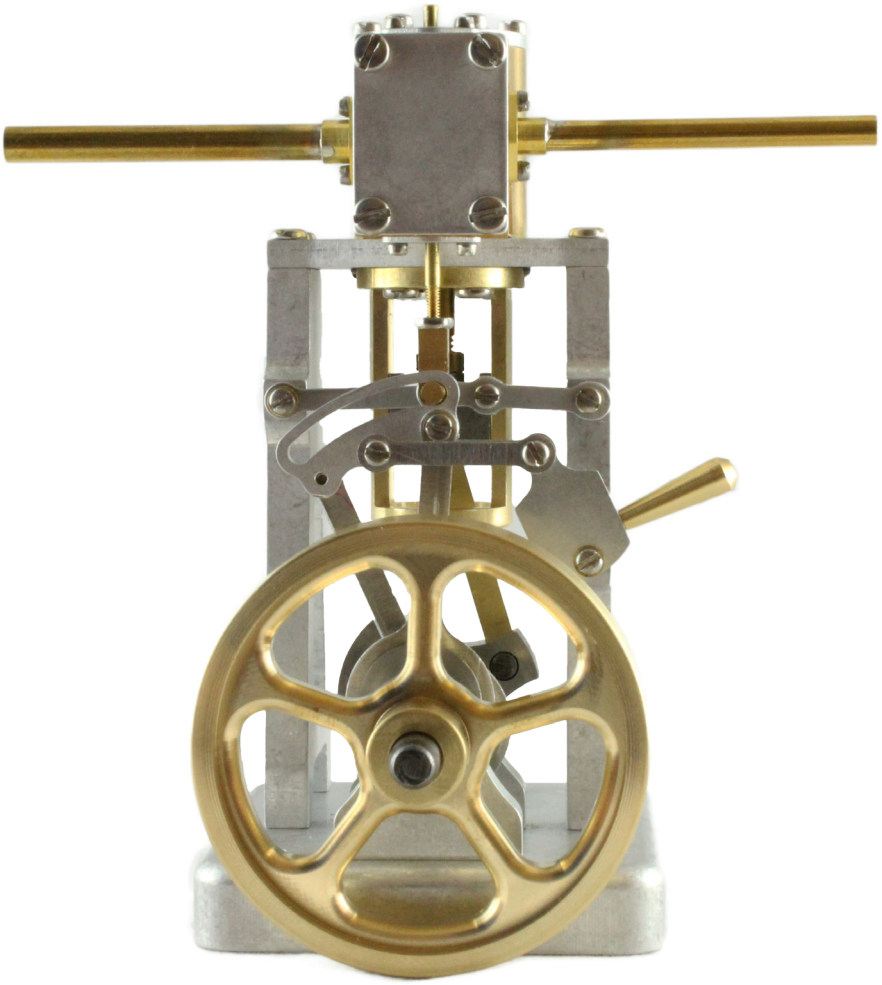
Assembly Instructions

VR1A

1/2” bore, 5/8” stroke, single cylinder, reversing steam engine kit



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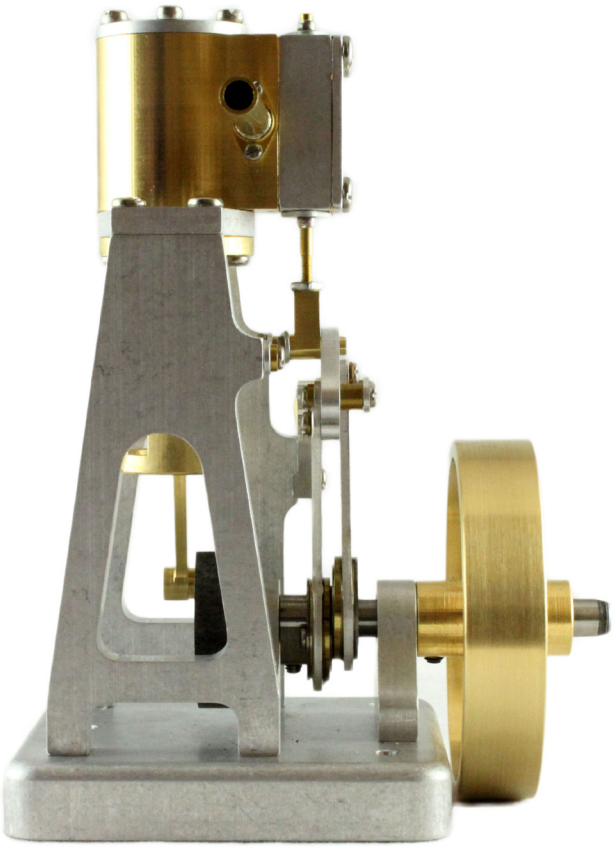

