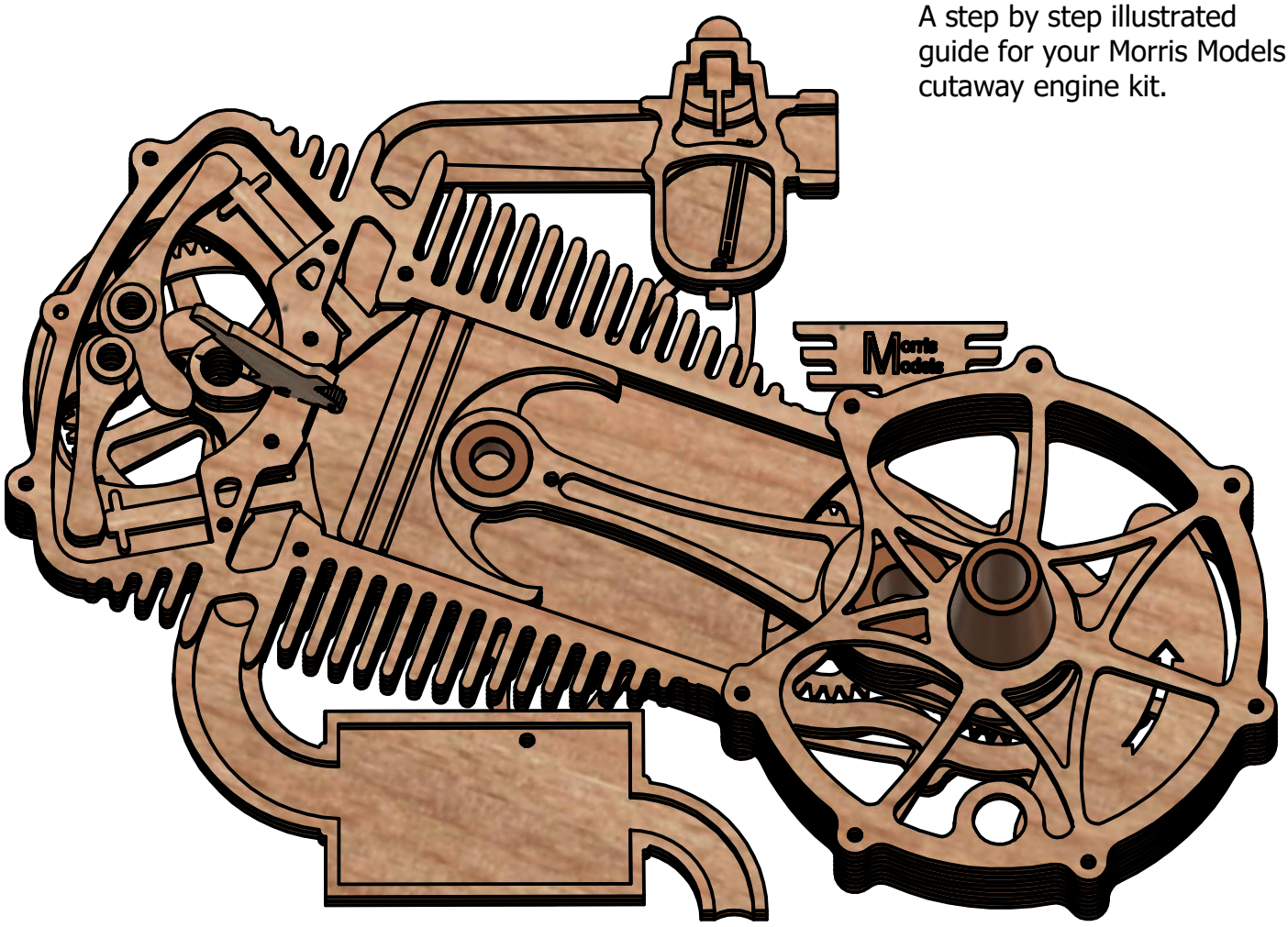
Overhead Cam (OHC) Engine

Assembly Manual

Build a stylized flattened cutaway to understand and illustrate how a four stroke internal combustion engine works.

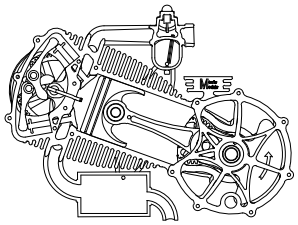
A step by step illustrated guide for your Morris Models cutaway engine kit.



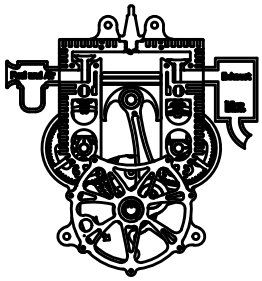
Morris Models currently offers three single cylinder four stroke cutaway engine kits: the Flathead, the Overhead Valve (OHV), and the Overhead Cam (OHC) engine. These kits all share many parts and features, and are intended to show how engine design has evolved and progressed over time. As of 2021, this is our most technically advanced kit and is designed for the highest speed operation. OHC engines are designed to have the lightest valve trains which allows them to run at a much higher RPM than the previous designs. This allows the engine to produce much more power than the older designs of similar displacements.

Before you begin

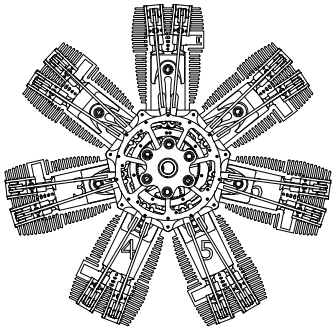
OHC Motorcycle



This Engine



Flathead



Radial

Most of this kit was cut out of Baltic birch plywood on a laser cutter. Plywood is a natural product, and every piece is different. Because of this, the laser cannot cut every piece perfectly. This means that in some places, there is smoke and scorching. In other places, the wood did not cut completely and there are splinters hanging on the edges. The more time you spend preparing your parts, the better your completed model will be.

You should begin by making sure that all the parts are included. Look over the rest of the steps in this manual, and find all the parts for each step. Check the parts to make sure that they are in good condition. Minor damage can be repaired with glue. Splinters should be removed using an X-acto type knife and sandpaper. Scorched marks should be lightly sanded off. If any parts are badly broken or are missing, you can get replacement parts from www.morrismodels.com.

A few of the parts for this kit are cut from hardwood - either maple or birch. These form the engine shafts. These also should be sanded for splinters. The ones that are included in this kit are basic cylinders. If you have access to tools, they can be made to look a little more realistic if you drill holes in some of them and cut or sand a bevel in the front shaft. The parts shown in this manual have had this done, but this step is for appearance only, and is completely optional.

This engine is designed to be assembled with any type of wood glue. I personally use Elmer's "Glue-All" glue. Do not use Elmer's "School Glue." It will not work. Whatever glue you use, use only enough glue to stick the parts together. Extra glue will squeeze out from between the parts and stick the engine together in places where it should not. Any glue that does squeeze out from between parts should be wiped up with a damp cloth while it is still wet.

Many of the plywood parts have small 1/8" holes. These holes are to help line up the layers. As you work, try to keep the glue away from these holes. When you put on a new layer, push short 1/8" wood dowel pins into the layers to help you line tham up. These are called alignment pins. You should remove the alignment pins after the glue has had a few minutes to dry.

Many people ask if they can varnish, paint, or stain the engine. I do not recommend using paint or varnish, but oil-based finishes or stains are appropriate. Assemble the engine before using them. Another alternative is to use water-based markers. You can color each part after it is assembled. These parts absorb a lot of marker ink, so it will take quite a few markers to do the job.

Real engine use oil to keep them sliding smoothly. This wooden engine model would be ruined with oil. Most people use wax when assembling these wooden engine kits to help the parts slide smoothly. This step is optional. I have used candle wax and I have used colored crayons. Either of these will work fine. So does paraffin wax.

This manual shows how to build the engine step by step. Sometimes it is hard to explain things in a manual, but easy to understand it on a video. At the www.morrismodels.com web site, you can find a link to an assembly video that shows the same steps that are in the manual. Use this video if you prefer, or use the video to view any steps where you have trouble understanding the manual. (Note - video is not yet available as I type, but should be soon.)

I hope you enjoy building this kit. If you do, you may want to consider taking apart old engines to see how they work. You will find that it has very similar parts to the parts in this kit - except that the parts are round. You may also want to consider building some of the other model kits on our website as well.

Background Information

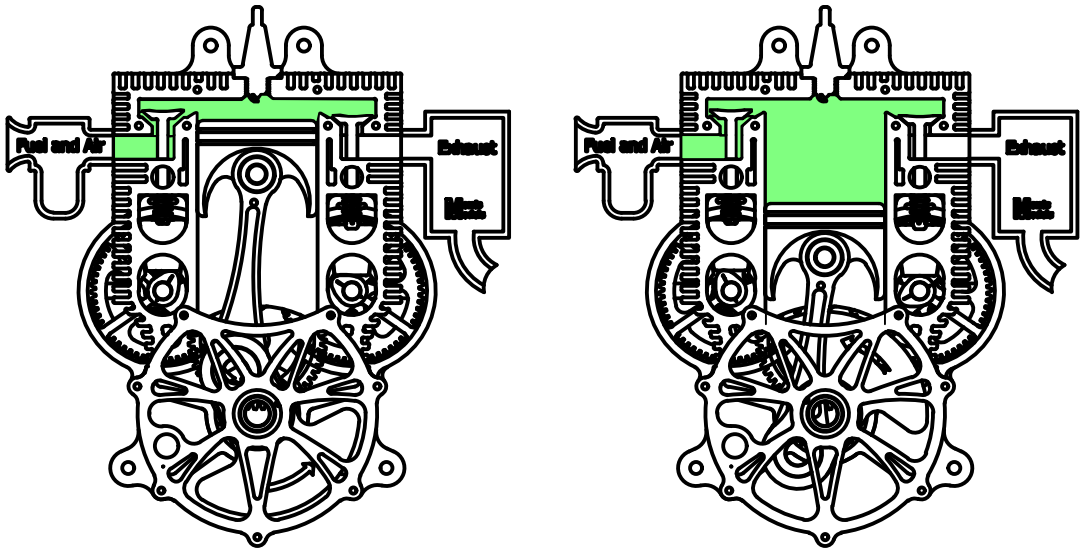
Note: Our Flathead model engine is shown in illustrations.

You are about to put together a cutaway model engine. It is designed to help you understand how a real four stroke engine works, but it is not a real four stoke engine. It has been rearranged so that all the parts are easy to see. It has also been flattened so that it is cheaper to produce and easy to hang on a wall or keep in a desk drawer.

The idea behind the four stroke engine was invented in 1861, but the first working engine was not built until 1876 by a man named Nikolaus A. Otto. Since then, four stroke engines are also known as Otto cycle engines, and they all work the same way.

