The Basics of a Rotary Table with Cross Slide mounted on a Mill Table, Version 2

by Gerry Goldberg as told to Rick Sparber

08/21/2008

On 08/16/2008 the Valley Metal Club of Phoenix visited Gerry Goldberg's shop. He demonstrated his rotary table with cross slides that was mounted to his mill. It was humbling to see what a master machinist can do! Here is what I learned.

Scope

A rotary table with cross slide mounted on a mill *in the right hands* can be used to cut very complex curved features. This technology was replaced by Computer Numeric Control so is becoming a lost art. Many home shop machinists, like myself, have not made the plunge into CNC so may find this arrangement of great value. I have done my best to grasp what Gerry told and showed me but fully expect others to correct and improve this article. Hence, the version number in the title.

This subject is huge so I have chosen to limit myself to just the logic involved in operating this tool. A much larger article could be written on the techniques needed to actually do the machining.[1]

There are two types of rotary tables with cross sides and they do different things.

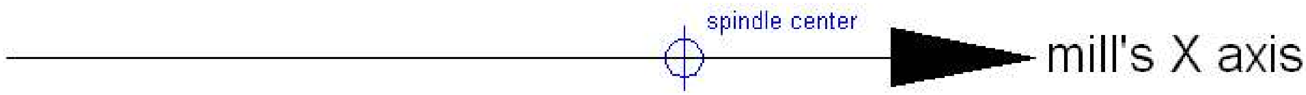
One type has the XY table at the bottom and the rotary table on top. It is used mostly on drill presses. The XY table moves the rotary table around under the spindle. You can drill holes at a radius set by the XY table as you turn the rotary table.

1 Issues include the problems associated with cutting a slot and backlash of the rotary table and XY feeds.

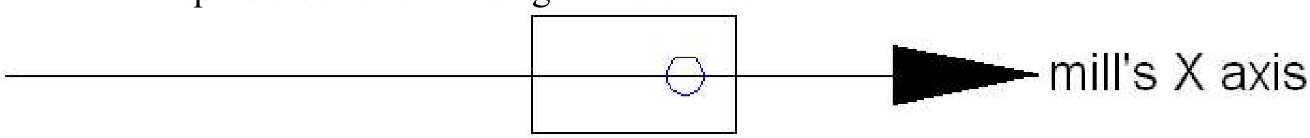
The other type is the one presented here. The XY table is on top of the rotary table. It is mostly used on a mill. Note that if you put the first type of tool on a mill that the XY table would be of little use since it is redundant with the mill's XY feeds. That wasn't obvious to me until Gerry pointed it out.

Starting at the Bottom: the mill XY axes

The complete set up is difficult for me to get my head around all at once. Instead, lets sneak up on it. First we have the mill.

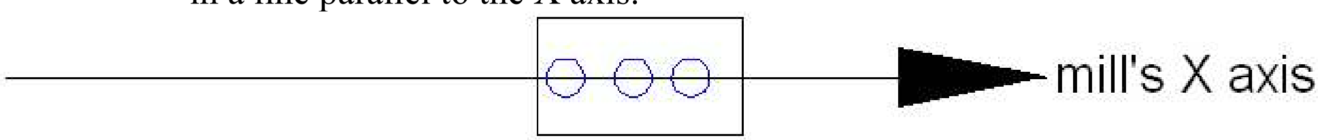


The mill has an X, Y, and Z axis but only the X axis is shown here. I have also marked the center of the mill's spindle. With a drill bit installed, anything placed on the mill table at the spindle center can then get a hole in it.



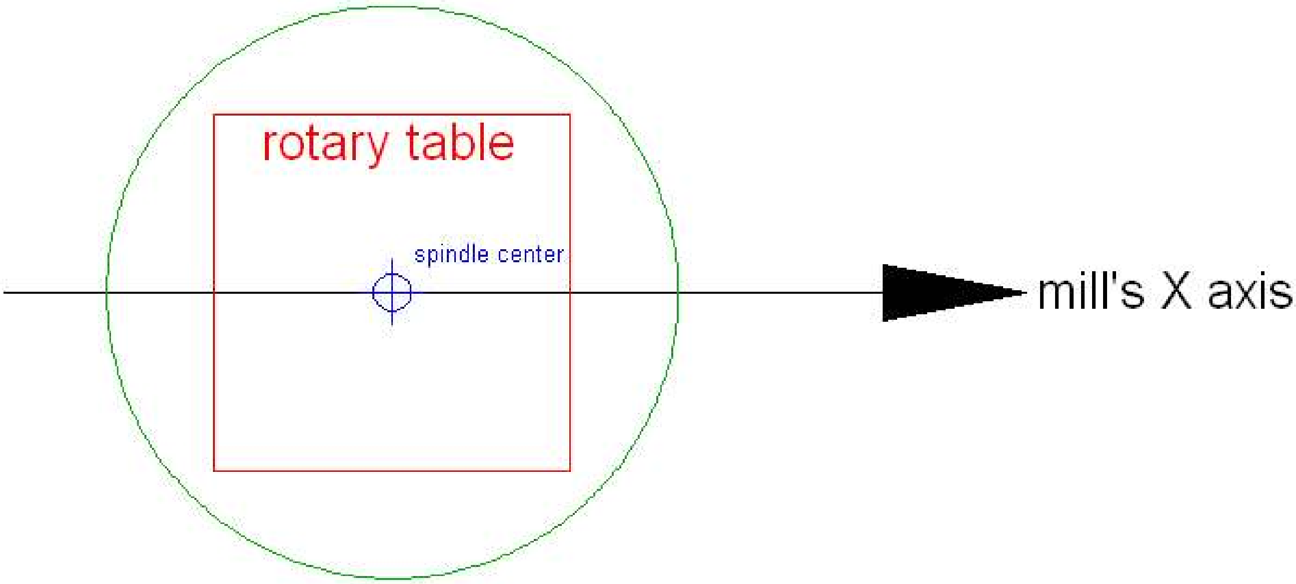
Nothing mind blowing about this but hang in there.

I can feed the X axis and get a series of holes which will all be in a line parallel to the X axis.

