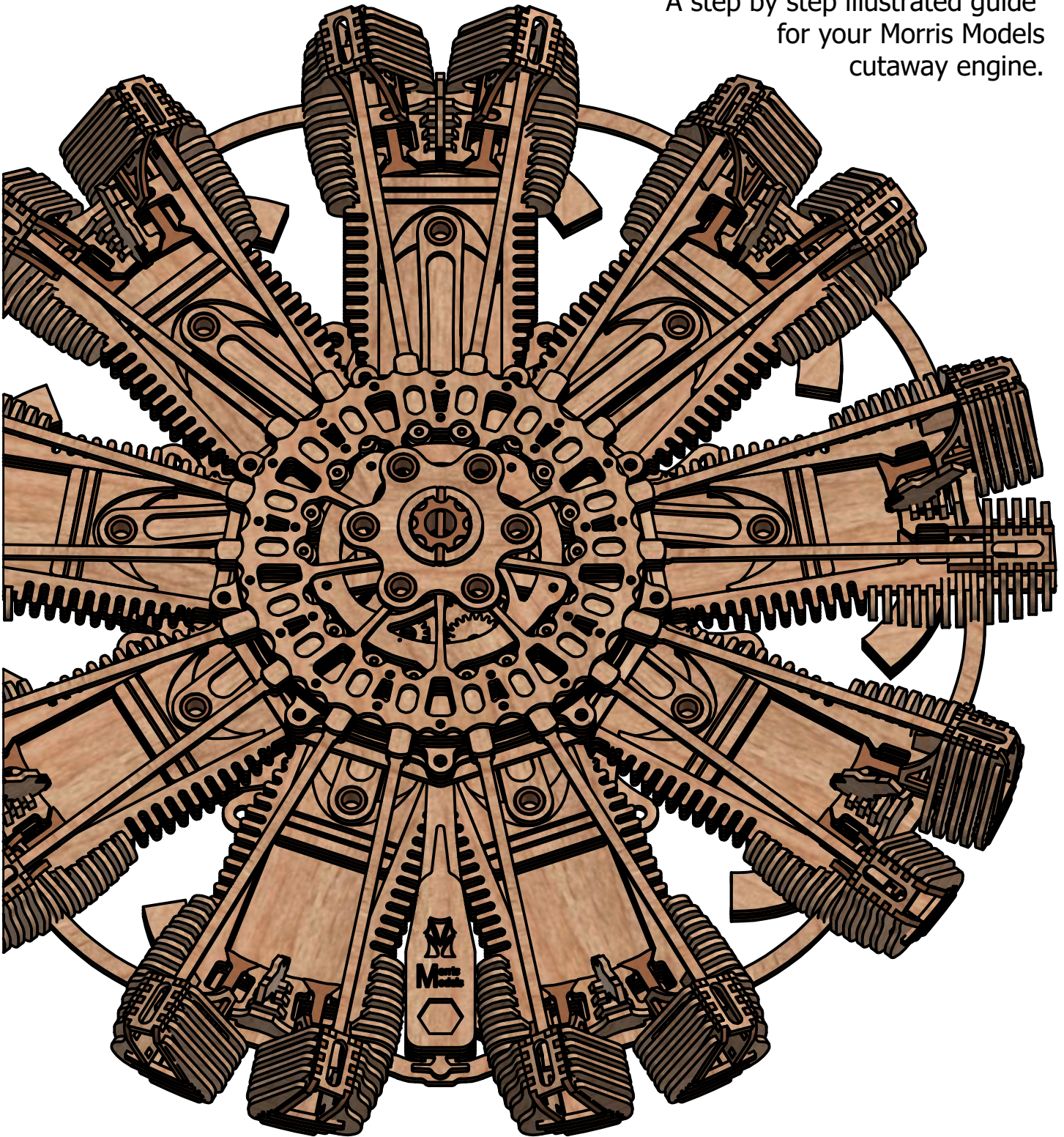


# Nine Cylinder Radial Engine

## Assembly Manual

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



# Before you Begin

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](http://www.morrismodels.com).

Many of the parts for this kit are cut from round dowel rods. These form most of the shafts. These also should be sanded for splinters. If you have access to power tools, they can be made to look a little more realistic if you bevel the front of each shaft and drill holes through the bodies of the 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. Most of the plywood parts have 1/8" or 3/16" 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. 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. 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.

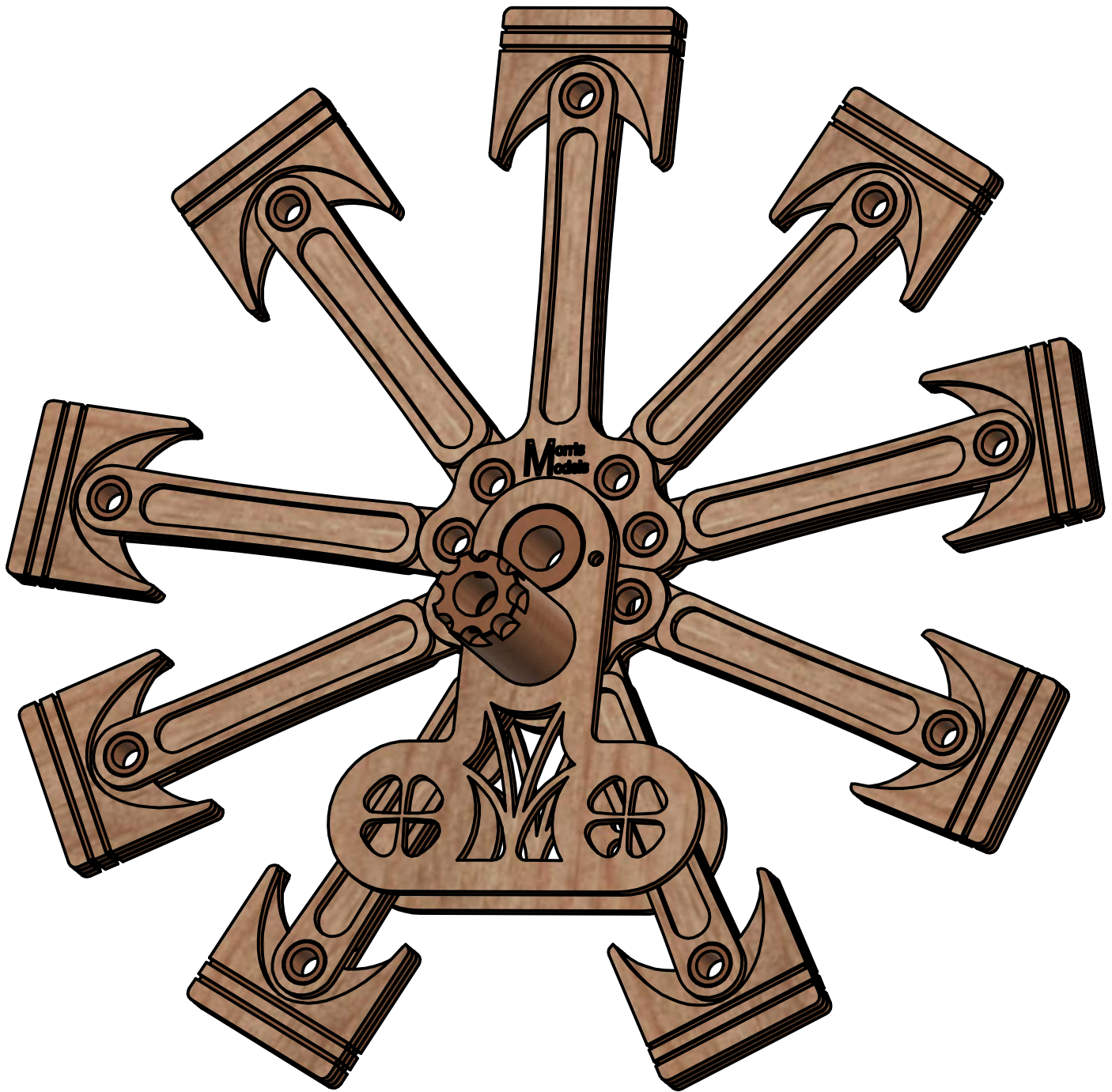
This manual shows how to build the engine step by step. Sometimes it is hard to explain things in a manual, but easy to understand it on a video. We try to shoot videos for each engine as time allows. If a video for this engine is available, it will be posted on the web site [www.morrismodels.com](http://www.morrismodels.com). 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.



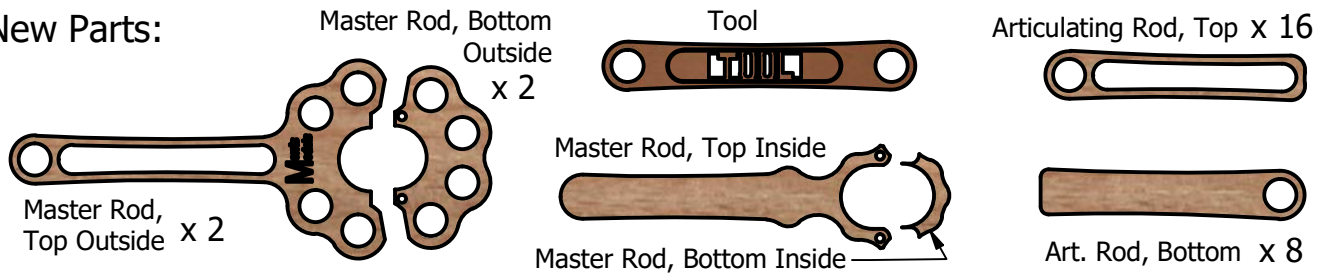
# Section 1 - The Rotating Assembly



The rotating assembly consists of the crankshaft, the master rod, the articulating rods, and the pistons. Proper alignment is key to a smoothly turning engine - particularly on the crankshaft. In a real engine, the weight of the rods, pistons, and crank all have to be counterbalanced by an enormous counterweight. This model includes decorative cutouts on the counterweight so that you can see what is happening behind it. A "splined" prop carrier attaches to the front of the crank much like actual radial aircraft engines.

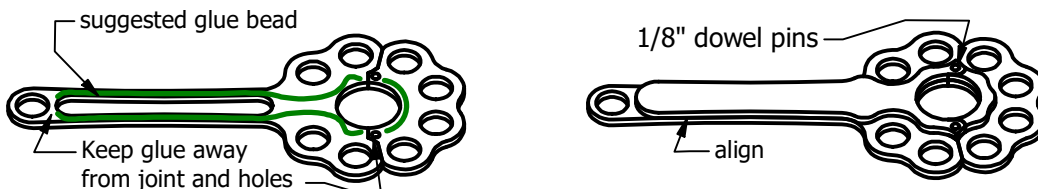
# Rods: Master and Articulating

## New Parts:

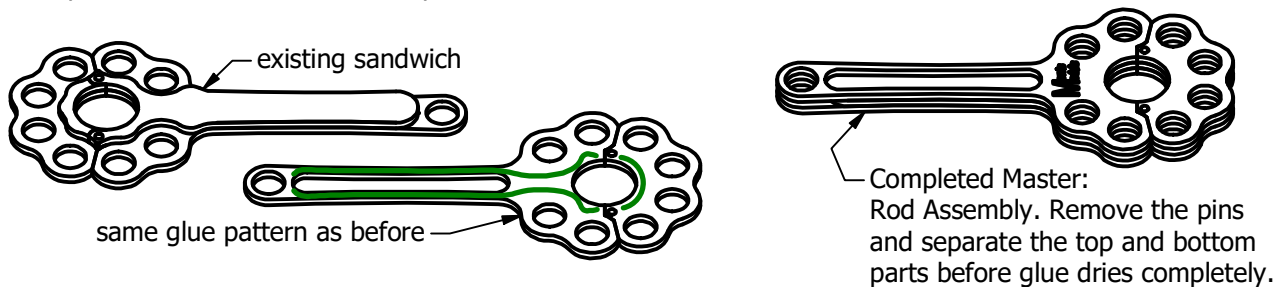


## Master Rod: Build 1;

Lay the two halves of the Outside Master Rod in front of you, face down. Spread a thin bead of glue as shown in the diagram below. Set the two halves of the inside layer onto the glue, and align them carefully.

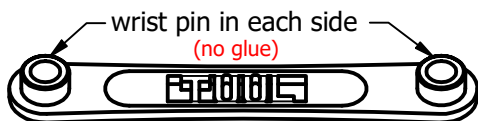


Clean up any glue squeeze-out. Temporarily pin the two halves of the rod together with short bits of 1/8" dowel rod. You may wish to check alignment of the bore with the crank throw (shown on a future page). Set out the other two halves of the master rod, and glue them in the same way as before. Add them to the sandwich. Make sure that you do not glue the upper and lower halves of the master rod together. You must be able to pop the 1/8" dowel pins out and separate the rod in order to complete the model.

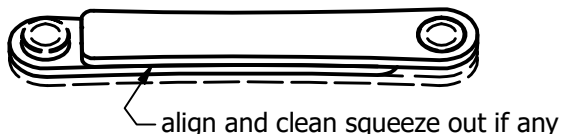
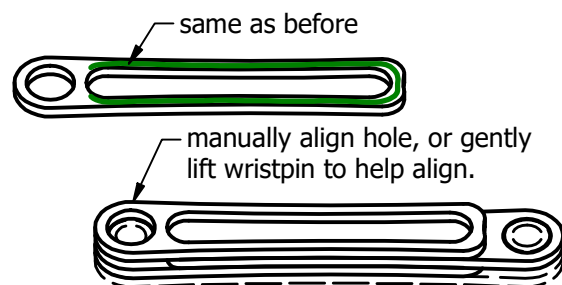
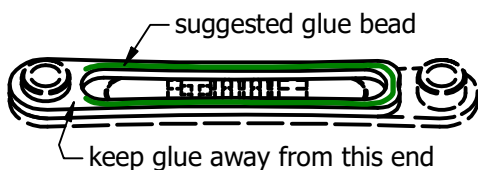


## Articulating Rods: Build 8;

Set the articulating rod spacing tool in front of you, and place one of the wrist pins (shown on a future page) in each socket. Place one of the articulating rod outsides over the tool, and apply a thin bead of glue as shown.

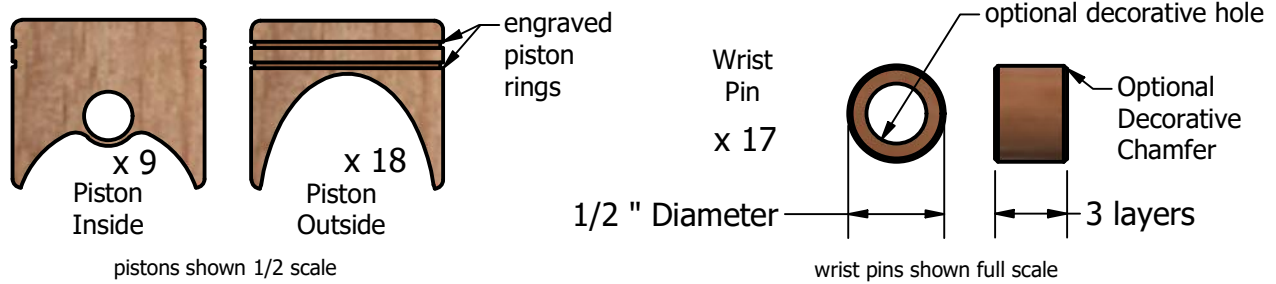


Add another glue bead on the other half of the articulating rod, then set it glue downward on top of the assembly. Make sure that the alignment is perfect. Remove from the jig when dry.



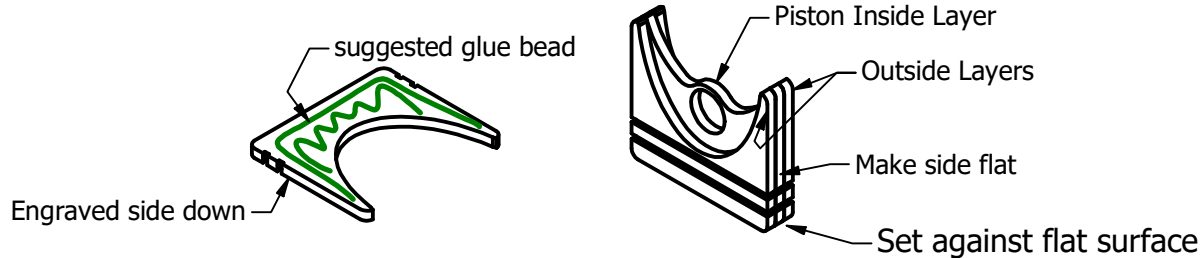
# Pistons and Wrist Pins

## New Parts:



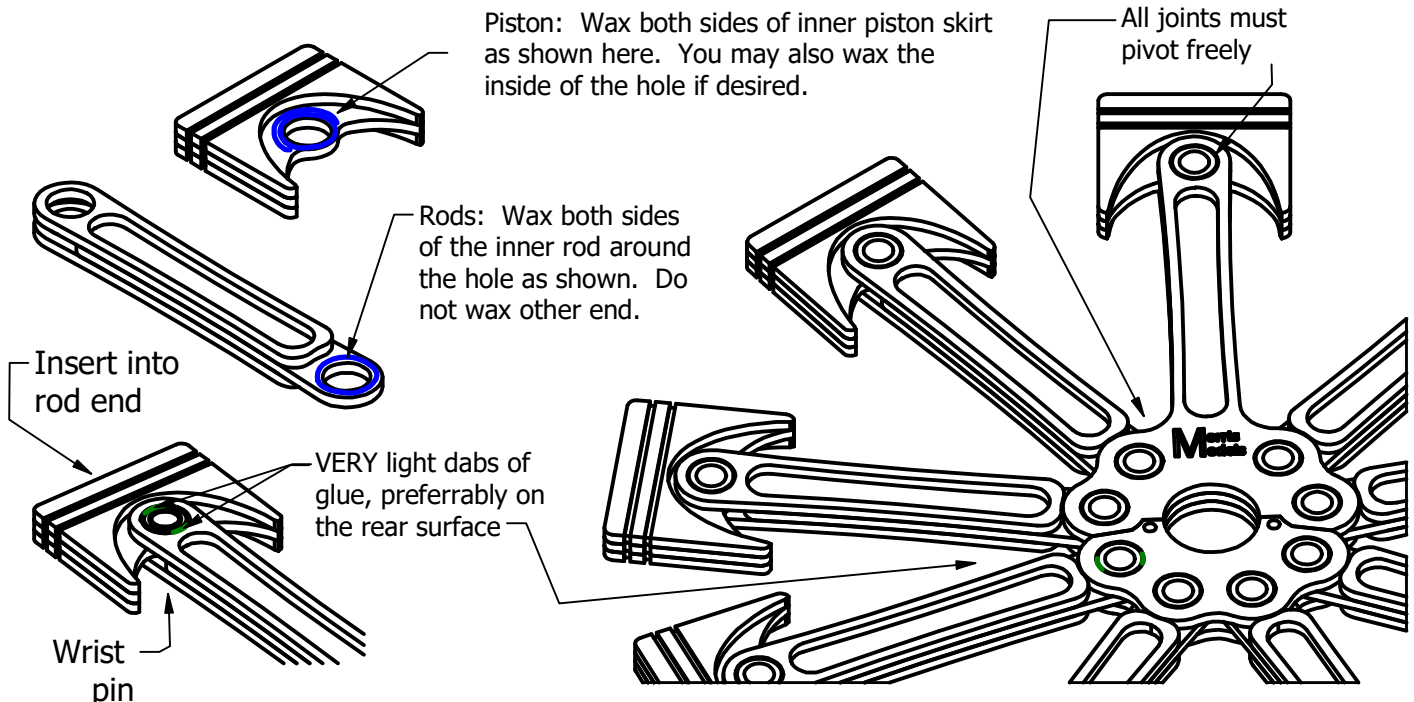
## Pistons: Build 9

Lay two of the outside pistons engraved ring side down on the table in front of you. Make a thin bead of glue on each of them as shown below. Use the two outside pistons as the crust in a piston sandwich. Use the table or a similar surface to make sure that all three sides align. Clean up any squeeze-out. Set aside to dry.



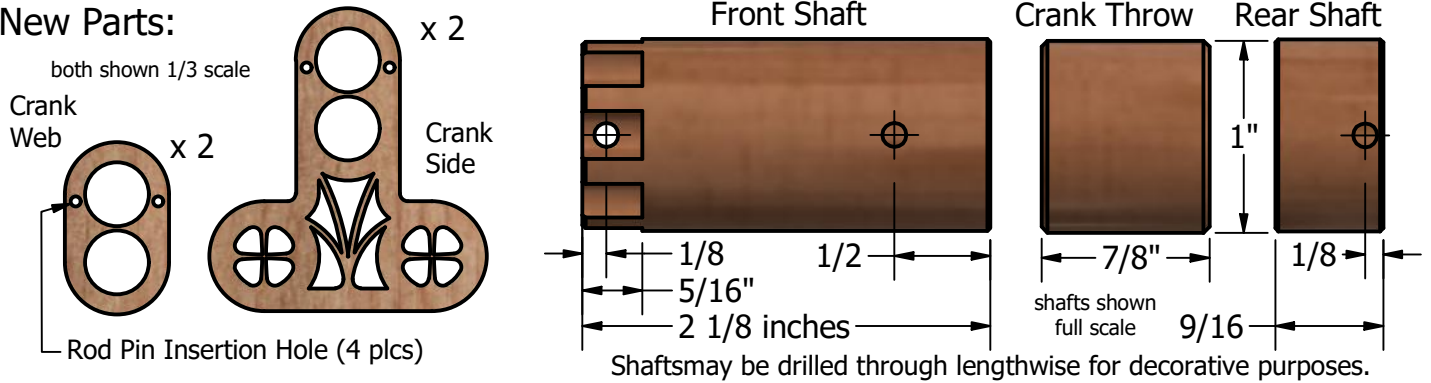
## Pin Assemblies Together

After all previous assemblies have dried completely, it is time to pin them together with the wrist pins. If you are going to wax the engine, this is the time to do it. Wax only the parts shown then pin together. Place a small drop of glue onto each pinned joint to retain the pin. Do not allow the glue to keep the joints from pivoting. They must move easily in order for the engine to turn.



