

Using a Beam Compass for Curved Parts

Many parts in a paper model are segment of cones, and have circular arc boundaries. While it is possible to do a good job in cutting these edges out by eye, there are inevitably some variations in the contour that translate into gaps on assembly. To eliminate this problem, a beam compass is a very useful device, delivering exactly circular cut edges, which mesh perfectly with no gaps or irregularities when the parts are brought together. The beam compass is preferred, as opposed to the more familiar bow- or school-type drawing compass, because these cut radii are often quite large, up to several feet, and an expandable device is needed to cover the range of radii likely to be encountered. While a beam compass is not a common piece of equipment, it is not difficult to obtain (or make) and use, nor need it be very expensive.

Commercial devices:

A classic beam compass has two components: a *beam* (which may be in joinable segments or separate pieces of various lengths), and a set of *trammel points*. The trammel points consist of a *pivot point*, which sticks into the center of the arc, and a *drawing or scribing or cutting point*, which carries a pen (or pencil lead) or a hardened steel point or a blade, respectively. In a good quality set, the pivot point has a *vernier screw*, which enables the point-to-point distance to be set very precisely. The beam is simply a device for holding the two points at a specific distance apart. Traditionally, the trammel points are sold separately, and the user supplies his own beam, which is usually a straight piece of light wood with a rectangular cross section about 3/8" by 3/4", of whatever length is desired. A typical set of trammel points (in this case made by Starrett Tools) is shown in the figure below. As will be shown later, the only part of this set that is really valuable to the paper model builder is the vernier-equipped pivot point – everything else can be easily made from simple materials.

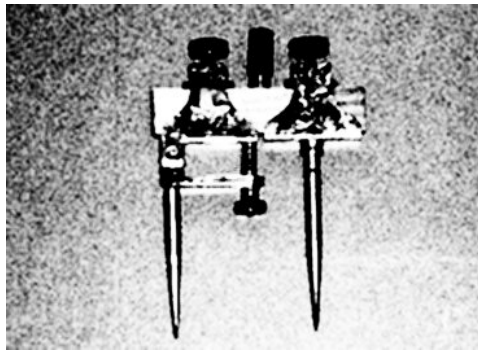


Figure 1 – The \$100 beam compass

A much less expensive system is available at most art or craft shops, and is designed for cutting mattes for mounting pictures. It consists of two aluminum cylinders, one of which has a point and the other a replaceable cutting blade. The points are designed to be mounted on an ordinary yardstick, and are moved by loosening and retightening a clamp. This will actually do a good job, if the yardstick is reinforced properly, although it can be frustrating to adjust properly. By making a substitute for the yardstick, any desired length of radius can be cut. The replaceable blade is not rigidly aligned in the cutting cylinder and must be aligned by eye relative to the cutting line, which can lead to some frustration if it is not set just right.

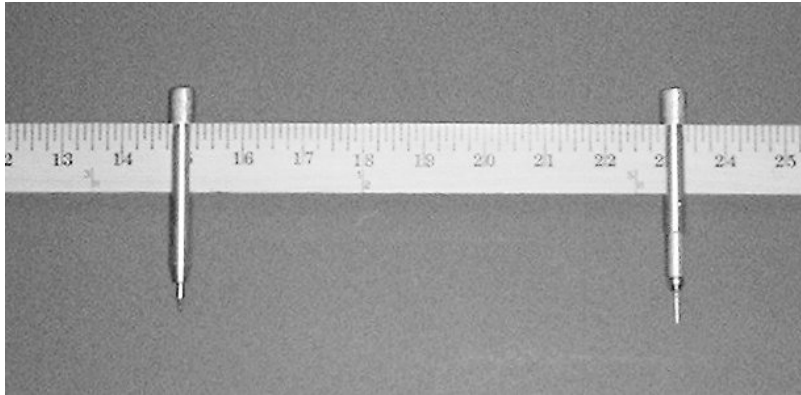


Figure 2 – The \$2 beam compass

There are other beam compasses available of intermediate cost, but they are designed specifically for drawing and are rather difficult to modify for cutting. One is shown below. It is made by the Alvin Co. (Model 961B), and consists of two adjustable points, and a two-piece aluminum beam, allowing it to work radii between about 2" and 24". While easier to adjust than the yardstick compass, the knurled-wheel adjusters tend to move in fixed increments of about 0.01", which can make a radius that is maddeningly just too big or just too small. The device is supplied with one pivot point and a combination scribing/drawing point. If this point is removed, a #11 (or better yet a #10) X-acto blade can be mounted in the chuck, as shown below.