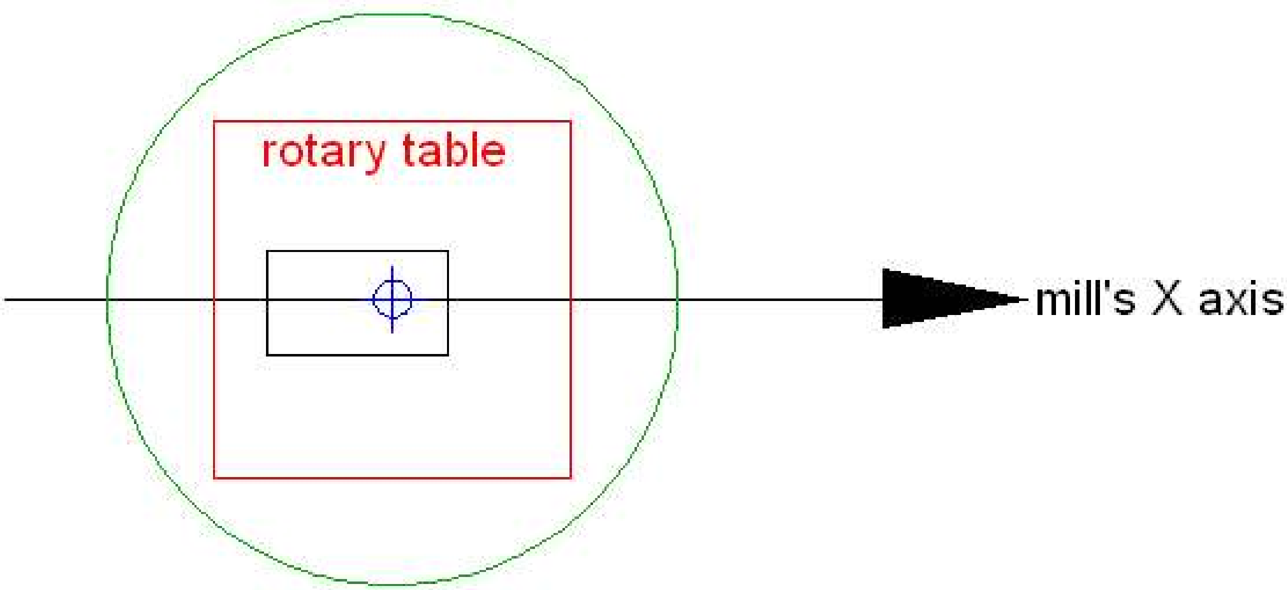


The key thing to understand here is that the spindle center never moved relative to the body of the mill. Instead the table moved which moves the block. We therefore get our series of holes all nicely lined up.

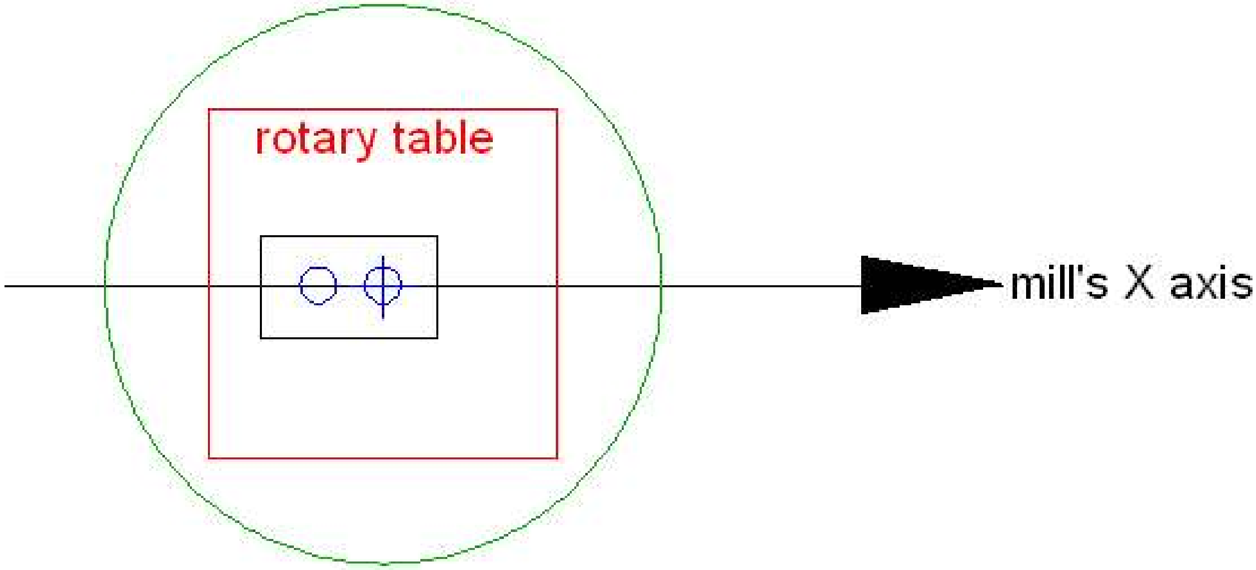
Now Drop on the Rotary Table



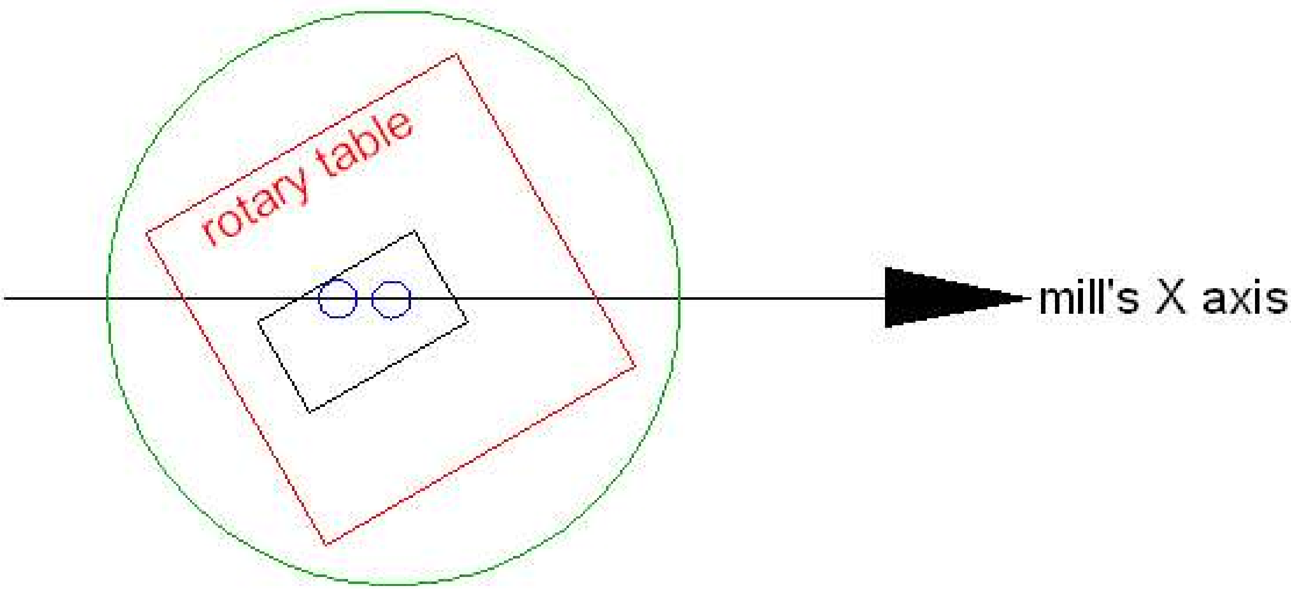
Now lets add the rotary table (RT). I have put the center of rotation of the RT at the spindle center.



