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Oscillating Steam Engine Building Tips

While we can’t provide a complete course on machining, this document provides some tips on building the Oscillating Steam Engine.

There is no reason to build the parts in the order given (except that you should make the cylinder before you make the piston). The components are listed here in the order in which the plans are printed. That order is dictated by the (arbitrary) order of the callout numbers on the assembly drawing. Tips with a gray background follow many of the steps in this document. We provide the tips only once, when we first discuss a particular operation.

We also provide a list of tools and accessories you might need for each operation. Again, we show them only the first time we discuss the operation.

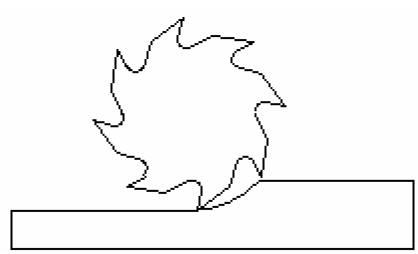
Upright

The upright is the backbone of the engine. All the other parts mount on the upright.

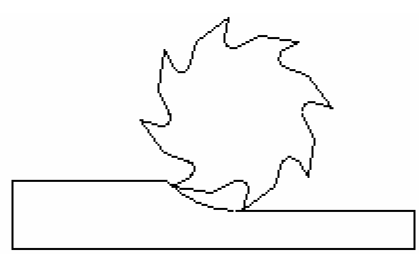
1. Square the ends of the material. Use a mill if you have one, or a file if you don’t.

   To square the ends with a mill, first square the vise to the mill table. Then place the workpiece flat in your vise, supported on parallels so it is at the top of the vise jaws with the end that you are trimming extending out past the vise jaws. Use the side of a 3/8" to 1/2" diameter end mill to trim the ends of the workpiece.

   Use conventional milling to remove most of the material. Use climb milling to remove the last 0.002" to 0.003" for a better surface finish.



Climb Milling



Conventional Milling

Number	Description
1244	End Mill Set, 20 pieces 2 & 4 Flute
1242	End Mill Set, 6 Piece 2 Flute
1243	End Mill Set, 6 Piece 4 Flute
1245	End Mill Set, 10 pieces 2 & 4 Flute
1893	Thin Parallels, 3" long
2220	Thin Parallels, 3" Long Ultra-Precision
1232	Thin Parallels, 6" long

2. Lay out the hole locations on the face of the upright.

Coat the surface with layout die. If you don't have layout die, use a felt tip marker to coat the surface.

A simple way to scribe layout lines is to use a caliper. Set the caliper to the dimension. Hook one jaw over the edge of the work and use the point of the other jaw to drag a line through the layout die.

If you have a milling machine, use the dials on the machine to move to the hole locations. Use the layout on the workpiece to double-check that you are in the correct spot.

If you are using a drill press, use a prick punch or automatic center punch to mark each hole location. Use a center punch to enlarge the center marks.

Number	Description
2620	Automatic Center Punch, Starrett
1820	Center Punches, Starrett
1235	Dial Caliper, 6"
1830	Dial Caliper, 6", Starrett
1776	Electronic Digital Caliper, 4"
1758	Electronic Digital Caliper, 6"
2530	Electronic Digital Caliper, 6", Starrett 797
2522	Inspection Kit, 3-Piece
2518	Inspection Kit, 6-Piece
1259	Measurement Starter Kit with Dial Caliper
1260	Measurement Starter Kit with Digital Caliper

3. Drill the thru holes in the upright.

Start every hole with a center drill. The thick body of the center drill ensures that the point does not wander.

Next, use a pilot drill to start the hole. Use a bit that is about 1/8" in diameter (but always smaller than the final size).

Now, enlarge the hole to just under the final size. Choose a drill that is 1/64" to 1/32" smaller than the final hole size. (In the case of holes that are smaller than 3/16" you can skip this step.)

Finally, drill, ream, or bore the hole to final size. If the size has to be very accurate, ream or bore the hole. Drills do not make accurately sized holes. For this project, most of the tolerances are such that you can use a drill to achieve the final size.

Number	Description
1230	Center Drills, Set of 5

4. Drill the semi-blind hole for the 10-32 thread in the face of the upright. Be sure that you do not drill clear through.

   The appropriate tap drill size for a 10-32 thread in aluminum is a #21 drill (0.1590").

5. Tap the 10-32 thread in the face of the upright.

   Taps come in three styles: tapered, plug, and bottoming. Tapered taps are great for starting threads because they have a gradual taper to the point that makes them easy to start. Plug taps are the most common. They have a relatively steep taper so they are cutting a full thread after a few turns. Bottoming taps have almost no taper. They are for tapping to the bottom of blind holes.

   Start tapping with a tapered tap if you have it, or with a plug tap if you don’t. Finish the threads with a bottoming tap. Never try to start a thread with a bottoming tap.

Number	Description
2540	Tap & Die Set

6. Lay out the hole locations on the bottom of the upright.
7. Drill the blind holes for the 10-32 threads in the bottom of the upright.
8. Tap the 10-32 threads in the bottom of the upright.

Cylinder

The cylinder provides the definitive gage for measuring the diameter of the piston.

1. Chuck the 1" square bar in your 4-jaw chuck. Put it as far into the jaws as you can.

   First, center the workpiece by eye. The 4-jaw chuck has circles turned into the face of it to make this easier.

   Then, use a dial indicator to precisely center the workpiece. Mount the dial indicator so it is horizontal at the centerline of the lathe. The plunger should bear on the front side of the workpiece.

