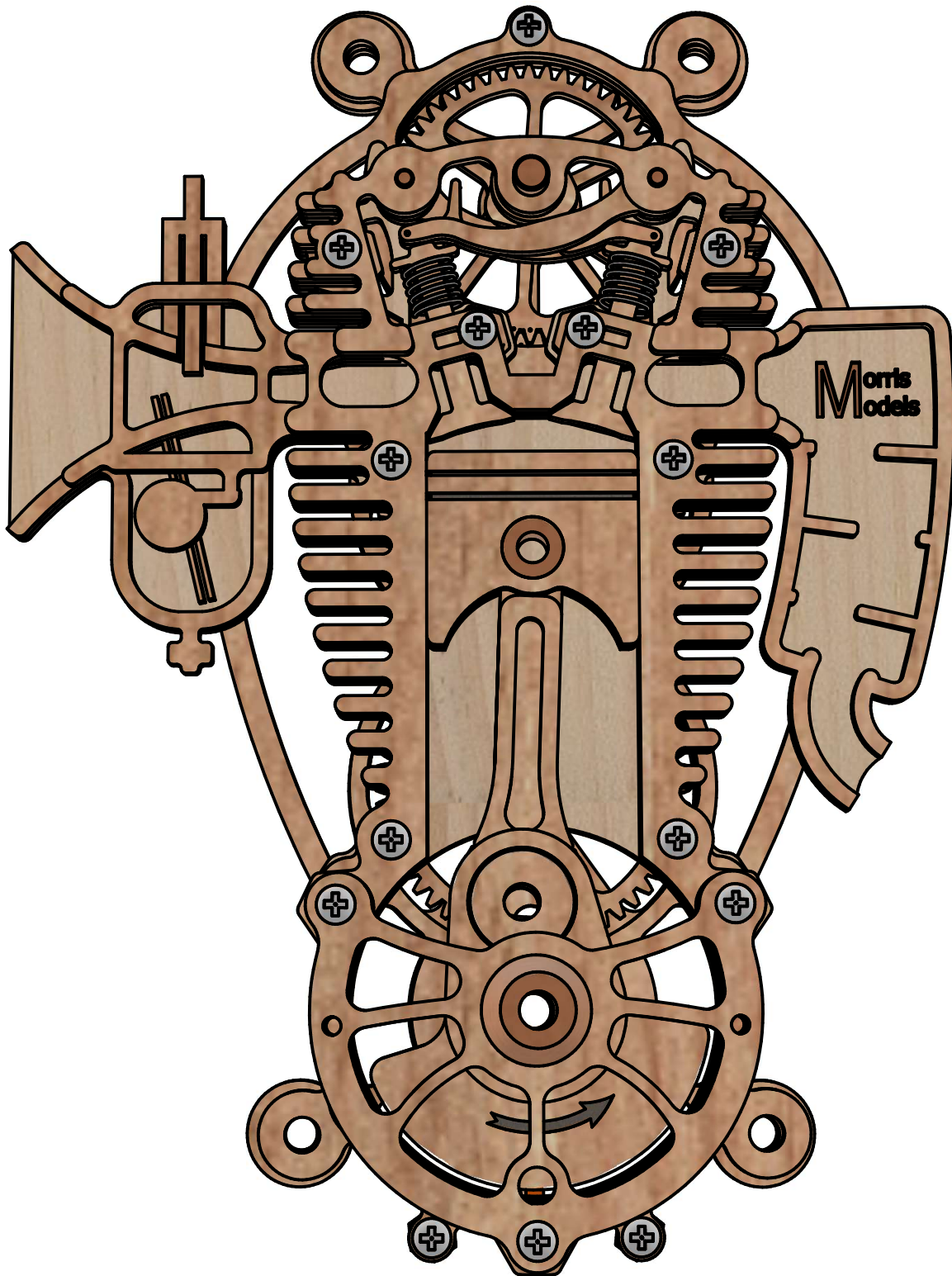


Morris Models 4-Stroke Mini Cutaway Engine



www.MorrisModels.com

This 4-Stroke mini model engine is designed to demonstrate how engines work. Building this model will teach the names of the parts in an engine as well as how the parts move and work.

Model Outlines and Instructions Copyright (C) 2024 Don Morris. Designed, printed, and cut in the USA from raw goods with many origins.

Before you Begin

Warning: This kit contains many small parts. Keep out of the reach of small children. Knives cut, glue sticks, and things can get caught in your nose. Use only under competent adult supervision. You have been warned!

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 none of the parts are missing. 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 can 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 maple or birch wood. These form most of the shafts. These also should be sanded for splinters. If you have access to power tools, they will look a little more realistic if you bevel or round the front of each shaft. 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. Most of the plywood parts have 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 dowel pins into the layers to help line them 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 before or 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 engines use oil to keep them sliding smoothly. This wooden engine model would be ruined with oil. Some 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. I have also assembled quite a few of these engines without any wax. This also works. Just don't use wax on your engine before gluing the parts together, as this will interfere with the glue. It will also interfere with staining or painting the parts, so plan ahead.

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. We try to shoot videos for each engine as time allows. If a video for this engine is available, it will be posted on the web site www.morrismodels.com. Our videos show the same steps that are in the manual. Use a video if you prefer, or use the video to view any steps where you have trouble understanding the manual.

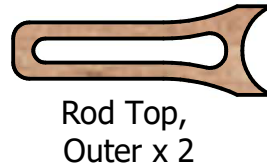
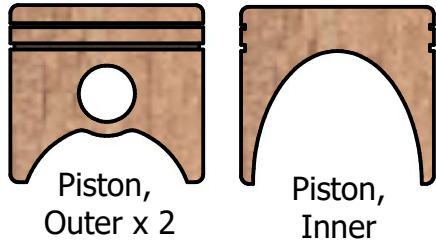
If you have access to Facebook, you can also interact with us there. We have a group that is intended to share tips, tricks, and questions with other builders. This group is entitled "Laser Cut Model Engines and Art," and we would appreciate it if you check it out and post pictures of your completed builds.

We hope you enjoy building this kit. If you do, you may want to consider building some of the other model kits. We have several more models available on the web site, and we add another model every few months - so check back.

Section 1: Rotating Assembly

New Parts:

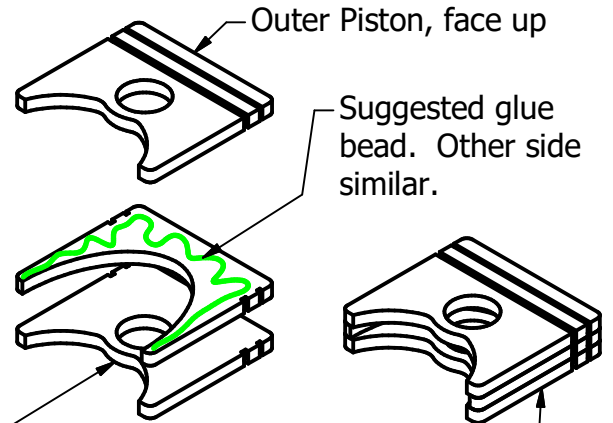
These parts shown 2/3 scale



GLUE AS LIGHTLY AS POSSIBLE. THE MOST COMMON PROBLEM IS TOO MUCH GLUE!

Piston:

Assemble the piston from the three piston parts. Spread a thin bead of glue as shown on the **inner piston**, and glue it to the flat side of the **outer piston**. Spread a similar bead of glue on the other inner piston side, and glue the other outer piston to it. Make sure that the edges are lined up perfectly. If glue squeezes out of the edges, clean up the glue while it is still wet, and use less glue in the future. Set the piston aside to dry.



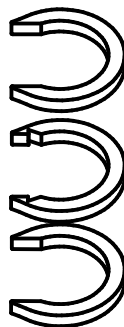
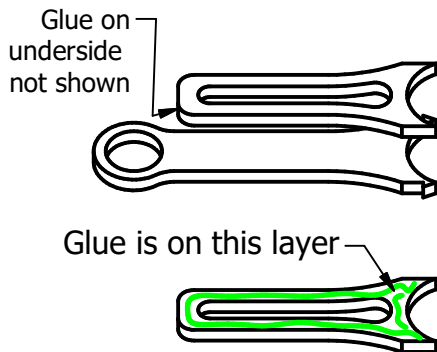
Outer Piston, engraved rings facing down

Outside edges lined up on top and both sides - no glue squeeze-out allowed

Rod (Top and Bottom):

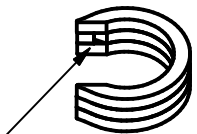
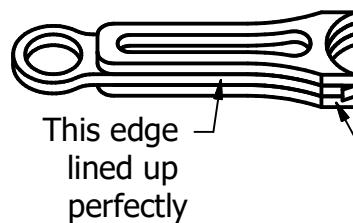
The top and bottom rod are assembled almost identically to the piston. Follow the diagrams, making the three layer sandwich. Be especially careful to line up the circular edges at the bottom of the upper rod and on the lower rod. Clean up any glue squeeze-out, and set aside to dry.

The inside of the circle (both top and bottom) must be lined up correctly!