If I mounted a block onto the rotary table with the main axis of the block lined up with the X axis, it looks like this.



If I turned the X axis[2] feed of the mill, I would just get the same series of holes as shown without the RT. Not too exciting. What if I turn the rotary table first?

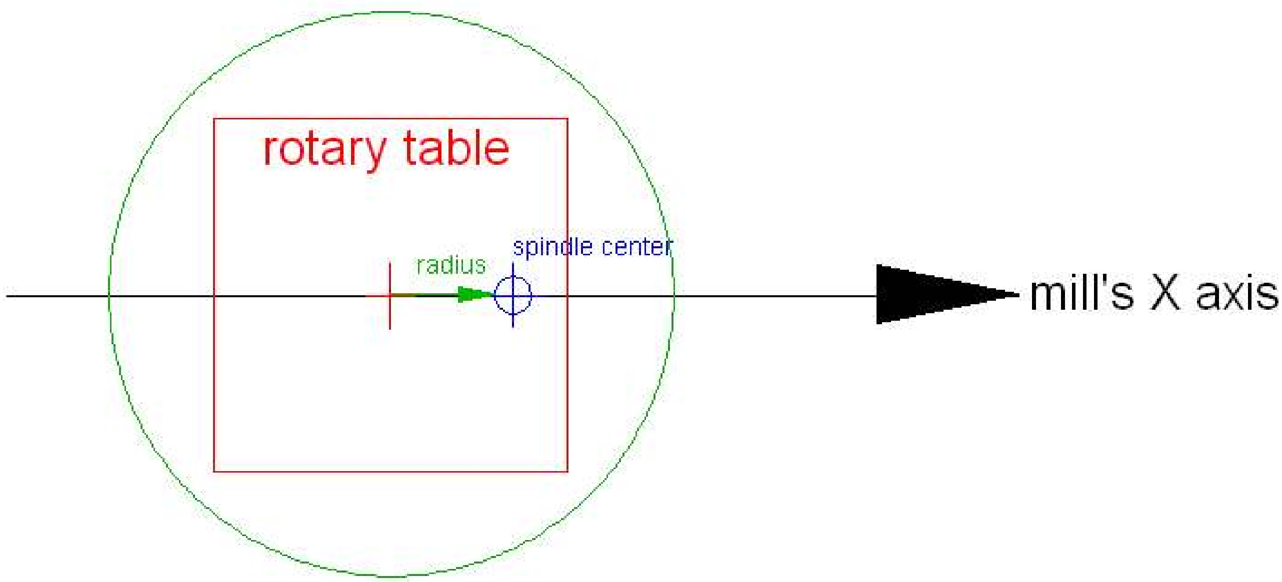


I have now rotated the block relative to the mill's X axis so my line of holes is no longer lined up with the edge of the block. It *is* still lined up with the mill's X axis and the hole will always be line up with
the spindle's center.

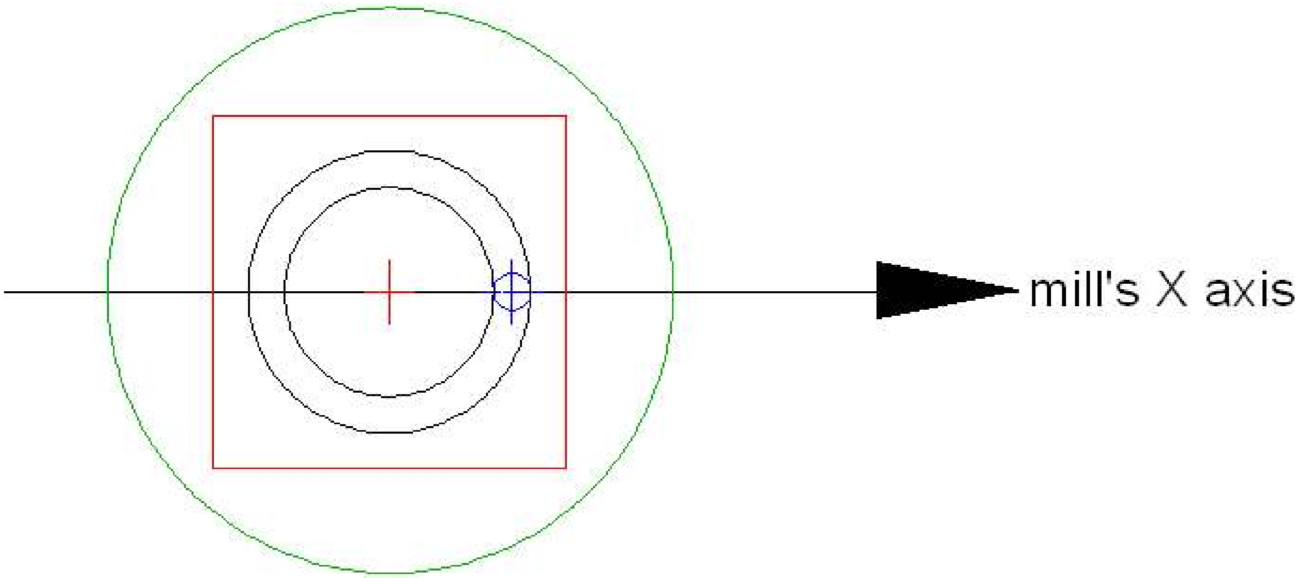
2 There is nothing special about using the X axis here. You could use the Y axis if it was more convenient.

What is disorienting here is that when you take the block away from the RT and mill, you see that the second hole moved up. In reality, the block was moved on the RT. I can say that the second hole rotated up but in fact the block was rotated down.

OK, OK, still not maybe all that exciting. Remove the drill and install an end mill.