# Crankshaft: 1 of 2

## New Parts:

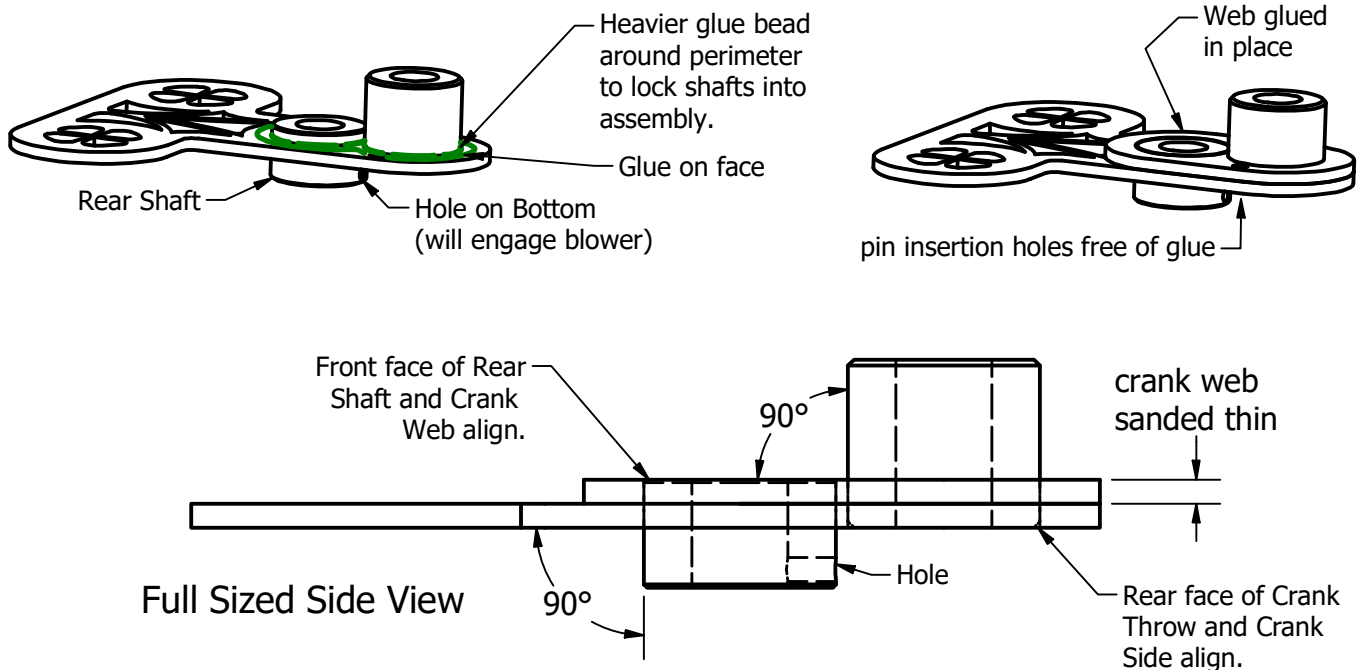


## Prepare your parts

Carefully sand away any burrs from the edges of the shaft parts. If desired, lightly sand outside of the shafts and sand small chamfers around the edges as shown in the diagram above. Next, sand one surface of each of the crank webs, removing at least half of the outside layer of one side. Do not remove more than one layer. This step is necessary to allow the crankshaft to spin freely in the engine case. Ideally, the final thickness of each crank web should be between 2 and 2.5 mm, or about 3/32nds of an inch.

## Assemble the Crankshaft

Insert the rear shaft with the small 1/8 inch hole downward in the center hole of the crank side. Insert the crank throw in the other hole. Position the rear shaft so that one layer projects forward of the side and two layers project behind the side. It is not important which direction the hole on the rear shaft faces. The crank throw should be even with the rear face of the side. Spread a thin layer of glue on the face of the side as shown, and another thin bead around the perimeter of each shaft where they project through the side. Add the crank web over the shafts and onto the side as shown, making sure that the rod pin insertion holes line up. Make sure that the forward face of the rear shaft aligns with the face of the crank web, and the rearward face of the crank throw aligns with the rear face of the crank side. See side view for clarification. Clean any glue squeeze-out and allow to dry.

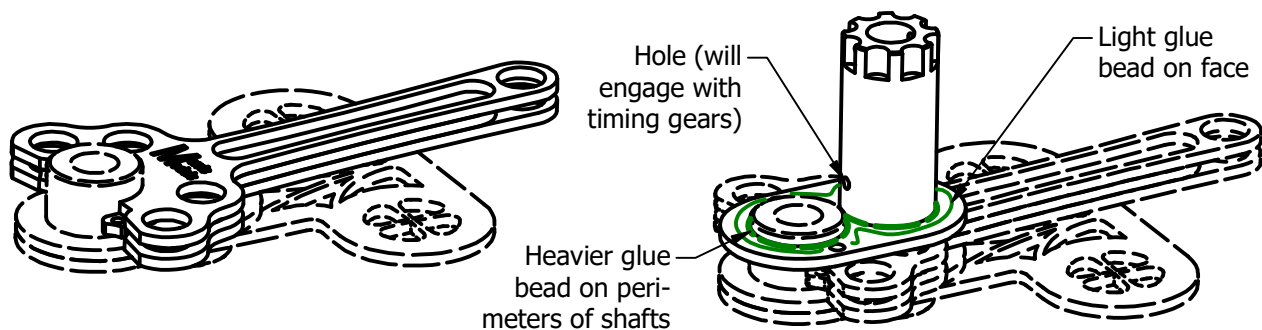


Make sure everything lines up where it should, that there is no glue squeeze out, and that the shafts are perpendicular the crank web and sides. Allow assembly to dry thoroughly before continuing to the next step. (You can always start building cylinders while you wait.)

# Crankshaft: 2 of 2

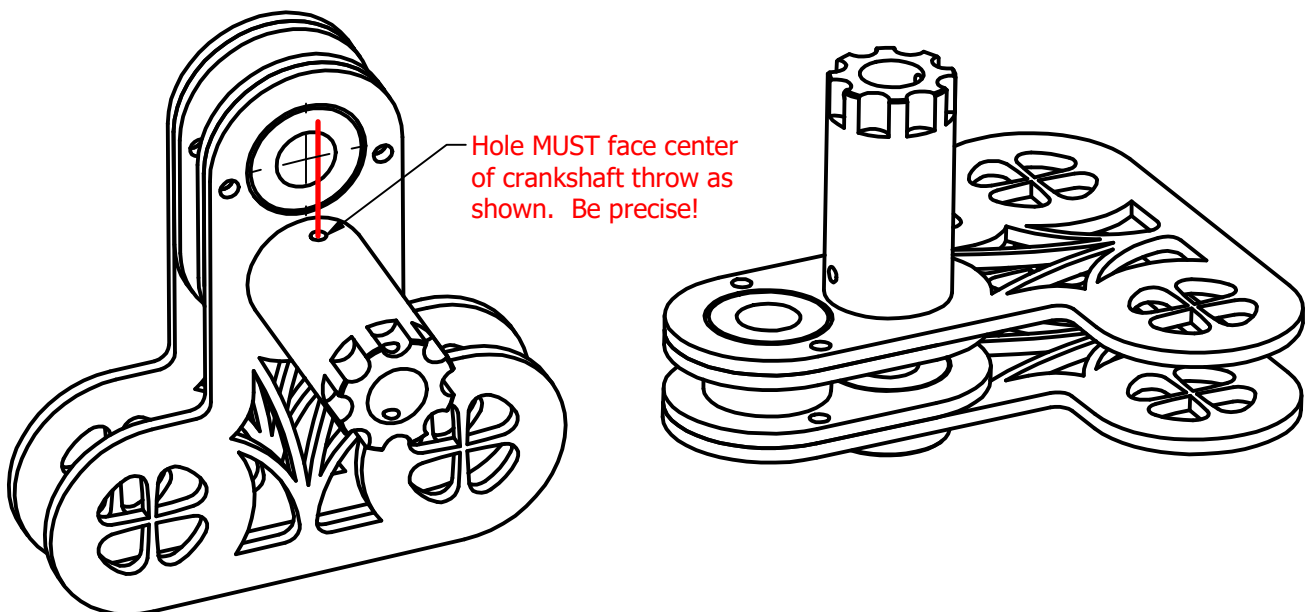
## Set the Front Web

Temporarily set the top part of the rod assembly (only partly shown) over the crank throw as shown. This will help you to properly space the next web. Set a notecard spacer (not shown) over the side of the master rod to give it enough space to spin freely. Set the second crank web you sanded thin over the top of the assembly, and set the forward shaft in place as shown. Note that **the small hole should point straight towards the center of the crank throw** (see bottom left). This alignment **does** matter, as it will set the timing at a later step.



## Set the Front Crank Side

In nearly the exact same manner as before, apply a light glue bead to the forward face of the web and two slightly heavier glue beads around the perimeters of the shafts. Set the other crank side over the shafts and into the wet glue. Clean up any squeeze-out, including glue in the pin insertion holes. Make sure that the hole in the forward shaft is facing the correct direction. Make sure that the front and rear halves of the crank are aligned straight and true. Make sure that the forward shaft is set at a 90 degree angle from the crank side. It may be easier to check all of this if you gently remove the rod assembly from the sandwich. Gently replace it (and the notecard) again to help hold things in place while the glue dries.





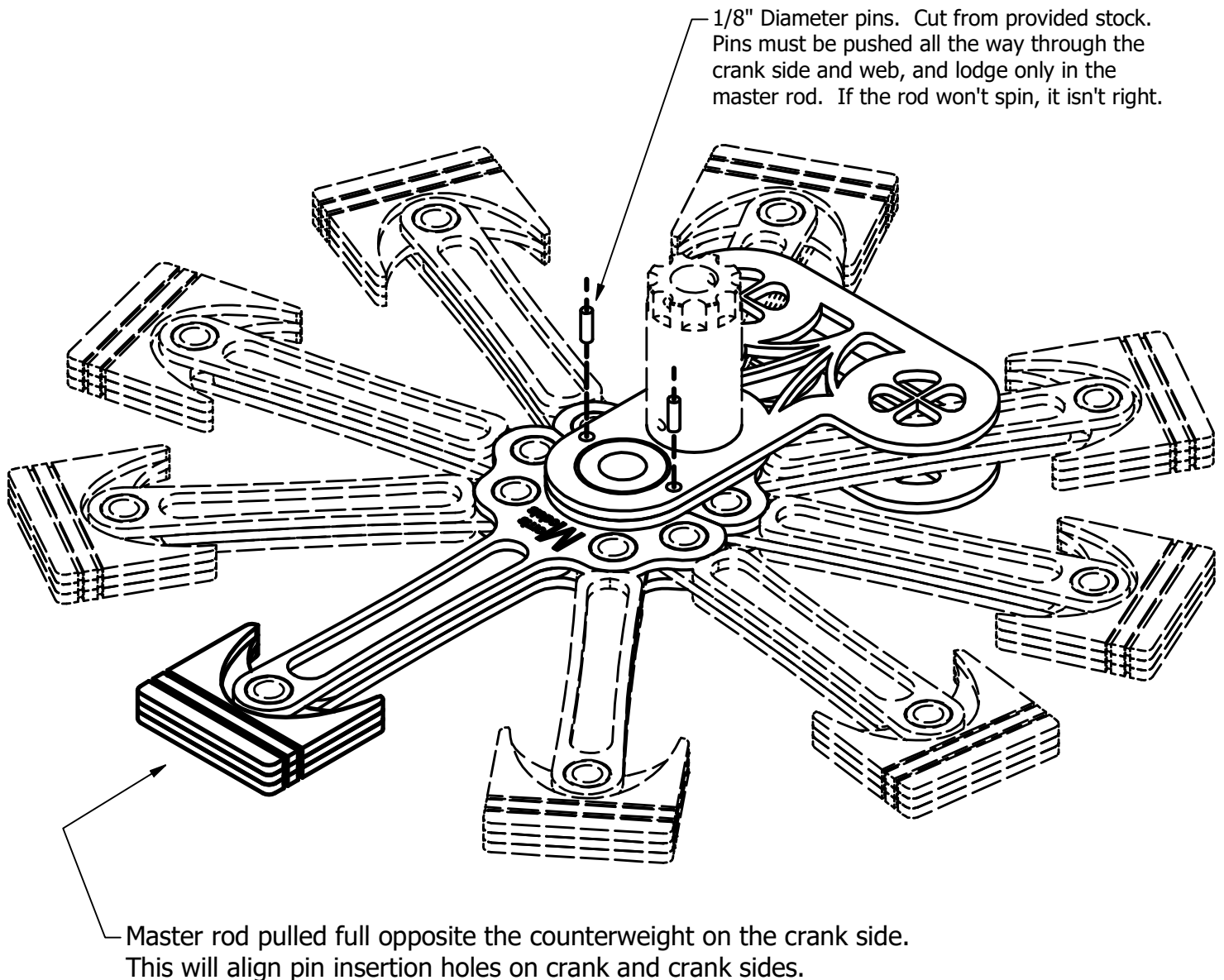
# Assemble Rotating Assembly

## Installing the Rods on the Crank

For the master rod to go onto the crank either the crank must split or the master rod must split. Different engines handle this different ways. In this model, the master rod splits into two parts which are pinned in place over the crank. This is why there are pin insertion holes in the crank sides and webs.

Before attaching the master rod to the crank, it is a good idea to wax the surfaces. Since nothing further will be glued to any part of either assembly, you may wax anywhere that you feel is important.

Begin the assembly by cutting two lengths of 1/8 inch dowel rod into sections that are just a tiny bit shorter than the three layer thickness of the master rods. Assemble the two halves of the rotating assembly, and pin them together with these pins - preferably doing a test fit not attached to the crank before assembling on the crank. It is not recommended to glue the pins in place. Should you need to split the master rod at a later date, align the pins with the pin alignment holes and press them back out.





## Section 2 - The Cylinders (9 Required)

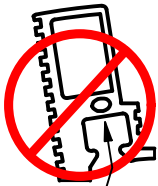


The cylinders are probably the most tedious part of the assembly process. This is partly because of the huge number of fins required, and partly because you need to make nine of them. As with all the other parts of the model, careful assembly is key to smooth operation and long life.

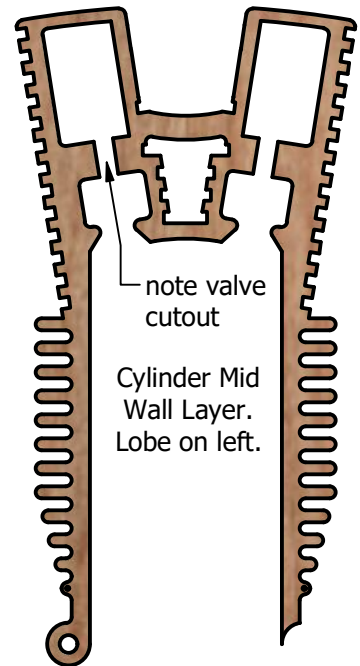
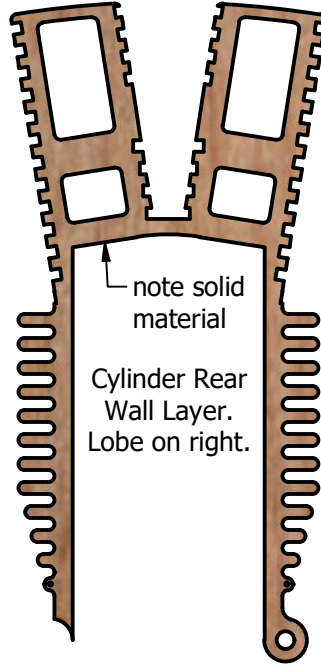
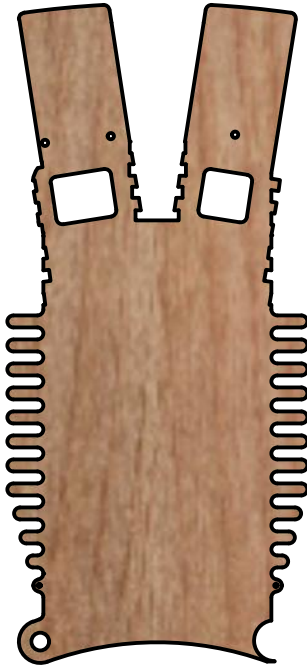
# Cylinder - Base Layers

## New Parts:

Cylinder Base. Lobe on left when top cylinder viewed from front of engine.



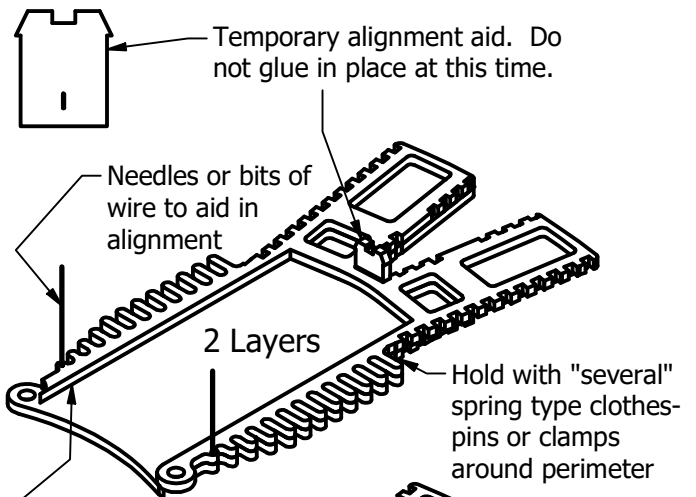
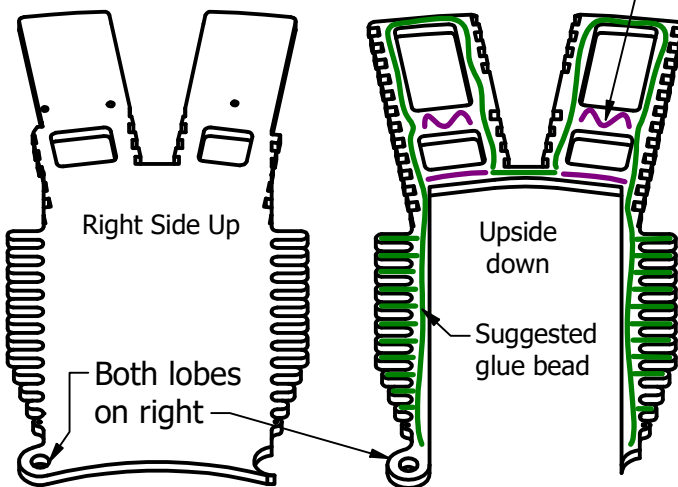
Careful: the layer with the oval hole is for a later step



## First Layer

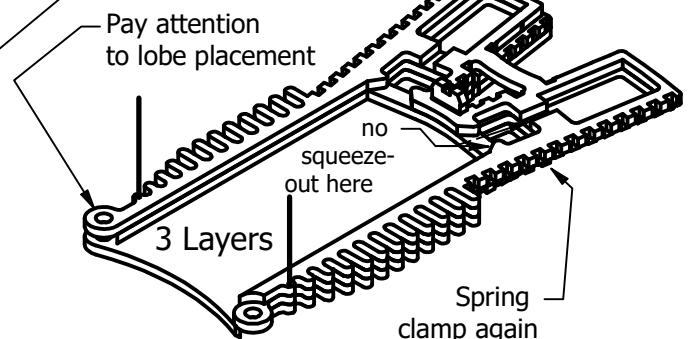
Set the cylinder base in front of you face up on the table as shown. Set the rear wall layer beside it, but upside down as shown. Apply light beads of glue to the face of the rear wall layer as shown, then invert it and glue it to the base. Use needles or appropriately sized bits of wire on the small alignment holes and temporarily install the "number 1" center fin to help you keep everything aligned. If there is glue squeezing out of the joint, you have used too much glue. Clamp the layers together with spring type clothespins or clamps, and set aside to dry. Remove your alignment pins and the fin before they are permanently glued in place.

Apply to the back side, but not to the front (4 places).



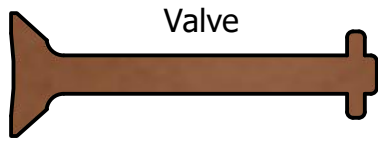
## Second Layer

In almost a repeat of the last step, spread thin beads of glue over the top of the rear wall layer (the part you just glued). The only differences are that 1) it will be a mirror image, because it isn't upside down any more and 2) you need to avoid the four areas shown in purple on the gluing diagram. Glue the next layer on.



# Cylinder - Captive Valves

## New Parts:



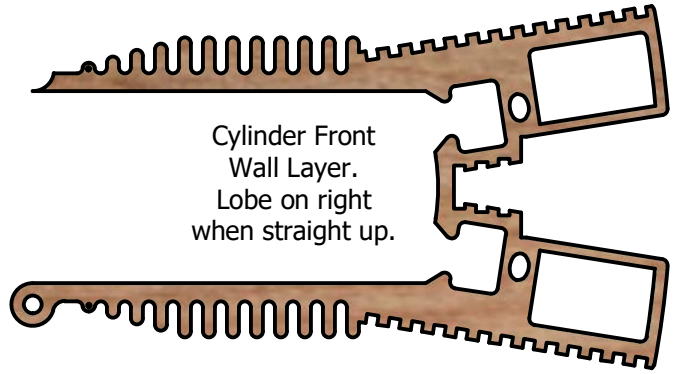
Valve

2 valves and 2 springs per cylinder. Note: intake and exhaust valves are identical on this model.

