

VR1A  
ASSEMBLY  
INSTRUCTIONS

## PARTS LIST

<u>Qty</u>	<u>Part #</u>	<u>Description</u>	<u>Qty</u>	<u>Part #</u>	<u>Description</u>
1	A1001	Steam pipe and flange (1/8" OD)	1	53004	Cylinder, machined
1	A1002	Exhaust pipe and flange (5/32" OD)	1	53007	Steam chest
1	A2001	Piston and rod assembly	1	53008	Valve, slide
1	A2004	Valve spindle assembly	1	53009	Cylinder mount
1	A2005	Valve drive block assembly	1	53023	Nut, 5-40 x .047" special
2	A2006	Eccentric strap assembly	1	53032	Flywheel, 1-3/4" diameter, finished
1	A2010	Crankshaft assembly	1	53040	Eccentric, with hub
			1	53041	Eccentric, without hub
2	10000	Nut, 0-80	1	53045	Base, VR1A
7	10208	Screw, 0-80 x 1/8" pan head slot	2	53046	Link, 2 hole, short
6	10212	Screw, 0-80 x 3/16" pan head slot	1	53047	Lever, reversing
1	10216	Screw, 0-80 x 1/4" pan head slot	1	53048	Handle
1	10224	Screw, 0-80 x 3/8" pan head slot	1	53049	Link, 2 hole, long
12	10408	Screw, 0-80 x 1/8" fillister head slot	1	53050	Link, 3 hole
7	12216	Screw, 2-56 x 1/4" pan head slot	1	53051	Link, curved
9	12220	Screw, 2-56 x 5/16" pan head slot	1	53053	Standard, left
5	12228	Screw, 2-56 x 7/16" pan head slot	1	53055	Standard, right
7	12412	Screw, 2-56 x 3/16" fillister head slot	1	53061	Crosshead guide
1	12608	Setscrew, 2-56 x 3/32"	1	53062	Crosshead
1	14608	Setscrew, 4-40 x 3/32"	1	53064	Pin, crosshead - con rod
			1	53095	Connecting rod
2	40003	O-ring, 1/16" ID x 3/16" OD	6	54003	Bushing
1	40006	O-ring, 1/8" ID x 1/4" OD	1	54008	Bushing
1	40012	O-ring, 3/8" ID x 1/2" OD	2	54020	Bushing
1	40030	Wrench, male hex, .035" AF	1	54101	Bushing
1	40031	Wrench, male hex, .050" AF	1	54103	Bushing
1	51004	Cylinder cover			
1	51005	Steam chest cover			
1	51006	Washer, 3/16" ID			
2	51007	Seal retainer, 1/16" ID			
1	51008	Seal retainer, 1/8" ID			

## **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.

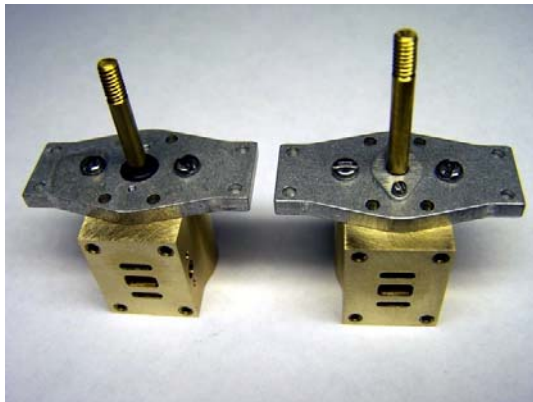
- If someone needs to, the reversing lever can be placed on the right side, but it will require some work and a few precautions. First, the reversing lever will have to have a hole drilled and tapped on the opposite side for the handle. The left and right standards must be switched which is OK as they will fit 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. Slide the CYLINDER MOUNT 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 one of the flat sides faces the valve port face on the cylinder.
- Slide the crosshead guide (53061) over the crosshead and secure with four 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 screws. Thread a 0-80 nut 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 it is 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.
- 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 in 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.



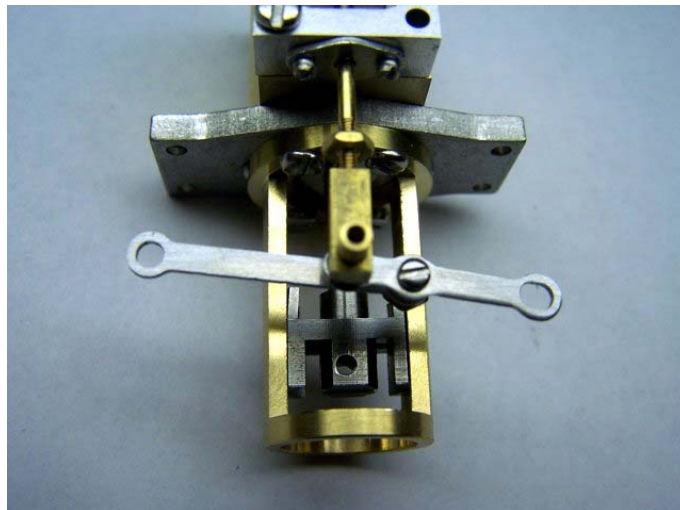
- Start a 2-56 x 3/32" SET SCREW (12606) in the hub of the ECCENTRIC WITH HUB (53040). Set the eccentric on a flat surface with the hub down. Place the bottom eccentric strap over the eccentric.
- Insert the ECCENTRIC WITHOUT HUB (53041) into the other eccentric strap from the top. Turn the assembly 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 on 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 54046 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 54046 links to the right side. Screw HANDLE (53048) into the side of the REVERSING LEVER (53047).
- Insert the double ended BUSHING (54101) between the two 53046 links engaging the 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. 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 & 53055). Attach the standards to the base (53045) using four 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 will be on your left and the 0-80 tapped holes towards the bearing block end.