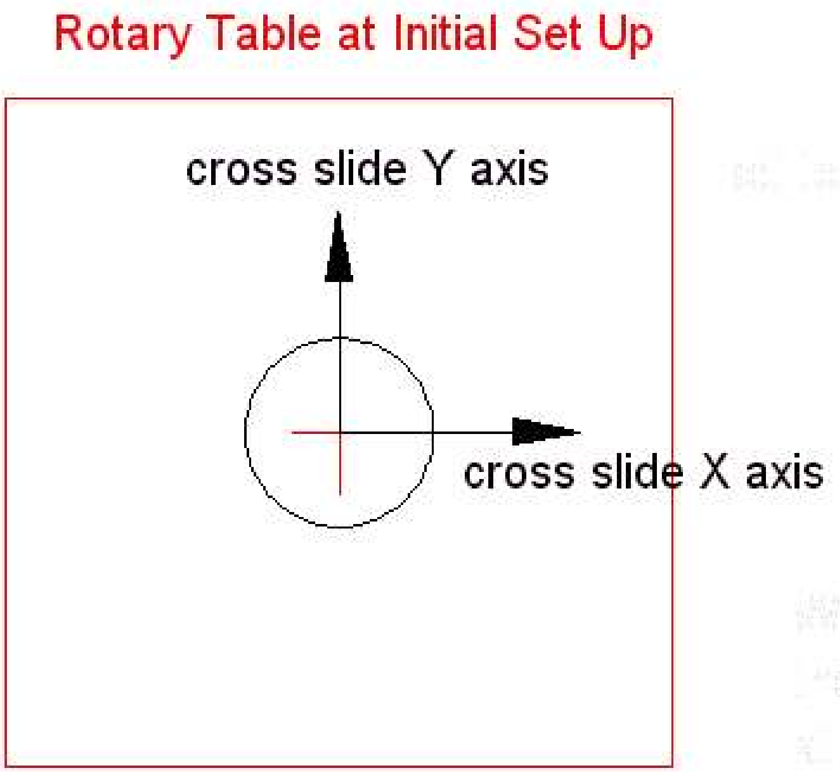
If I offset the RT center from the spindle center, a radius can be cut. Note that the radius shown above allows for the diameter of the end mill shown as a blue circle. The face of the end mill towards the RT center defines the inside edge of the radius. A second radius, not marked above, will exist that equals the inside radius plus the diameter of the end mill.



After turning the RT through the entire 360°, I get a slot with the two radii noted above. I can mill away the material inside the center of this slot and get a hole or mill out around the outer radius and get a round stud. I can also turn less than 360° and get many useful contours as you will see later.

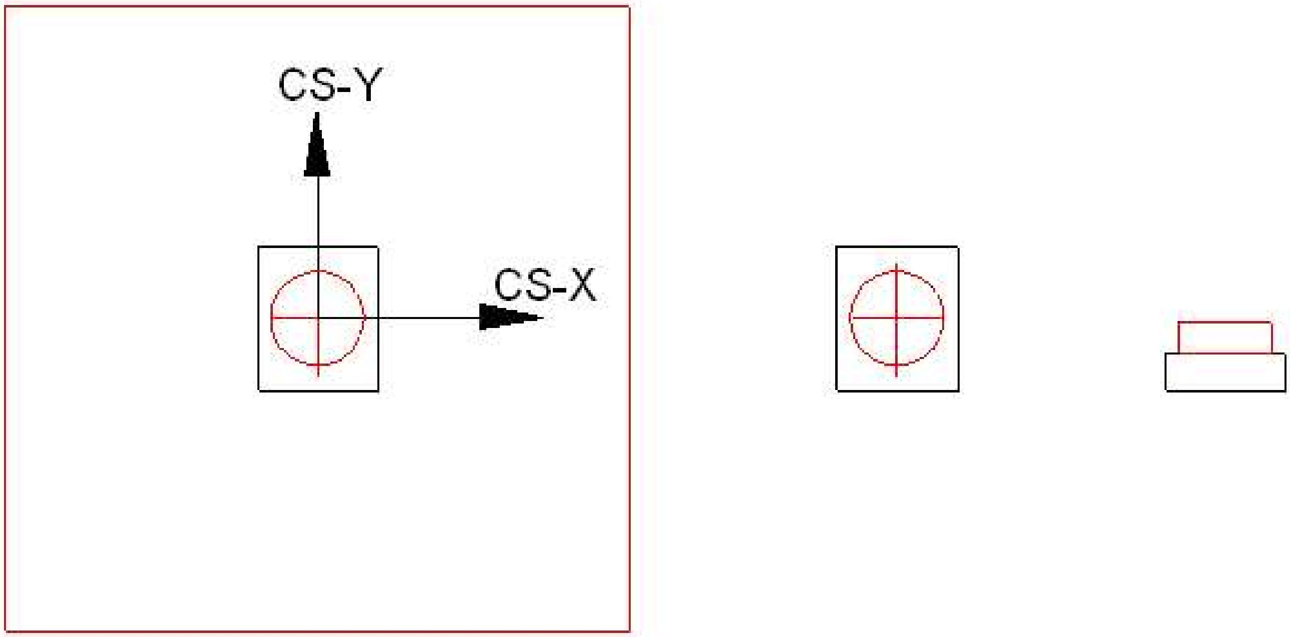
So far we have look at moving the mill's X axis and the RT's angle. Time for the next layer of confusion.

The Rotary Table's Cross Slide



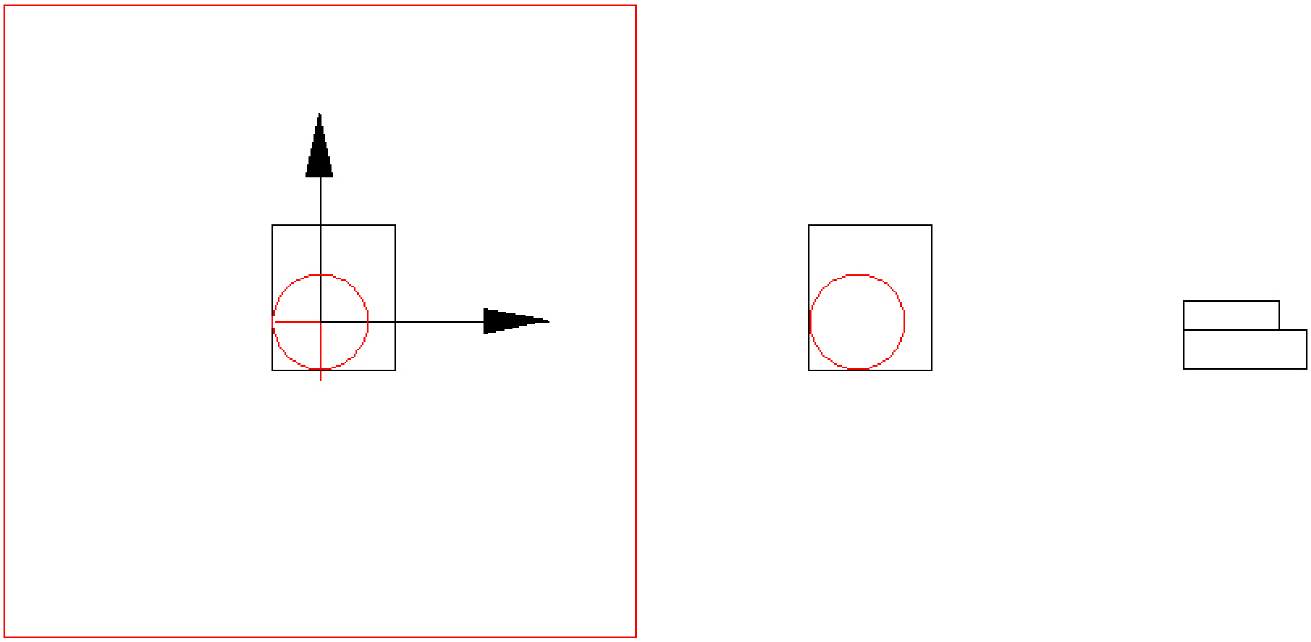
The cross slide is identical to the X and Y axes of the mill except smaller. Before it can be used in a sane manor, I must align it. We already went through the alignment of the spindle center to the RT center. The cross slide's X and Y axes must now be aligned. Typically a part is clamped to the cross side and some feature of it is defined as zero. When the RT X axis is aligned with the mill's X axis, I set zero degrees.