   Work on two opposite jaws at a time, turning the workpiece 180 degrees between measurements. On each side of the work, note the minimum indicator reading as you rotate the workpiece a little. Adjust the jaws half the difference in the indicator readings from opposite sides of the workpiece.

Number	Description
1175	Lathe Chuck, 4-Jaw 3"
1588	Lathe Chuck, 4-Jaw 4"
1697	Lathe Chuck, 4-Jaw 4" with Adapter

2338	Lathe Chuck, 4-Jaw 5"
2346	Lathe Chuck, 4-Jaw 5" with Adapter

2. Face the end of the workpiece.

Number	Description
1965	Tool Bit, 1/4" Right Hand Presharpened
2250	Tool Bits, 1/4" Presharpened Set of 6
2412	Tool Bits, 5/16" Brazed Carbide Set of 5
1734	Tool Bits, 8 mm Presharpened Set of 8
1719	Turning Tools, 1/4" Indexable HSS Inserts
1913	Turning Tools, 1/4" Indexable TCMM inserts
1619	Turning Tools, 3/8" Indexable HSS Inserts
1679	Turning Tools, 3/8" Indexable TCMM inserts
1669	Turning Tools, 3/8" Indexable TCMT Inserts

3. Turn the workpiece around and chuck the other end in the 4-jaw chuck.
4. Face the workpiece to length.
5. Offset the workpiece 1/8" in the 4-jaw chuck.

Rig the dial indicator to bear against the front of the workpiece. Slightly loosen the top and bottom jaws. Now loosen the back jaw and use the front jaw to push the workpiece back 0.125" as shown on the dial indicator. Once in position, retighten all four jaws, checking the position of the workpiece as you go.

Number	**Description**
1593	Dial Indicator and Magnetic Base
1782	Dial Indicator, Magnetic Base & Point Set
2518	Inspection Kit, 6-Piece
2029	Magnetic Base Indicator Holder (Mini)
1259	Measurement Starter Kit with Dial Caliper
1260	Measurement Starter Kit with Digital Caliper

6. Use a center drill to start the hole in the cylinder.

Number	**Description**
1804	Arbor, Drill Chuck 2MT Stub to 33JT
1190	Arbor, Drill Chuck 2MT Tang to 33JT
1230	Center Drills, Set of 5
1212	Drill Chuck, 1/2"
1148	Drill Chuck, 1/2" with 2MT Arbor

7. Using a ¼" drill bit, drill the hole to full depth.

Drill this hole by “pecking”. Drill about ½", then extract the drill from the hole to clear the chips. Repeat this process until you have reached the full depth.

8. Using a 31/64" drill bit, enlarge the hole.
9. Ream or bore the hole to final size.

If you have a 0.500" or 0.501" reamer, then use it to finish the hole. Reaming finishes holes to an accurate size with a good surface finish.

Lacking a reamer, bore the hole to final size. A boring bar works just like a turning tool, but cuts on the inside of a hole rather than the outside of the workpiece.

While it is good practice to make the diameter within the tolerances given, in this case if you miss you can simply turn the piston to match the cylinder.

Number	Description
1700	Boring Bar Holder, 1/2"
1247	Boring Bar Set, 1/2" Shank
1246	Boring Bar Set, 3/8" Shank
1779	Boring Bar, 3/8" Indexable CCMT Inserts
1720	Boring Bar, 3/8" Indexable HSS Inserts
2484	QC 3/8" Boring Toolholder, A2Z CNC
1968	Tool Bit, 1/4" Boring Bar Presharpened

10. Remove the workpiece from the lathe.
11. Lay out the hole locations on the side of the cylinder.
12. Using a mill or drill press, drill the 1/8" hole that intersects the cylinder bore at the top of the cylinder.
13. Drill the hole for the 10-32 thread in the side of the cylinder. Be sure that you do not drill into the cylinder bore.
14. Tap the 10-32 thread in the side of the cylinder.

Piston

Follow these steps to make the piston.

1. Chuck the 5/8" bar in your 3-jaw chuck. About ½" of the length should be in the jaws of the chuck.
2. Face the end.
3. Rough out the smaller end of the piston, leaving 0.030" of material for finishing.

   When you rough out a part, the primary goal is removing material efficiently. Take as deep a cut as your lathe can comfortably handle. Don’t worry about taking precise measurements, but do be sure that you don’t remove too much material.

4. Turn the smaller end to finished size.
5. Now turn the workpiece around and chuck the smaller end in the 3-jaw chuck. Keep the full-diameter “piston” at least 1/8" from the chuck jaws.
6. Face the piston to the final length.
7. Turn the piston end to size.

   Measure carefully as you get close to the final size.

Use the cylinder as a gage to check the final size. Use a file to break the sharp edge on the end of the piston before attempting to fit the cylinder. The cylinder should move over the piston with a little drag.

8. Lay out the hole location on the small end of the piston.
9. Using a mill or drill press, drill the hole through the small end of the piston.

To find the center of a round workpiece in the mill, use an edge finder to locate one side of the workpiece. Zero the dial at the position where the edge finder “jumps”. Now use the edge finder to locate the other side of the workpiece. Move back half the distance indicated by the dial, and you are over the center of the workpiece.

Number	Description
1240	Edge and Center Finder
1959	Edge and Center Finder, Fisher
2606	Edge and Center Finder, Laser 1/2" Shank
2543	Edge and Center Finder, Laser 1/4" Shank
2624	Edge and Center Finder, Laser 10 mm Shank
2604	Edge and Center Finder, Laser 3/8" Shank
2623	Edge and Center Finder, Laser 6 mm Shank
1822	Edge and Center Finder, Starrett
1961	Edge Finder 1/4" Audible, Fisher
1960	Edge Finder 3/8" Audible, Fisher
1823	Edge Finder, Starrett

Shaft & Pin

The process for both these parts is the same.

