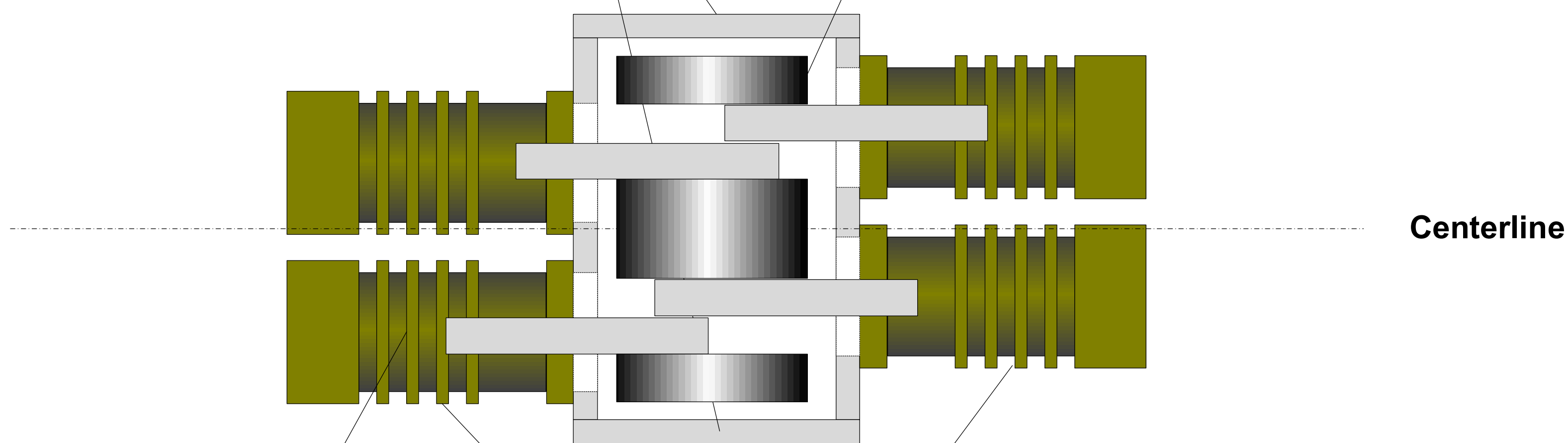
Opposed 4 Cylinder
Compressed Air Engine
General Layout

End plates are made from 1/8" thick steel, silver soldered onto the ends of the square tubing. Corners are ground to match the rounded corners of the square tubing

Engine Crankcase is made from 2" long, 1.5" square steel tubing with .120" wall thickness



Cylinder barrels are made from 1.5" long, 1" x .75" solid brass bar. The “Head” and Fins are left rectangular. The base is milled square .75" x .75"

Left and right cylinder barrels are offset from each other by .200". Left side is shifted.100" forward and right side is shifted .100" back

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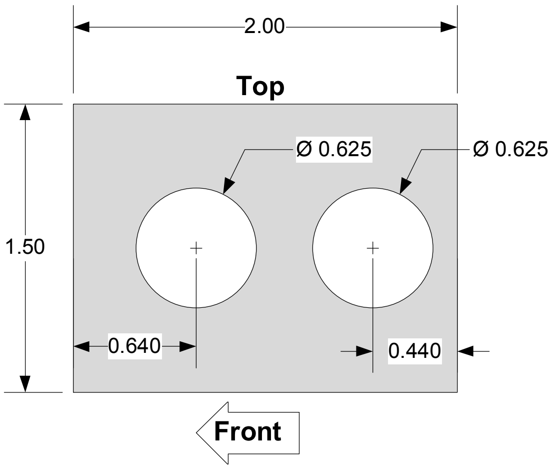
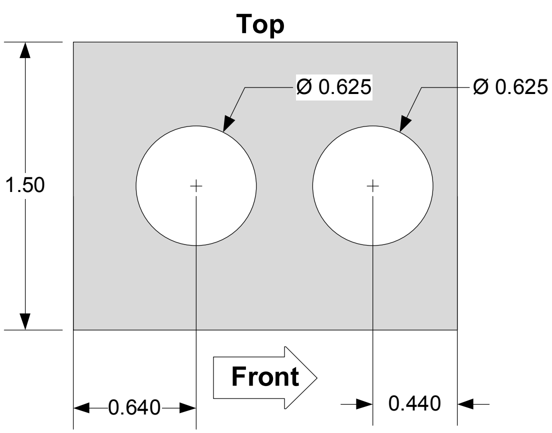
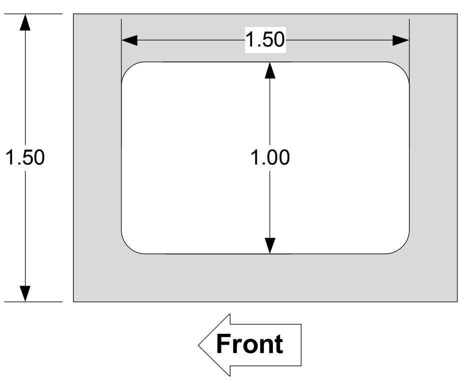
Opposed, 4 Cylinder Engine



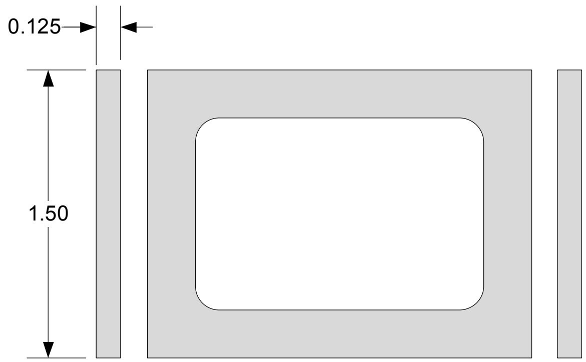
The crankcase is made from 1½” square steel tubing with a .120" thick wall. The dimensions shown are <u>without</u> the 1/8" thick steel plate that gets soldered onto each end and to which the bearing housings are attached. The view to the left is the right side of the engine as viewed from the front.