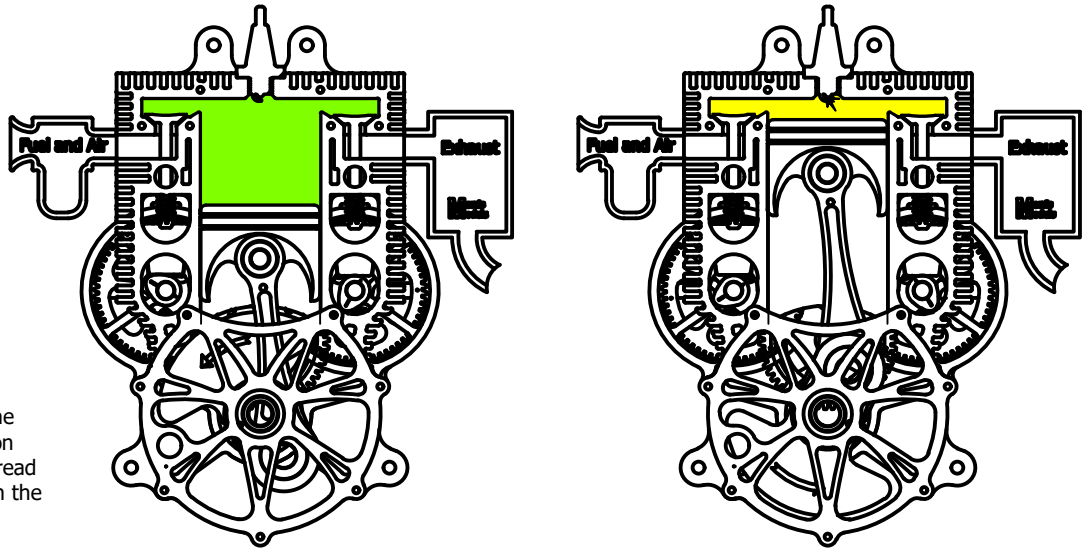
Intake:

The cam forces the intake valve open, and lets fuel and air flow in. At the same time, the crank pulls the piston down, which pulls the fuel and air into the cylinder.



Compression:

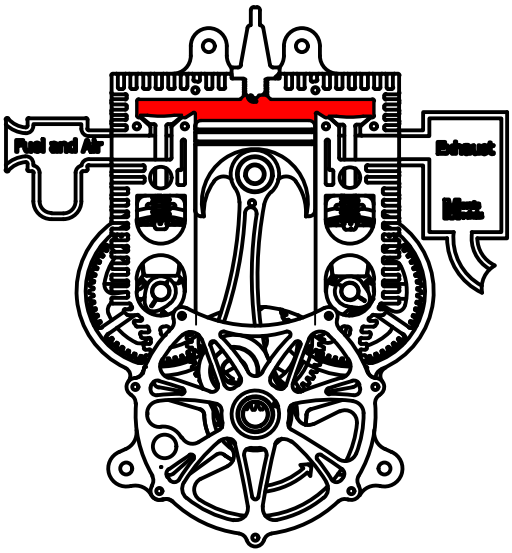
The cams allow the valves to shut. Nothing can enter or leave the cylinder. The crank forces the piston up, squeezing the fuel and air. The fuel and air gets hot, and is almost ready to catch fire. The spark plug makes a spark near the end of the compression stroke, and flames spread through the mixture in the cylinder.

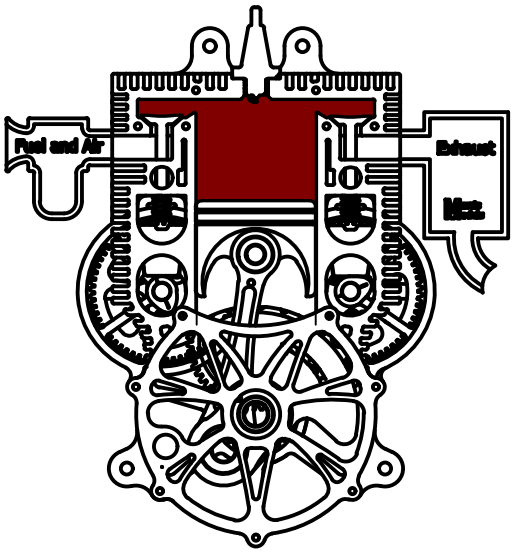


Background Information

Power:

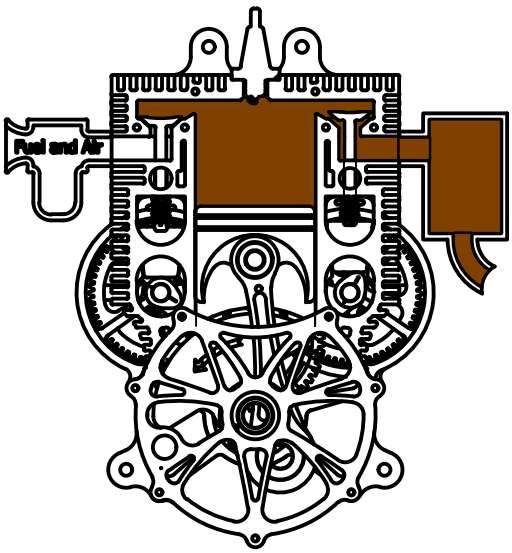
As the fuel and air burn, they get very hot, causing them to increase in pressure. The high pressure in the cylinder pushes downward on the piston, which turns the crank on the crankshaft. This is the only portion of the Otto cycle where power is produced.

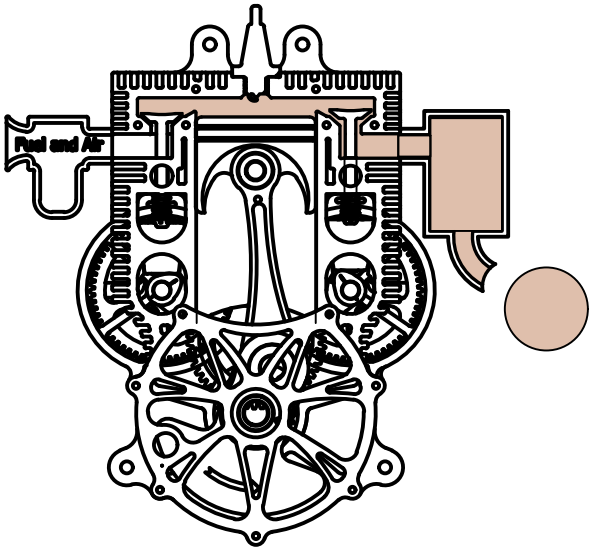




Exhaust:

The cam forces the exhaust valve to open. The crank forces the piston to move back upwards, pushing the already burned air and fuel (now called exhaust) out of the exhaust pipe. Most engines have a muffler to make this quieter.



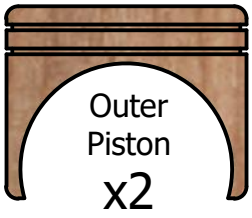


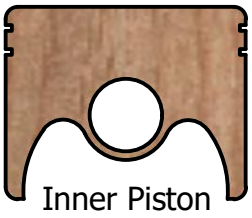
These four strokes happen over and over again, many times each second. Since the engine only makes power during one of the four strokes, a flywheel is used to keep it turning during the rest of the time. Most larger engines have more than one cylinder. Each cylinder goes through the same INTAKE - COMPRESSION - POWER - EXHAUST strokes. However, the engines are usually set so that each stroke happens at a different time in each cylinder. For eaxample, a four cylinder engine has one cylinder doing intake, one doing compression, one doing power, and one doing exhaust at any particular time. This lets it run much more smoothly.

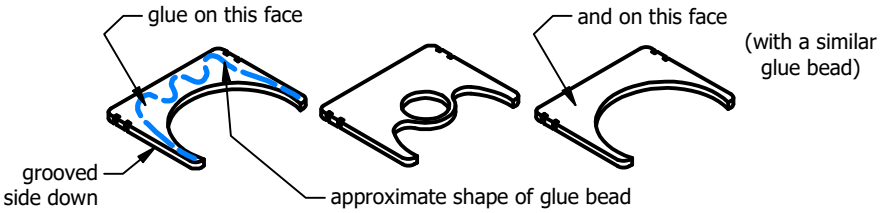
It is the differences in sizes, numbers, and shapes of cylinders and the valves that makes four stroke engines so interesting and different from each other. A single cyclinder engine like this one is simple to understand and cheap to build. Visit www.morrismodels.com to see models with different arrangements.

Step 1: The Piston

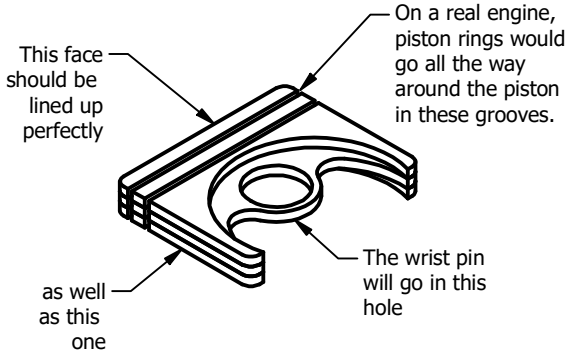
New Parts:





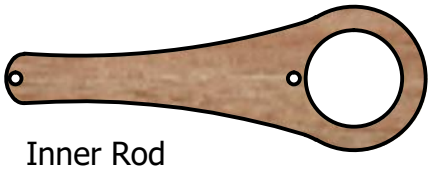


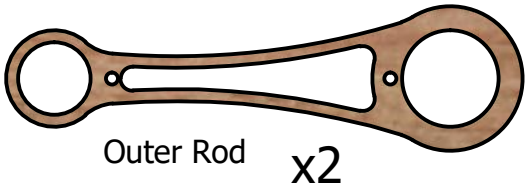
Set the two outer pistons grooved side down on your work table. Lay the inner piston between them. Lay out a light bead of glue on the ungrooved side of the two outer pistons. Set the inner piston on top of one of the outer piston, making sure that the edges line up perfectly. Turn the other outer piston over, and set it on top of the stack, again making sure that the edges align perfectly. Press them together firmly. If glue squeezes out of the sides, wipe it up with a damp paper towel. If a lot of glue squeezed out, use less glue on the next steps. If no glue squeezed out, use a little more glue in the future.

