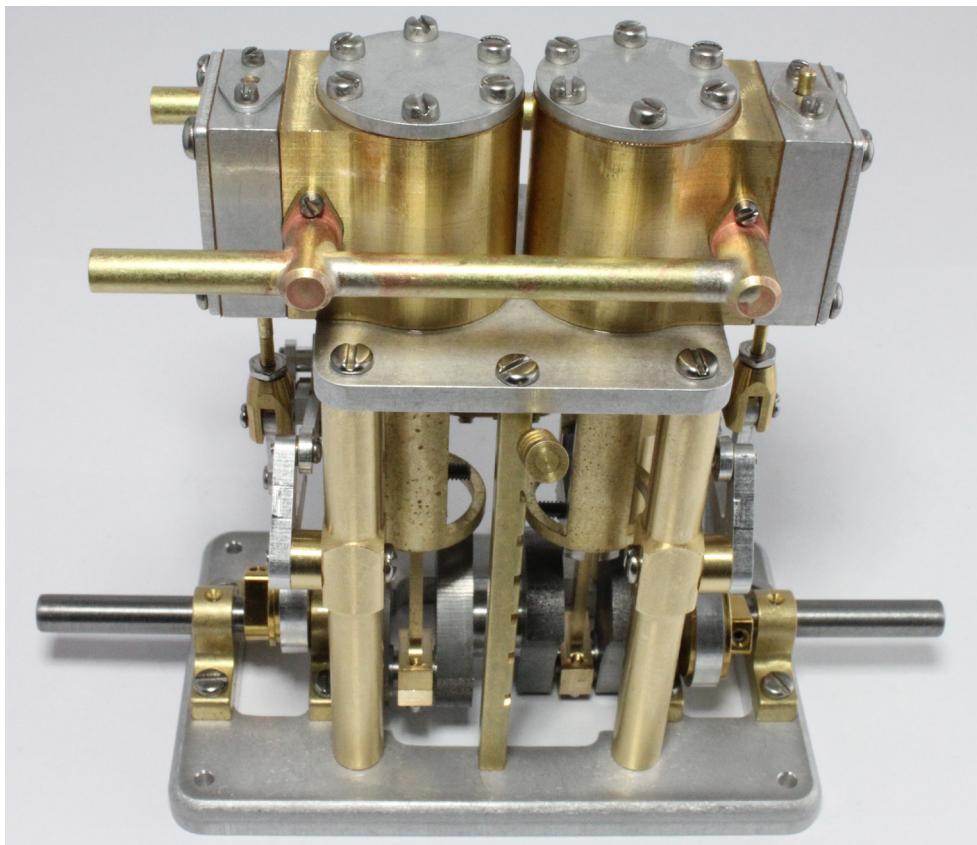


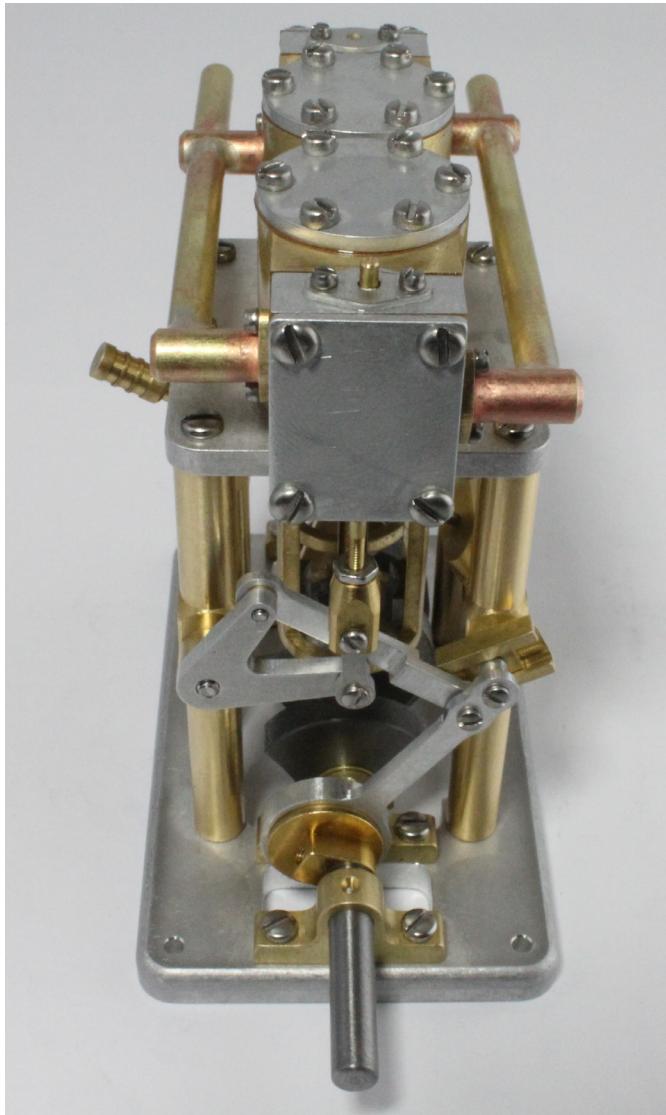
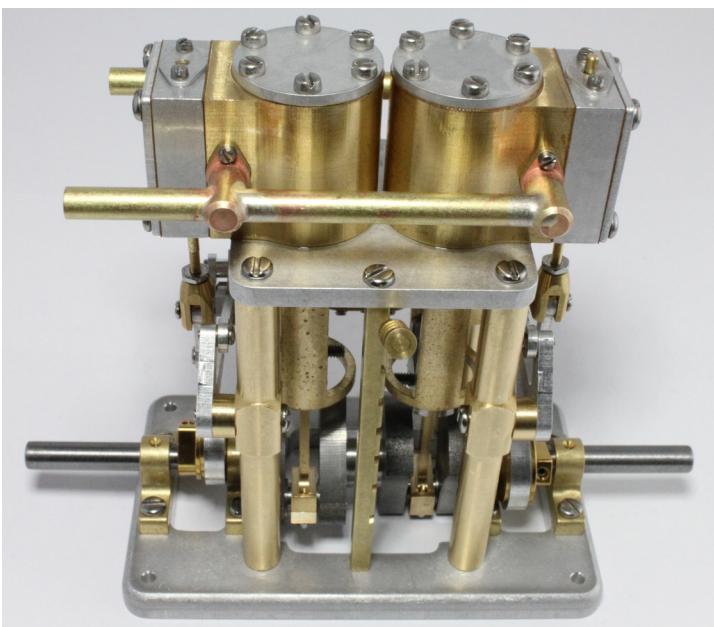
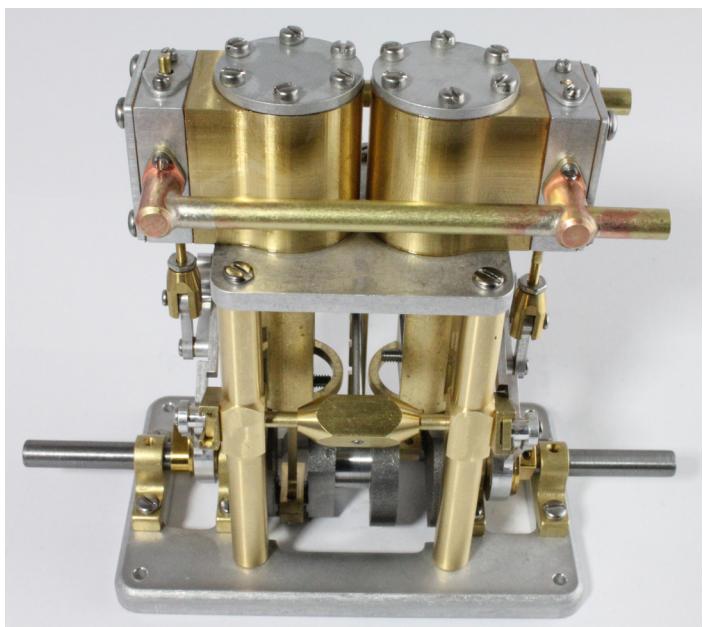
# Assembly Instructions