Completed Upper Rod

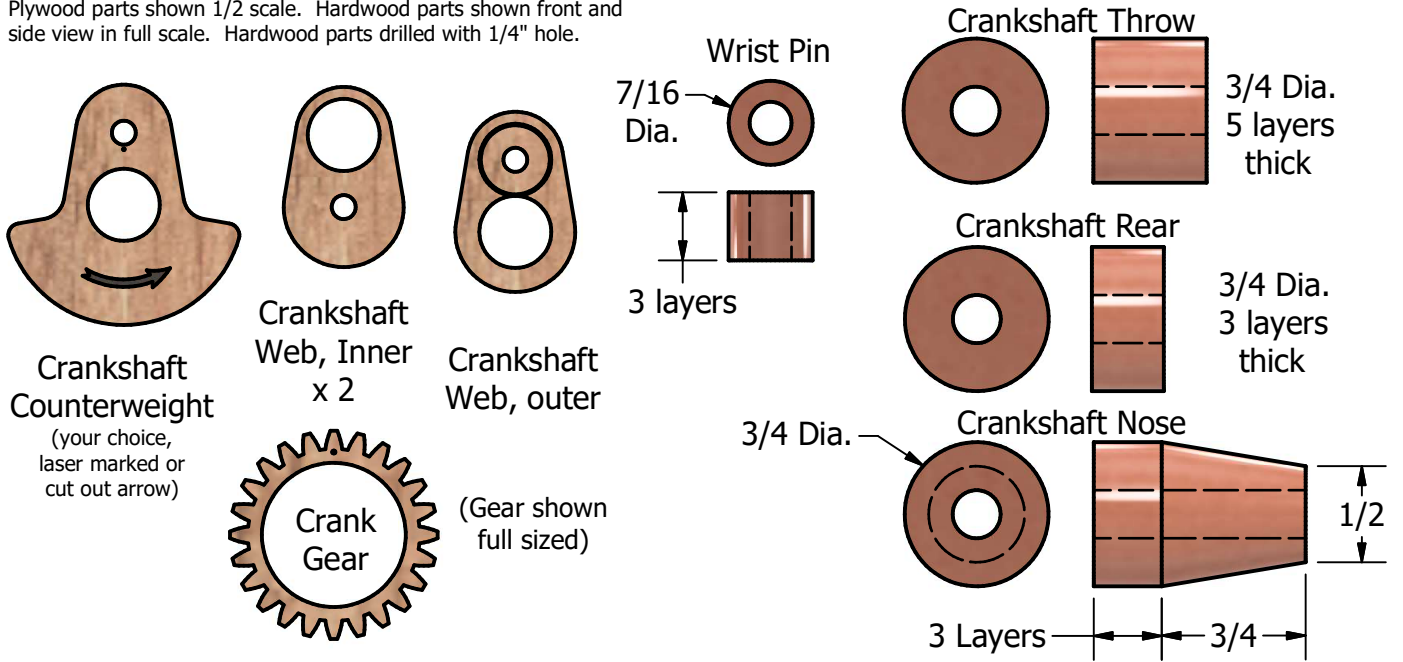
Completed Lower Rod



No glue allowed in the notch or on the face of the rod where these will join.

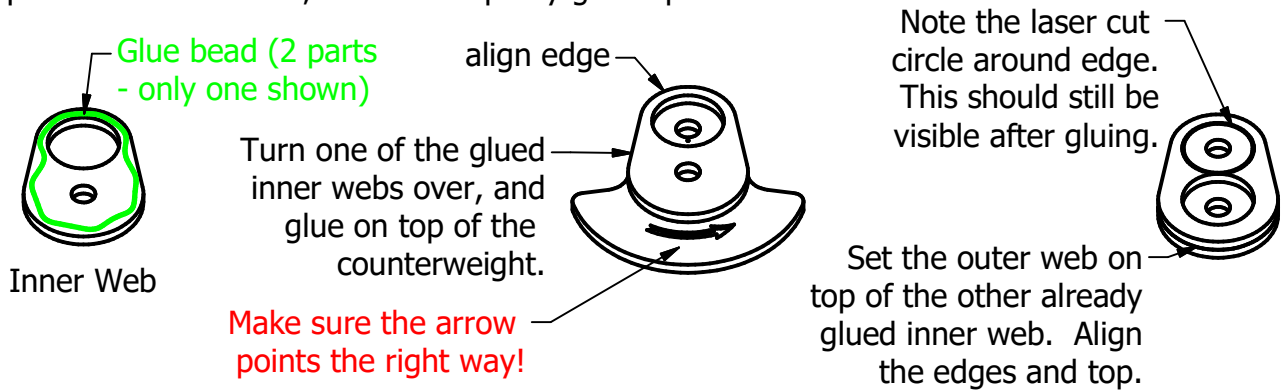
New Parts:

Plywood parts shown 1/2 scale. Hardwood parts shown front and side view in full scale. Hardwood parts drilled with 1/4" hole.

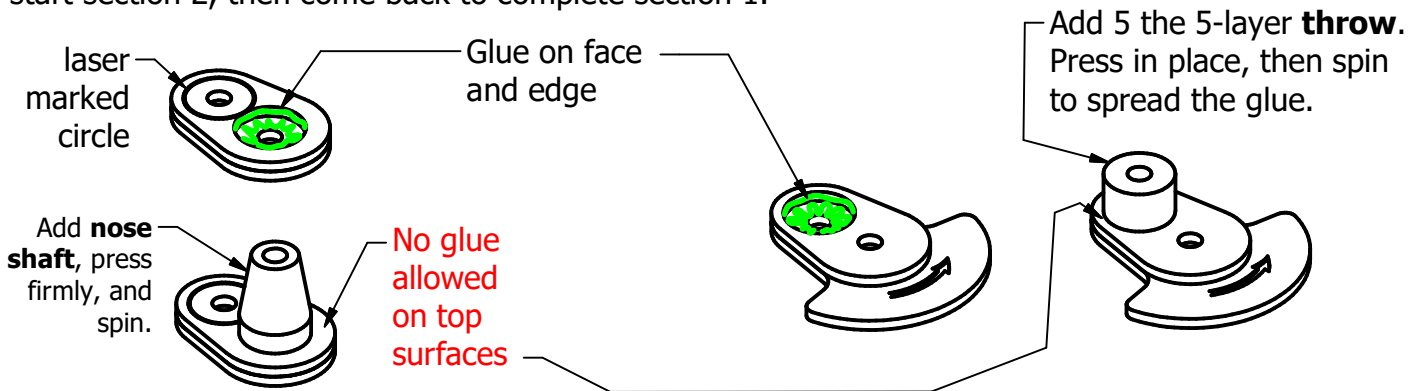


Crankshaft:

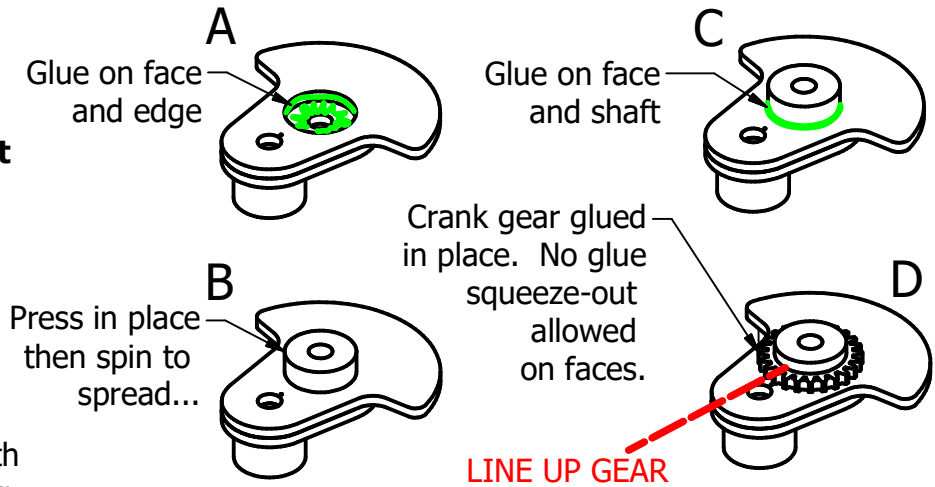
1) Spread a thin bead of glue as shown on the two **crankshaft inner webs**. Glue one to the top of the **counterweight** and one to the bottom of the **outer web** as shown. Be very careful to line up the holes and sides, and clean up any glue squeeze-out.



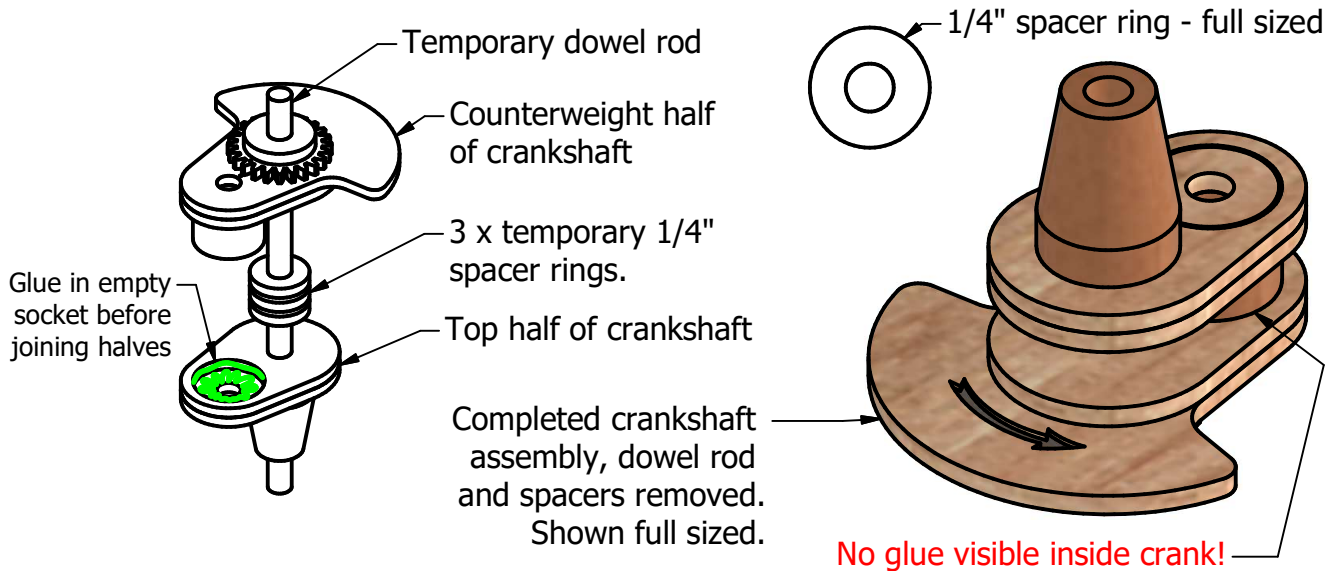
2) Apply glue to the inside of the circles as shown, then glue the shafts in place. Use a little more glue than used on the plywood parts, but still not enough that it squeezes out of the joint. Again, if any does squeeze out, clean it up. Set these parts aside to dry. If desired, you can start section 2, then come back to complete section 1.