This is the left side of the engine as viewed from the front. Note that the cylinder holes on the left side are .200 offset horizontally from the ones on the right side.

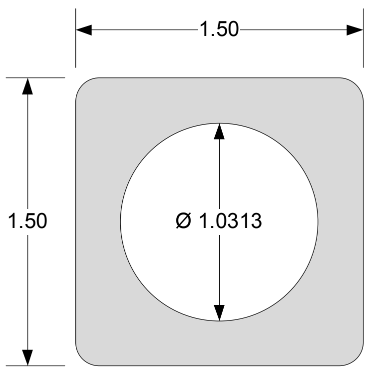


This is the bottom of the engine. The rectangular hole is centered vertically and horizontally in the crankcase and is milled with a ¼” diameter end mill. Its primary purpose is to provide access for assembling and, later, oiling the engine.

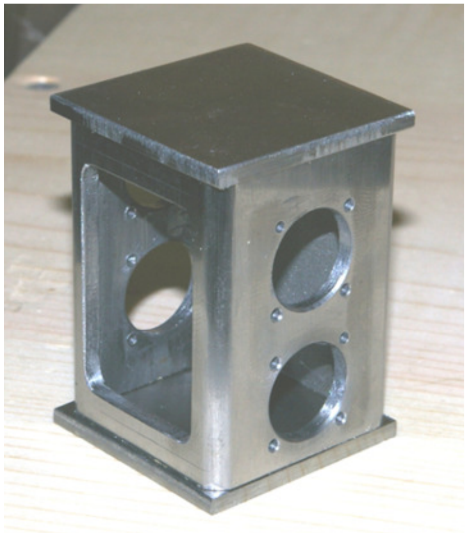


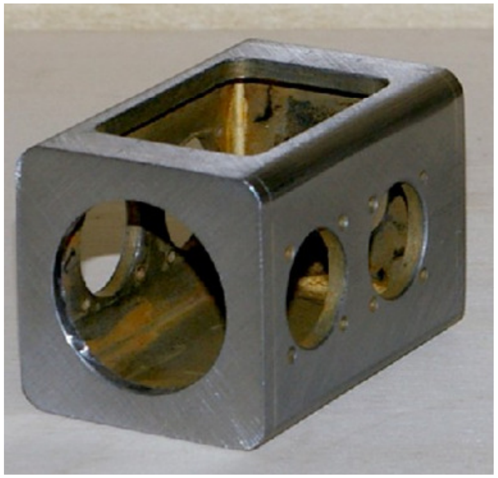
After the cylinder holes and the bottom hole have been cut in the crankcase, the end plates can be silver soldered on to each end. It's easier to cut these slightly oversized and grind them down to match the outside dimensions of the crankcase after they are soldered in place.

Note that the crankshaft bearing carrier holes are bored in the ends of the crankcase after it is soldered together and ground down to finished dimension. This is to assure that the holes are centered in the crankcase.

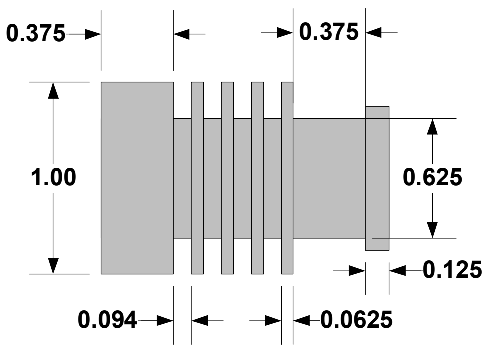


I will cover the size and placement of the threaded holes for attaching the cylinders and the crankshaft bearing carriers later on.

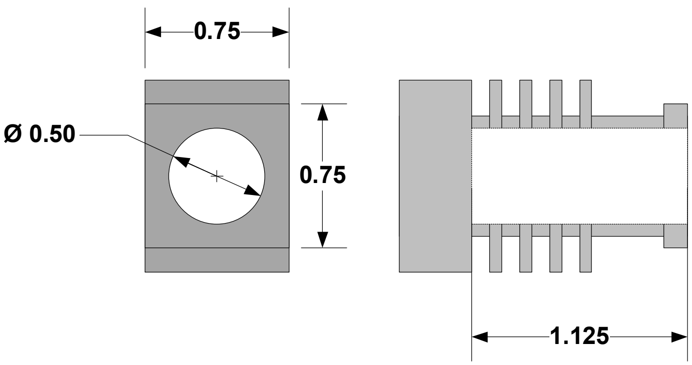




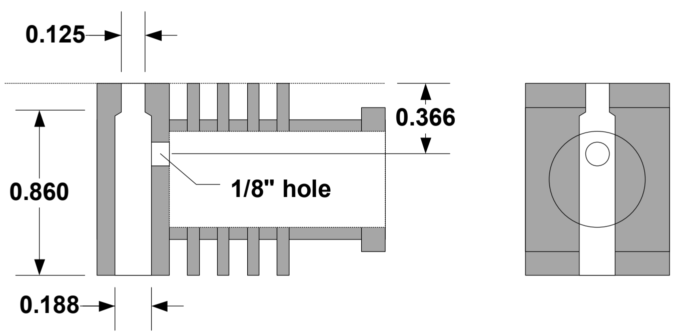
Opposed, 4 Cylinder Engine



The cylinder is drawn in the same orientation as positioned on the engine. The cooling fins are 1/16" thick. A 3/32" parting tool was used to cut the spaces between the fins. Note that the OD on the turned part of the cylinder is 5/8".