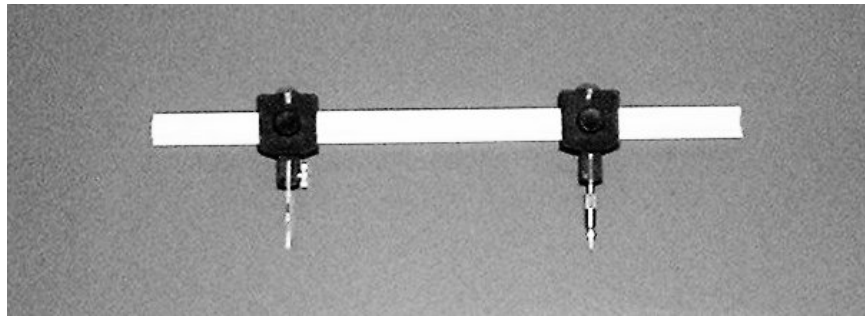


Figure 3 – The \$34 beam compass.

All of the above devices suffer from one common fault: the beams are too flexible. When drawing or scribing for tool-and-die work, this is not a problem, but when cutting, the drag of the blade causes the beam to bend, which steers the blade away from the ideal radius, the cut itself then steers the blade further off-line, and the cut is ruined. The solution is to a) use very light cuts, taking perhaps 5 passes to cut the paper, and b) reinforce the beam. Fortunately, this is easy to implement. In the figure below, the yardstick compass has been stiffened up by clamping two aluminum channels (bookshelf standards) to the yardstick with two spring clamps. It is not very attractive, but does the job. Each of the other types of compass can be stiffened in the same fashion.

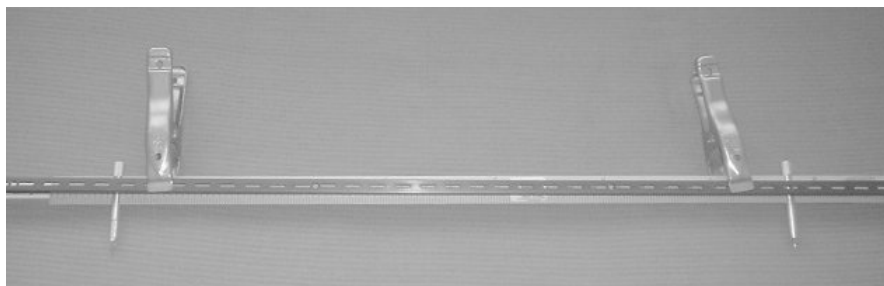


Figure 4 - Stiffened beam compass

These beam compasses are also very inconvenient for small radii, and usually can't go below 1 or 2 inches. For small parts, we have another solution, the Olfa-type cutter. These are small plastic devices that can cut radii between about 3/8" to about 7". There are several brands, which use a common replaceable blade, and look very much alike. I've found the C-Thru brand (Model C-101) to be the better made, and slightly cheaper, although the Olfa brand will cut slightly smaller radii. All require some judicious use of Scotch tape or paper shims to remove some of the slop in the mechanism that would otherwise cause the radius to creep while making the cut. Their pivot points are also rather dull which makes them harder to center accurately and tears up the paper while cutting, but this is easily remedied with a file.

