# **Lathe-based Pin Valve Modifications for Patrick Carroll's AeroTech RMS 54/1280 Hybrid Revival Project V.3**

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This is an alternative set of procedures using a conventional "hand dialed" lathe to modify an *Interstate Pneumatics* brand WRCO2-PV model pin valve (stock part shown above) for use with Patrick Carroll's revival of the unique and long out-of-production *AeroTech* RMS 54/1280 hybrid rocket motor (see his website for details of this project): **https://pcarroll2525.com/high-power-rocketry/**

## **Objectives:**

Three main tasks need to be performed to make the *Interstate Pneumatics* pin valve compatible with the *AeroTech* RMS 54/1280 hybrid motor. First, and most significantly, the threads on the outlet side of the valve body must be re-shaped, second, the diameter of some valve ports and the pin itself must be altered, and third the depressor pin of the injector plate of the motor must be lengthened.

**Reshaping Threads:**

Please note these methods are unconventional but will help reduce your stress level and prolong the life of your lathe because:

1) The standard right-hand thread cutting method (the tool moving rapidly toward the headstock) is one of the most ill-conceived and potentially damaging procedures in all of traditional hand-dialed (crank yanker) machining. However, many skilled machinists have figured out clever ways to bypass this fundamental problem and we will apply some of those here.
2) Chasing pre-existing threads is a fairly tricky procedure for the traditional hand-dialed machinist to master. Doubly difficult if your tool is jamming rapidly toward a hard stop! However, if you have at least a basic familiarity with using a lathe, and you understand the terms used here, you should be able to obtain useable results your first time if you follow these instructions closely!

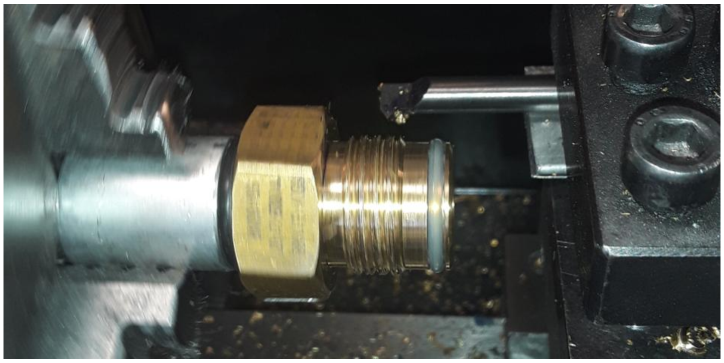
Overview of my basic method:

1) Obtain a *Scientific Cutting Tools* tm *(SCT)* model TT2901000 single-point threading tool. This tool is the optimal size for our needs (note: this type of tool is actually designed to cut ID threads):

   **Single Point Tools — Scientific Cutting Tools, Inc. (sct-usa.com)**

2) Change the gearing of your lathe to 14 threads per inch.

3) Set up the tool post with the *SCT* threading tool ON THE BACK SIDE of the work, shaft oriented parallel to the bed and the $60^{o}$ angled tip pointing in perpendicular to the bed (see photo).



4) Run the lathe in REVERSE, never take it out of reverse until finished with the thread reshaping.

5) With the half-nut engaged, index the tool tip to any existing thread groove.

6) Release the half-nut and back the carriage to the stop.

7) Begin the cutting. Be sure to engage the half-nut only on one of the proper index marks on the thread dial. Check your lathe manual.

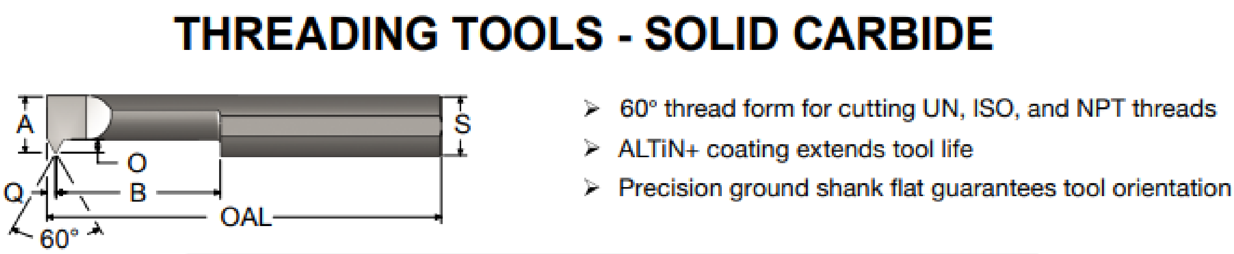
8) You will actually be cutting the threads with the point face of the tool that is aimed toward the tailstock (not how it was designed).

