Rotary Vane Pump Rebuild

Back to the Kim Group Homepage

Rotary vane vacuum pumps are dependable and durable. After many years of service, many pumps are often neglected and unused. We recently inherited a few pumps, and in this webpage we document a full rebuild using a 1970s Welch 1402 as a model pump.

Service includes replacement of vanes, exhaust valves and baffles, intake and oil tank gaskets, and oil. The internal components and overall design of the Welch 1402 has hardly changed since the 1970s. Late models acquired changes to the shaft, where the collar is replaced for a pair of woodruff keys, and fusing of the center plates. If you are rebuilding a late model pump, these minor changes will be apparent during the rebuild process. This guide is an excellent reference for rebuilding both early and late model pumps, or pumps of rotary vane design. With enough preparation and the appropriate tools, a rebuild of a pump can be completed in less than 8 hours.

The rebuild kit (PN:P102024) was purchased from pchemlabs.com, although our chemistry stock room has some authentic Welch parts. A full rebuild and repair kit includes a V-belt, exhaust valves and springs, phenolic vanes, shaft seal, and gaskets. If you are massaging an old pump, you might also have to replace the motor if the bearings have gone bad or if it is spewing the magic smoke. The motor brackets should be left in place to avoid having to make major adjustments to the pulley ratio and V-belt tension.

CAUTION: The mating surfaces and internals of the pump are made of soft steel. Do not scratch or marr any surfaces, as this will ruin the performance of the pump.

Corrections, comments, and suggestions can be sent to me, Ignacio Lopez: ilopezpe AT ucsd DOT edu

Sections

Literature

I. **Owner's Manual (1975)**

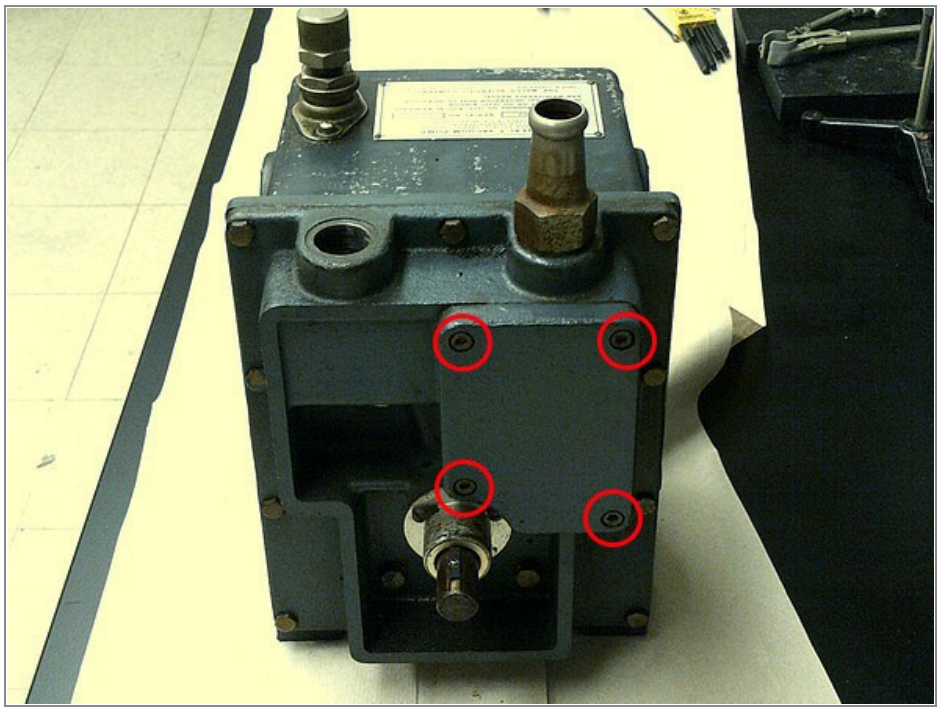
Tools and Materials

- Standard Wrenches
- Standard Sockets
- Standard Allen Keys
- Gear Puller
- Rubber Mallet
- Putty Knife
- Copper Brush
- #0000 Steel Wool
- Petroleum Ether
- Vacuum Pump Oil
- Vacuum Pump Oil w/ detergent (optional)
- Replacement Oil Drain Valve (optional)