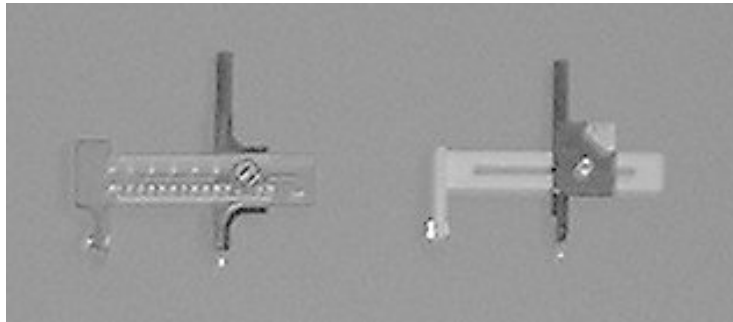


Figure 5 – The \$6 (small) beam compass

Finally, for very small radii, there are punches and paper drills that can work radii down to fractions of a millimeter, but this is outside the scope of this discussion.

All of these devices can be purchased and modified, but the chances are some sort of home-built device will wind up the best choice, combining the best features of other systems.

A home-brewed beam compass

When my Dad left Lockheed in 1945, he had a set of Starrett toolmaker's trammel points, which I've managed to hold onto ever since. They are seen in Figure 1. The vernier point became the core of my paper-cutting compass. Combined with the cutting head of an Olfa cutter, a 5" piece of 1x4 wood, and a set of various lengths of 3/8" x 3/4" wooden beams, the gadget looks like this:

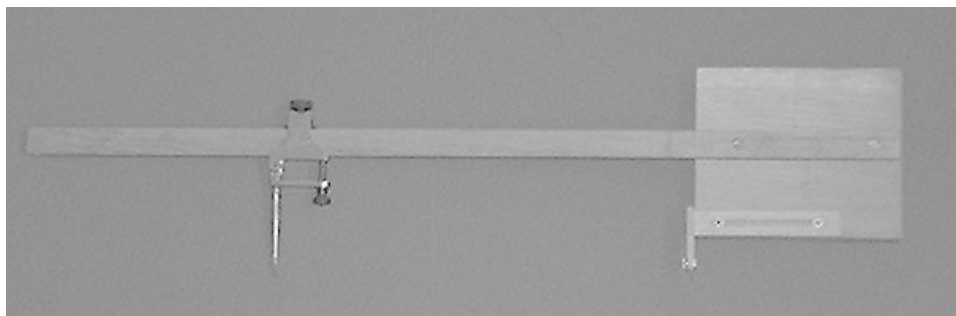


Figure 6 – The home-made beam compass

If a vernier trammel point is not available, a substitute can be made up from a block of wood and an adjustable bow compass available at any craft store for about \$5-\$10. In the picture below, you can see how the drawing point has been removed and that leg locked to the wood block, while the pivot point leg can be adjusted by the screw wheel. The block would be clamped to the compass beam with spring clamps as shown for rough adjustment, or possibly a more sophisticated system could be devised.

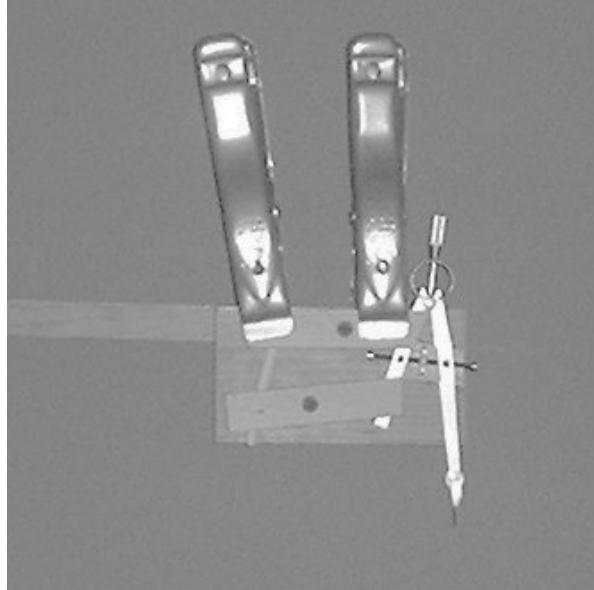


Figure 7 – Alternative adjustable pivot point

How to use it:

If you're looking at one of my model designs right now, you will find that the center of every circular cut is located. It may be off the part page, but if so, it can be located without the use of any drafting equipment other than the human eyeball and your beam compass. The choice of compass is up to you, but whatever it looks like, here is how to use it with one of my models.

