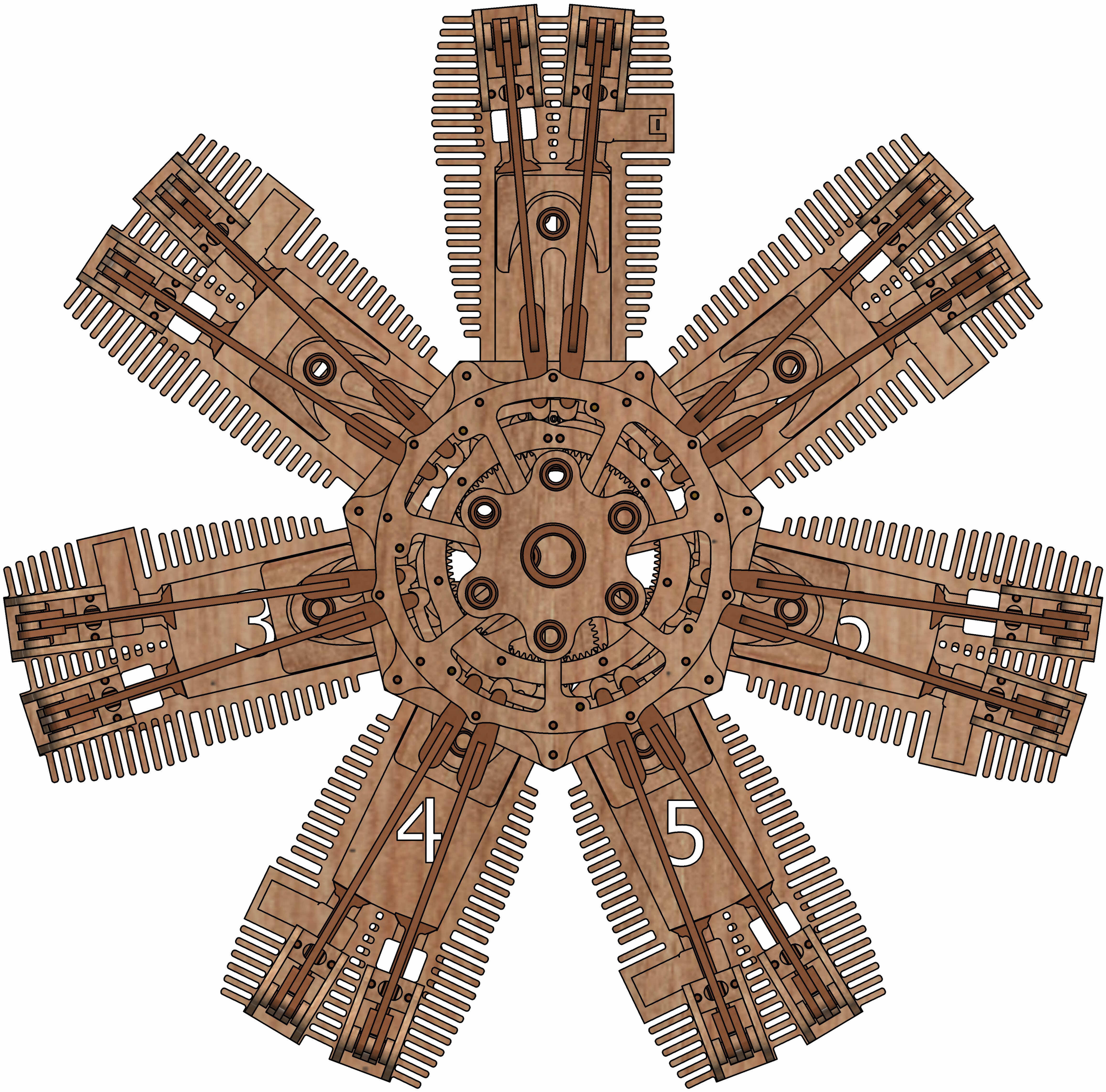
7 Cylinder Radial Engine

Assembly Instructions



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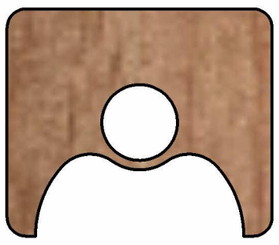
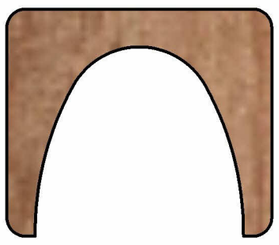
1: Pistons and Rods

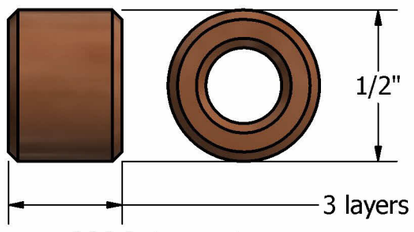
New Parts:



Inner Piston
x 7

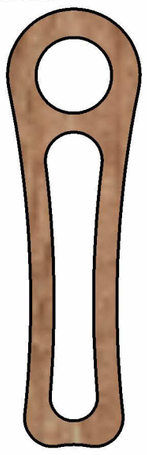


Outer Piston
x 14



Wrist and
Articulating Pins x 13

Articulating
Rod, Inner
x 6



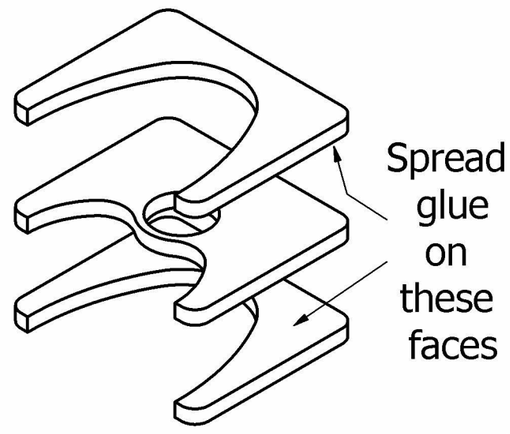
Articulating
Rod, Outer
x 12

Master
Rod,
Inner
x 1

Master
Rod,
Outer
x 2

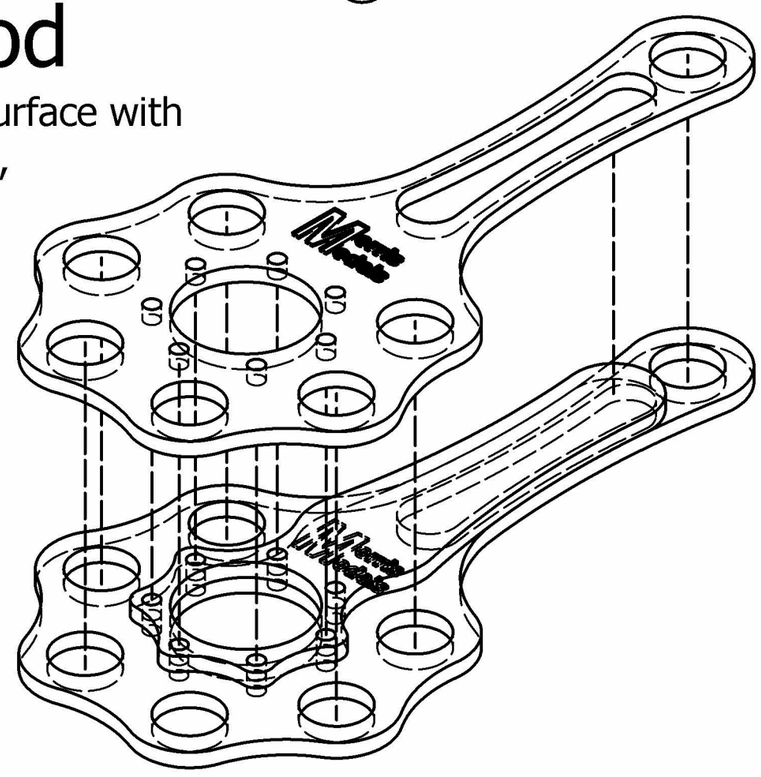
A: Assemble 7 Pistons

Spread glue on one side of an outer piston, and lay it glue side up. Carefully align an inner piston to the glued face. Spread glue on one side of another outer piston, and add this to the stack. Set aside to dry, making sure alignment remains perfect. Do this for all seven pistons. Lightly sand off any hardened glue on the edges of the pistons.



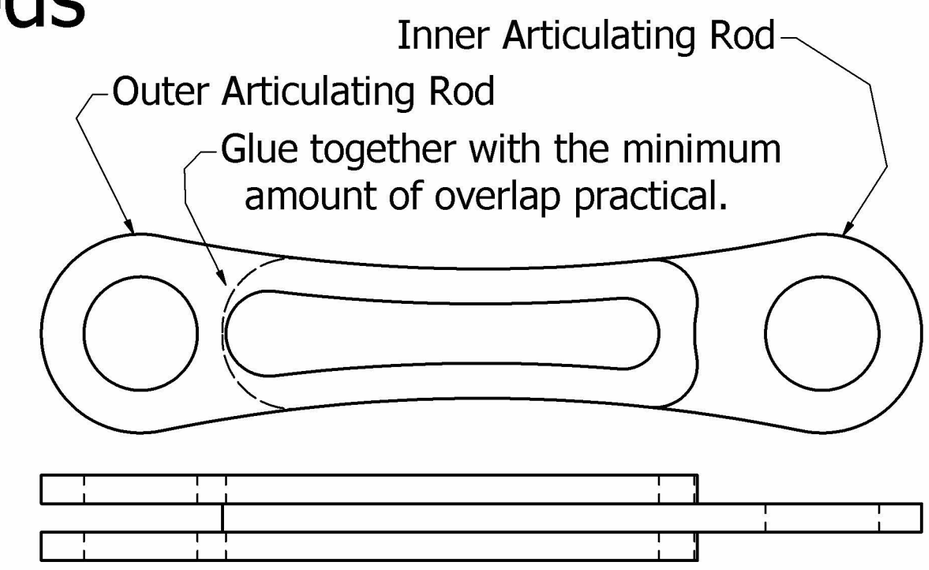
B: Assemble the Master Rod

Set one of the outer master rod pieces on to a flat surface with the text side down. Lay the inner master rod on top, using short pieces of 1/8" dowel rod to help aligning them. Trace lightly around the edge of the inner rod with a sharp pencil. Repeat this procedure with the other outer master rod, lightly penciling in where it overlaps with the inner rod. Spread a light layer of glue on an outer master rod staying inside the light pencil marks. Again using bits or alignment dowel, glue the inner rod to the outer rod. Spread glue on the final outer rod, again remaining inside the light pencil marks. Glue this over the top of the assembly as shown. Set aside to dry.



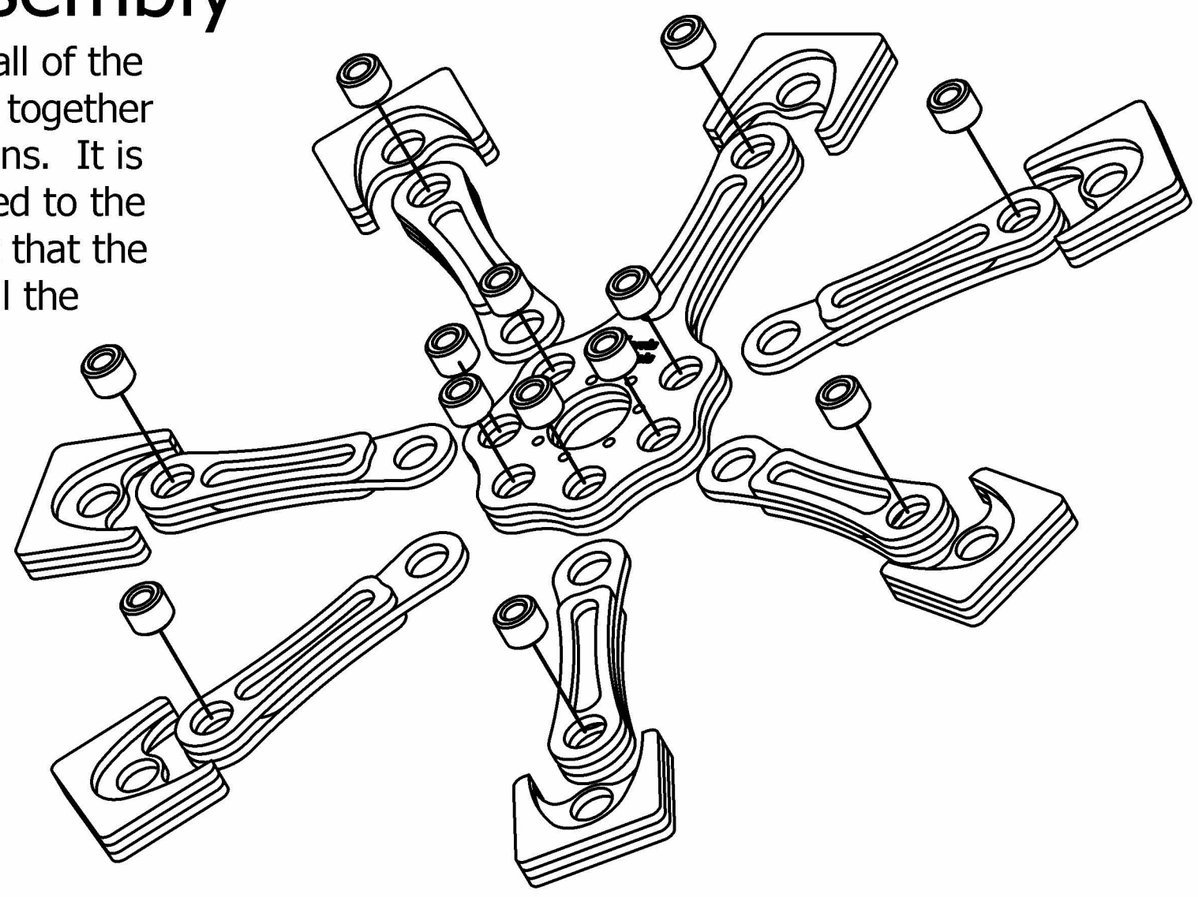
C: Assemble 6 Art. Rods

The six articulating rods are assembled in a similar manner to the master rods, but are more difficult to align. Glue them together as shown, leaving them as long as possible while completely filling in the cut out in the outer rod with the solid inner rod. Ensure that the two outer sides are aligned well enough that the wrist pin will slip through both sides. Set these aside to dry.



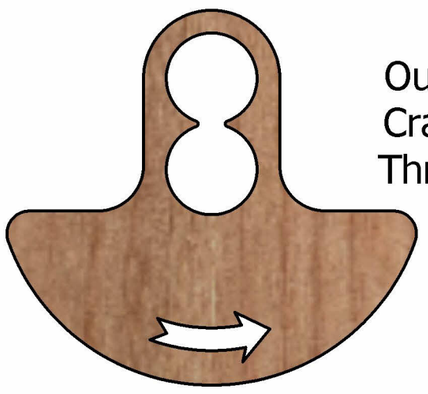
D: Assemble the Rotating Assembly

After the glue has dried on all of the above assemblies, pin them together with the wrist/articulating pins. It is critical that the pins are glued to the back layer of each joint, but that the center layer is not glued. All the joints must be free to rotate. (You may want to wax the joints before assembly for smoother operation.)

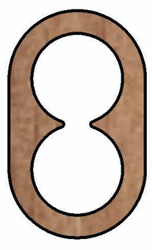


2: Crankshaft Assembly

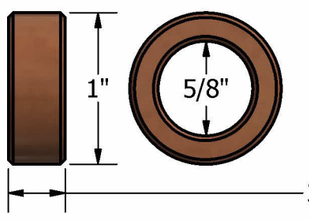
New Parts:



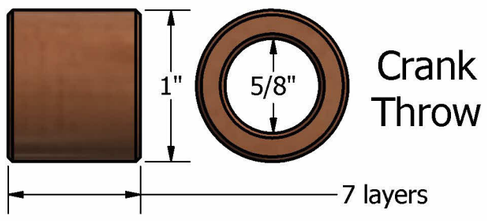
Outer Crank Throw x 2



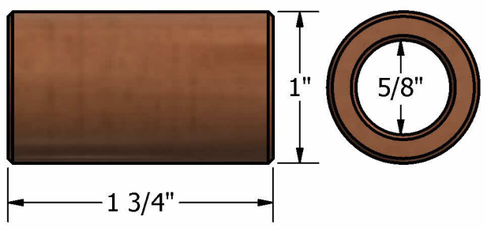
Inner Crank Throw x 2



Rear Shaft

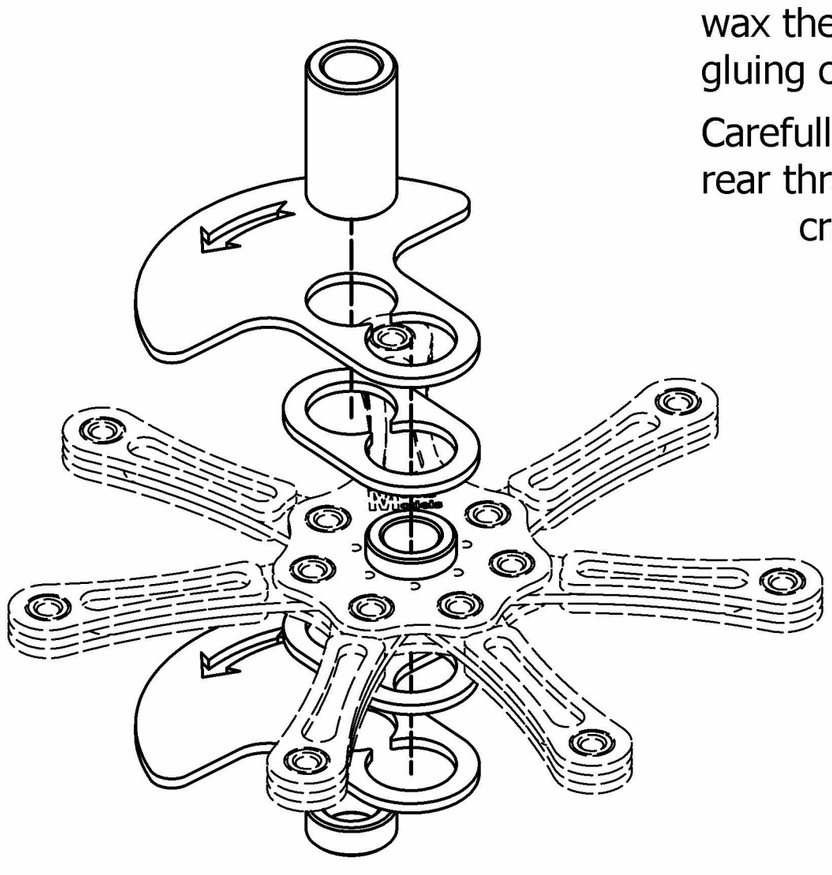


Crank Throw



Front Shaft.
(May have more elaborate bore)

All three parts - inner bores optional.