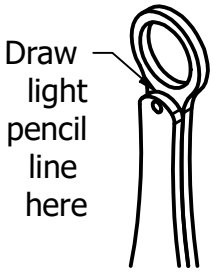


Step 2: The Connecting Rod

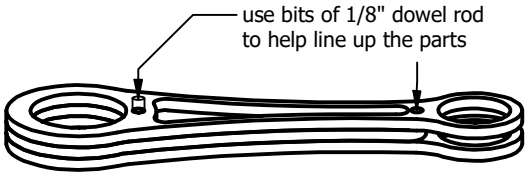
New Parts:

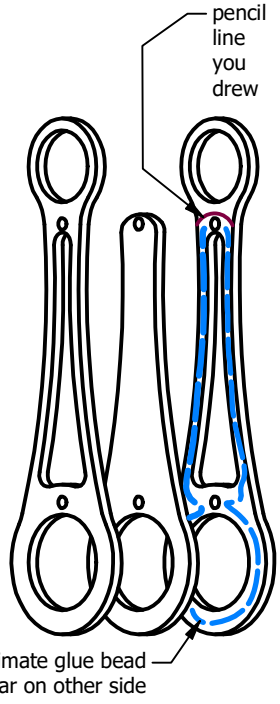






The outer rods will have one side that is better than the other. The not-so-good sides should face the inner rods. Temporarily set the inner rod over the outer rod as shown on the left, and draw a light pencil line on the outer rod where the inner rod ends. This will help you not to glue in the wrong place. Make a light glue bead on the outer rod, stopping before you reach the pencil line you drew. Assemble the connecting rod like you assembled the piston, making sure to line everything up. The small holes in the rod are to help line them up. You can use small pieces of 1/8" dowel rod in these holes to help with alignment. If you like, you can glue these pieces in place as part of the part. However, I personally choose to remove them, so I make sure they aren't glued in place.

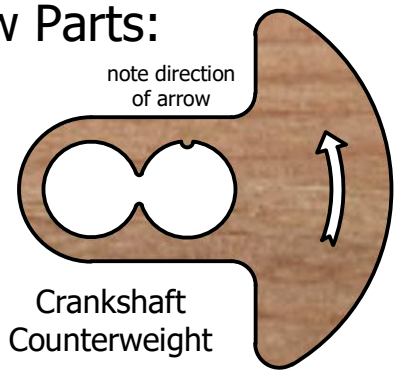


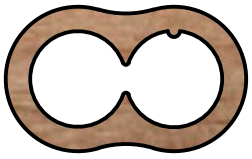


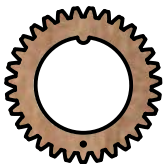
Step 3: The Crankshaft (Rear)

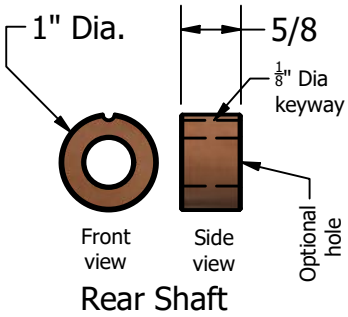
In most four stroke engines, the crank is usually all one part, and the rod comes apart to attach it. In our model, we make the crank in two parts, and glue it together over the rod. This is similar to how most two stroke engines go together in real life, and works well for plywood.

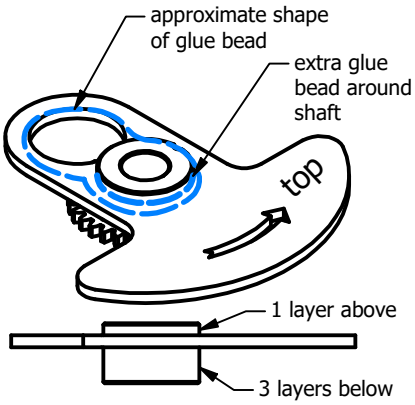
New Parts:



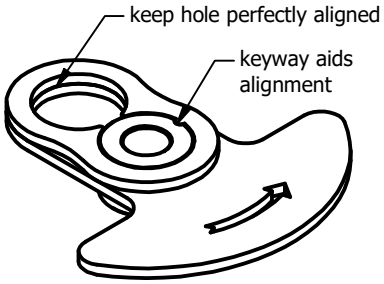


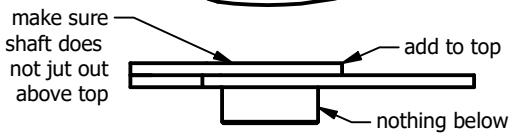




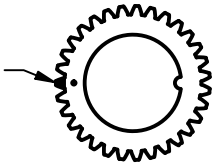


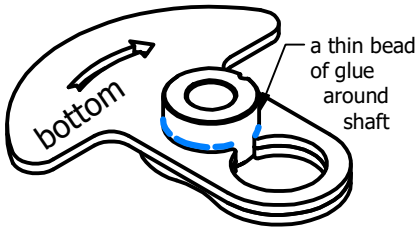
Position the rear shaft in the crankshaft counterweight part as shown. Make sure that the arrow is pointing the proper direction, and that the shaft is straight up and down. Add a medium bead of glue around the base of the shaft, and a light bead of glue where the crankshaft web will go. Push the crankshaft web down onto the top of the assembly. See figures to the left and right. Make sure that no glue squeezes out into the other hole in the assembly.
Also make sure that the top of the shaft is level with the top of the crankshaft web, or even slightly below it.



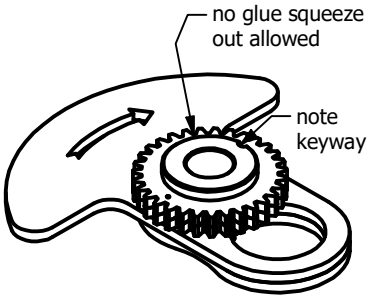


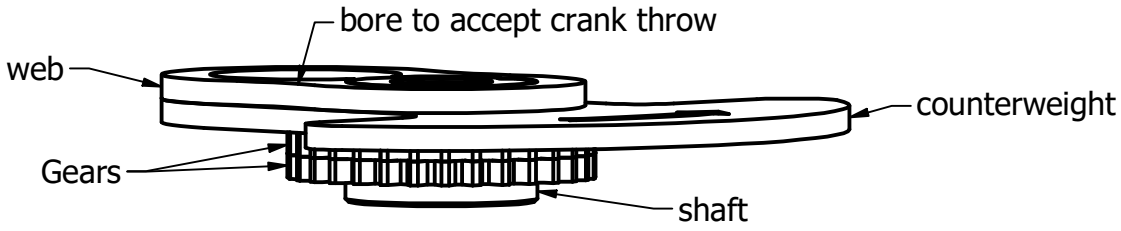
Use a pencil or marker to color both sides of the tooth next to the dot on the crank gears.





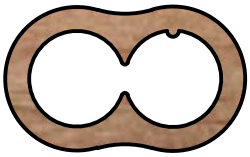
Turn the assembly over onto its back, and lay a thin bead of glue around the bottom of the shaft. Line up the keyway with the shaft, and slide the gear over the shaft. Bed it into the glue. Add another bead of glue, and bed the second gear into it - making sure they line up perfectly. Make sure that no glue squeezes out to interfere with the gear teeth. The shaft should stick out 1/8" beyond the edge of the gears.



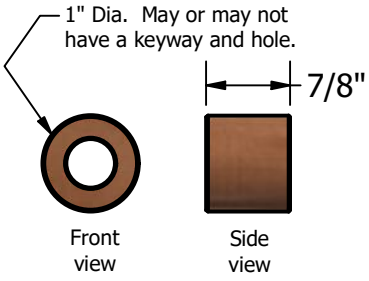


Step 4: The Crankshaft (Front)

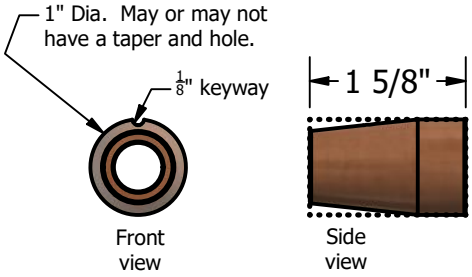
New Parts:



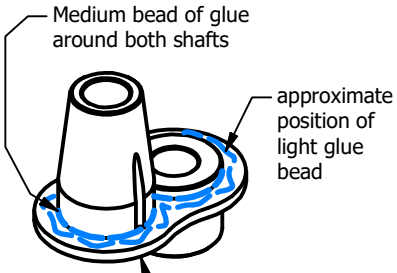
Crankshaft web x 2

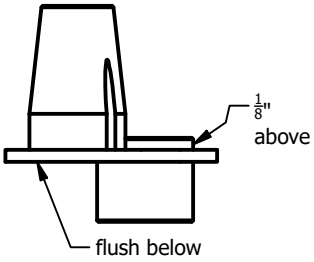


Crankshaft throw



Forward shaft (PTO)

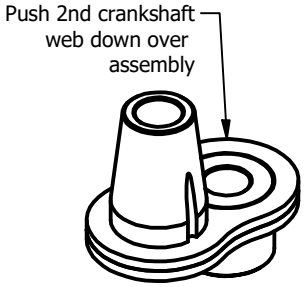


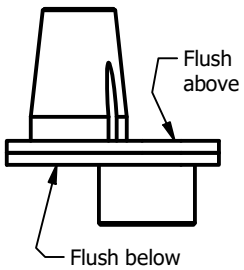


Not Shown but Important: This engine will spin much more freely if you sand away about 1/4 (1/32 inch, or 1/2 mm) of the thickness of one of the crankshaft webs before building this half of the crank.

There is no couter-weight on the forward half of the crankshaft on this model because it would make it hard to see the crank, so I have left it out. Otherwise, the assembly is similar. Take one of the crankshaft webs, and thread the forward shaft (sometimes called the Power Takeoff, or PTO shaft) over it, making sure to engage the keyway. It should end flush with the web. Slide the crank throw into the other side of the web, extending it 1/8" past the crank web. Make sure both shafts are straight in their sockets. Place a light bead of glue on the crank web and a medium bead of glue around each shaft, then add the second crank web. Make sure that both sides are now flush, and the shafts are straight. Allow the glue to dry.

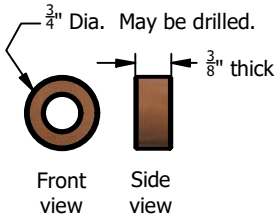
This is a good time to see why this is called a crankshaft. Notice that if you hold one shaft, you can spin the other shaft like it is a crank!





Step 5: Rotating Assembly (A)

New Part:



Wrist Pin

Previous Assemblies:

In this step, you will assemble the crank-shaft, the rod, and the piston. Together, these parts form what is often called the rotating assembly.