9) Take numerous very small (0.001” to 0.002”) cuts because once the tool tip engages the work the frictional contact increases dramatically very quickly and this can produce big time chatter!

Tooling and Setup:

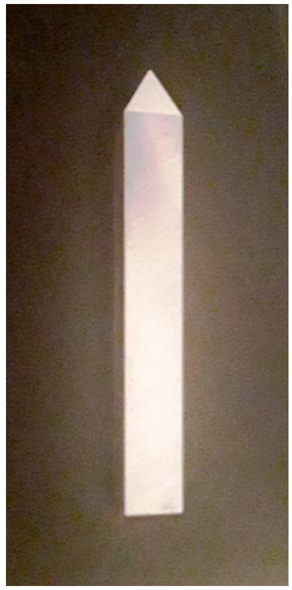
1) There are two tools I have used for this job:

   a. A *Scientific Cutting Tools* $^{tm}$ *(SCT)* model TT2901000 single-point internal threading tool.




   The advantage of this particular tool is the small cutting tip that fits into the gutter groove of the pin valve and needs no modification to use. But it is not being used for ID threading as intended and it is thus prone to chatter (due to a slight rake away from the forward cutting edge)! Set this tool up parallel to the bed and the tool point oriented 90$^{o}$ to the bed. This is the tool used for the procedures detailed below.

   b. With a little more effort, one can use a standard high speed steel (HSS) 60$^{o}$ tip threading tool (e.g. *McMaster Carr* #3364A36) by grinding away 1/3 of the right side of the tip for about 1/2" to allow clearance so it can reach into the gutter of the valve body.



To use this tool for threading away from the headstock you will need to; 1) position the tool post on the front side of the work, 2) clamp the threading tool UPSIDE-DOWN in the tool post aimed perpendicular to the work and 3) run the motor in REVERSE. Sometimes clamping the tool upside-down requires a bit of “futzing around” with multiple shims to get the tip aligned even with the part centerline. Also, it is more difficult to see the actual tool/part interaction during cutting with this tool arrangement. This method is better left to those with some previous threading experience.

While more involved, this approach imparts less chatter. Since the tool post sits in front of the work you will need to reverse the direction of the cross-slide dial rotations in the following instructions!

2) I also like to use:

   a. Some quick-and-dirty collets made from short lengths of hacksaw-slotted 5/8” and 5/16” ID aluminum tube to protect the threads (0.625” and 0.403” ODs) and to chuck odd shaped parts like the square pin body (about 0.302”).

   b. A dial indicator.

   c. Machinist’s blue layout dye.

<u>Step-by-step instructions:</u>

- Set all gibs and other lathe adjustments so there is the least amount of backlash slop possible. I even like my adjustments a bit tighter than usual for this thread reshaping operation.
- Set the gears to 14 threads per inch (TPI). Refer to your lathe's manual for details.
- Be sure the compound-rest is set to 0 degrees (parallel to the bed) with a protractor or square block.
- Remove O-rings from the pin valve and disassemble the internal components. Sometimes these valves are very tightly put together! Use a proper fitting hex key and have a longer-handle wrench or small torque bar available.
- Chuck the valve body by the tank-side threads using a protective collet (do not chuck on the hex faces) and get the part running true with a dial indicator to +/- 0.002" for best results.

- Clamp the cutting tool of choice in the tool holder. For the *SCT* single-point tool, this is with the shaft pointing toward the headstock and parallel to lathe bed with the point oriented exactly at 90 degrees to the bed.
- Make sure the tool tip is on the back side and at the centerline of the work.
- Set the bed stop, and thus the resulting carriage position, so the tool point will be above the center of the gutter groove in the pin valve body and cannot accidentally be cranked back into the chuck.
- Turn the cross-slide inward (clockwise) thus backing the tool tip away to give plenty of clearance from the work.
- Set the motor to REVERSE; do not change until done. This will cause both the spindle and the leadscrew to turn in opposite directions to normal.
- Using the speed control run the lathe at very low RPMs.
- Engage the half-nut at the proper thread dial index mark (for example, for my lathe at 14 TPI that is 1 or 5).
- The tool tip should be clear of the part and moving toward the tailstock at the same rate as the pitch of the existing threads.
- Disengage the half-nut and stop the lathe.
- If this trial run went OK crank the carriage back to the stop.
- Turn the cross-slide crank counterclockwise to move the tool closer to the work but leave a visible gap above the threads.
- Again, run the lathe at very low RPMs, engage the half-nut at the proper thread dial index mark.

