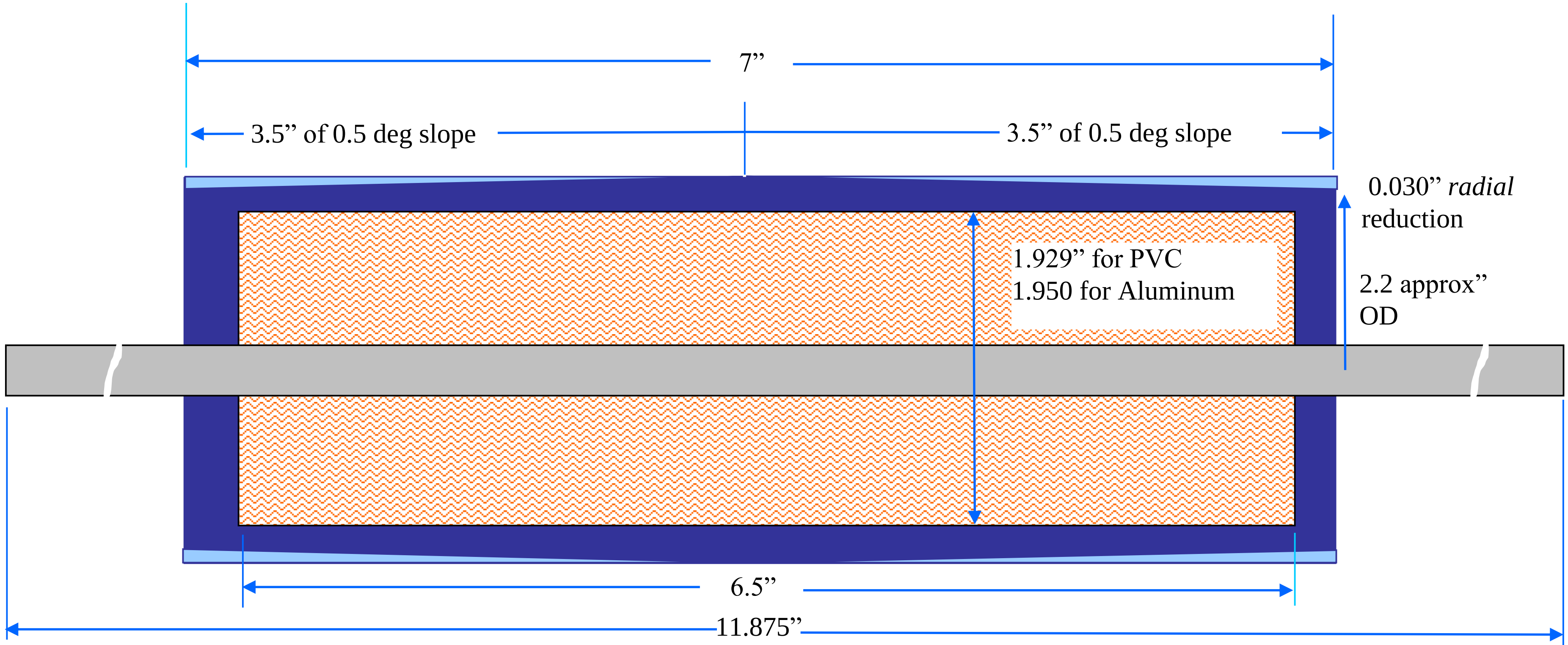
## Roller assembly (actual size)




Roller assembly consists of:

a. 5/16 x 11.875” nominal SS rod,
b. 6.5” x 1.935” redwood core
c. Schd 80, 2” OD PVC pipe (2.375” OD, 1.913” ID x 7” length nominal; Schd 80 structural aluminum pipe can be used in an alternative design)

0. Check the lathe for longitudinal runout. Adjust tail stock if necessary.

1. Core is made from 3.5” x 3.5”x 1 ft block of redwood. It is first roughed out in a lathe using a 4 jaw chuck to a 2.25” diameter cylinder for PVC roller, 2.35” for aluminum roller. While still mounted, the cylinder is bored first with a regular length (“jobber”) drill for rigidity considerations, and then with a long 5/16 drill for about 8.5”. total depth. Then the cylinder is cut off to a nominal 6.5”. A portion of the still-mounted stub can be turned down to 1.929”, cut off and saved for use as a “pusher” for later use. The cylinder should be left to dry in a low humidity environment for a few days.