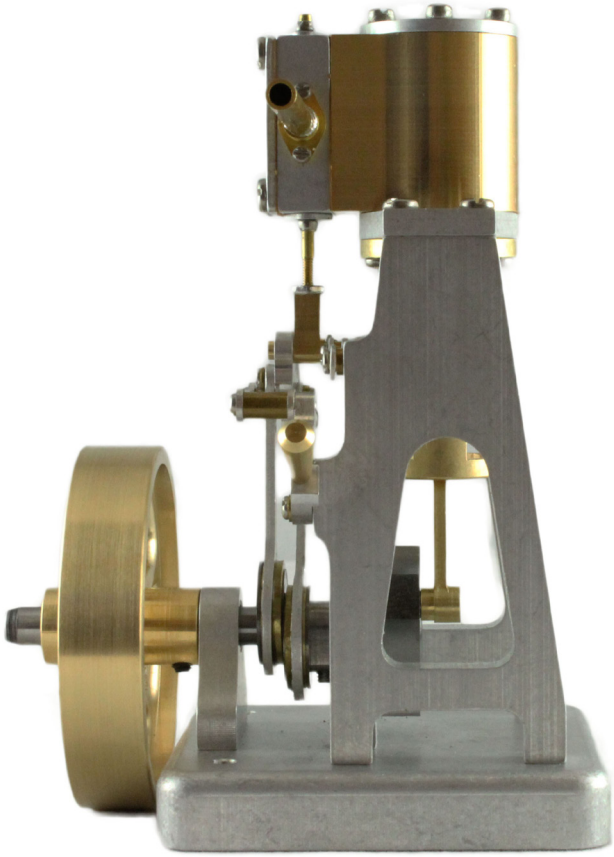

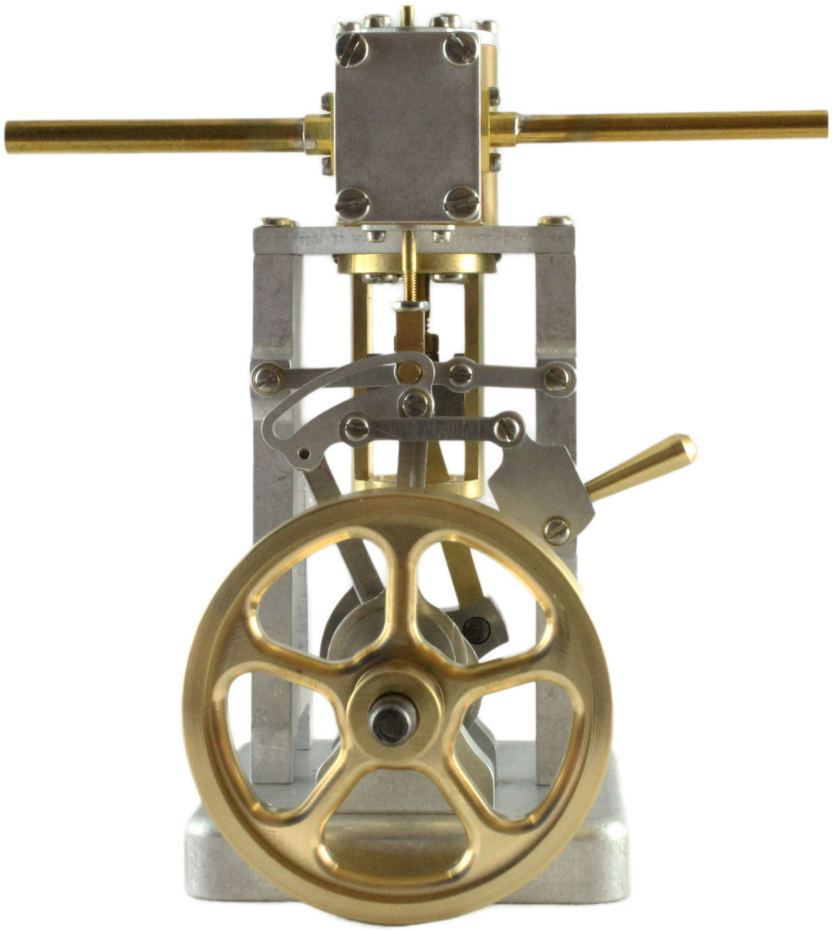

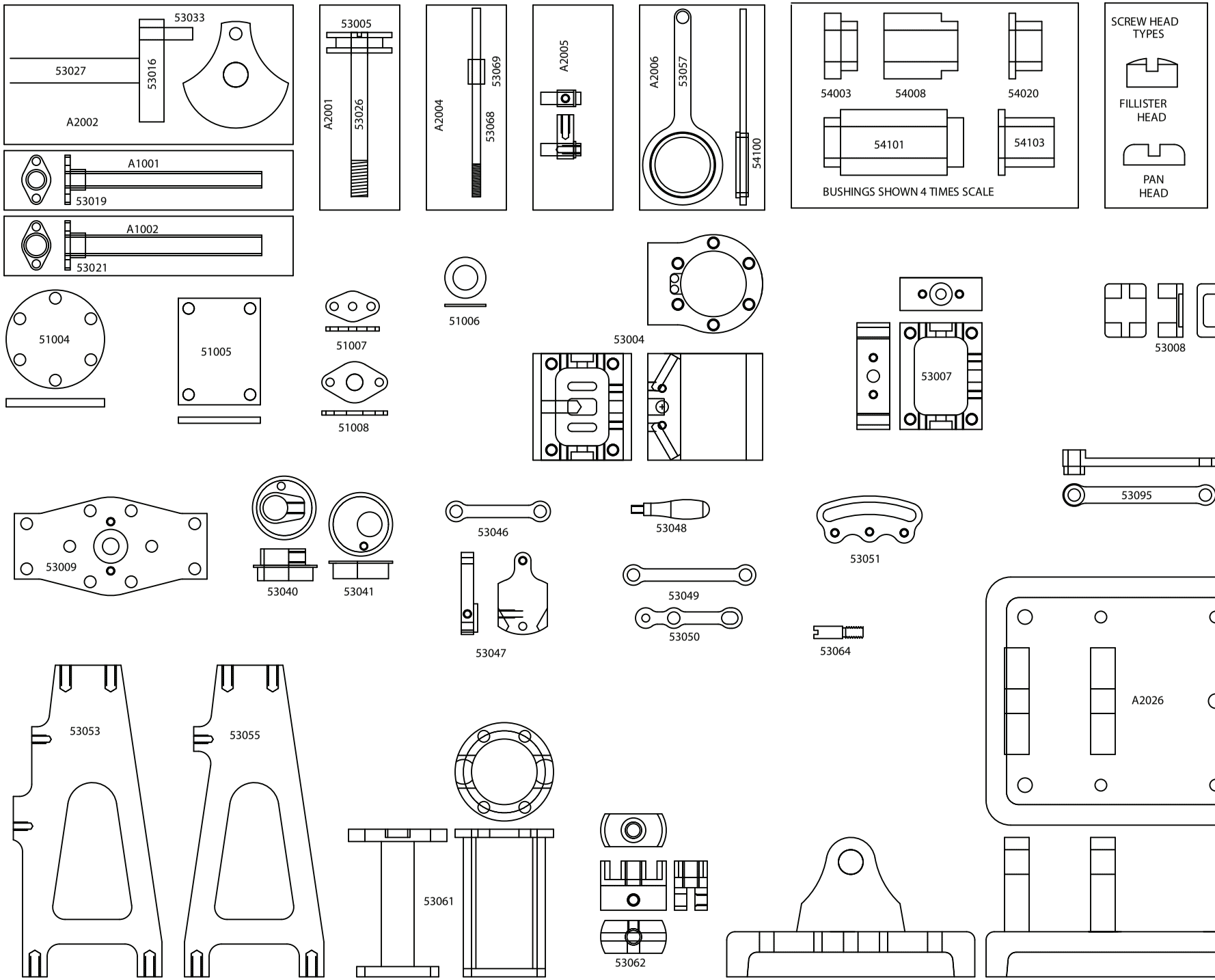
53033
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54003
54008
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54101
54103
BUSHINGS SHOWN 4 TIMES SCALE
SCREW HEAD TYPES
FILLISTER HEAD
PAN HEAD
51004
51005
51007
51008
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A2026

PARTS LIST

Qty	Part #	Description
1	A1001	Steam pipe and flange (1/8” OD)
1	A1002	Exhaust pipe and flange (3/32” OD)
1	A2001	Piston and rod assembly
1	A2004	Valve spindle assembly
1	A2005	Valve drive block assembly
2	A2006	Eccentric strap assembly
1	A2010	Crankshaft assembly
2	10000	Nut, 0-80
7	10208	Screw, 0-80 x 1/8” pan head slot
6	10212	Screw, 0-80 x 3/16” pan head slot
1	10216	Screw, 0-80 x 1/4” pan head slot
1	10224	Screw, 0-80 x 3/8” pan head slot
12	10408	Screw, 0-80 x 1/8” fillister head slot
7	12216	Screw, 2-56 x 1/4” pan head slot
9	12220	Screw, 2-56 x 5/16” pan head slot
5	12228	Screw, 2-56 x 7/16” pan head slot