3) Turn the crankshaft counterweight assembly you just built over, and add the 3-layer **rear shaft** to the empty space for it. Make a light bead of glue around the base of the shaft, and then place the **gear** over the shaft into the ring of glue. Twist the gear until the dot on the gear tooth lines up with the tiny dot on the counterweight. This assembly should be set aside to dry before continuing with step 4. Again, you may work ahead in the next sections while waiting for the glue to dry if you like.

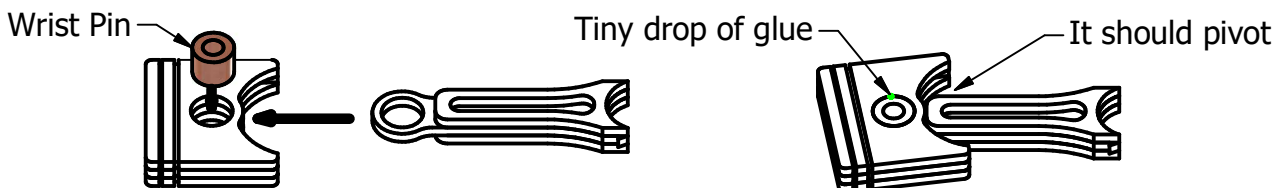


4) Turn the front half of the crankshaft over, and add glue to the remaining empty socket. Press the crankshaft throw from the other half of the crankshaft into the socket, again pressing and twisting slightly to spread the glue. While the glue is still wet, line up both sides of the crankshaft by threading a 1/4" diameter dowel rod through the nose shaft, through three separate 1/4" rings, and then through the rear shaft. Make sure not to glue the rings or the dowel in place. Remove them after the glue has dried.



Assemble:

Carefully fit the upper (circle) end of the rod into the piston. Line up the hole in the rod and the hole in the piston. Gently press the **wrist pin** into the hole. The rod should be able to pivot back and forth (like your wrist) without coming detached. Place a small drop of glue over the edge of the wrist pin and piston to keep the wrist pin from falling out.

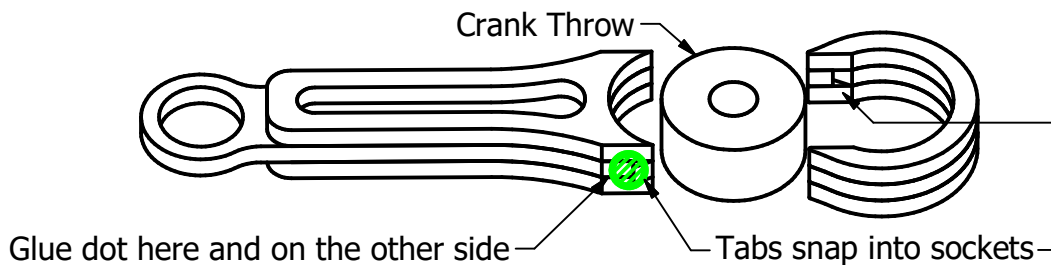


Assemble (continued)

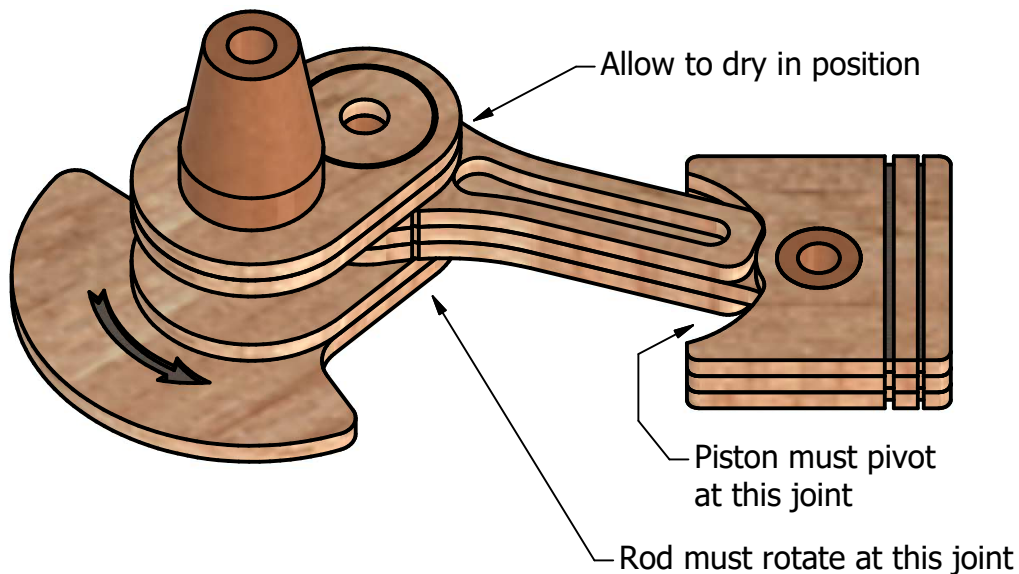
After the glue is dry on the parts of the crankshaft, rod, and piston, check the fit of the rod in the crankshaft. Insert the half circle end of the upper rod between the crank webs until it covers half the crank throw. The fit should not be tight. Check the fit of the lower rod there as well. If the fit is tight on either part, sand the upper and lower faces of the rod until it fits without sticking. Once all the parts fit individually, place a dot of glue on each side of the upper rod as shown. Gently push the lower rod into place on the other side of the throw. Don't let any glue stick the rod to the crankshaft. The upper and lower halves should sort of "snap" into position on the crankshaft. Leave the rod to dry in place.

Parts on this page shown full sized.

View shown without crank webs or piston for clarity



Completed Rotating Assembly



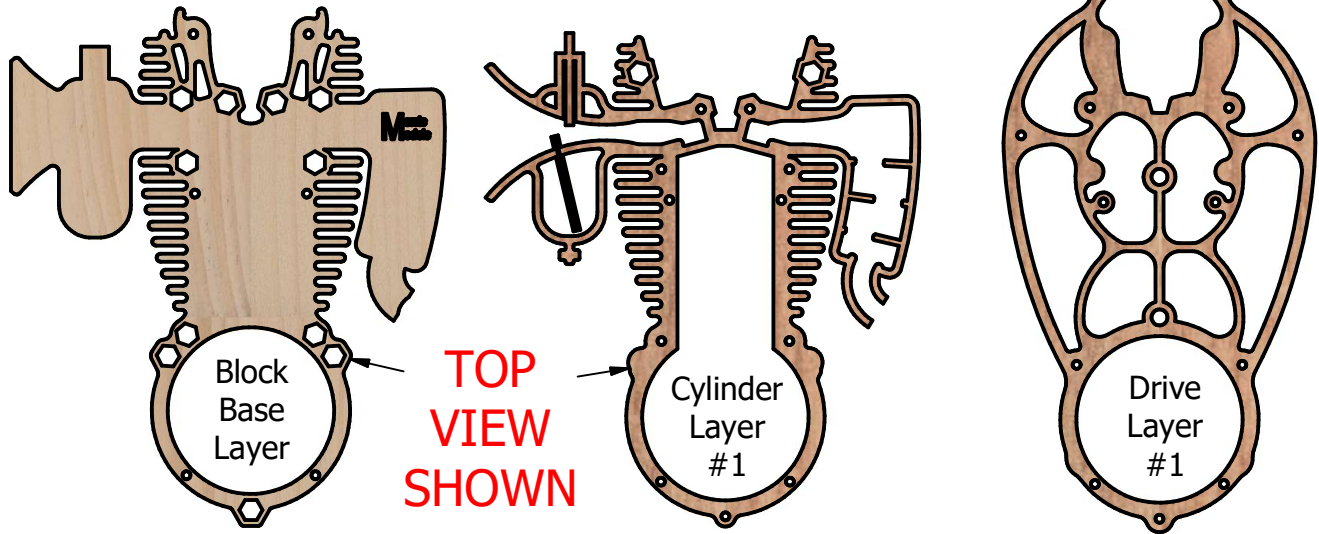
Section 2: Main Block

Alignment pins x 4
1/8" dowel. Cut about 1-2".