1. Chuck the workpiece in your 3-jaw chuck. Most of the length should be in the jaws of the chuck.
2. Face the end and use a file to create a generous chamfer on the end.

The chamfer will help the threading die get started.

3. Re-chuck the workpiece so that the part to be threaded is clear of the jaws.
4. Using a tailstock die holder and the appropriate threading die, thread the workpiece.

Don’t turn on the lathe when threading with a threading die. Turn the lathe chuck by hand.

If you want to learn how to thread using the threading capabilities of your lathe, parts like this provide a good learning experience. Many people will cut threads like this most of the way using the threading capability of the lathe, and then finish them with a threading die. Using the threading capability of the lathe ensures that the threads are concentric and straight to the workpiece. Finishing them with a threading die ensures that they are accurately sized.

Number	Description
2314	Die Holder
2572	Tailstock Die Holder, OMW

5. Chuck the workpiece in your 3-jaw chuck with the threaded end in the chuck. Most of the final length of the workpiece should be in the chuck.

   If the chuck jaws are going to bear on the threads, use a soft material between the jaws and the workpiece to protect the threads. A suitable source of thin aluminum is from beer or soda cans.

6. Part off the excess material. Leave about 0.030" of length for finishing.

   Parting off is difficult to do on a small lathe. The work should turn relatively slowly. Use cutting fluid. Be sure your cut-off blade is sharp and that the cutting tip is right at the centerline of the lathe.

   If you don't want to attempt parting off, you can saw the part to length.

Number	Description
1929	Cut-Off Blade, P1
1728	Cut-Off Blade, P1 A. R. Warner Co.
1930	Cut-Off Blade, P1N
1729	Cut-Off Blade, P1N A. R. Warner Co.
1552	Cut-Off Blade, P1X
1551	Cut-Off Tool Holder
2485	QC Cut-Off Toolholder, A2Z CNC

7. Face the end to length.

Crank Wheel

Follow these steps to make the crank wheel.

1. Chuck the workpiece in your 3-jaw chuck. Most of the length should be in the jaws of the chuck.
2. Face the workpiece.
3. Reverse the workpiece in the 3-jaw chuck. Make sure that less than half the length is in the jaws.
4. Rough the hub diameter. Leave 0.030" of material for finishing.
5. Turn the hub to the final diameter.
6. Face the hub.
7. Face the large diameter of the crank wheel.
8. Reverse the crank wheel in the 3-jaw chuck. Clamp the chuck on the hub.
9. Turn the outside diameter to size.
10. Lay out the hole location on the large diameter of the crank wheel.
11. Drill the hole for the 6-32 thread on the large diameter of the crank wheel.

The appropriate tap drill size for a 6-32 thread in aluminum is a #36 drill (0.1065").

12. Tap the 6-32 thread on the large diameter of the crank wheel.
13. Lay out the hole location on the hub of the crank wheel.
14. Drill the hole for the 6-32 thread on the hub of the crank wheel.
15. Tap the 6-32 thread on the hub of the crank wheel.

Base

Follow these steps to make the base.

1. Square the ends of the material. Use a mill if you have one, or a file if you don't.
2. Lay out the hole locations on the base.
3. Drill the thru holes in the base.
4. Use a 3/8" end mill to create the counterbores in the base.

   Perform steps 3 and 4 for each hole before moving the part. This ensures that the holes and counterbores are concentric.

Flywheel

Follow these steps to make the flywheel.

1. Chuck the workpiece in your 3-jaw chuck. Most of the length should be in the jaws of the chuck.
2. Face the workpiece.
3. Reverse the workpiece in the 3-jaw chuck. Most of the length should be in the jaws of the chuck.
4. Face the workpiece.
5. Rough the short hub diameter. Leave 0.030" of material for finishing.

   The short hub diameter is the side of the hub that does not extend past the rim of the flywheel.

   Use standard turning tools to rough out the hubs. Use a right-hand turning tool (which cuts on its left edge) to plunge into the middle of the recessed area and face toward the hub. Each plunge should be about 0.020" deep.

   This will leave you with a square hub, but a tapered area where you plunged in. Once you are at full roughed depth, switch to a left-hand turning tool and cut out toward the rim.

6. Finish the hub diameter.
7. Finish the inside of the rim.

8. Face the recessed area.
9. Drill a through hole through the center of the flywheel to the tap diameter for the ¼-28 thread.

   The appropriate tap drill size for a ¼-28 thread in aluminum is a #3 drill (0.2130").

10. Tap the ¼-28 thread using a tap wrench and a tap guide.

Number	Description
1963	Tap Guide
2621	Tap Wrench, Starrett

11. Reverse the workpiece in the 3-jaw chuck. Most of the length should be in the jaws of the chuck.
12. Rough the long hub diameter that extends past the edge of the flywheel rim. Leave 0.030" of material for finishing.
13. Rough the rest of the long hub diameter. Leave 0.030" of material for finishing.
14. Finish the hub diameter.
15. Finish the inside of the rim.
16. Face the recessed area.
17. Drill, then ream or bore, the unthreaded portion of the flywheel bore.

    The flywheel will run truer if you ream or bore this diameter. If you don't have the tools to do this, drill it carefully with a ¼" drill bit. The engine will still work.