2. The stainless steel axle is made from 5/16” diameter stainless steel ground rod, 11.875” long and is faced and center drilled at each end. A three jaw chuck (usually accurate to a few thousandths) can be used thereafter.

(A center drill was broken in the process of machining an axle. The axle was discarded and used for experiments and tests. During this process, the damaged end was cut off and soaked in a little bit of “The Works” toilet bowl cleaner. It has 20% HCl and detergent (use $H_2SO_4$ for aluminum). The theory was that the HCl would attack the broken drill bit, but not the stainless steel. After a few hours the container was shaken and the broken bit fell out. The bore could have been resurfaced, and so the axle need not have been discarded. Center boring of stainless requires perfect tail stock alignment, high speeds, a rigid setup, lots of cutting oil suitable for stainless steel, and frequent in-and-out motion of the drill. (Another (unrelated) broken bit removal was performed on a large bolt, same method, same success) )

3. The wooden core and axle are coated with 60 minute epoxy and then slipped together. Each end of the axle overhangs the core by about 2.3”. Let the epoxy set for a day. (If later there is a problem that requires removal of the axle, the whole assembly can be heated in an oven to 300 F, and then the axle can be pulled out.)

4. The axle and core assembly is then turned between a three jaw chuck and a live tailstock center until the OD of the redwood is about 1.950”. Shallow cuts are used because this assembly is not particularly rigid. This operation should remove any eccentricity due to off center drilling. It is then turned, tested, recut, filed several times to see if there is a good fit with the PVC (note: there will always be some variations in the dimensions of these materials.) Sanding off the final 0.002” is the preferred method. The final fit will have essentially no radial play.

5. The PVC (or aluminum) pipe is cut to 7” length. (I preferred to use a band saw; facing and truing can be done later in the lathe with a three jaw chuck and a live tailstock center.)

6. The wooden portion of the redwood core axle assembly is first coated with a thin layer of 1 hour epoxy; the inside of the PVC (or aluminum) is also coated. Then the two are carefully pushed together. Excess epoxy that is pushed out is used to seal the ends of the redwood. Let the epoxy set for a day.

7. The assembly can then be checked for any eccentricity (usually a few thousandths) which can be turned out. The ends can be faced to remove any slope due to the band saw cut. Once everything is trued up, a 0.5 degree “slope” is cut center-to-end (3.5 inches) on both halves of the aluminum. The OD at the ends of the PVC will be reduced by about 0.060” (0.030” radius) down from the value at the center. Also, this is not a particularly rigid setup; use minimal tool overhang, a sharp pointed tool, and shallow cuts (0.005) to minimize chatter). Several passes at the same setting may have to be made during the last set of cuts. The output of this operation is a roller with an obviously rough surface.

Note: only the aluminum rollers are crowned. Crowning both rollers will result in a belt tracking instability. This is especially apparent with wide, reinforced belts. Customarily, only the *driven* (not driving) pulley is crowned. The crown here is the “double cone” type. (I am trying to avoid using the word “taper” here because it means something else to machinists.)

This machine is intended to use sprayed charge (25,000 volts) to put a positive charge on the belts. However, belts also charge "triboelectrically" by so-called "friction". What actually happens is that two different surfaces are pressed together momentarily and then are separated. This will leave a charge imbalance on each surface, the resulting polarities depending on where each surface is in the list of triboelectric materials. PVC and clear, flexible vinyl have somewhat different positions, and the result will be a positive charge on the belt. This charge would be stable, except that the van de Graaff electrodes are designed to remove the positive charge from the belt and conduct it to the upper terminal. The spray effect and the triboelectric effect thus operate in unison to give the upper terminal a positive charge. Too much crown will reduce the (triboelectric) contact area, but too little makes belt tracking difficult.

8. The outer surface of the roller is first smoothed with a flat file, and then progressively sanded with 200, 400, 600, and 1500 grit paper I used kerosene as a lubricant). Oils can be removed by wiping the final surface with a small piece of paper towel saturated with isopropanol (Caution: isopropanol is VERY flammable; do not keep more than a few ounces in your shop. Store the rest elsewhere).

9. About 1.25" on each end of the axle is turned to fit the bore of the ball bearings (the rod used for the axle is usually slightly oversized). This must be a tight fit with minimal radial play. Gentle filing and sanding is usually all that is necessary.