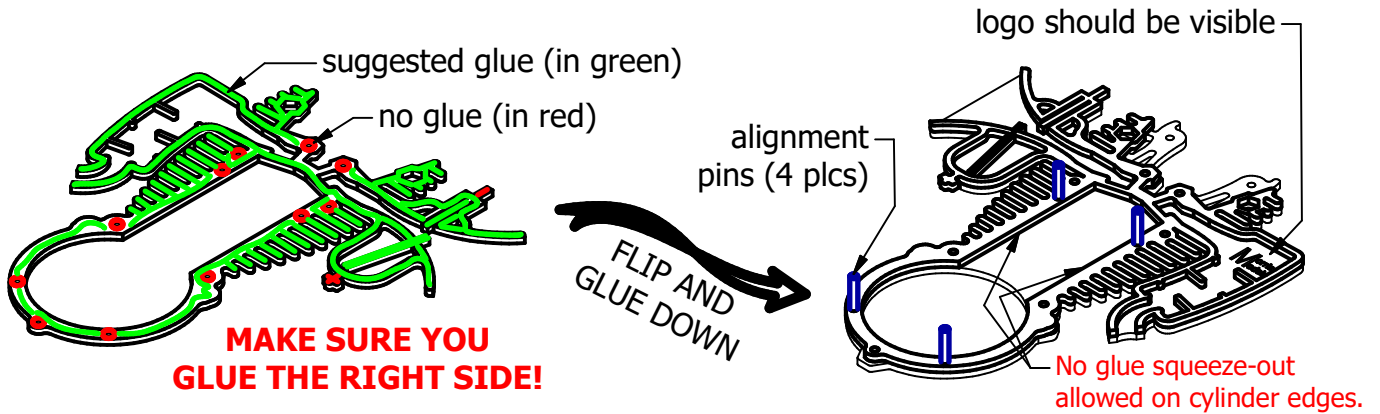
New Parts:

Parts shown 1/3 scale unless noted

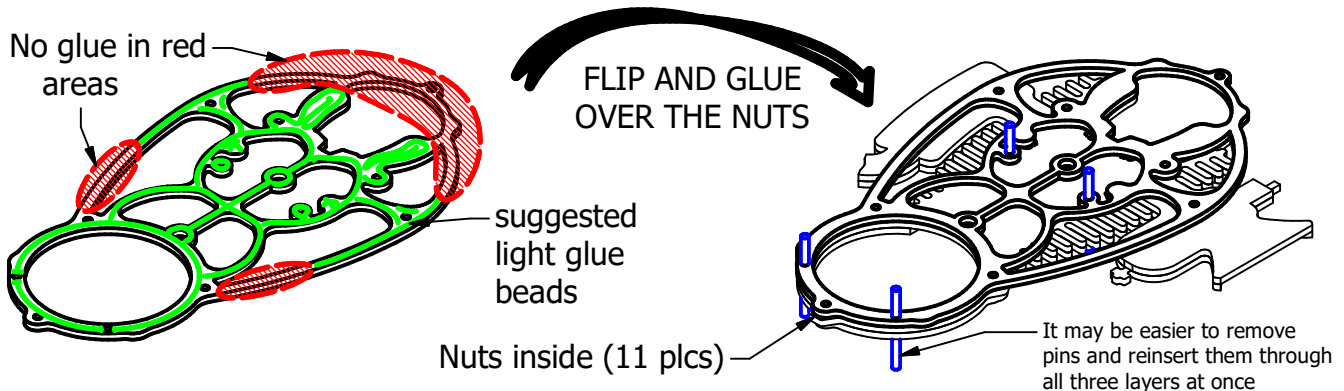
6-32 Nut x 11
(shown full scale)



Make light beads of glue over the entire **back side** of the **rear cylinder rear layer** EXCEPT for the point on the top and the knob on the bottom of the carburetor. Avoid getting glue too close to any of the small holes. Turn the freshly glued layer over, and glue it to the top of the **base layer**. You will see that four small holes are the same in both layers. Use 1/8" dowel pins in these holes to help you line up the layers - but still make sure that all the sides that are the same line up before the glue dries. Again, clean up any glue that squeezes out. If there is a lot of glue squeeze out, make your glue beads thinner in the future.

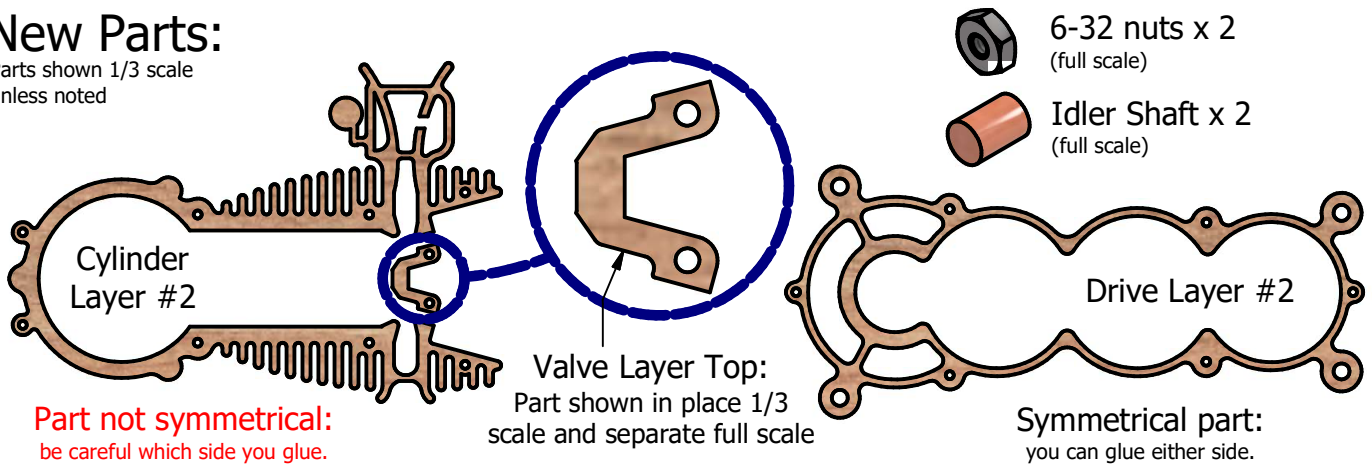


Turn the sandwich you just made over, and place a **6-32 nut** in each of the 11 hexagons. Make light beads of glue as shown on the **drive layer #1** (this part is symmetrical, so which side is which doesn't matter). Turn the drive layer over, and glue it to the other parts, enclosing the nuts permanently in the part. Line everything up.

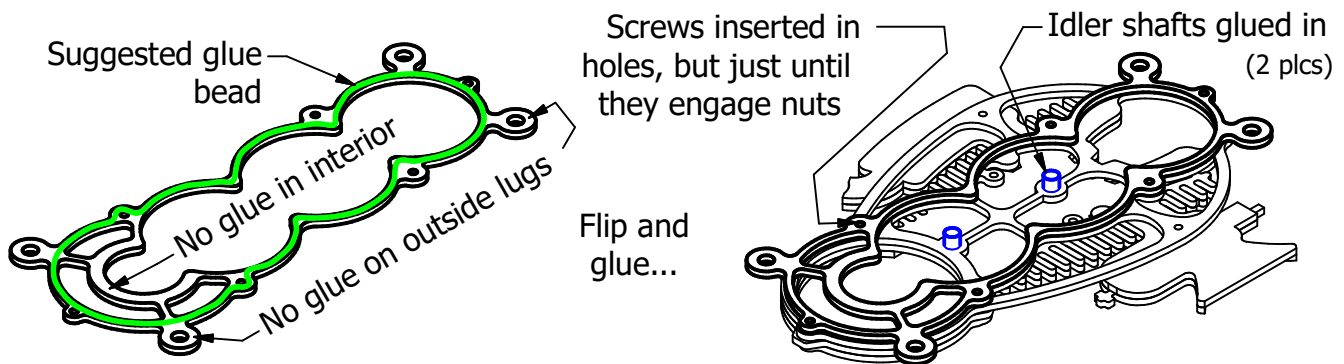


New Parts:

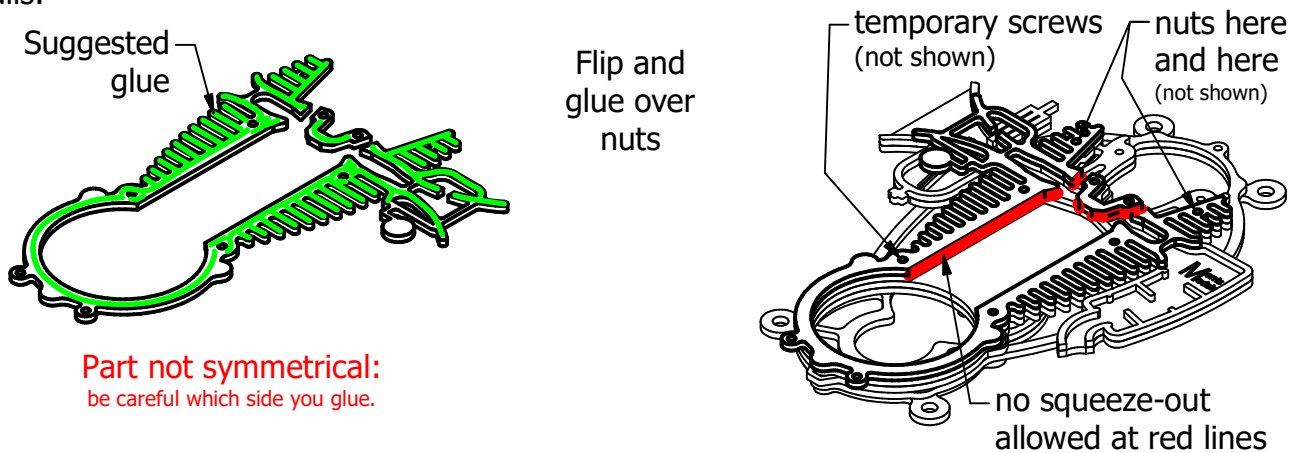
Parts shown 1/3 scale unless noted



Begin work on the back side of the block you are building. Remove the alignment pins. Spread light beads of glue on the **drive layer #2** as shown. Glue this layer down to the back side of the block. You may use the 6-32 screws that are included with the kit to help line up the layer. **Do not screw them all the way in** - just screw them in far enough to engage the trapped nuts in the base. (This is not shown in the diagrams.) Add a dot of glue in the two idler sockets, and glue the **idler shafts** into position. You may want to tape the idler shafts in place to dry.



Turn the block over, and place the **two nuts** in the hexagonal cutouts. Next, glue the **cylinder layer #2** to the block, using thin glue beads as shown. Use 6/32 screws to help align the layer, again putting them in just far enough to engage the captive nuts. Add the separate **valve layer top** part, using two 6-32 screws to help with alignment. Be **VERY PARTICULAR** about alignment, especially on the separate top part. Don't allow **ANY** glue squeeze-out near the valves or cylinder walls.