Fitting the Piston to the Cylinder

At this point the piston probably does not move smoothly in the cylinder. Follow these steps to make it fit properly.

1. Put the small end of the piston in the chuck of a power drill. A cordless drill works best.
2. Coat the piston liberally with an abrasive-based metal polish like Brasso or Bright-Boy.
3. Insert the piston into the cylinder.
4. Run the drill while you move the piston in and out for about 30 seconds.
5. Clean both parts and check the fit.
6. Repeat steps 4 and 5 until the piston moves smoothly in the cylinder.
7. Wash both parts with detergent and water to ensure there is not polish on either one. Dry thoroughly.
8. Coat the piston with a drop or two of light oil to prevent rust.

Assembling the Engine

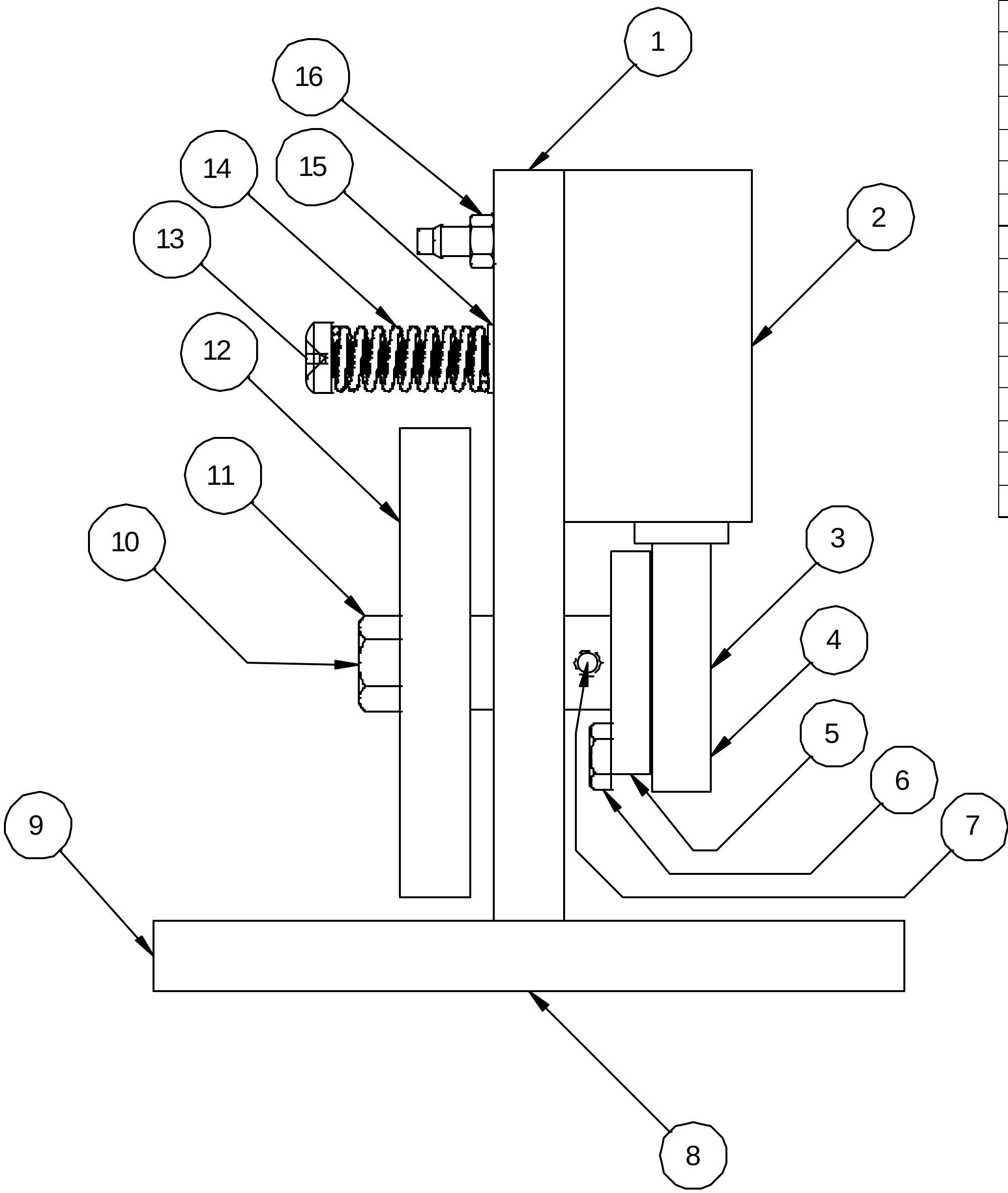
You have made all the parts. Now it’s time to assemble the engine.

1. Mount the upright on the base with the two 10-32x1/2" socket head cap screws.
2. Thread the crankshaft into the flywheel and install the 1/4-28 lock nut.
3. Screw the crank pin into the crank wheel and install the 6-32 lock nut.
4. Thread the 6-32x1/8" set screw into the crank wheel. Make sure it does not extend into the bore.
5. Put the crankshaft through the upright and put the crank wheel on the crankshaft. Tighten the setscrew, making sure the flywheel assembly turns freely.
6. Assemble the 10-32x1.5" machine screw, the spring and the #10 flat washer.
7. Put the piston into the cylinder.
8. Put the hole in the rod end of the piston over the crank pin.
9. Hole the piston against the upright and thread the 10-32 x1.5" machine screw into the cylinder.
10. Install the air fitting.