## Materials

Schd 80 2" x 12" PVC pipe nipples (2.375" OD, 1.913" ID) TOE (or unthreaded) x 2 each (ACE Hardware store or Zoro)

Schd 80 structural aluminum pipe 6061-T6 2" (2.38" OD x 1.939 ID) x 12" x ( 2 each used; www.onlineMETALS.COM )

5/16" SS ground rod (ACE Hardware)

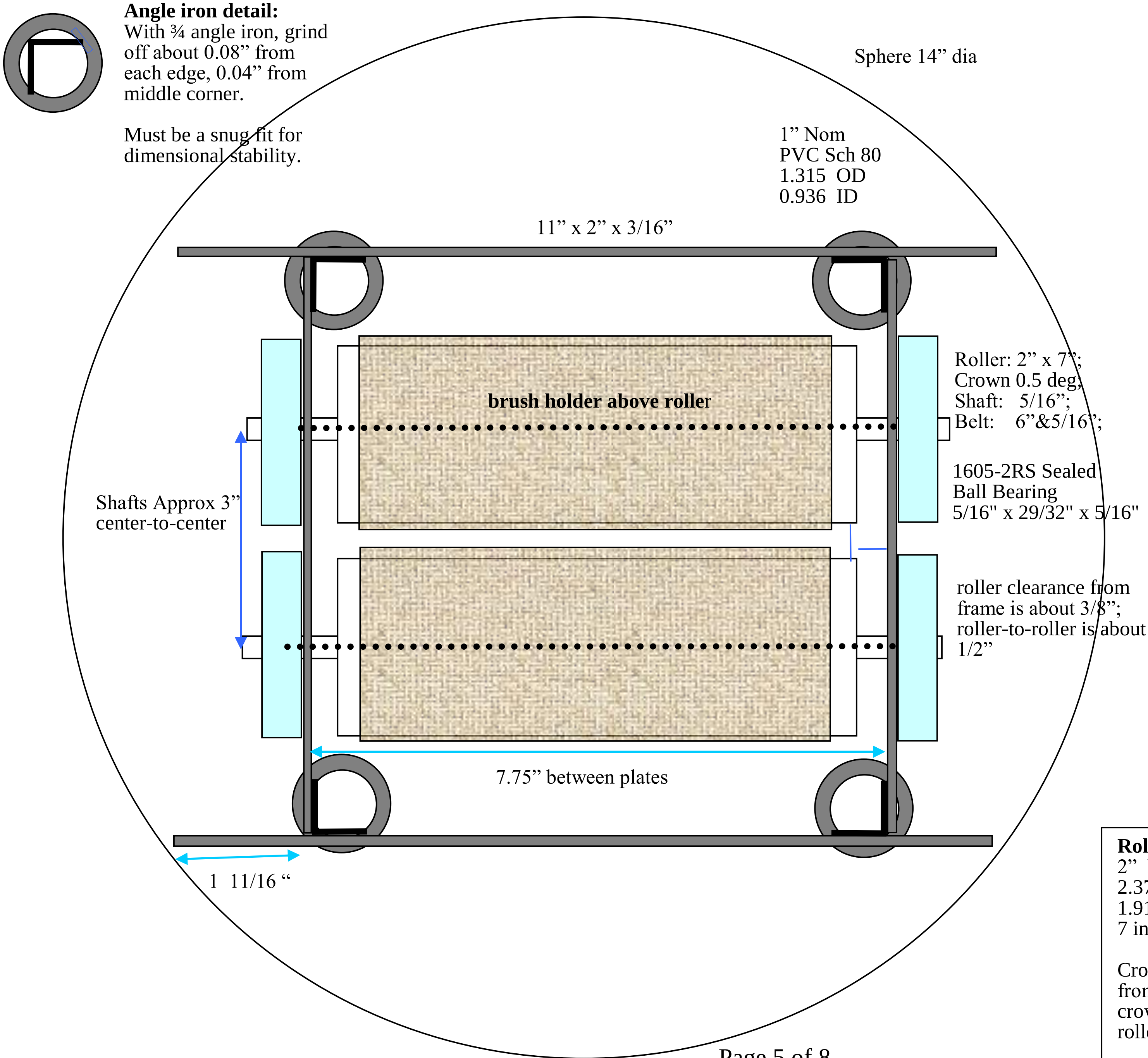
redwood block 3.5" x 3.5" x 12" (4 used)

Epoxy, 1 hour

What follows below are conceptual sketches that were used in the design process. They do not necessarily depict the final design.