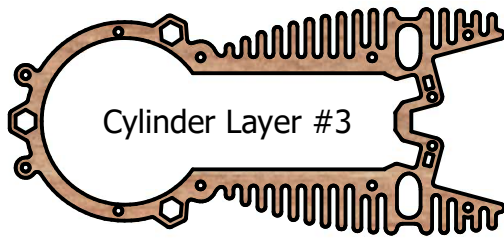


Section 3: Cylinder Top

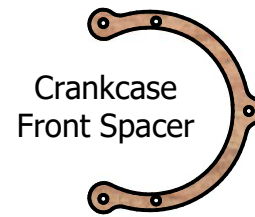
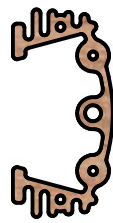
Note: This part would likely be combined with the block on a real engine.

New Parts:

Parts shown 1/3 scale

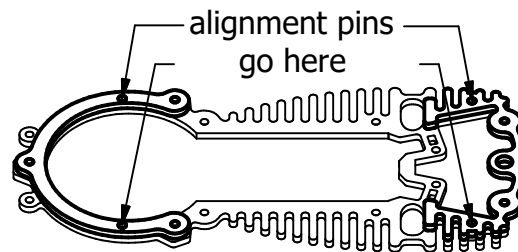
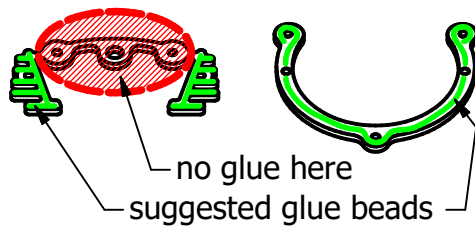


Cylinder Cap



Crankcase Front Spacer

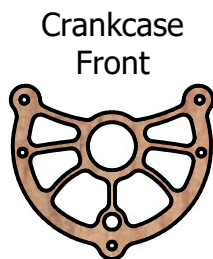
Make light beads of glue over the entire back side of the **cylinder cap** and the **crankcase front spacer** as shown. Glue them down to the same side of the **cylinder layer #3** - preferably the cleanest looking side. Use alignment pins (not shown) in the two side holes of each to help with alignment.



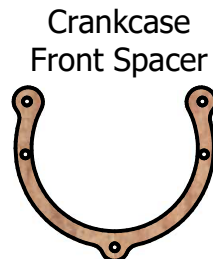
Section 4: Crankcase Front

New Parts:

Parts shown 1/3 scale

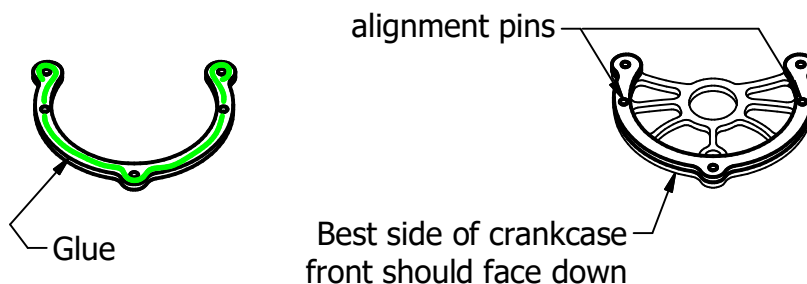


Crankcase Front



Crankcase Front Spacer

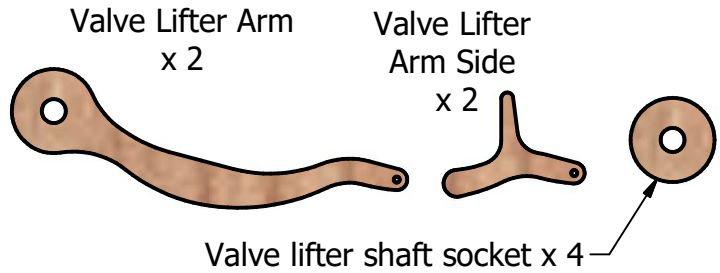
Make light beads of glue over the entire back side of another **crankcase front spacer** as shown. Glue it down to the **crankcase front**, using alignment pins on the two side holes.



Section 5: Valves, Lifters, and Cam

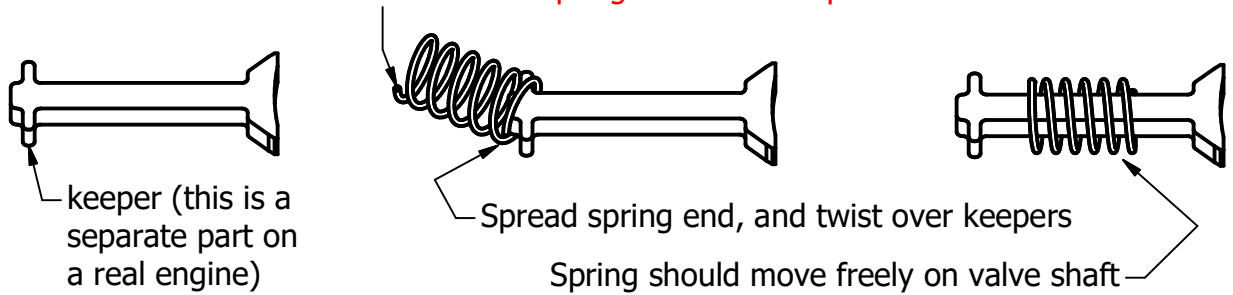
New Parts:

Parts shown full scale



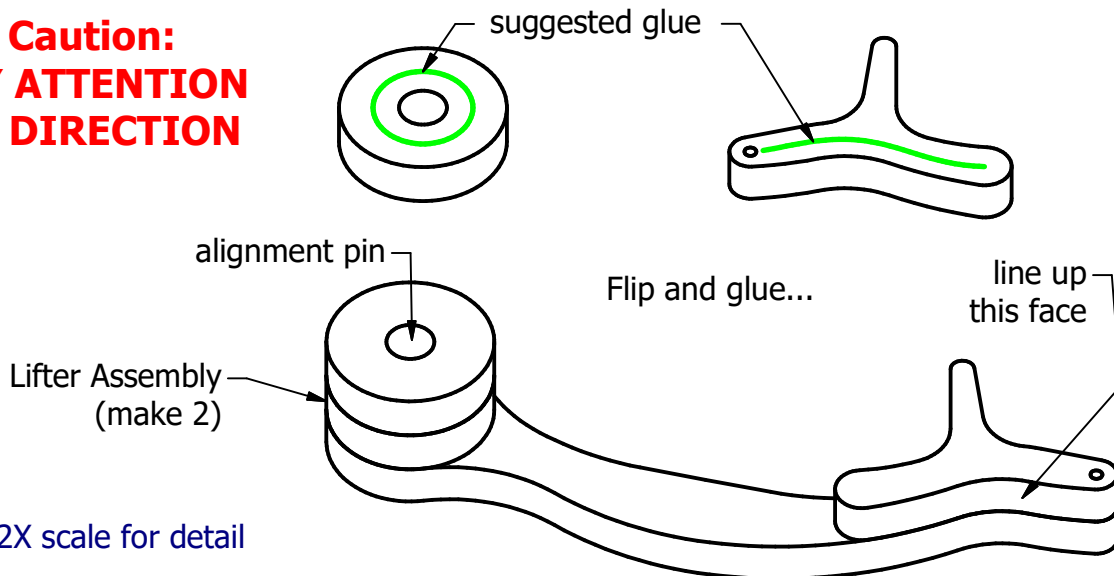
Carefully spread the end of the spring, and screw it down over the valve keepers on the end of the valve. Screw it on all the way, and make sure it can slide back and forth on the valve. Do not permanently bend the spring. Do this for both valves and springs.

Caution - the valve spring ends are sharp!



Carefully put tiny dabs of glue on the **valve lifter arm side** and two of the **valve lifter shaft sockets**. Use an alignment pin to help you glue the sockets to the **valve lifter arm**. Then carefully align the lifter arm side and the lifter arm, using a small paper clip or something similar through the tiny holes as an alignment aid if desired. Do not glue the sockets or the arm to the alignment pins. Do this twice, making two identical valve lifter assemblies.

**Caution:
PAY ATTENTION
TO DIRECTION**



Shown 2X scale for detail

New Parts:

Parts shown full scale

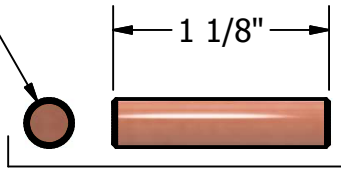


Cam x 2



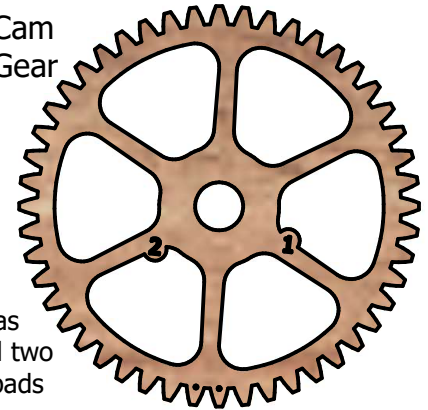
Cam Spacer x 3

1/4 Dia.