Running the Engine

Most small “steam” engines are powered by compressed air. Although they run fine on steam, steam is simply too dangerous (and hard to find) for projects like this.

This kit includes two air fittings and a couple feet of tubing. Use the second air fitting to make an adapter to your air compressor or whatever other air supply you have available. A block of aluminum with the furnished air fitting in one side, and a fitting suitable for your air supply in the other side is all you need.



Bill of Materials

Item	Name	Material
1	Upright	3/8" x 2" x 4.1" Aluminum Rectangle
2	Cylinder	1" x 1" x 2.1" Aluminum Square
3	Piston	0.625" dia. x 2" Steel Round
4	Crank Pin	9/64" dia x 1" Drill Rod
5	Crank Wheel	2" dia. X 0.6" Aluminum Round
6	Nut	6-32 Steel Machine Screw Nut
7	Setscrew	6-32 x 1/8" Cup Point Socket Set Screw
8	Cap Screw (2)	10-32 x 1/2" Socket Head Cap Screw
9	Base	3/8" x 4" x 4.1" Aluminum Rectangle
10	Crank Shaft	1/4" dia x 2" Drill Rod
11	Nut	1/4-28 Steel Machine Screw Nut
12	Flywheel	2.5" dia. x 0.6" Aluminum Round
13	Machine Screw	10-32 x 1.5" Pan Head Phillips Machine Screw
14	Spring	Steel Spring, 1" Long, 11/32" OD, 0.047" Wire
15	Flat Washer	10 Flat Washer
16	Air fitting	10-32 Thread x 1/8" Hose Air Fitting

Notes

Break all sharp edges
Tolerance ±0.010 unless specified

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Oscillating Engine Assembly

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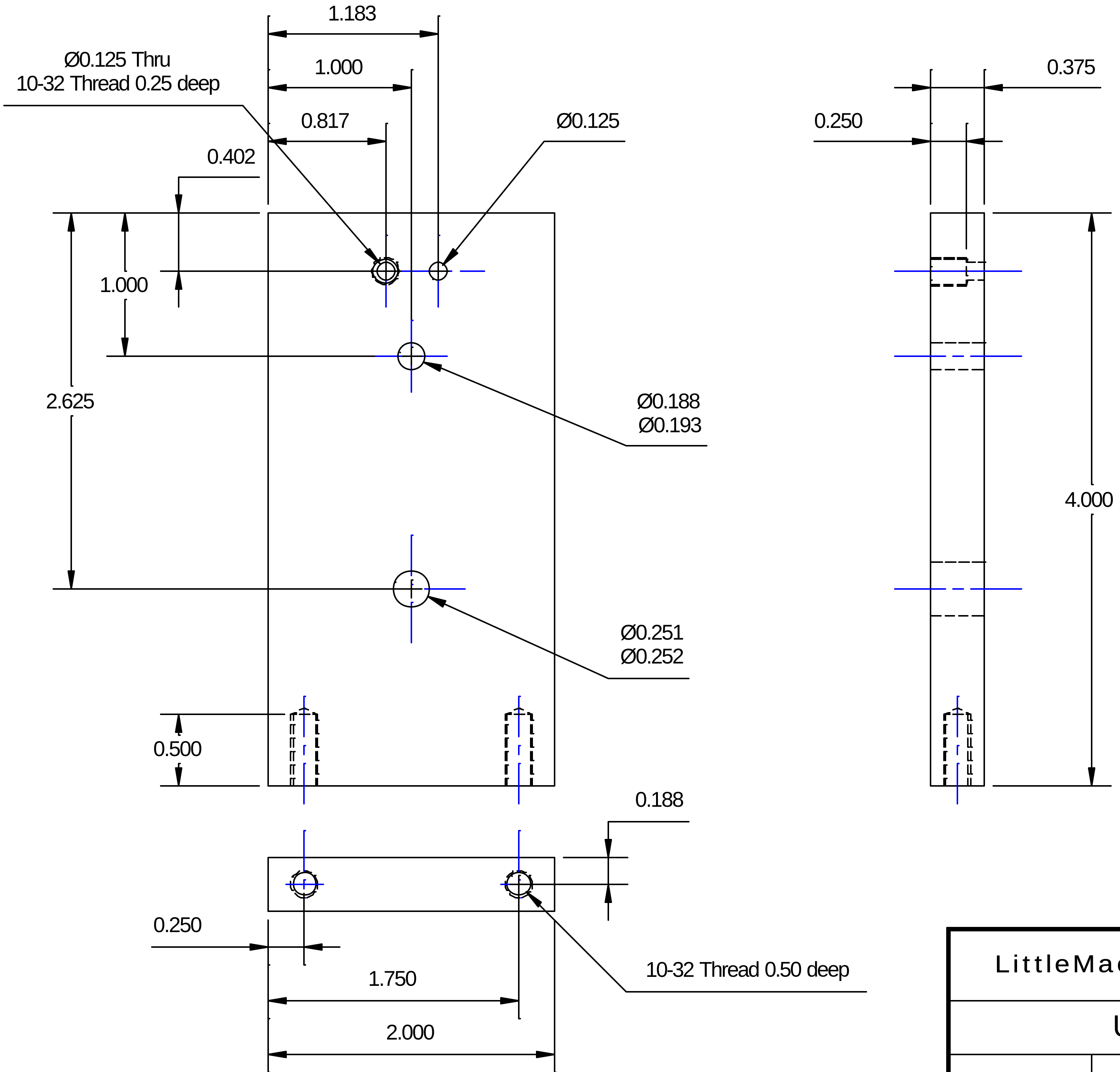