**TVR1A**

1/2" bore, 5/8" stroke, twin cylinder reversing  
steam engine kit

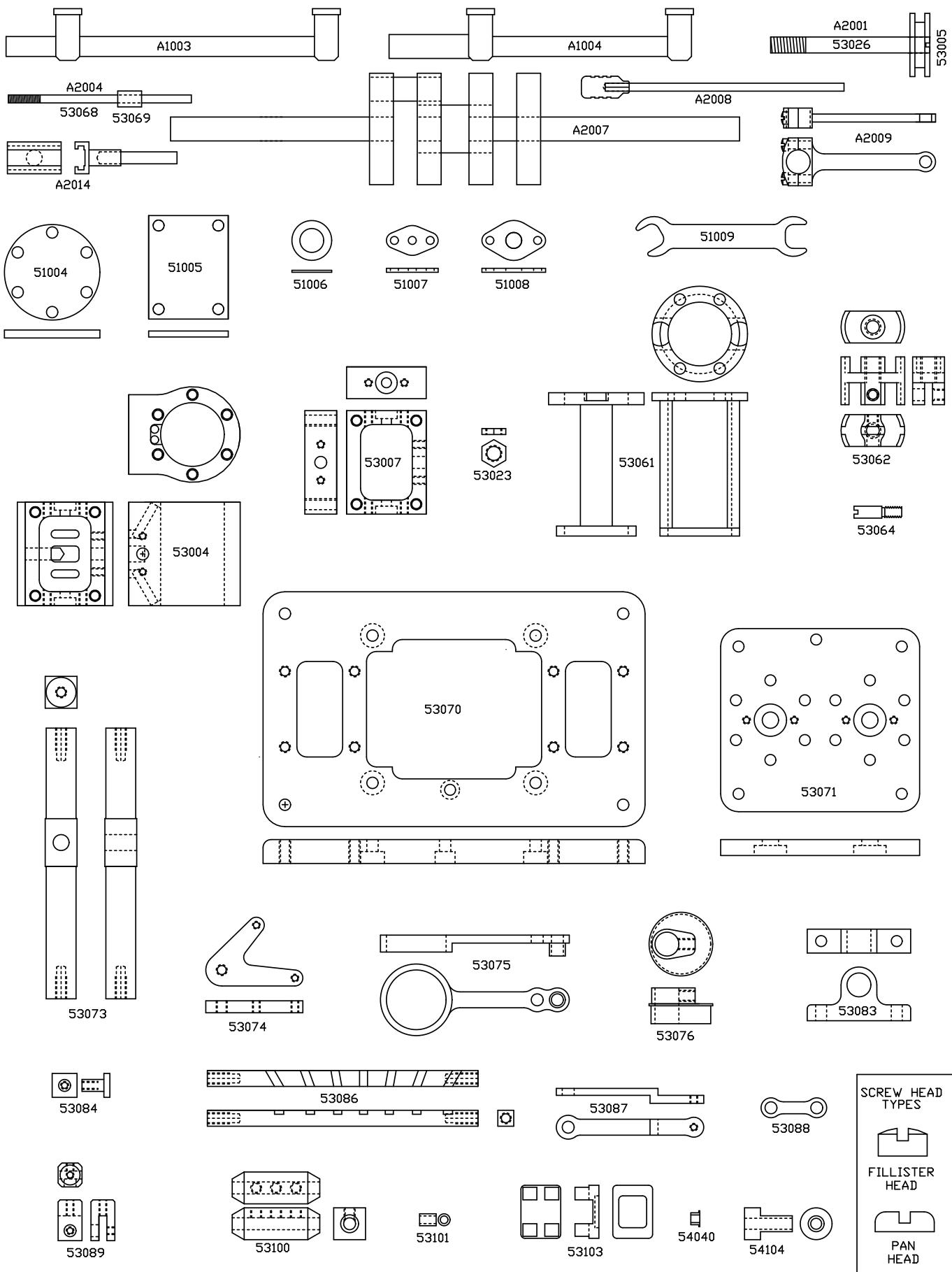


Graham Industries  
PO Box 15230  
Rio Rancho, NM 87174-0230  
[www.grahamind.com](http://www.grahamind.com)



## PARTS LIST

Part#	Qty	Description
10000	2	Nut, 0-80
10208	7	Machine Screw, 0-80 x 1/8" pan head slot
10212	5	Machine Screw, 0-80 x 3/16" pan head slot
10408	22	Machine Screw, 0-80 x 1/8" fillister head slot
12216	22	Machine Screw, 2-56 x 1/4" pan head slot
12220	9	Machine Screw, 2-56 x 5/16" pan head slot
12228	9	Machine Screw, 2-56 x 7/16" pan head slot
12232	2	Machine Screw, 2-56 x 1/2" pan head slot
12412	21	Machine Screw, 2-56 x 3/16" fillister head slot
12608	5	Setscrew, 2-56 x 1/8"
39001	2	Abrasive paper, 400 grit, 2 3/4" x 4 1/2"
40003	4	O-ring, 1/1 6" x 3/16" AS568-003
40006	2	O-ring, 1/8" x 1/4" AS568-006
40012	2	O-ring, 3/8" x 1/2" AS568-012
40030	1	Wrench, male, Hex, .035" AF
51004	2	Cylinder cover, Finished, Machined
51005	2	Steam Chest Cover
51006	2	Washer, 3/16" x 5/16" x .015"
51007	4	Seal Retainer, 1/16" hole
51008	2	Seal Retainer, 1/8" hole
51009	1	Wrench, 3/16" AF
53004	2	Cylinder, Finished, Machined, 1/2" x 5/8"
53007	2	Steam Chest, Finished, Machined
53008	2	Slide Valve
53061	2	Crosshead Guide, Finished, Machined
53062	2	Crosshead
53064	2	Pin, Crosshead - Connecting Rod
53070	1	Base, Machined
53071	1	Cylinder Mount
53073	4	Column, 2 1/8" long
53074	2	Bellcrank
53075	2	Eccentric Strap
53076	2	Eccentric
53083	4	Bearing, 3/16" ID
53084	2	Slide, T-Slot, Male
53086	1	Bar, Valve Detent
53087	2	Link, Offset
53088	2	Link, 2 hole
53089	2	Fork, Rod End, 0-80 Internal Thread
53100	1	Connector, Reverse Linkage
53101	2	Bushing, .093" OD, .060" ID, .130" Long
54040	6	Bushing, A.125", B.093", C.060", D.065", E.008"
54104	2	Bushing, Bellcrank Mount
80005	1	Assembly Manual
A1003	1	Manifold, Steam Inlet
A1004	1	Manifold, Steam Exhaust
A2001	2	Piston Assembly, with Rod
A2004	2	Valve Spindle Assembly
A2007	1	Crankshaft Assembly
A2008	1	Handle Assembly
A2009	2	Connecting Rod Assembly
A2014	2	Slide Assembly, T-Slot, Female



## **BEFORE STARTING**

Thank you for purchasing the TVR1A Twin cylinder Vertical Reversing steam engine assembly kit.

## **GENERAL NOTES**

The first time a part is used, the part number will follow the name. In some cases the part number will be repeated later if clarification is needed where parts have similar names. Part numbers are 5 characters long. A part number beginning with the letter "A" is an assembly of two or more parts. The parts identification drawing shows the assembly along with the individual parts in the assembly. The parts list only shows the assembly part number.

For descriptive purposes, the following conventions are used to describe the orientation of the engine. The side of the engine that has the reversing lever (53047) protruding and the reversing lever detent bar (53086) is the right side. The base is the bottom and the cylinder covers are at the top or up. When facing the right side, the end of the engine to the right is the front, and the end to the left is the rear. The photographs show the steam inlet and the exhaust to the rear of the engine.

The direction of rotation of the engine is clockwise looking at the engine from the front when the reversing lever is towards the bottom of the engine, and counter clockwise when the lever is raised toward the top.

It is possible to make some changes in the engine steam inlet and exhaust layout without altering the performance of the engine. These may be desired to accommodate a particular boilers piping or other similar situations. The cylinders can be positioned so the exhaust is on the left side and the steam inlet on the right side. This needs to be done when the cylinders are mounted to the cylinder mount. For reference, the exhaust manifold mounts directly to the cylinders, and the steam inlet mounts on the steam chests. Either or both of the manifolds can be mounted to face the front of the engine. This can be changed after the engine is built.

Although all the parts are machined, you may wish to polish or refine the finish on parts of the engine either before or during assembly. If you do, be careful not to distort the ports on the cylinder. The finishing of this face is detailed in the instructions. Mating surfaces on the steam chests, steam chest covers, cylinder covers, cylinder ends, and manifold flanges also require care to keep them steam tight. To remove machining marks, use waterproof abrasive paper such as is supplied in this kit. Use a little light oil on the paper and if the surface is flat, lay the paper on a flat surface and rub the part against the paper. Start with 400 grit and then move on to 600 grit. Finish with 1 000 grit if desired, although polish works well after 600 grit and even after 400 grit.