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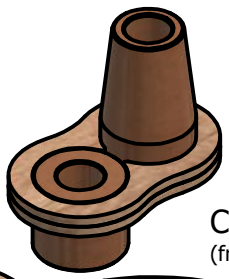
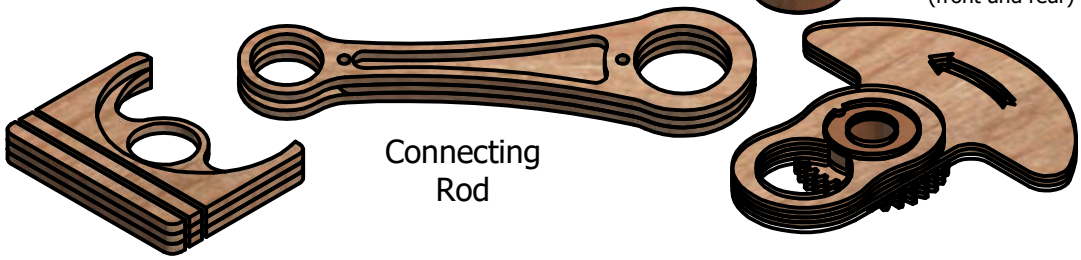


Crankshaft (front and rear)



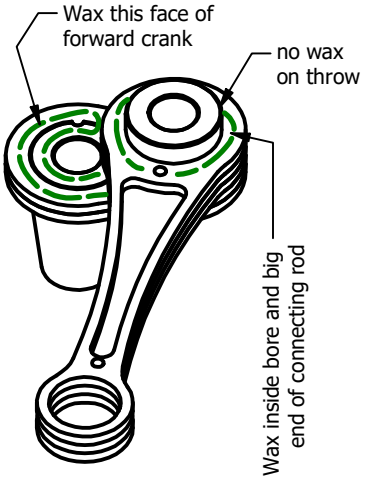
Connecting Rod

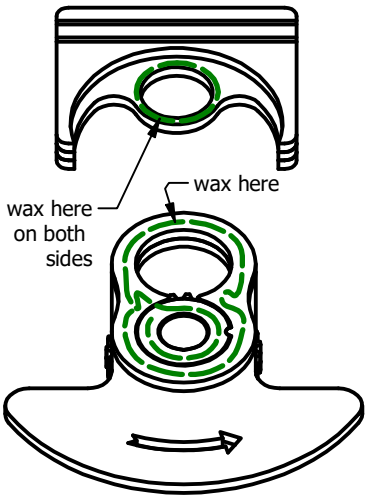
Piston

Step 5: Rotating Assembly (B)

Waxing Before Assembly

Before you put the rotating assembly together, decide which side of the piston and the connecting rod look the best. When you glue the assemblies together, the best sides should face forward. You should also decide if you are going to wax the assembly, which will make the engine turn a little easier. Wax the parts as shown below. If you don't want to use wax, just skip this part and the other waxing instructions later in the manual.

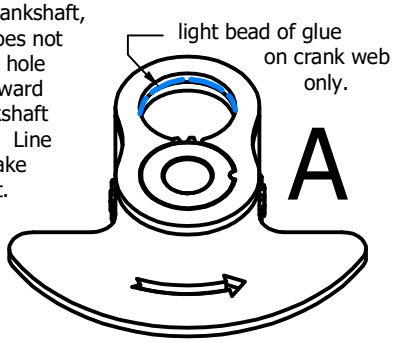


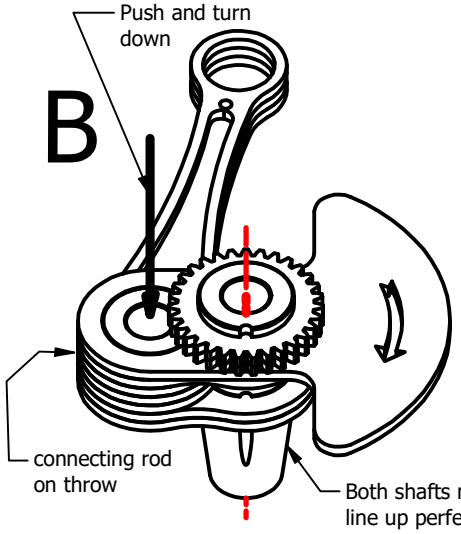


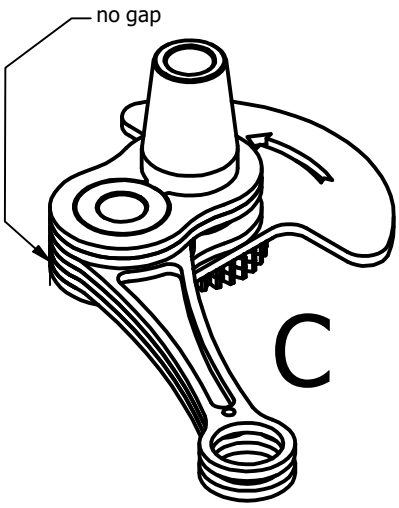
Gluing the Assembly

The two halves of the crankshaft need to be glued together over the connecting rod, which must spin freely on the crank throw. This means that the glue cannot be allowed to touch the connecting rod. Similarly, the wrist pin needs to be glued in its place in the connecting rod, but the piston must be able to pivot freely. This means that no glue can touch the layers of the piston. This means that this step must be done very carefully.

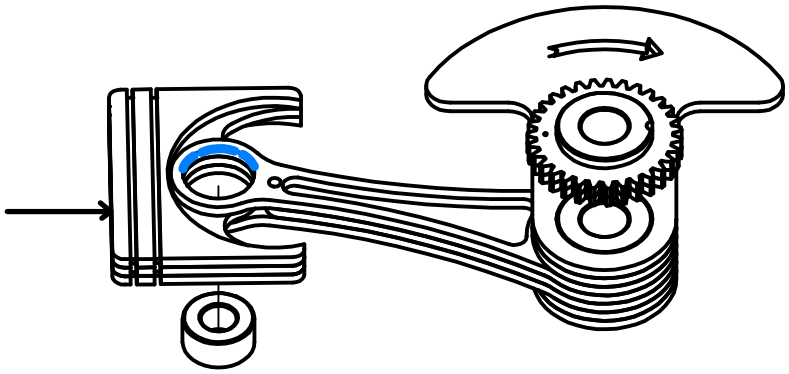
Lay a light bead of glue inside the bore of the rear crankshaft, near the inside surface. It is best if this glue bead does not touch the counterweight layer below. Slide the large hole int he connecting rod over the crank throw in the forward crankshaft, then gently twist and push the rear crankshaft down over the crank throw until the parts just touch. Line up the forward shaft with the rearward shaft, and make sure that the connecting rod can still turn on its shaft.







Slide the piston into the top of the connecting rod. Lay a thin bead of glue around the edge of the wrist pin bore, making sure you do not get any onto the second (piston) layer. Set the wrist pin in from the opposite side, so that the glue smears away from the piston.

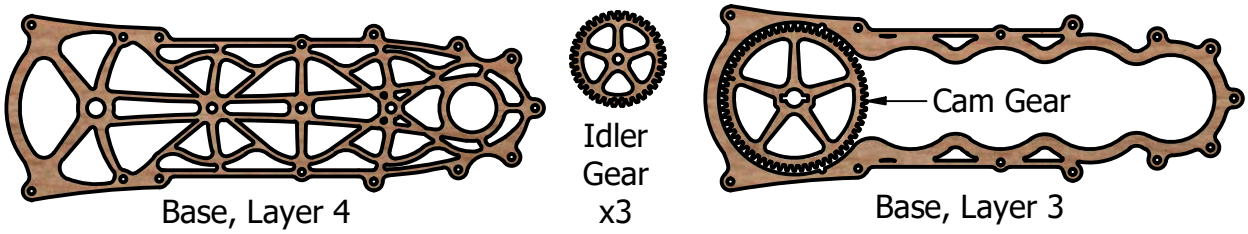


As the glue dries on the assembly, pivot the connecting rod and the piston every few minutes. This will ensure that any glue that accidentally got on the wrong parts can't lock the assembly.

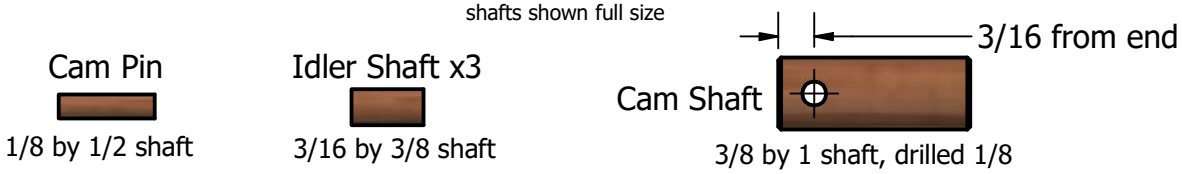
Step 6: Base and Gear Train

New Parts:

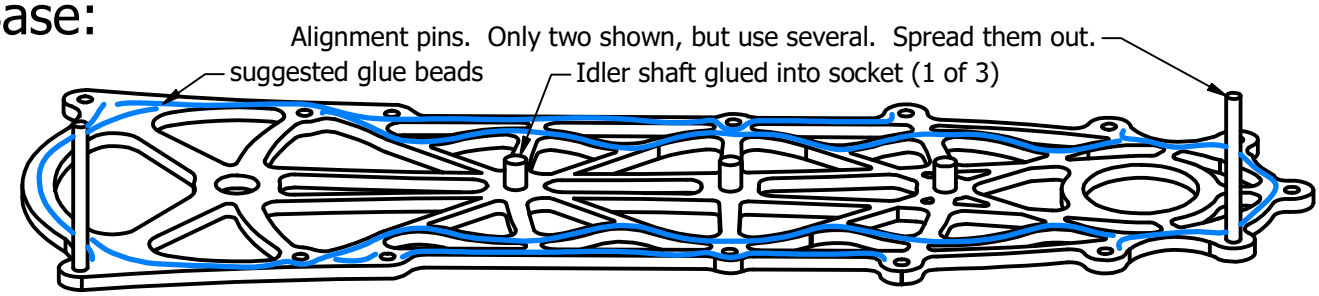
bases and gears shown 1/4" size



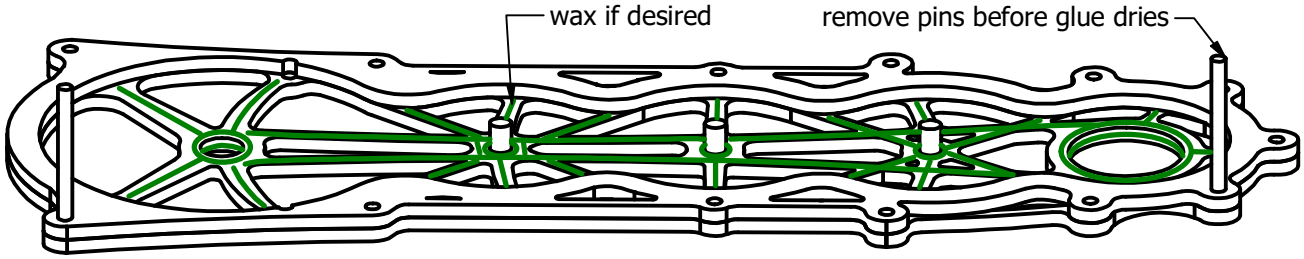
shafts shown full size



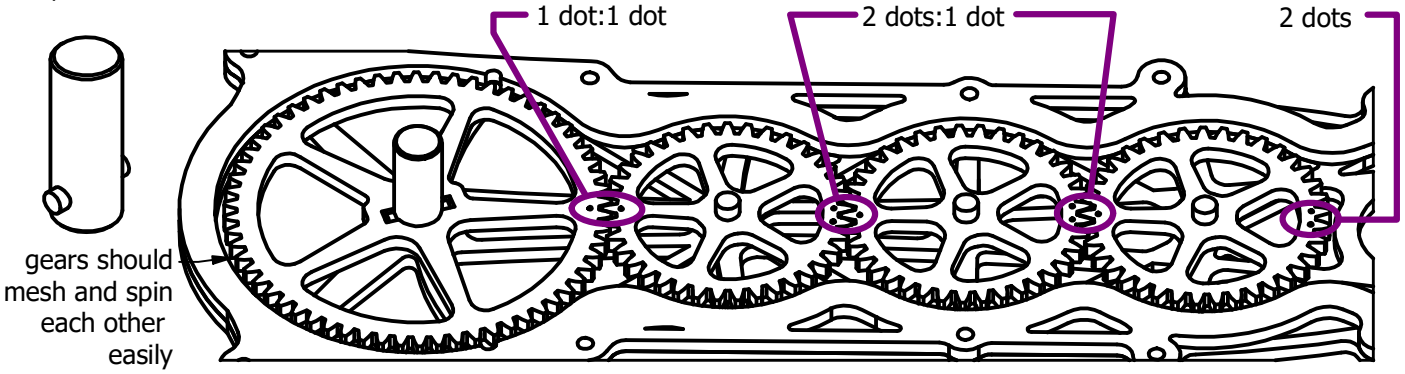
Base:



Set the best side of layer four face up on the table in front of you, and glue the three idler shafts into the idler holes as shown. Don't let any glue squeeze out around the shaft bases. Spread thin beads of glue on layer four as shown in the picture on the top. Insert several pieces of 1/8 inch dowel pins (alignment pins) into the holes around the edge to help you line up layer 3. Glue down layer three as shown below. If desired, wax as shown. Remove the alignment pins before the glue has a chance to dry.



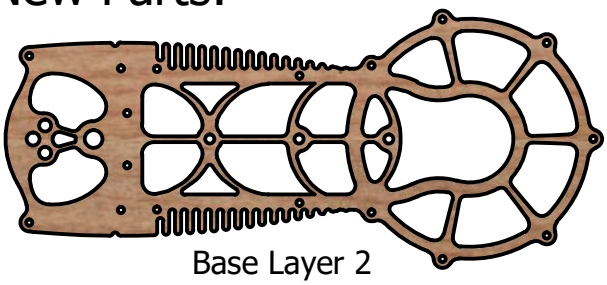
Cut the Cam Pin out of the 1/8 inch dowel stock provided. Cut it between 1/2 and 9/16 inch long. Insert the cam pin into the small hole on the cam shaft, and center it. This will lock the cam shaft to the cam gear. Place the cam gear, cam shaft, and idler gears onto the base assembly as shown, taking care to line up the timing marks as shown. Do not glue anything on this step.



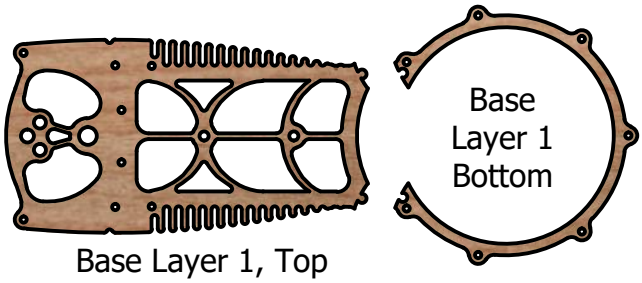
WARNING: The timing marks will get "lost" if you make many turns of the gears. Feel free to turn, but return them to the aligned position each time you move them until the engine is completely built.

Step 7: Complete Base

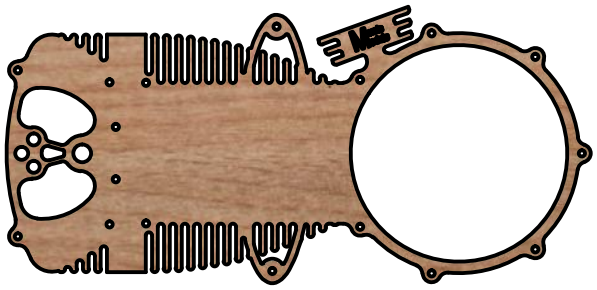
New Parts:



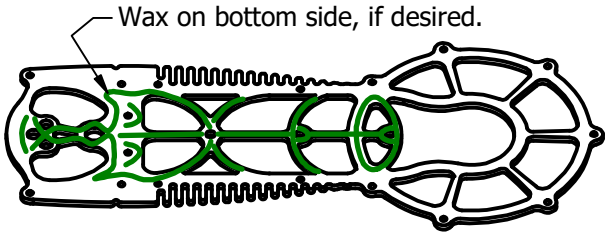
Base Layer 2



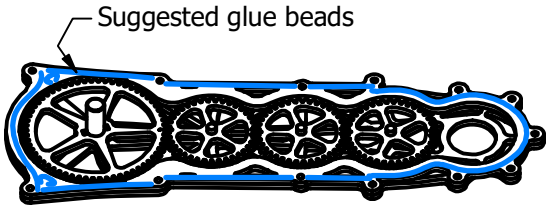
Base Layer 1, Top

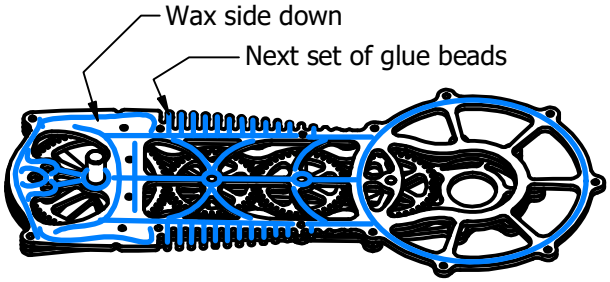


Cylinder Rear Wall Layer

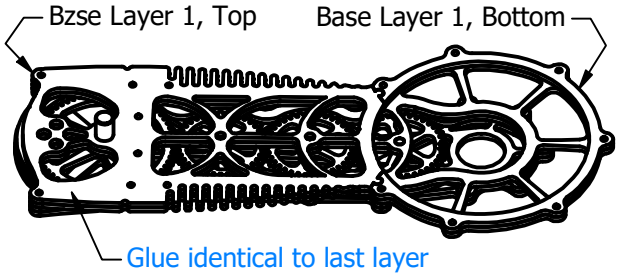


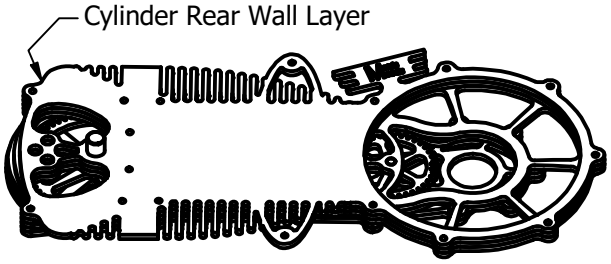
If waxing engine, wax the bottom side (worst side) of the base layer two piece. Then spread glue on the assembly you built in the last step as shown. Turn the base layer 2 piece over and place it wax side down over the wet glue, using alignment pins (not shown) to help you position it properly. Apply thin glue beads to the new layer as shown.





Continue adding layers without waxing. The Base Layer 1 is composed of two parts with "puzzle joints" between them. Glue them both in place using alignment pins to help you. The glue on top of this layer is identical to the last layer, so it is not shown. Glue the Cylinder Wall layer down over the top of the last layer, again using alignment pins. Allow the glue to dry before continuing.

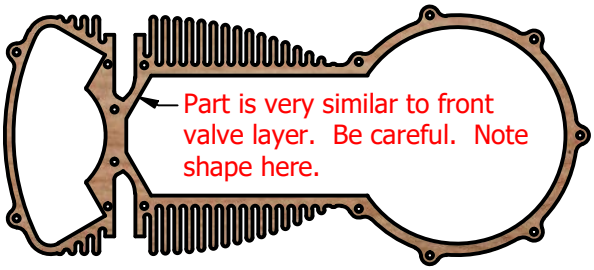




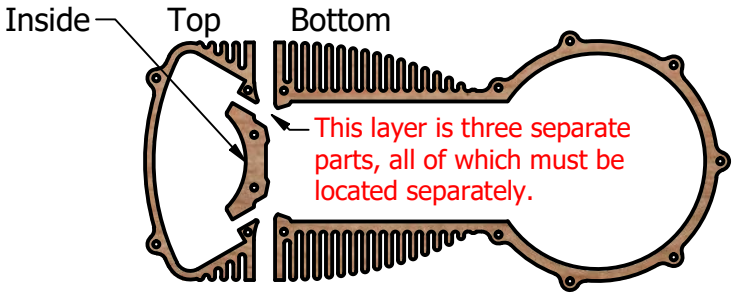
Step 8: Begin Cylinders

All parts shown 1/4 scale.