## Valve Spring



## Lower Interior Fin (#1)

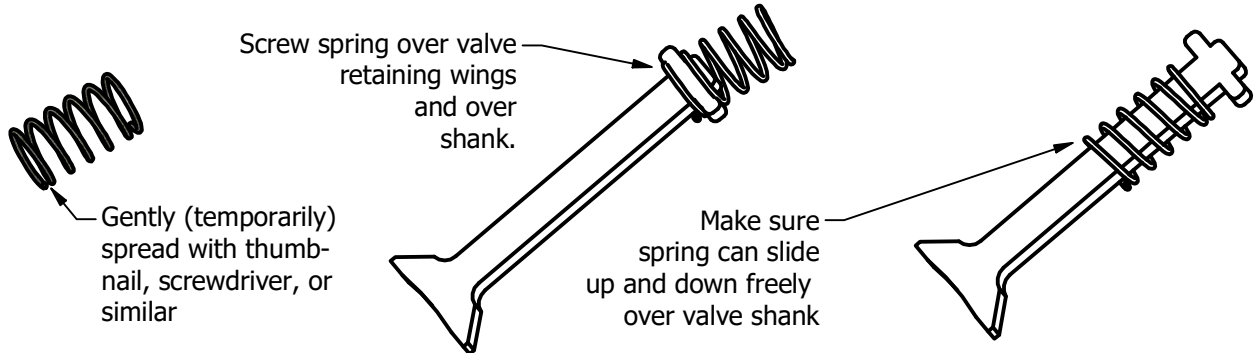


Cylinder Front Wall Layer.  
Lobe on right when straight up.

## Sand the Valves

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.

## Screw the Springs onto the Valves



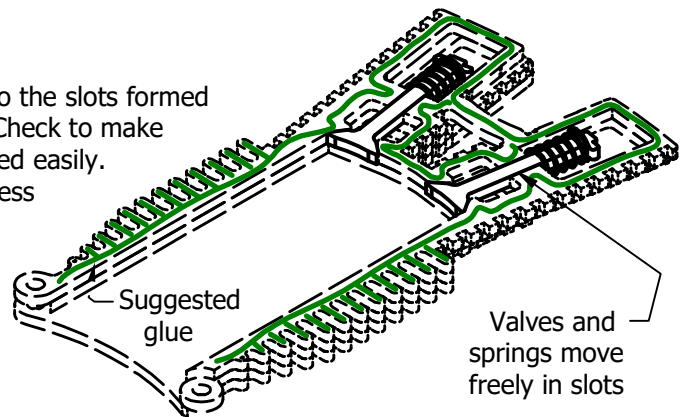
Screw spring over valve retaining wings and over shank.

Gently (temporarily) spread with thumb-nail, screwdriver, or similar

Make sure spring can slide up and down freely over valve shank

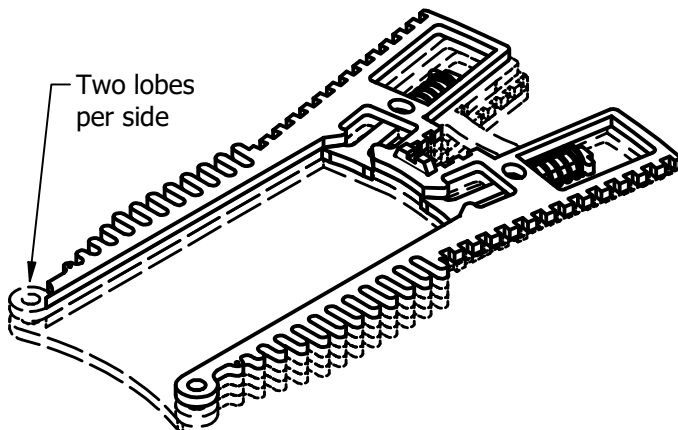
## Set the Valves into the Guide Slots

Gently compress the springs and then place the valves into the slots formed by the middle valve layer you installed on the last page. Check to make sure the valve opens easily, and the spring can pull it closed easily. Temporarily place the upper valve layer into place, and press it down firmly over the valves. The valves should still move easily. If they do not, remove the spring and sand some more.



Suggested glue

Valves and springs move freely in slots



Two lobes per side

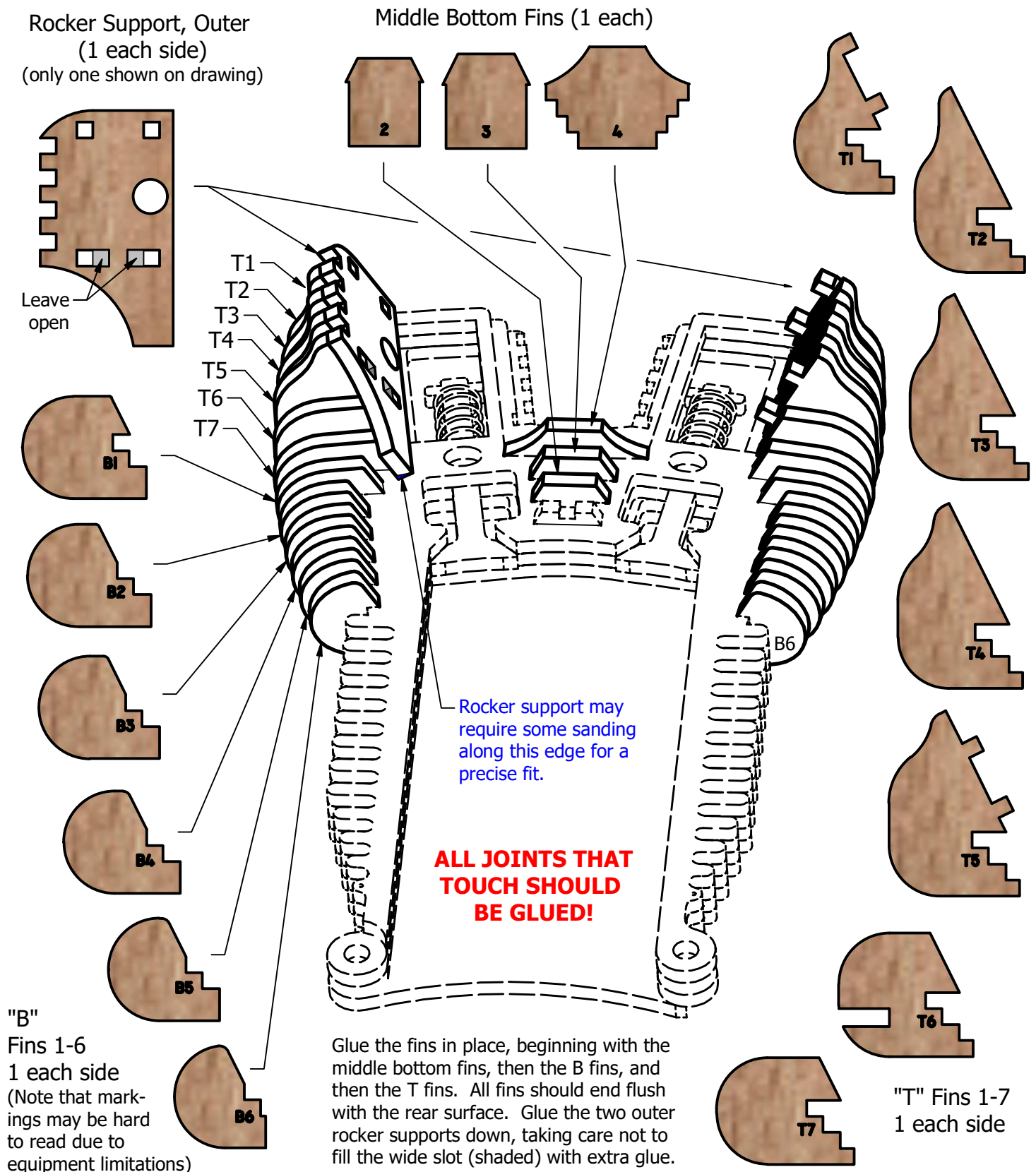
## Glue Down Cylinder Front Wall Layer

In the now familiar manner, lay light beads of glue as shown above, and glue the next layer over the top, being careful to maintain alignment. This time, you should glue the alignment fin in place. Clamp with clothespins or spring clamps. Make sure there is no squeeze-out. Check valve movement one more time, then set aside to dry.

# Cylinder - Fins

New parts shown full sized and arranged around drawing.

*It would be wise to dry fit all the parts before gluing the first time you assemble a cylinder.*





# Cylinder - Rocker Arms and Housings

*Dry fit all the parts before gluing the first time you assemble a cylinder.*

## New Parts:



Rocker Arm,  
Center x2



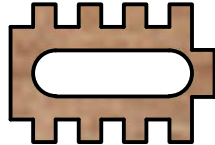
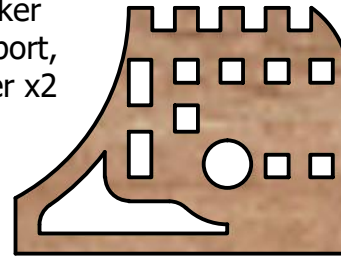
Rocker Arm,  
Spacer x4



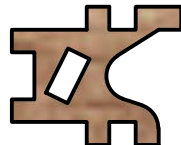
Rocker Arm,  
Shaft x2

Note rounded edge. A similar part is used in the blower, but has faceted edge (see 3-4).

Rocker  
Support,  
Inner x2



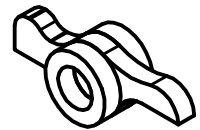
Rocker Tower,  
Front x2



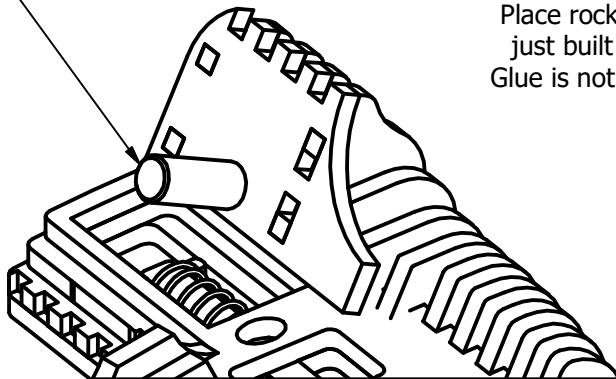
Pushrod,  
Guide x2

- 1) Use the rocker arm shaft to help you glue one spacer to each side of the rocker arm centers. Make sure the rocker arms don't get glued to the shaft. Remove the shaft, and allow to dry. You will need two completed rocker arms per cylinder.

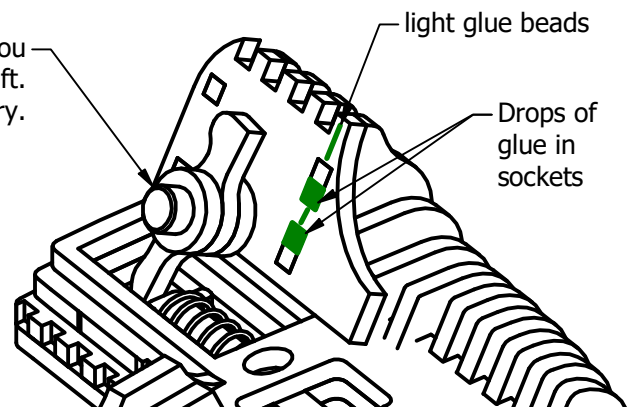
## Build Two



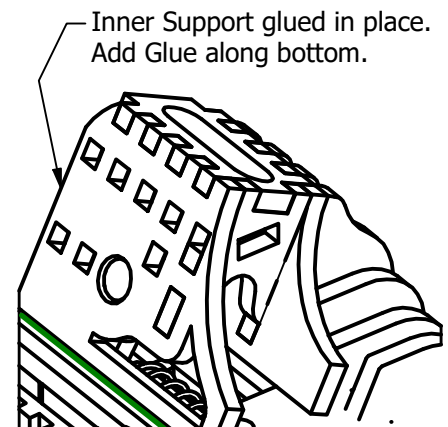
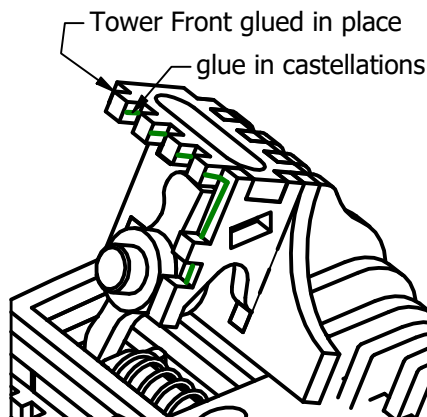
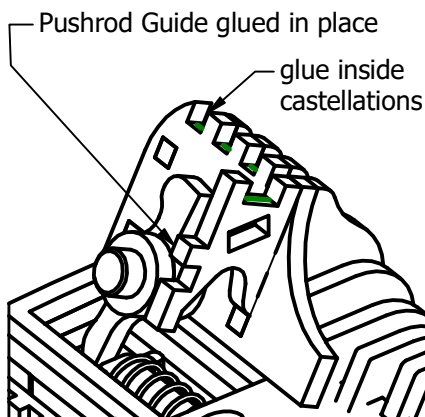
Insert Rocker Arm shaft into socket. Glue is not required.



Place rocker arm you just built over shaft. Glue is not necessary.

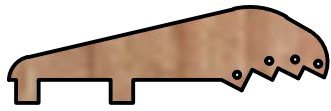


- 2) Build the rocker towers that contain the rocker arms. These are symmetrical, and only one side is shown. You must build both sides. Begin by dropping the shaft in the hole of the outer rocker guide (upper left). Then, place the rocker arm over the shaft so that the thin end of the arm will push on top of the valve (upper right). No glue is needed for these steps. Next, add drops of glue in the two sockets shown and a thin bead of glue to the support face as shown on the lower left. Add the Pushrod Guide, making sure that the long side is towards the center of the piston and the slot is parallel with the back of the piston. Glue on the tower front and the other rocker supports as shown. Go on to the next step before the glue has a chance to dry.

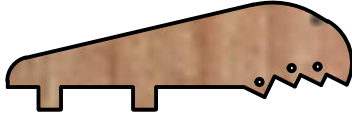


# Cylinder - Finish the Front

## New Parts:



Fin, Middle  
Top (4 dots) X2



Fin, Middle  
Top (3 dots) X2



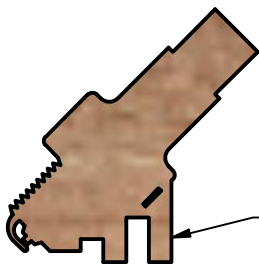
Fin, Middle  
Top (2 dots) X2



Fin, Middle  
Top (1 dots) X2



Fin, Middle  
Top (0 dots) X2



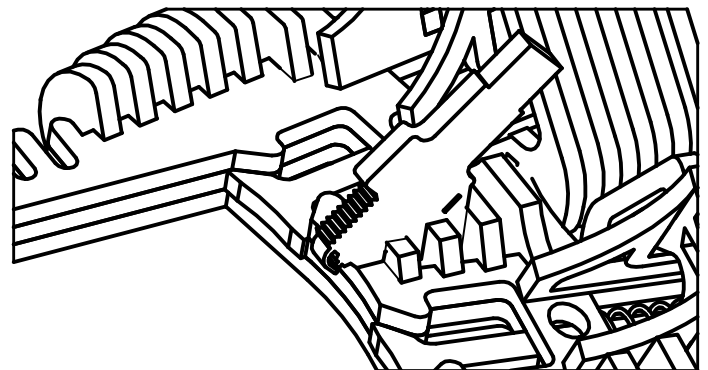
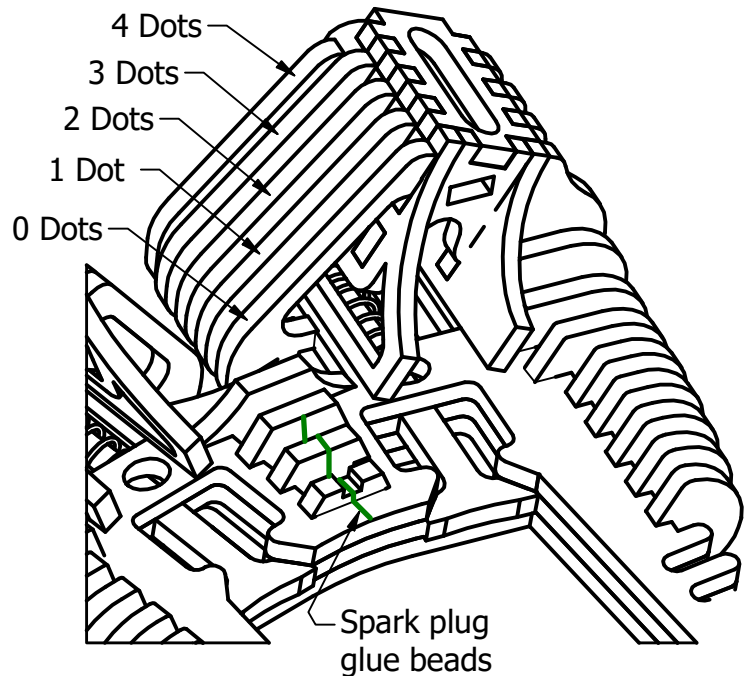
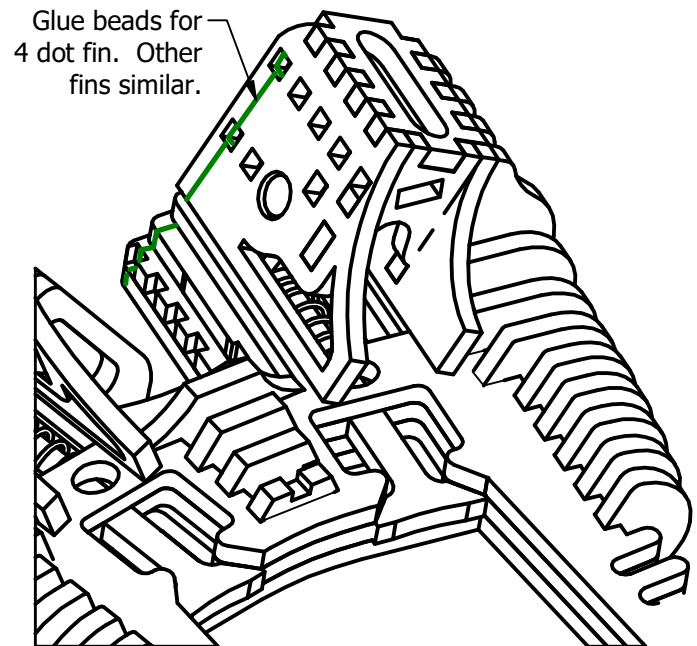
Spark Plug

mounting  
projections

Remember to dry fit your parts on your first time through before you glue them in place. Apply glue to the sockets and face of the tower support and the base of cylinders. Press the fins in place, using the sockets to help position them properly. They should press into position. Make sure they are glued securely, and that the sawtooth edges are at the rear of the cylinder. Do both sides - only one is shown.

The spark plug on this model is purely decorative. Apply glue as shown, and work the mounting projections of the spark plug down between the fins. The end of the spark plug should just hang over the edge into the cylinder as shown.

Allow all the glue to dry on the cylinder before continuing.



# Cylinder - Finish the Rear

## New Parts:

### Exhaust Pipe Sides

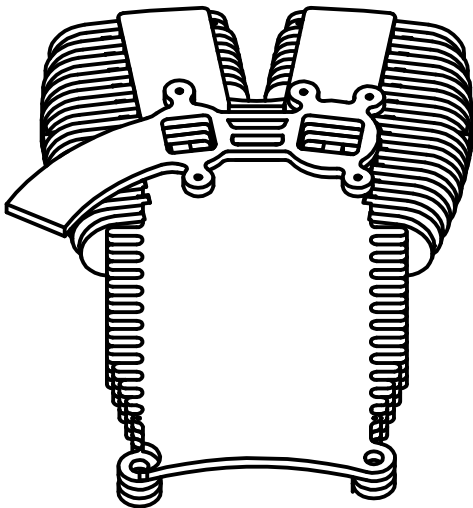
### Intake/Exhaust Mount

Exhaust Pipe  
Rear

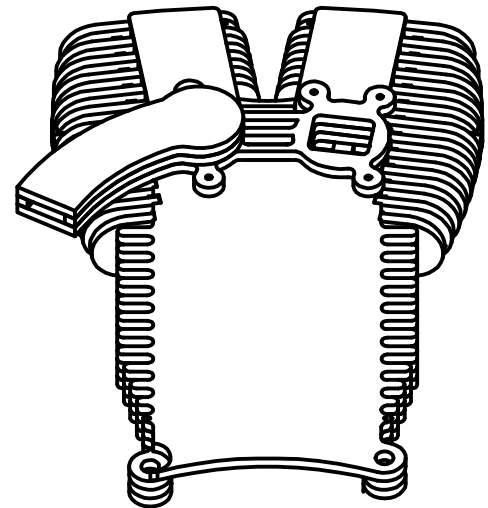
Intake  
Front

Intake  
Sides

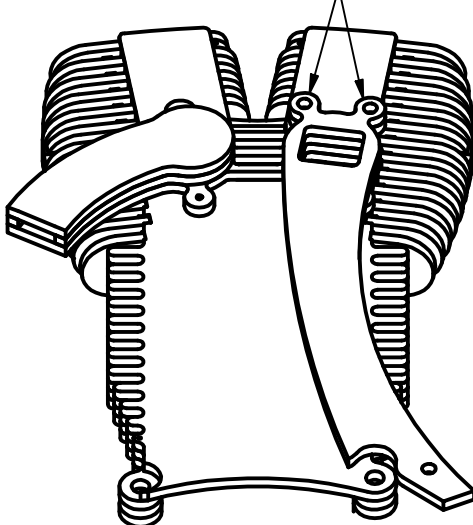
Intake  
Rear



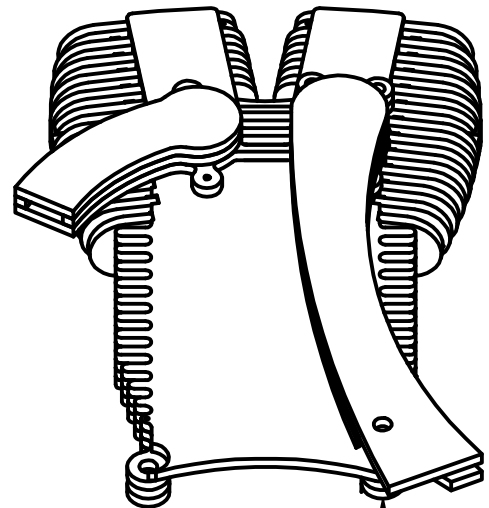
Turn the cylinder over, and glue the Intake/Exhaust mount to the back of the assembly. Use the small holes in the back of the cylinder and the intake/exhaust mount as well as the cutouts to guide you in positioning. The exhaust stack should face left as shown on the left. Glue on the walls and rear to form the exhaust pipe as shown on the right.