The set-up for cutting a long-radius part is shown below. To the right is the basic part sheet. To the left is the auxiliary sheet which helps locate the center point. In some cases, if the radius is big enough, it may take several auxiliary sheets to reach the center point. Underneath the auxiliary sheet is a pad of heavy card stock (I usually use 110# cover stock) to help grip the pivot point firmly. A similar sheet (which doesn't show) is underneath the part sheet, to help protect the cutting blade point, which will dull very rapidly if it contacts the board underneath. All of the sheets are taped down firmly to a cheap particle-board bookshelf.

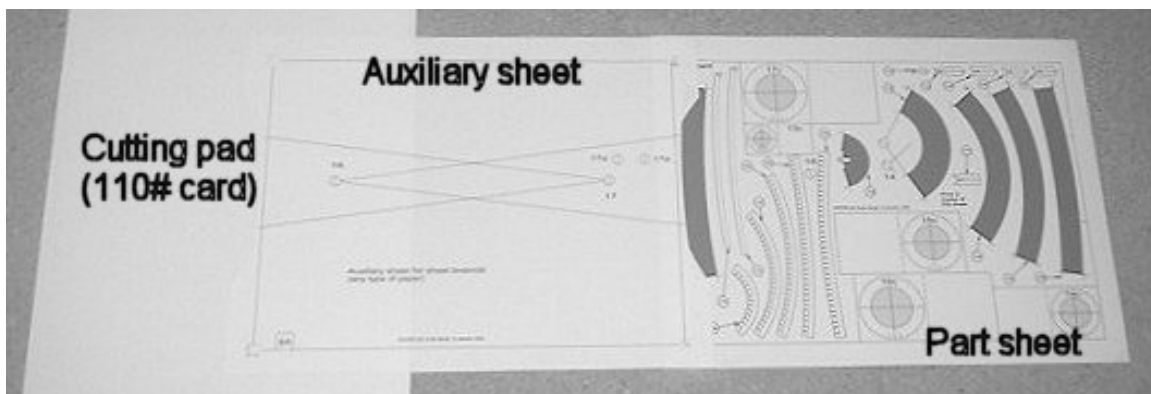


Figure 8 - Radius cutting setup

To begin, tape the part sheet (with the pad underneath) to one end of the cutting board. Position the sheet involved on the board at the end away from where the center point will lie.

Cut out the small x-ed-out boxes along the side boundary of the auxiliary sheet and lay it down so that the right-side boundary lies exactly over the left-side boundary of the part sheet, using the cutouts at the top and bottom corners to adjust the side-to-side alignment (see the figure below).

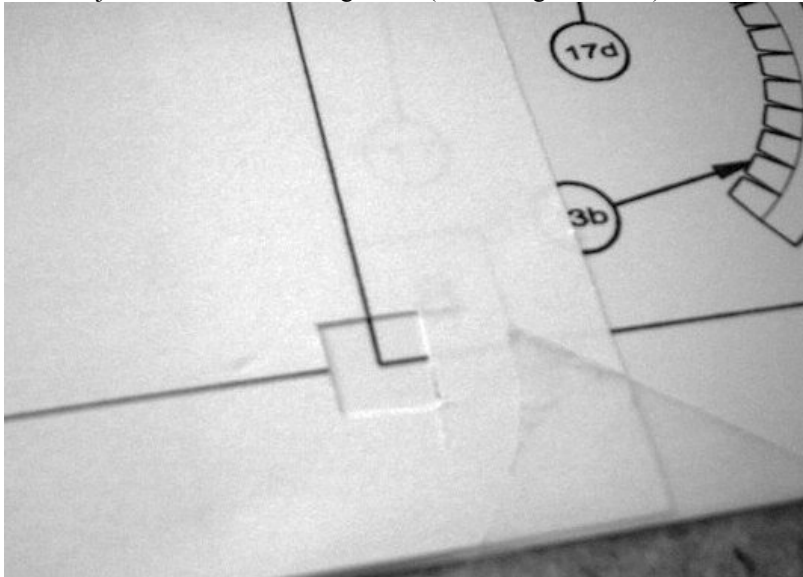


Figure 9 – Initial lateral alignment

Adjust the vertical alignment by fitting the cut radius lines extending over the edge of the auxiliary sheet to the short segments at the edge of the part sheet. It will help if about half of the radius line that extends over the boundary of the auxiliary sheet is trimmed away (see the figure below).