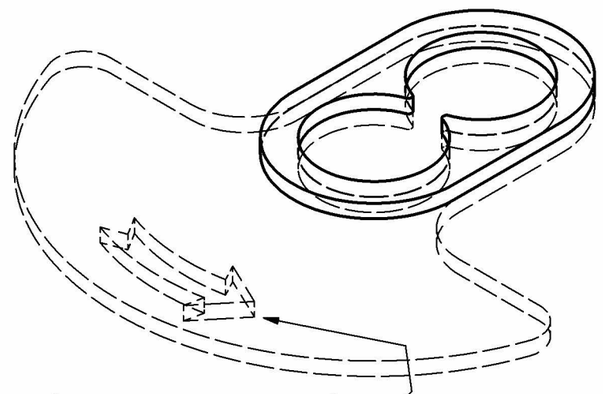


Pistons Omitted for Clarity

A: Laminate 2 Crank Webs

Place an outer crank throw on a flat surface with the arrow facing in a counter-clockwise direction as shown. Spread a thin layer of glue on one face of an inner crank throw, and glue it down over the outer crank throw, making sure that alignment is maintained. Set aside to dry. Repeat process with the other inner and outer throws, except this time the arrow must face in the clockwise direction.

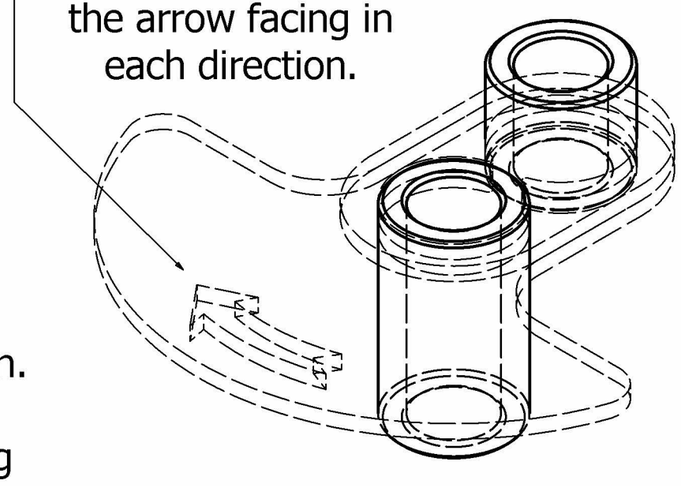
Crank web
(Rear shown)



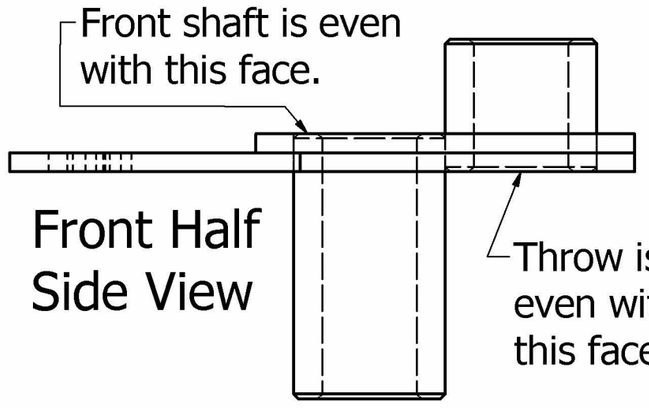
Make two - one with the arrow facing in each direction.

B: The Front Half

Locate the forward crank web (the one with the arrow facing clockwise when lying face down). Set it face down, and glue the crank throw into the outside socket. Make sure that there is no glue squeeze-out to interfere with rotation. Next, glue the front shaft into the center socket. Note side view for orientation. It works well to turn the unit over and slide the crank throw off the side of the table while gluing the front shaft. (Use a scrap of wax paper to protect your table.)



Front shaft is even with this face.



Front Half Side View

Throw is even with this face.

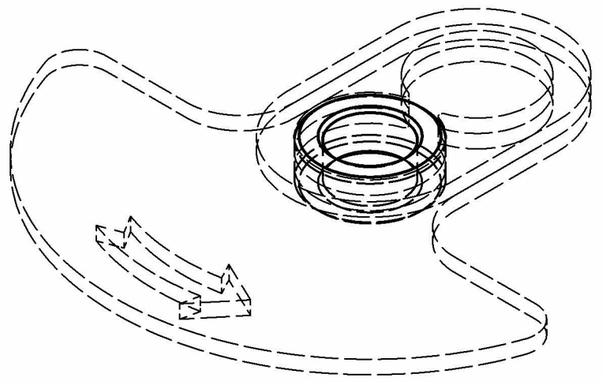
C: The Rear Half

Take the other crank web, and set it face down - confirming counter-clockwise facing arrow. Glue the rear shaft into the center socket. once again, note side view for profile.

D: Assemble Crank

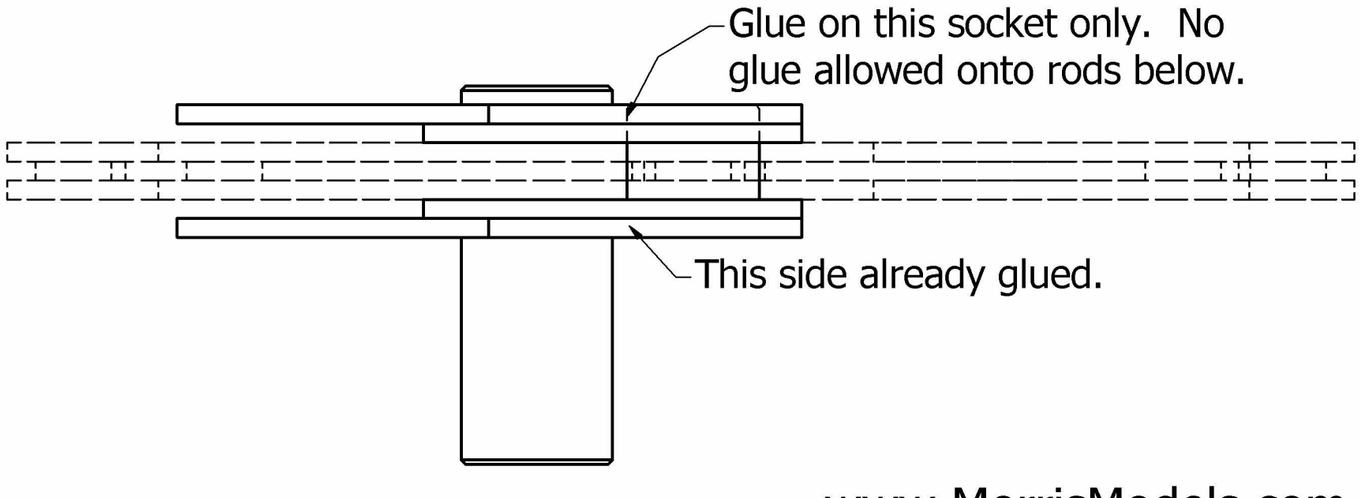
The front and rear crank halves must be glued in near perfect alignment during this step. It is also very important that no glue strays from the crankshaft to the rods that are sandwiched in it. If you are waxing the moving parts of the engine, wax the bore and faces of the master rod before gluing crank halves together.

Carefully glue the inside of the socket of the rear throw. Then assemble the two halves of the crank, capturing the bore of the master rod. Use several strips of wax paper to help keep the glue from getting on to the master rod. Ensure free movement by occasionally moving rods while glue dries.



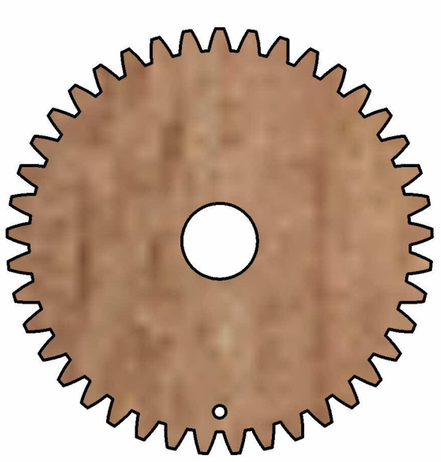
Rear shaft is even with this face.

Rear Half Side View

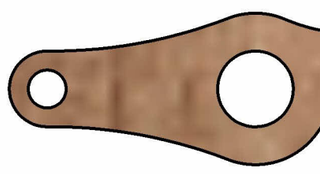


3: Small Subassemblies

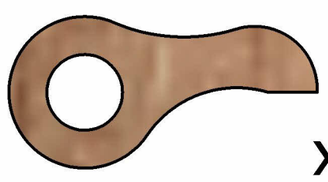
New Parts:



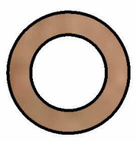
Small and large timing reduction gears - 1 each



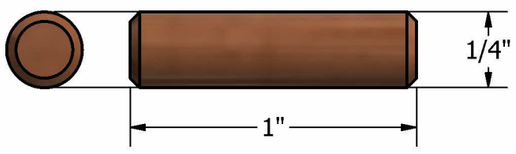
Inner Rocker Arm x 14



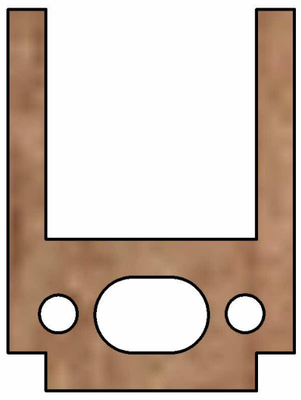
Outer Rocker Arm x 28



Rocker Arm Spacer x 28



Rocker Shaft x 14



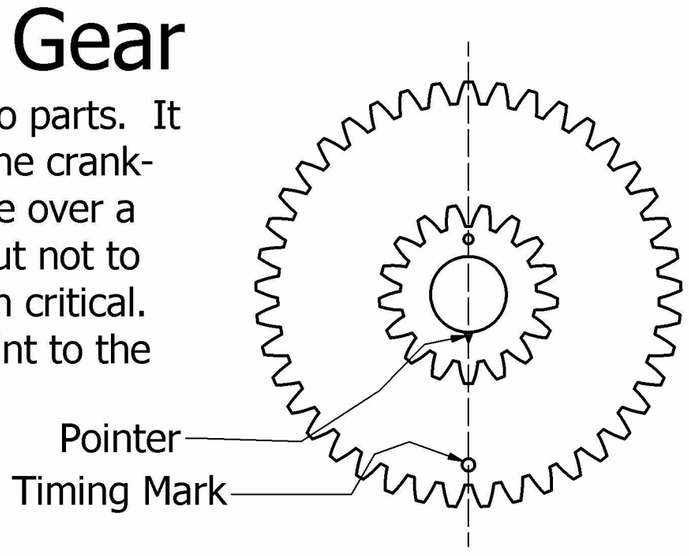
Rocker Arm Base x 14

Rocker Arm Side x 28

All new parts on this page are shown at full size when this is printed on A sized paper.

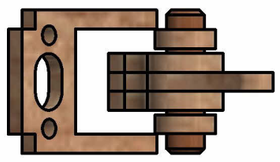
A: Timing Reduction Gear

The timing reduction gear consists of two parts. It helps make the 6:1 reduction between the crank-shaft and the cam plate. Assemble these over a 1/4" dowel. Glue them to each other, but not to the dowel rod. Timing gears are position critical. The pointer on the small gear should point to the timing mark (dot) on the large gear.

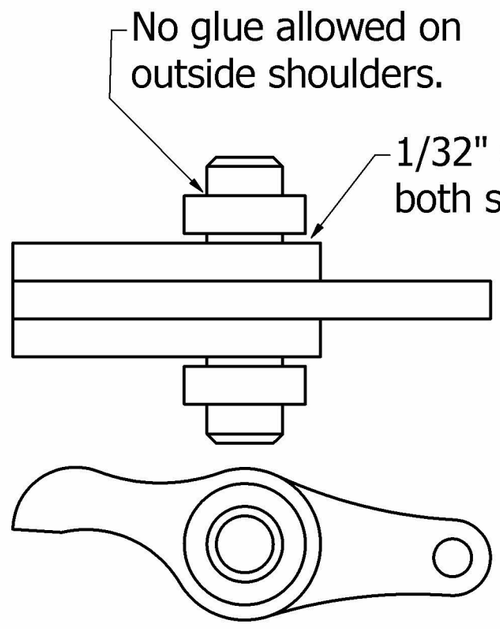


B: 14 Rocker Arms

The rocker arms are assembled on their associated shafts. All of these parts are glued together as units. Begin by gluing an inner rocker arm to the center of a rocker shaft. While the glue is still wet, glue an outer rocker arm onto each side of the center arm, making sure they align. Next, add the two spacers, one to each side. Note the 1/32" space between the outer rocker arms and the spacers.



Check spacing by holding a rocker arm base up to the rocker arm before the glue dries.

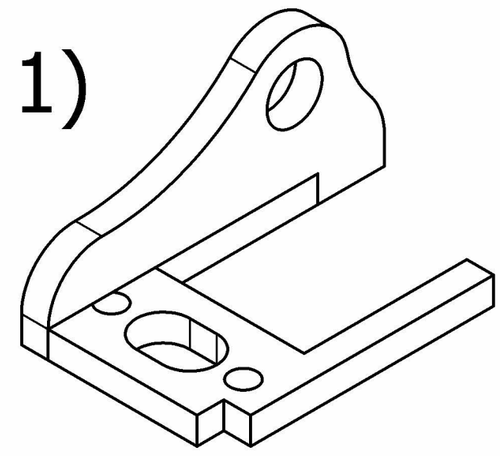


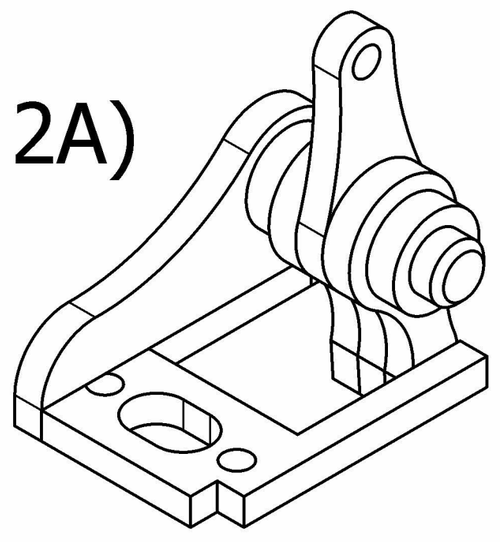
C: 14 Rocker Assemblies

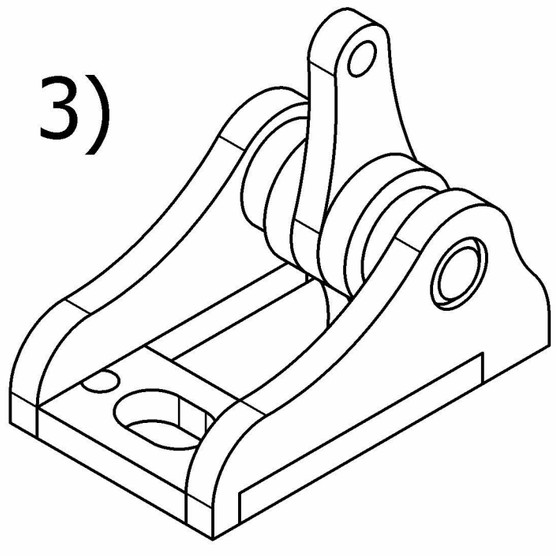
1) Glue a rocker arm side onto the rocker arm base as shown. Allow to dry while you make the rest of these.

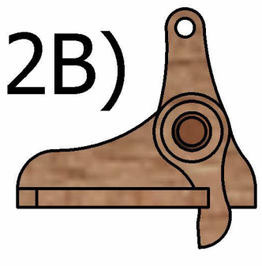
2) Taking a previously glued part made in the last step, wax the bore of the rocker arm side if desired. Insert the previously made rocker arm as shown in 2A along with side view 2B.

3) Wax the bore of an unattached rocker arm side if desired. Slip it onto the assembly, and glue it firmly to the base as in step 1. Make sure that the rocker arm is free to pivot in the assembly.



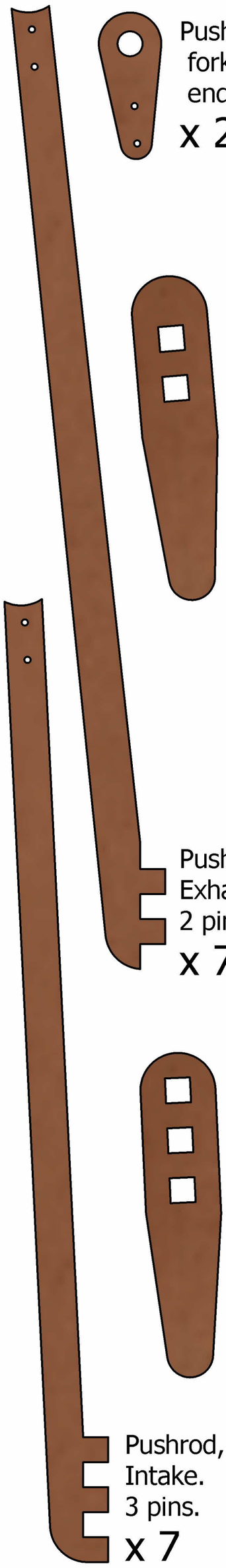






4: Pushrods and Valves

New Parts:



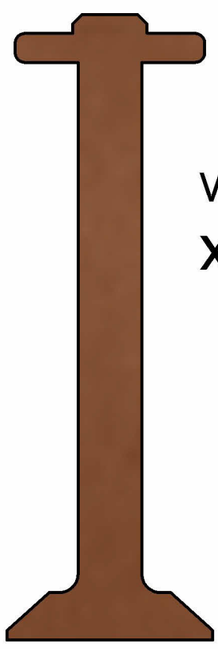
Pushrod fork end
x 28

Exhaust Pushrod Lifter
x 7

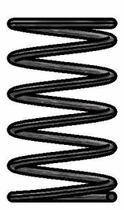
Pushrod, Exhaust. 2 pins.
x 7

Intake Pushrod Lifter
x 7

Pushrod, Intake. 3 pins.
x 7



Valve
x 14



Valve Spring
x 14

All new parts on this page are shown at full size when this is printed on A sized paper.

A: Pushrods

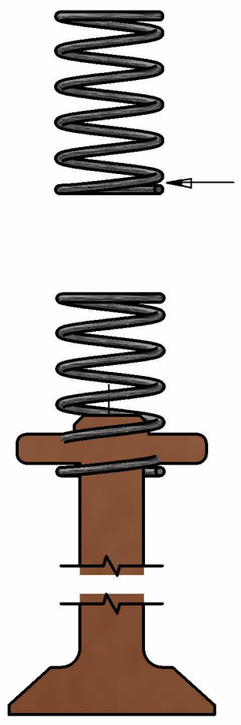
The exhaust and intake pushrods have different angles. This means they must be distinguishable from each other. The exhaust pushrod lifter has two mortices, and the intake has three mortices. Glue the lifters onto the pushrods as shown. Then, using the two tiny holes and the 1/8" hole as alignment aids, glue a pair of fork ends to each pushrod. It may be easiest to assemble these over two pieces of wire of the appropriate diameter and a bit or 1/8" dowel rod. Set aside to dry.

(If desired, you may sand off the outer half of each fork end for a slightly more scale appearance.)