# Top Roller Assembly; Plan view (1/2 scale)

Conceptual sketch

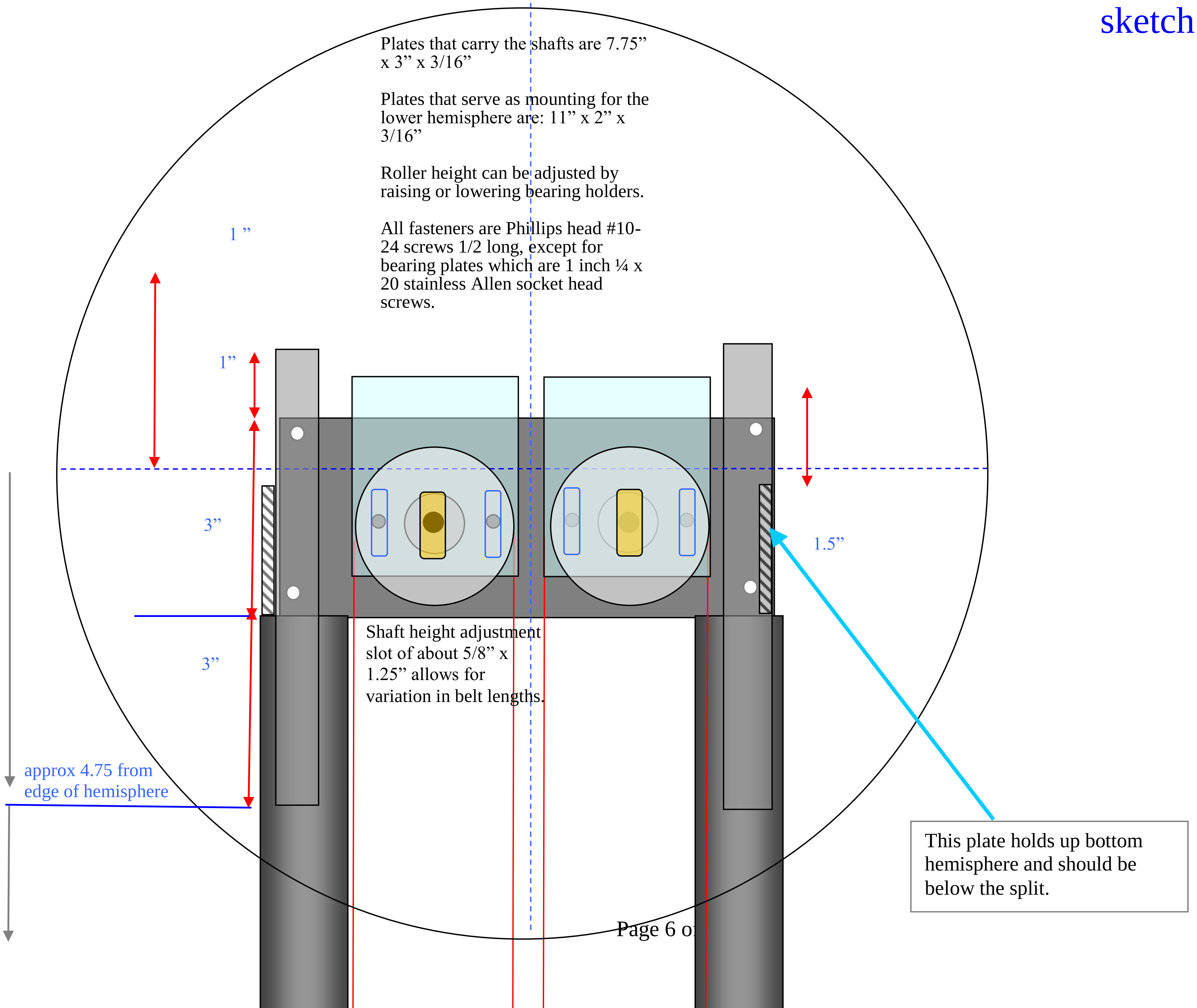



**Roller:**
2” Nom Schedule 80 PVC
2.375 inches OD
1.91 inches (48.5 mm) ID
7 inches length

Crown: 0.5 deg slope away from center (“double cone” crown) Only the aluminum roller is crowned.

