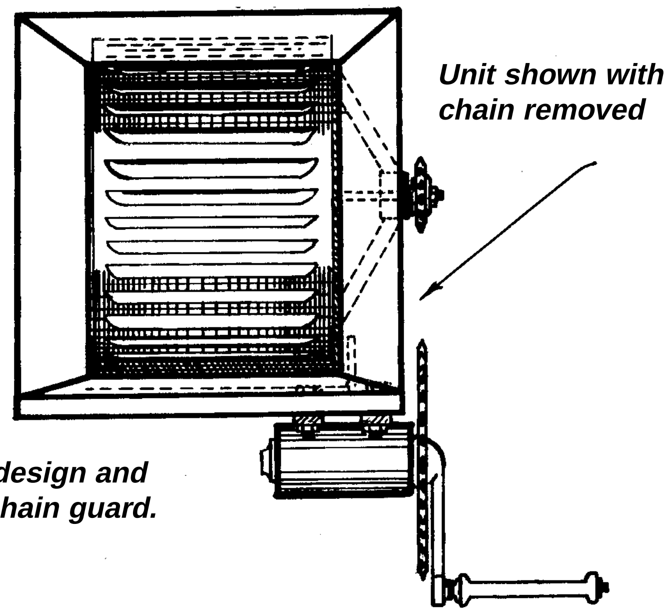
In addition to determining the stability of all stages together, the upper stage alone, etc., it is also important to check the stability of the booster by itself as it would be after upper stage ignition and stage separation. In this case, however, we want results completely different from those for an upper stage. A booster stage should be unstable by itself. This is so that it will tumble to earth instead of streamlining in. When we pivot the lower stage on the calipers at its center of gravity, we want it to rotate freely and not point into the wind.

HAND-POWER for your MODEL WIND TUNNEL

SIDE



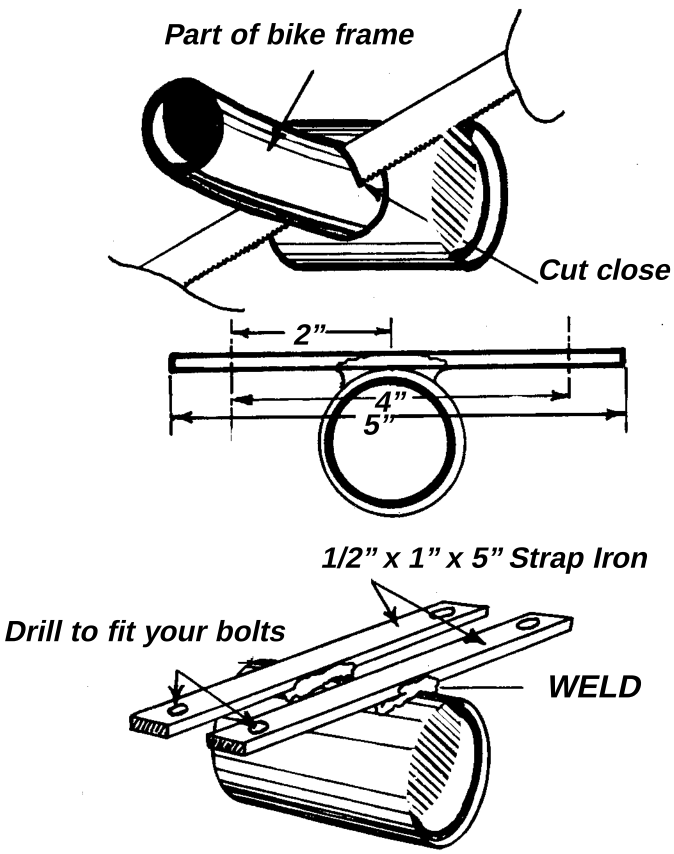
END



We urge builders to design and install an adequate chain guard.

Note rubber pads and brackets are removed, leaving pedal axle and housing as crank-handle.

BOTTOM "PEDAL" UNIT DETAILS



If your wind tunnel is to be used on the firing range, chances are that electric power won't be available to run a motor. To allow the range control officer to check any rockets of questionable stability, you might build your wind tunnel for hand power.

The parts for the drive unit on the hand-powered wind tunnel can be salvaged from a used bicycle. The bearing carrier for the pedal-sprocket unit is cut from the frame, and the pedal on the side away from the sprocket is cut off completely. The mounting for the rubber blocks on the remaining pedal are removed to make a hand crank.

Two pieces of strap iron are welded to the bearing carrier as in the drawing. This unit is then mounted at the rear of the wind tunnel under the blower. The sprocket on the blower can be one from the rear wheel of the bicycle, although a smaller sprocket will give a higher speed. Be sure that the teeth on both sprockets fit the chain. The chain should be adjusted to fit fairly tight around the two sprockets (about the same fit as for a bicycle). Design and install an adequate chain guard to protect the operator.