New Parts:

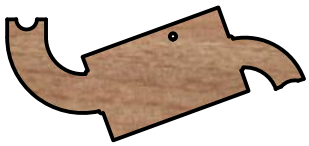


Rear Valve Layer

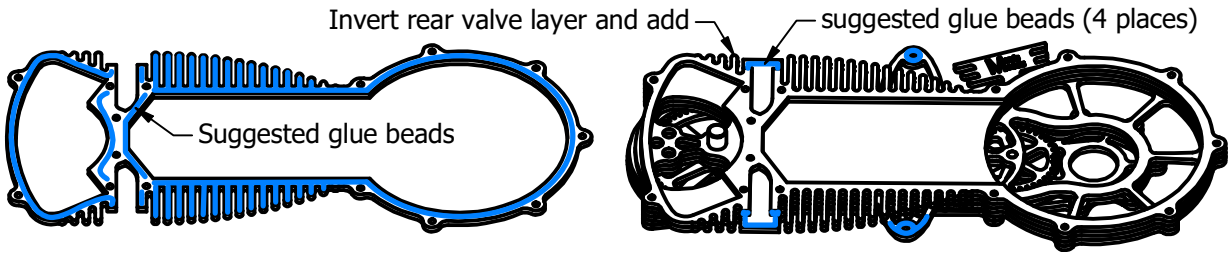


Mid Valve Layer

Intake, Back



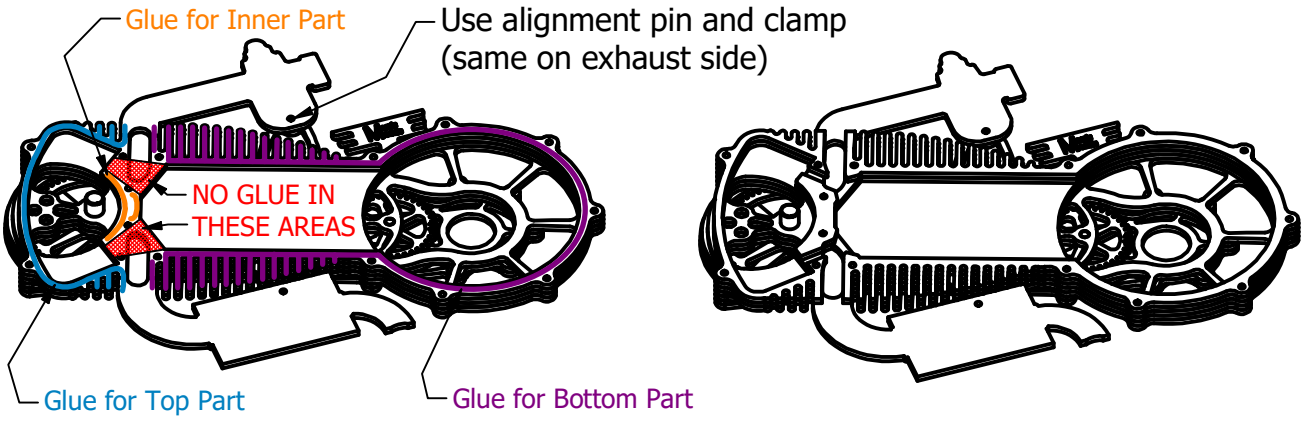
Exhaust, Back



Apply glue to the worst side of the rear valve layer as shown. Invert and glue on the growing model base.

Add glue beads to the two "wings" and the two intake and exhaust ports on the previous layer as show, and glue the backs of the intake and exhaust down. Use alignment pins for everything, including the intake and exhaust if possible. If you have access to appropriate clamps, clamp the joints between the intake and exhaust layers and the "wings" where the alignment pins go. This will make them significantly stronger.

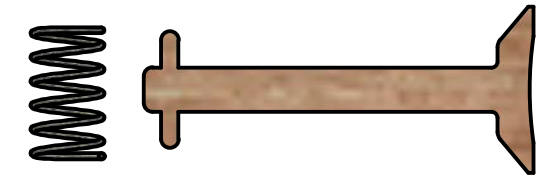
Finally, add the glue beads shown for the mid layer and glue the parts down one at a time. Begin with the top part (shown in blue), then the inner part (shown in orange), and finally for the bottom part (shown in purple). Use alignment pins as you secure the parts down. Also DO NOT LET ANY GLUE get into the red areas shown.



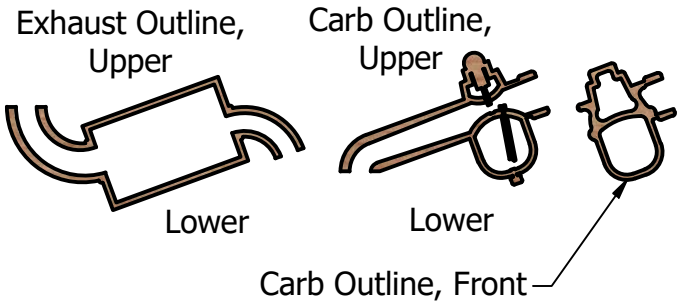
Step 9: Prepare Valves

Springs and Valves shown full sized. Other parts shown 1/4 scale.

New Parts:

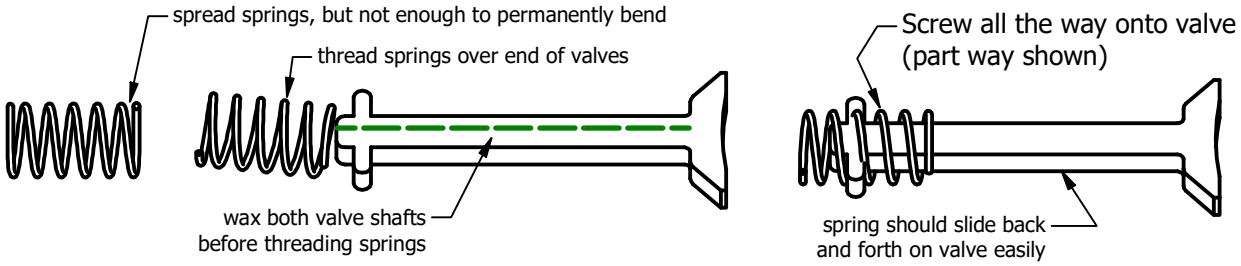


Spring x2 Valve x2



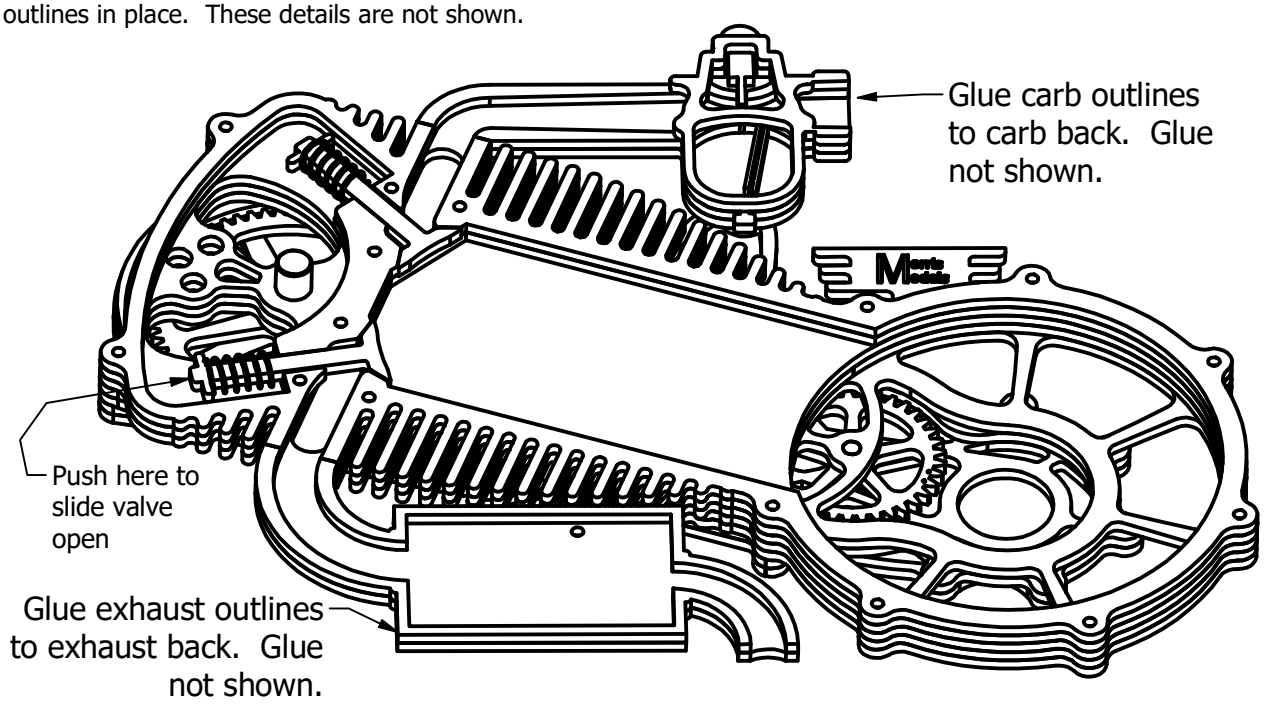
Prepare Valves and Springs:

The valves MUST be free to slide up and down inside their seats. This means that they must be thinner than the layer they are set in. You will need to sand about 1/64 inch (0.5 mm) off the face of each valve. This must be done carefully and thoroughly. After this, you may wax the valves if desired.



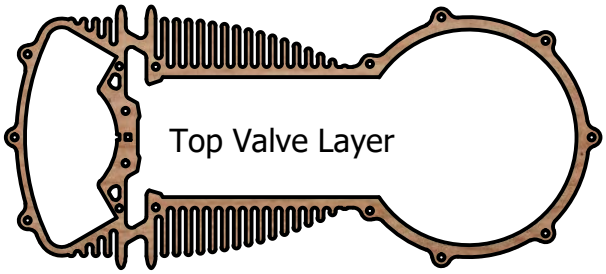
Carefully spread the end of the spring, and screw it down over the little knobs on the end of the valve. Screw it on all the way, and make sure it can slide back and forth on the valve. Do not permanently bend the spring. Gently compress the spring, and insert the valve into the model as shown below. Test to make sure you can push the valve down towards the bottom of the engine into the open position. It should move easily and the spring should snap it shut as soon as you release it. If the spring is too short, gently pull it enough to permanently make it longer. If the valve sticks, take it out and sand away any area that sticks. Rewax and try again.

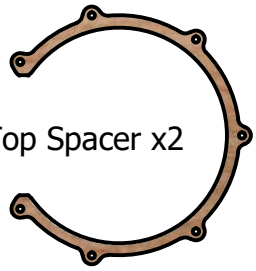
Once the valves are set, glue the carb and exhaust outlines in place. These details are not shown.