7	12412	Screw, 2-56 x 3/16” fillister head slot
1	12608	Setscrew, 2-56 x 3/32”
2	40003	O-ring, 1/16” ID x 3/16” OD
1	40006	O-ring, 1/8” ID x 1/4” OD
1	40012	O-ring, 3/8” ID x 1/2” OD
1	40030	Wrench, male hex, .035” AF
1	51004	Cylinder cover
1	51005	Steam chest cover
1	51006	Washer, Brass, 3/16” ID
2	51007	Seal retainer, 1/16” ID
1	51008	Seal retainer, 1/8” ID

Qty	Part #	Description
1	53004	Cylinder, machined
1	53007	Steam chest
1	53008	Valve, slide
1	53009	Cylinder mount
1	53023	Nut, 5-40
1	53040	Eccentric, with hub
1	53041	Eccentric, without hub
2	53046	Link, 2 hole short
1	53047	Lever, reversing
1	53048	Handle
1	53049	Link, 2 hole long
1	53050	Link, 3 hole
1	53051	Link, curved
1	53053	Standard, Left
1	53055	Standard, Right
1	53061	Crosshead guide
1	53062	Crosshead
1	53064	Pin, crosshead/con rod
1	53095	Connecting rod
4	54003	Bushing
1	54008	Bushing
2	54020	Bushing
1	54101	Bushing
1	54103	Bushing
1	BFLY1	Flywheel

BEFORE STARTING

Thank you for purchasing the Graham Industries VR1A vertical reversing steam engine assembly kit.