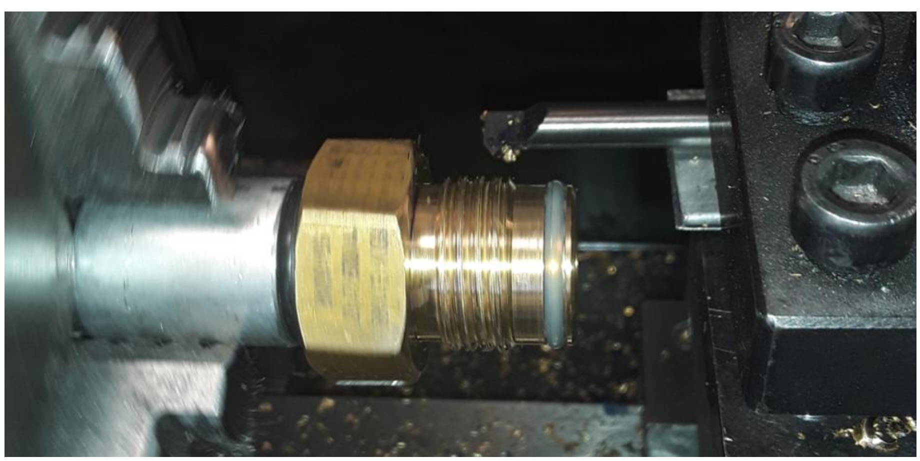
- This time let the tool run out only about half way along the threads. Quickly turn the speed control to zero and, for safety, shut the power off; LEAVE THE HALF-NUT ENGAGED while locating the tool point in the thread groove as follows...
- Crank the cross-slide carefully outward (counterclockwise) so the tool tip works down into the threads. Simultaneously wiggle the compound-rest crank back and forth allowing tool tip to settle into the very bottom of any one of the thread grooves. Magnified viewing helps here!
- You have now indexed your thread reshaping operation! DO NOT CHANGE THE COMPOUND-REST SETTING after making this adjustment .
- Set the measurement collar on the cross-slide dial to read 0 depth.
- Disengage the half-nut .
- Crank the cross-slide in (clockwise, thus moving the tip away from the part) exactly 2 turns (this should amount to 0.050" + 0.050" = 0.100" of travel and thus moving clear of the threads).
- Crank the carriage back to the bed stop. Hopefully the tool tip is still positioned reasonably well over the gutter. If it has shifted too much, redo the index steps and try not to shift the tip as much.
- Apply machinist's layout bluing to the threads of the valve part.
- Turn the cross-slide outward (counterclockwise, moving the tool tip toward the work) the same 2 turns less 0.010" to be assured there is a small positive clearance a known distance from the work.

- Turn the power on and set the speed control to run at very slow RPMs.
- Engage the half-nut at the proper thread dial index mark and WATCH CAREFULLY. As the tool tip passes the end of the threads disengage the half-nut.
- More than likely the tool cleared the threads. Turn the cross-slide inward (clockwise) moving the tool tip away from the work the same 2 turns less the 0.010” deducted at start of the cut.
- Crank the carriage back to the bed stop.
- Now turn the cross-slide outward (counterclockwise) again by the 2 turns this time less 0.005” thus moving the tip even closer to the part.
- Start the lathe and again run at very slow RPMs.
- Engage the half-nut at the proper thread dial index mark and WATCH CAREFULLY looking for any contact of the tool with the work.