Everyone has their own method for polishing metal. For brass, I use Wright's brass polish. It is available in many supermarkets and hardware stores for polishing domestic brass items. For aluminum I use products sold for polishing aluminum automobile wheels. Flat surfaces are best polished on a strip of cloth stretched tight on a flat surface. For cylindrical areas, cloth tape, such as twill tape, is available in various widths from sewing supply stores. Cotton works best if you can find it, but polyester is more common and also works well. Of course a regular cloth strip will also work, but the tapes don't fray on the edges as you pull them back and forth.

A nice semi-matte finish can be produced using one of the non-woven abrasive pads sold for cleaning pans in the kitchen. Use it wet or dry. These are commonly about 1/4 inch thick and about 4 X 6 inches in size.

I rarely use gaskets on model engines, relying instead on lapping the mating surfaces flat. Some builders however may desire to use gaskets. Ordinary paper makes very serviceable gaskets if it is soaked in oil before installation. A sheet printed with several sets of gaskets is included in this book. If used, cut them out with scissors and a sharp modeling knife before oiling them. Another alternative, which I prefer over gaskets, is to use one of the gasket replacement compounds which are available at automotive supply stores. I have used both Loctite 515 and Loctite 518 with excellent results. Be careful not to use too much. Only a thin layer is necessary and excess can get into the valves or block steam passages.

The 2-56 set screws are very small. Additional 2-56 X 3/16 fillister screws are included in the kit and can be used to replace the set screws if desired. The set screws do make the model look nicer, but the fillister head screws are easier to make adjustments with.

## **TOOLS REQUIRED**

Only a few tools are required to assemble this kit.

Required are a small flat blade screwdriver, preferably two. One with a 3/32 blade width and the other with 1/8 blade width.

A sharp file. A 6 inch single cut mill bastard is recommended. For safety please use a handle on it.

Small needle nose pliers.

Tweezers are recommended for handling the small parts and a magnifying glass may be helpful. A modeling knife with #1 blade is useful for removing burrs and cutting gaskets if used.

## **GENERAL PROCEDURES**

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 and photographs to get an overview of where the parts go.

It is helpful to read over each section and lay out the parts before starting on that section.

The TVR1A kit contains approximately 175 parts. As many of the 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 clean well lighted area is essential. A large sheet of paper or light colored cardboard makes a good work surface.

"File the surface flat and lap" is used in the instruction in several places.

To file a small part flat, place the file on a flat surface with the handle towards you. Let the handle hang over the edge of the surface so the file can lay flat. Files can and do bend if used unsupported. This is no problem for general filing, but will round the edges on parts when you are trying to get them flat. Then hold the part on the file and pull it towards you. On tall parts be careful that the part does not tip. Try to keep a uniform pressure on the part. As a rule, the edge that is towards you will be cut more than the trailing edge, so rotate the part 180 degrees and make a second cut. Only a few strokes should be necessary to remove any machining marks or burrs. Keep the file clean. Brush out any chips often.

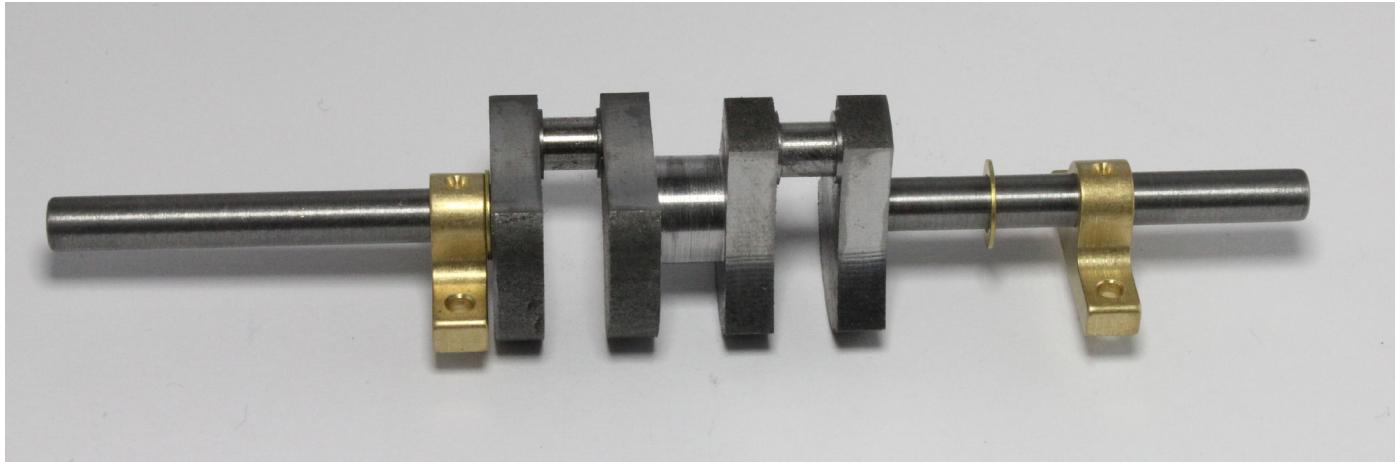
After filing the surface, lap it using the 400 grit abrasive paper supplied. Place the paper on a flat surface with the abrasive up. Put several drops of light oil on the paper, and rub the part on the paper using light pressure. A super flat surface is not necessary. A table or counter that has a pressure laminate surface will work well. Other surfaces that work well are a piece of thick plate glass or the table of a table saw. Use a figure 8 pattern and rotate the part every few strokes. This keeps the cut even over the entire surface. Clean the part thoroughly after lapping to remove any trace of abrasive. Hot water and dish washing detergent work well with a small brush. Dry the part.

## ASSEMBLY

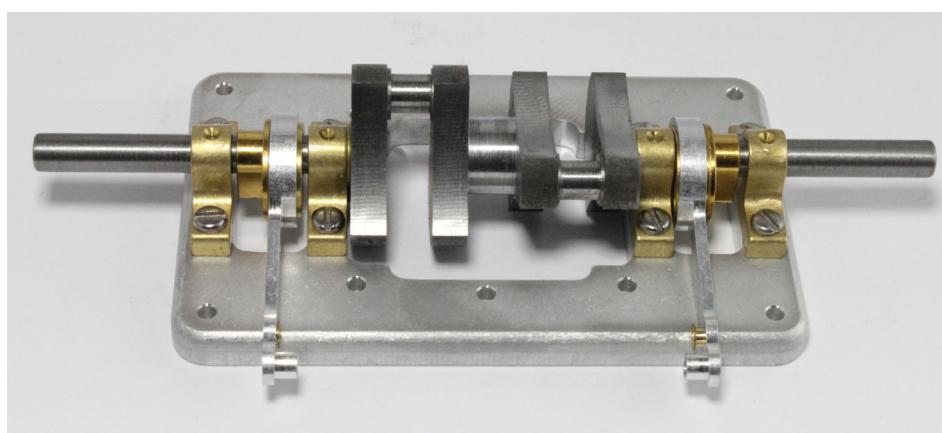
Now with all the preliminaries out of the way, lets build an engine.

Construction is broken into several sub-assemblies. The first is the base-crankshaft. Then the valve gear is partially assembled on the columns in two groups, front and rear. These are then attached to the base-crankshaft assembly. Last the cylinder assembly is built and attached to the other two sections. At this point the valve gear is adjusted and the remaining details are finished up.

### BASE-CRANKSHAFT ASSEMBLY



- Clean and remove and burrs on the BASE (53070), BEARINGS (53083), CRANKSHAFT ASSEMBLY (A2007), ECCENTRICS (53076), and ECCENTRIC STRAPS (53075). Polish any parts if desired.
- Slide a 3/16" x 5/16" x 0.015" WASHER (51006) on each end of the crankshaft assembly. Place a drop of oil on each end of the crankshaft and then slide a bearing on each end of the crankshaft. Slide each bearing back and forth to distribute the oil. Slide the bearings and washers against the crankwebs of the crankshaft assembly.