The VR1A kit contains approximately 100 parts. As many of these parts are very small, care must be used in opening the parts packages to prevent loss of any of these parts. A compartmented tray is useful for holding parts while assembling your engine. A well lighted clean area is essential. A large sheet of paper or light colored cardboard to work on also helps.

The only tools required are a small slot screwdriver set and a small file. Light machine or instrument oil will also be necessary to lubricate the parts as the engine is assembled. While not required, a small pair of tweezers and a small pair of needle nose pliers are useful for holding small parts.

GETTING STARTED

Become familiar with the parts contained in the kit by comparing the parts with the identification drawing and parts list. In most cases, it will not be necessary to remove the parts from the packages. Look over the assembly drawings to get an overview of where the parts go.

For notation purposes, when referring to left and right sides of the engine, the engine is considered to be vertical with the flywheel end being the front of the engine. Left and right are then defined as if looking from the rear of the engine towards the front (flywheel) end. The reversing lever is then mounted on the left side of the engine.

As you assemble the kits, some of the parts may have burrs from machining on them. These can be removed with the aid of a small file or the abrasive paper supplied with the kit. Some parts may have machining marks on them from the cutters. Except as noted, these will not affect operation, however, you may want to remove them by filing and sanding for appearance. If you desire to paint your engine, it is suggested that you assemble it first, then decide what to paint. The engine can then be disassembled as necessary to paint these parts. If painting the flywheel and base, a good grade of primer is necessary to give good adhesion to the paint. Also, all oil must be removed for the paint to stick. This can be done in hot water using a dishwashing detergent. Rinse with hot water and dry completely.

The sealing and sliding surfaces of several parts need to be smoothed. As the operation is the same for all the parts, it is best to do all of them at the same time. The operation can only loosely be called lapping, but it will give a more than satisfactory finish. The following parts will be lapped.

1. Both ends and the port face of the cylinder (53004). Do not round the edges of the valve ports in the flat face of the cylinder block. They must be left sharp to preserve the valve timing.
2. The face of the valve (53008) with the rectangular cavity.
3. Both faces of the steam chest (53007) that have holes in each corner.
4. One side of the steam chest cover (51005). When the cover is examined, notice that one side has the edges slightly rolled from the stamping operation while the other side has sharp edges. Lap the side with the sharp edges.
5. One side of the cylinder cover (51004). Either side is fine.
6. One side of the table (53009). Lap the side that has only the center hole, and not the side that has the center hole counterbored.
7. The sealing face of the steam and exhaust flanges (A1001 and A1002).

Remove any large burrs with a file before the lapping operation. Keep the file clean at all times using a file card or brush if you have one. This is very important in the case of aluminum, as the small particles will scratch the surface of the aluminum. The same applies to other metals also, but to a lesser extent.

A sheet of 400 grit abrasive paper is supplied with the kit. Find a flat hard surface to use as a surface plate. It does not have to be super accurate. A table or counter top that has been finished with a pressure plastic laminate is satisfactory. If you are into woodworking, the table on a table saw will work well. Place the abrasive paper on the flat surface and wet the abrasive surface with either water or light oil. Place the part to be lapped on the abrasive paper and rub the part in a figure eight pattern. Rub only a few strokes, and then rotate the part and change your grip on the part. The entire sealing surface should show signs of the lapping operation. If not, continue lapping until it does.

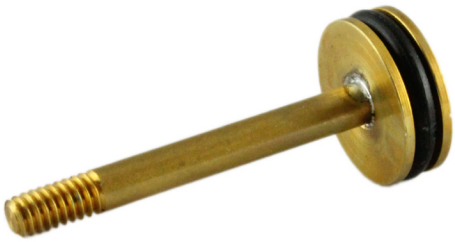
OPTIONS

Only a few assembly options are available. The only simple one is the position of the steam and exhaust pipes. The drawings show the steam inlet on the left side and the exhaust on the right side. As the cylinder and steam chest are completely symmetrical, these can be reversed during assembly if desired. Both steam and exhaust pipes can actually be on the same side, but except in special applications, it would look odd.

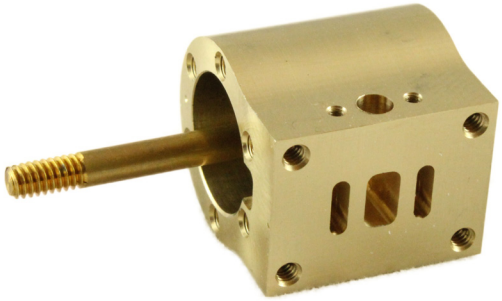
If someone needs to, the reversing lever can be placed on the right side, but it will require some work and a few precautions. First, the reversing lever will have to have a hole drilled and tapped on the opposite side for the handle. The left and right standards must be switched which is OK as they will fit in either place. The parallel motion linkage for the valve can be assembled either as shown or mirrored left to right as desired. Do NOT rotate the eccentric 180 degrees. It must stay in the same relationship with the crankshaft as shown on the drawings.