B: Valves

The valves are cut out with their valve retainers permanently attached. They must slide up and down freely within a single layer of plywood, so they should be sanded until they are slightly thinner than a standard layer of plywood.

After you have sanded one face of the valve (7/64" or 2.8 mm is a good target thickness), wax the shank of the valve. This is the most important wax job on the engine.

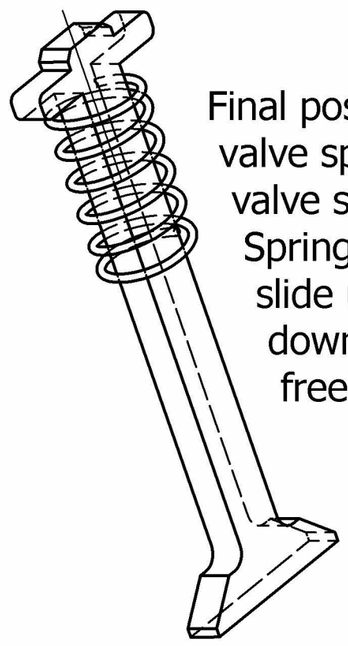


Spread here. Do not bend enough to permanently deform spring.

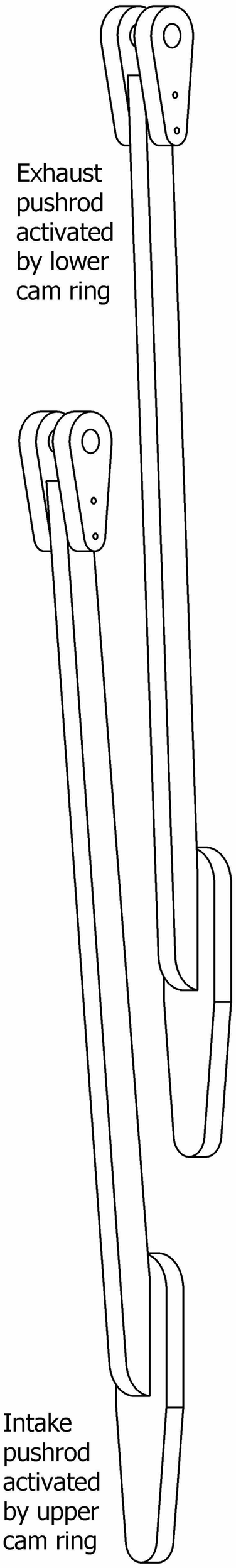
You will need to thread a valve spring over the valve retainer on each valve.

Begin by spreading the base of the spring just far enough to clear the retainer end of the spring.

Thread the spring downward over the valve until the entire spring is within the shank portion of the valve as shown below.



Final position of valve spring on valve shank. Spring should slide up and down valve freely.

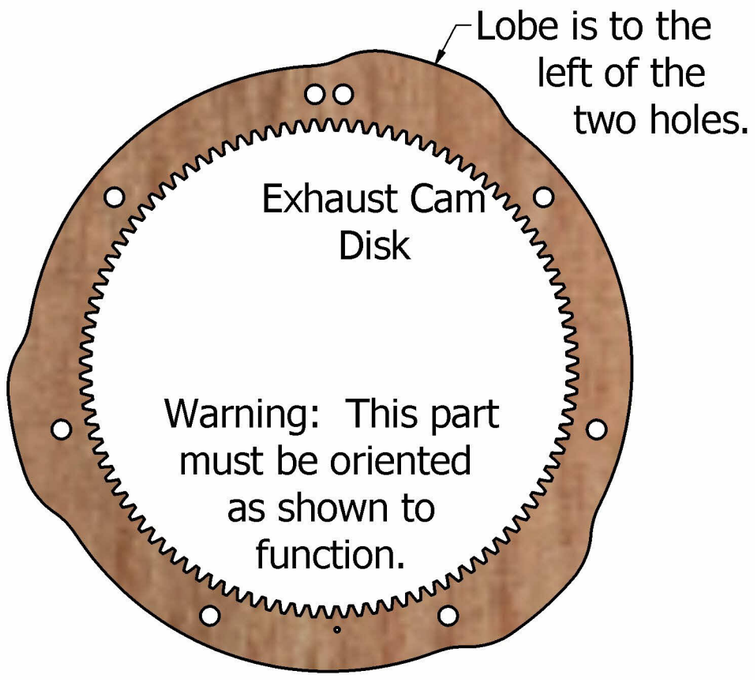


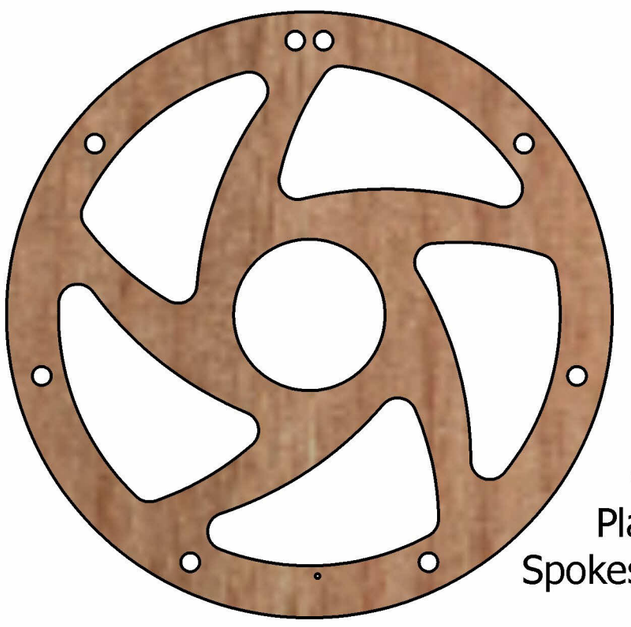
Exhaust pushrod activated by lower cam ring

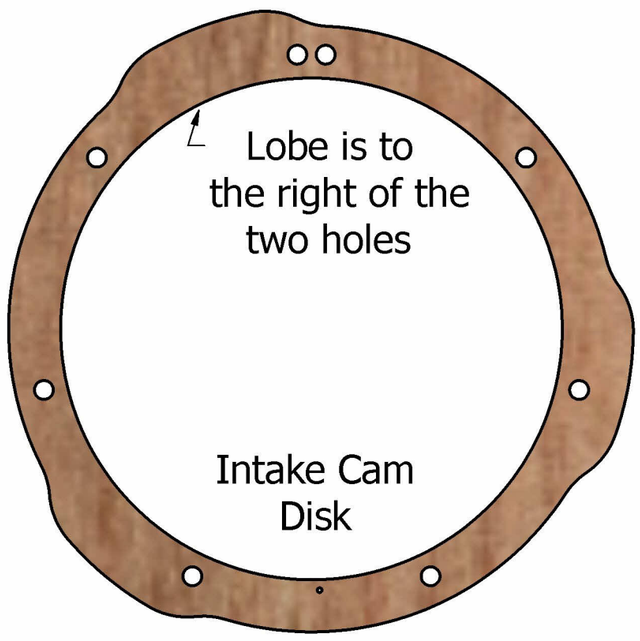
Intake pushrod activated by upper cam ring

5: Cam Plate

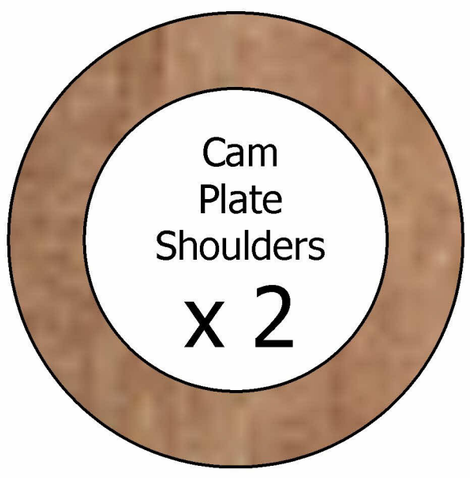
New Parts:







Parts above this note are shown 1/2 size. The cam plate shoulders shown below are full size.



The valve timing on a radial engine is accomplished by a low speed cam plate. It differs from the classical single lobe cam shaft found in most 4-stroke engines in that it spins at lower speeds and has more lobes. The number of lobes on the plate can be found by dividing the number of cylinders in two, which will give a half number. If the cam plate spins in the same direction as the crankshaft, add 1/2. If it spins in the opposite direction, subtract 1/2. In real radial engines, the valve lifters are usually of the roller type. In this wooden engine, the lifters are trailing links. This is simply a nod to the fact that our building material is less than optimal.

Assemble the Cam Plate

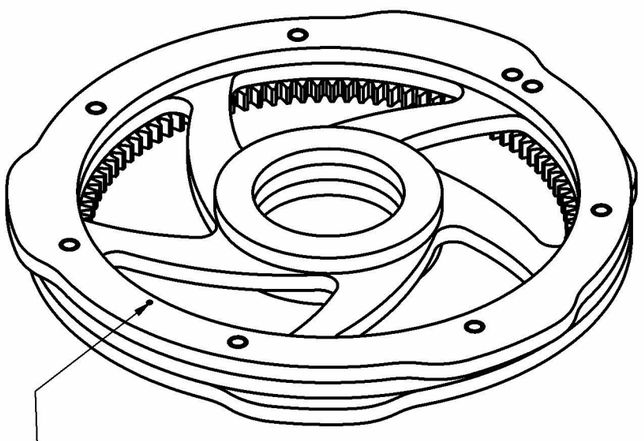
Caution: The cam discs are directional. They must be correctly oriented for the valves to open at the proper points. Note the orientation shown in the new parts section. These are shown from the front view.

Begin by setting the exhaust disk face up in front of you and set one of the cam plate shoulders in the center. Spread a thin layer of glue on each, and add the cam plate spokes. Maintain alignment by using bits of 1/8 inch dowel rods - shown in the drawing below. You can also add a piece of 1 inch dowel rod to maintain alignment of the shoulders.

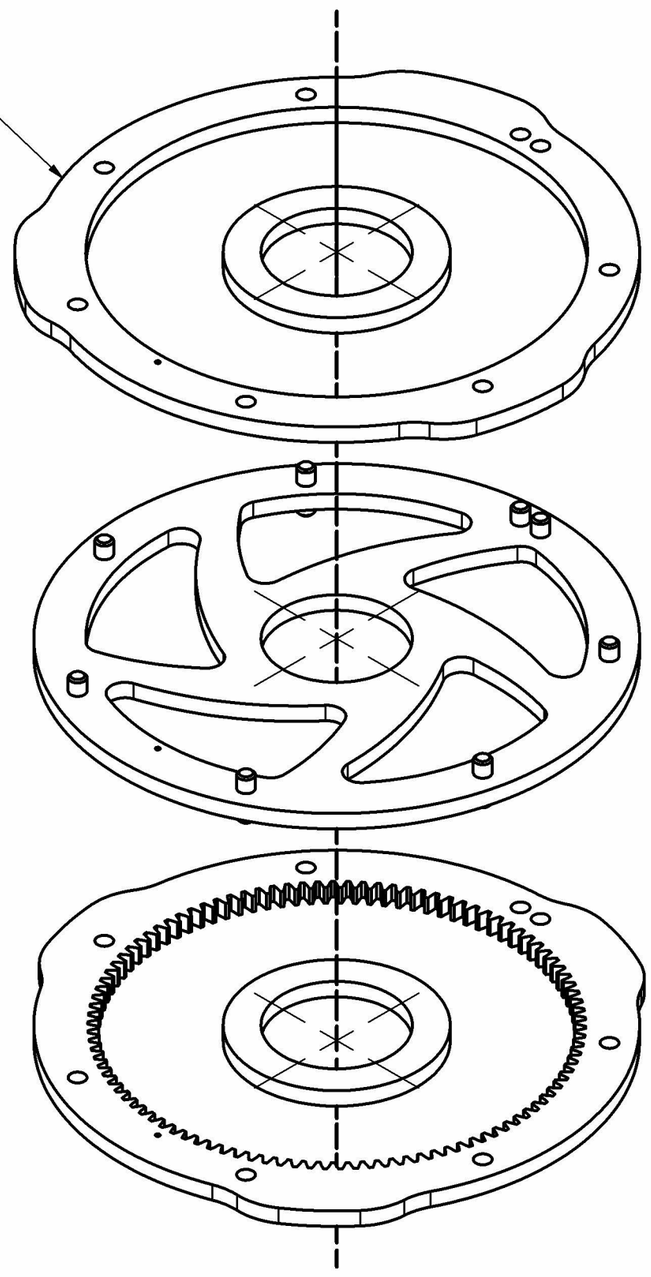
Spread a thin layer of glue on the rear of the Intake cam disk and the other pair of cam shoulders. Add these to the stack, again maintaining alignment. Make sure not to glue the 1 inch dowled rod in place. Allow glue to dry.

You may need to lightly sand the cam plate bore after the glue dries. Check to make sure the plate spins freely on the crankshaft.

Assembled View

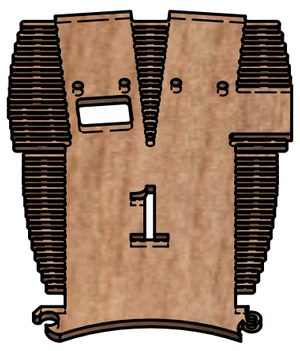


Assembly view



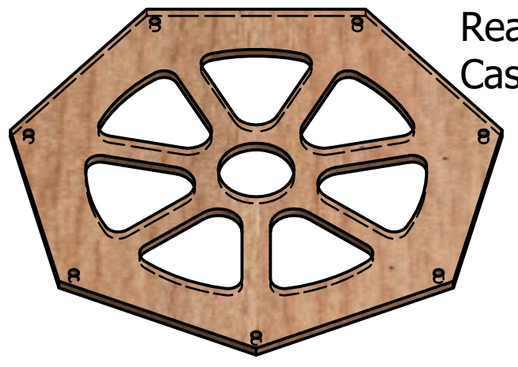
6: Begin Case

New Parts:

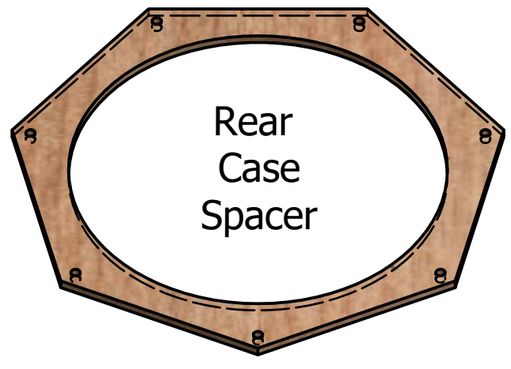


Base Cylinder (numbered 1 through 7) x 7

Rear Cylinder Fins x 7



Rear Case



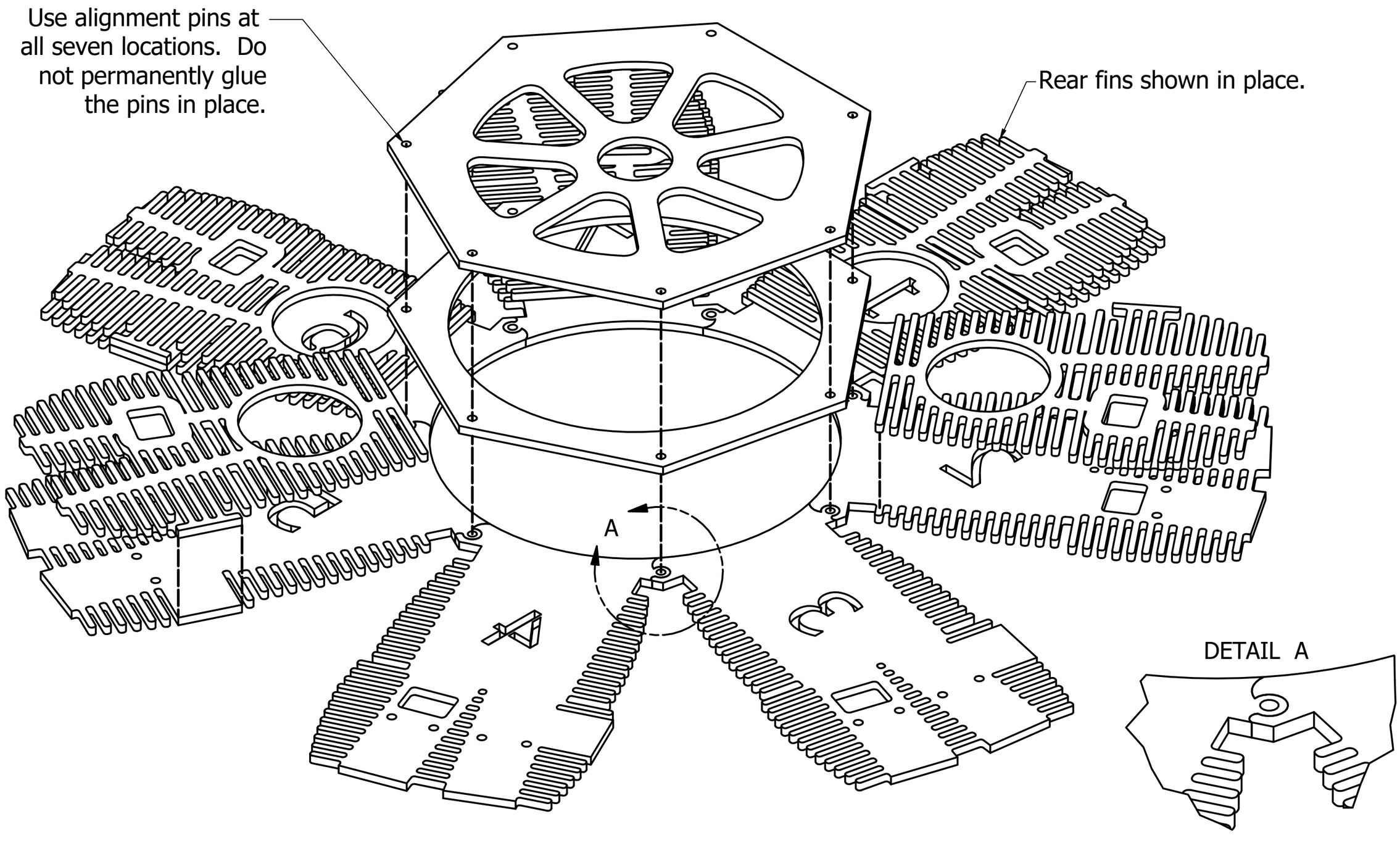
Note: Some early versions of the kit featured the seven base cylinders cut as one part. If you have one of these kits, you can still use these instructions.

The first part of the case will be assembled upside down. Begin by locating the seven base cylinders, and set them out upside down in front of you with the puzzle joints interlocking (see A).

Dry fit the Rear Case Spacer and the Rear Case on top of the Base Cylinders. Use bits of dowel rod as locator pins in all seven of the holes to lock the assembly in position.

Dry fit the seven sets of rear cylinder fins (which are purely cosmetic) over the Base Cylinders. The rear fins are omitted from cylinders three and four for clarity. Use the edges of the exhaust cutout and intake port on the cylinder head to aid you in alignment. When you are happy with your alignment, glue these down.