The bore is 1/2” and is bored to a depth of 1 1/8"



To create the air inlet and exhaust ports, first drill a 1/8" vertically all the way through the head. Then flip the cylinder over and enlarge the hole to 3/16" to the depth indicated. If you’re using brass, take precautions so the work doesn’t pull the bit in with nasty results! Finally, drill the 1/8" port from the cylinder through to the inlet/exhaust port.

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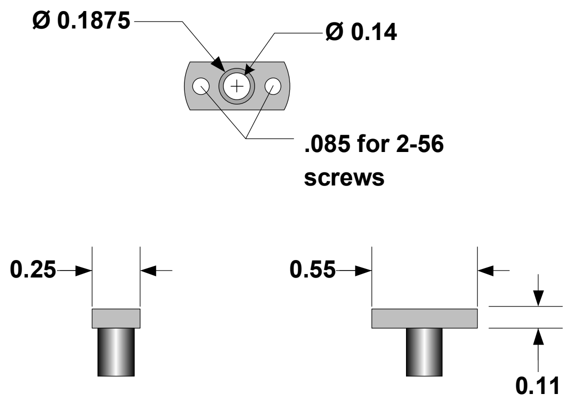
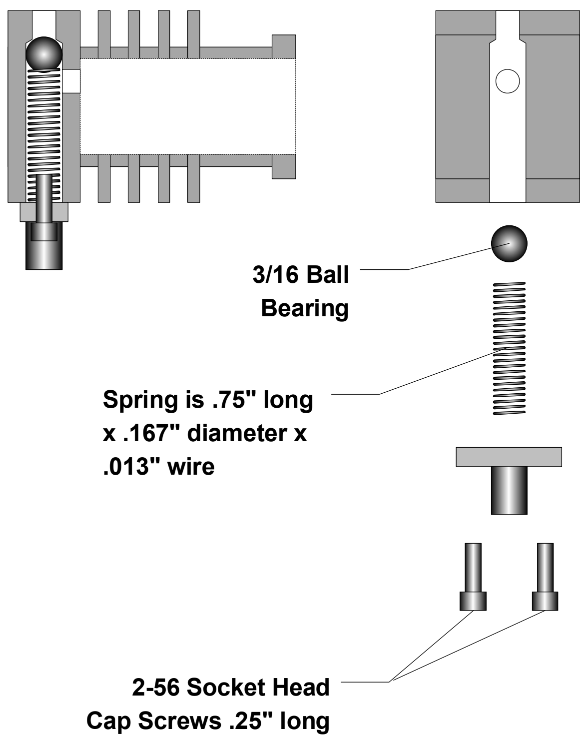
Opposed, 4 Cylinder Engine

Exhaust Manifold, 4 required



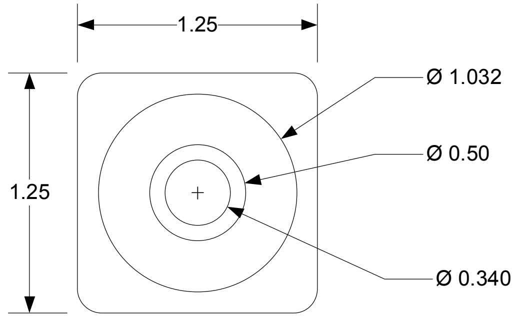
The four exhaust manifolds are made of brass. The OD of the round portion can be changed to fit the ID on brass tubing if it's decided to solder on exhaust pipes. The center hole was drilled with a #28 drill bit. A 1/8" bit should work OK if a #28 isn't available.



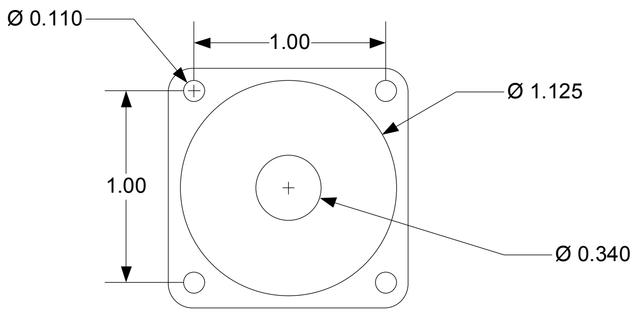
The spring size is somewhat important. This particular size is commonly found in ball point pens. This spring size is good for smooth idling at a low speeds. A longer or heavier spring yields higher RPM's, but more air pressure is required.

Opposed, 4 Cylinder Engine

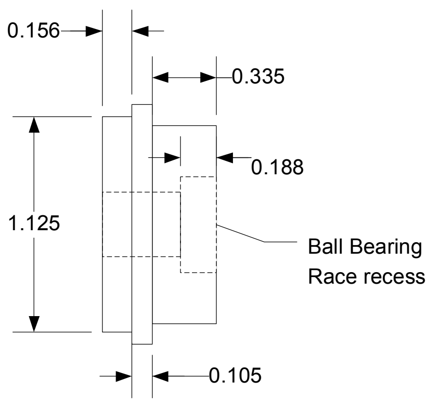
Rear Bearing Block



This is the internal side of the rear bearing block. I used a .5" OD x .25" ID ball bearing race on both ends of the crankshaft. The 1.032" boss fits into the 1.032" hole in the crankcase. The .5" recess holds the ball bearing and the .340" hole is bored all the way through to permit the crankshaft to pass through.



This is the external side of the rear bearing block. The 4 mounting holes are .110" diameter for 4-40 screws and on a 1" square pattern.



This is a side view of the rear bearing block. The side with the ball bearing recess goes into the engine.