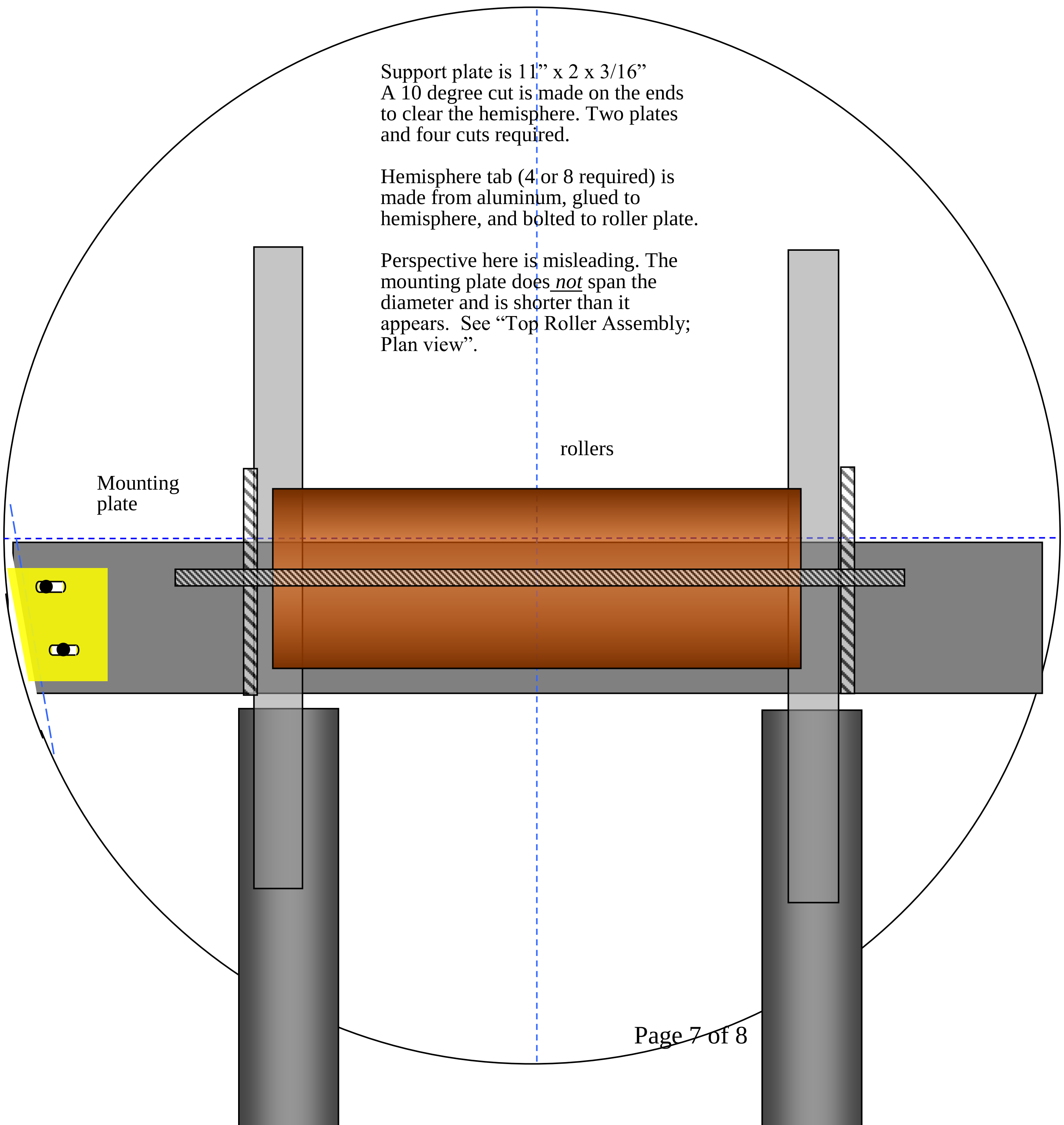
## Top Roller Assembly; Elevation view (1/2 scale)