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Upright

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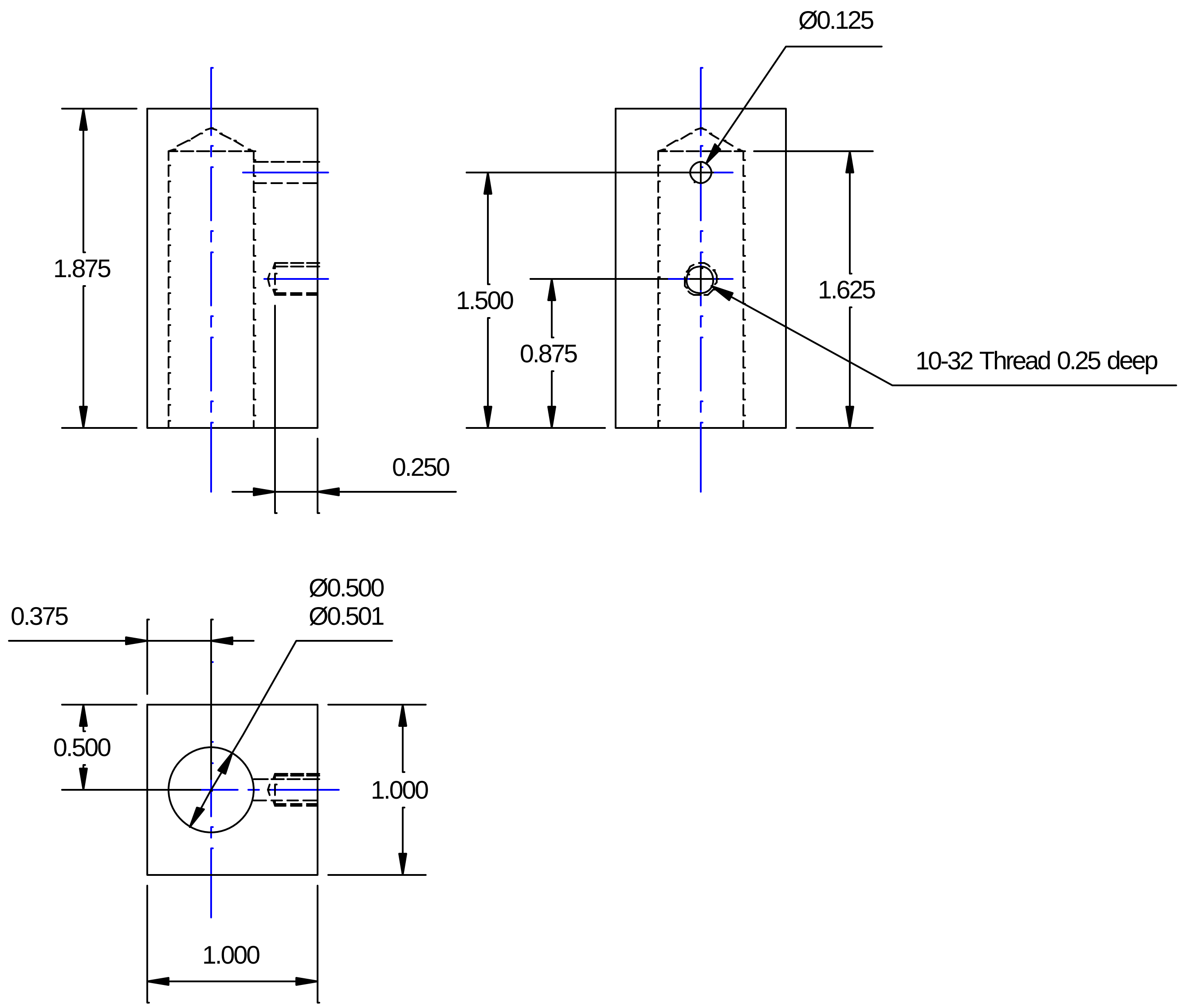

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Cylinder

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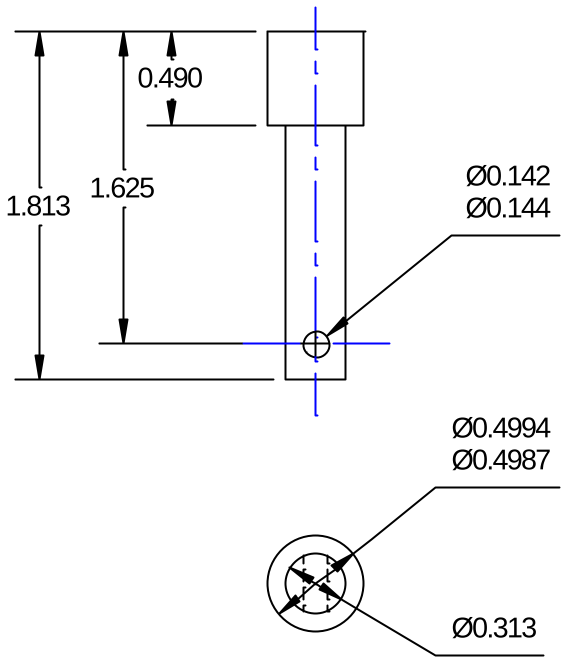