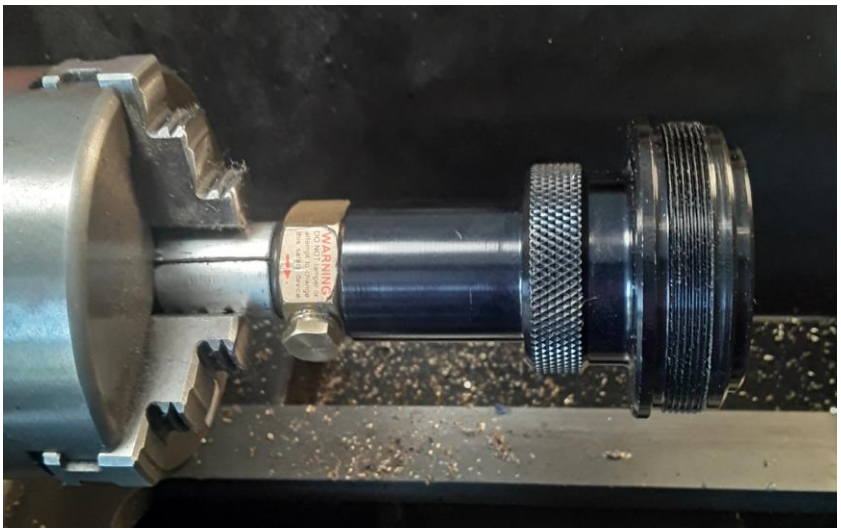

- Repeat this series of steps until the bluing starts to show a scratch cut.

Be careful, IT DOES NOT TAKE MUCH OF A CUT TO FULLY ENGAGE THE ENTIRE TOOL FACE AGAINST THE THREADS (because we are running the point in perpendicular to the work, not at an angle like some thread-cutting techniques); so as you approach the part continue to use successively smaller cuts. This is a chatter prone method because of the long tool arm and because we are cutting on the wrong side of the tool point. Patience is a virtue here for sure and use cutting lubricants also!

- If all this has worked as expected and you are now cutting brass repeat the same steps for each new cut probably no more than 0.002" and more like 0.001" on a side (OAS):
    a. Make the cut
    b. Disengage the half nut
    c. Crank the cross-slide in 2 turns
    d. Back the carriage to the stop
    e. Crank the cross-slide out 2 turns plus the new cut



- Periodically check your work by trying to screw on the forward closure from the hybrid. I have worked with a few different *AeroTech* forward closures and they all have slightly different tolerances so test fit your particular closure if possible.




- Continue cutting in using fine cuts until the desired fit is achieved. It appears a total of around 0.005” to 0.010” OAS is needed to go from 1/2” G 14 TPI threads of the pin valve to 13/16” 14 TPI threads used by *AeroTech* in the forward closure.
- Once the forward closure just fits the modified threads of the pin valve repeat the final depth cut a couple of additional times using the same cut setting (spring cut) on the dial to help clean any chatter marks.
- Finally, use a fine flat file, 3-corner file and emery cloth to reduce any chatter marks and knock down the sharp crests as desired.
- The advantages of this method include:
    a. No crowding of the tool point as it approaches the gutter and shoulder of the valve body.

Compare this to cutting conventionally with the tool tip jamming fairly fast toward the chuck and not much room before hitting the shoulder and trashing the part…if not doing even more damage!

b. Turning proceeds AWAY from the chuck.

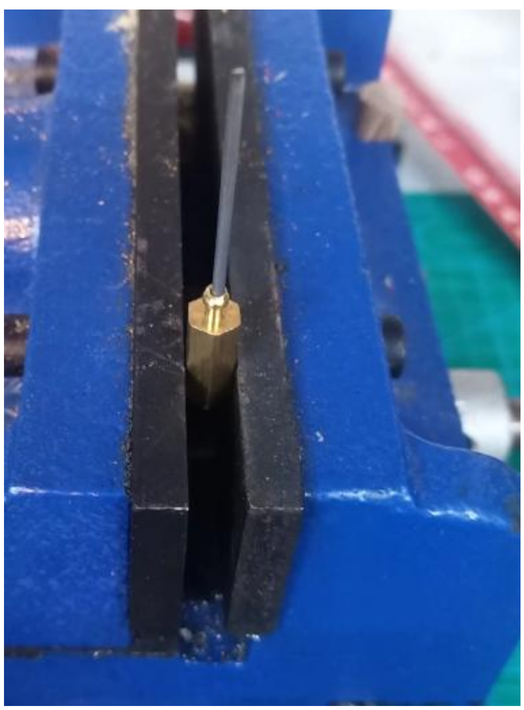
- PRACTICE ALL THIS FIRST! A short piece of ½" PVC pipe makes a good test victim.

- When done reshaping the threads BE SURE TO RESET YOUR GEARS to normal feed.