**DO NOT GLUE**



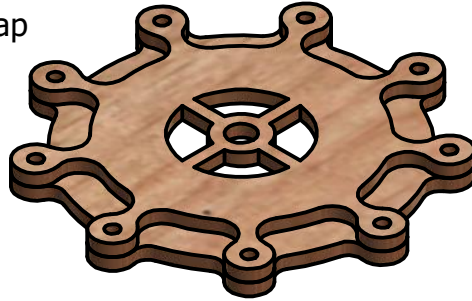
Build the intake runner from three layers as shown, but **DO NOT GLUE** it to the cylinder. It will be screwed on in a later step. Set the front part in position, curving towards the right. Glue the sides and the rear part onto the intake runner. Set aside both the cylinder and the intake runner for future use. If you have less than nine of these, go back to the start of this section and *do it again!*



Hole in intake runner lines up with cylinder mounting hole.

## Section 3 - The Rear Case

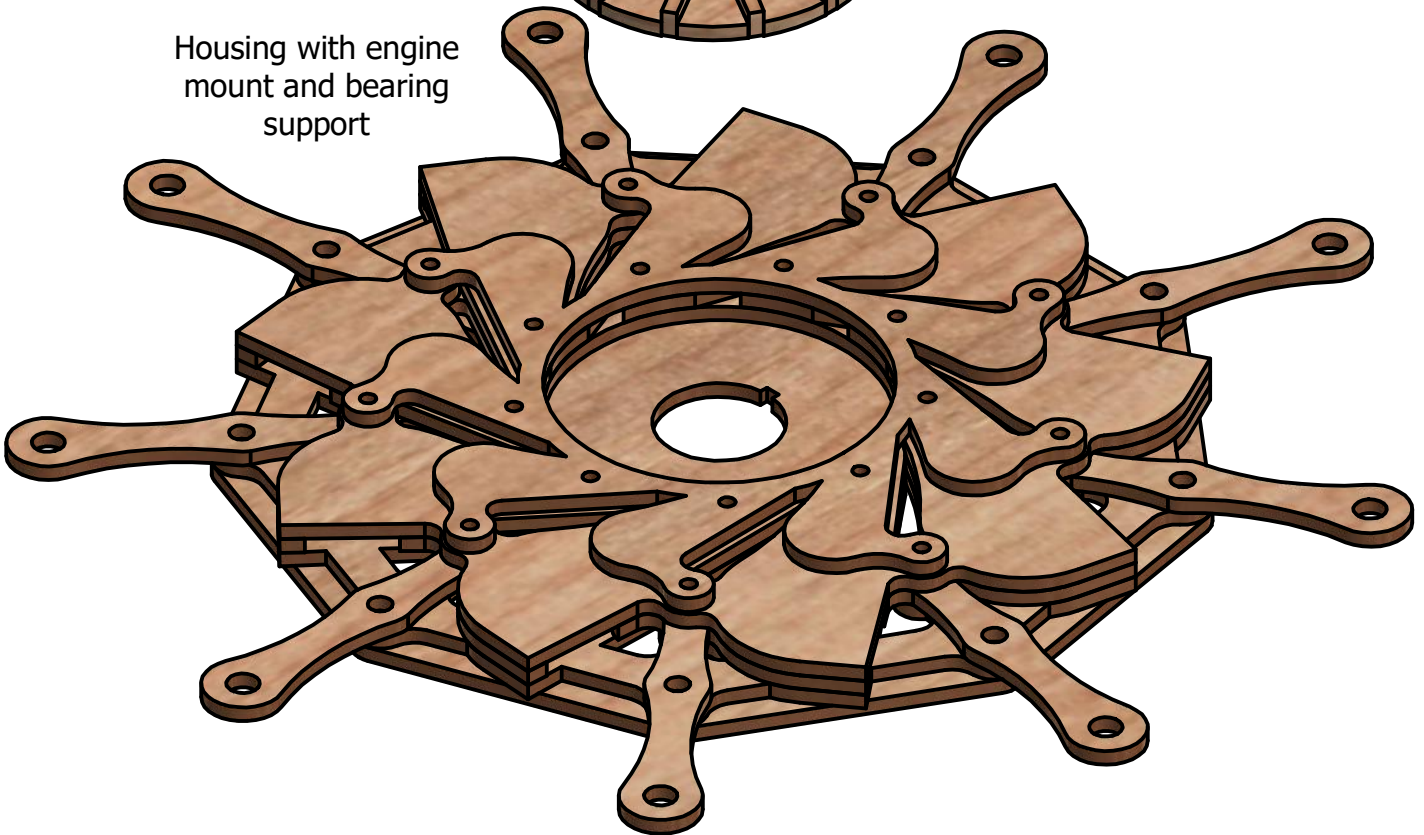
Rear Cap



Supercharger  
Impeller



Housing with engine  
mount and bearing  
support

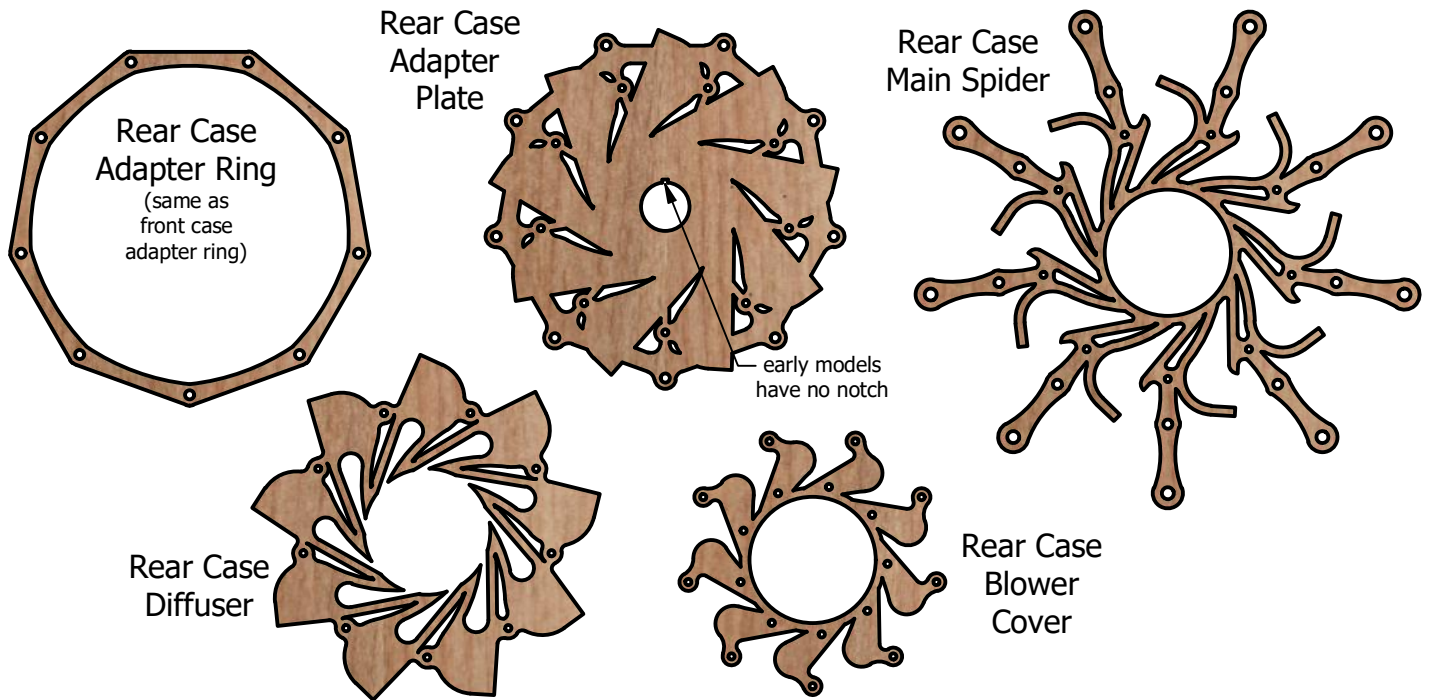


Real radial engines usually have a geared supercharger impeller. These typically spin at around 10 times the speed of the crankshaft. This model has a direct drive supercharger because of limitations with plywood gears. The accessory case on a genuine radial would also carry a base for magnetos, twin oil pumps (a big one to scavenge the the oil from the engine and a smaller one to feed the oil back to the engine), a carburetor, and any other accessories deemed important by the designer. In addition to its decorative functions, our accessory case serves as the rear support for the crankshaft. It is designed for disassembly, and will be screwed together in later steps.



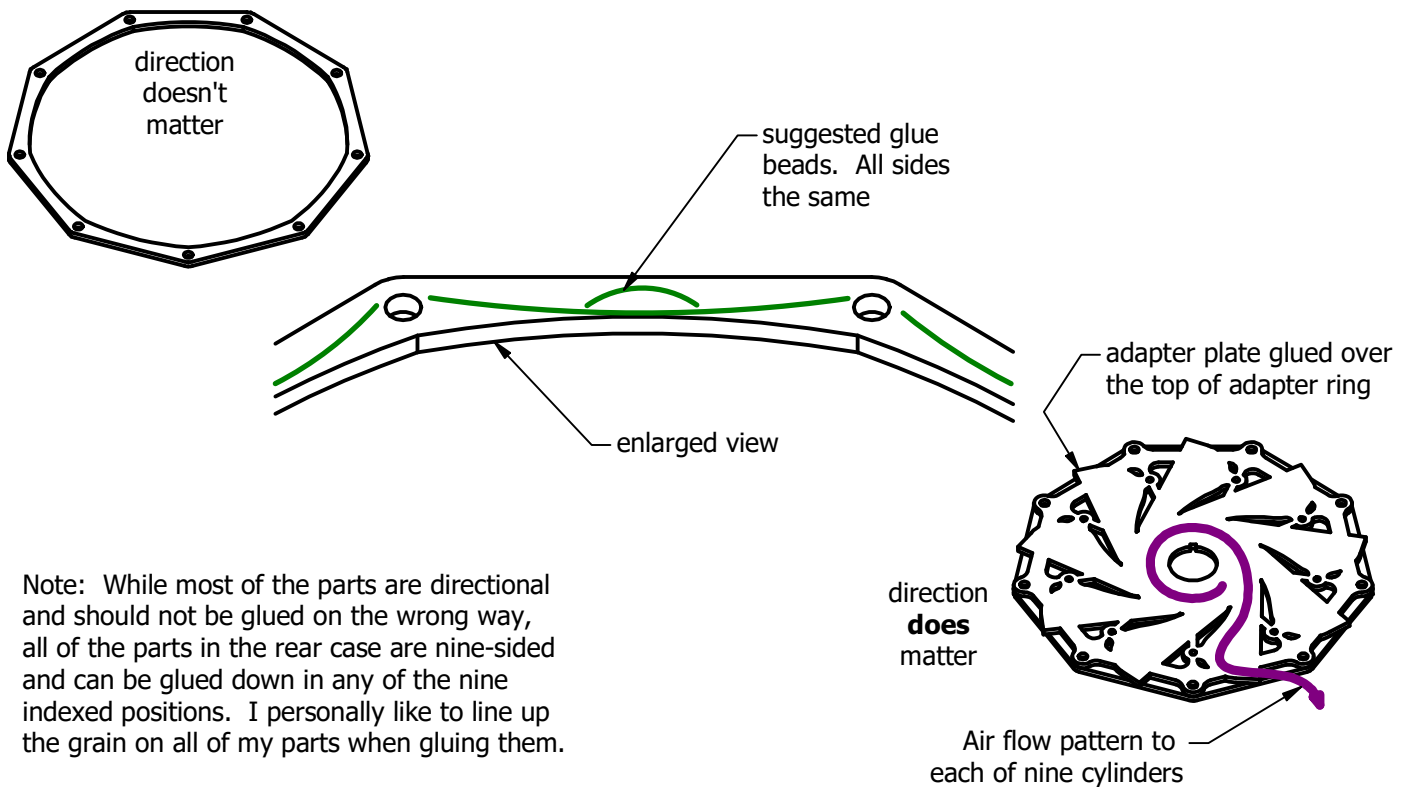
# Rear Case - Main Layers (1 of 2)

## New Parts:



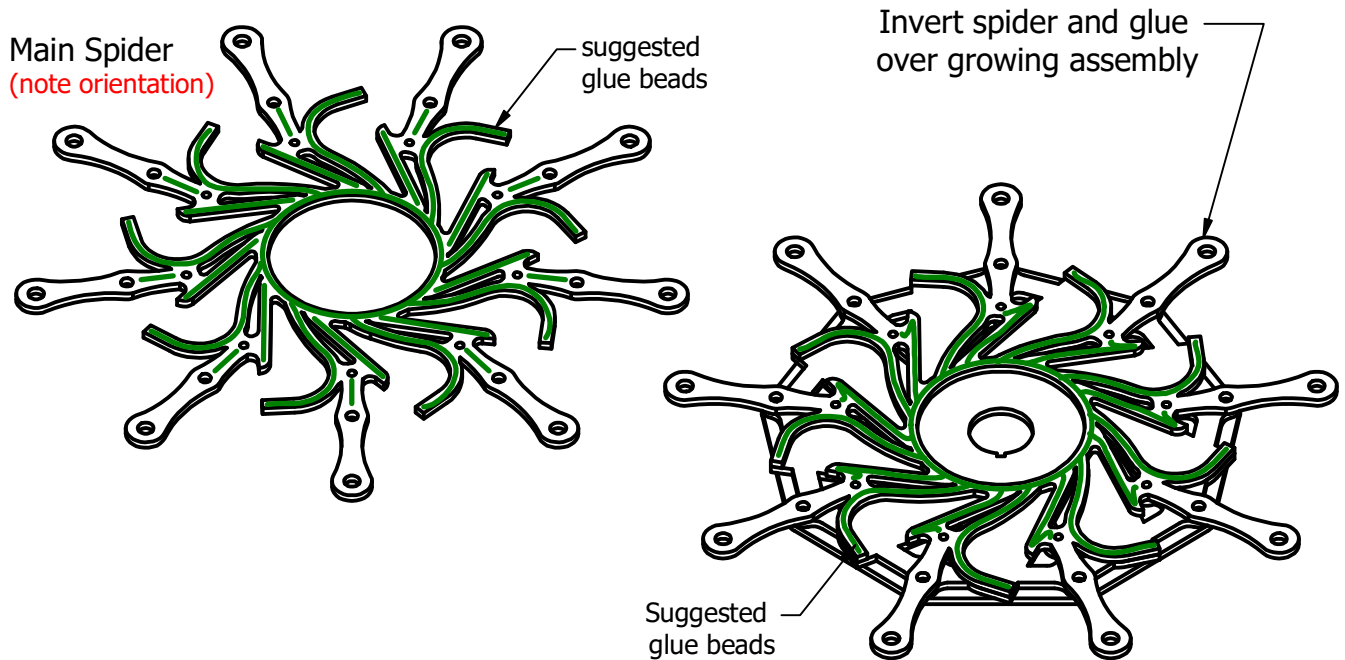
*These parts shown at 1/4 scale*

Pay careful attention as you assemble the rear case. Most of the parts are directional. The first three layers are best assembled over the 1/4" AN bolts that will eventually hold the entire engine together. Thread all nine of these bolts through the holes in the case adapter ring. Set the ring down in front of you with the threaded part of the bolts facing upwards (the bolts are not shown). Add thin beads of glue as shown, and glue on the adapter plate.

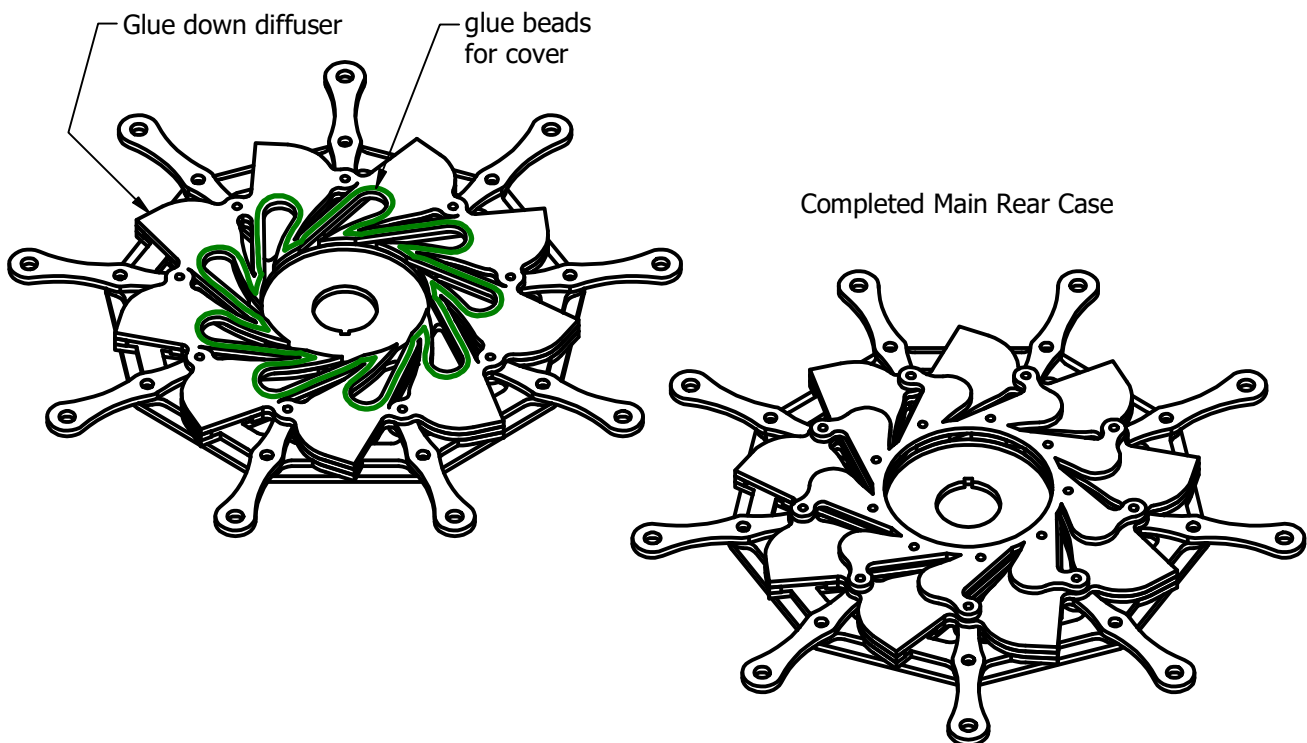


Note: While most of the parts are directional and should not be glued on the wrong way, all of the parts in the rear case are nine-sided and can be glued down in any of the nine indexed positions. I personally like to line up the grain on all of my parts when gluing them.

## Rear Case - Main Layers (2 of 2)

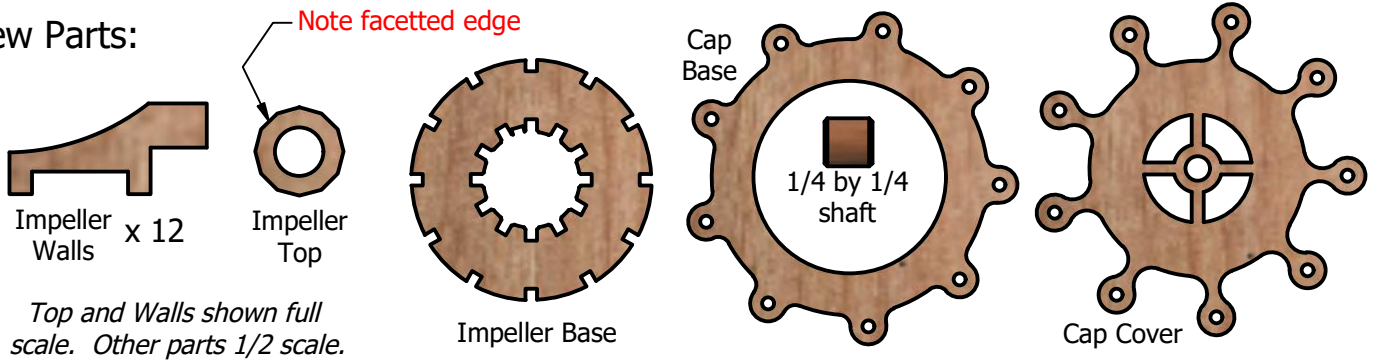


Invert the spider (note orientation shown) and add glue to its face as shown. Turn it back over, and place it over the bolt threads on your growing assembly (bolts still not shown). Add glue over the top of the layer, again as shown. Add the diffuser, paying attention to its direction. Use 1/8 inch alignment pins in the small holes to aid in alignment. Spread beads around the holes in the diffuser as shown, and then complete the assembly by gluing down the cap. Set the assembly aside to dry.