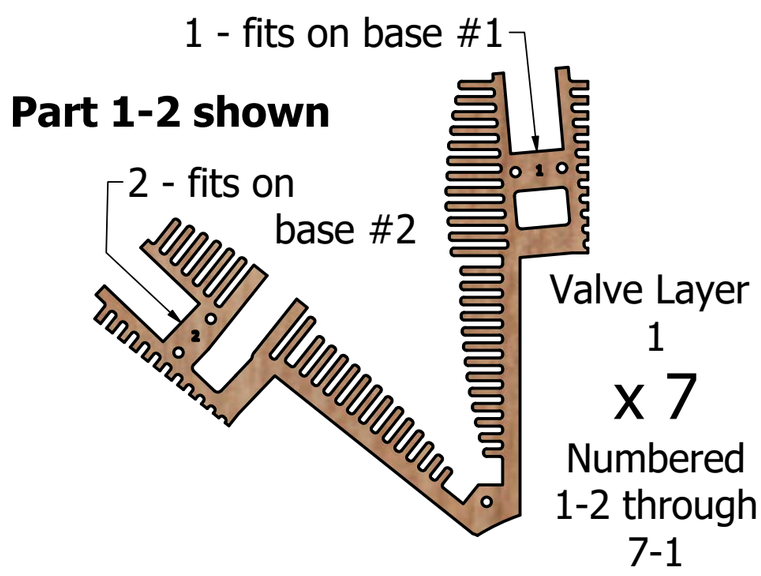
Remove the rear case spacer and rear case from the assembly, taking care not to disturb alignment. Lightly spread glue on one side of the rear case spacer, and glue it down over the center of the base cylinder assembly. Reinsert the bits of 1/8 inch dowel rod. Lightly glue the other side of the rear case spacer, and glue down the rear case over the spacer.

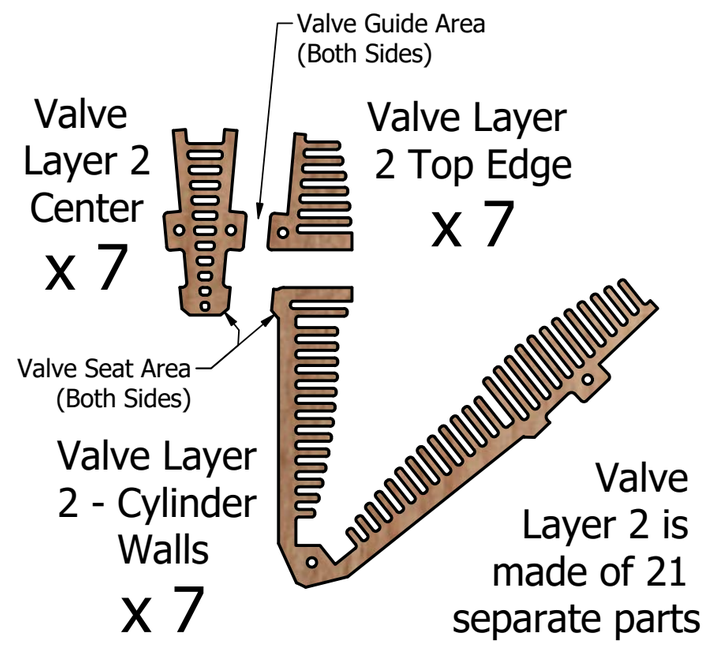


NOTE: If practical, you should glue down valve layer 1 on page 7 before the glue dries from step 6.

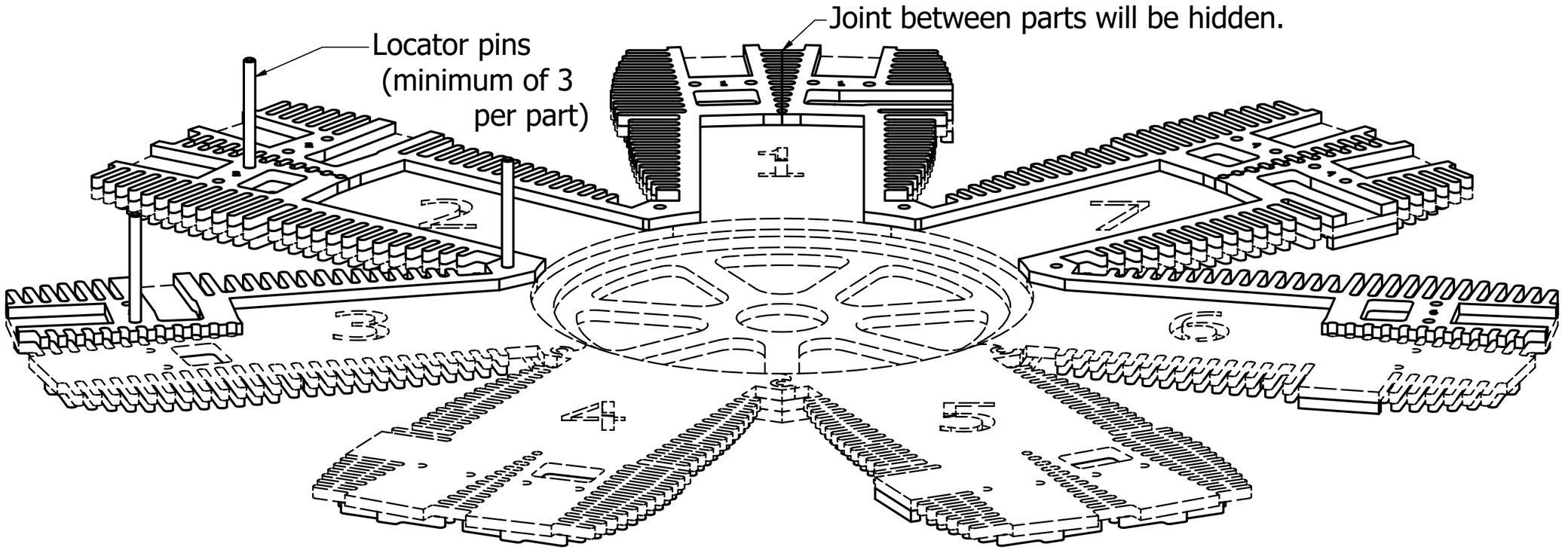
7: Valve Layers 1 and 2

New Parts:

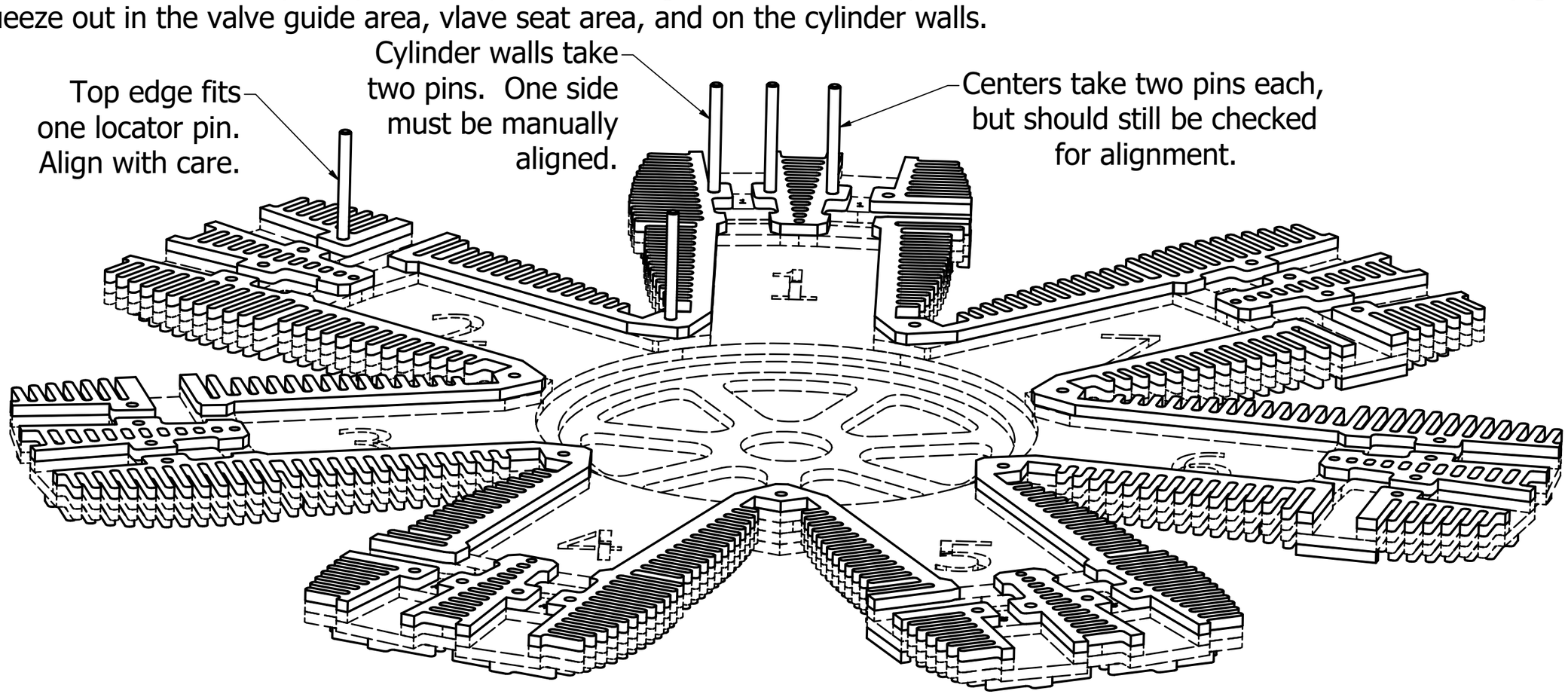




Glue each of the valve layer 1 parts into position, using a minimum of three locator pins on each part as shown in the diagram below on part 2-3. Parts 1-2, 6-7, and 7-1 are also shown installed on the diagram. Make sure to avoid any glue squeeze out in the valve guide area, vlave seat area, and on the cylinder walls.



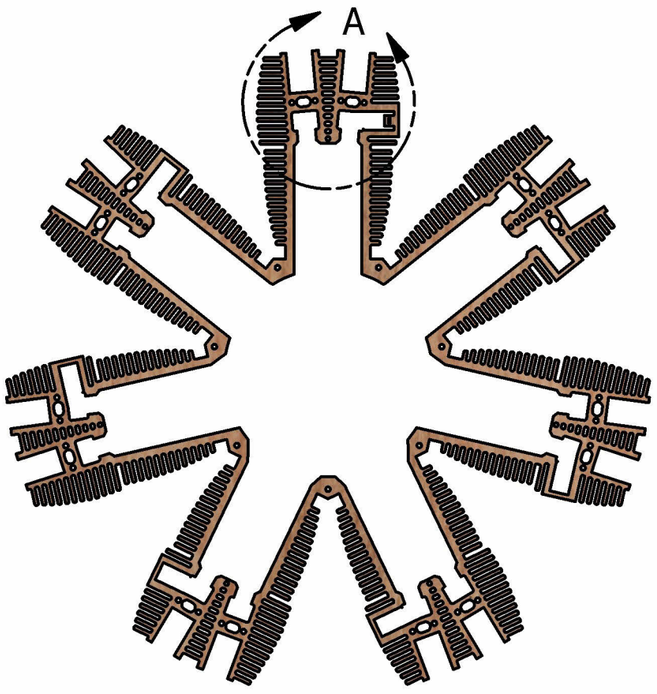
Glue each of the valve layer 2 parts into position, using all of the locator pin locations available. Make sure to avoid any glue squeeze out in the valve guide area, vlave seat area, and on the cylinder walls.

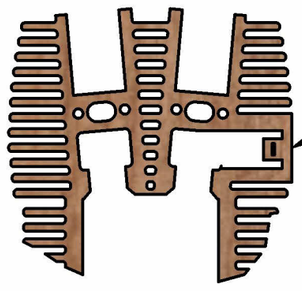


Only a few locator pins are shown in the diagrams. Use them all. Make sure to remove them before the glue dries completely.

8: Adding the Valves

New Parts:

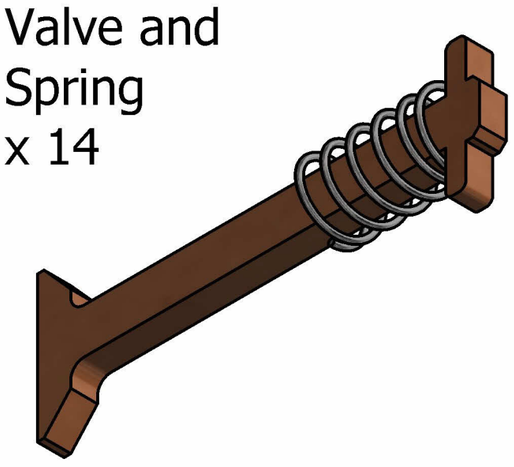


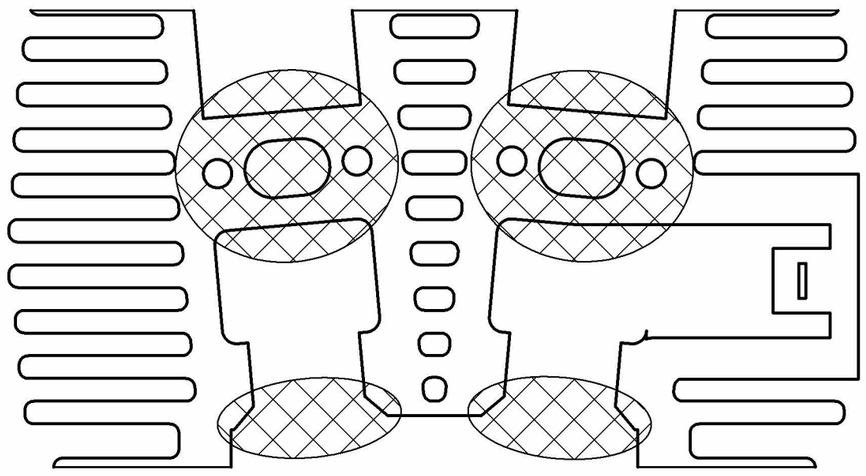


Flag on cylinder #1 only.

Valve Layer 3 Overview and Detail View A

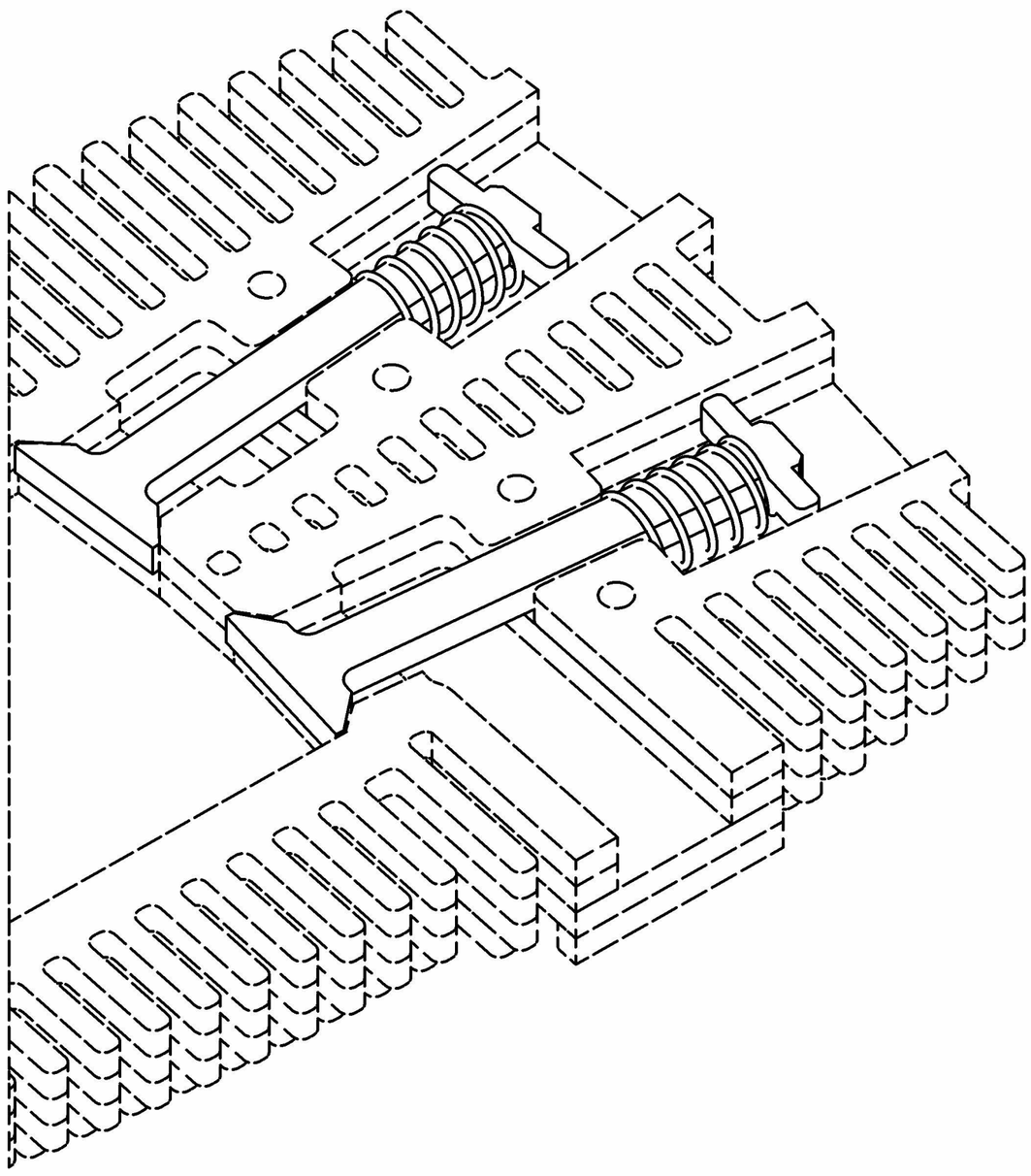
Previously Assembled Valve and Spring x 14





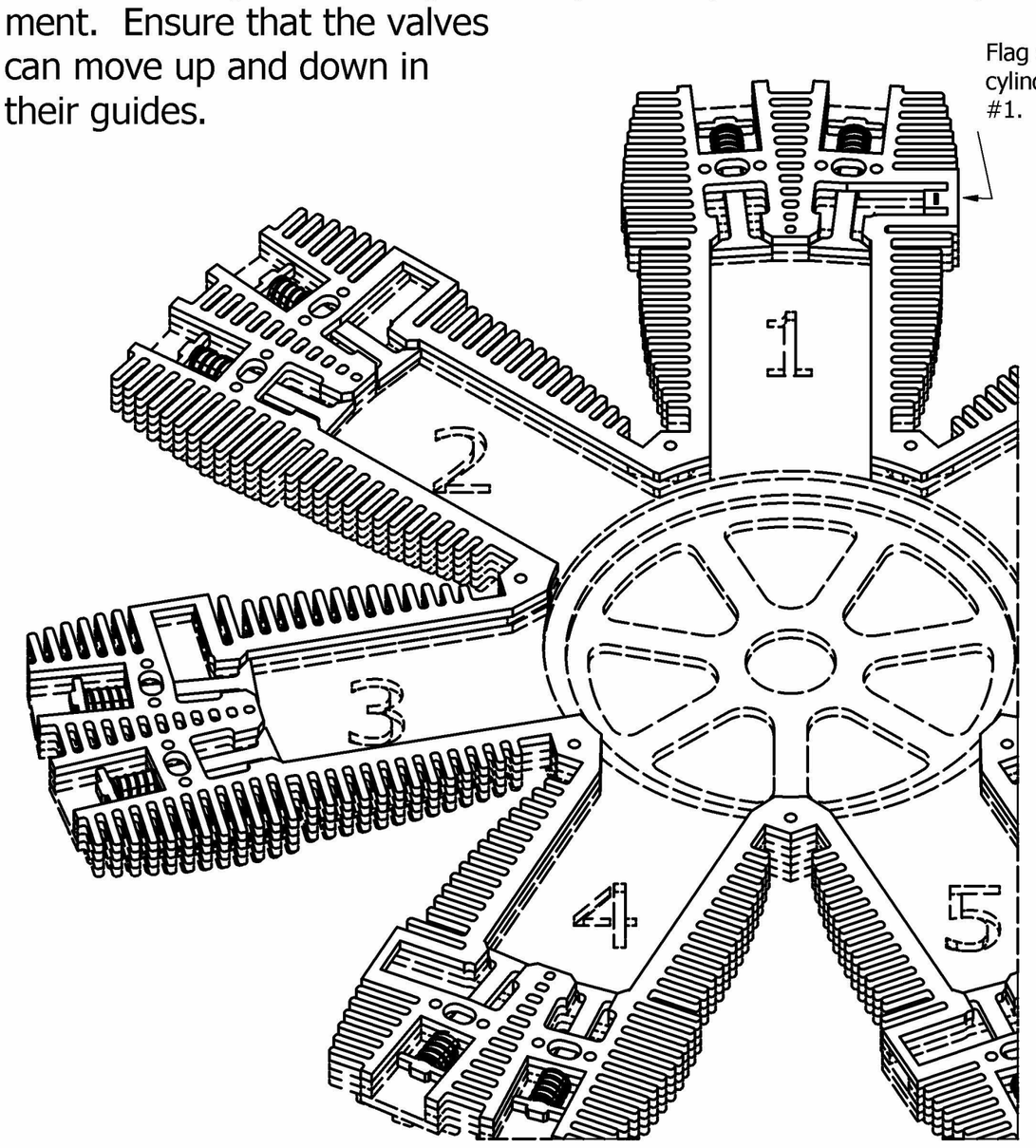
A: Add Valves

Compress the spring on each valve, and slip the valve into the valve guide. The spring should provide tension to help the valves stay in place. Do this for all 14 valves. One cylinder is shown below.