**Additional Pin Valve Lathe Work**:

- In addition to the thread re-shaping some other modifications need to be done.
- First, the pin itself must be turned down or replaced.
    a. Be sure your lathe gearbox has been set back to conventional feed.
    b. Use a small collet to hold the square pin body in a 3-jaw chuck.
    c. Use a standard facing/turning tool.

d. Turn the pin from 0.103” down to 0.063” this is 0.020” OAS.
e. CAUTION THIS PIN IS EASILY SNAPPED OFF. Take small cuts (about 0.002” OAS) and run the lathe at moderate to high RPMs. While I have successfully flown motors using this turned down brass pin, I worry about its strength given how easily it can snap off while turning.
f. OPTIONAL: So given the potential weakness of the 0.063” brass pin, it will most likely be stronger to employ Patrick’s original idea of cutting off the stock brass pin near the seal retainer and drilling its body out to take a 1/16” steel pin (photos below). See Patrick’s web site for additional details.




- Next, the pin port must be drilled out to 5/32”.
- And finally the jam nut holding the valve parts together must be drilled out to 0.190” (a #11 drill is 0.191”).

- Completed brass pin valve on the left, steel version on the right

- Be sure to thoroughly clean away the cutting oils from the parts before exposing them to nitrous oxide!

**Extending the Length of the Depressor Pin on the Injector**:

- Comparing the original pin valve provided with the stock *AeroTech* RMS 54/1280 hybrid it can be seen in the following photo that the body of the pin valve that inserts into the forward closure of the motor is longer on the original (right in the photo) than it is on the *Interstate* (left in the photo):

The *AeroTech* plans show the length of the exposed pin valve that seats, and threads into, the forward closure is 0.716”. Measuring the same exposed length on the *Interstate* valve we get 0.650” a difference of 0.066”!

In order to gain a better understanding of the actual valve operation, I used a flight tank filled with compressed air and then compared the number of “turns” needed to seat the pin valve into the forward closure. There is about one turn difference between the two types of valves when venting is first noticed. For example, my original *AeroTech* motor takes about 1 1/3 turns of the tank to fully seat the pin valve after the first venting is detected.

On the other hand, the *Interstate* pin valve motor required only 1/3 turn to fully seat after first venting is detected! So that means the pin valve may not be fully actuated when using the depressor pin dimensions in the *AeroTech* plans along with an *Interstate Pneumatics* pin valve! It appears that a length equivalent of one additional turn should be added to the pin to match the operation of the stock *AeroTech*. At 14 threads per inch that translates to about 0.070” of pin movement. Therefore between 0.066” and 0.070” should be added to the pin length to actuate the *Interstate Pneumatics* valve to the same degree as the *AeroTech* version.

- When implementing this required extension it is better, if possible, to lengthen the depressor pin on the injector plate located in the forward closure of the motor. In most cases this is not a problem as you are probably making (or having made for you) your own injector plate and the depressor pin along with it. In this case just add 0.070” to the specified 0.164” of the original for a total pin length of around 0.234” beyond the injector plate.
- Alternatively, if you can’t change the depressor pin for some reason, you can cut the valve pin itself off near its shoulder, drill the remaining stub and solder in a longer stainless steel pin as Patrick Carroll did on his original modifications (photo below). If choosing this approach be sure to measure the length of the pin unit before cutting so the final length can easily be determined! The problem with this approach is that accidental venting is slightly more likely with the greater length of pin extending beyond the valve body.

However, this approach can solve two problems at once: 1) it can address the above discussed pin length issue and, 2) it can address the weaker brass pin issue discussed earlier. See Patrick's website (linked at the beginning of this document) for more details on installing steel pins.

- In either case it is better to go a little long. You can fine tune the pin length using test assemblies filled with compressed air. It is easier to trim a bit of the pin off with a file, grinding wheel etc. then to have to remake one that is too short.

**Some Comments on the Injector Plate**:

- While the details of fabricating the injector plate are covered in another publication, there are a couple of points worth noting here. The original *AeroTech* injector plate is fairly complicated with four tapped orifice jets drilled through the plate and four tapped blind "parking holes" drilled adjacent to the jets.

The idea being that small set screws could be used to change the jet configuration and the unused screws could be stored in the parking holes. This makes for a fairly complicated project!

- However simple “fixed jet” injector plates are actually a fairly easy lathe and drill press project. Turn the depressor pin and injector disc body from a single piece of ¾” aluminum rod. Use a drill press to carefully drill the desired number of 1/16” jet holes and you are done! A minor inconvenience to this approach is you must change out the injector plate to alter the number of open jets desired.
- For a prettier looking part you can use a milling machine with a rotary table to evenly space and drill the jets (photos below).
- Be sure to refer to the companion publication for details on making these injector plates.