

## 9.6. Pushing the Bounds of an Image Type

Oftentimes images appear to have lower bounds. If those bounds are pushed, the image tends to distort and become somewhat unrecognizable, just like a spring that is stretched too far. And sometimes new, unexpected things happen as well. We will use *spinning needle stars* from Section 11.8.1 to explore this issue. The smallest needle star known when that section was written was 5-points.

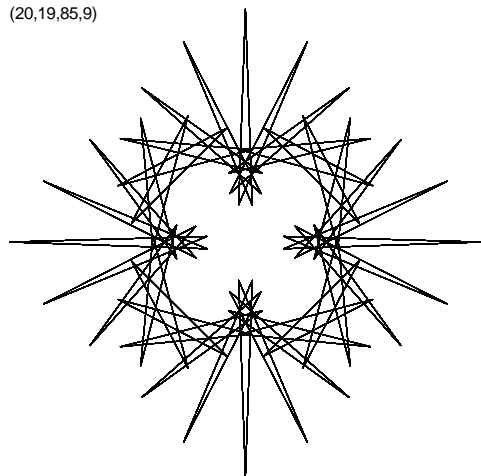
More than a year passed before this [\(20,19,85,9\)](#) 4-point image suggested that one could have needle stars with fewer than 5 points (perhaps the mental block on not searching for these was the fact that the smallest traditional continuously-drawn star is the pentagram). This image has the classic hallmarks of spinning needle stars. It is a 1-time around image with smallest-step of length 2. Opposite each point is a pineapple top center with double-line curves in this case somewhat akin to a four-leaf clover. One obtains such stars by having  $SCF = n/4$  which in this instance means  $SCF = 5$ .

This led to a search for 3-point and 2-point needle stars. Such images require  $n/SCF$  to be 3 or 2. Two of each are shown here. The pineapple tops are not as visible in the three at right, but each has a curved clover-leaf between these tops. Using Sections 9.4 and 7.1, the three to the right share a smallest-step of length 2 whose first step ends at Level 1 [ $MA. \pm 1 = 2 \cdot P \text{ MOD } S.$ ]. The first 3-point star, [\(30,11,50,17\)](#), has 5 Levels; the second, [\(42,15,112,17\)](#), has 7 Levels; and the 2-point star at bottom right, [\(46,19,180,17\)](#), has 9 Levels. The last two on the right appear to have much sharper points, somewhat akin to the ultra-needles in Section 11.9. Not shown is this 2-point star: [\(20,29,130,9\)](#).

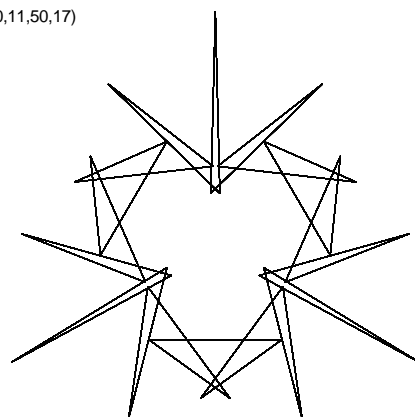
**Bottom left.** The most interesting among the images is [\(16,37,168,9\)](#). A casual inspection of that image suggests that it is a 6-point spinning star but in fact there are only two cycles because  $SCF = 8$ . The first smallest-step ends at Level 3, the 11<sup>th</sup> line ends at Level 2 and the 13<sup>th</sup> (at about 2 o'clock, near vertex 3) ends at Level 1. The point at the end of the 24<sup>th</sup> line (at about 4 o'clock, near vertex 5) is also at Level 1. [ $MA. 3 = 2 \cdot 168 \text{ MOD } 37, 35 = 11 \cdot 168 \text{ MOD } 37, 1 = 13 \cdot 168 \text{ MOD } 37, \text{ and } 36 = 24 \cdot 168 \text{ MOD } 17.$ ] This level change pattern is what allows the image to appear to have points. The illusion is enhanced because there are 18 levels, so levels are closer to one another.

**Ties to Section 8.6.** Increase  $P$  by 1 to obtain the bottom middle [\(16,37,169,9\)](#) image: a 592-line, single-step of length 7,  $\cup$  1-time around, shape-shifting 7,3-star (**the first star is shown in red**).

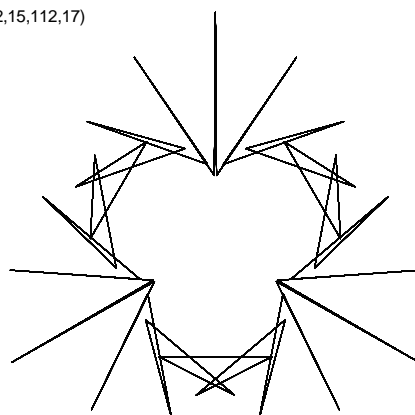
(20,19,85,9)



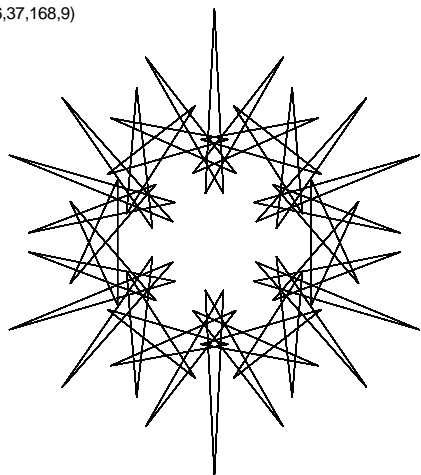
(30,11,50,17)



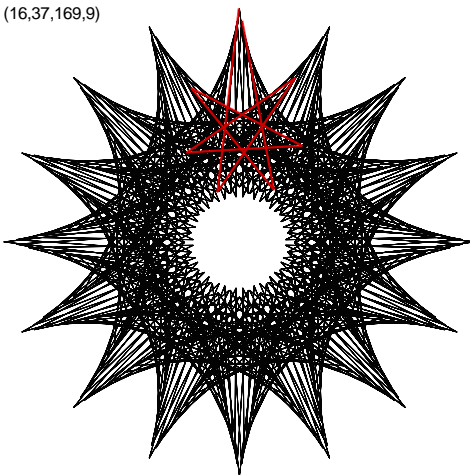
(42,15,112,17)



(16,37,168,9)



(16,37,169,9)



(40,19,180,17)