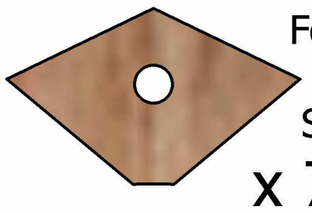
B: Add Valve Layer 3

Set layer 3 upside down (cylinder 1 flag to the left). Carefully spread a thin layer of glue on the back, taking care to avoid any of the areas shown shaded in the partial drawing above. It is very important that no glue can squeeze-out onto the valves, because it is not possible to remove this glue. Glue valve layer 3 onto the engine case, again using dowel pins to aid in alignment. Ensure that the valves can move up and down in their guides.



9: Fit Rotating Assembly

New Parts:



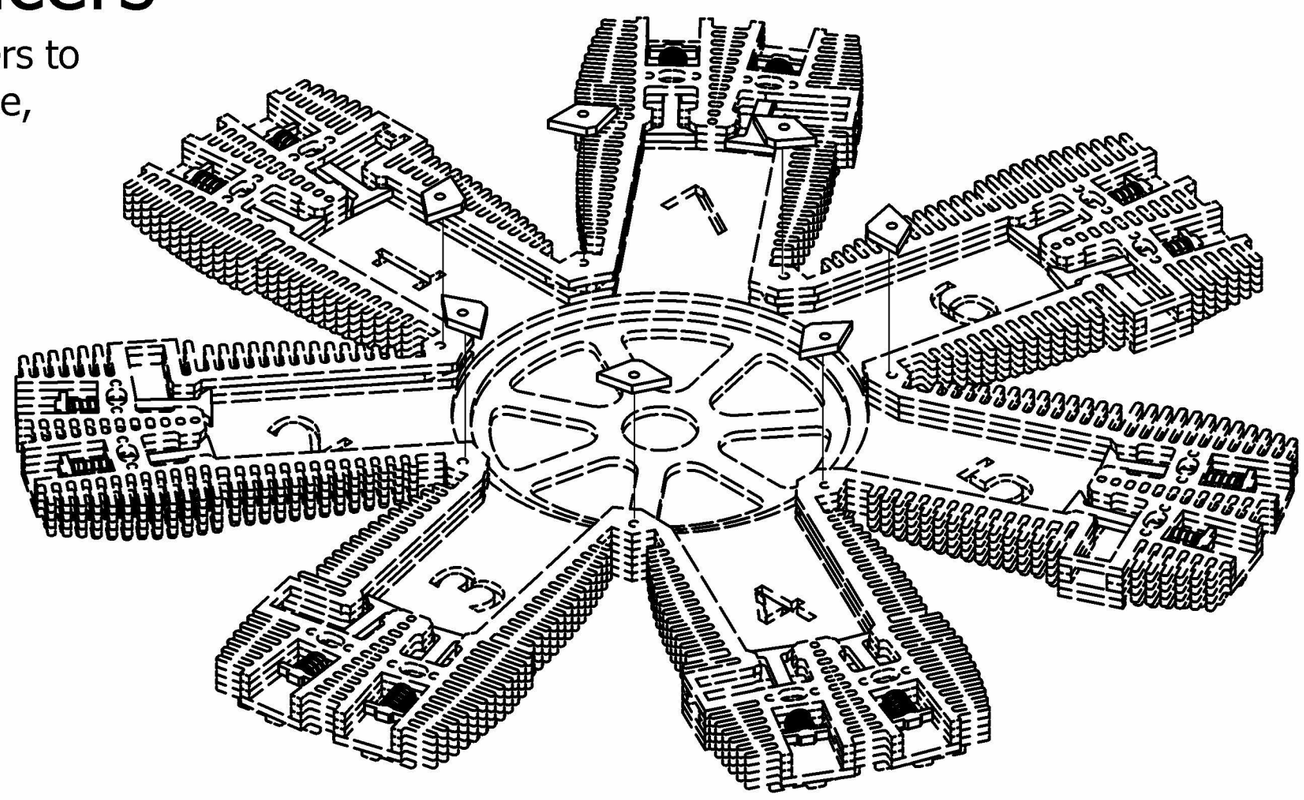
Forward Case Spacer

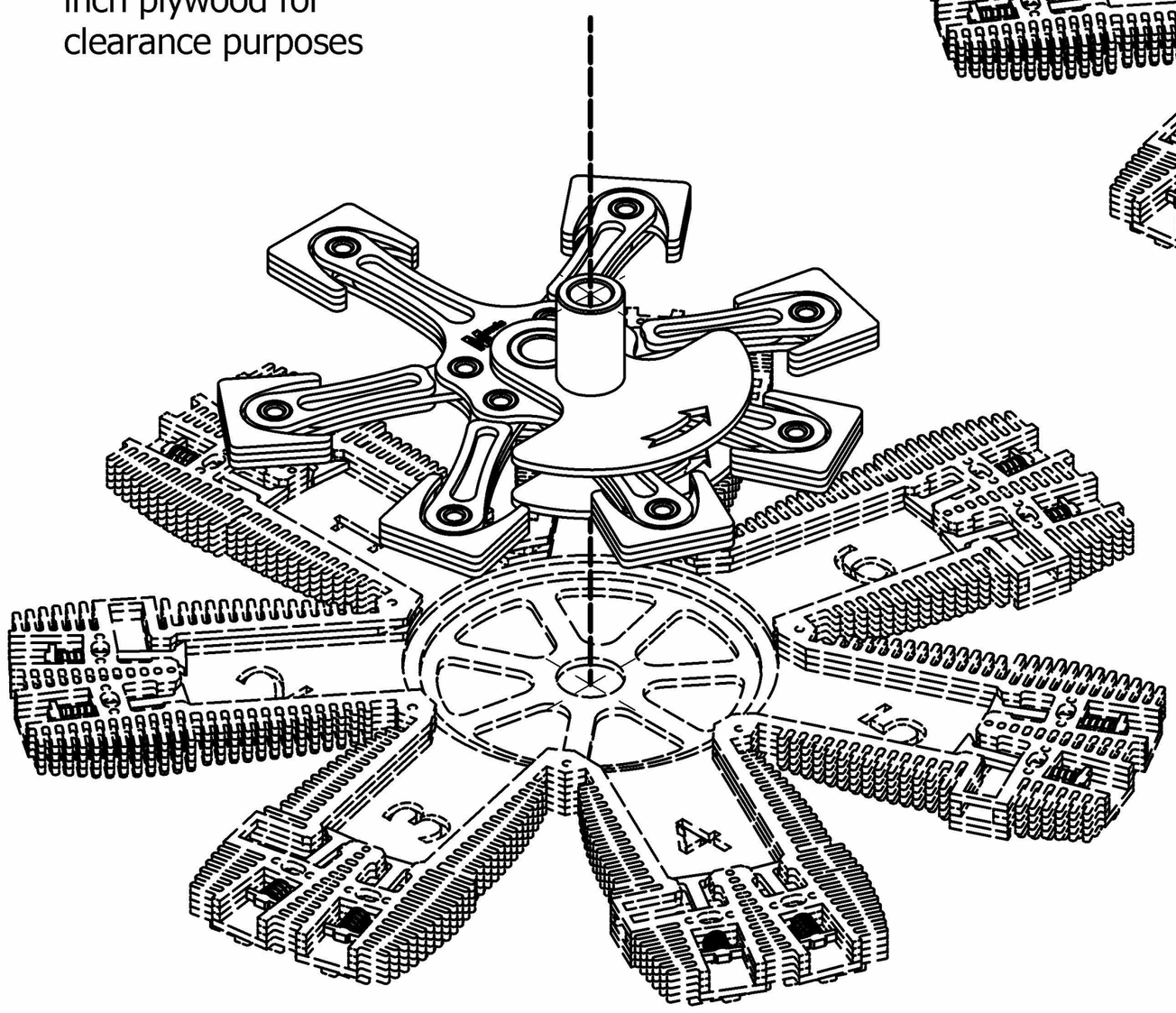
x 7

Shown Full Sized. Note - this part made from 5/32 inch plywood for clearance purposes

A: Case Spacers

Glue the 7 case spacers to the corners of the case, using 1/8 inch dowel rods as guides. See bottom view for final position.

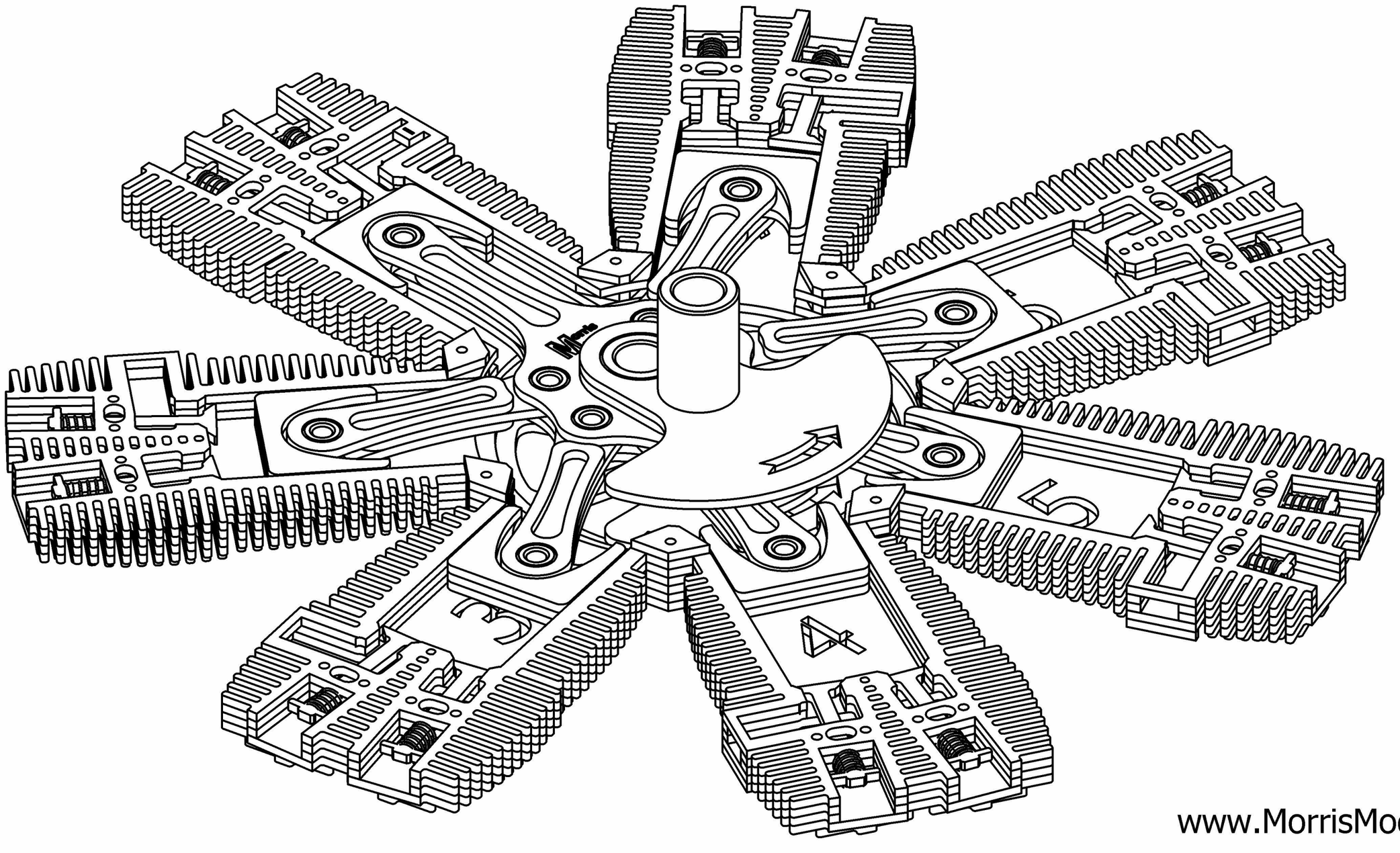




B: Rotating Assembly

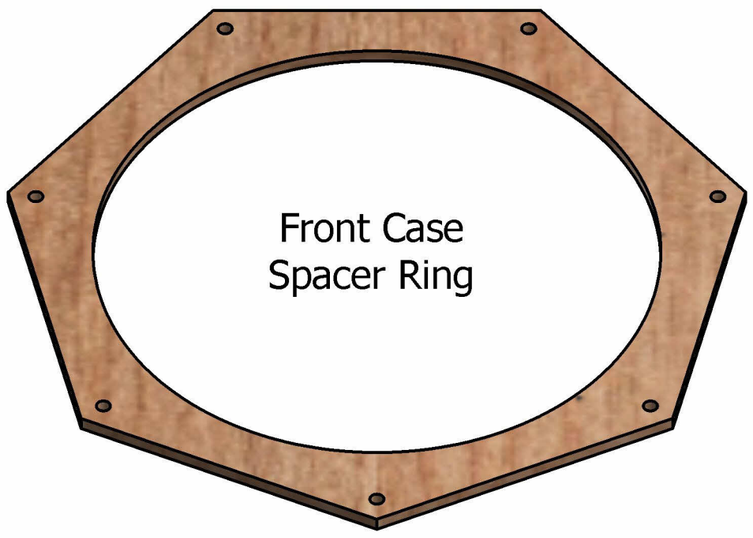
If you are waxing the assembly for easier motion, wax the bottoms and walls of the cylinders as well as the bottom of the case and sides of the hole in the rear case.

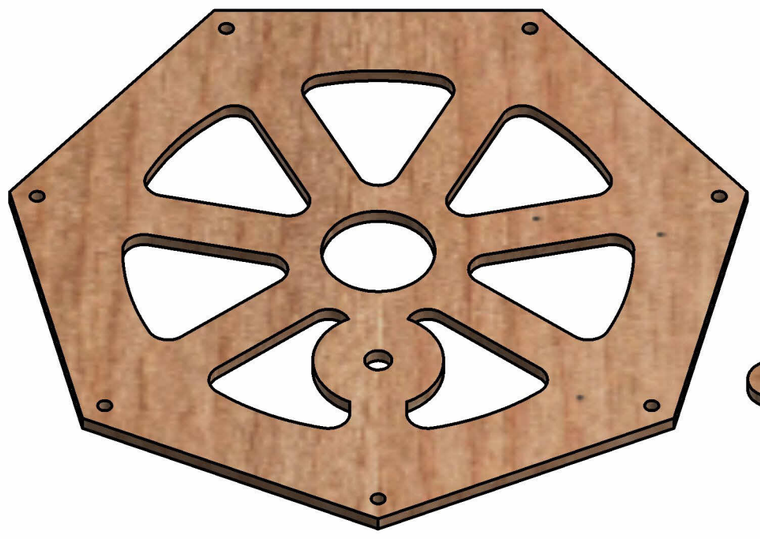
Locate the rotating assembly you previously constructed. With the long shaft facing upwards, turn the pistons and rods so that they can fit into the case and cylinders. Slide the pistons and rods into position with the lower crankshaft stub in its socket in the rear case. You should now be able to gently turn the crankshaft and watch the pistons move up and down. If anything catches so that things cannot move freely, correct it now.