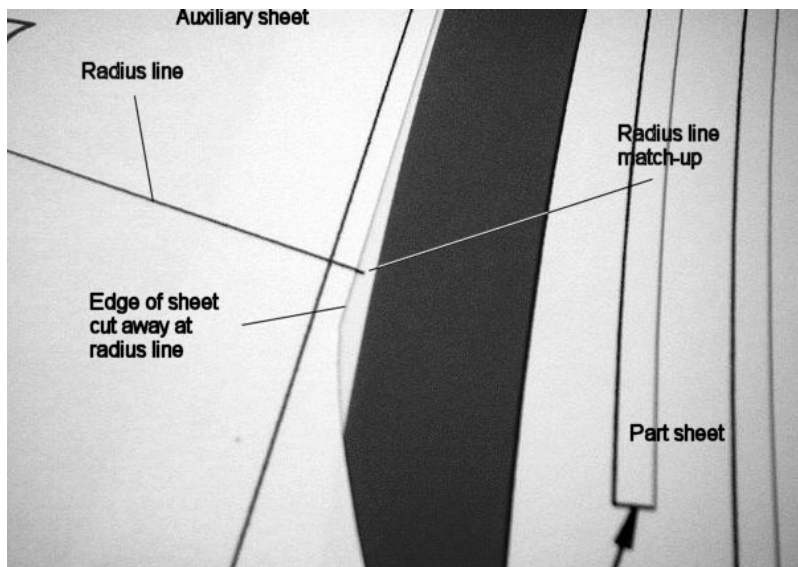


Figure 10 - Vertical alignment

Tape the auxiliary sheet down firmly, and repeat with additional auxiliary sheets (if there are any), aligning each to the edge of the previous sheet in the same fashion. Continue until the last center-point is reached. Again, place and tape down heavy card under each area where a center point target lies. The set-up should look like figure 8.

Now look at the part and notice that one of the extensions of the larger radius end of the part has a tiny circle. Set the pivot pin of the compass at the tip of the extension line at the center of the small circle, as shown below:

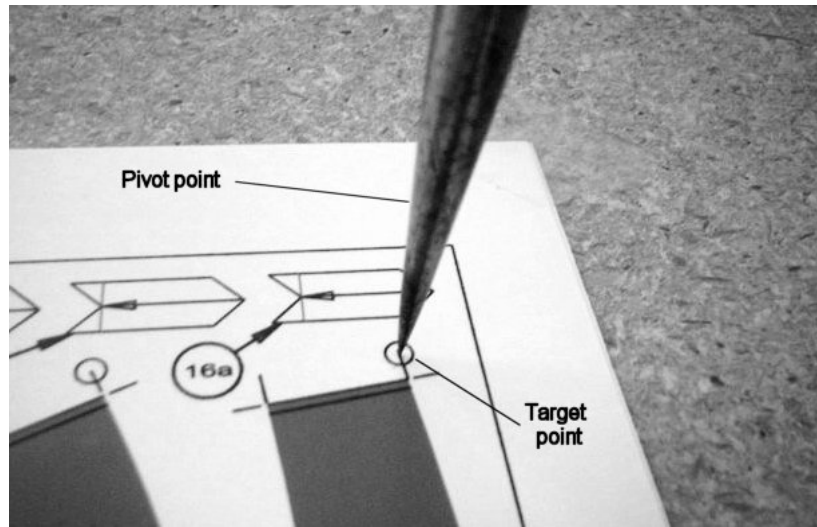


Figure 11 - Locating the target point

Adjust the knife blade position until it is over the center target on the auxiliary sheet. The target is the circle at the meeting-point of the two radius lines, with the appropriate part number nearby. Inside the circle is a short arc segment, which is centered at the point where your compass pivot point is resting. Adjust the point of the blade until it lies exactly on this arc segment, as shown in the picture below. Be very careful with this adjustment, as light, shadows, and reflections will all conspire to put the blade in the wrong place. It is easiest to locate the blade properly if the cutting edge is facing away from you. In the figure below, the blade is the wrong way around for this, and should be removed and reversed.