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Piston

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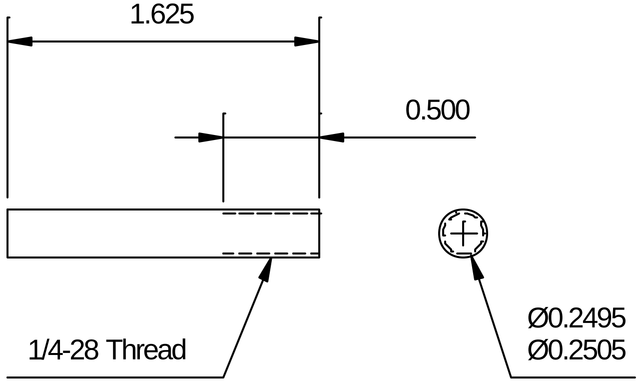
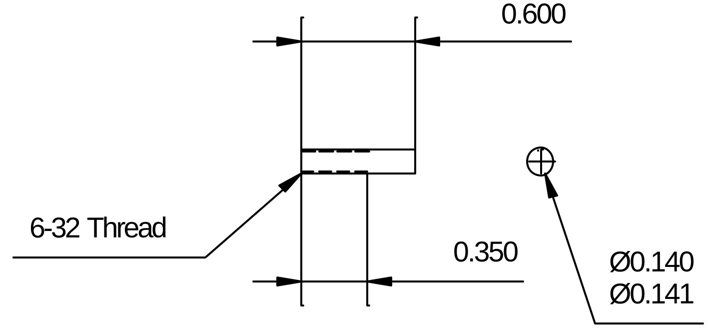


Shaft

Crank Pin



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Shaft and Pin

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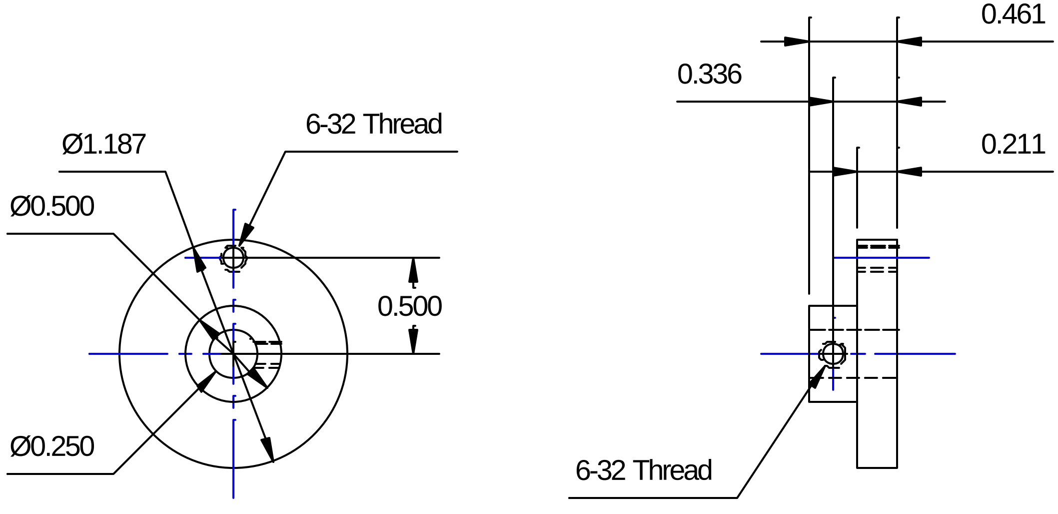

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Crank Wheel

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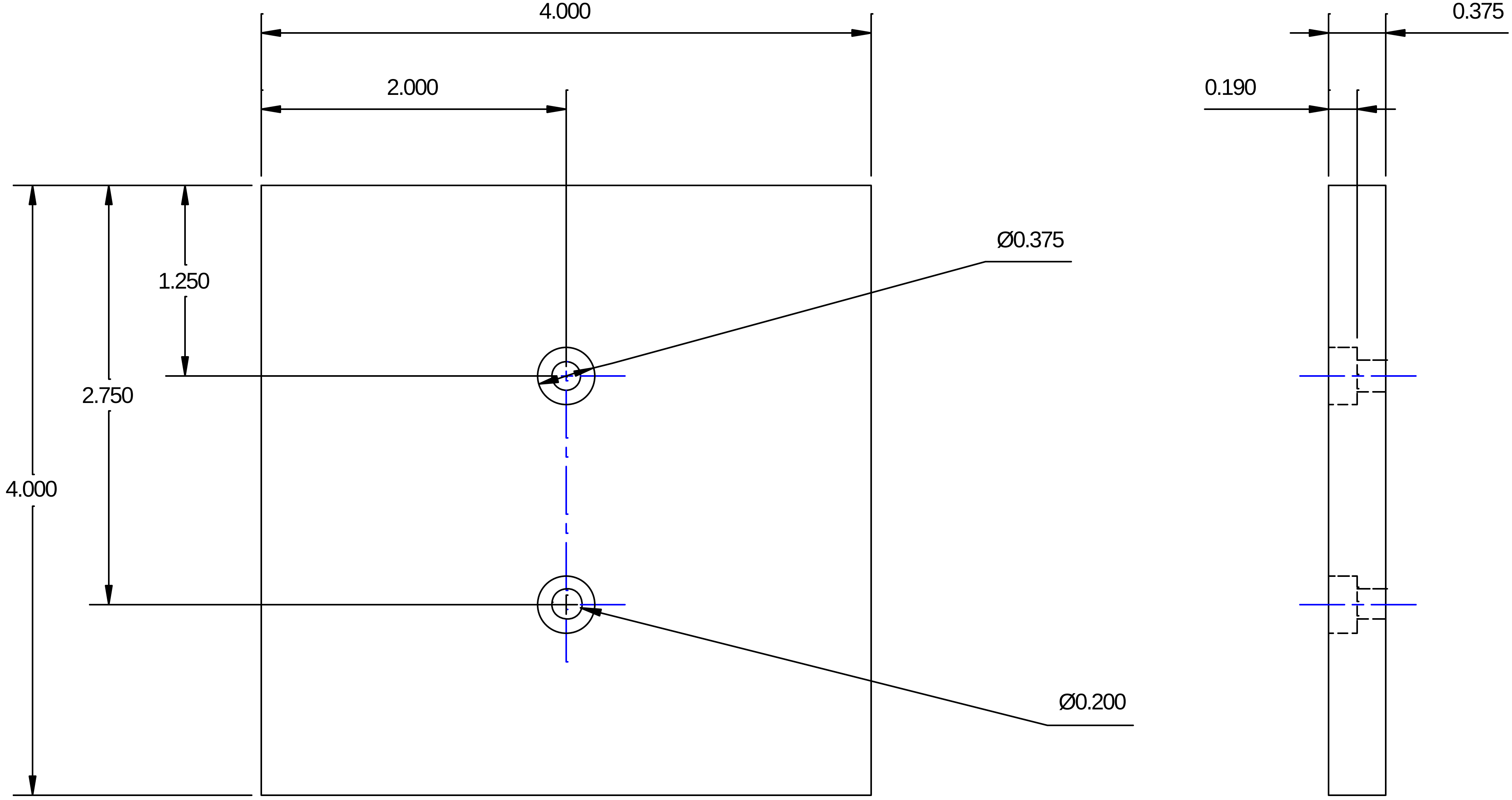