ASSEMBLY

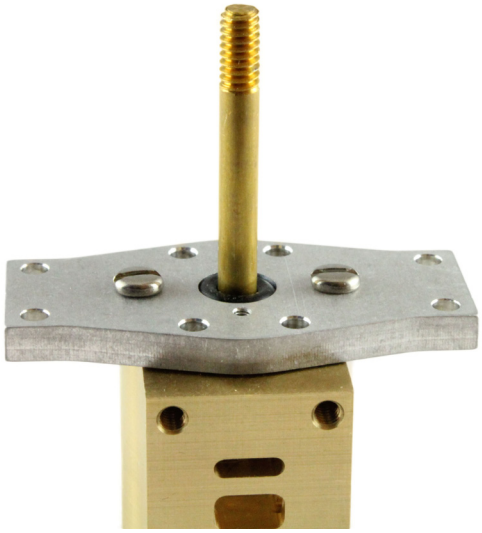
Inspect the PISTON - PISTION ROD assembly (A2001) for burrs or sharp edges on the piston and remove if necessary.



Lightly oil the piston groove. Slide the 3/8” ID O-RING (40012) over the piston and into the piston groove. Put a drop of oil on the o-ring.

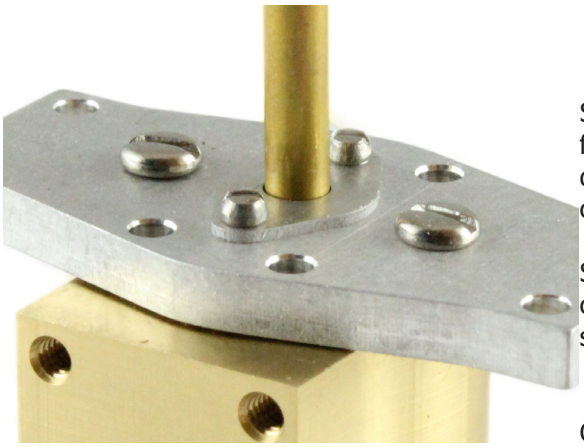


Hold the cylinder (53004) with the valve port face towards you and the exhaust opening to the left. Slide the piston into the cylinder with the piston rod down. If you want the exhaust on the other side, now is the time to change it. See OPTIONS.



Turn the cylinder over so the piston rod is pointing up. Place the round gasket with the hole in the middle on the cylinder, aligning the screw holes. Place a drop of oil on the gasket to keep it from moving. Slide the cylinder mount (53009) over the piston rod so the lapped side is next to the cylinder and the long dimension of the mount is perpendicular to the cylinder valve port face.

Secure the mount to the cylinder with (2) 2-56 x 1/4” (12216) pan head screws. These screws go into the holes towards the flat ends of the cylinder mount.



Slide the 1/8” ID O-RING (40006) over the piston rod. Be careful going over the threads on the piston rod so the threads do not damage the o-ring. Press the o-ring into the counterbore on the cylinder mount.

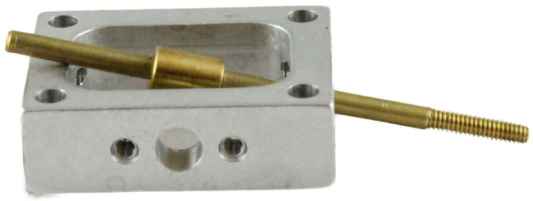
Slide the 1/8” SEAL RETAINER (51008) over the piston rod. Secure it to the cylinder mount with (2) 0-80 x 1/8” fillister head screws (10408).

Check the CROSSHEAD (53062) and CROSSHEAD GUIDE (53061) for burrs and remove if necessary. Check the fit of the crosshead in the guide Remove the crosshead from the crosshead guide.

Install the 5-40 special nut (53023) on the end of the piston rod. Thread it almost all the way up.

Install the crosshead on the piston rod. Thread it about 3 turns on the piston rod. Turn the crosshead so the flat side with the threaded hole faces the valve port face on the cylinder.

Slide the crosshead guide (53061) over the crosshead and secure with (4) 2-56 x 5/16” (12220) pan head screws.



Slide the threaded end of the valve spindle assembly (A2004) through one of the end holes in the steam chest (53007) from the inside of the steam chest until the unthreaded end of the spindle fits inside the steam chest. Then slide the unthreaded end through the other end of the steam chest.

Install a 1/16” ID O-ring (40003) on each end of the valve spindle rod using care not to damage the o-ring when sliding over the spindle threads. Use a little oil on each o-ring.

Secure each o-ring in place with a 1/16” hole seal retainer (51007) using 0-80 x 1/8” fillister head (10408) screws. Thread a 0-80 nut (10000) on the end of the spindle.

Check the fit of the valve on the valve spindle. It must be a free easy fit with the drive sleeve on the valve spindle fitting in the slot of the valve. If not, open up the slot in the valve with a small file.

Set the valve on the steam chest so it covers all the ports.

Place the rectangular gasket with the cutout in the middle on the cylinder face. Align the screw holes and place a drop of oil to hold the gasket in place.

Install the steam chest on the cylinder with the intake hole facing away from the exhaust hole on the cylinder and the valve rod facing the same direction as the piston rod. The drive sleeve of the valve spindle must engage the valve slot. Temporarily secure the chest to the cylinder with (2) 2-56 x 7/16” pan head screws (12228). Only SNUG these screws so as to not damage the lapped surface on the steam chest. These screws will be removed to install the steam chest cover later after the valve has been adjusted.