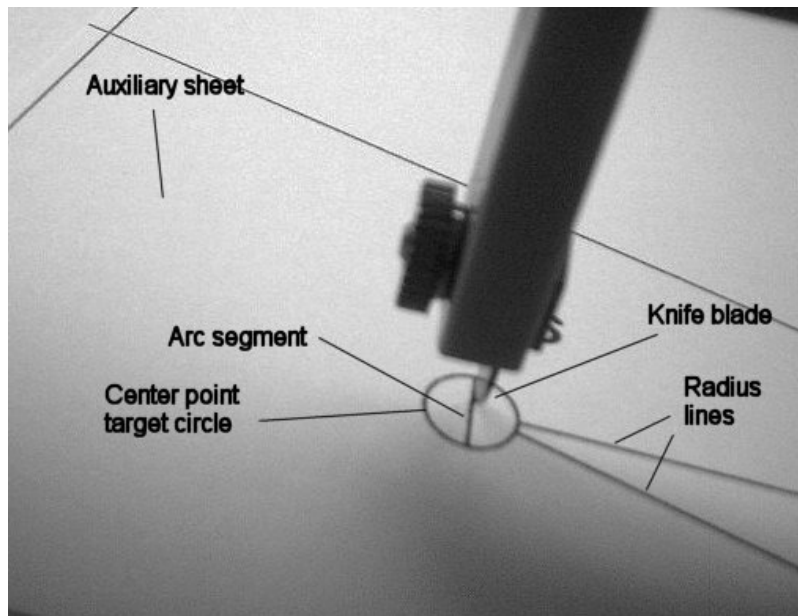


Figure 12 - Aligning to the arc segment

With the blade in this position, make a light cut along the arc segment, enough to scratch the surface noticeably along the arc segment. Now, *without adjusting the compass settings*, reverse the compass so that the tip of the knife blade is exactly on the edge of the part at the other end of the cut from where the pivot point was initially set, as shown below.

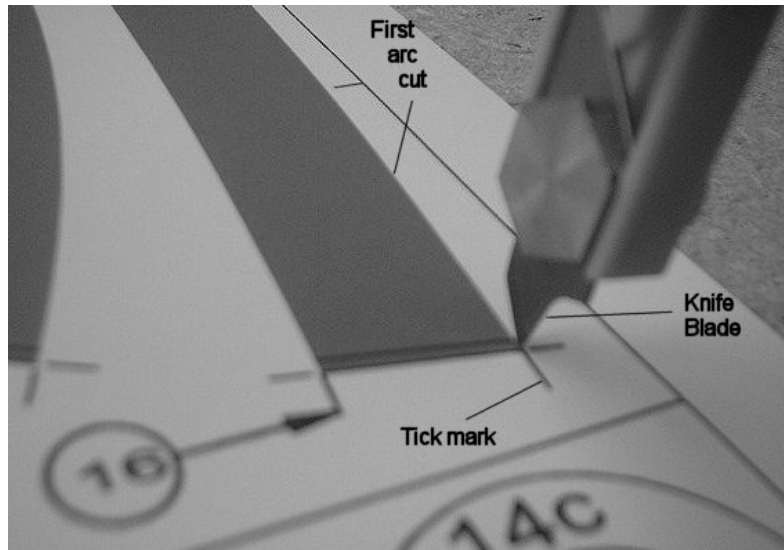


Figure 13 - Locating the blade

Again, take great care with this positioning. It is easiest to target on the tick marks that extend the boundary rather than on the boundary itself. Now, using the knife point as a pivot, swing the far end of the compass until the pivot point is on the center target arc segment. Lightly drag the point across the arc segment until you feel the point “trip” in the scratch mark. This is the required center point. Finding it in this fashion is far more accurate than doing it by eye. Press the pivot point down firmly into the sheet and underlying heavy card.