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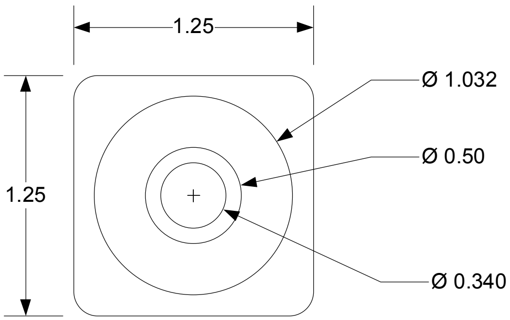
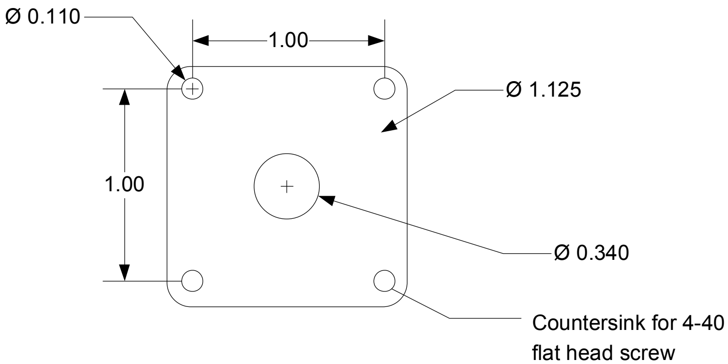
Opposed, 4 Cylinder Engine

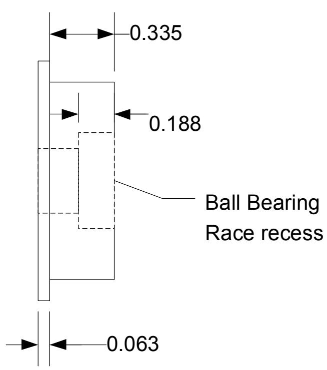
Front Bearing Block



This is the internal side of the front bearing block. The 1.032" boss fits into the 1.032" hole in the crankcase. The .5" recess holds the ball bearing and the .340" hole is bored all the way through to permit the crankshaft to pass through.



This is the external side of the rear bearing block. The 4 mounting holes are .110" diameter for 4-40 screws and on a 1" square pattern.



This is a side view of the rear bearing block. The side with the ball bearing recess goes into the engine.

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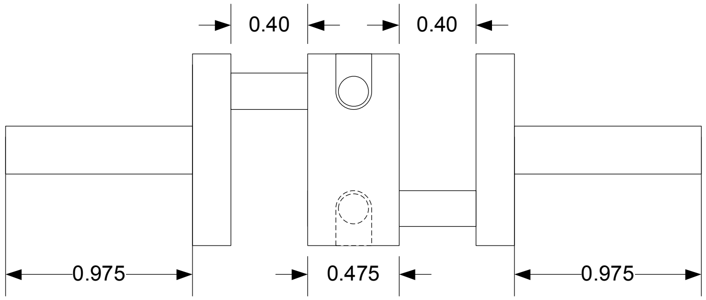
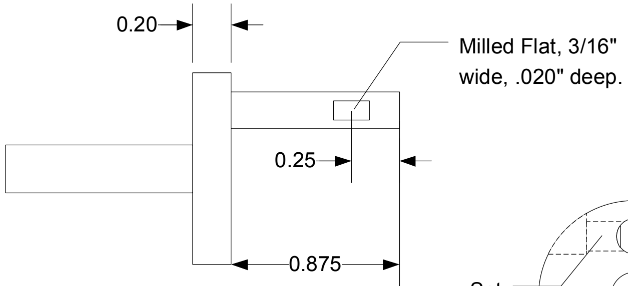
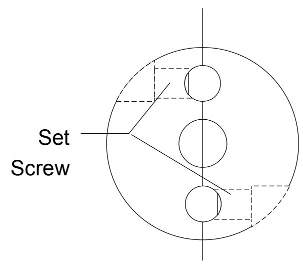
Opposed, 4 Cylinder Engine

Crankshaft

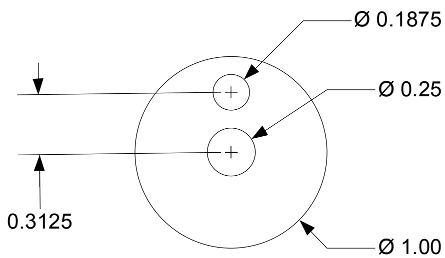


This is a view of the assembled crankshaft. The center web shows the counterbored set screws the clamp each throw to the center web. A 3/16" end mill is used to counter bore and the setscrews are 8 -32.



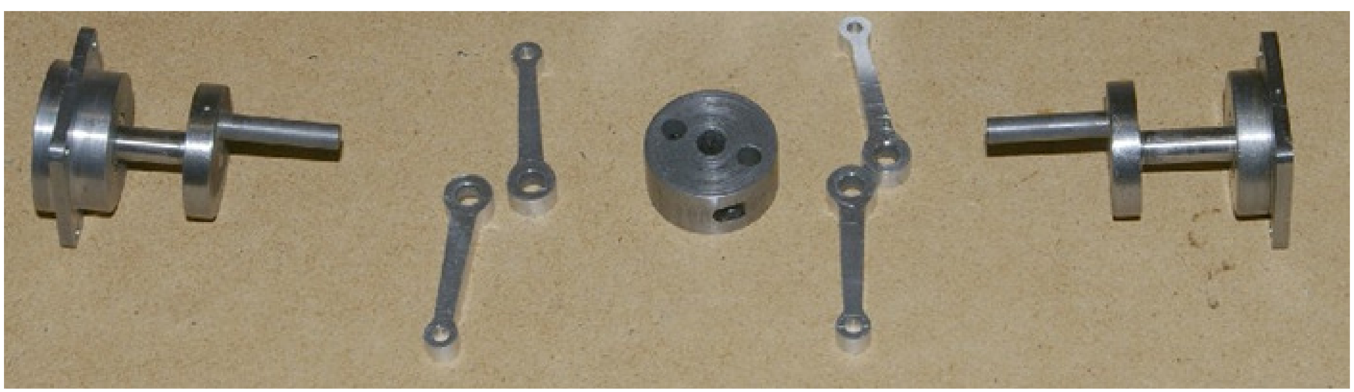


Center Crank Disk



This shows the crankshaft ends and 2 are required, one for each end. The main shaft and the crankshaft throw are silver soldered to the disk although loctite and pinning could also be used. The milled flat for the set screw in the center crank disk will help get the crankshaft parts perfectly aligned & square. Be sure to get the milled flat exactly parallel with the plane formed by the centers of the main crank shaft and the connecting rod shaft.