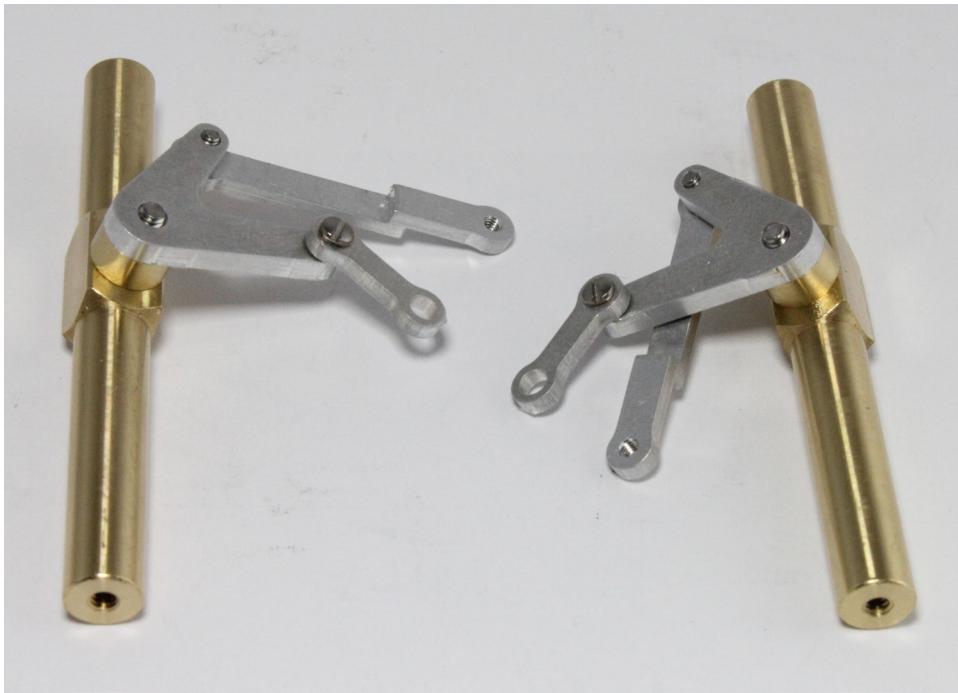
- Place the base on a flat surface with the rounded edges of the base up. Set the crankshaft assembly so the crankwebs set in the opening in the center of the base. Secure the assembly to the base using four 2-56 x 1/4 pan head screws (12216). Do not tighten. Place the two outer bearings on the crankshaft and secure with four more 2-56 X 1/4 screws. Tighten the 8 screws a little at a time while rotating the crankshaft to check for binding. Adjust the bearings so the crankshaft turns with a minimum of binding. Minor binding will not cause any problems, as the bearings will seat in after a short period of running.

- Mark the outer bearing as to position and which end they are on and remove them.
- Insert a BUSHING (54040) through the hole in the flat portion of each eccentric strap from the side opposite the flat side. Holding the bushings in place, file the small ends flush with the flat side of the eccentric straps. As it will be some time before assembly holds these bushings in place, temporarily use a 0-80 x 3/16 pan head screw (10212) and a 0-80 nut to hold them in place.
- Install a setscrew (12608) in each eccentric. Place a drop of oil on each eccentric where it will fit into the

eccentric strap. Slide each eccentric into the flat side of an eccentric strap. Position the setscrew towards the arm of the eccentric strap. Slide an eccentric assembly on each end of the crankshaft with the hub of the eccentric to the outside of the engine. Do not tighten the eccentric set screws. Replace the outer bearings in the same position that you removed them. Tighten the bearing screws and check the crankshaft for binding.

- Your base-crankshaft assembly should look like the photo on the previous page at this point. Set this assembly aside and start on the next assemblies.

## VALVE GEAR ASSEMBLIES



- Build the two valve gear assemblies at the same time. They are identical except that they are mirror images of each other. Only the front assembly will be detailed with notes for the rear assembly. Photo 2 shows the two assemblies with the front assembly on the left and the rear assembly on the right.
- Clean and remove burrs on the columns (53073), bellcranks (53074), offset links (53087), 2 hole links (53088), and Bellcrank mount bushings (54104).
- The bellcranks have the remains of three small tabs used to support the part during machining. These are on the outside edges of the parts. File these tabs off and then take a few extra strokes to remove the machining cutter marks on these edges. File lengthwise on these edges. Although not necessary for operation, the flat faces of these parts can be improved by filing. If you plan to polish these parts, wait a little while, as two screws need to be filed off flush during assembly. Then you can disassemble that part, polish the bellcranks, and reassemble.
- One end of the short links will also have a small tab that must be filed off. If you get a little flat on this end when filing, you can hide that end in slot of the fork a little later.
- Insert a bellcrank mount bushing into the side of a column. File the small protruding end of the bushing flush by placing the file on a flat surface and slide the assembly over the file while pressing on the bushing. Repeat for the rear assembly.
- The short end of each column goes toward the top of the engine. Insert a 2-56 x 1/2" pan head screw through the bushing from the small diameter end of the bushing. Thread the screw into a bellcrank. The bellcrank is spaced away from the column by the large end of the bushing. Repeat for the second column but place the bellcrank in a mirror image position. Rotate the bellcranks so the long arm is perpendicular to

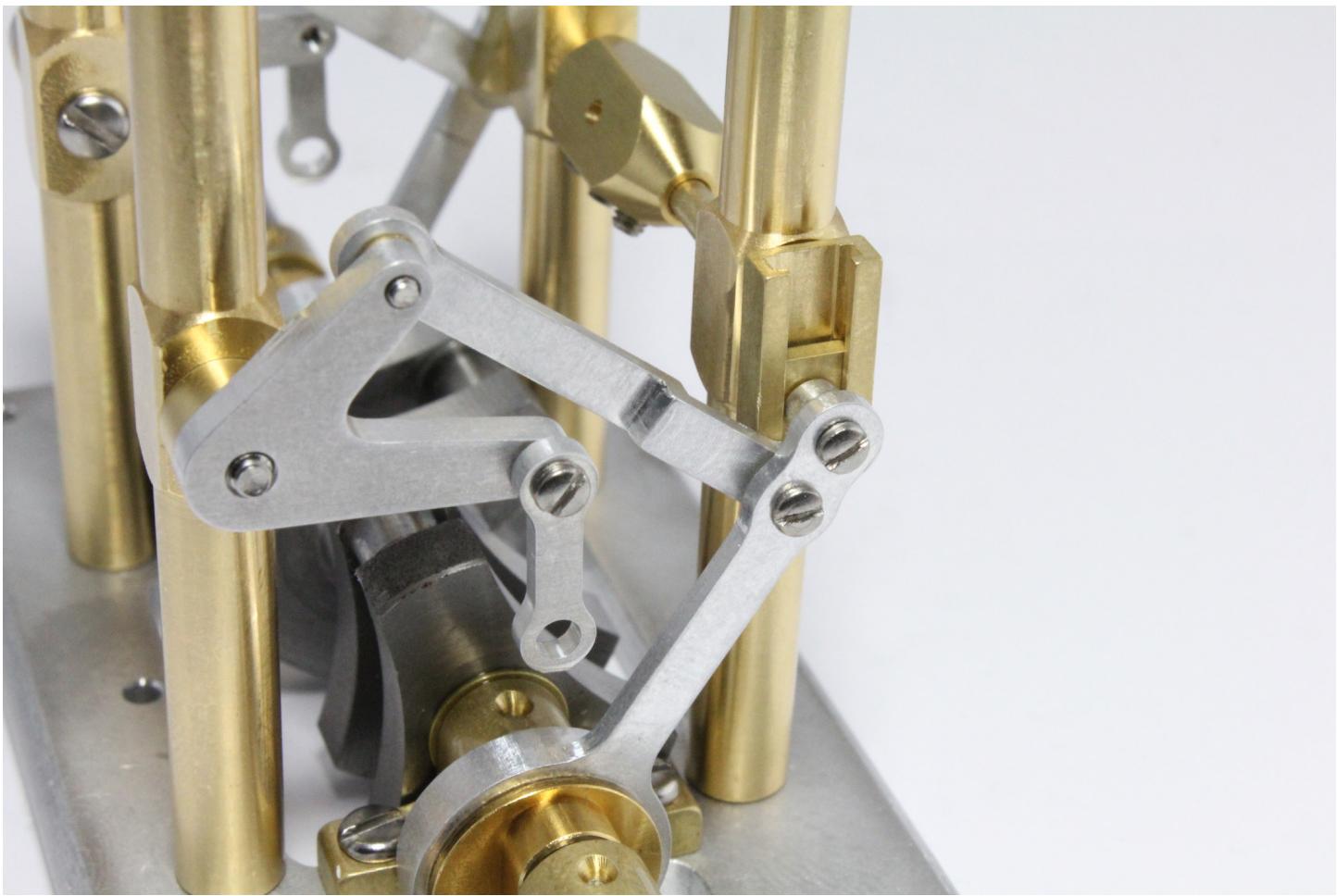
the column and the short end is toward the top of the column. Facing the bellcrank side of the assemblies, the front assembly will have the arms of the bellcrank to the right of the column and the rear assembly will have the arms to the left.