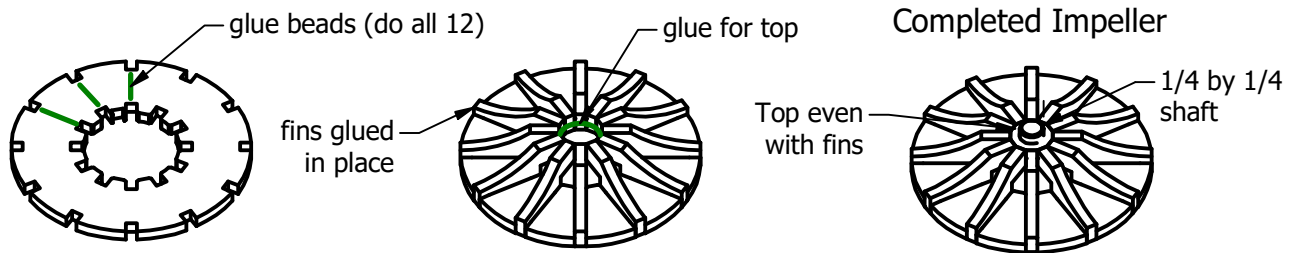
# Rear Case - Impeller and Cap

## New Parts:



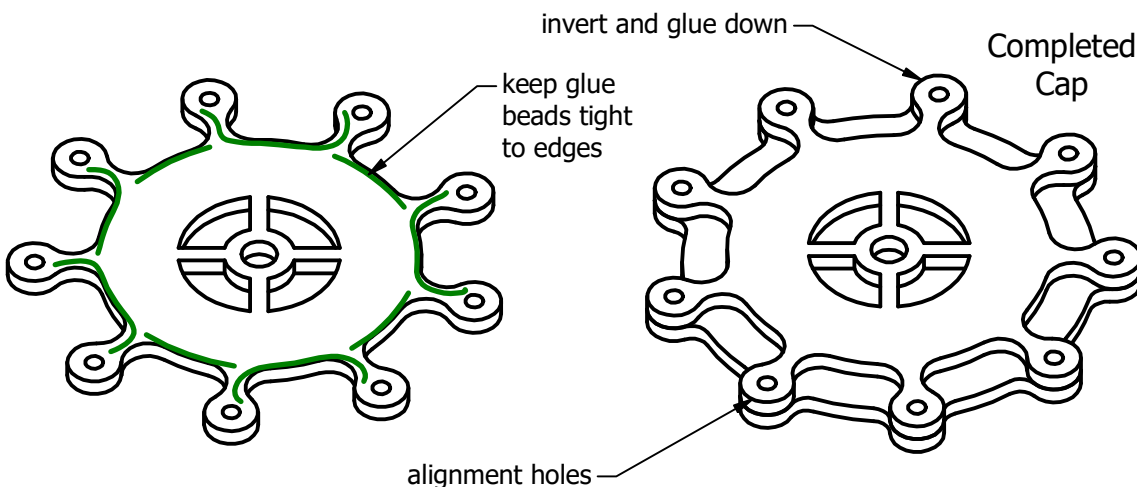
## Assemble Impeller

The impeller assembly should be largely self-explanatory. Add beads of glue for each wall (or fin), and glue them onto the base. It does not matter which side of the base you glue them to. Place dots of glue at the top corner of each fin, and glue the top into position. It may be easier to let this dry while sitting upside down on a table or other firm surface. Glue 1/4 by 1/4 inch shaft into top, extending half-way. Allow to dry.

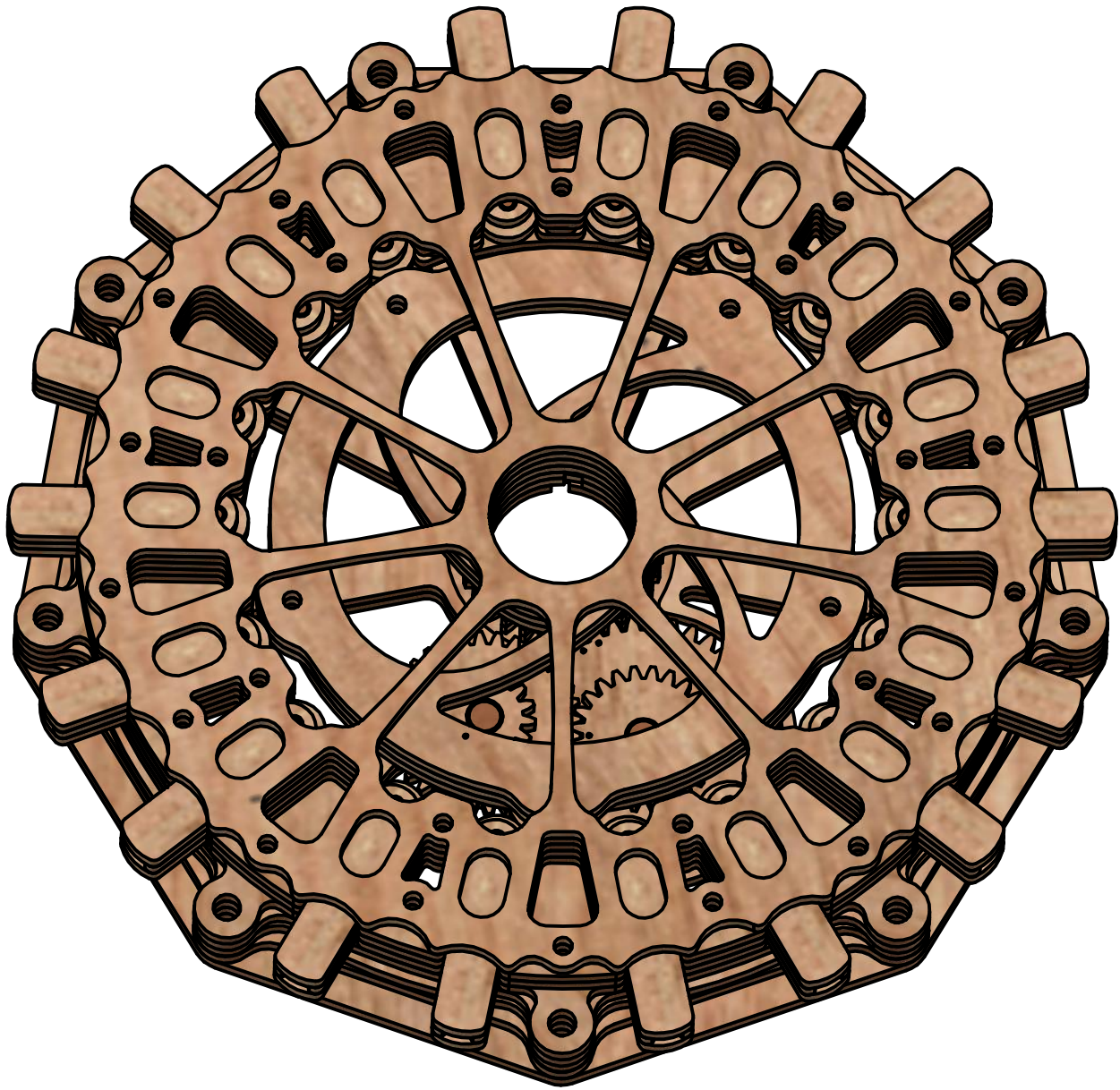


## Assemble Cap

The cap is even simpler than the impeller. Glue the cap cover over the base, using 1/8 inch alignment pins to aid in alignment. It is easiest to add the glue to the back of the cap before gluing rather than the front of the base. Suggested glue placement is shown below. Allow assembly to dry.



## Section 4 - The Valve Case



The valve case is where the magic happens. Our models contains a 10:1 gear reduction through two sets of pinion gears to drive a prograde cam plate (that means the cam plate spins the same direction as the crankshaft). 18 separate roller lifters are constructed and used, so there are a lot of parts to be assembled in this section. Please be very careful not to allow any glue squeeze-out into the lifter channels and be very careful about sanding parts thinner as these will be the keys to a smooth-running model.



# Valve Case - Roller Lifters

*Parts and Procedure are "Per Lifter." You will need 18 lifters.*

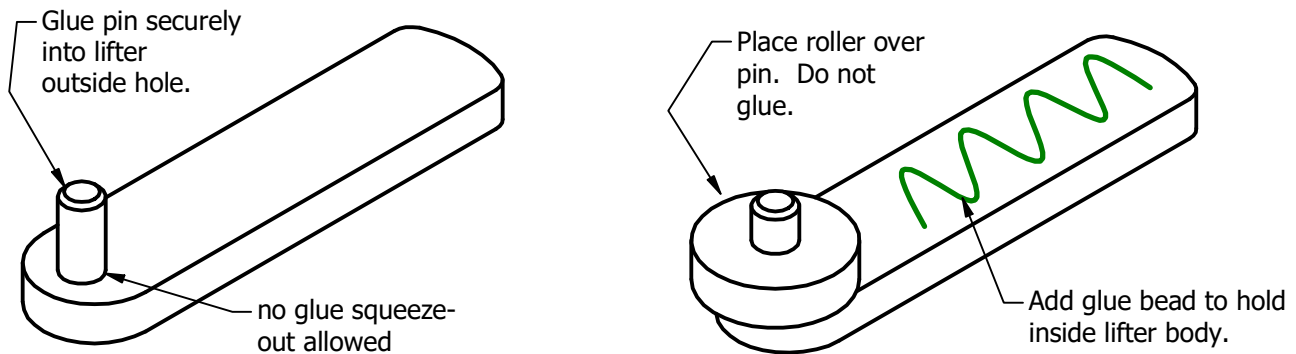
parts shown full scale

## New Parts:



## Part Preparation

Deburr all edges and lightly sand plywood parts. Cut 3/8" long shafts from provided 1/8 inch dowel stock. Sand one face of the lifter rollers and the outside lifter bodies enough to allow them to roll and slide easily when assembled. They should be about 1/64th inch thinner (0.5 mm thinner) than the other parts when you are done sanding them. Note that if any of the faces have smoke or engraving damage on them, sand material away from the less than perfect face, which can then be buried in the completed lifter assembly.

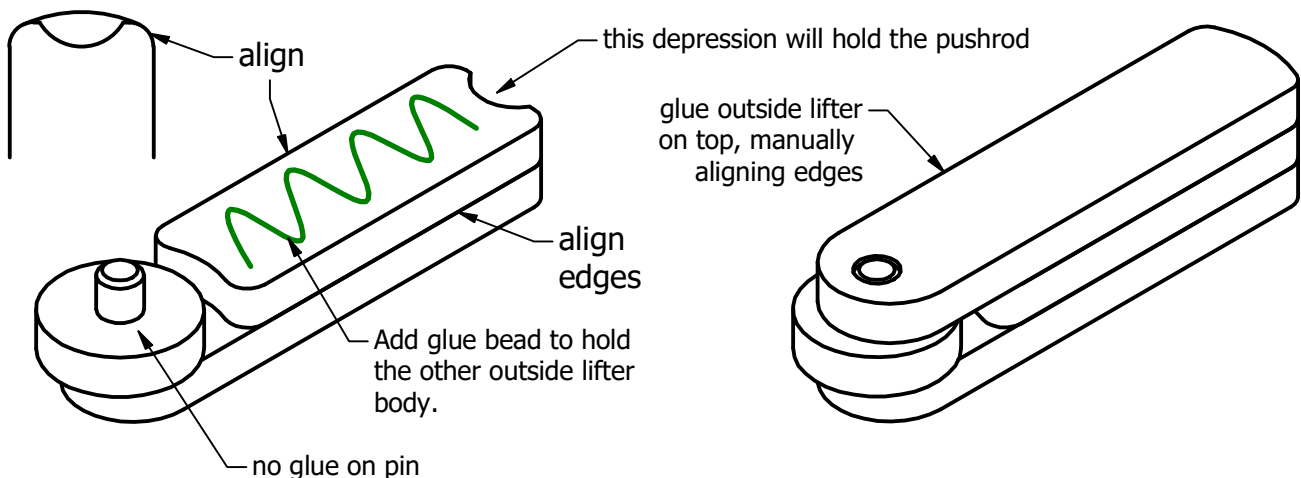


## Assemble Lifters

Glue the 3/8 long 1/8" shaft into the socket of one of the pre-thinned outside lifter bodies as shown in the upper left. Make sure there is absolutely no glue squeeze-out on the face of the lifter body. Place the pre-thinned roller over the shaft where it should be free to roll. Add a bead of glue as shown in the upper right, then add the lifter center (full thickness), manually aligning the sides and the top as shown in the lower left. Add another thin glue bead as shown, and glue the other pre-thinned lifter outside body on top of the assembly. Set aside to dry. Verify that the roller does indeed roll. You may wish to lightly sand the entire lifter body at this time.

**Build AT LEAST 18 lifters.**

## Top View



# Valve Case - Rear Section (1 of 2)

## New Parts:



Spacer  
Dot x8

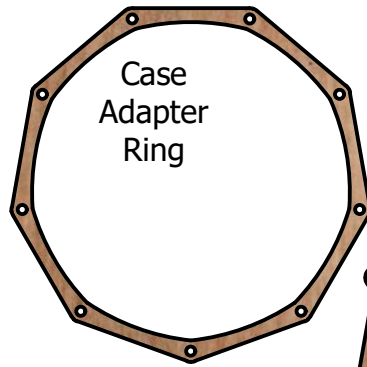


1/4 x 3/8  
shaft

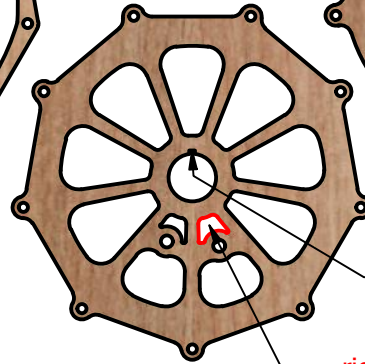


1/4 x 1/2  
shaft

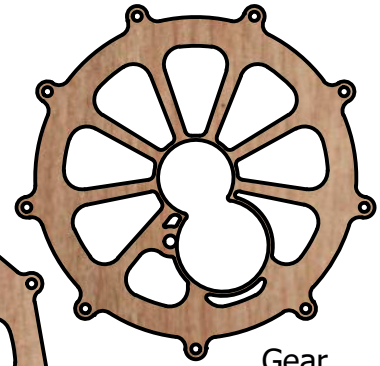
Dots and shafts are  
shown full size. Other  
parts are 1/4 scale.



Case  
Adapter  
Ring



Valve  
Case  
Adapter



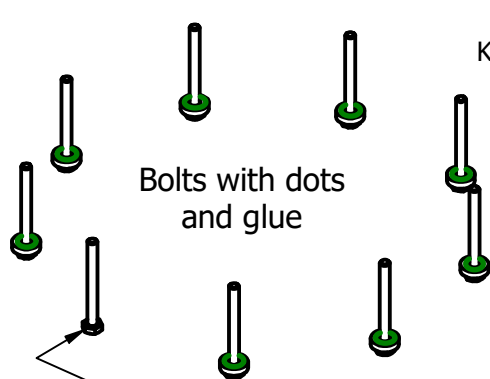
Gear  
Holder

**BEWARE: Both adapter  
and gear holder are  
asymmetrical, and  
both must be  
oriented correctly.**

early versions do  
not have notch

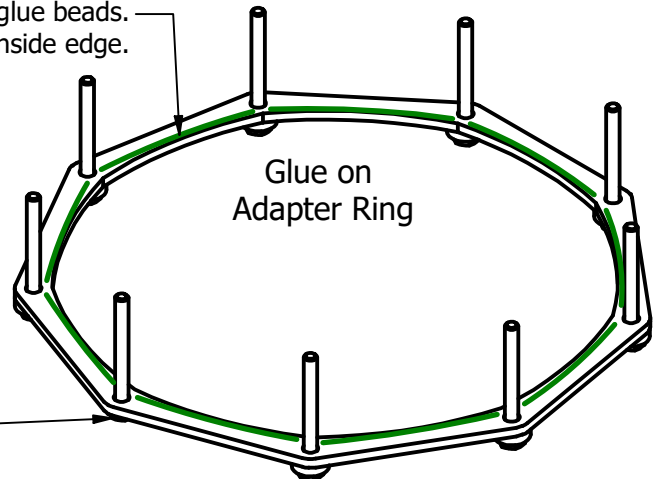
right side cutout a little  
larger than left side

Much like section 3, the valve case is easiest assembled using the through bolts as alignment aids. Set all nine of these bolts out on your work surface with the threads facing upwards. Place one spacer dot on each of the bolts except the bottom one. (You can add an extra one to the bottom one and not glue it on to keep your assembly level as you work.) Place small drops of glue on the dots in order to glue them to the adapter ring.



Bolts with dots  
and glue

Suggested glue beads.  
Keep close to inside edge.

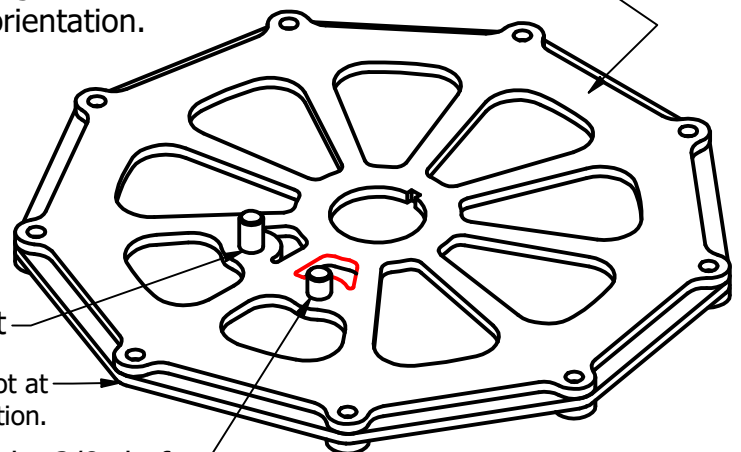


Glue on  
Adapter Ring

Bottom bolt does not have  
dot to glue to structure.

Glue the adapter ring over the top of the dots, and then add glue beads as shown. Keep them in close to the inside edge, as the adapter plate that goes on next is not as large as the ring. Glue the 3/8 gear shaft and the 1/2 gear shaft into their sockets as shown. Then glue the plate down over the bolts

Case adapter glued on.  
Note orientation.



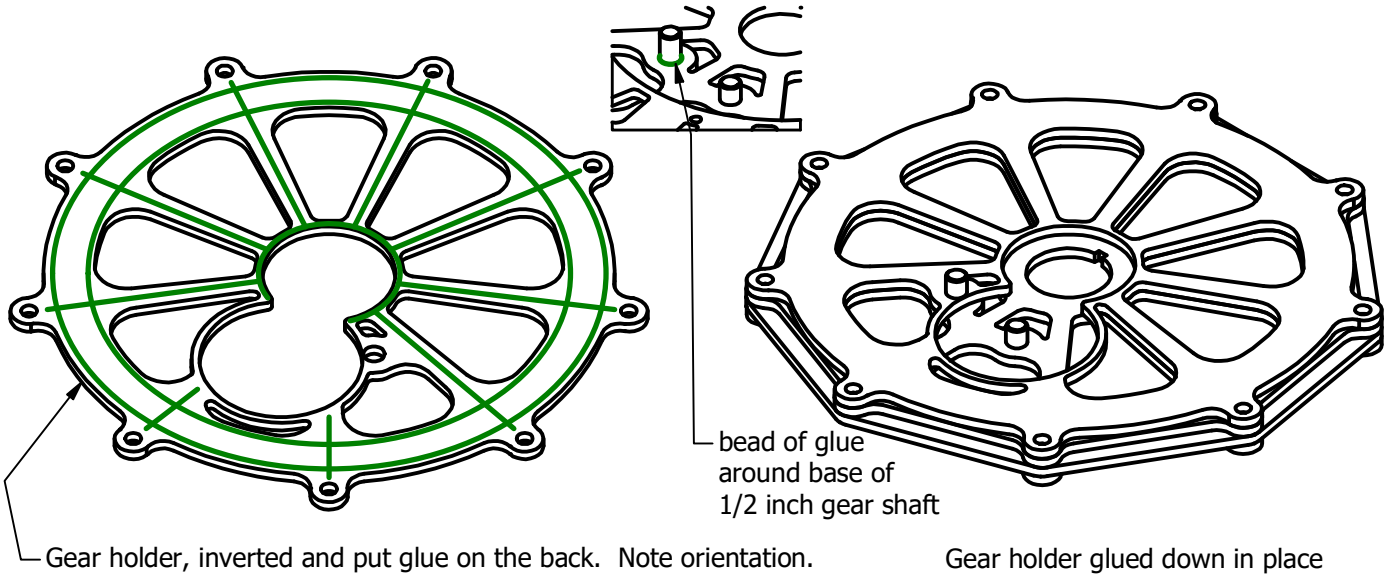
1/4 by 1/2 shaft

Shafts glued securely  
into adapter plate.  
Don't let them protrude  
out the back.

No dot at  
this location.