As can be seen in the drawing, the crankshaft throws are made from 3/16 drill rod and the center shaft is 1/4". The outer disk is made from 1" cold rolled steel.



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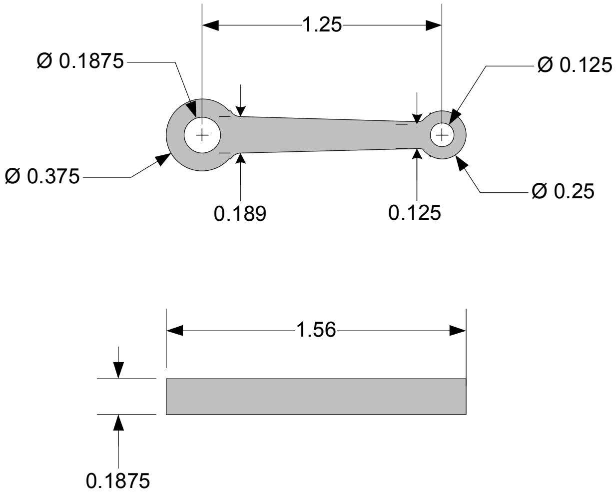
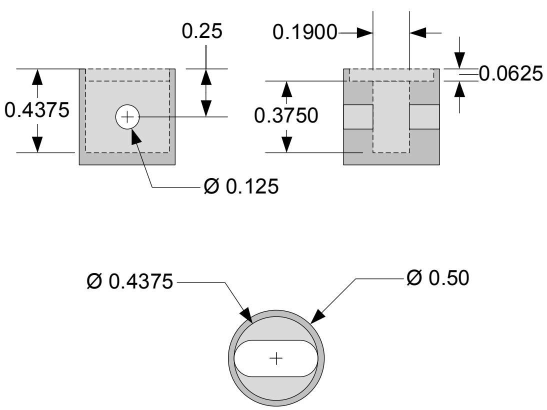
Opposed, 4 Cylinder Engine



The connecting rods are made from 3/16" aluminum. A 1/4" diameter end mill was used to mill the sides and the radius on the ends.



The pistons were made from 1/2" aluminum rod. The wrist pins were made 7/16" long and a center punch was used to put a small dent in the outside of the piston on each end of the wrist pin to keep it in place

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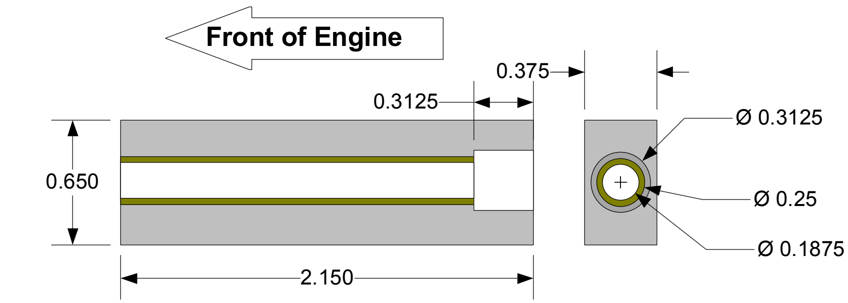
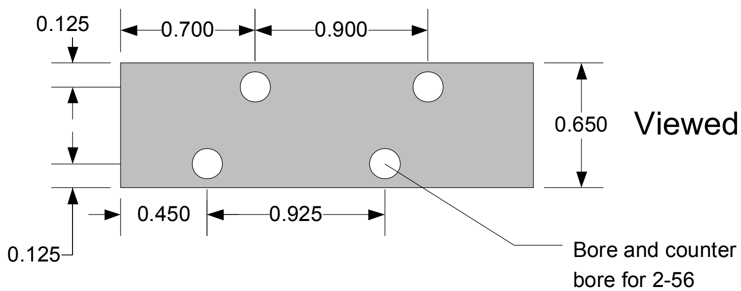
Valve Block **Opposed, 4 Cylinder Engine**

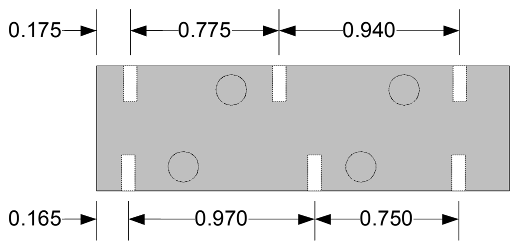


The drawing to the left shows the center hole for the valve tube. A .25" hole is bored through then a counter bore 5/16" diameter x 5/16" depth is bored into the back end. There is a .25" OD by .1875"ID brass tube through the center of the block but this doesn't get inserted just yet.



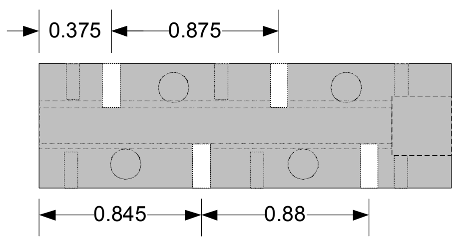
Viewed from the top

Next the holes and counter bores are drilled for the 2-56 socket head cap screws that fasten the valve block to the top of the crankcase. First drill the holes with a #51 drill which is the pilot size for a 2-56 screw. Then position the valve block on the crankcase and use the #51 holes as a template for drilling into the crankcase. The holes in the valve block can then be enlarged.