This ends the cylinder sub-assembly.

ECCENTRIC SUB-ASSEMBLY

Set the curved link (53051) on a flat surface with the 3 tapped holes nearest you. Insert a 0-80 x 1/8" pan head screw (10208) into a 54020 bushing from the large end of the bushing. Insert the bushing into the small hole in an eccentric strap assembly (A2006) and screw it to the right end of the curved link. You will notice that the eccentric strap has a brass insert. Install the eccentric strap so that the side where the brass insert sticks out farther is facing down. The strap should extend towards you. Turn the curved link over and repeat with the other eccentric strap. The two straps will be attached at opposite ends of the curved link and on opposite sides of the link.

Start a 2-56 x 3/32" set screw (12606) in the hub of the eccentic with hub (53040). Set the eccentric on a flat surface with the hub down. Place the bottom eccentric strap over the eccentric.

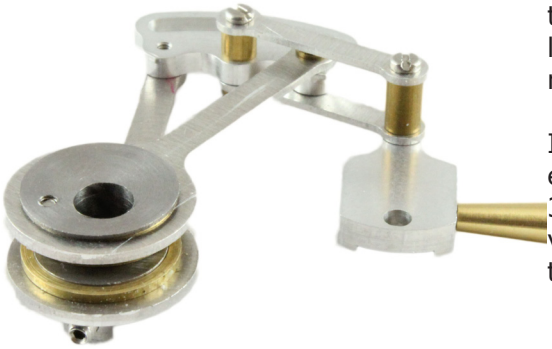
Insert the eccentric without hub (53041) into the other eccentric strap from the top. Turn the assembly over. Connect the two eccentrics with a 0-80 x 1/4" pan head screw (10216) but do NOT tighten.

Line up the 3/16" holes in the two eccentrics and slide the crankshaft (A2010) through the holes to maintain alignment. Tighten the screw holding the two eccentrics together. Remove the crankshaft.

Remove any burrs on links 53046, 53049 and 53051 by rubbing them onto the flat face of a file.

Set the assembly on a flat surface with the hub facing up. Insert a 0-80 x 1/8" pan head screw (10208) through a 54003 bushing from the large end of the bushing. Insert the bushing and screw in one end of a 53046 link and attach to the curved link in the center hole.

Turn the assembly over. Insert bushing 54008) in one end of the other 53046 link. Insert a 0-80 x 3/16" pan head screw (10212) in the bushing from the link side and secure to the center hole of the curved link.



Set the assembly on a flat surface with the hub facing down and the eccentric strap big ends towards you. Adjust the two 53046 links to the right side. Screw handle (53048) into the side of the reversing lever (53047).

Insert the double ended bushing (54101) between the 53046 links engaging the two holes in the ends of the links. Insert a 0-80 x 3/8" pan head screw (10224) through the bushing. Place the reversing lever under the bottom link with the flat side up and secure the linkage to the reversing lever with the 0-80 screw.

This finishes the eccentric sub-assembly.

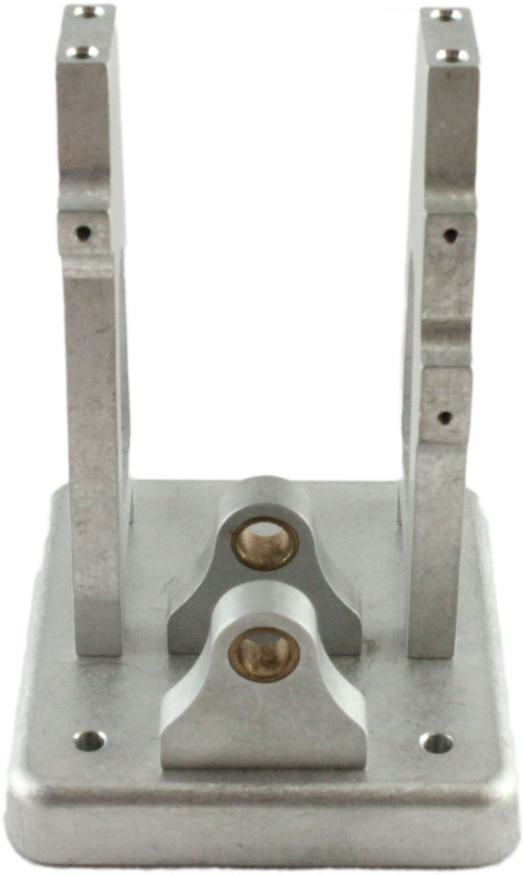
PARALLEL MOTION LINKAGE

Insert a 54003 BUSHING in the center hole of LINK 53050. Insert a 0-80 x 3/16" pan head screw (10212) in the bushing from the opposite side of the link that the bushing was inserted from. Insert the screw into the small hole in LINK (53049) and secure with a 0-80 NUT (10000).