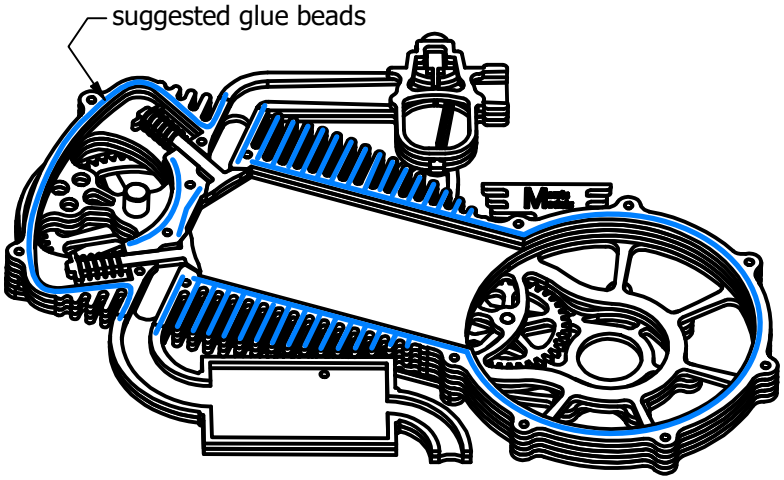


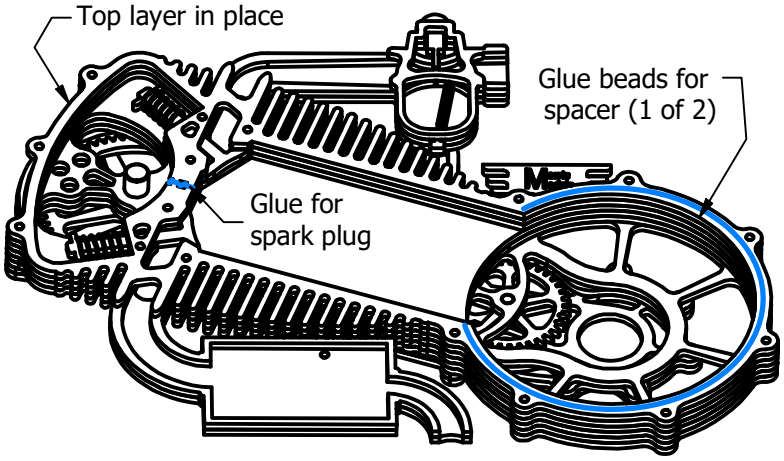
Step 10: Finish Case

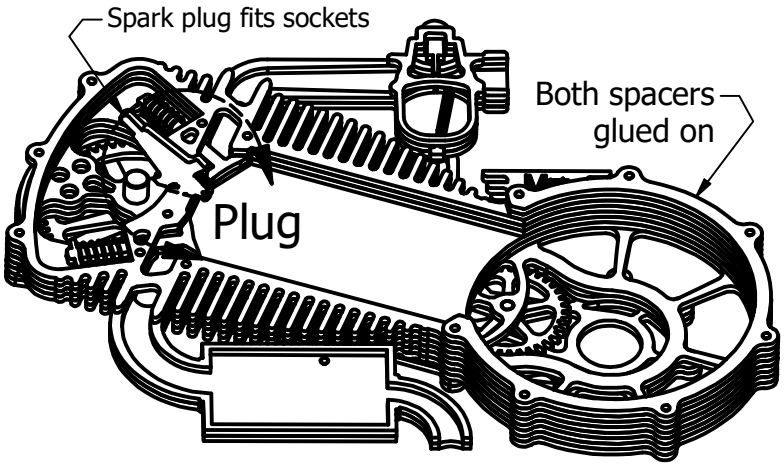
New Parts:







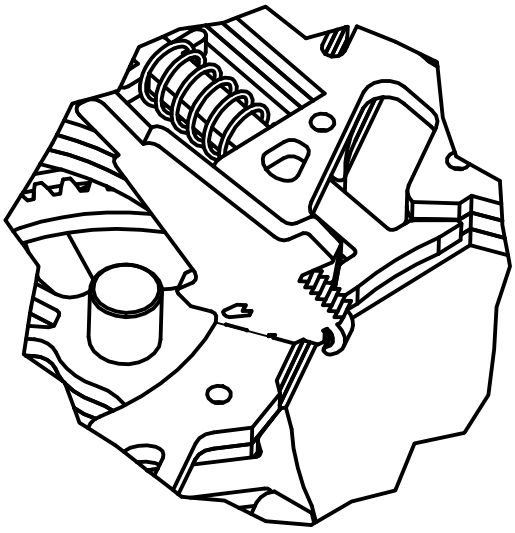




Finish the case by spreading glue on the assembly you have been working on as shown, and gluing down the top valve layer. Make certain that no glue gets near the valves, as they must be free to slide up and down in their sockets. Use alignment pins to help keep everything lined up.

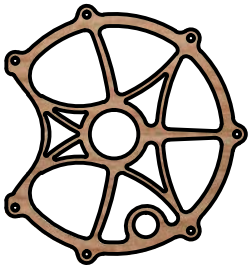
After gluing on the top layer, add the spark plug. This fits into the sockets between the valves. Dry fit the plug to make sure you know how it fits, then glue it into place. See the detailed view on the bottom right.

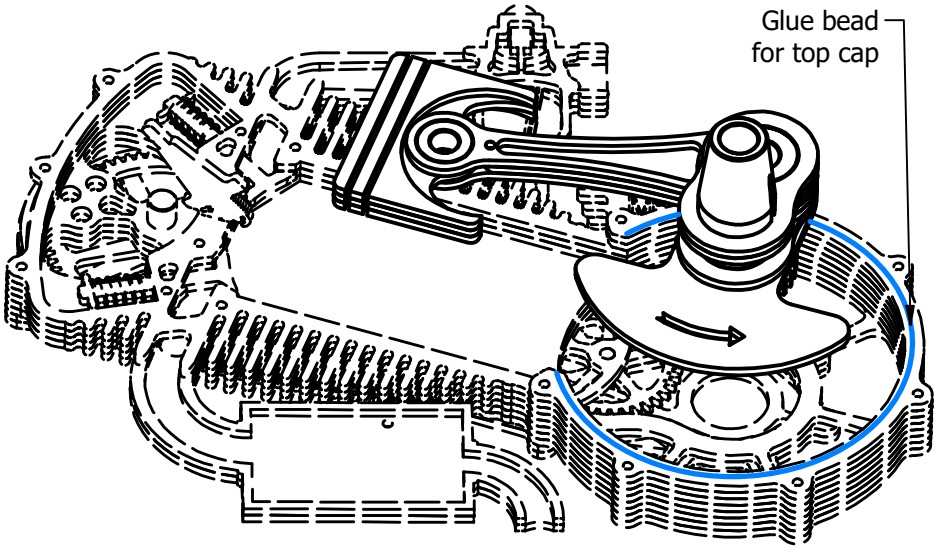
Next, glue the two top spacers in place over the crank case. One bead of glue is shown. Use alignment pins and glue the first spacer down. Add an identical bead of glue and glue down the second spacer. Remove the alignment pins and allow the glue to dry.



Step 11: Fit Rotating Assembly

New Part: Top Cap

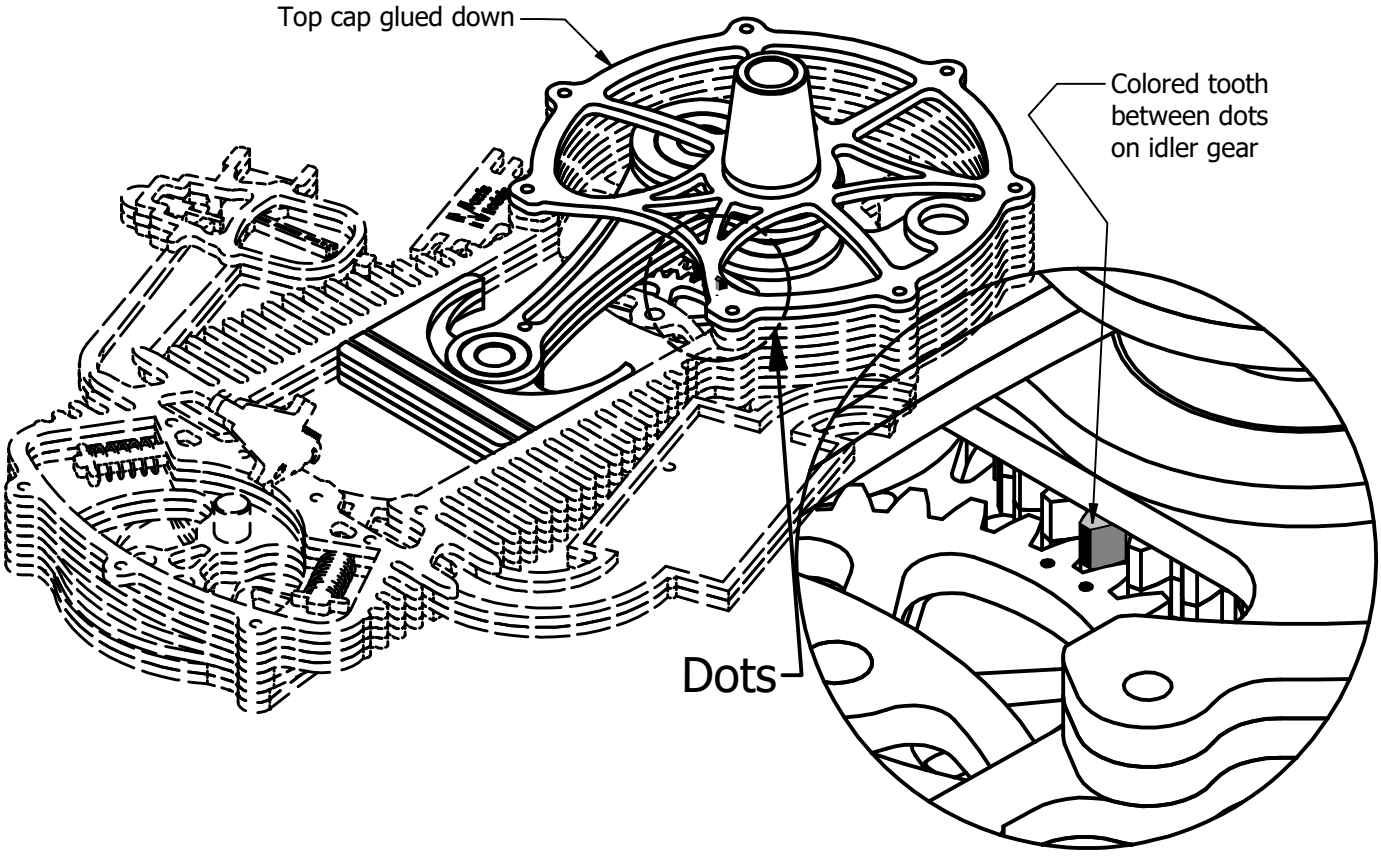




Wax the rotating assembly if desired. Include the bottom and sides of the piston, the bottom of the crank, the tops of the crank, and the base of the tapered shaft where it will go through the hole in the cap.

Gently align the rotating assembly as shown, and set it into the case. The gear on the bottom of the crank should engage with the idler gear already in the model. Remember the tooth I asked you to color? That tooth should fit between the idler teeth marked with dots as shown in the detail view on the lower right.