Viewed from the top

Here is the layout for the 2-56 holes drilled and tapped on a centerline into the sides of the valve block. These holes can be drilled thru into the .25" center hole.



Viewed from the top

Here is the layout for the 4 air transfer ports that are drilled on a centerline into the sides of the valve block. These holes are 3/32" diameter. Before drilling these holes, epoxy the .25" brass tube into place. Then drill the transfer holes all the way through the sides of the brass tube.

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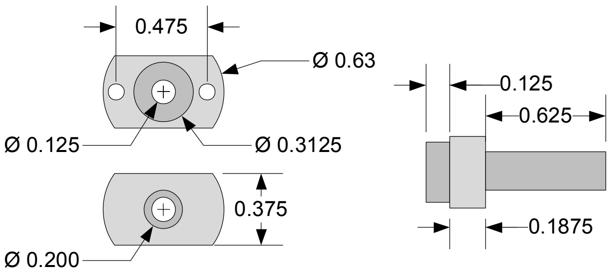
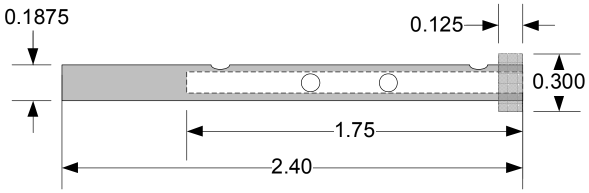
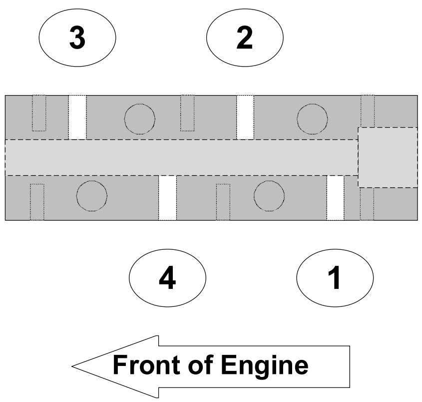
Opposed, 4 Cylinder Engine



Here is the air supply tube & block that attaches to the back end of the valve block with 2, 2-56 socket head capscrews.



The valve tube is made from a length of 3/16" drill rod and the 0.3" x 0.125" flange is heat shrunk on to the end. Next, drill the 0.110 center hole to a depth of 1.75". I also used a center punch to slightly expand the tube against the inside of the flange.



The best way to position and drill the radial air transfer holes in the valve tube is to use the transfer ports in the valve block as guides. The drawing to the left shows the “Firing” sequence of the cylinders.

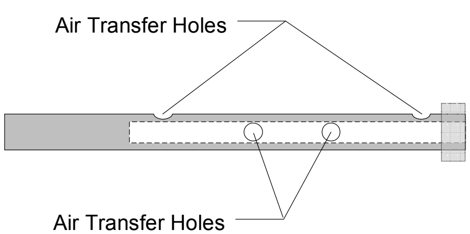
The process for drilling the transfer holes is:

1. Insert the valve tube fully into the valve block. It’s a good idea to temporarily fasten a gear or pointer to the protruding front of the tube to a) hold the tube firmly positioned in the valve block and b) to accurately measure rotation of the valve tube in 90 degree increments.

2. Drill the first 3/32" radial hole in the valve tube through the valve block transfer port at position 1.

3. Rotate the valve tube 90 degrees clockwise as viewed from the front of the engine and drill the second 3/32" radial hole in the valve tube through the valve transfer port at position 2.

4. Repeat the process of rotating the tube 90 degrees clockwise and drilling the hole at position 3 and then position 4.



This should result in a hole pattern as shown to the left, 2 outer holes on top and 2 inner holes on the front, side. This pattern will result in a counter-clockwise rotation of the crankshaft as viewed from the front.

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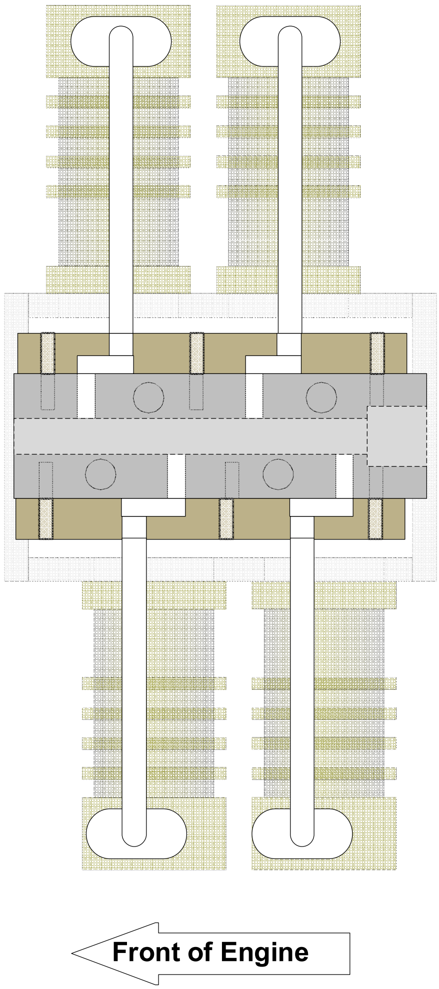
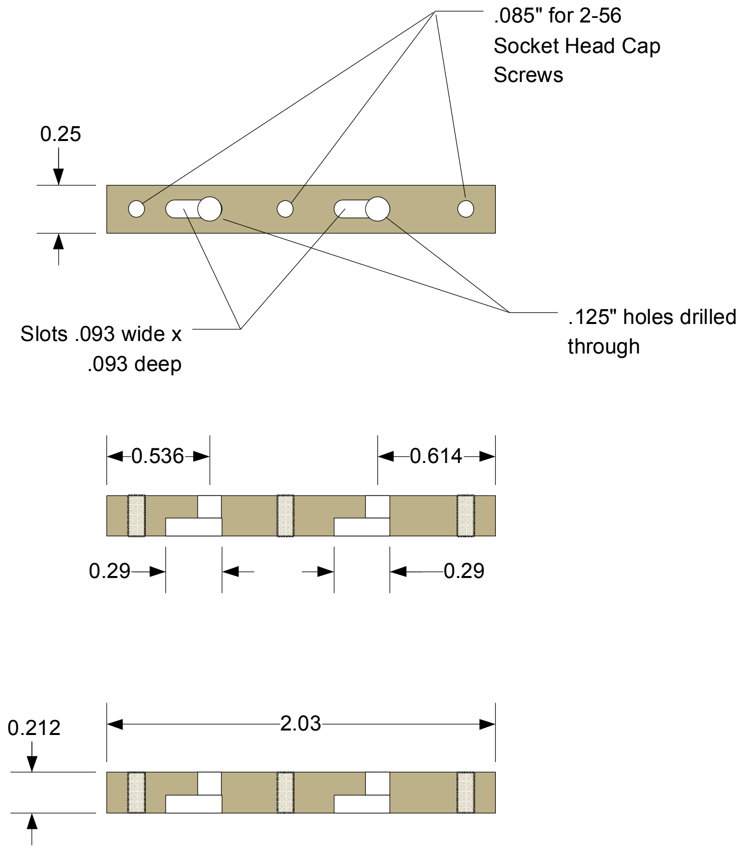
Opposed, 4 Cylinder Engine