- Place the offset links on a flat surface so the long end lays flat on the surface. The short end will not touch the surface. Insert a BUSHING (54040) in the hole in the long end of each link. File the bushings flush on the other side. Insert a 0-80 X 3/16" pan head screw through the small end of each bushing. Thread the screw into the short arm of the bellcrank from the side of the bellcrank nearest the column. Repeat for the other assembly.

[OPTIONAL] The two screw ends that protrude from the bellcrank look much better if they are filed flush with the bellcrank. After filing these screws flush, the screws may be removed and the bellcrank polished. Then reassemble.

- Insert a Bushing (54040) in one end of each of the short 2 hole links. If one end of the link is distorted from filing the tab, insert the bushing in the best looking end. The other end will be hidden during final assembly. File the protruding small end of the bushing flush with the link. Insert a 0-80 X 1/8" pan head in the small end of the bushing and attach to the long arm of the bellcrank on the side away the column. Repeat for the second assembly.

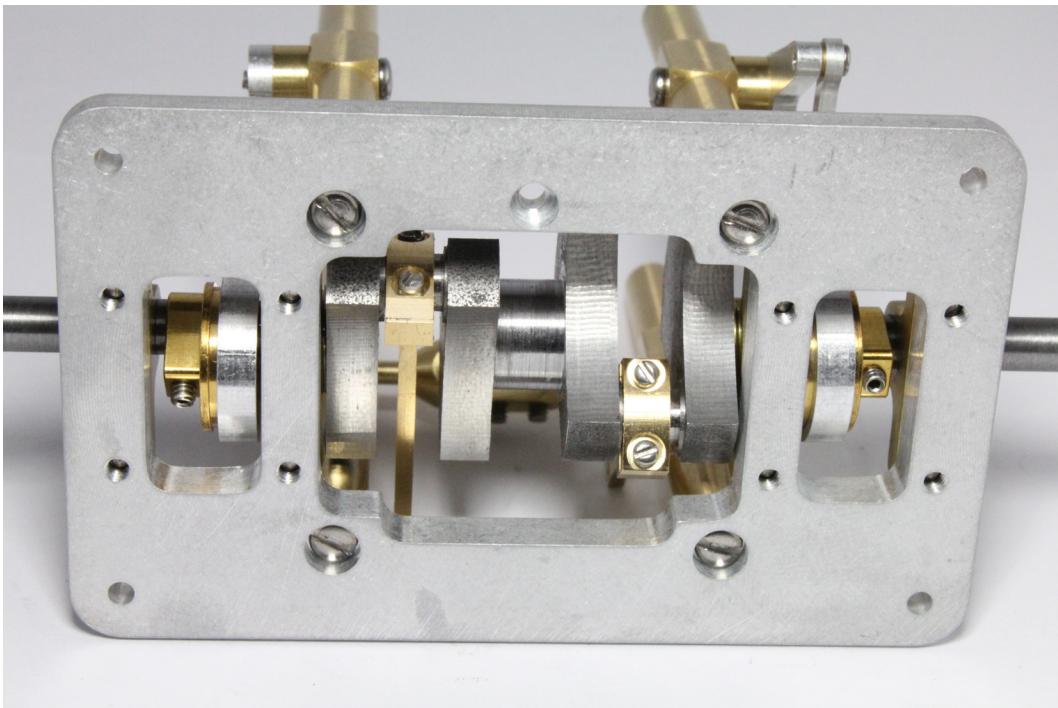
## BUILDING UPWARD



- The photo above shows how to tie together everything we have done so far plus add a few more pieces.
- Attach the 2 valve gear assemblies just completed to the right side of the crankshaft-base assembly. The right side is the side that has the extra hole near the center of the crankshaft assembly. Facing the right side, the front valve gear assembly goes to your right. Attach the columns to the base using 2-56 X 1/4 pan head screws. Make sure the long ends of the columns are next to the base. The linkage is to the ends of the engine, approximately in line with the eccentrics. As you tighten the screws, lay a straight edge between the two columns along the flat edges of the columns. Adjust the columns rotation so the straight edge touches all along both the flats on the columns.
- Remove the screws used to hold the bushings in the eccentric straps. Position the bellcrank so the long end is horizontal and over the eccentric. The short end should be towards the top of the engine. Place a 0-80 X 1/8 screw through the bushing in the eccentric strap from the flat side of the strap and thread it into the tapped hole on the offset link and tighten. Slide the eccentric towards the center of the engine. View the assembly from the top of the engine. The bellcrank should be parallel to the long end of the offset link and have a uniform space between them. If not, slightly adjust the rotation of the column. Repeat for the other end of the engine. All the linkages should move freely at this point.
- Clean, remove burrs, and polish the male t-slot slides (53084), the female t-slot slide assemblies (A2014), and the reverse linkage connector. Put a drop of oil in each of the female t-slot slides. Slide a male slide into each female slide assembly to check for fit. Please note that the male slides are NOT square. The narrow dimension only will fit in the female slide assembly. These will be a close fit. Do not file the slides unless absolutely necessary to fit them together. Remove the male slides. Insert the male slides in the end holes of the eccentric straps with the flat faces of the slides facing each other. Secure the male slides to the eccentric straps with 0-80 X 1/8 pan head screws.  
Insert 3 setscrews (12608) in the tapped holes on the reverse linkage connector.  
Attach the columns to the left side of the base using 2-56 x 1/4 inch screws aligning them in the same way

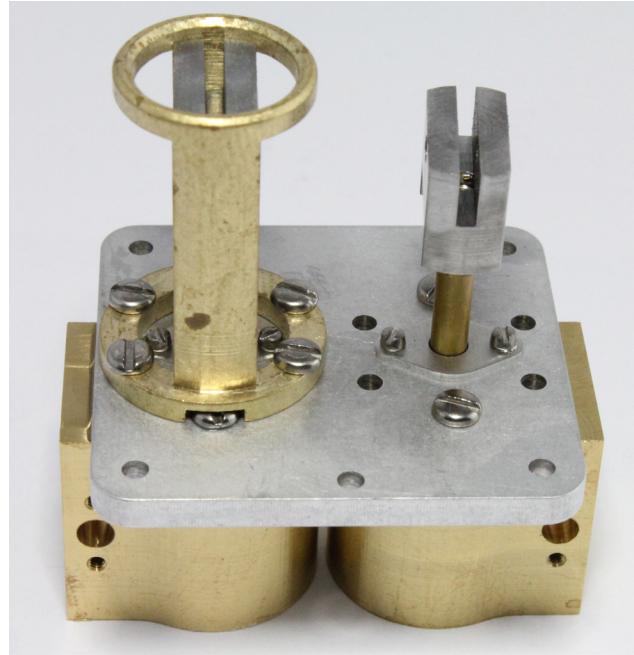
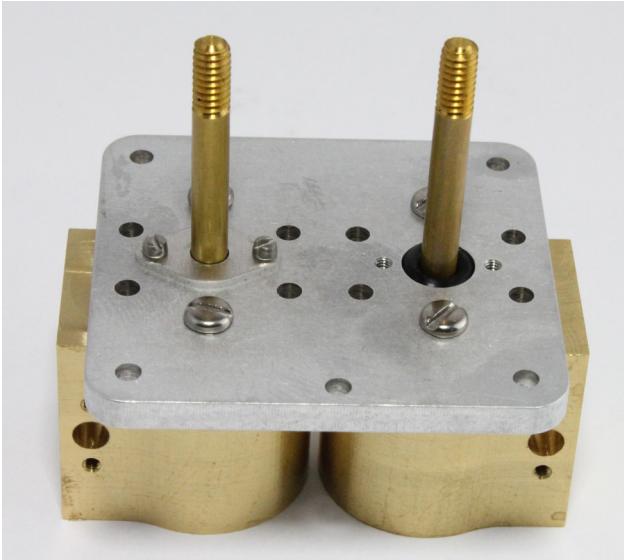
you aligned the other columns. You should be able to see through both holes at the same time.

- Rotate the eccentric straps so they are vertical with the "U" on the bellcranks facing upward. With the connector between the columns, insert a female slide assembly through each column and into the ends of the connector block
- Now comes the tricky part. I had you insert the male slides in the female part earlier so you know they really do fit. Rotate a female slide about 30 degrees so that its opening is towards a point over the crank-shaft at the top of the engine. Move the male slide into position over the end of the female slide by rotating the eccentric strap. Guide the male slide into the female slide and rotate the female slide so the slide part is vertical and the male slide is fully engaged. Repeat for the other set of guides.
- Before setting this assembly aside, install the connecting rod assemblies (A2009) onto the crankshaft assembly. Do this one at a time so the parts of the two connecting rods do not get mixed up.