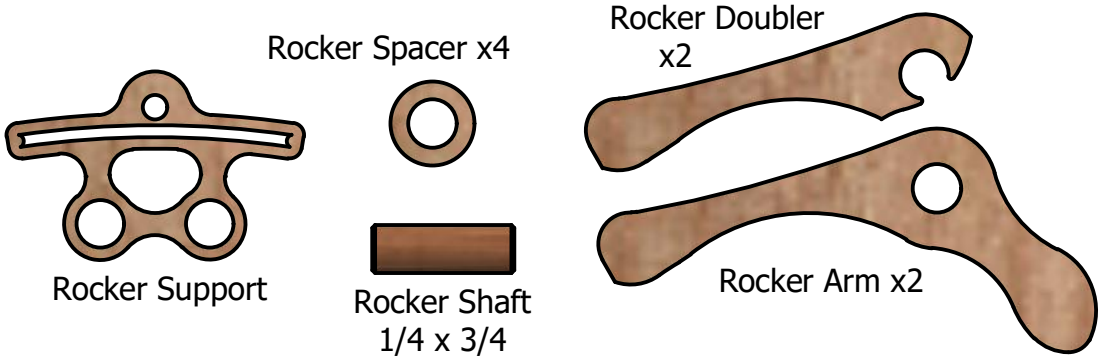
Glue the top cap down over the top of the crankshaft, locking it in place. Use alignment pins. Allow the glue to dry.



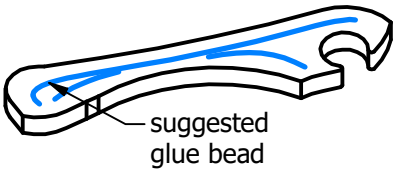
Step 12: Rockers

All parts shown full scale.

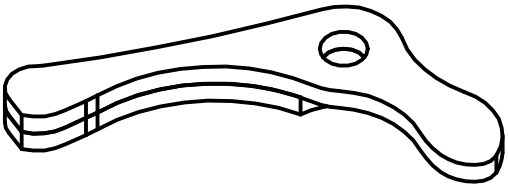
New Parts:



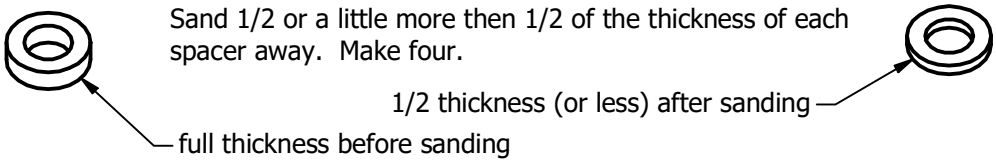
Assemble Rockers (x2):



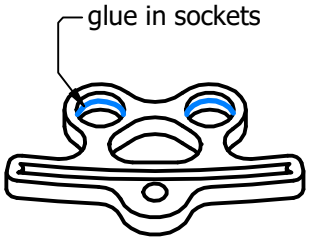
Spread a thin bead of glue on the rocker doubler as shown. Glue the rocker down over the doubler. Make sure that the parts are in the same position as shown. MAKE TWO THE EXACT SAME.



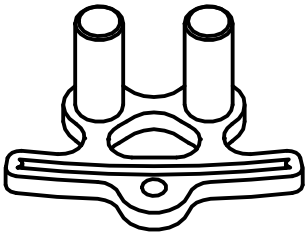
Prepare Spacers (x4):



Build Rocker Support Clip:

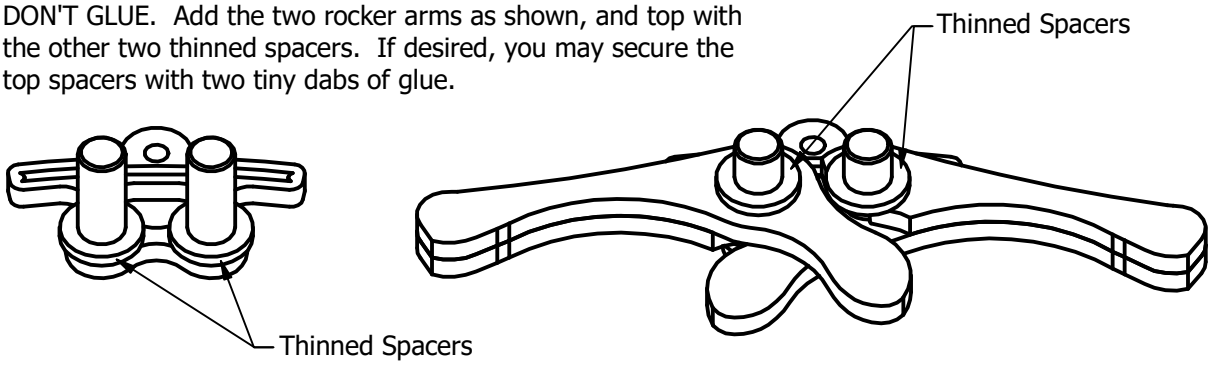


Put a small amount of glue into the two sockets on the rocker support. Glue the two shafts into the holes, with the backs of the shaft even with the back of the rocker support. Make sure the shafts are straight. Allow time to dry.



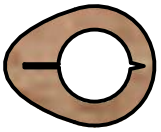
Place Parts on Clip:

Set the clip in front of you, and add two of the thinned spacers. DON'T GLUE. Add the two rocker arms as shown, and top with the other two thinned spacers. If desired, you may secure the top spacers with two tiny dabs of glue.



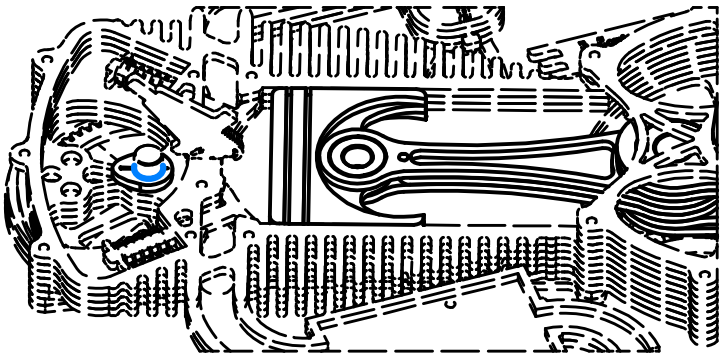
Last Step: Finish Model

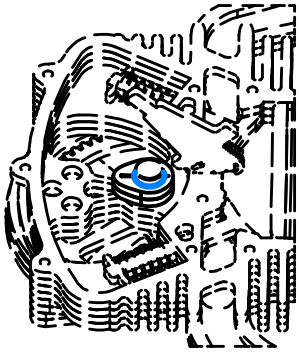
New Parts:

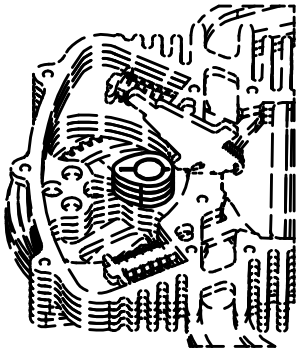


Cam
x3

Wax the ends of
the rockers if desired.

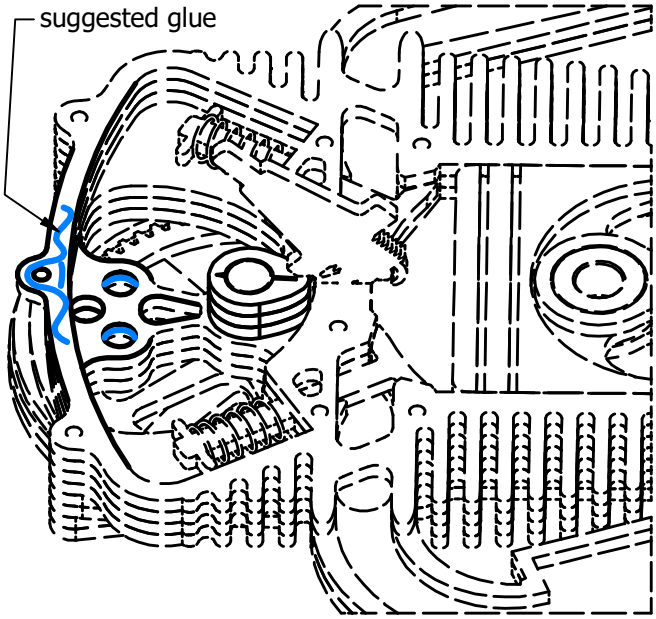


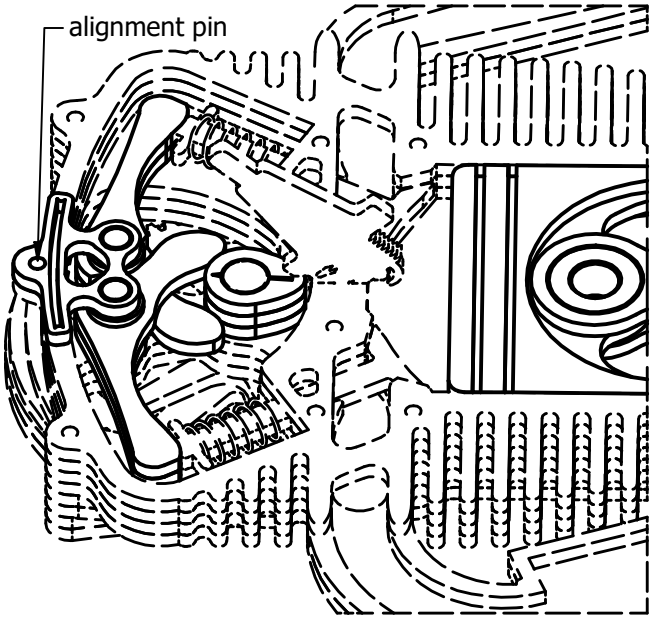




Set the Cams:

Turn the crankshaft until the piston reaches the exact top of the stroke. Set one of the cams over the cam shaft, pointing exactly towards the top of the engine. Add a thin bead of glue around the edge of the shaft as shown. Add another cam, manually lining them up. Add another bead of glue and then add the third cam. Make sure all the cams are lined up, that the cam is facing up, and the piston is facing up. Let the glue dry.





Set the Rockers:

Turn the crankshaft one full revolution until the piston returns to the top of its stroke. This should bring the cam into the full downward position. Place thin beads of glue as shown, or on the back side of the rocker clip if preferred. Gently work the rocker clip down into position with the two shafts engaging in the holes shown. Use an alignment pin in the top socket to help line up the parts while the glue dries. It may prove easier to hold the engine upside down over your head while you set the rocker clip into position, as this will keep the rockers and spacers from falling off. In any case, set the clip and allow the glue to dry before turning the now complete engine.

We hope you have enjoyed building this model and that you continue to enjoy the model as you show it to other people. If you do, please consider our other engine models. Thanks for choosing Morris Models.