Air Supply Manifolds





The top (left from front of engine) is shown and the bottom (right side) is virtually identical in dimensions and construction. The bottom one is merely rotated end for end.

As in most of my construction, I don’t depend on my ability to locate hole positions. In this case, I first located and drilled the mounting holes in the manifolds, then used those as templates to drill the threaded mounting holes in the valve block.

The 1/8" holes for the brass air tubes are centered on the cylinder. The 3/32" slots on the underneath side of the manifold are needed to connect the brass air tube with the air supply hole from the cam tube in the valve assembly block.

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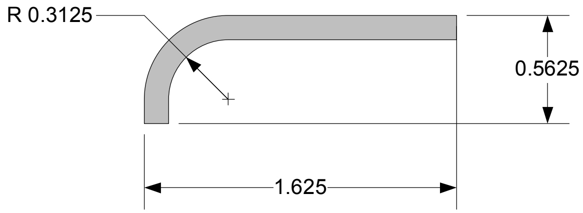
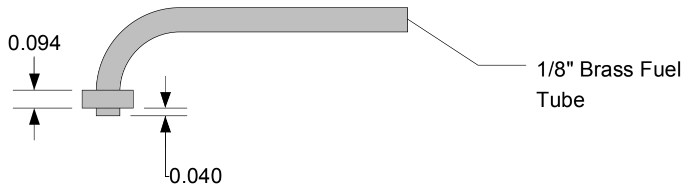
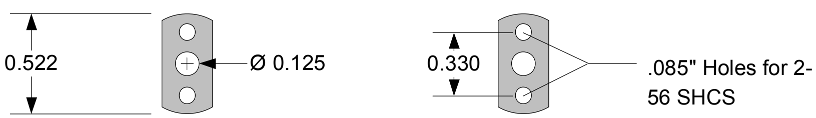
Opposed, 4 Cylinder Engine



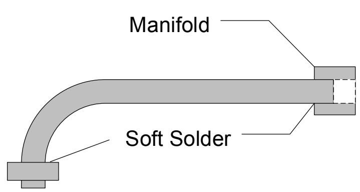
The air tubes are made of 1/8" soft brass tubing, also sold as brass fuel line. This type of tube is much easier to bend than the rigid brass tubing.

My tube bending form just happened to be a 5/16 radius, but that is probably not critical as long as it doesn't kink.





The flange is also made of brass so it can be soft soldered to the tube. Note that the tip of the brass tube extends 0.40" beyond the bottom of the flange. This makes assembly easier.



The other end of the brass tube is soft soldered to the manifold holes. The brass tube extends in to the inner edge of the milled air passage in the manifold.

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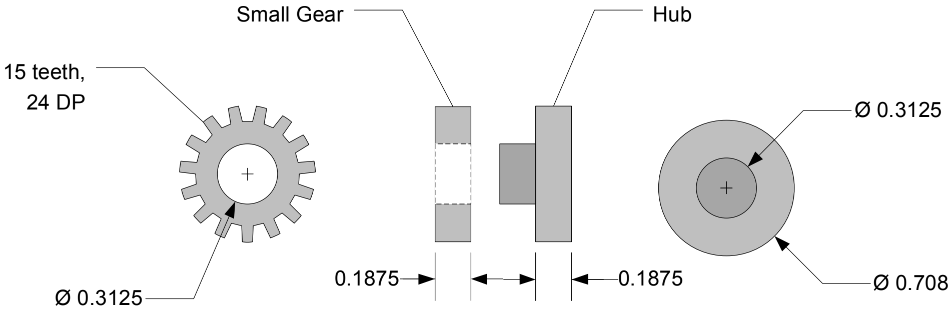
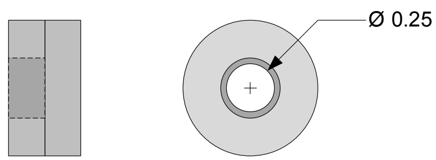
Opposed, 4 Cylinder Engine