Cutting Our First Part



I have put a block down on the RT with its center defined as 0,0. The X axis was then moved to cut a radius. That was followed by milling away all material outside of the cut. I am left with a stud as you see above.

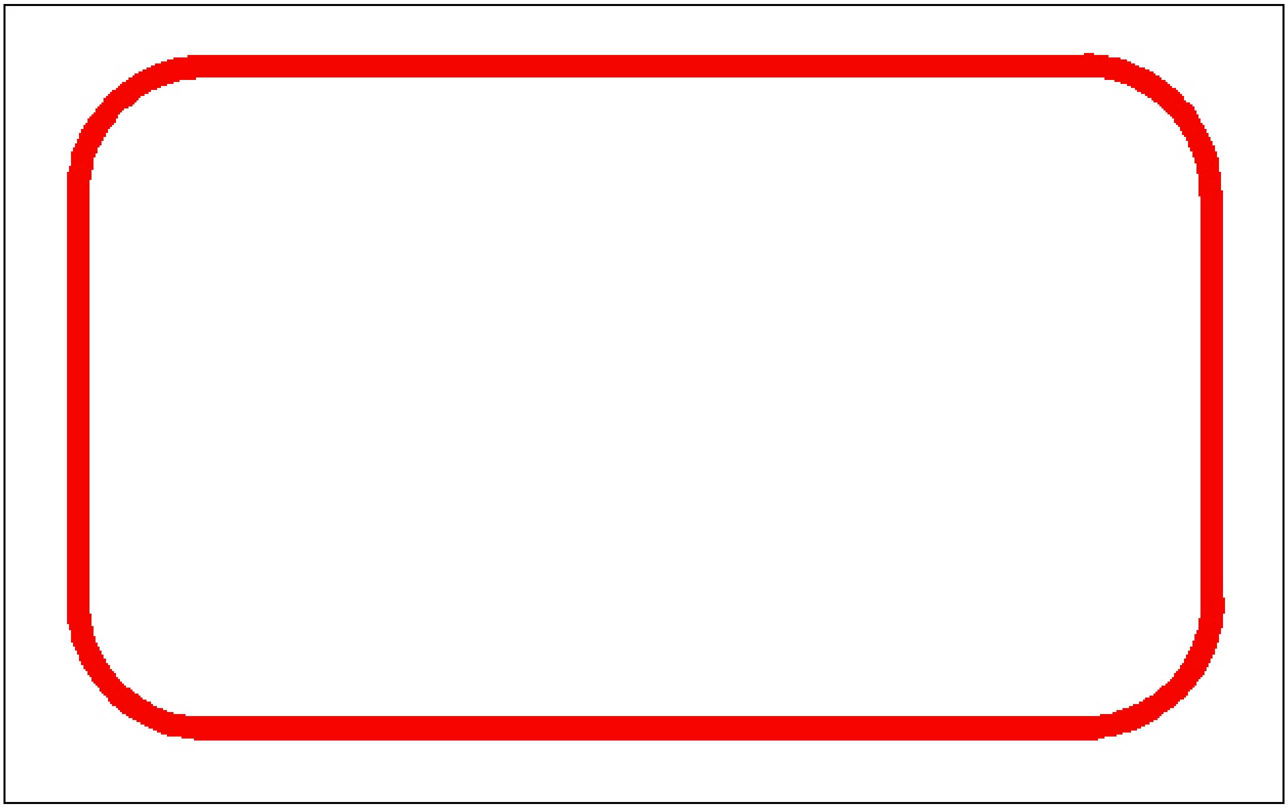
Cutting Our Second Part



Using the RT cross slide, I have moved an identical block so the center of rotation is closer to the lower left corner of the block. No change to the mill's X axis. The machining operations are repeated and I get the same diameter stud but now it is offset into that corner. As I move around the block with the RT cross slide, I am moving around the center of the machined feature.