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Base

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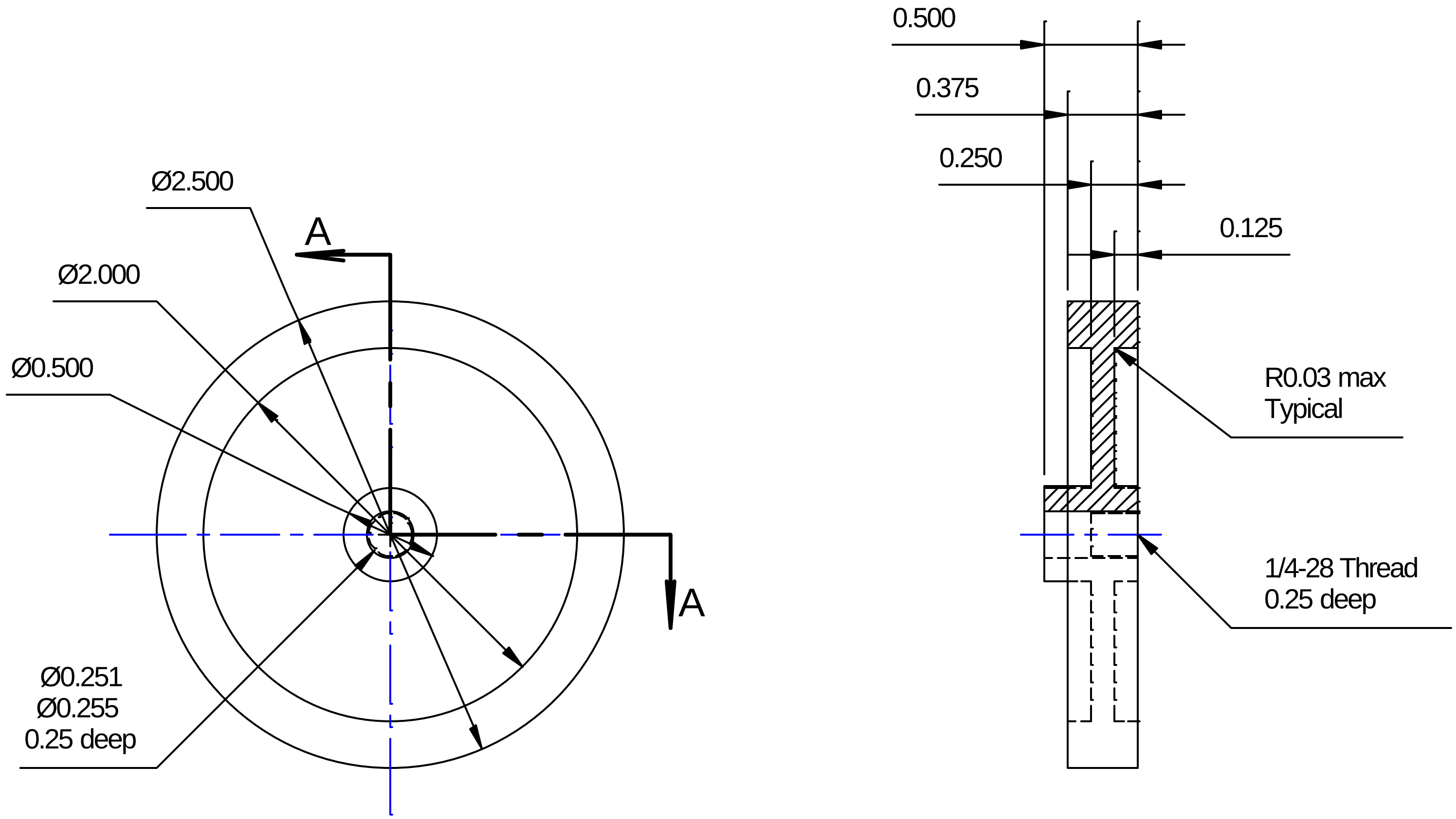

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Flywheel

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