1/4 by 3/8 shaft

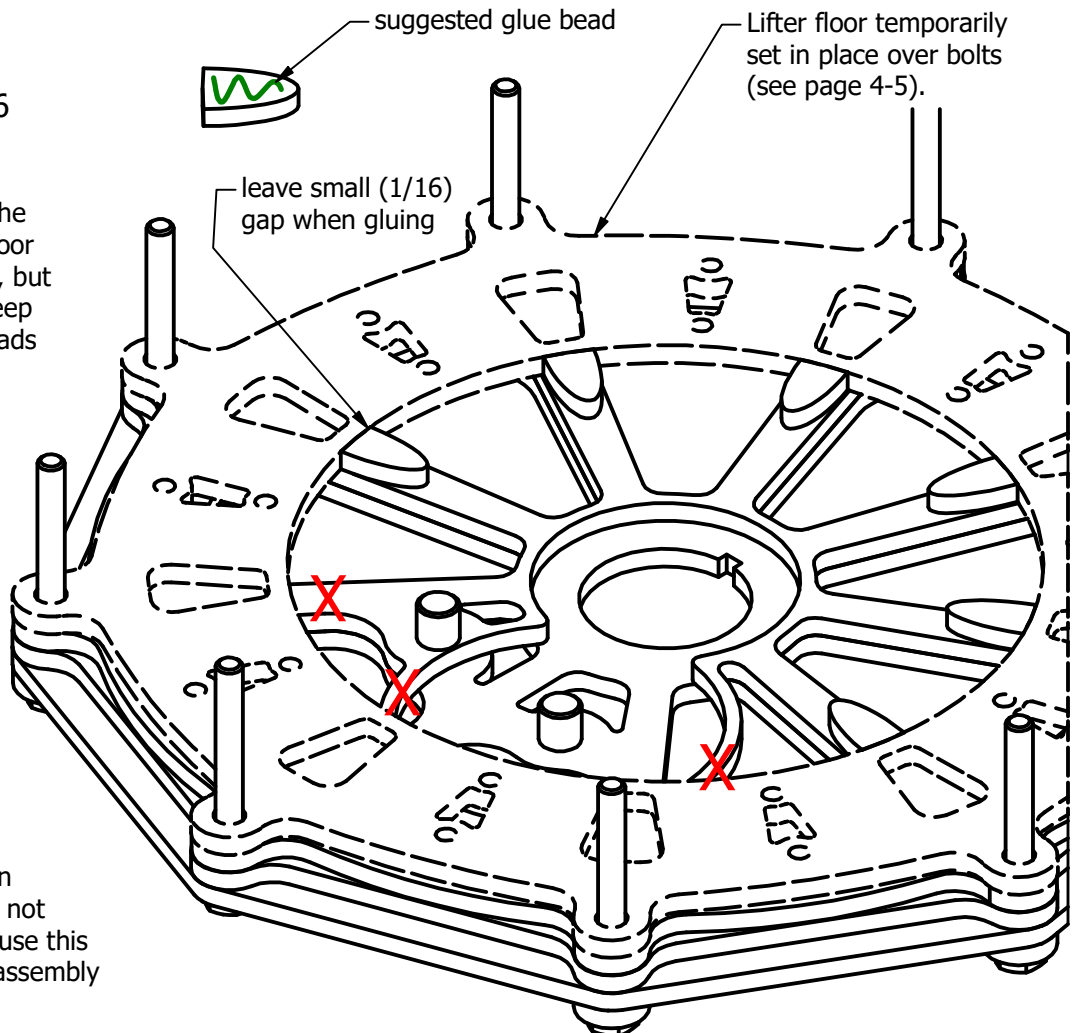
# Valve Case - Rear Section (2 of 2)



## New Parts:



The valve disk will run at the same height as the lifter floor (installed in the next step), but it must run straight. To keep it from tipping, stabilizer pads are added to the top six spokes. They are not added to the bottom three spokes, as they would interfere with the reduction gears. Temporarily fit the lifter floor in position over the bolts. Add glue to the stabilizers and glue them to the spokes shown. Leave a small (1/16 inch, 1 mm) gap between the edge of the lifter floor and the stabilizer pads. This will allow for easier assembly in later steps. (The pads are not part of the lifter floor because this would interfere with later assembly and disassembly).



# Valve Case - Front Section (1 of 2)

*Parts and Procedure are "Per Wall." You will need 9 of each wall.*

Lifter wall parts are shown full size.

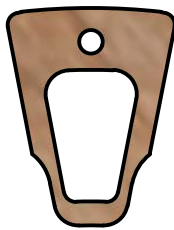
## New Parts:



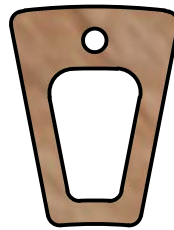
Lifter Wall  
Small Center



Lifter Wall <sup>x2</sup>  
Small Edges



Lifter Wall  
Large Center

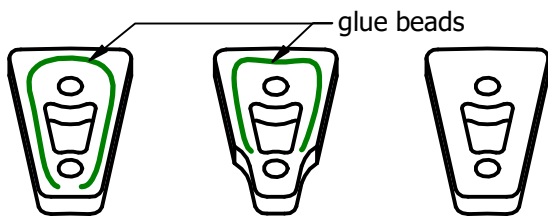


Lifter Wall  
Large Front



Lifter Wall  
Large Rear

## Small Lifter Walls

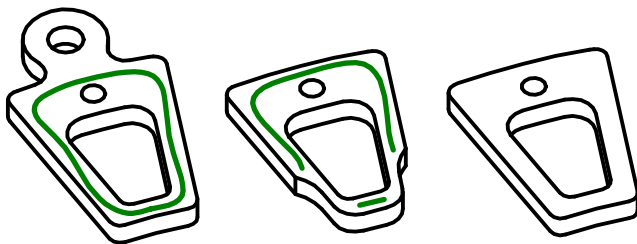


Assemble the small lifter walls over 1/8 inch alignment pins. Make sure you do not allow squeeze-out.

Build 9 of these.

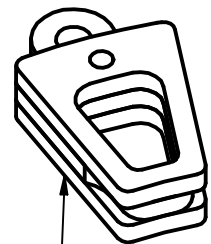


## Large Lifter Walls



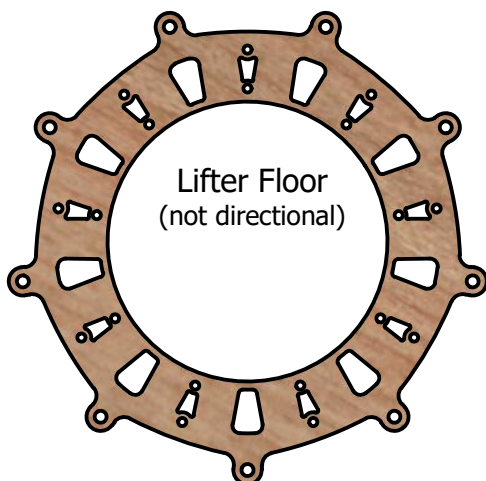
Assemble the large lifter walls over one 1/8 inch alignment pin. Make sure you do not allow squeeze-out. Make sure the walls are perfectly aligned.

Build 9 of these.



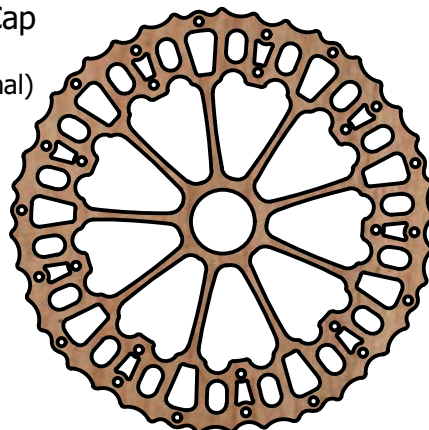
line up walls

## New Parts for next page:



Lifter Floor  
(not directional)

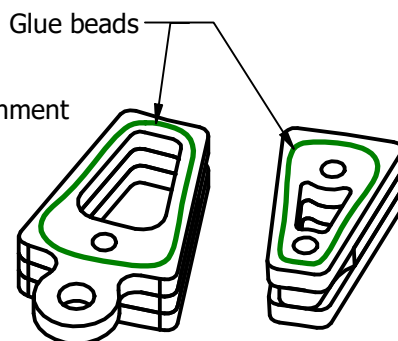
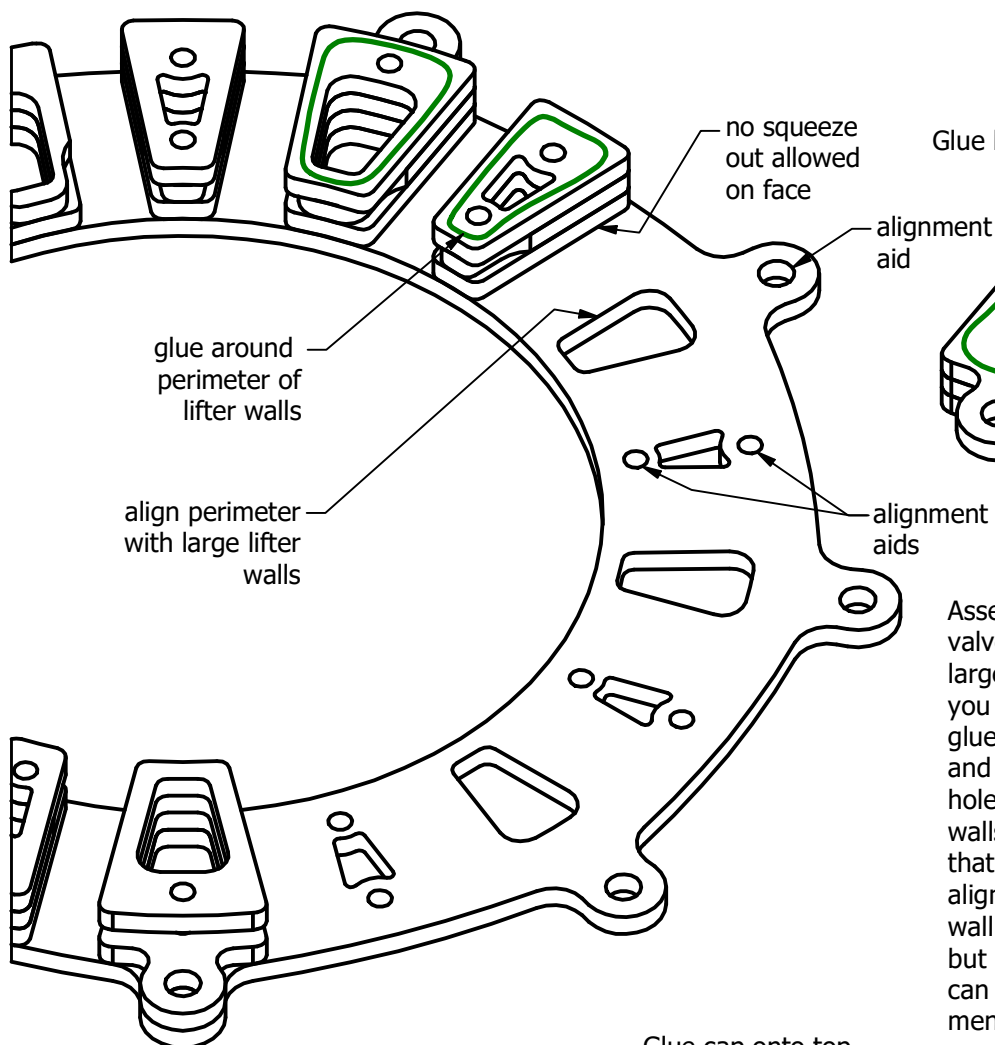
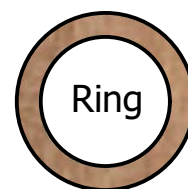
Lifter Cap  
(not directional)





# Valve Case - Front Section (2 of 2)

New Part:

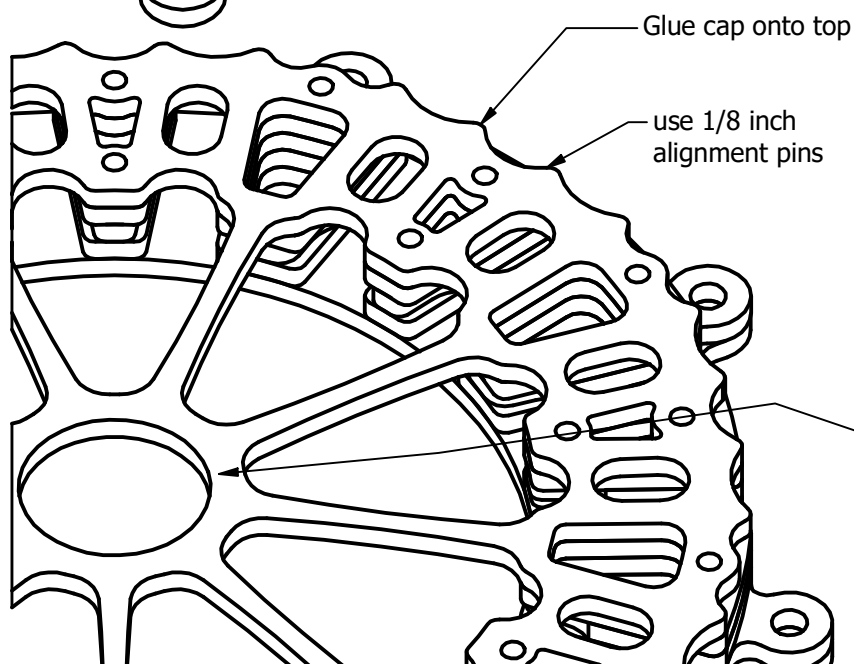


Assemble the front section of the valve case by gluing down alternate large and small lifter wall assemblies you built in the last step. Spread glue as shown above, then invert and glue down. Use the 1/4 inch holes to help you line up the large walls - but you will need to insure that the cutout in the lifter floor is aligned with the cutout in large lifter wall. The small lifter wall is similar, but it is easier to align because you can use two sets of 1/8 inch alignment pins. Make sure there is no squeeze-out. Gently fit a few of the lifter bodies into the slots made by the lifter walls. They should slide smoothly in and out.

Spread glue on top of the lifter walls (both types) and then glue the cap down on top of the assembly. Use 1/8 inch alignment pins while gluing this down. Keep these glue beads thin to make sure there will be no squeeze-out on top.

**NOT SHOWN:** glue the ring onto the front of the assembly. See page 5-5 for what this looks like.

Set assembly aside to dry.

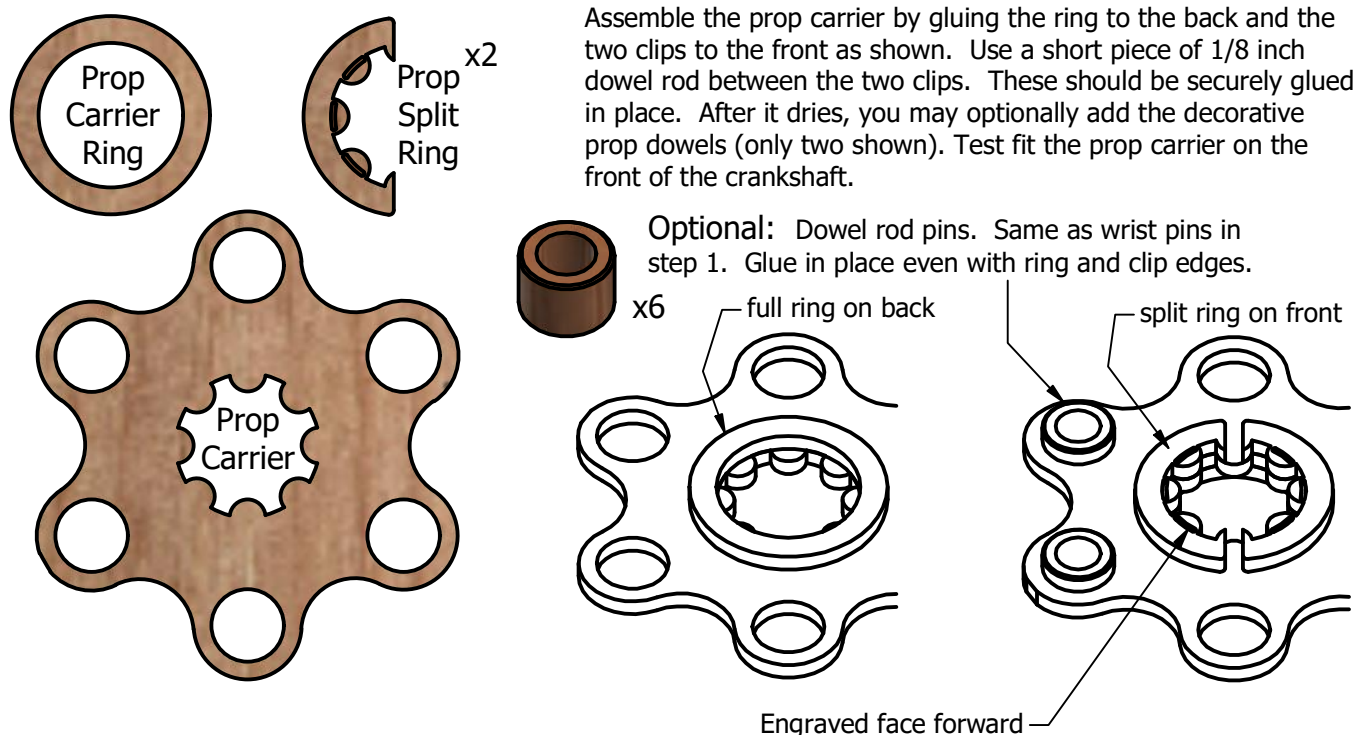
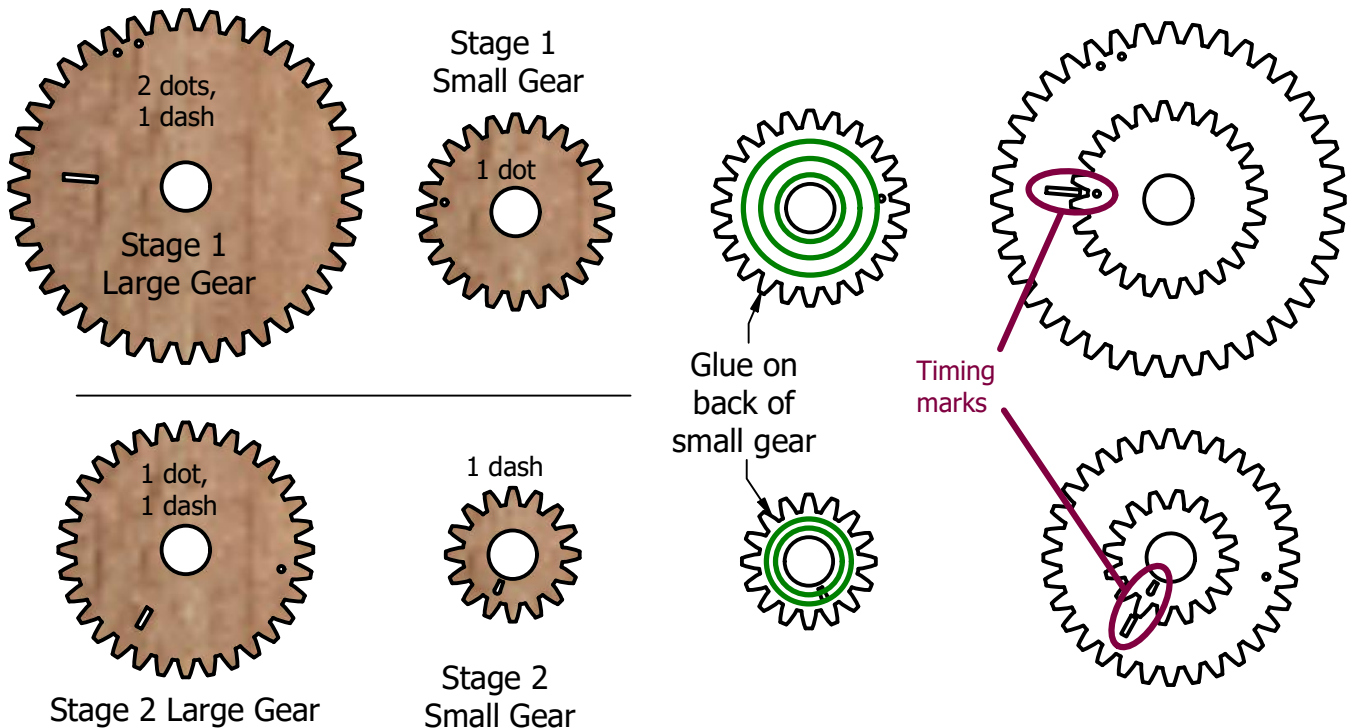


# Valve Case - Reduction Gears, Prop Carrier

The gears are, of course, highly critical. They need to run concentrically and cleanly. There should be more than one of each gear included. Select the best gears of each type to assemble into the timing reduction units. Assemble the timing reduction gears as shown below. Note that these gears are directional. Make sure to keep them aligned as shown. Since the timing marks go all the way through the gears, make sure that they are not reversed as you work. Also, make sure that there is no glue squeeze-out between the gear teeth of the small gears. Align the timing marks, and glue the gears together. Assemble over a 1/4 inch bolt or dowel rod.

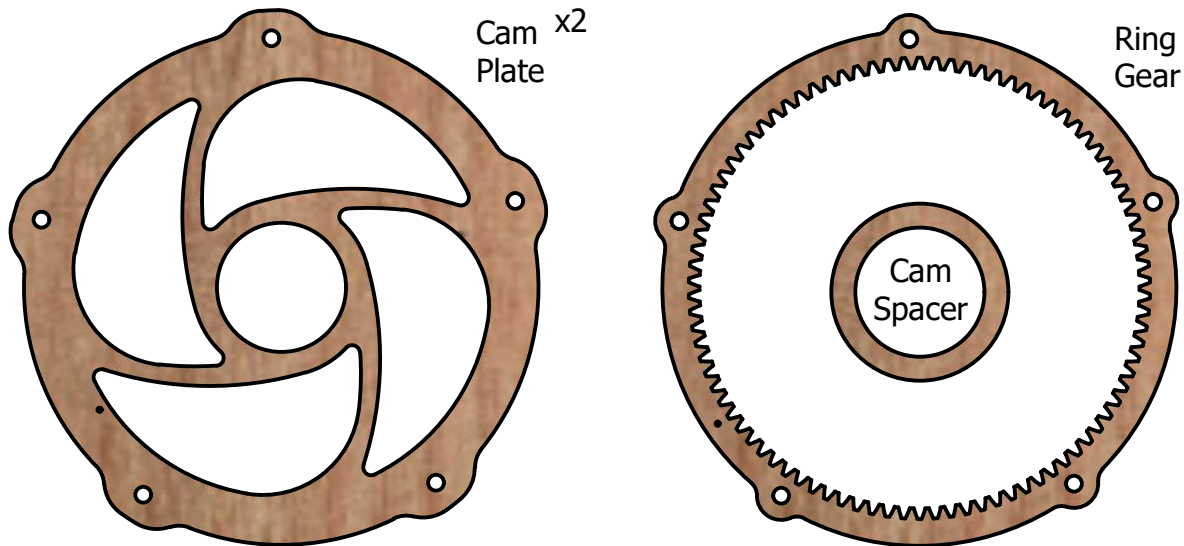
## New Parts:

All gear figures shown full sized.