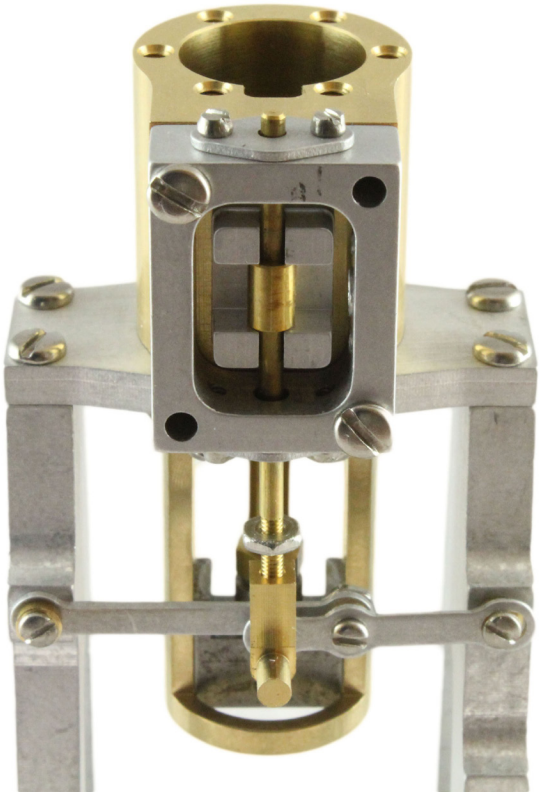
Attach the linkage just assembled to the VALVE DRIVE BLOCK (A2005) by sliding the remaining ROUND hole in link 53050 over the short end of the pin extending from the valve drive block. The long link must be away from the valve drive block. Secure with a 0-80 x 1/8" pan head screw.

Screw the valve drive block to the valve spindle on the cylinder sub-assembly about 3 turns. Make sure you installed a 0-80 nut on the valve spindle before the previous step. Position the cylinder assembly so the steam chest is nearest you and the crosshead guide is down. Rotate the valve drive block so the links are nearest the crosshead guide. Position the links so the elongated hole in link 53050 is to your right and the long link is to your left.

FINAL ASSEMBLY

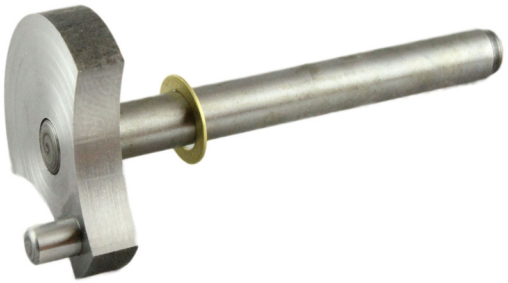


Remove any burrs from the standards (53053 and 53055). Attach the standards to the base (A2026) using (4) 2-56 x 5/16" pan head screws (12220). The bearing blocks on the base are at the front of the engine. With the bearing blocks away from you, standard 53053 (the standard with two 0-80 holes in it) will be on your left and the 0-80 tapped holes will be towards the bearing block end.

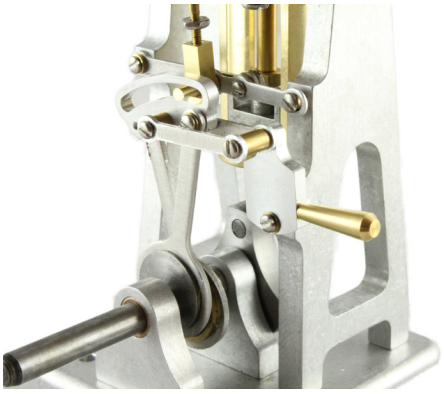


Insert a 54003 bushing into the elongated hole in link 53050 from the side of the link nearest the 53053 standard. Secure the link and bushing to the standard with a 0-80 x 1/8" pan head screw. Insert a 54003 bushing into the 53049 link from the side of the link away from the standard and secure to the upper hole in the 53055 standard using a 0-80 x 1/8" pan head screw (10208).

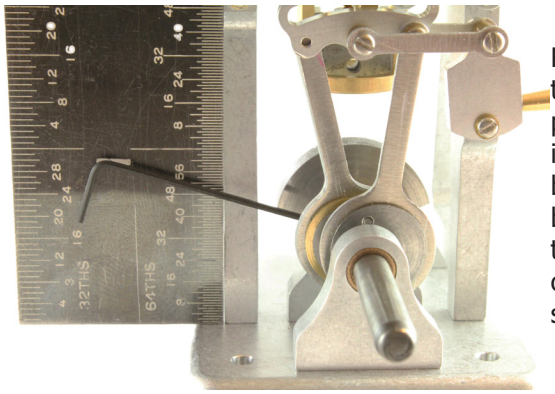
Position the eccentric assembly so the hub faces the steam chest and the curved link is up. Slide the eccentrics between the bearing blocks and engage the pin on the valve drive block into the curved slot.



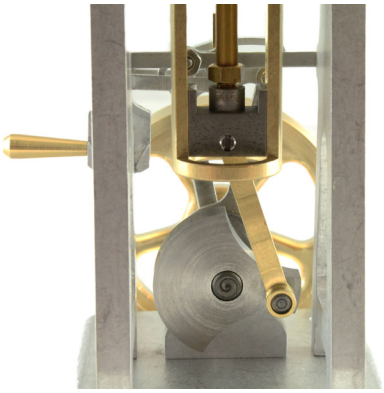
Slide the 51006 washer on the crankshaft. Slide the crankshaft through the inside bearing (between the standards), the eccentrics and the outer bearing.