Cutting Our Third Part

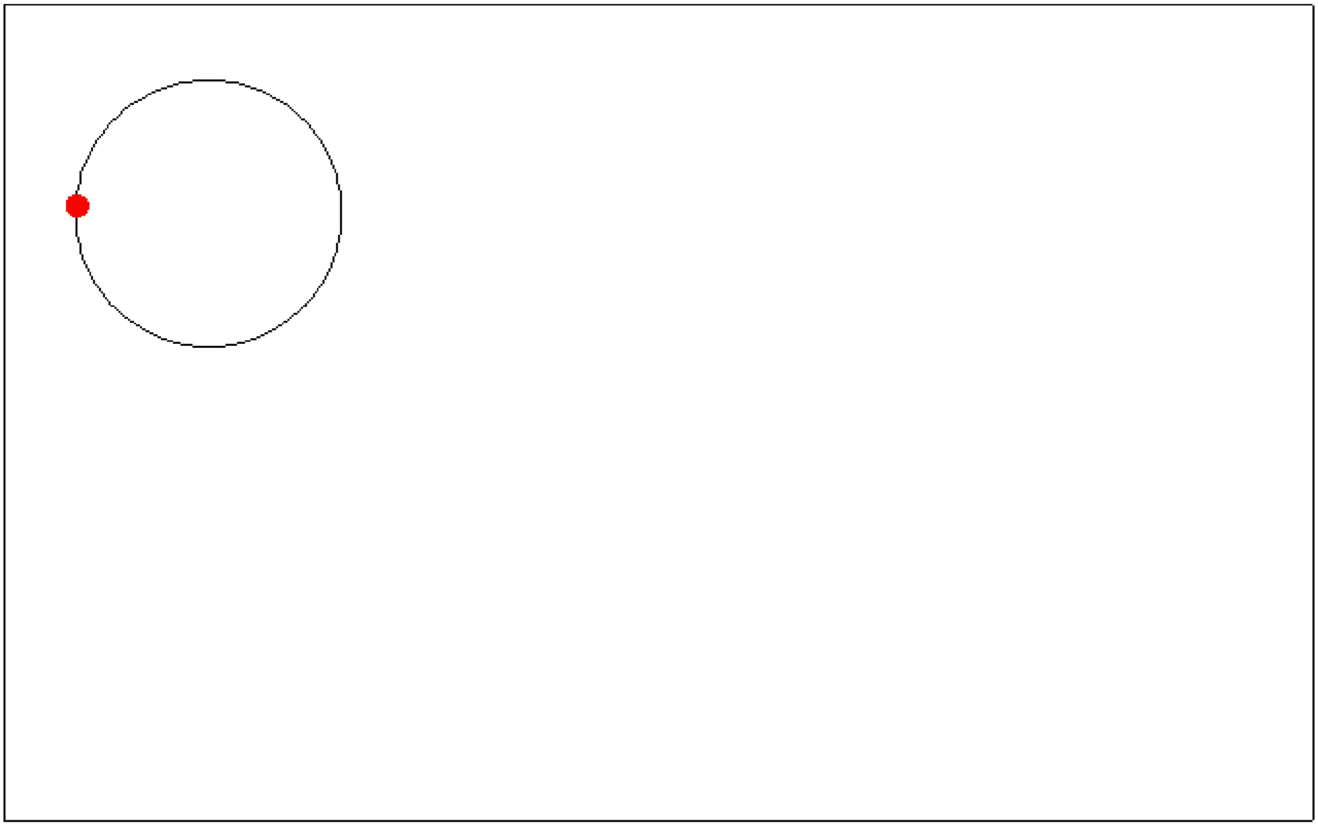
I will now try to pull it all together into a final example. Consider what it takes to machine a round corner slot in a block.



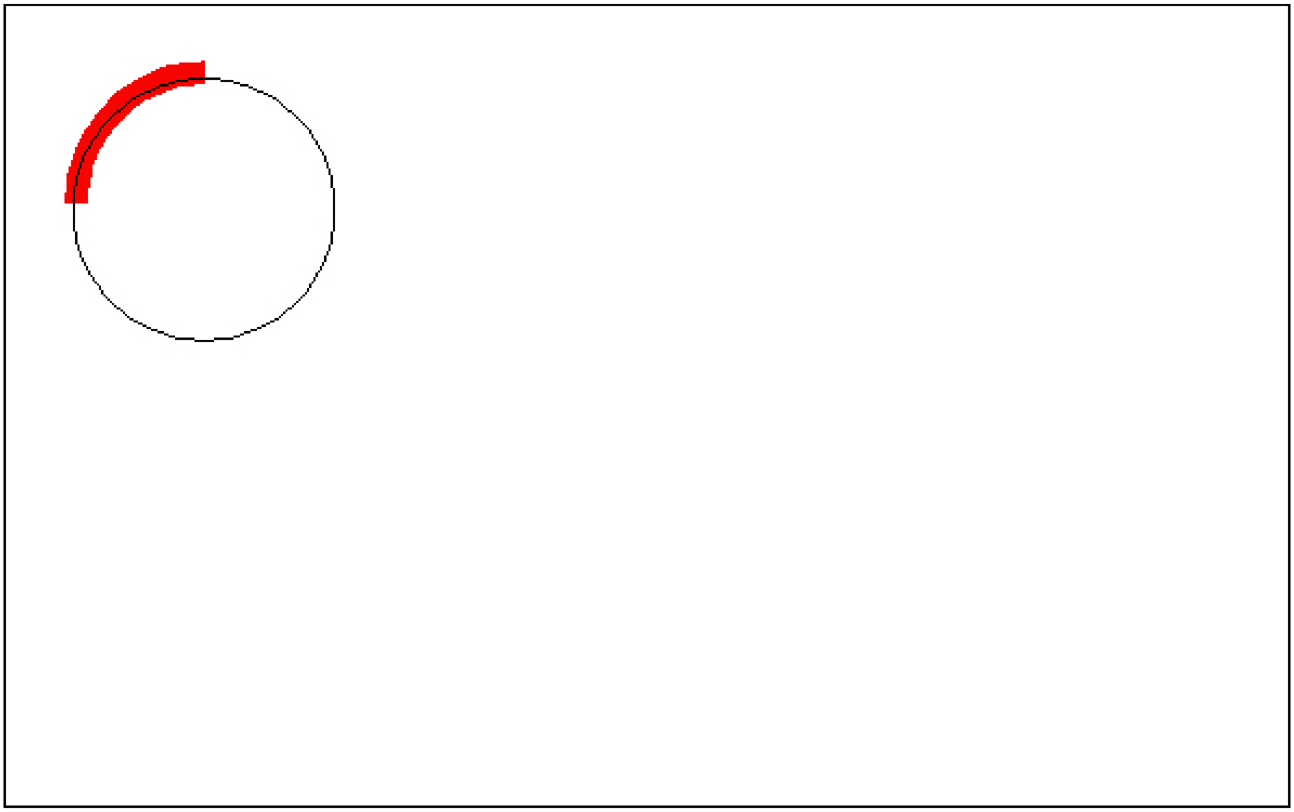
In this example I have chosen to always show the part in the same orientation. Remember that as the RT is turned, the part turns. If you could stand on the RT and look down, you would see these pictures.

All four corners have the same radius. The set-up is flexible enough to have each corner with a different radius but it takes a bit more math. I'll leave that “as an exercise to the student.”