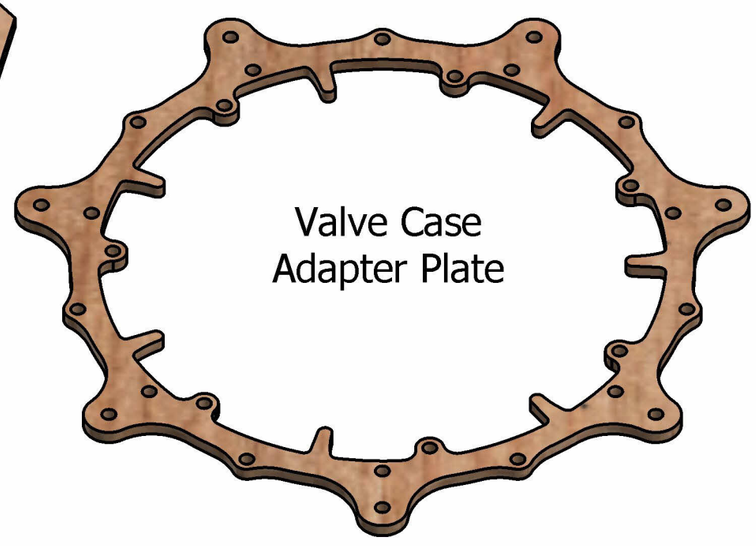
10: Crankcase to Valve Case

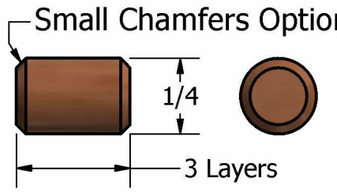
New Parts:



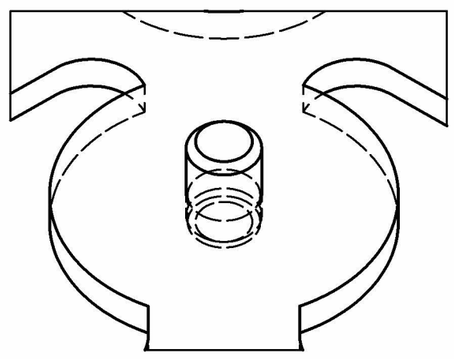


Front Case
Support Web





Timing Gear
Idler Shaft



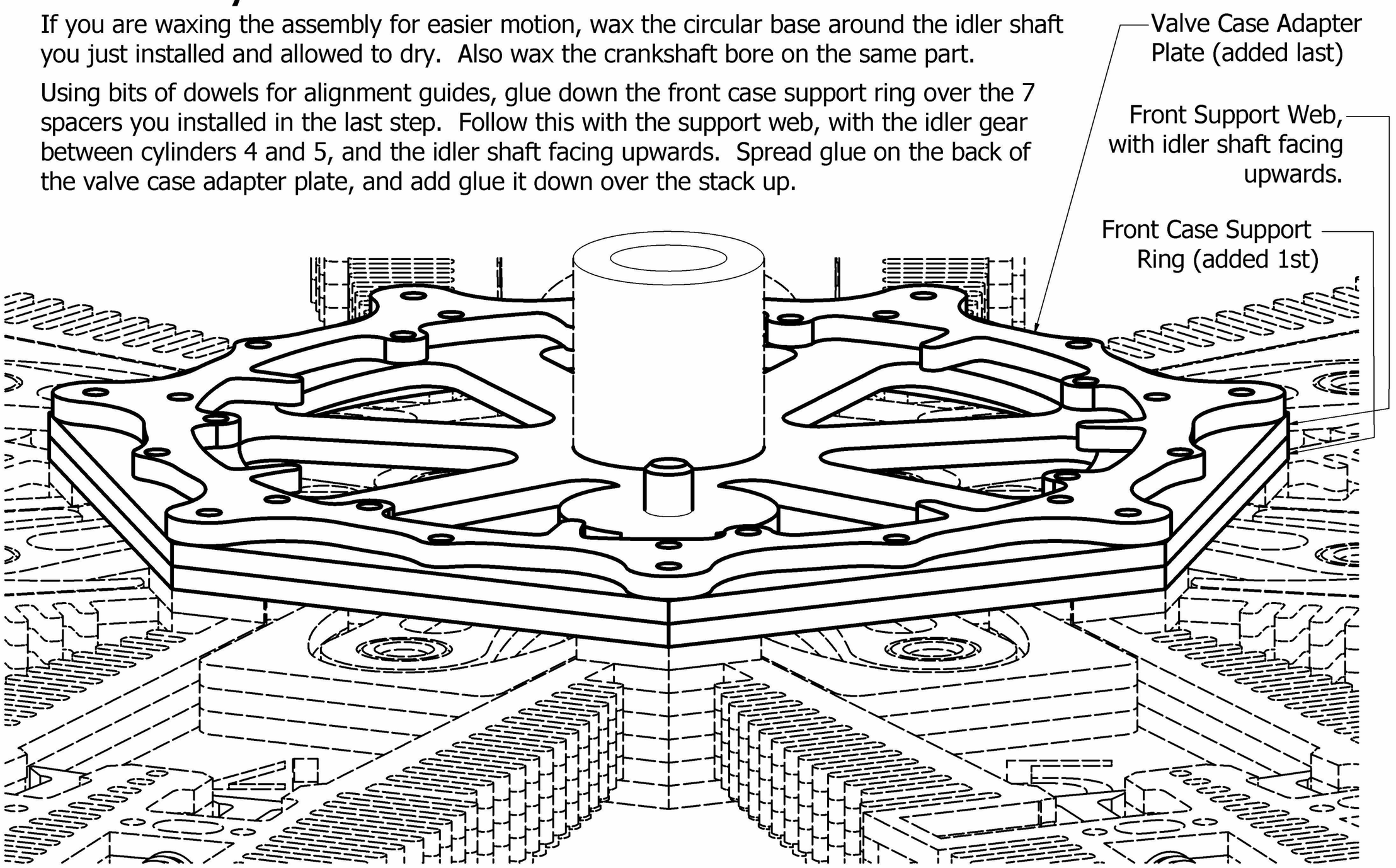
A: Idler Shaft

Set the front case support web on a sheet of waxed paper. Glue the timing gear idler shaft into its socket, making sure that it does not interfere with the bottom face of the support web, and that no glue squeeze-out appears around its edges. Set aside to dry.

B: Fit 3 layers

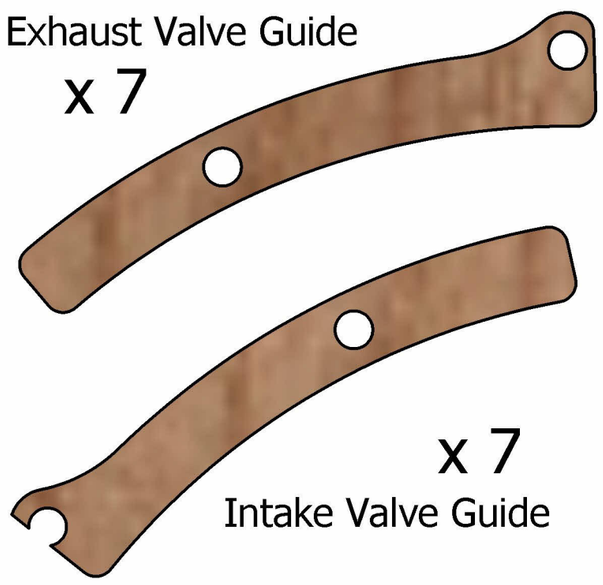
If you are waxing the assembly for easier motion, wax the circular base around the idler shaft you just installed and allowed to dry. Also wax the crankshaft bore on the same part.

Using bits of dowels for alignment guides, glue down the front case support ring over the 7 spacers you installed in the last step. Follow this with the support web, with the idler gear between cylinders 4 and 5, and the idler shaft facing upwards. Spread glue on the back of the valve case adapter plate, and add glue it down over the stack up.

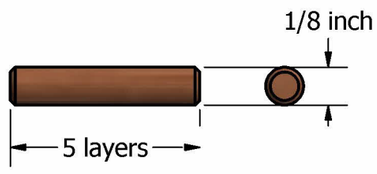


11: The Valve Case

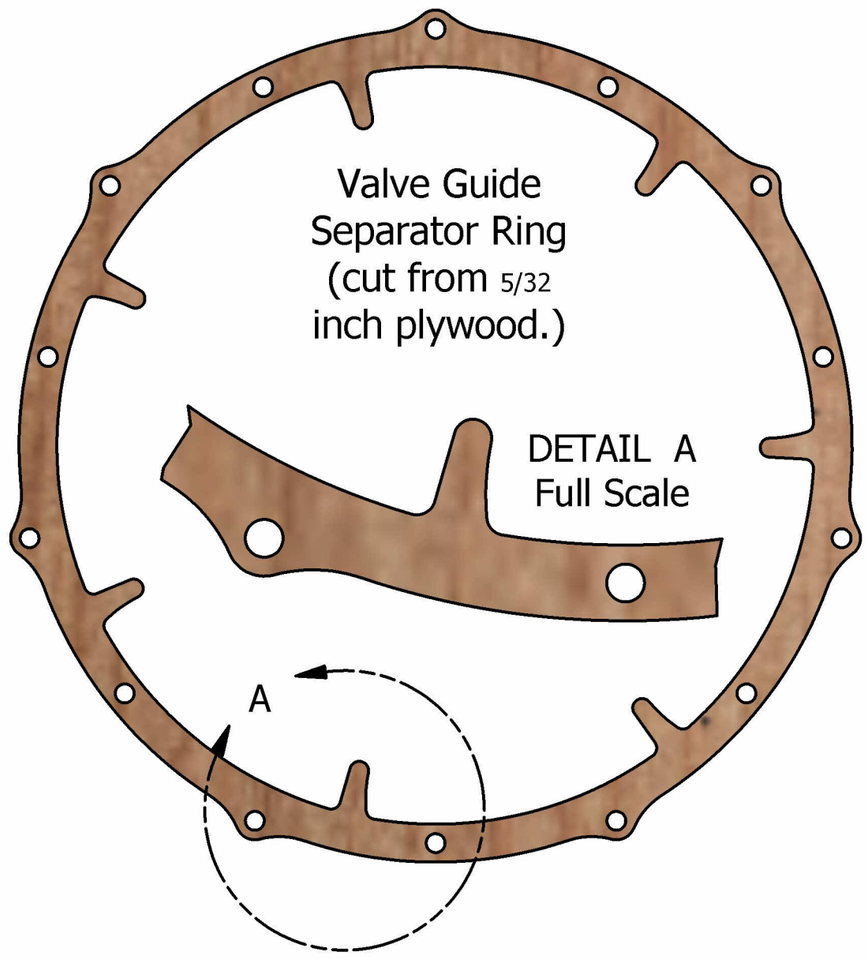
New Parts:

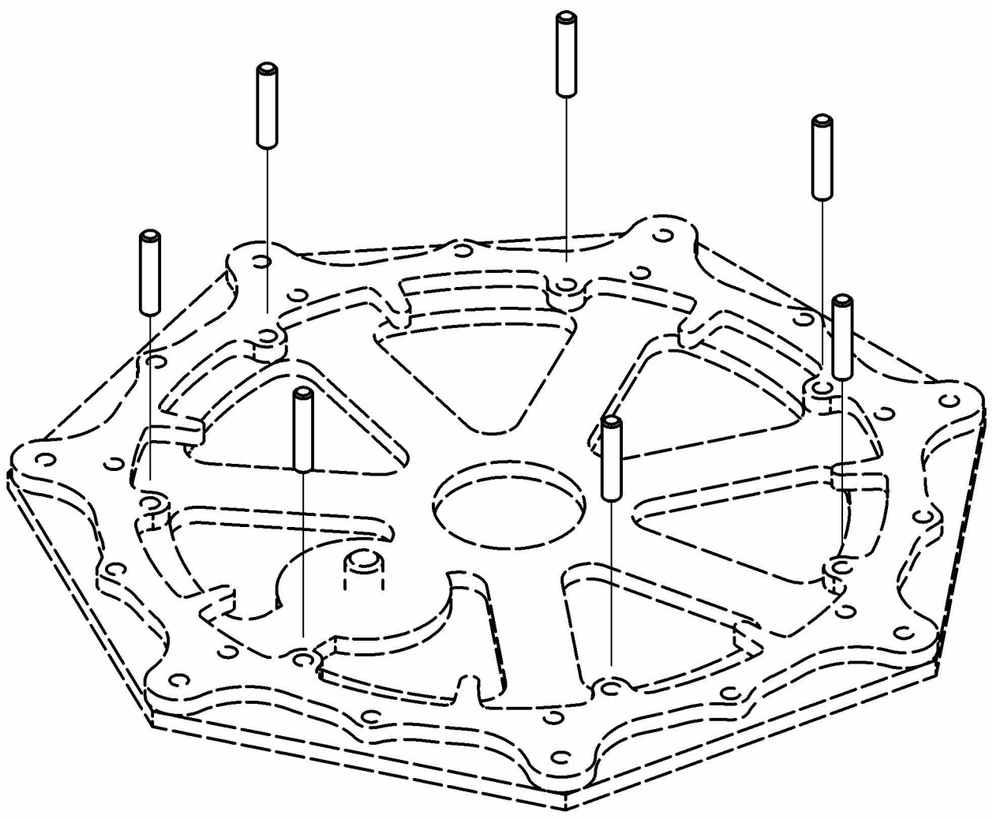


Note: The valve guide layers are formed from 7 separate parts each. These parts are directional, and are shown here full sized. They can be distinguished by whether or not they have two complete alignment holes. Do not confuse them.



x 7
Valve Guide Pin



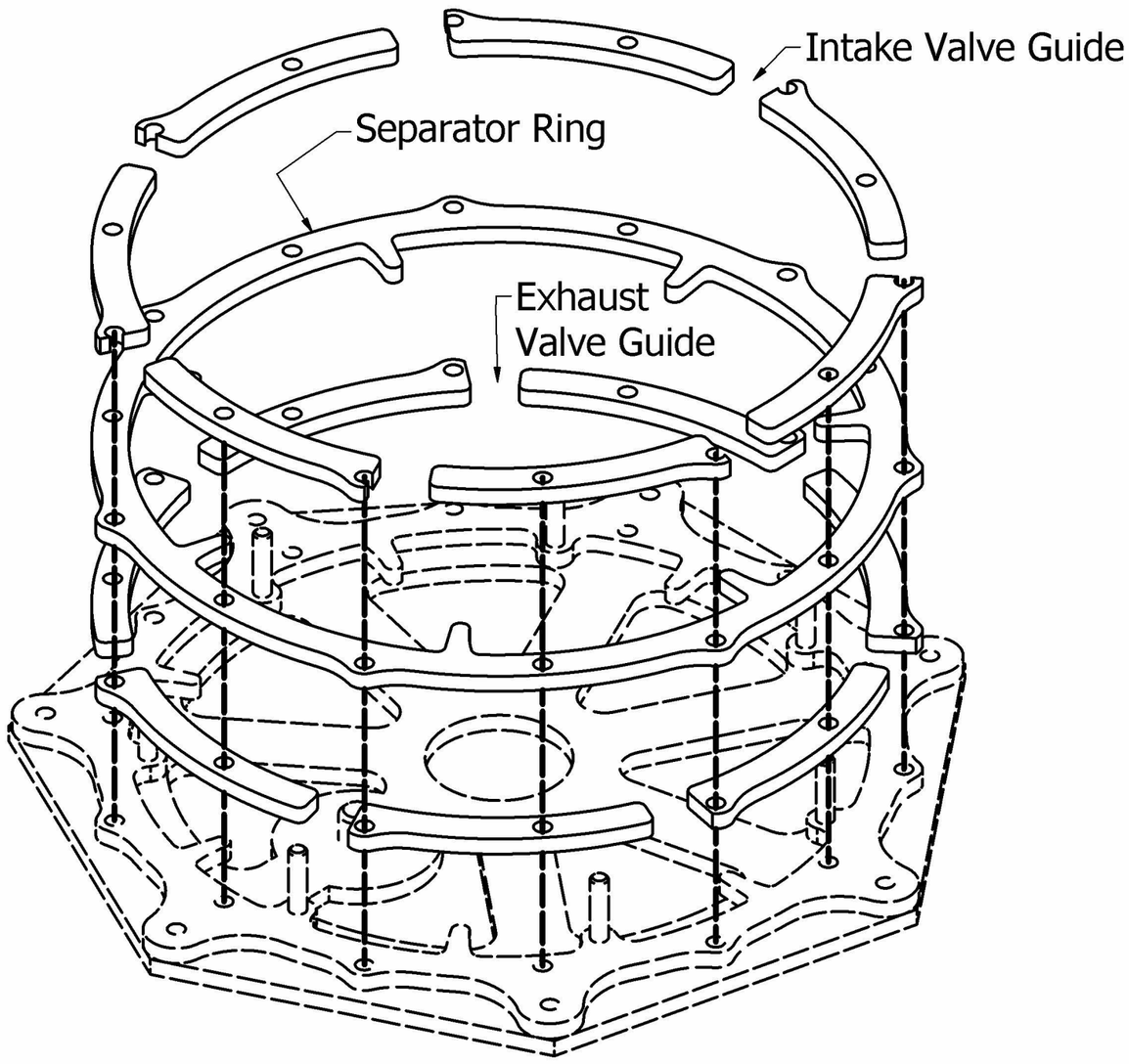


A: Valve Guide Pins

The 7 valve guide pins fit into the 7 sockets in the inside of the Valve Case Adapter Plate which was installed in step 10. Lightly glue these pins into their sockets, making sure that no glue squeeze out will interfere with the valve guides as they are slid over them in a future step. Do not allow these to dry before going on to the next step. Note that only the last two layers completed on the engine are shown in these illustrations for visual clarity.

B: Valve Guide Walls

Using dowel pins for alignment aides, lightly glue the 3 layers into place. Begin by gluing the backs of the 7 exhaust valve guides and stick them in place - making sure to avoid squeeze out in the gaps. In similar fashion, apply glue to the tops of the same pieces and glue the separator ring down. This is also a directional piece, so make sure it is oriented correctly. See detail view for guidance. Finally, glue the backs of the 7 intake valve guides, and stick them down in the same manner as the exhaust valve guides - again watching out for the problematic glue squeeze-out in the gaps.



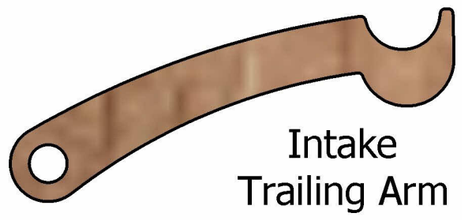
Warning:

It is important that the valve guide pins be held straight while the glue dries from step A. The best way to do this is to dry-install the valve case cover as shown in step 13. Leave it in place over the temporary alignment pins while the valve guide pins dry, then remove it before moving on the step 12.