Camshaft Center

Cam Gear

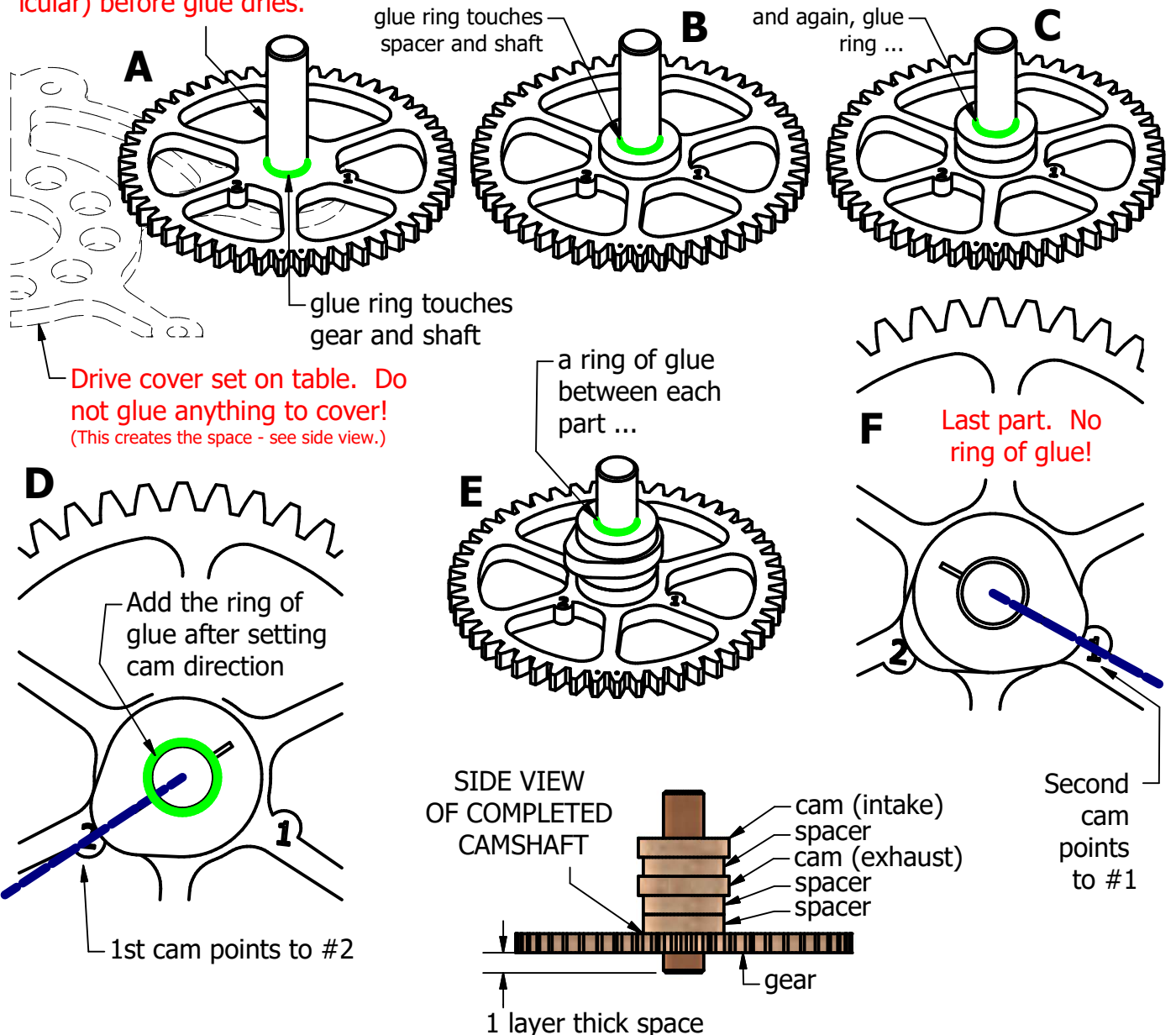


Cam gear has six spokes and two numbers on pads

Find a plywood part with a 1/4" hole. (The drive cover from the next page is shown in the diagram). Set it on a flat surface, and set the **camshaft center** so that it sticks out. **DO NOT GLUE**, as this is just to hold it in position.

Set the cam gear in place over the shaft. Add a ring of glue around the shaft and gear as shown. Add one of the **cam spacers**. Repeat the ring of glue and add another spacer. Repeat the ring of glue, and add a **cam**. Before the glue hardens, point the cam towards the number 2 as shown. Add another ring and cam, again using rings of glue. Point the second cam towards the number 1 as shown. Allow cam to dry before using.

Shaft set in cover. Make sure shaft is straight in gear (completely perpendicular) before glue dries.

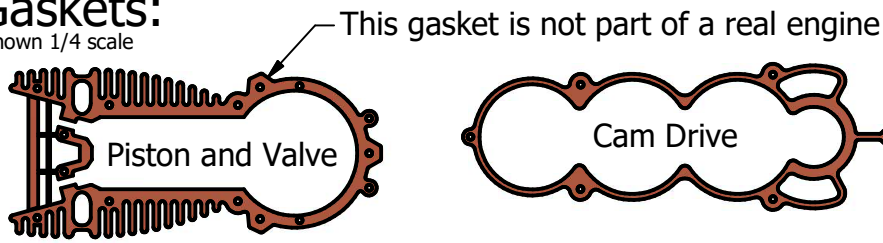


Section 6: Gaskets and mounts

Note: Gaskets are used between the parts of a real engine to help them seal. In this model, three gaskets are used to create space to let the parts slide freely. Do not skip these thick paper gaskets.

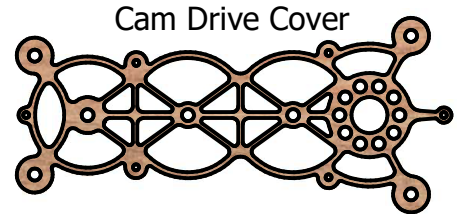
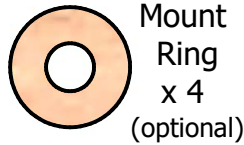
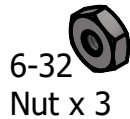
Gaskets:

Shown 1/4 scale

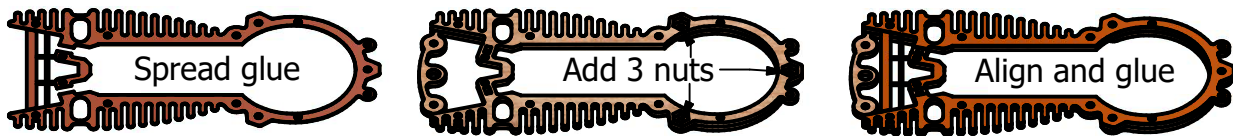


Other Parts:

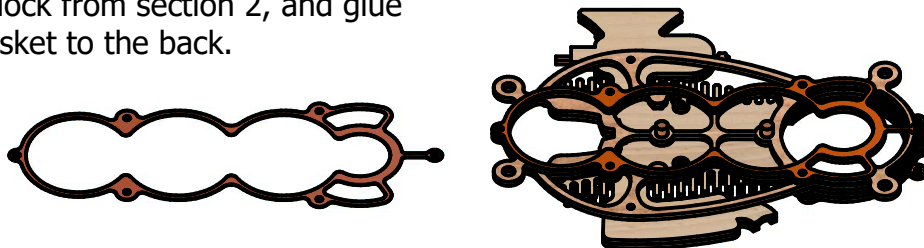
Shown 1/4 and full scale



Locate the cylinder top you built in section 3. Turn it over, and add the **6-32 nuts** to the three empty hexagonal cutouts. Spread a very thin layer of glue on the **piston and valve gasket**, then glue it down on the back of the cylinder top, permanently trapping the three nuts. Make sure to align it as perfectly as possible - especially on the valves and cylinders. Do not allow any glue squeeze-out - especially along the sides of the cylinders and valves.



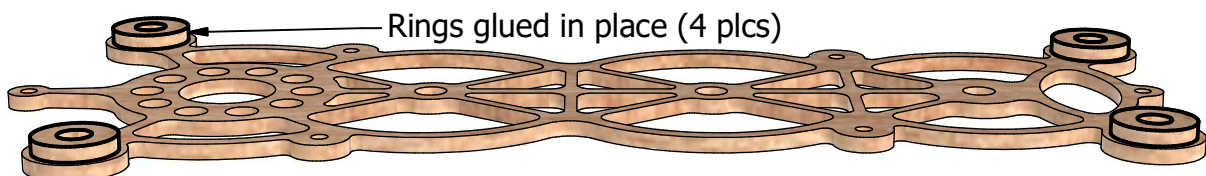
Locate the main block from section 2, and glue the **cam drive** gasket to the back.



Do the same for the **front gasket**, gluing it to the back of the crankcase front from section 4.



Optional: Locate the cam drive cover. Locate its best face, and set it face up on the table. Glue the four **mount rings** into place over the four engine mounts as shown below. Align.