Conceptual sketch

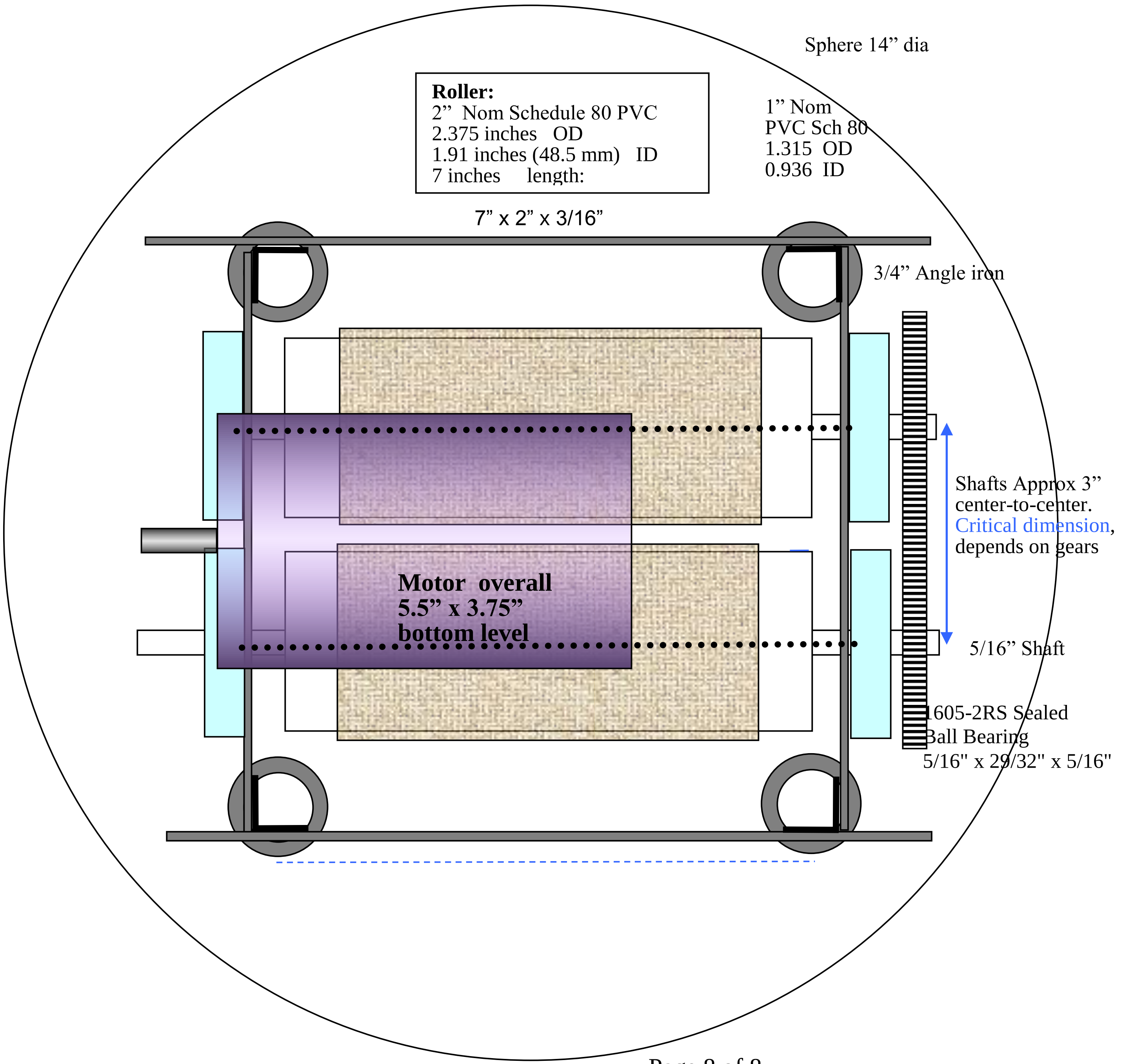


## Lower Hemisphere attachment to roller frame; Side view (1/2 scale)

Conceptual sketch



**Bottom roller assembly; Plan view (1/2 scale)**




Conceptual sketch

**Power Train**

Gears: Nordex LASB2060, 20 pitch pin hub spur gear, Stainless steel (two used). Alternative: 2 pulleys with figure 8 belt (much cheaper)

MISUMI MBT10-690 Polyurethane Round rope belt

MISUMI MBR80-5-N12 Belt pulley, steel or for speed increase MBR140-5-N12 (motor shaft)

MISUMI MBR80-5N8 Belt pulley, steel (roller shaft)

One pulley is specific to customized motor shaft adapter.

A36 Steel Rectangular bar (12 x 6 x ¼) Amazon Supply. (1018 steel preferred)