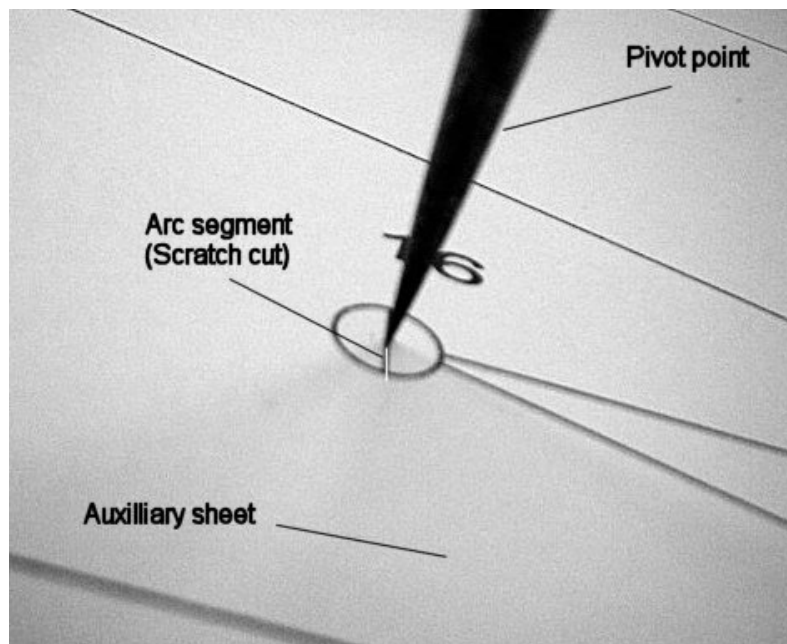


Figure 14 - Locating the center point

Now, swing the compass to check that the blade point will track on the boundary all along the arc, and make any adjustments to the center point that might be indicated. Make the first cut. When cutting, DO NOT put pressure on the cut; this will inevitably cause the blade to flex and steer off of the desired cut line. Let the sharpness of the blade do the work in three or four or more passes. When the cut is finished, leave the pivot point in position and adjust the blade tip until it is over the smaller cut radius of the part, and make that cut.

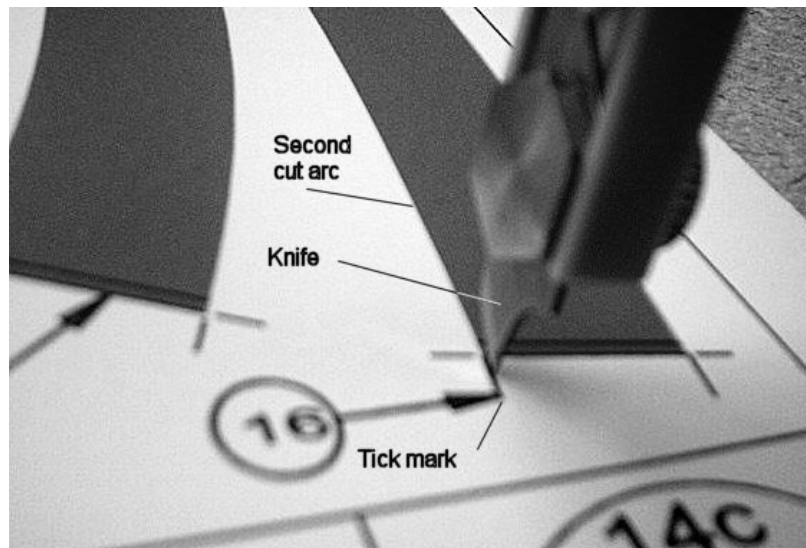


Figure 15 - Second arc cut

Make all the circular arc cuts on a single sheet in one session, working in sequence from one side of the paper to the other. You can free the parts from the sheet later when you cut their straight edges.

While not everyone will wish to go to the trouble to make and/or use a beam compass in paper modeling, I think you'll find that the results will greatly outweigh the trouble.