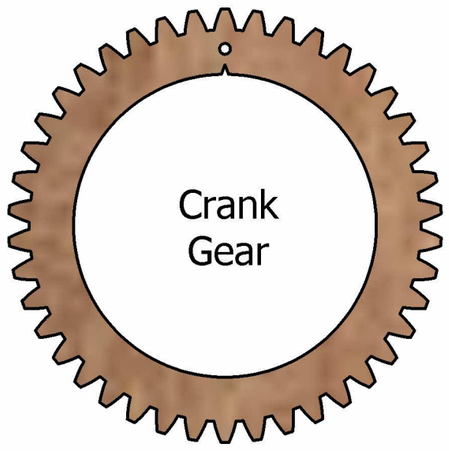
12: Filling the Valve Case

New Parts:

Exhaust
Trailing Arm
x 7



Intake
Trailing Arm
x 7



Valve arm spacer
x 7

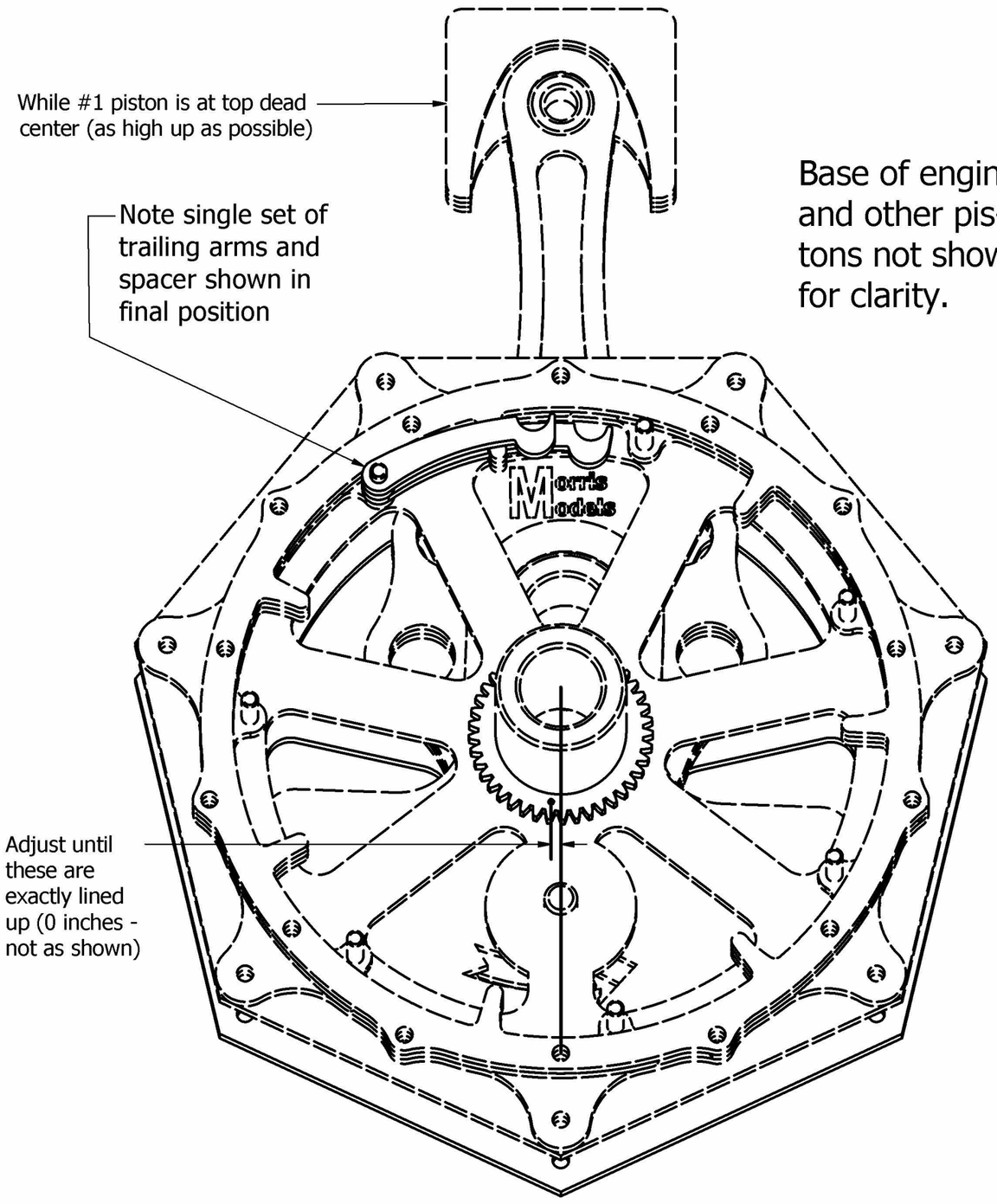
All new parts on this page are shown at full size when this is printed on A sized paper.

This step must be completed with a lot of care and finesse. Begin, by gluing the crank gear over the forward crankshaft. The gear must be glued in such a way that it is glued to the shaft, but is not glued to the support web behind it, or to the cam plate which will set in front of it. This is highly critical and very exacting. Begin by setting several small strips of waxed paper around the edge of the crankshaft. Dry fit the crank gear in position, making sure that the timing mark on the gear is as low as possible (straight down, 180°) while the number one piston is as high up as possible (straight up, 0°). Use a pencil to make a small alignment guide on the crankshaft, them remove the crank gear.

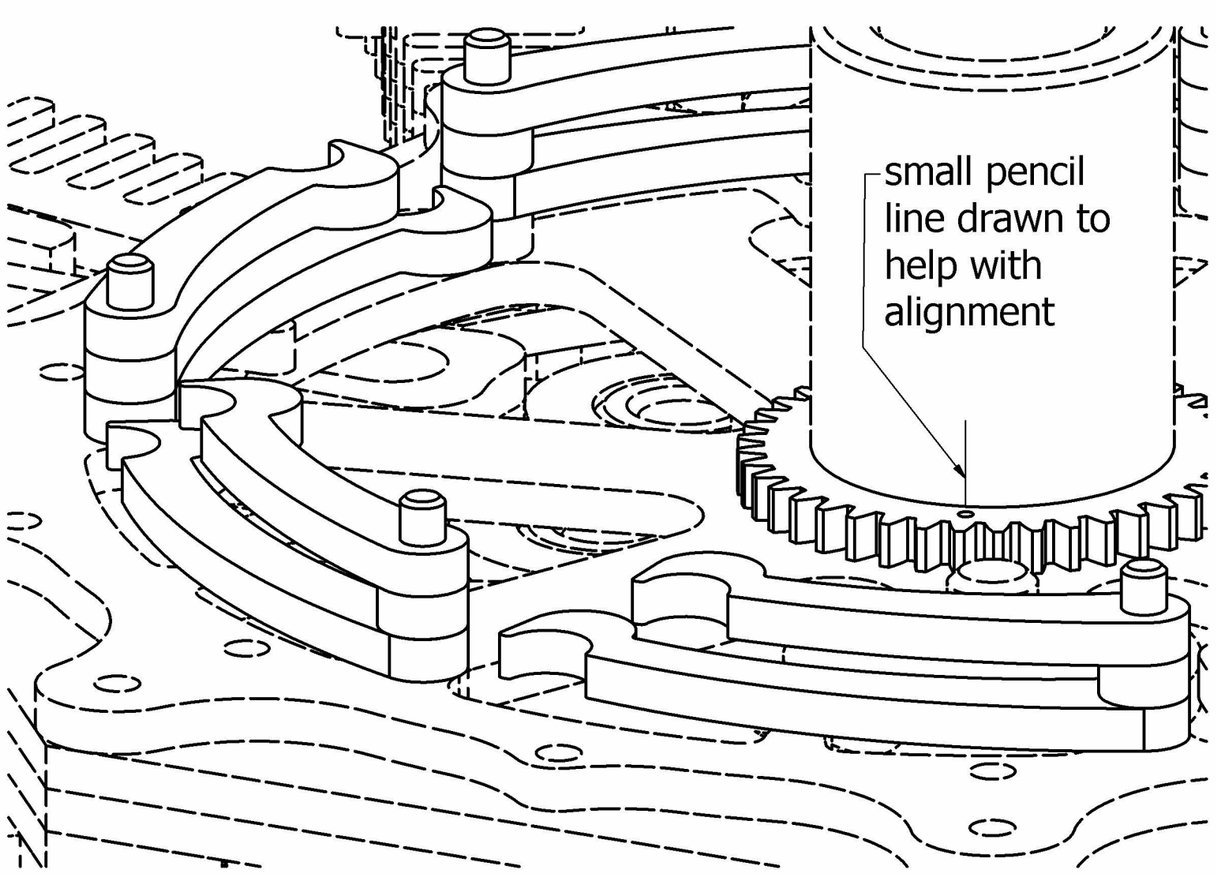
Now, use a small toothpick or similar device to spread a VERY thin ring of glue about 1/8 inch above the bore in the crank web. Carefully re-install the crank gear, twisting and wiping the glue into the the space between the gear and the shaft, but not allowing it to be pushed downwards onto the rear face of the gear. Leave a space about as thick as a playing card between the rear face of the gear and the forward face of the bore in the web. While the glue dries, rotate the crankshaft every few minutes, making sure that the crank gear stays lined up with your mark. This will prevent any traces of glue from locking up the engine.

While the glue is drying on the crank gear, position the trailing arms and spacers on the pins you installed in the last step. The final positions are shown. However, the guide walls are not shown on the bottom diagram for clarity. Beginning with the exhaust trailing arms, slide them onto the pins. You will need to pull the socket ends of the arms towards the crankshaft to clear the side guides built into the adapter plate and separator ring. Once the arm is all the way seated on the pin, pivot it as close to the guide wall as possible. Do this for all 7 exhaust trailing arms. Then add the 7 spacers to the pins. Install the 7 intake trailing arms last. They should lay across the top of the guides on the separator plate.

Do not forget to keep turning the crankshaft every few minutes until the risk of engine lockup from stray glue is over.

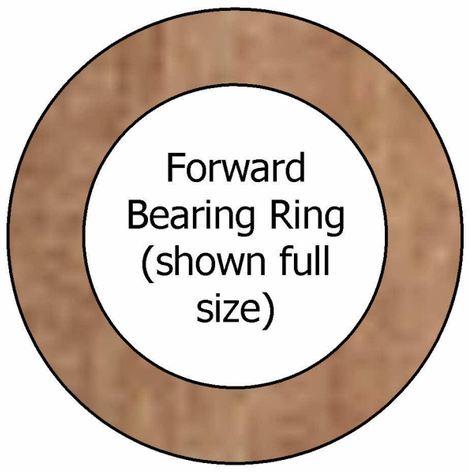


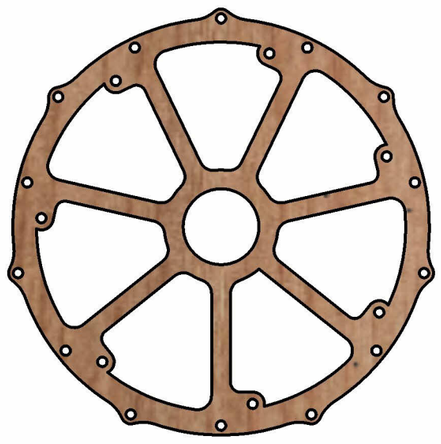
Base of engine and other pistons not shown for clarity.



13: Closing the Valve Case

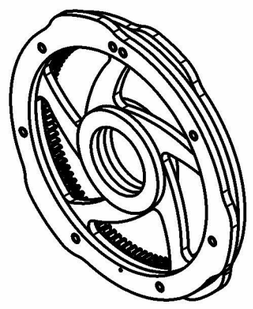
New Parts:



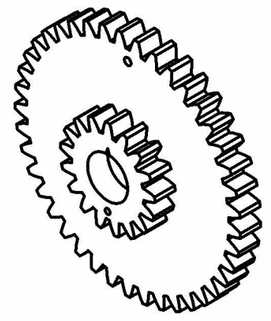


Valve case cover
(shown much smaller
than the bearing ring)

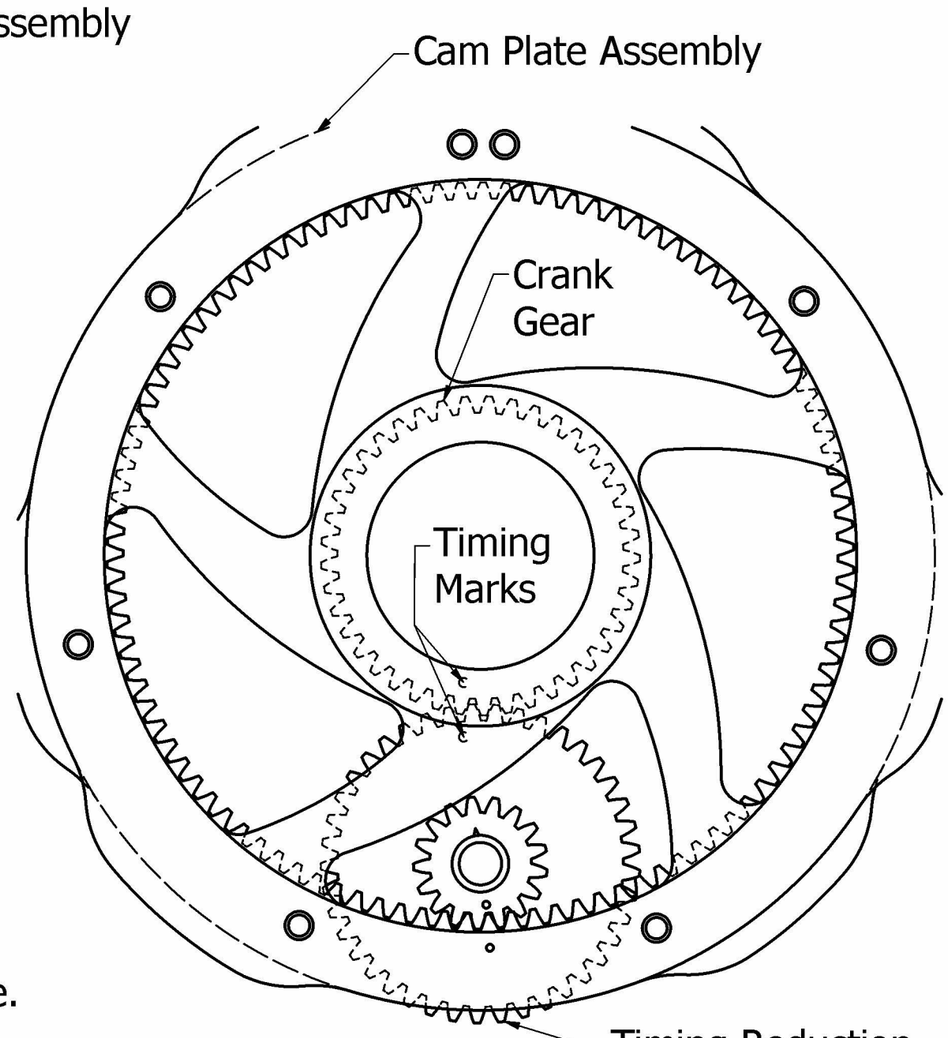
Previous Assemblies:



Cam Assembly



Timing
Reduction
Gear
Assembly



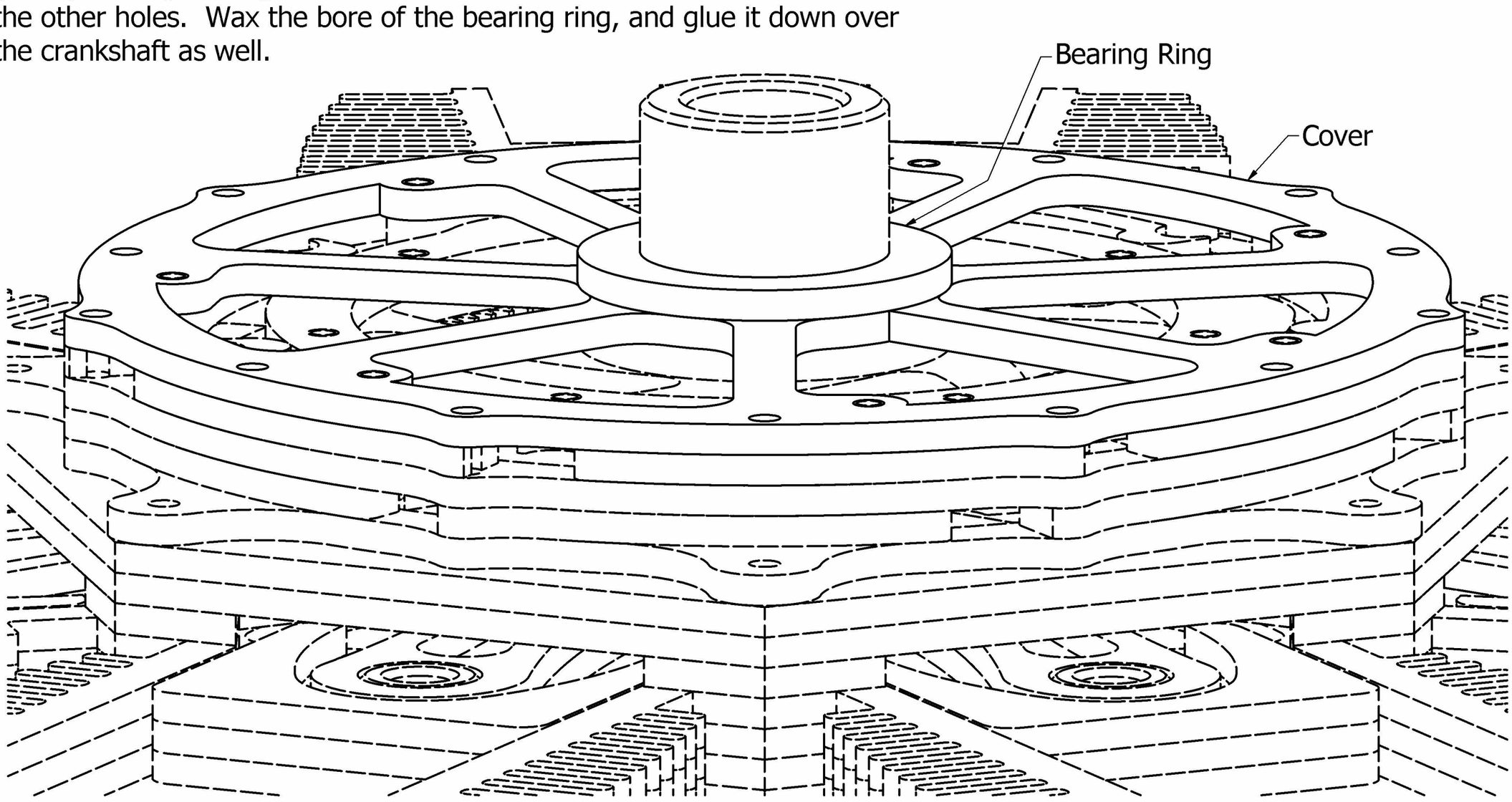
A: Cam Plate and Reduction Gear

Wax the timing gear idler shaft and the back of the timing reduction gear assembly. Slip the timing reduction gear assembly over the idler shaft, making sure that timing mark on the large gear matches the coresponding timing mark on the crank gear.

Wax the bore and front and rear bearing shoulders of the cam plate, and fit the cam plate over the crankshaft with the gear teeth to the rear. You will need to make sure that the trailing arms are pivoted all the way against the walls in order for them not to interfere with the cam plate. Again, timing marks are provided and must be followed. This time, align the mark on the large internal cam gear with the mark on the small gear tooth.