- Before removing the connecting rod bearing cap from the connecting rod, mark one side of the rod and bearing cap with a marker or pencil so you know which way to reinstall the cap on the rod. A small scratch will also work and will be permanent for future use if necessary. The rod and cap have had the bearing surface machined at the same time so everything will match properly. If the caps are mixed up on the rods, there is a fair chance that one of the rods will fit tight on the crankpin.
- Rotate the crankshaft so one of the crankpins is at the bottom of the engine.
- Remove the connecting rod cap from the connecting rod by loosening the two screws holding the cap on. Leave the screws in the cap. Put a drop of oil on the bearing surface of the connecting rod.
- From the top of the engine, slide the connecting rod between the crankwebs onto the crankpin that is at the bottom of the engine.
- While holding the connecting rod in place, turn the engine over and place the bearing cap with screws on the connecting rod and tighten the screws. Pay attention to the alignment marks that you made on the two parts. The connecting rod will probably be slightly tight on the crankpin, but should move easily with finger pressure.
- Repeat the procedure with the other connecting rod.
- Now set this assembly aside and smile. It's starting to look like an engine.

## THE CYLINDER GROUP



- In this assembly section a number of parts will require lapping as described in the general procedures. I prefer to lap all the parts at the same time and then clean and oil them before beginning assembly.
- Check the paragraph on gaskets and gasketing materials in the general notes. For most builders, gaskets or gasketing materials will not be necessary if lapping is done carefully. However laser cut gaskets are included.

The areas that require lapping are:

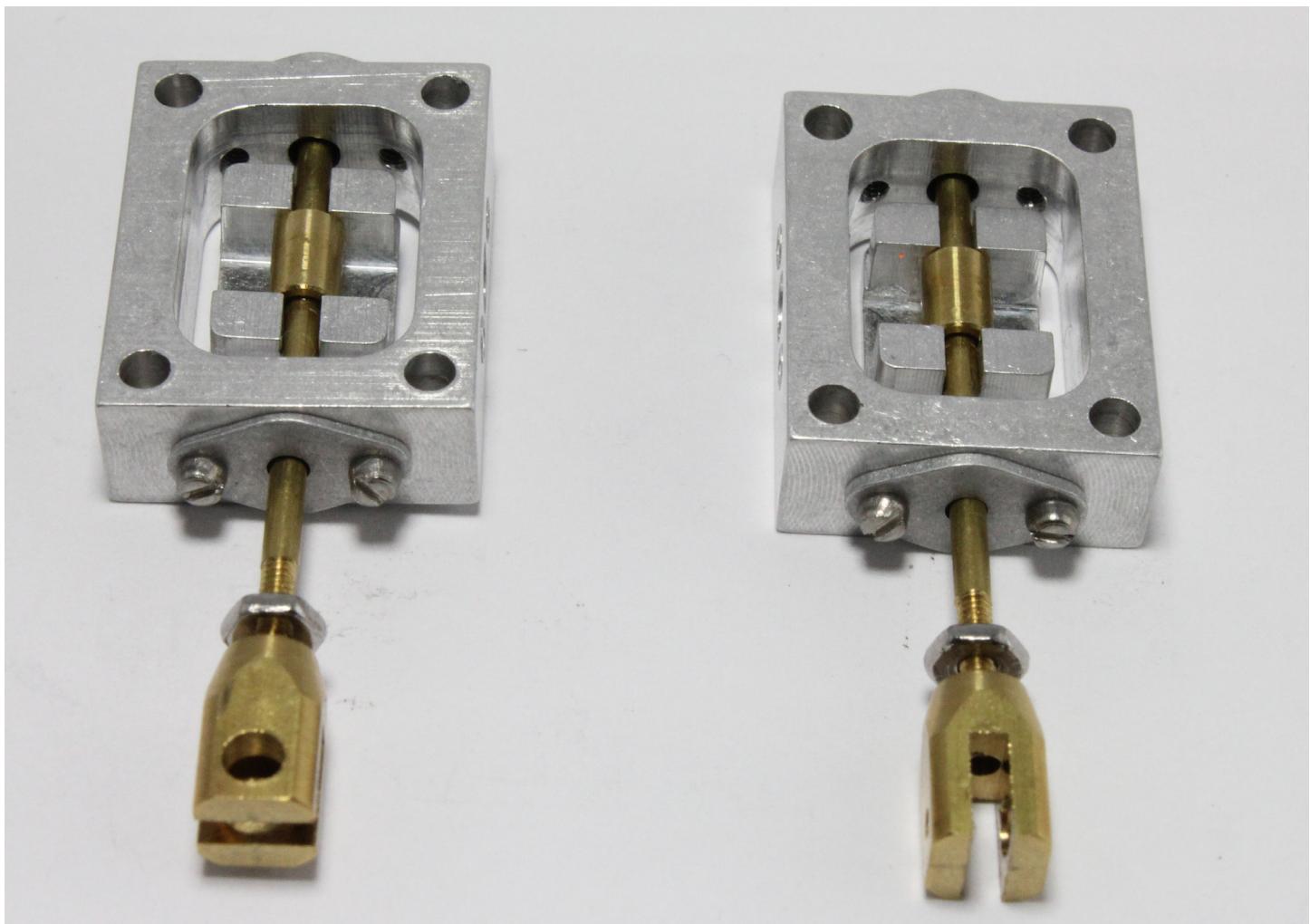
1. Both ends of each cylinder.
2. The cylinder port face on each cylinder.
3. The steam chest faces that contact the cylinder and chest cover.
4. The side of the steam chests that mount the steam manifold.
5. One side of the steam chest covers.
6. One side of the cylinder covers.
7. The side of the cylinder mount that does not have a seal recess.
8. The flanges of the manifolds.
9. The steam valve face with the rectangular recess.

- Using a corner of the abrasive paper, remove any burrs that are around the exhaust holes on the side of the cylinder.
- After lapping, clean everything to remove all traces of abrasive compound. This will require more than wiping with a cloth. The parts must be cleaned with either solvent or hot water with a detergent added. Be sure to flush out the steam passages in the cylinders.
- Remove any burrs from the piston-piston rod assembly (A2001). Put a drop of oil in the groove on each piston. Slide the 3/8 ID O-Ring (40012) over the piston and into the groove. Place a drop of oil on each O-Ring and rotate the piston to coat the O-Ring with oil.
- Hold the cylinder (53004) with the valve port face towards you and the exhaust opening to your left. Slide the piston into the cylinder with the piston rod down. This is the front cylinder set.
- Install the piston in the other cylinder in the same way except the exhaust opening must be to your right. This is the rear cylinder set.

- Hold the cylinder mount (53071) with side containing the seal recesses away from you. Rotate the mount so the edge with three holes is down. Insert the piston rod for the front cylinder in the center hole of the right set of holes and position the cylinder so the flat port face is to your right. Secure the cylinder to the cylinder mount with two 2-56 X 1/4 pan head screws (12216). Install these two screws in the holes that are rotated 90 degrees from the 0-80 tapped holes in the cylinder mount.
- Check the assembly. The exhaust outlet on the side of the cylinder must be towards the edge of the cylinder mount that has 3 holes.
- Mount the second cylinder in the same manner. When mounted, both cylinders will have the exhaust outlets on the same side.
- Slide a 1/8 ID O-Ring (40006) over each piston rod and press it into the seal recess on the cylinder mount. Be careful going over the threads of the piston rod so the threads don't damage the O-Ring.
- Slide a 1/8 ID seal retainer (51008) over each piston rod and secure each to the cylinder mount with two 0-80 X 1/8 fillister head screws (10408).
- Thread a 5-40 X 0.047 nut (53023) on each piston rod. Position it about the middle of the threaded part of each piston rod. It will be adjusted later.
- Inspect each crosshead (53062) and crosshead guide (53061) and remove any burrs. Check by test fitting the crossheads in the guides. Remove the crossheads from the guides.
- Install a crosshead on each connecting rod. Thread each crosshead on about 2 to 3 turns and adjust the crossheads so the threaded 2-56 hole in each of them faces the middle of the assembly (the holes will face each other).
- Slide a crosshead guide over each crosshead so the two notches in the guide fit over the two screws holding the cylinder mount to the cylinder. Secure each crosshead guide using four 2-56 X 5/16 pan head screws (12220). Put a drop of oil on each side of the crosshead guide where it touches the crosshead.