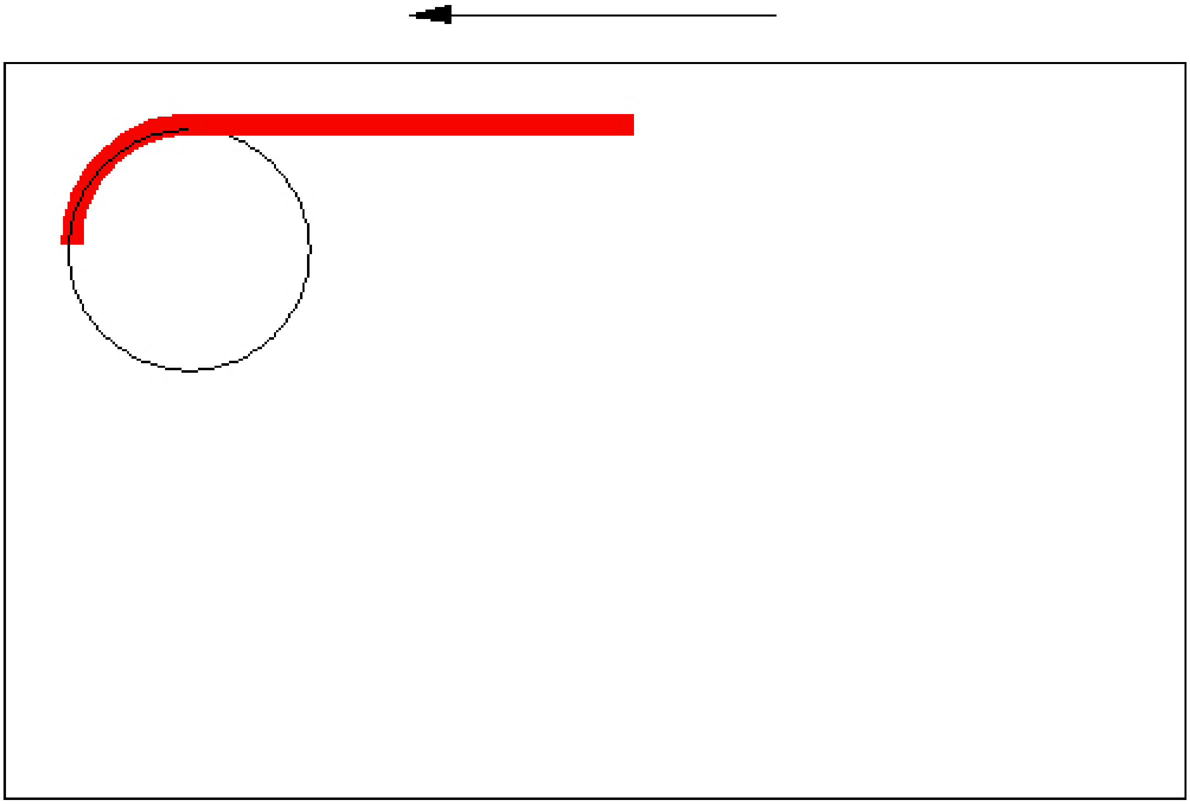
The RT axes are adjusted so the first corner can be milled.



The red dot is the hole I will drill with the end mill. The black circle is the center line of the slot I would get if I turned the RT through a full 360°.



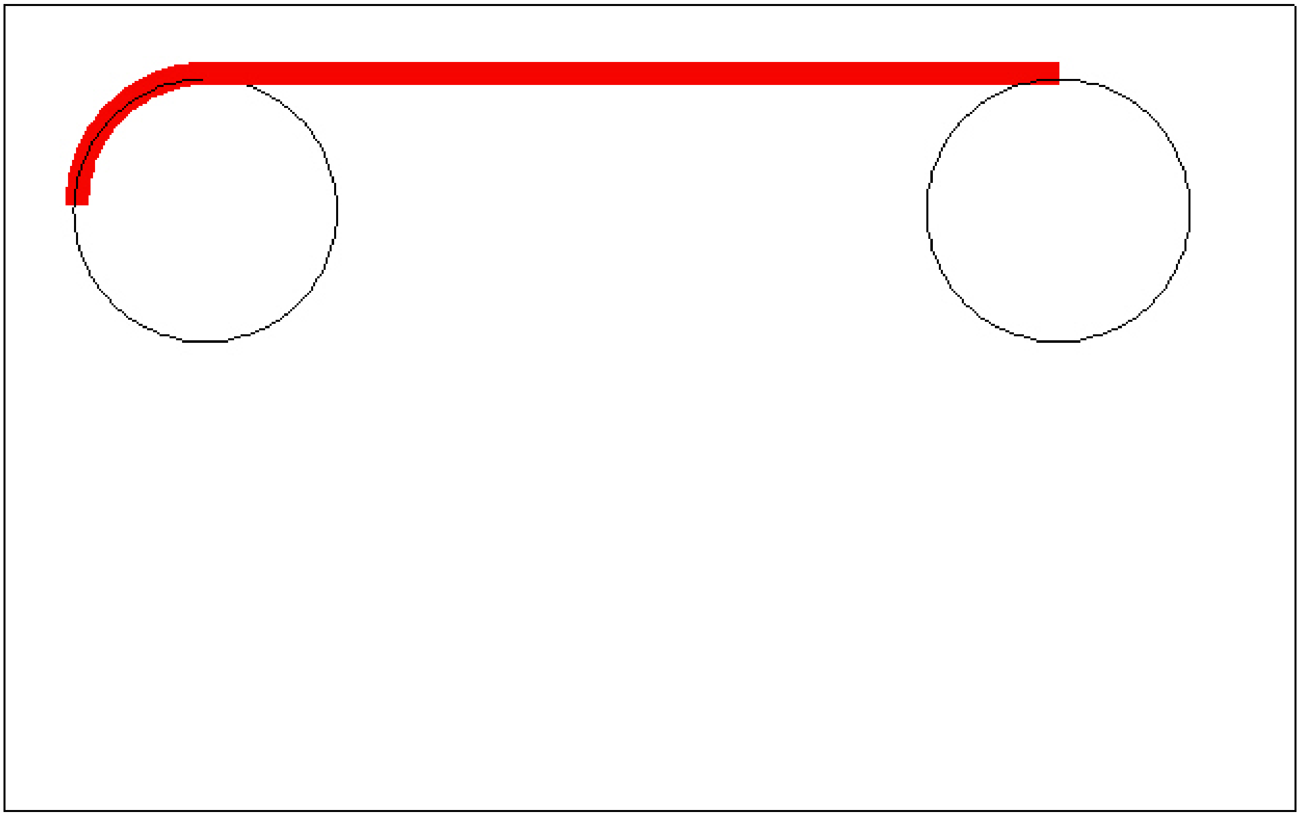
I will move the RT through 90° as I cut the arc. The fat red line represents the slot I have cut.