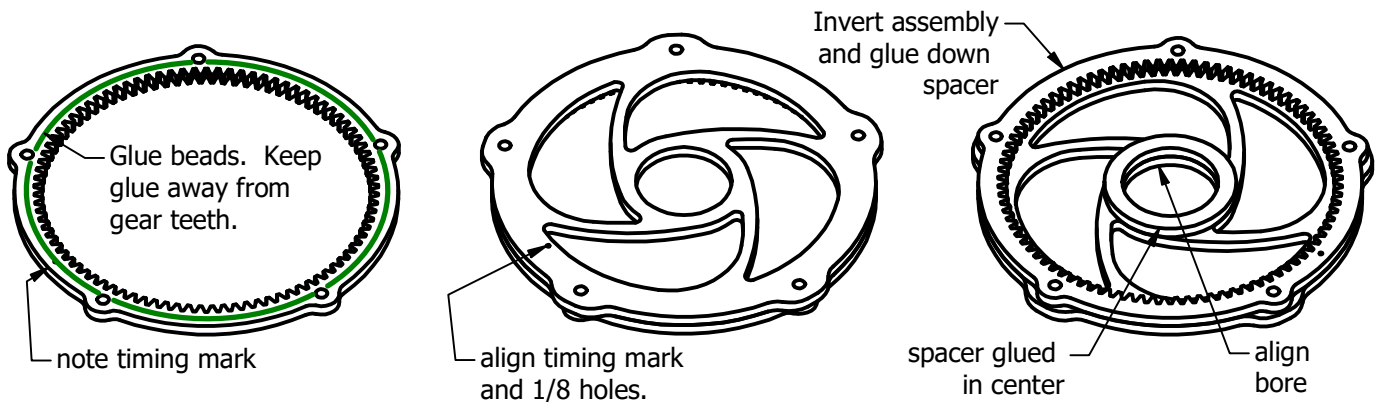


# Valve Case - Cam Plate

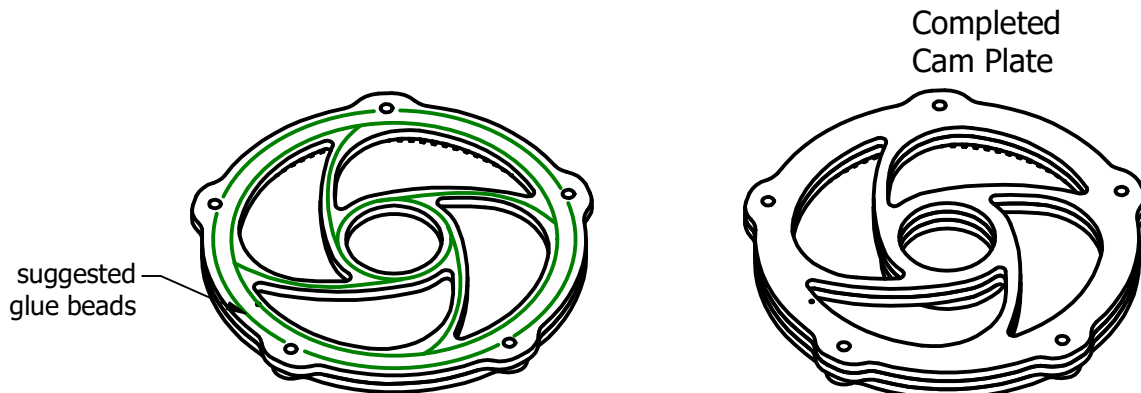
New Parts:



Parts are directional. Pay attention to timing marks. Parts shown 67% size.



Assemble the cam plate beginning with the ring gear. Spread glue beads, and glue down one of the cam plate layers. Make sure to align the timing marks. Use 1/8 alignment pins in the holes around the perimeter. Make sure to keep the orientation as shown, as the timing marks will be inaccurate if the cam plate is glued on incorrectly. Allow to dry. Invert the assembly and add the spacer to the bottom as shown. Allow to dry. Return the assembly to the upright position, and add the final cam plate layer, once again using the alignment holes and paying attention to the timing mark. Allow assembly to dry.

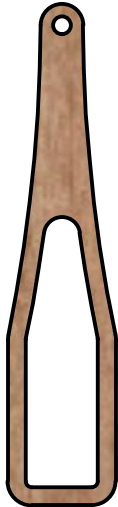


# Valve Case - Oil Pan

New Parts:

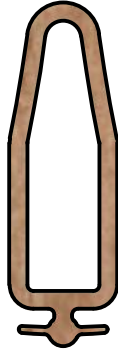


Oil Pan  
Front



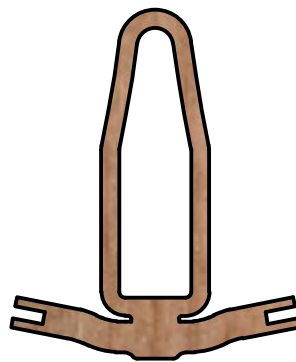
Oil Pan  
Hanger

Oil Pan  
Decorative  
Walls



1 of 2

Oil Pan  
Line  
Layer

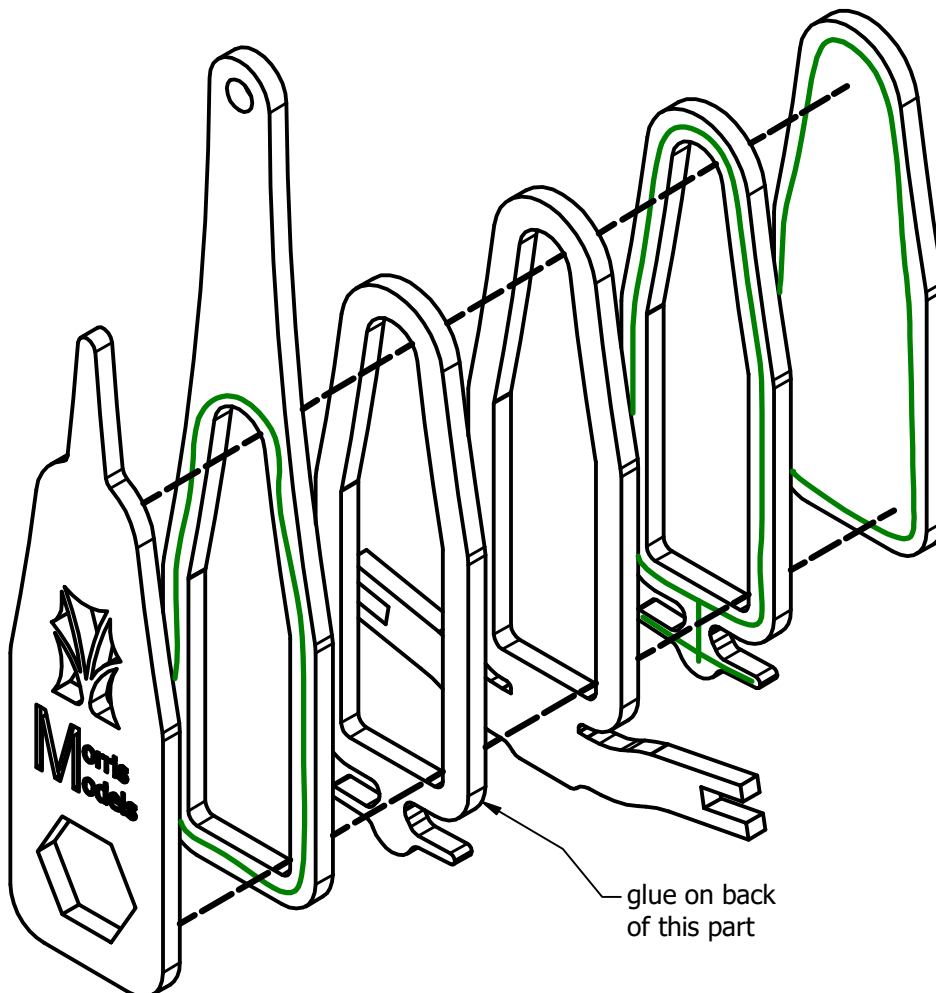


Oil Pan  
Decorative  
Walls

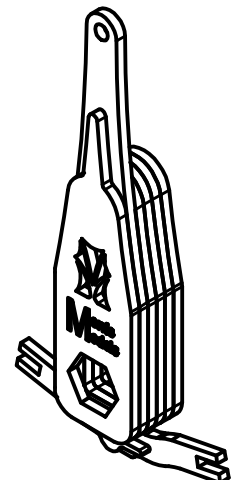


2 of 2

Oil Pan  
Rear



Assemble the oil pan as shown, manually aligning the layers. Suggested glue beads are shown, and the finished assembly is also shown.





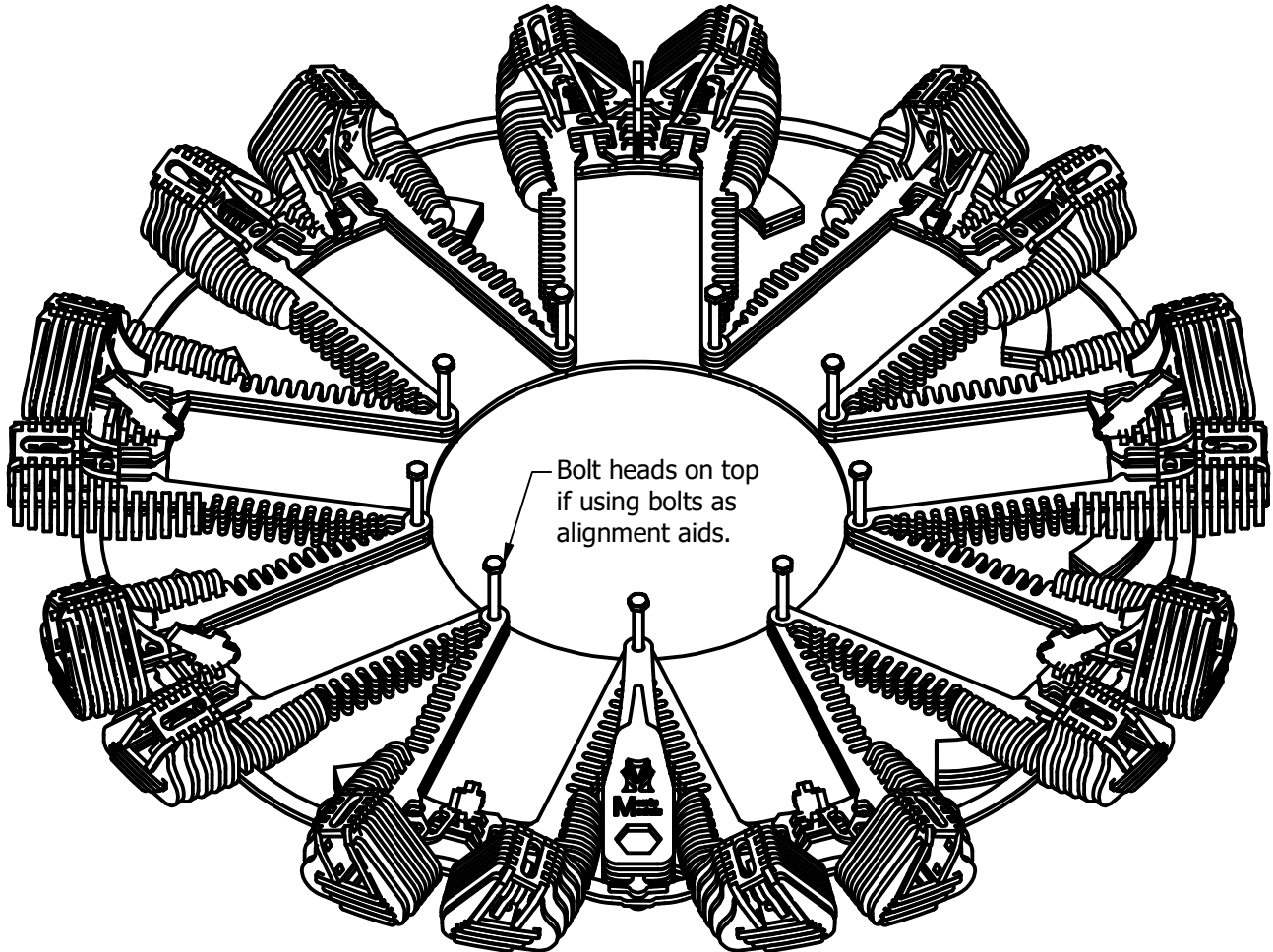
# Section 5 - Final Assembly

New Parts:

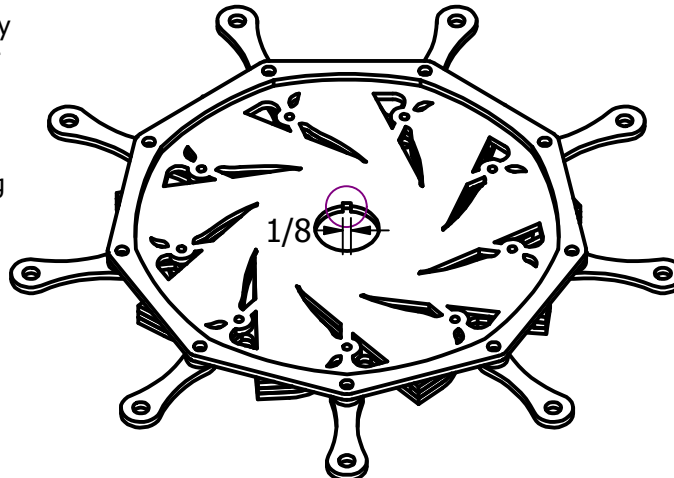


Cylinderhead Oil Lines x8

- 1) Begin assembly by temporarily fastening cylinders together into a ring of nine. Pin the bases of the cylinder with 1/4 inch dowels or bolts, and slip the oil lines between the cylinderheads on the slotted fins. This will require patience and a bit of finesse. Complete the ring of oil lines with the oil pan, pinning its 1/4 inch hole in place along on the same fastener as the cylinders are pinned with. Note: if you are using bolts to pin these together, leave the heads on the TOP side of the assembly.



- 2) Continue assembly by adding the main rear case. Simply press the bolts on down through the main bolt locations in the rear case, insuring that the grain direction of the parts is as desired.



Recall that some early models do not have the notch on the bore of the rear case. If yours has the notch, it does not matter which way it faces. If your case does not have the notch, you may wish to add it now. It is 1/8 wide by 1/16 deep, and makes future disassembly much easier.

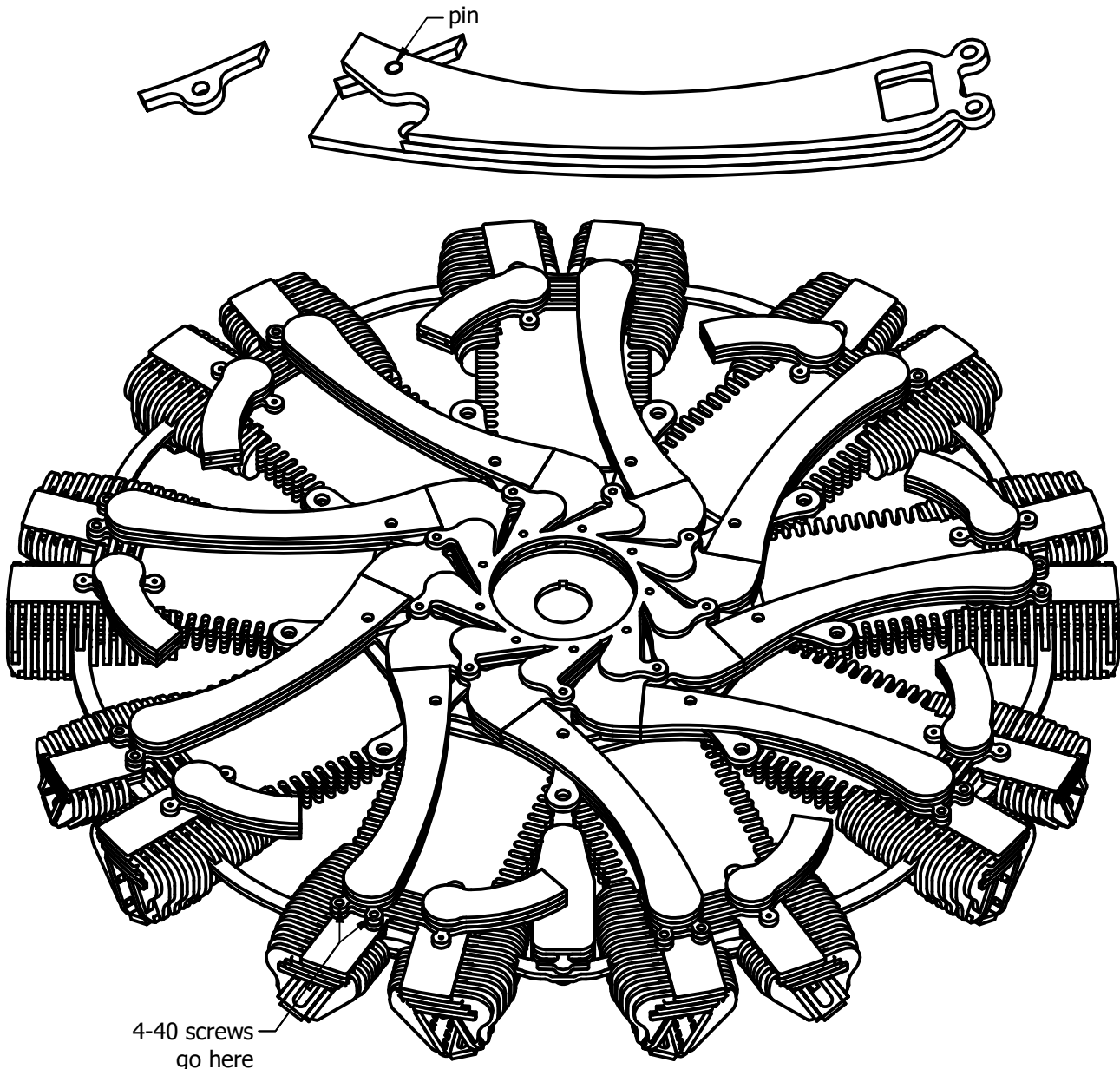
# Final Assembly - Rear Case

Optional New Parts:



Intake Runner Closer x9

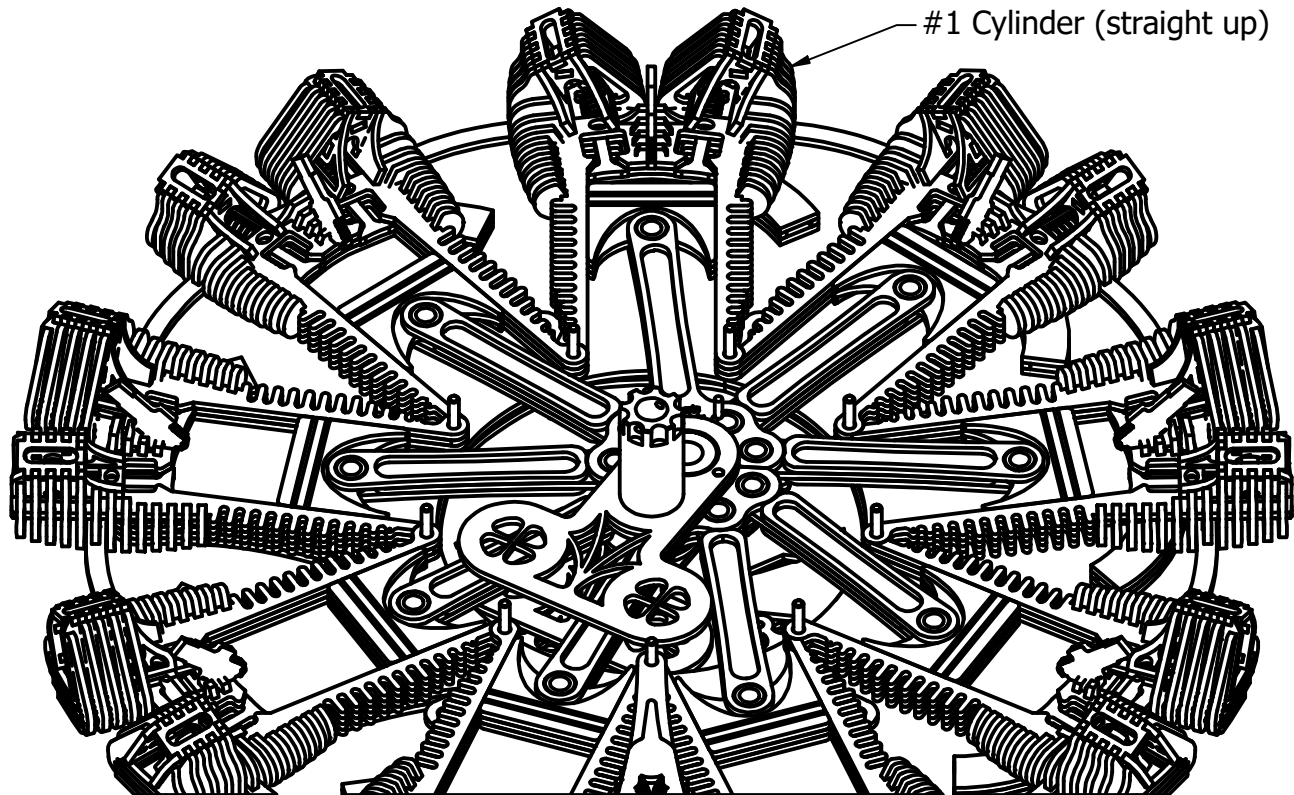
Optional (I do not do this myself): Locate the intake runners. Cut 1/4 inch long (2 layer long) bits of 1/8 inch dowel rods to pin the intake runner closers. Place the intake runner closers in the position shown in the intake runners, and pin them in place with the dowel rod bits you just cut. It is not necessary to glue these parts, as they will not be able to fall out once the runners are placed in the step below. The fragments will need to pivot as shown in order to place the runners.



Remove one of the bolts or dowel rods you used to pin the assembly together on the last page. Gently work the intake runner into position, straddling the engine mount. (This is much tougher if you added the closer above). Re-insert an AN3-21A bolt through the intake runner, the rear case, and the cylinder mounts with the head in the back of the assembly. Do this for all nine of the main case through-bolts (heads not shown). If you used the closers, you will have to "tease" them closed before threading each bolt into position. Screw the intake runners to the cylinderheads using the 4-40 3/8 long screws - 2 per intake runner. (These are the smallest screws.)