- A retaining compound is used to locate the valve driver on the valve spindle on the valve spindle assembly (A2004). There may a small amount of this retaining compound at each end of the valve driver. If so, scrape it off with a knife or screwdriver blade.
- Test fit the valve driver in the valve (53103) slot. It should be a free easy fit, but with very little play. If it is tight, file the inside of the valve slot until it is an easy fit.
- 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 not threaded end of the spindle fits inside the steam chest. Then slide the not threaded end through the end hole in the other end of the steam chest.
- Place a drop of oil on each end of the valve spindle rod. 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 threaded portion of the rod.
- Secure each O-Ring in place with a 1/16" hole seal retainer (51007) and two 0-80 X 1/8 fillister head screws (10408).
- Repeat for the second set of valve chest parts.
- Center the valve driver in each of the steam chests. Set the steam chests next to each other with the threaded end of the valve spindle facing you and the two steam inlets facing each other. Place a valve on each spindle.
- Place a drop of oil on the port face of each of the cylinders between the steam port openings.



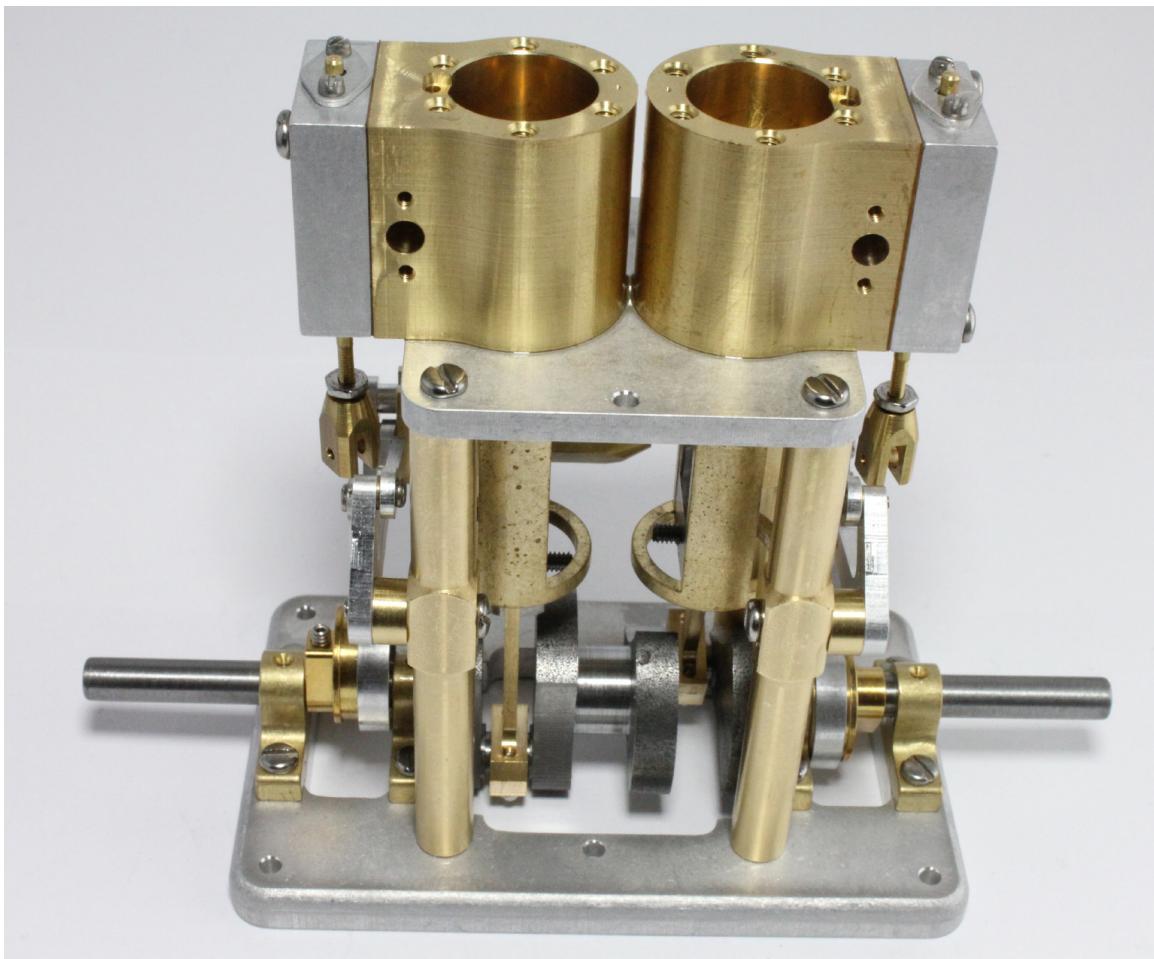
- Place the steam chest assembly on your left on the port face of the front cylinder with the threaded end of the valve spindle at the crosshead end of the cylinder. The rectangular cavity of the valve must touch the port face of the cylinder. The steam inlet on the steam chest must be on the opposite side of the cylinder from the exhaust outlet in the cylinder. If not, you probably have the steam chest on the rear cylinder. Temporarily hold the steam chest to the cylinder using two 2-56 x 7/16 pan head screws (12228). Gently tighten these screws. If tightened firmly, they will damage the lapped surface of the steam chest and may cause a steam leak later.

- Install the other steam chest assembly on the rear cylinder in the same manner.
- Thread a 0-80 nut (10000) to the middle of the threaded portion of each valve spindle. Thread the tapered end of a fork (53089) on each valve spindle approximately 6 turns. Position the fork so the 0-80 tapped hole in the side of the fork that faces the crosshead guide.



## FINAL ASSEMBLY AND ADJUSTMENT

Now it will really become an engine. It is time to tie everything together, make all the adjustments, and finish up the engine.

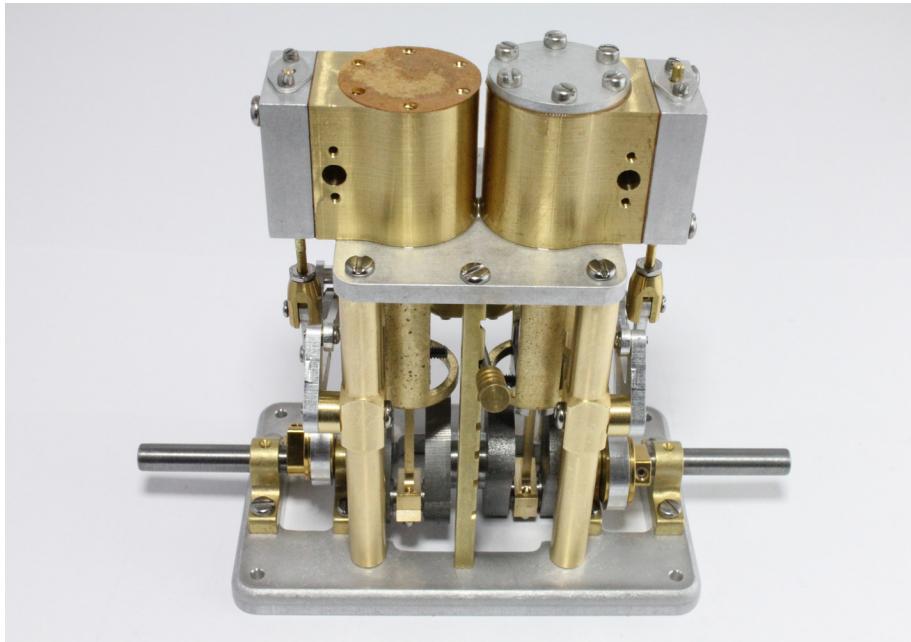


- Place the base assembly with the front to your right. The coupler for the valve gear should be away from you. Notice the hole in the base on the side nearest you near the center of the crankshaft assembly. With the crosshead guides down, rotate the cylinder assembly so the side with the hole near the middle is nearest you.
- Place the cylinder assembly on the 4 columns of the base assembly with the connecting rods entering the crosshead guides. Make sure the side of the cylinder assembly with 3 holes lines up with the side of the base with 3 holes.
- Secure the cylinder mount to the 4 columns with four 2-56 x 1/4 pan head screws.
- Place the connecting rod end in the crosshead slot and align holes between the connecting rod and the crosshead. It may be necessary to rotate the crankshaft and slide the piston up or down to accomplish this.
- For the following operation, it may be necessary to rotate the eccentric, the t-slide, or both to obtain clearance to work in. Insert the threaded end of the crosshead-connecting rod pin (53064) in the crosshead and through the connecting rod. Screw the pin into the far side of the crosshead. Tighten the pin securely. Repeat for the other cylinder.
- Place the free end of the short 2 hole link in the slot in the fork on the valve spindle. Align the holes. Insert a bushing (53101) through the hole in the fork and the hole in the link. The bushing will be almost flush with the surface of the fork. Insert a 0-80 X 3/16 pan head screw in the bushing and tighten. Repeat for the other end of the engine.
- Rotate the connector on the valve gear so the setscrews face down. Insert the end of the handle assembly

(A2008) in the hole of the connector from the other side of the engine until the end is flush on the far side of the connector. Tighten the center set screw on the connector to hold the handle assembly.