Section 7: Final Assembly

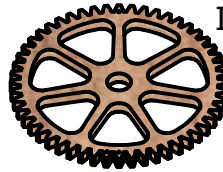
New Parts:



6-32 x 1/2
screw x 19
(head style may vary)



6-32
Nut x 3



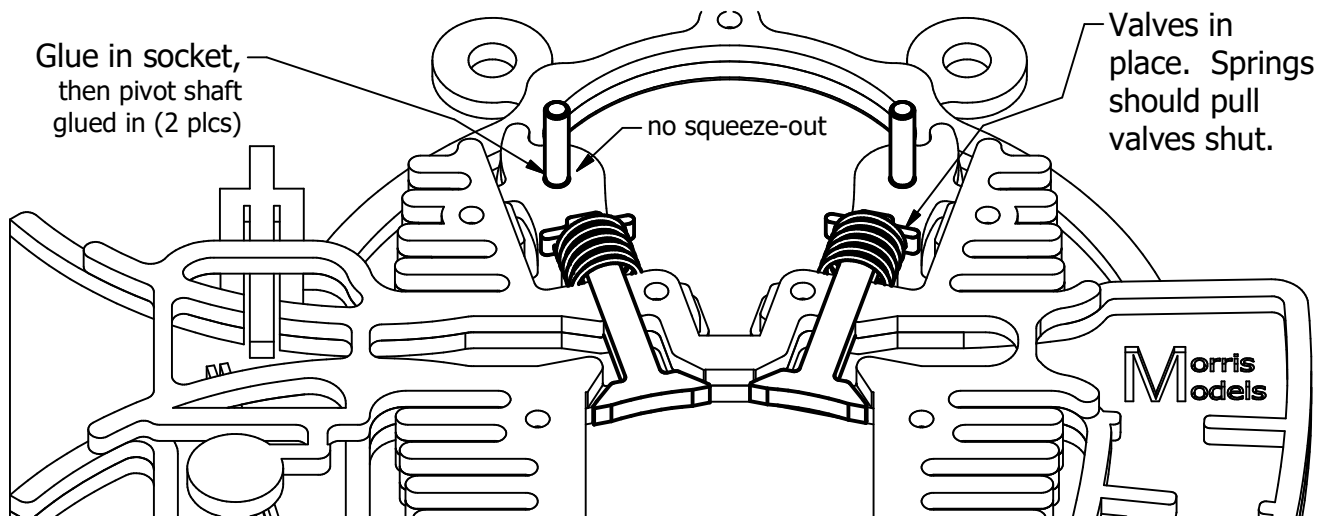
Idler Gear
x 2
(note 7
spokes)



Valve
Pivot Shaft
x 2

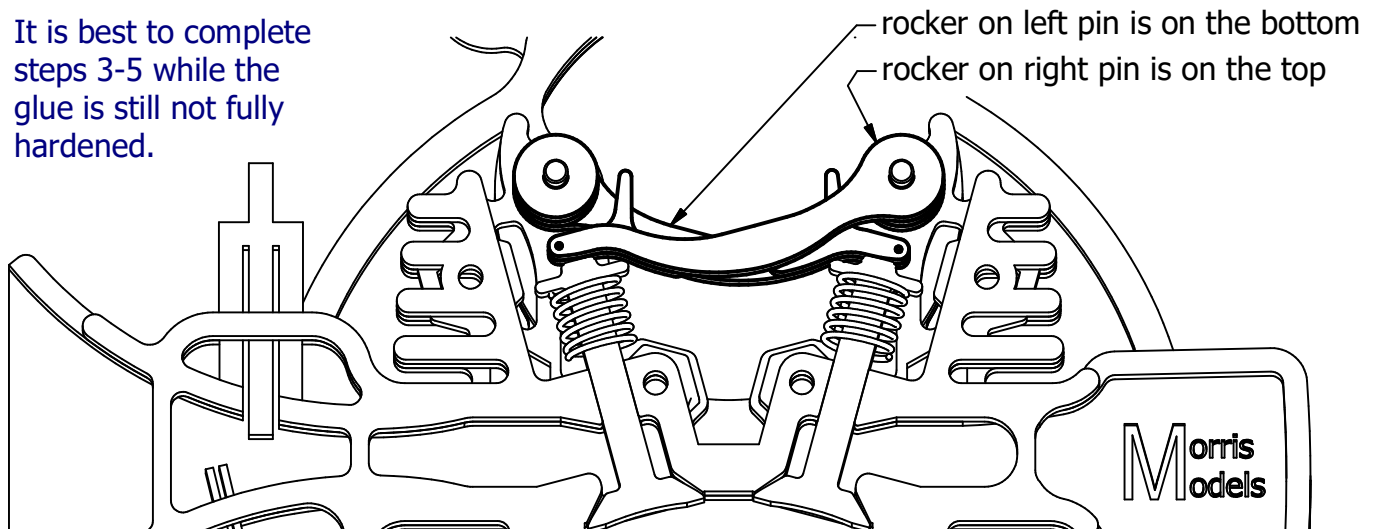
Caution: Do not over-tighten screws. Doing so will damage the wooden parts.

- 1) Make the valve pivot shafts from 1/8" dowel rod. They should be 5/8" (or 5 layers) long.
- 2) Slide the valve springs against the valve keepers, and compress the springs. Set the valves in their slots in the block. The springs should hold them in position when released. Place a dot of glue into each of the valve pivot sockets, and push the valve pivot shaft into each socket. Do not allow any glue squeeze-out.

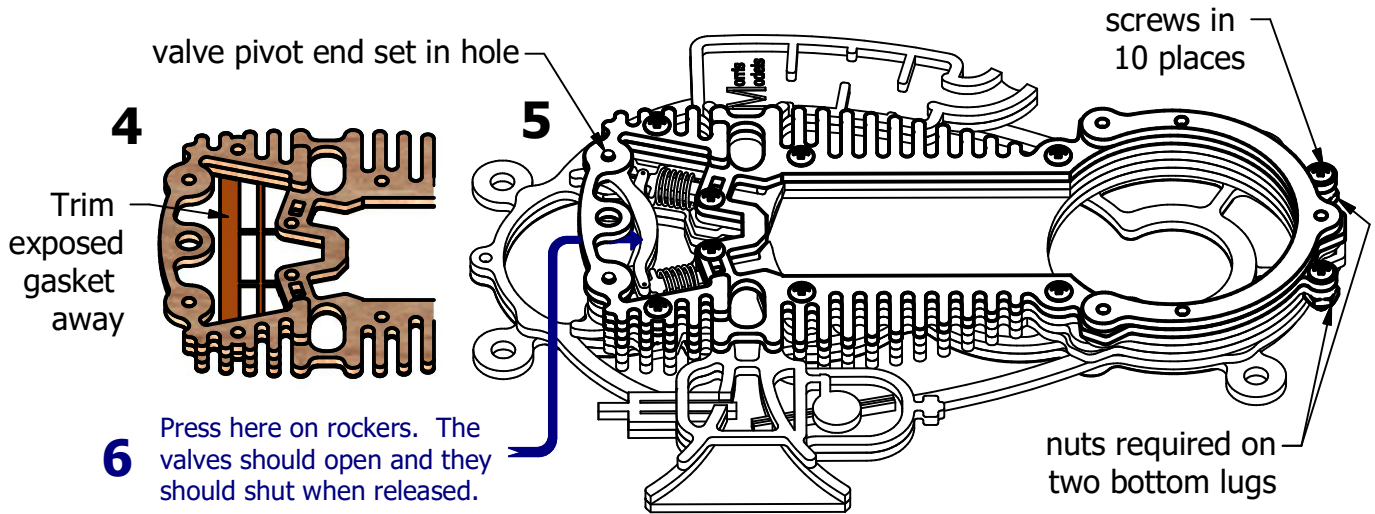


- 3) While the glue is still not yet set, place the two lifter assemblies you made in section 5 over the pivot shafts as shown below.

It is best to complete
steps 3-5 while the
glue is still not fully
hardened.



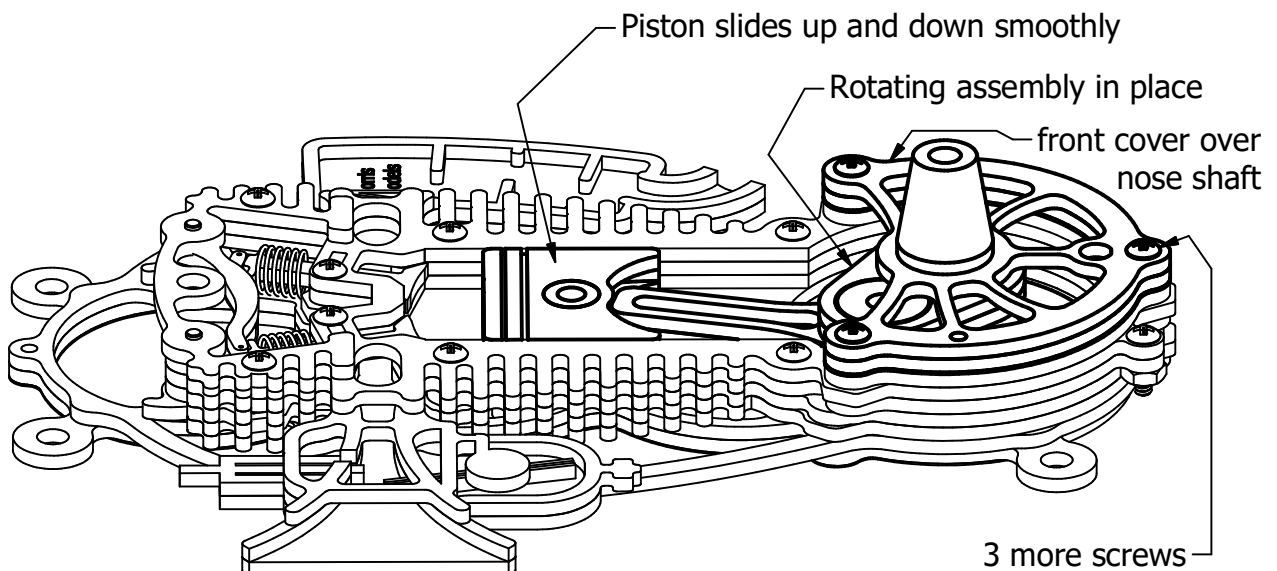
4) While the glue is still not yet set, locate the cylinder top with its gasket. Using a sharp knife, gently trim the gasket material that is not glued to the plywood away.