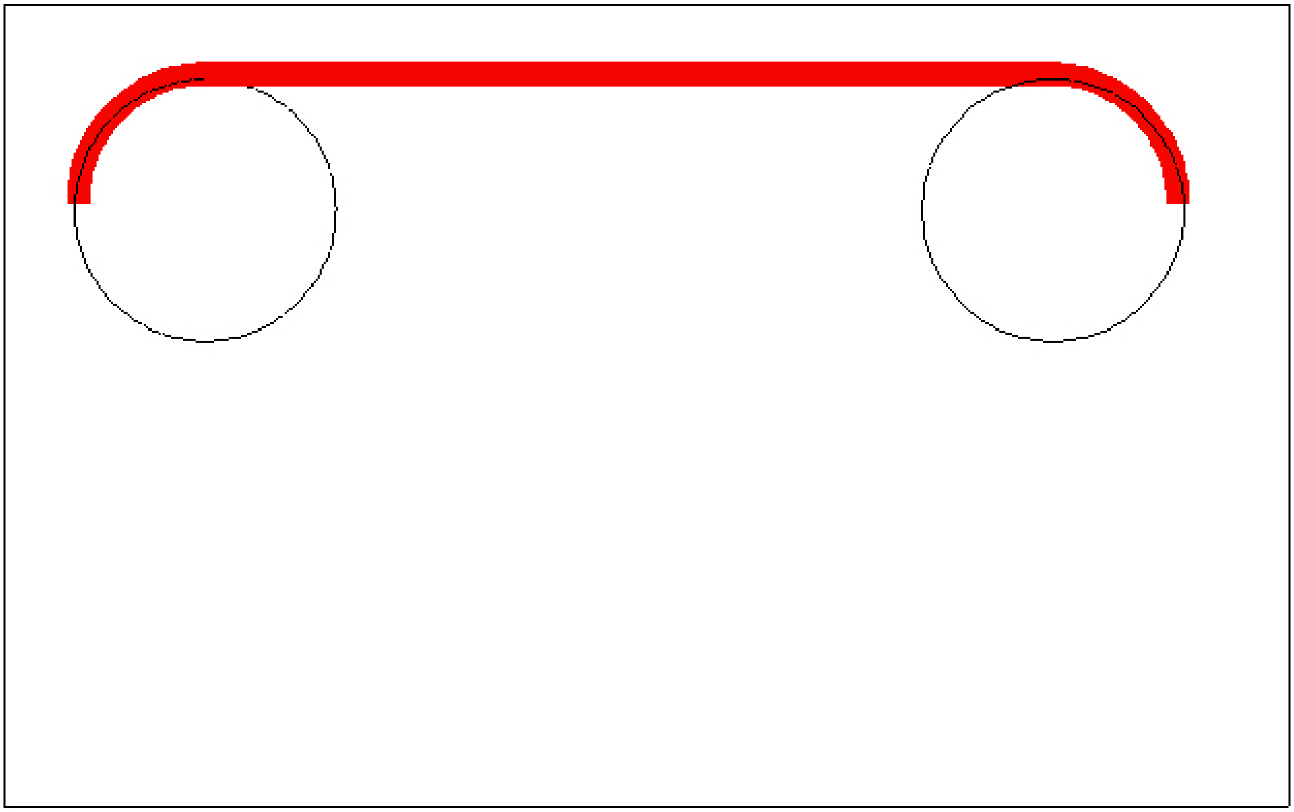
The RT X axis is now advanced as I cut the slot across the top[3].

My slot is growing to the right which means my block is moving to the left as shown by the arrow. Don't loose track of the fact that the spindle and its cutter are fixed and it is the block that is moving. Like I said, a bit disorienting.

3 While we started with the mill's X axis aligned with the RT X axis, after the 90° turn we now have the mill's Y axis aligned with the RT X axis. Hope this observation does not confuse you.

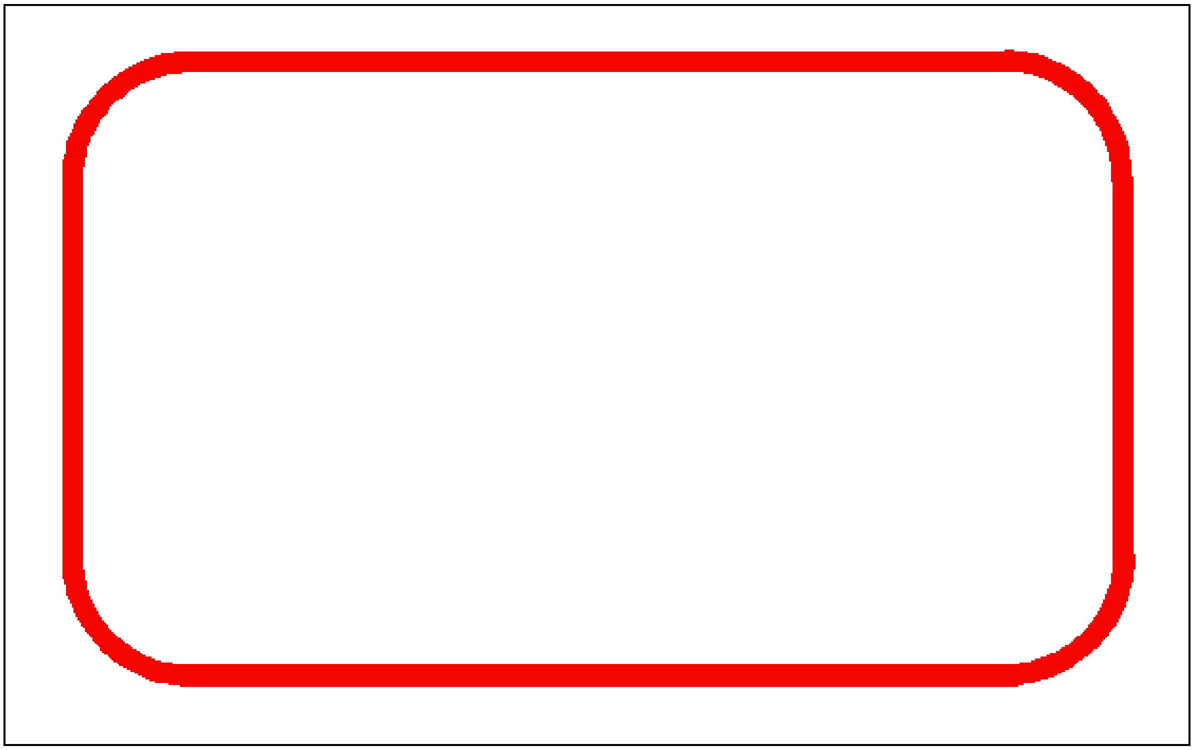


I continue to crank the RT X axis until I reach the start of my second arc.



My RT is again rotated 90° and my second arc is done. The cycle repeats except this time I advance the RT Y axis. The lower right arc is then cut. The RT X axis is again turned until we are back at zero as the bottom slot is cut. One more arc to cut in the lower left corner. Then the RT Y axis is cranked back to zero and we are left with our slot.

Ta da!



Even in this relatively simple example, I would have to write down the steps with all critical coordinates. It is profoundly humbling that Gerry is "one with his machine" and does things far more complex all in his head. My hat off to you sir!

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