Timing Gears

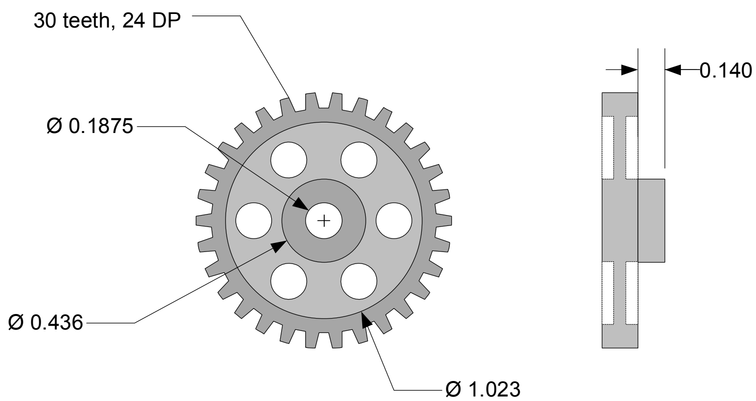


The small timing gear and its hub are formed separately then soldered together. It is 24 DP with 15 teeth. The gear blank will have an OD of .708". Alternatively, it could be 32 DP with 20 teeth. The important thing is that the gear have a circular pitch of 0.625".

Solder gear and hub together



After the hub and gear are soldered together, a 0.25" center hole is drilled through to fit on the crankshaft. I also I drilled and tapped to radial holes in the hub, 180 degrees apart, for 8-32 set screws to secure the gear to the crankshaft. I like this setscrew arrangement to adjust out any wobble in the gear.



The large timing gear is 24 DP with 30 teeth. The gear blank will have an OD of 1.333". If 32 DP is used the gear must have 40 teeth. Both timing gears must use the same diametral pitch. The pitch circle of the larger gear must be 1.25". The hub is drilled and tapped to accept two 8-32 set screws 180 degrees apart, again to allow adjusting out any gear wobble.

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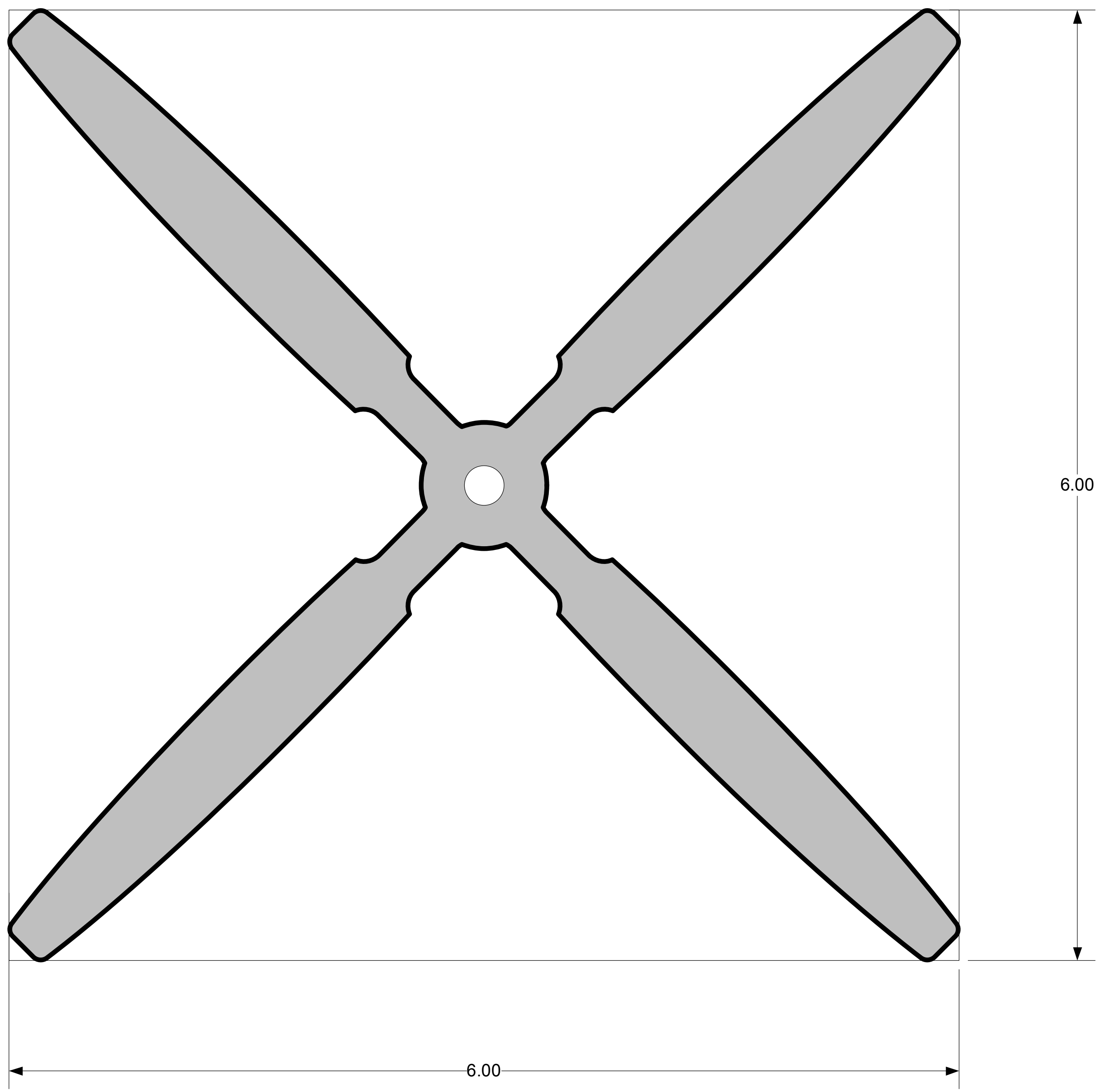
Opposed, 4 Cylinder Engine



Here is the template for the steel propeller. It was cut from a 6" x 6" square piece of 3/16" thick cold rolled steel.

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