- Install the valve detent bar (53086) between the cylinder mount and the base. The notches must be nearest the cylinder mount, and face the front of the engine. With the connector slid toward the front of the engine, the bar on the handle will lightly engage the notches on the valve detent bar. Secure using a 2-56 x 3/16" fillister head screw (12414) through the base and a 2-56 x 1/4" pan head screw through the cylinder mount. You may have to loosen the four screws holding the cylinder mount to the columns to make it easier to get the detent bar in there.
- Place the handle bar in the notch nearest the base of the engine. Rotate the two female T-slides so they are vertical and align with the flat sides of the columns. Slide the connector so it is centered between the columns. This will bend the handle bar slightly so it is forced into the notches on the valve detent bar. Make sure the female T-slides are pushed up against each column and tighten the two outer setscrews in the connector.
- Rotate the crankshaft until one of the pistons is at the top of its stroke. Adjust the position of the piston by rotating it with a screwdriver in the slot in the center of the piston. Adjust it so it is flush with the top of the cylinder, and then turn it 3/4 of a turn clockwise to lower it into the cylinder. Tighten the 5-40 lock nut using the supplied open-ended wrench (51009). Repeat for the second cylinder.
- Position the handle bar in the center notch of the valve detent bar. Rotate the crankshaft so the FRONT piston is at the BOTTOM of its stroke. Set the eccentric on the REAR so the setscrew is in line with the arm of the eccentric strap and tighten the setscrew. It may be necessary to rotate the valve spindle in the fork to adjust the position of the valve so it does not strike the end of the steam chest.
- Rotate the crankshaft so the REAR piston is at the TOP of its stroke. Set the eccentric on the FRONT so the setscrew is in line with the arm of the eccentric strap and tighten the setscrew. Check that the valve has clearance in the steam chest.
- Check that the handle is in the center notch. With the REAR piston still at the top of its stroke, adjust the REAR valve spindle to center the valve so it covers all the ports on the port face. Place the handle in the first notch above the middle notch. Rotate the crankshaft while observing the valve. The edges of the valve should just come to the edge of the cylinder ports. The cylinder ports may or may not be visible at any position. If one port is visible and the other is not visible at any position, adjust the valve spindle to center the valve on the ports.
- Check the adjustment by placing the handle in the first notch below the center notch. Rotate the crankshaft and observe the valve. The valve should line up on the ports so they are completely covered at all times or have equal clearance between the both edges of the valve and the cylinder ports as the crankshaft is rotated.
- Lock the valve spindle by tightening the 0-80 nut on the valve spindle against the fork.
- Rotate the crankshaft so the FRONT piston is at the top of its stroke. Adjust the FRONT valve spindle to center the valve so it covers all the ports on the port face.
- Adjust the front valve in the same way as the rear was adjusted. Lock the spindle with the 0-80 nut.

Now it's getting close to test run time. Before closing up everything, put a drop of oil in each cylinder and in each steam chest.



- Place a cylinder cover on each cylinder with the lapped side of the cylinder cover against the cylinder. Secure each cover with six 2-56 X 3/16 fillister head screws.
- Remove the 2 temporary retaining screws holding the steam chest in place. Install a steam chest cover (51005) on the steam chest with the lapped side next to the steam chest and secure with four 2-56 X 7/16 pan head screws. Repeat for the second steam chest.
- Install the steam inlet and exhaust manifolds on the steam chests and cylinders respectively. Use four 0-80 X 1/8 fillister head screws on each manifold.

## **TEST RUNNING**

### **OIL EVERYTHING!**

Even if you are planning to run the engine on steam, it is better to test run it on compressed air. With air, the engine will remain cool and be easier to adjust if any adjustments are necessary.

A pressure regulator or other means must be used to prevent the engine from being over pressurized. The engine is rated for 35 PSI and this must not be exceeded. For the first 30 minutes of operation do not exceed 15 PSI.

Mount the engine to a heavy base with screws or hold the base in a vice with protective strips so the base is not scratched.

Place the reversing handle in the bottom notch. With the handle in this position, the engine will run clockwise as viewed from the front of the engine.

Connect the air supply to the steam inlet manifold. The inlet manifold has the smaller pipe and hooks to the steam chests. Set the air supply regulator to 15 PSI. The engine should start running. If it does not, try moving the reversing handle to the top notch, and then back to the bottom notch. Since the engine has not been run, the valves may not be seated on the cylinder face, and this movement will seat them with air pressure on the valve.

After the engine starts, let it run for a few minutes, then move the reversing lever to the top notch. The engine will run in the opposite direction. Reduce the air pressure to about 10 PSI and let the engine run for about 30 minutes. During this time, reverse the direction of rotation several times with the reversing lever.

After this run in, the supply pressure can be increased gradually to 30 PSI. Do not run at this high a pressure for more than a few minutes at a time if there is no load on the engine.

Disconnect the air and place several drops of oil in the steam inlet manifold. Reconnect the air and continue to run. While running on air, this oiling procedure should be done every 30 minutes for the first few hours of operation. After this time, a few drops of oil in the manifold every 4 or 5 hours of operation is sufficient. At the same time, put a little oil on all the bearings, pivot bushings, and sliding surfaces. A lightweight instrument or sewing machine oil is good for this. Be careful about using some of the common household oils. Many of these contain more solvents than oil.

As the engine starts to run more easily, the reversing lever can be moved to the next to the end notch. This will reduce air consumption. The reversing lever is not intended as a speed control, but can be used to increase efficiency when running with a light load by placing it in the notches next to the end. The center notch is an off position, and the notches to each side of the center are used only for adjustment. Some engines may run in these notches, but it is not a reliable operating position. Most engines will not run in this position.

After the engine is run in it will have black oil everywhere. Clean all the excess oil off the engine. Hot water and detergent can be used to clean up the engine. Dry off the engine and oil everything. Only a small amount of oil will be necessary now, as everything will have established running clearances by running.

## **STEAM OPERATION**

Do not attempt operation on steam until the engine has run for at least one hour on compressed air.

When operating on steam, the boiler **MUST** have a safety pressure release valve set at no higher than 35 PSI and 30 PSI is preferred. Pressure higher than 35 PSI may cause mechanical failure in the engine.

When operating on steam, the engine will require more lubrication than when operating on air. Steam is very effective at removing grease and oil and is used for this purpose.

The most effective way to lubricate the engine is with a lubricator in line with the steam supply. The most

popular type of lubricator is the displacement lubricator. If it is used, it should be mounted as close to the engine as possible, and after any steam regulating valves or governors. This type of regulator will not work with compressed air. It works on the principle of a small amount of steam condensing into water, and the oil floating on the condensed water.

A special steam cylinder oil is recommended for lubrication. It is compounded so it does not wash away from the surfaces as easily with steam as does more common oils. If any super-heat is applied to the steam, it is essential.

It is not recommended at super heated steam be used with this engine. If any is used, it should be only moderately super heated. The use of saturated steam is recommended, as the condensation of the steam will provide additional lubrication to the engine.

### **RADIO CONTROL OF THE TVR1A**

The TVR1A can be used in radio controlled devices. The recommended procedure for this is to use two servos. One to control the steam supply by a valve and to act as a throttle. The second is used to reverse the engine.

To set up the engine for servo reversing, the following is recommended.

Remove the reversing handle assembly and replace it with a piece of 1/16 inch diameter music wire. The wire should be long enough to engage the notches on the detent bar the same as the regular handle does. The other end of the wire can pass through the connector and attach to linkage to your servo.

Loosen the detent bar and rotate it so the notches face the outside of the engine and the music wire slides on the smooth side of the detent bar. This end of the music wire can now be used as an indicator to set up the servo operation. The servo and linkage is then adjusted so the wire lines up with the top and bottom notches at the extremes of the servo travel.

### **DISPLAY OPERATION**

When using the VRLA as an operating display model, it is an advantage to mount a flywheel on the engine. This will assist the engine in running at a lower speed so the works can be seen. A good size is from 2 to 3 inch diameter and 4 to 6 ounces in weight. Of course the youngsters will want to see how fast it will go, and in such cases the engine can be operated with out a flywheel or with only a light flywheel. In such cases, the maximum RPM will be about 3800 to 4000 RPM at 30 PSI of air pressure.