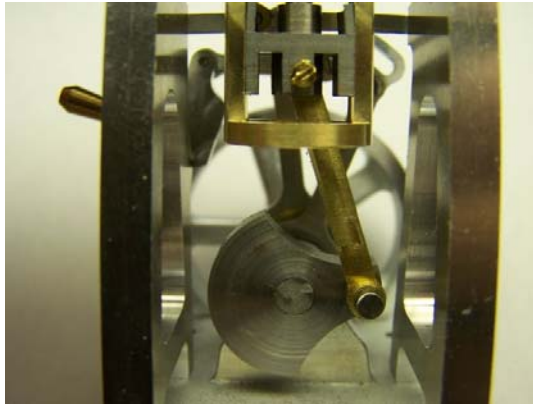
- Set the cylinder assembly on the standards with the steam chest towards the crankshaft bearings. Secure the cylinder sub-assembly to the standards with four 2-56 x 1/4" pan head screws.



- 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 nearest the standard and secure to the upper hole in the 53055 standard using a 0-80 x 1/8" pan head screw (10208).



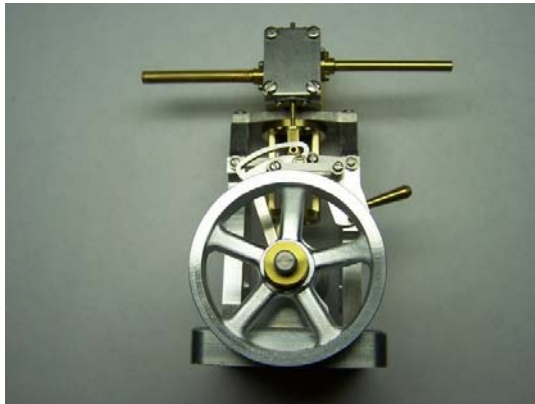
- Position the eccentric assembly so the hub faces the steam chest and the curved link is up. Slide the eccentrics between the bearing blocks and enGraham Industries the pin on the valve drive block in the curved slot.



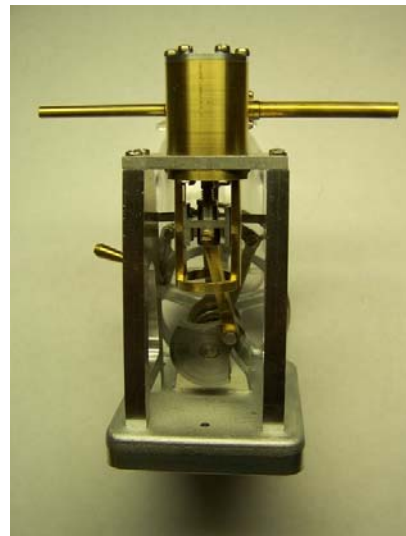
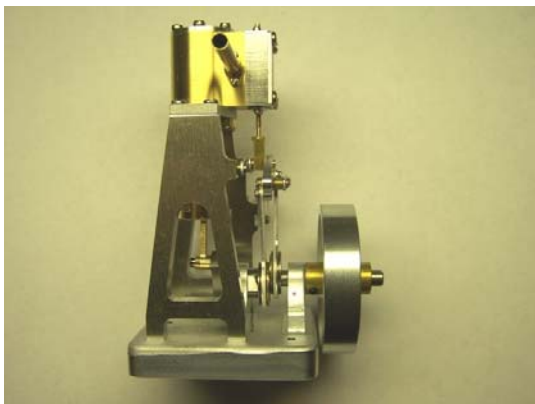
- Slide the 51006 WASHER on the crankshaft. Slide the crankshaft through the inside bearing (between the standards), the eccentrics, and the outside bearing.
- Insert BUSHING 54103 in the reversing lever and secure to the standard with a 0-80 x 3/16" pan head screw. Make sure the lugs on the reversing 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 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.
- Slide the FLYWHEEL on the crankshaft and secure with the 4-40 x 3/32 SETSCREW. There should be some fore-aft play in the crankshaft with the flywheel attached.
- 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 the pin in firmly.
- 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.



- Install the CYLINDER COVER (51004) with the lapped side against the cylinder. Secure with six 2-56 x 3/16" fillister head screws.
- Remove the two screws holding the steam chest to the cylinder. Install the steam chest cover with the lapped side next to the steam chest. Secure with four 2-56 x 7/16" pan head screws.



- Attach the EXHAUST PIPE ASSEMBLY (A1002) to the cylinder using two 0-80 x 1/8" fillister head screws. This is the larger pipe.
- Attach the STEAM PIPE ASSEMBLY (A1001) to the steam chest using two 0-80 x 1/8" fillister head screws.



## **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 4000 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 rotated 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 warrants 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.