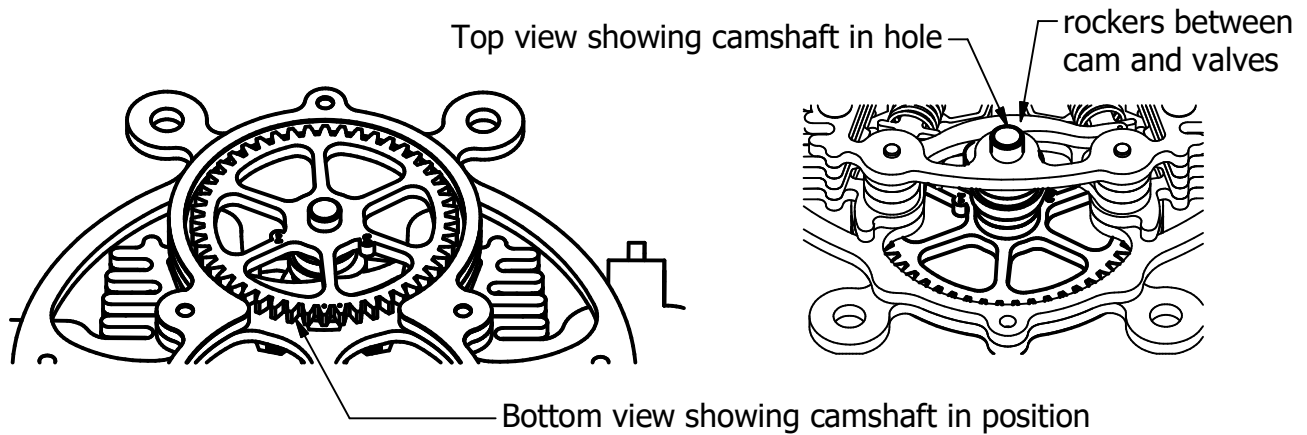
5) Set the cylinder top in place on the block, capturing the valve pivot ends in the matching holes on the cylinder top. Gently screw 10 of the 6-32 screws into place as shown above, being careful to only tighten them until snug. The two bottom screws will require separate nuts added under the lugs. Do not over-tighten the nuts or the screws.

6) Check that the rockers can pivot, and that the valves can move up and down. The valves and rockers should move easily enough that the valves will shut themselves if you press them open against the springs. If they do not open and shut, you will need to unscrew the screws, sand the valves wherever they are sticking, and then repeat the assembly steps as required.

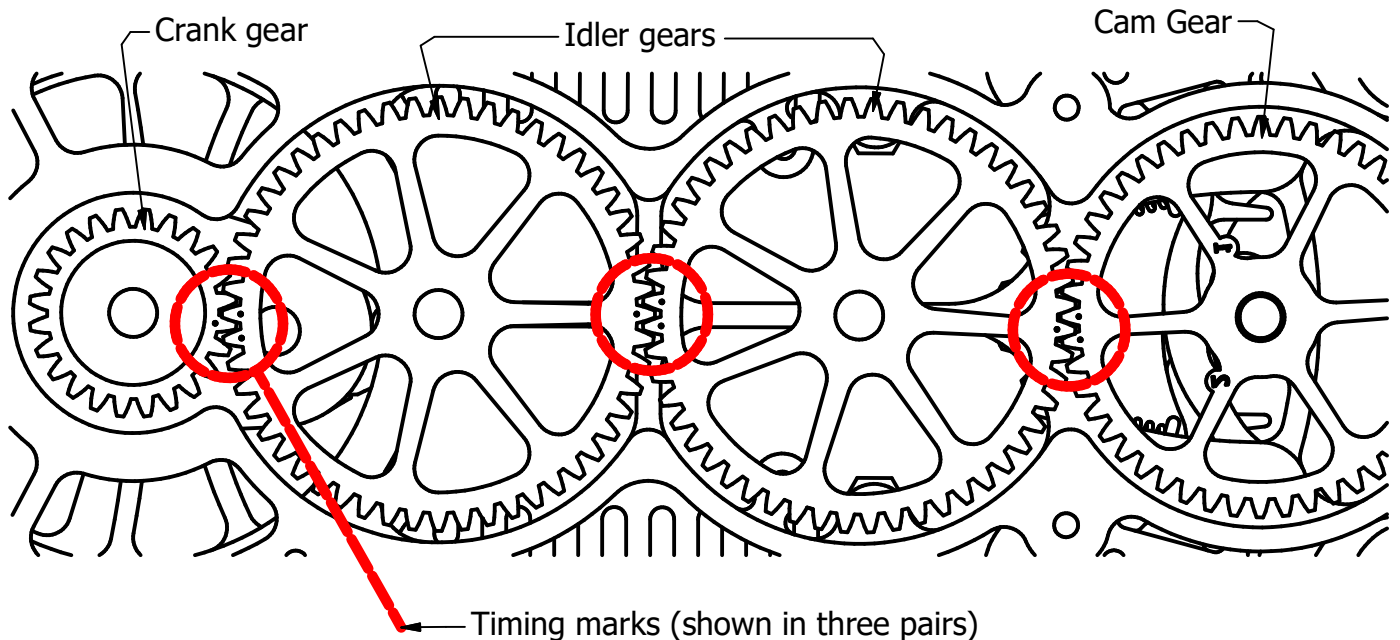
7) Check the fit of the piston inside the cylinder. It should slide up and down easily. If it does not, gently sand the sides of the piston or the sides of the cylinder until it does. Set the rotating assembly into rough position, and then add the front. Secure the front with three 6-32 screws, again being careful not to over-tighten them.



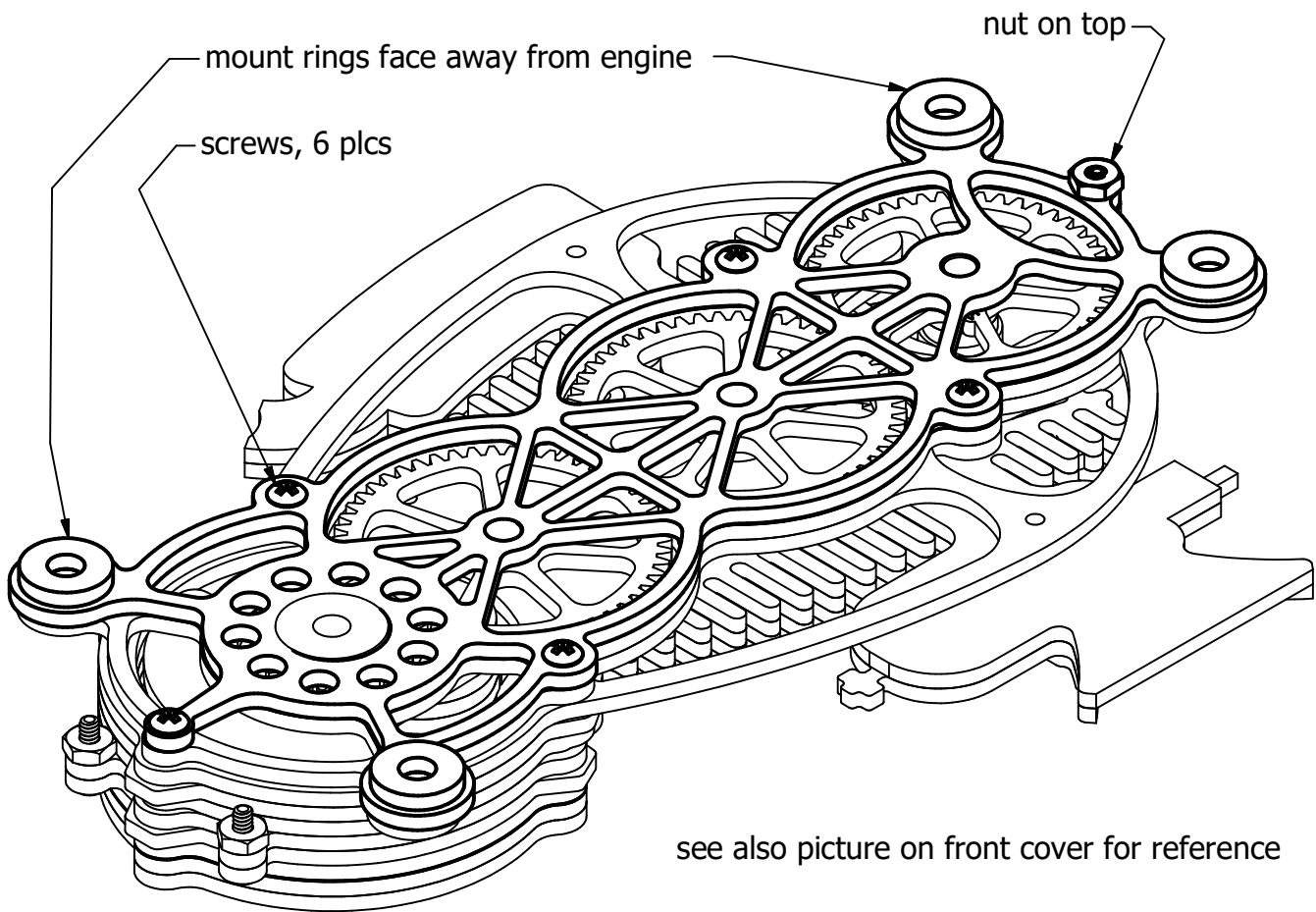
8) Turn the engine assembly over, and add the camshaft as shown. Be careful to work it into position around the rocker arms. The exposed shaft on the end of the cam should fit into the hole in the cylinder front.



9) Being careful not to let the cam slip out of place, gently turn the cam gear until the two dots on the gear are in the position shown below. Twist the rotating assembly until the dot on the crank gear is in the position shown. (The piston should be at the top of the cylinder.) Add the two **idler gears** which are set over the idler shafts, again using the dots on the gears and the diagram for reference. **PAY ATTENTION.** This step is virtually identical to working on a real engine, and is crucial for the model to work right.



10) Be sure not to let anything slip out of position. Carefully add the cam drive cover. If you added the mount rings, these should face away from the engine as shown. Secure the cover with six 6-32 screws, adding a nut to the top fastener. Again, be careful not to overtighten.



Operating: You should be able to turn the nose shaft of the motor and watch everything work as it should. If the motor does not turn, do not force it. Instead, figure out which pieces aren't right, disassemble the engine as much as possible, and clean, wax, and/or sand as needed to make the parts move easily as they should move.

Thank you for building a Morris Model. Treat your model gently and with respect, and it should last forever.