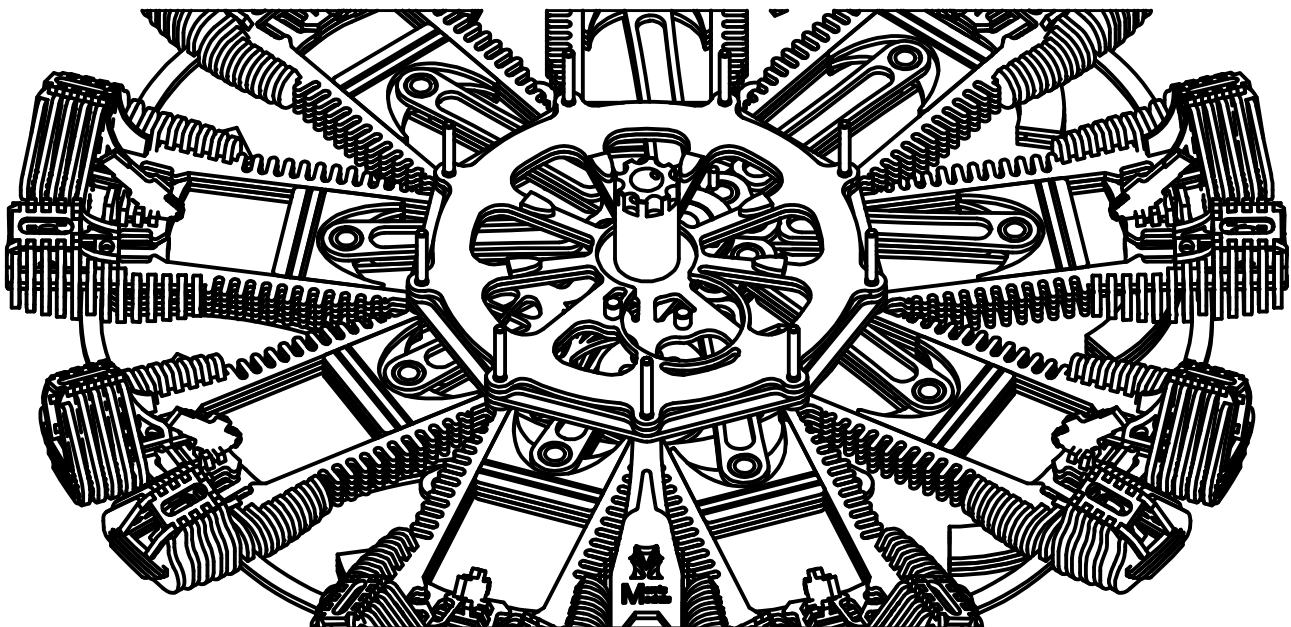
# Final Assembly - Rear Valve Case

If you wish to wax your assembly, do so now. Wax the rear and side walls of the cylinders, the rear of the case, and the bore of the case. Gently align the rear shaft, rods, and pistons of the rotating assembly with your engine, and set the assembly in place. The master rod should go in the straight up cylinder across from the oil pan. It should spin relatively freely. If it is binding on something, figure out what it is binding on and fix it.



Wax the center bore and rear face of the rear valve case if desired. Add the rear valve case, positioning it as shown. It will probably be difficult to thread it over the bolts. Recall that the bottom position on the rear valve case should have no spacer dot - the oil pan takes its place.

**Note - if you added a notch to the accessory case, add a similar notch to the rear valve case. See page 5-1.**

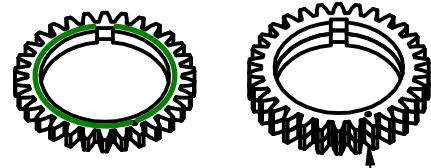


# Final Assembly - Valve Timing

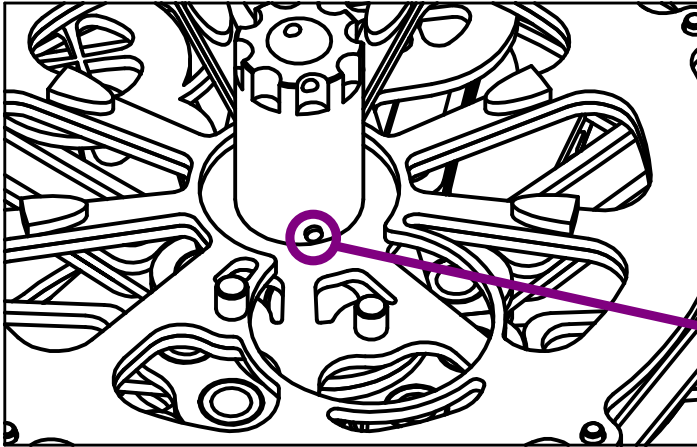
New Parts:



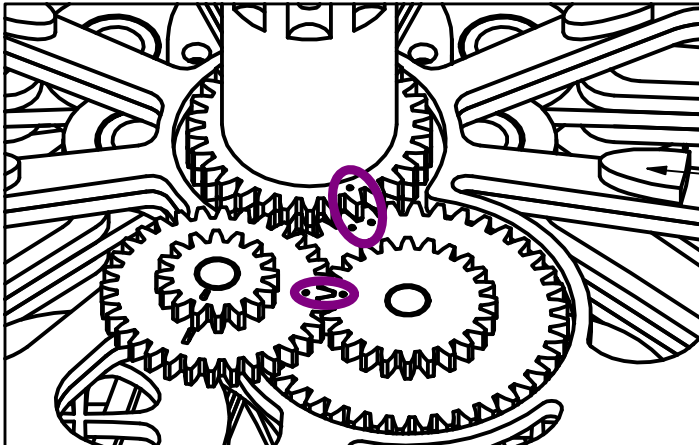
Glue the two crank gears together, making sure that the alignment is perfect. Don't allow any glue squeeze out. Let dry.



Timing marks align

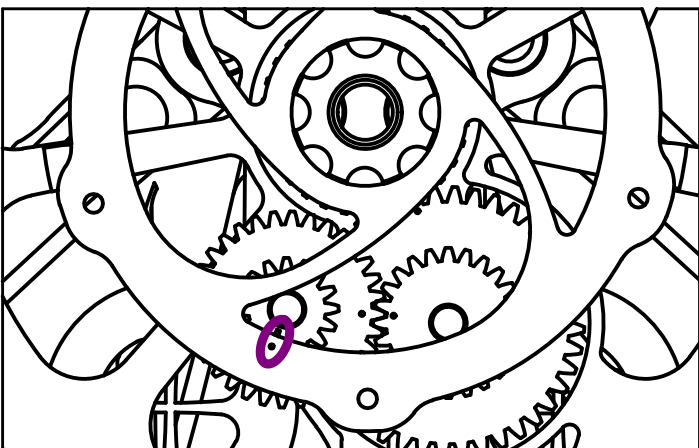


Insert a short piece of 1/8 inch dowel rod into the lower hole on the front shaft as shown and highlighted to the right. Make sure that the piece bottoms in the hole, and that it is long enough to fully engage with the slot in the crank gear. It is probably best to insert a piece that is significantly too long, mark where to cut it, and then remove and cut it. Re-insert the correct length. Do not glue this piece into the shaft, or you may not be able to remove the crankshaft from the valve case. (Later versions of the valve case have a small keyway cut in the bore so that this will not be a problem).



Wax the front shaft, reduction shafts, and areas around where the timing gears will be if desired. Pull the master piston all the way to the top of its cylinder. The pin you added should face straight up. Slide the double thick crank gear over the shaft and key. The timing dot should face the shorter of the two reducer gear shafts. Add the larger of the two reduction gears, lining up the 2 dots on it with the single timing dot on the crank gear. Add the smaller reduction gear set, aligning the timing marks as shown.

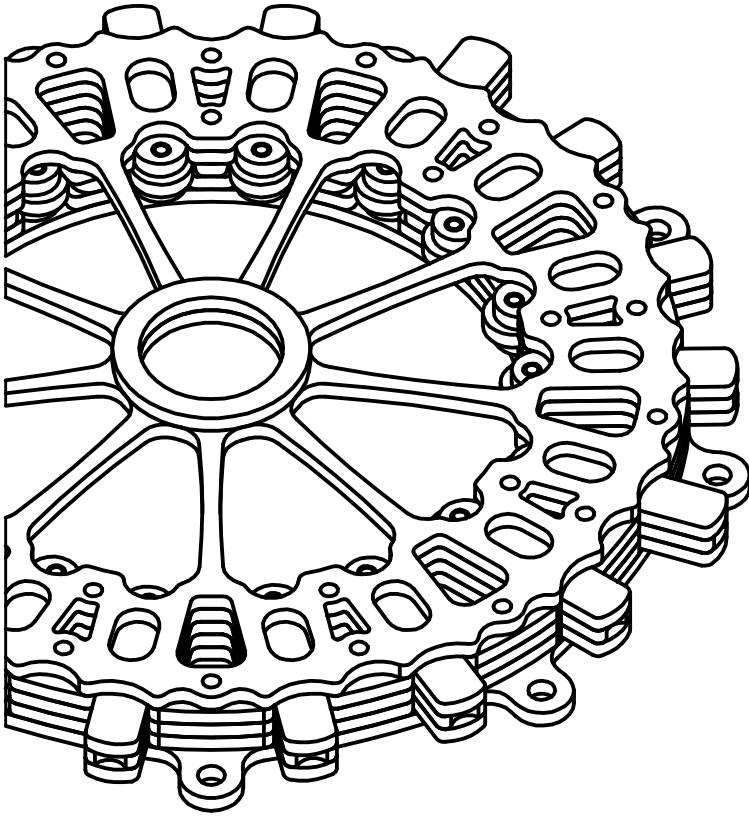
cam balancing pad (1 of 6)



Wax the front of the reduction gear set and the 6 cam balancing pads if desired. Add the cam plate, gear side downward. Engage the cam plate gear teeth with the small reduction gear, noting the timing marks as shown on the right. You should now be able to turn the crankshaft and watch the timing gears slowly spin the cam plate. The timing marks will only properly align once every 10 turns.

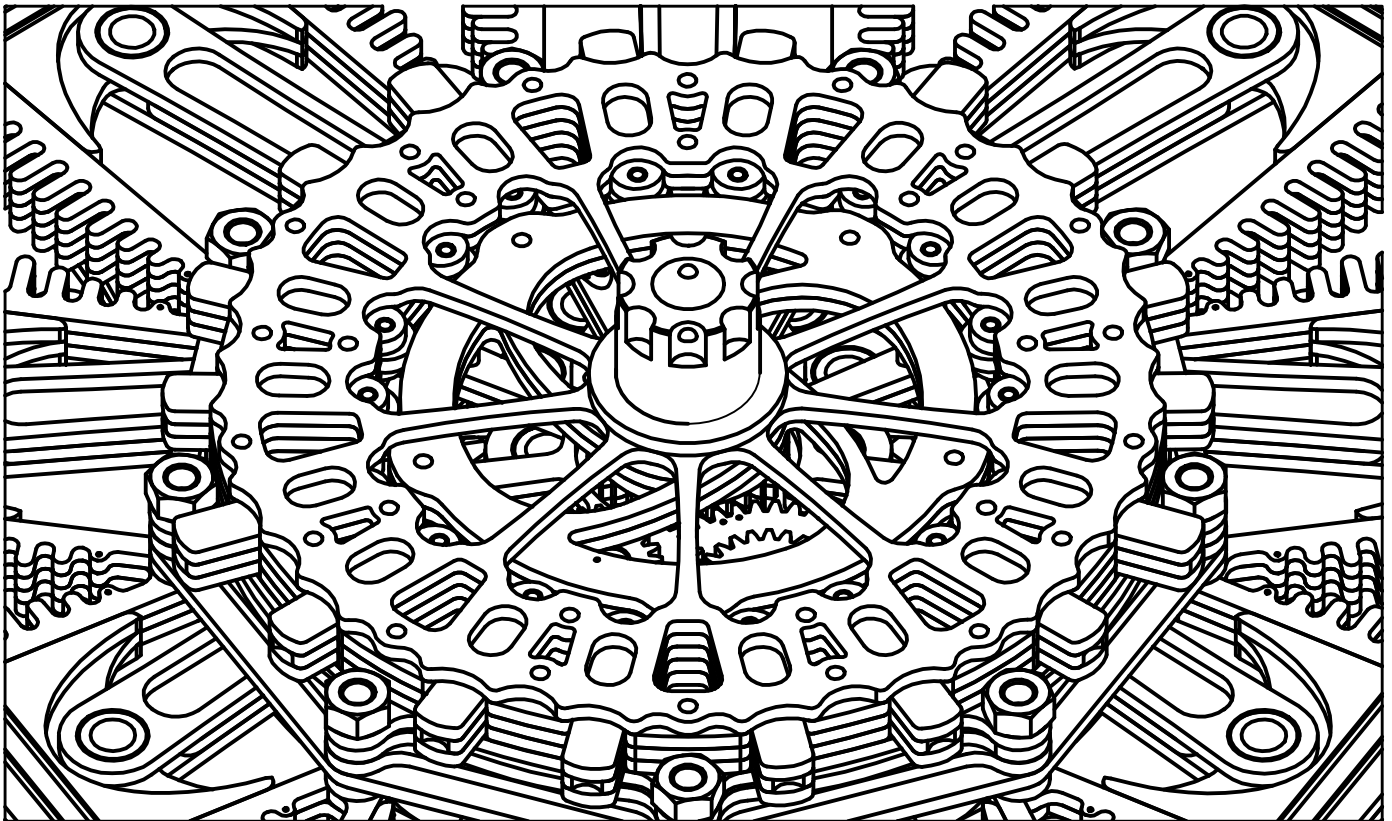


# Final Assembly - Roller Lifters



Wax the valve lifters if desired. Also, wax the bore of the valve lifter case and the top of the cam plate if desired. Slide the valve lifters into their slots in the front lifter cage from the back inside of the assembly. They must slide in and out freely. If any of the lifters do not slide easily, remove them and sand them until they do slide freely. Rewax and refit.

Once all of the lifters are in place and sliding with almost no resistance, slide them all in as far as they can go. Set the entire lifter assembly into place over the top of the valve disk on the engine assembly engaging the nine main bolts. Use the AN3-364 nuts (the ones that fit the bolts) to secure all of the assemblies on the engine. This is a plywood engine, and these are powerful airplane bolts. Tighten the nuts just enough to clamp down over the parts and eliminate play. Do not overtighten, as this could damage the engine model.



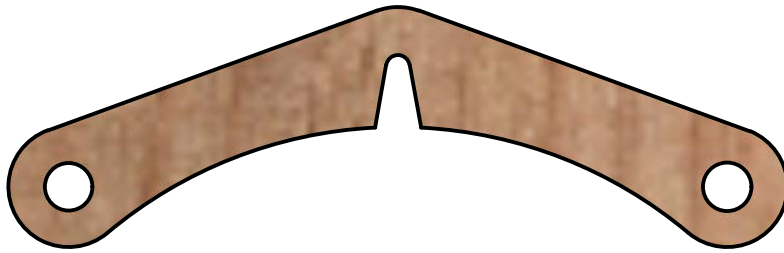
# Final Assembly - Back

## Optional New Parts:

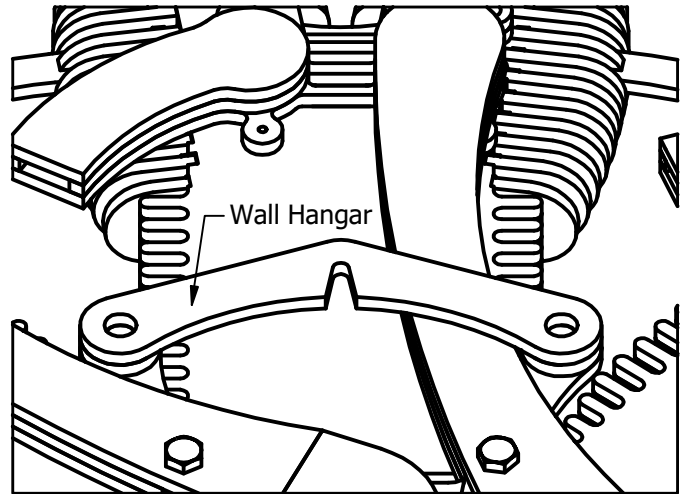
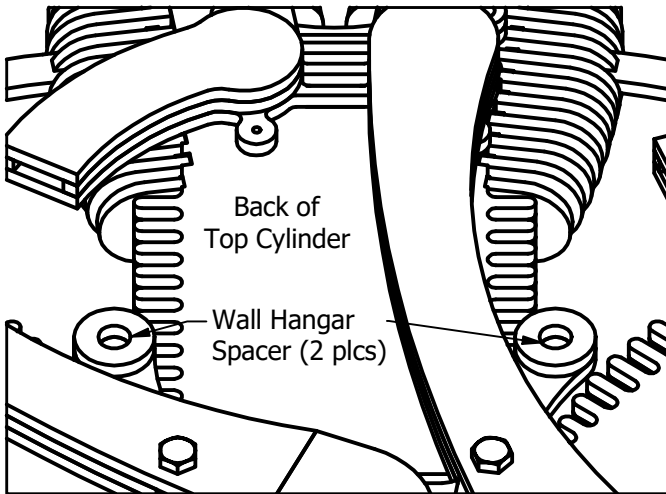
shown full size



Wall Hanger Spacer x2

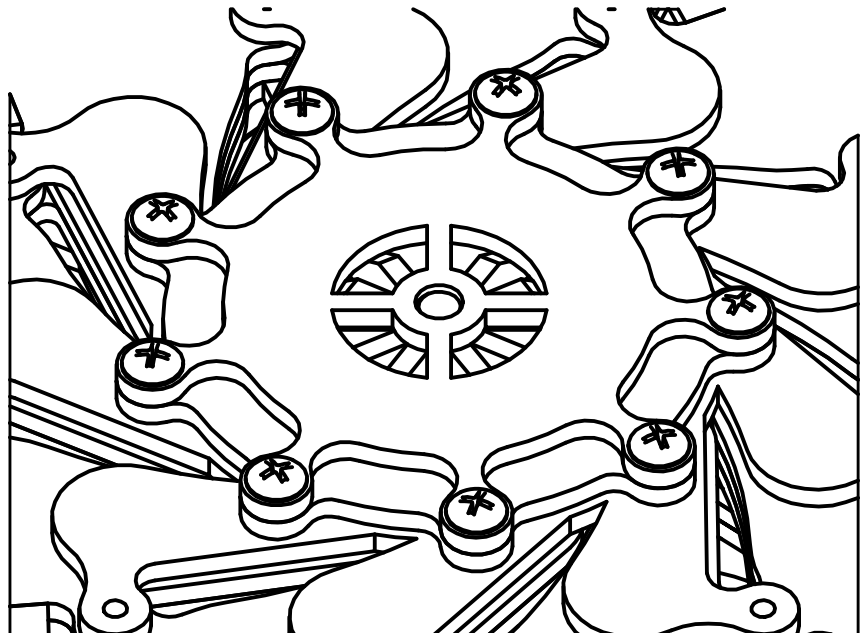
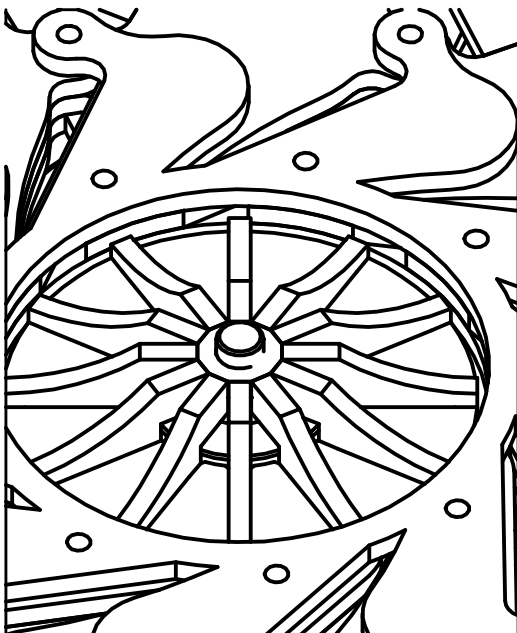


Wall Hanger



If desired, glue or bolt on the wall hanger along with its two spacers (bolts not included). If using glue, make absolutely sure that the hanger is glued on very securely. This will allow easy wall hanging.

Add a small bit of 1/8 inch dowel rod to the keyway hole on the rear shaft - in much the same way as you did in section 5-4. This will key the impeller to the rear shaft. This step is not shown. Please refer to section 5-4. Wax the impeller cavity if desired. After adding this shaft, place the impeller onto the shaft, turning it so that the keyway matches the key in the impeller and it seats fully. Wax the top of the impeller if desired. Then place the impeller cap over the top of the impeller, and secure it in place with the provided 6-32 x 1/2 inch screws. These should go in easily, and may need drops of glue to help secure them. Do not overtighten.



# Final Assembly - Front

## New Parts:

Pushrod



Lifter End

Rocker End

Thin the ends of the pushrod much like you thinned some of those earlier parts. It is not necessary to thin the entire pushrod body. The rounded lobe on the lifter end must be a little thinner, and the last inch or so of the rocker end must be thin enough to slide in its slot. It is best to sand a little from each side to do this.

Fit the pushrods into the engine one at a time. Carefully slip the rocker end into the the rocker slot and slide it inward, compressing the valve spring through the rocker. With the spring compressed, set the lifter end into place in the lifter socket. The valve spring should provide enough force to hold the pushrod in its socket. If it does not, something is sticking. Disassemble the engine to figure out what it is and fix it.

Finally, set the prop carrier in its position over the front shaft and secure with a length of 1/8 inch dowel rod (shown in blue). Test the engine by gently spinning the prop carrier. If you have executed each of these steps carefully, your model should now function, and there should be an enormous grin on your face. Go on and show it to everyone.