Insert bushing 51003 in the reversing lever and secure to the standard with a 0-80 x 3/16” pan head screw (10212). Make sure the lugs on the reversing lever fit on either side of the standard.



Rotate the crankshaft so the crankpin is nearest the base. Rotate the eccentric so the hub setscrew is to the side of the engine opposite of the reversing lever. Insert the .035” hex wrench (40030) in the eccentric setscrew. While keeping the crankpin nearest the base, rotate the eccentric so the hex wrench is 3/4” above the base where it crosses the standard. Slide the crankshaft against the inside bearing and slide the eccentric towards the opposite side of the inside bearing. Tighten the eccentric setscrew. The crankshaft should be able to slide in the bearings a little bit.



Place the small end of the connecting rod (53095) in the crosshead guide and slide the large end on the crankpin of the crankshaft assembly. Slide the piston and rotate the crankshaft until the connecting rod can be engaged in the slot in the crosshead. Align the holes in the connecting rod and the crosshead and insert pin (53064) from the rear of the engine. Screw in the pin firmly.

Slide the flywheel on the crankshaft and secure with the 4-40 x 3/32” setscrew and the .050” hex wrench. There should be some fore-aft play in the crankshaft with the flywheel attached.

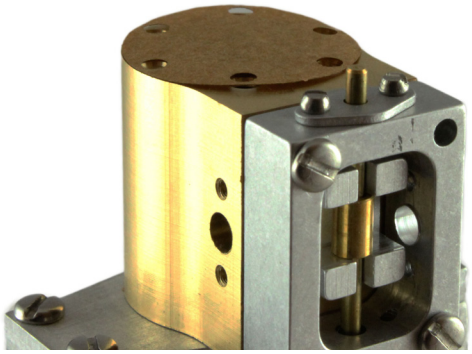
Rotate the crankshaft until the piston is nearest the top of the cylinder. Adjust the piston position by rotating the piston with a small screwdriver in the slot in the piston rod. The piston is adjusted so the top of the piston is half way between the top of the cylinder and the point where the steam passage meets the cylinder bore. This is about 0.015” below the top of the cylinder.

Rotate the crankshaft to bring the piston down and tighten the 5-40 lock nut on the piston rod against the crosshead.

Move the reversing lever to one extreme. Rotate the crankshaft until the valve is in the uppermost position of travel. Adjust the valve spindle until about 3/4 of the lower steam port is uncovered by the valve.

Rotate the crankshaft until the valve is at the bottom of travel. The upper steam port should be uncovered the same amount as the lower one was in the previous step. If not, adjust the valve spindle until the openings are equal at the two valve extremes.

Tighten the lock nut on the valve spindle against the valve drive block.



Place the remaining round gasket with no center cutout on the top of the cylinder and align the screw holes. Use a drop of oil to hold it in place. Place the cylinder cover (51004) with the lapped side against the cylinder and gasket. Secure with (6) 2-56 x 3/16” fillister head screws (12412).

Remove the two screws holding the steam chest to the cylinder.

Install the remaining rectangular gasket with no center cutout on the face of the steam chest. Install the steam chest cover (51005) with the lapped side against the gasket. Secure with (4) 2-56 x 7/16” pan head screws (10228).

Attach the exhaust pipe assembly (A1002) to the cylinder using (2) 0-80 x 1/8” fillister head screws (10808). This is the larger diameter pipe.

Attach the steam inlet pipe assembly (A1001) to the steam chest using (2) 0-80 x 1/8” fillister head screws (10808).

RUNNING

The VR1A is designed to run on a maximum of 30 PSI steam or air. At 30 PSI, the no load speed will be about 4,000 RPM. Pressures higher than 30 PSI may cause mechanical failure in the engine. If the engine is run on steam, the steam supply boiler MUST have a safety pressure release valve set to no higher than 30 PSI.

After the engine has a few hours of running on it, it will run on less than 5 PSI with no load. For testing and running it in, air operation is recommended. When running on steam, a lubricator to supply oil to the engine is necessary. When running on air, a few drops of oil in the steam pipe every few hours of running is all that is necessary.

Oil all the bushings, eccentrics, crankshaft bearings, crosshead and any other rotating or sliding points before starting the engine for the first time.

To test and adjust the engine, connect an air source of about 10 PSI to the steam pipe. The reversing lever can be set for either direction of operation. The flywheel will rotate in the same direction as the reversing lever is rotated. After connecting the air, rotate the engine flywheel in the same direction as the reversing lever has been roated and the engine will start.

Do not apply more than 15 PSI to the engine until it has run for at least one hour.

The settings used to adjust the engine while assembling are close enough for casual running, however, you may want to refine the adjustments by adjusting the eccentric position until the engine runs equally well in both directions.

LIMITED WARRANTY

Graham Industries warranties that the materials supplied in this kit are free from defects for a period of 60 days from the date of purchase. If any defects in material are discovered during this period, the defective material will be replaced upon written notification to Graham Industries. Graham Industries reserves the right to require the defective material be returned to us for inspection. This warranty does not apply to materials that have been damaged by improper assembly or by operation outside the limitations described in the running portion of the assembly manual.