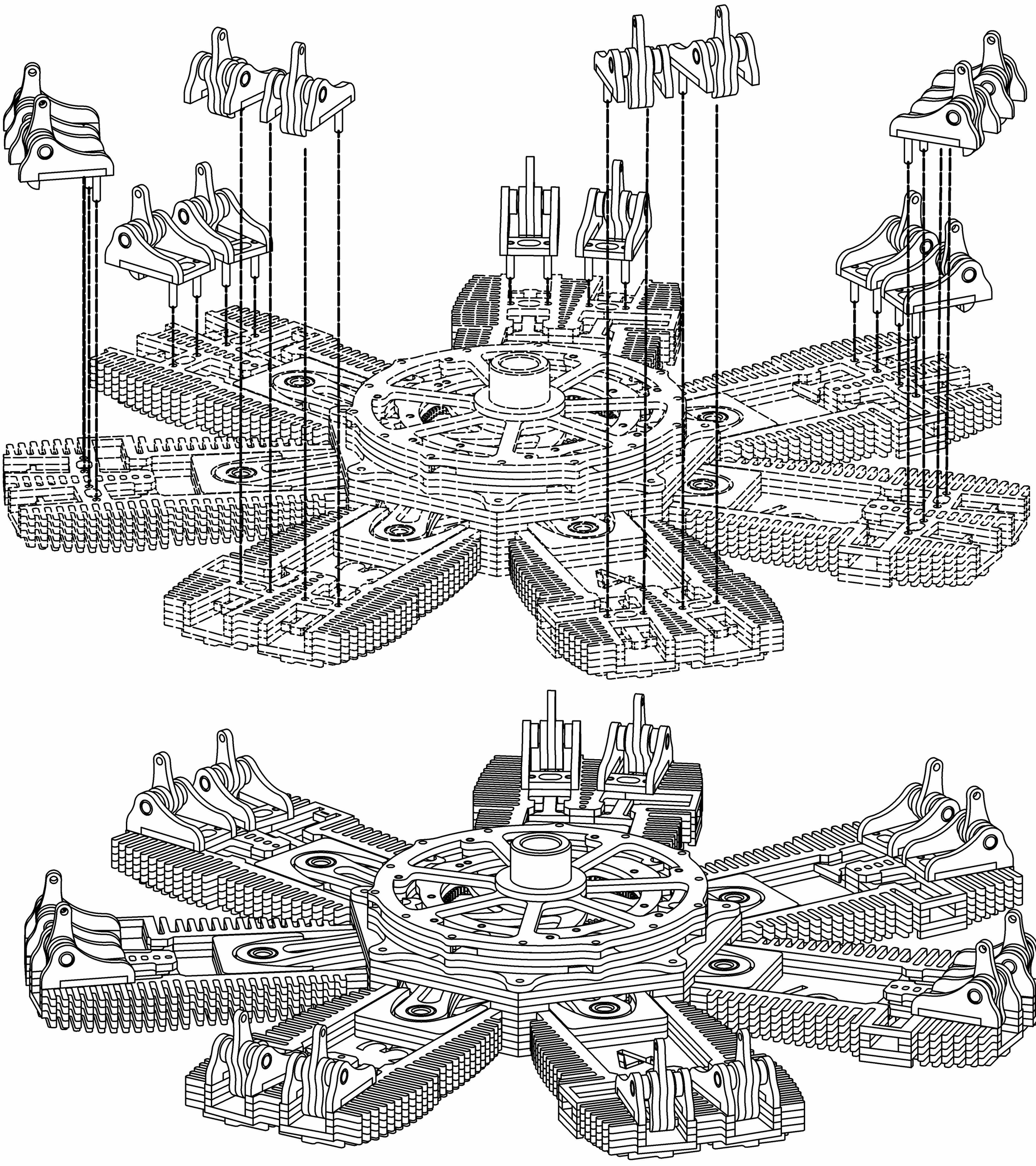
B: Cover and Bearing Lip

Wax the bore of the valve case cover and forward faces of the cam plate. Carefully spread a thin layer of glue over the tops of the 7 intake valve guides, taking care to avoid placing any glue where it would squeeze into the valve guide gaps. Note that the valve case cover is directional. Slide it over the crankshaft, and bed it down over the previously installed valve guide pins. Again, alignment should be aided with bits of dowell rods in the other holes. Wax the bore of the bearing ring, and glue it down over the crankshaft as well.



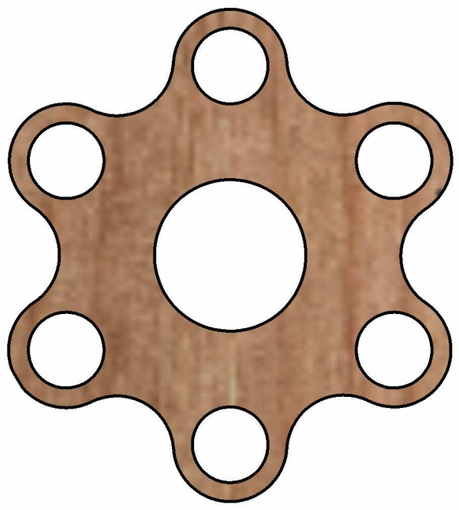
14: Rocker Arm Assemblies

Install the 14 rocker arm assemblies you previously built. This is best done by cutting 28 short (approximately 1/2 inch) dowell rods and gluing them into the holes in the backs of the assemblies. These alignment pins will not be removed at the end of this step. Lightly coat the backs of the rocker arm assemblies with glue and glue them in place - two to a cylinder head. Before the glue dries, make sure that each rocker arm engages with it's valve and can move it inwards and outwards. Also, make sure that the rocker arm can pivot into position with the hole facing forwards as shown in the diagram.

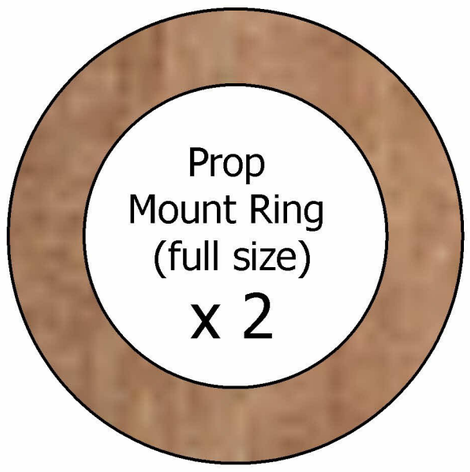


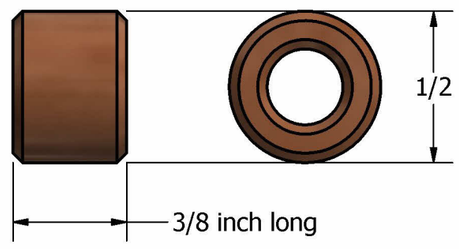
15: Prop Hub and Spinner

New Parts:



Prop Mount and Knob



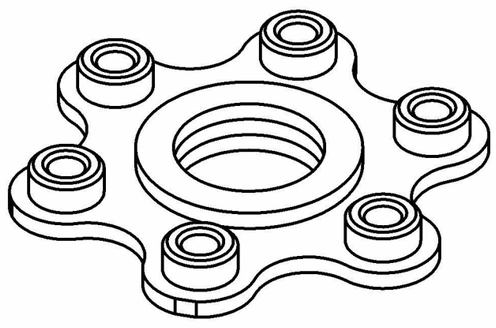


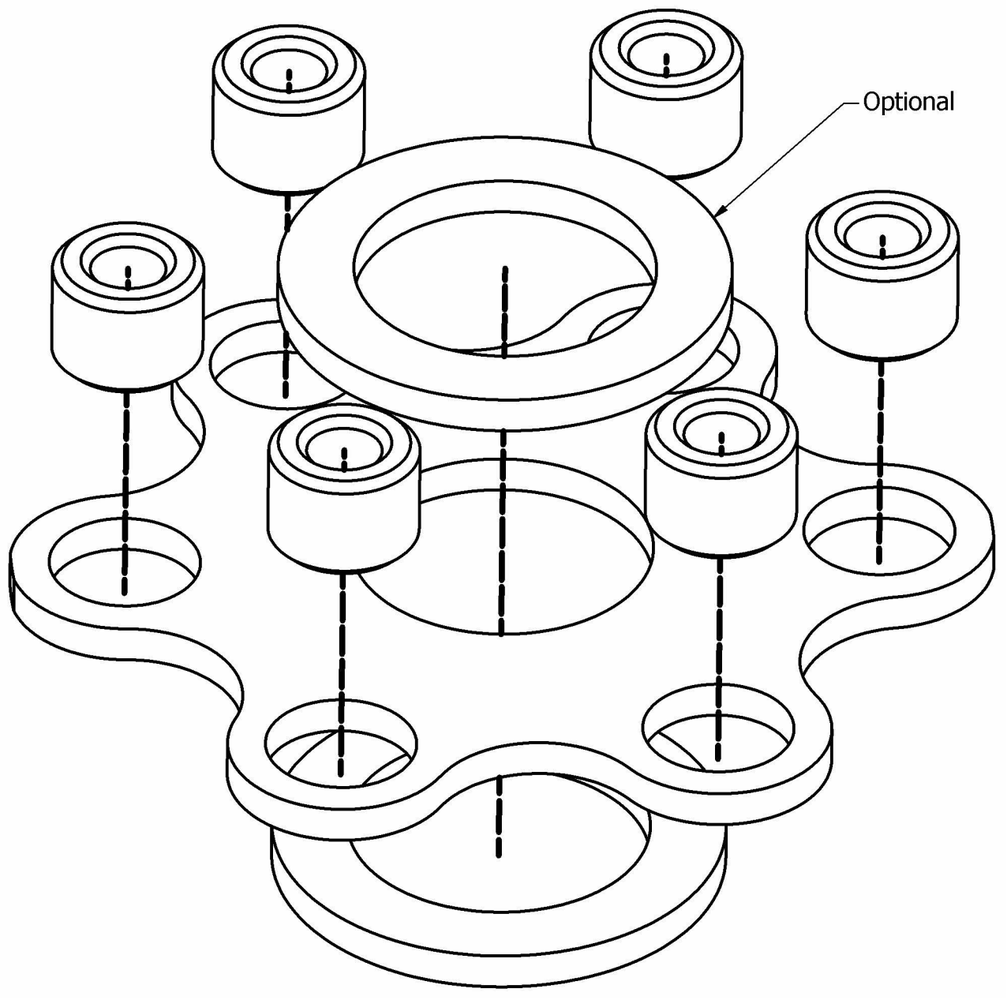
Prop Mount Stud

X 6

A: Assemble Prop Hub

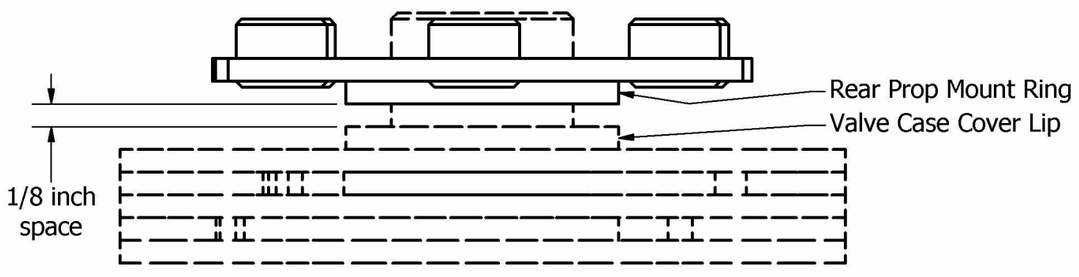
The prop hub doubles in function as a convenient handle to allow for easy rotation. Assemble the prop hub by gluing a prop mount ring to the top and another one to the bottom of the prop mount central bore. Glue the prop mount studs to the six smaller bores.



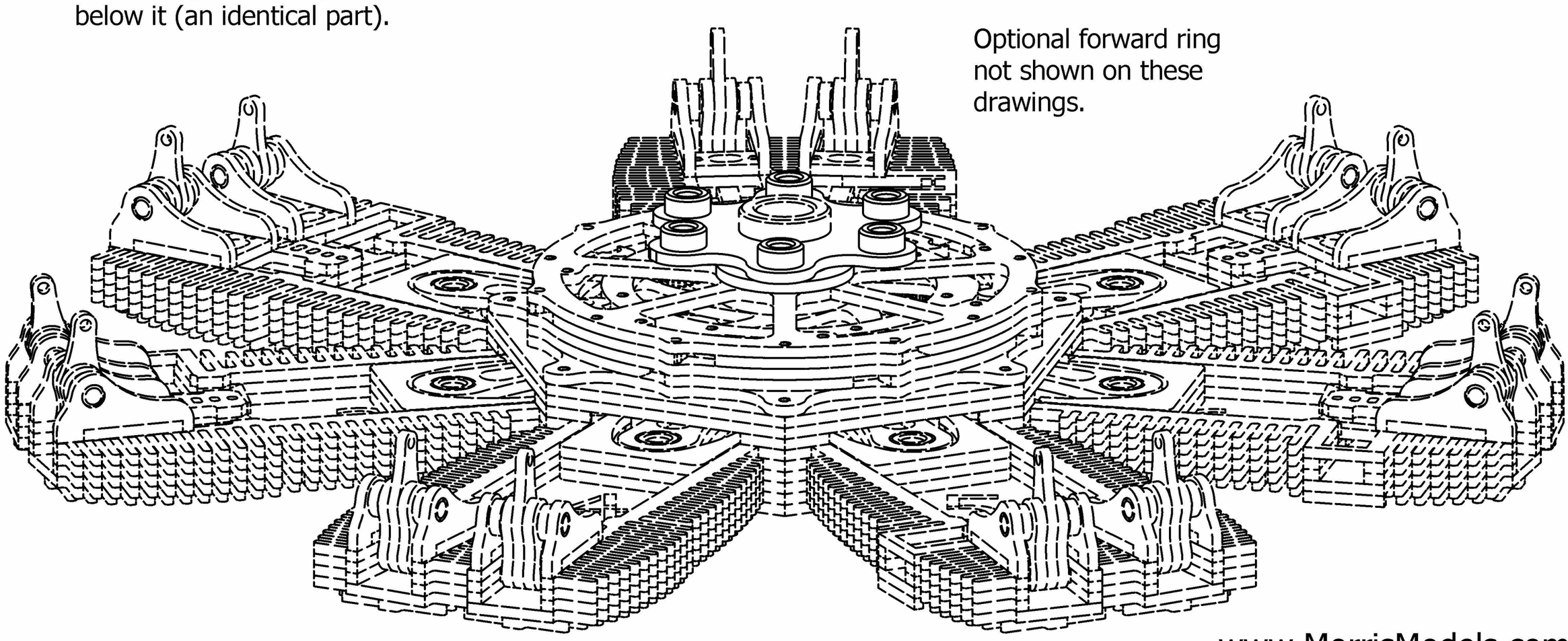


B: Attach the Hub

Glue the prop hub to the crankshaft, leaving an approximately 1/8 inch space between the rear mount ring and the lip on the valve case cover below it (an identical part).



Optional forward ring not shown on these drawings.



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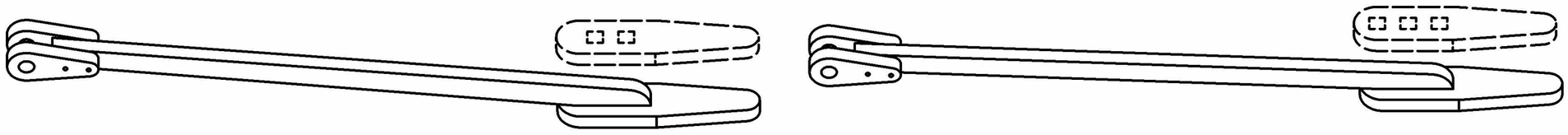
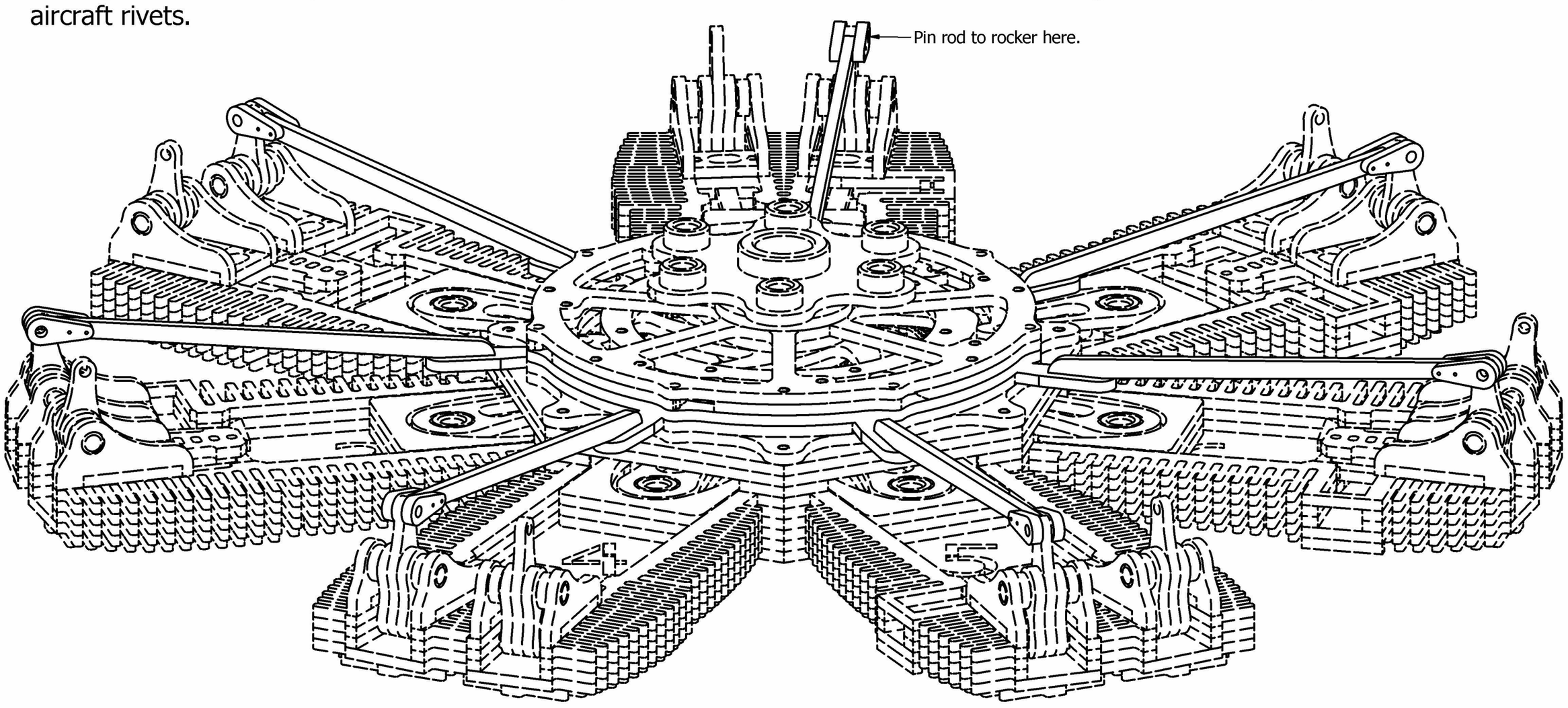
16: Install Pushrods

Assembly Reminder:



Exhaust pushrod has a two stub joint, and a slightly steeper angle than the intake pushrod with its three stub joint.

Wax the tapered portions of the pushrod lifters on all 14 of the pushrods. Slip the exhaust pushrod ends (7 of them) into the lower valve guides. Pin the top end of the exhaust pushrods to the rocker arms with 1/2 inch long bits of dowel rod, or with AN470AD-8 aircraft rivets.



Slip the intake pushrod ends (7 of them) into the upper valve guides. Pin the top end of the exhaust pushrods to the rocker arms with 1/2 inch long bits of dowel rod, or with AN470AD-8 aircraft rivets. Check the operation of the valves. If any valves do not close all all of the way, remove the rod from the affected valve and sand a tiny bit off of the end that goes into the valve case. Go slowly, and check fit before removing more material. It is easy to sand more material off, but quite difficult to sand more material back on. Replace the rod, and check again. When all of the valves open and close as they should, a tiny dab of glue on the out-side edge will keep the pins from falling out.