Step 1

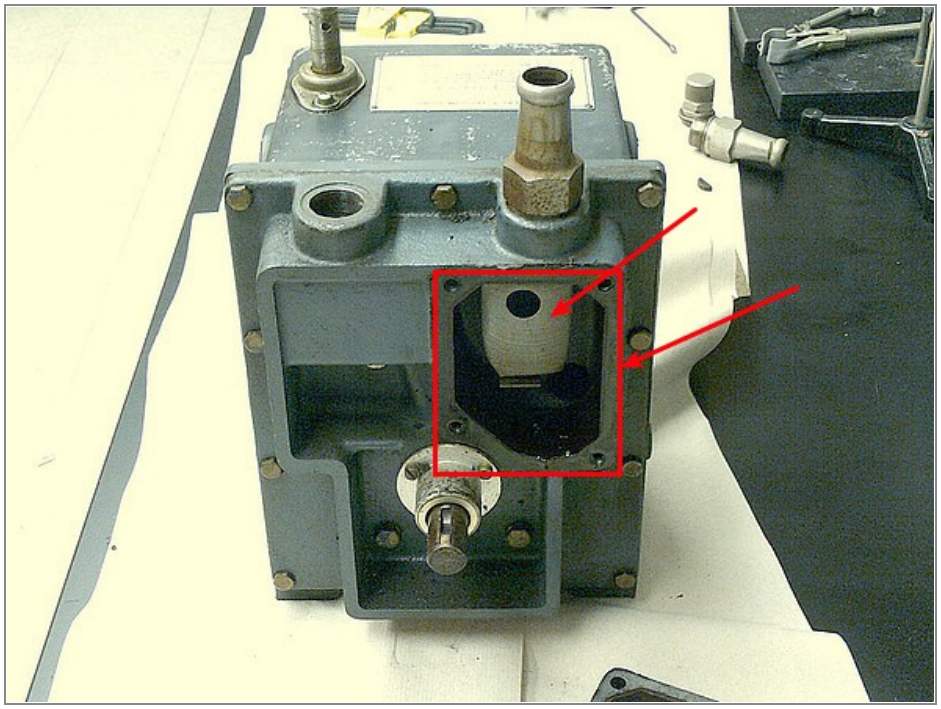
Large end plate disassembly

- Remove the V-belt and major pulley from the pump (not shown, reference reassembly).
- Remove pump from the platform (not shown).
- Remove the four hex head screws securing the intake chamber with an allen key.
- Remove the chamber by tapping on it with a rubber mallet, if stuck.



Go to cleaning

Go to reassembly

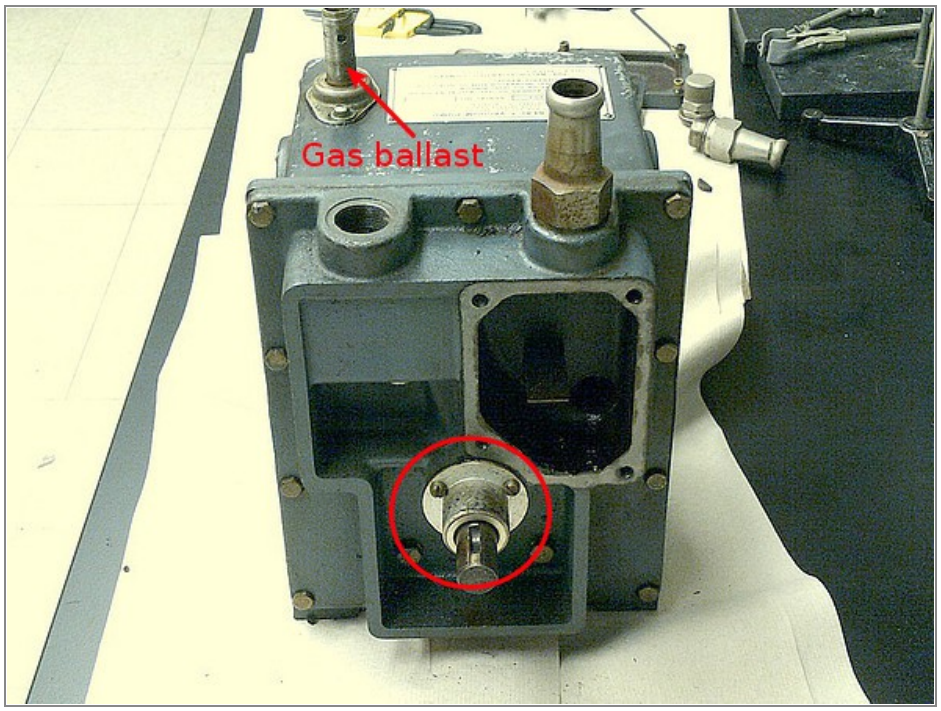


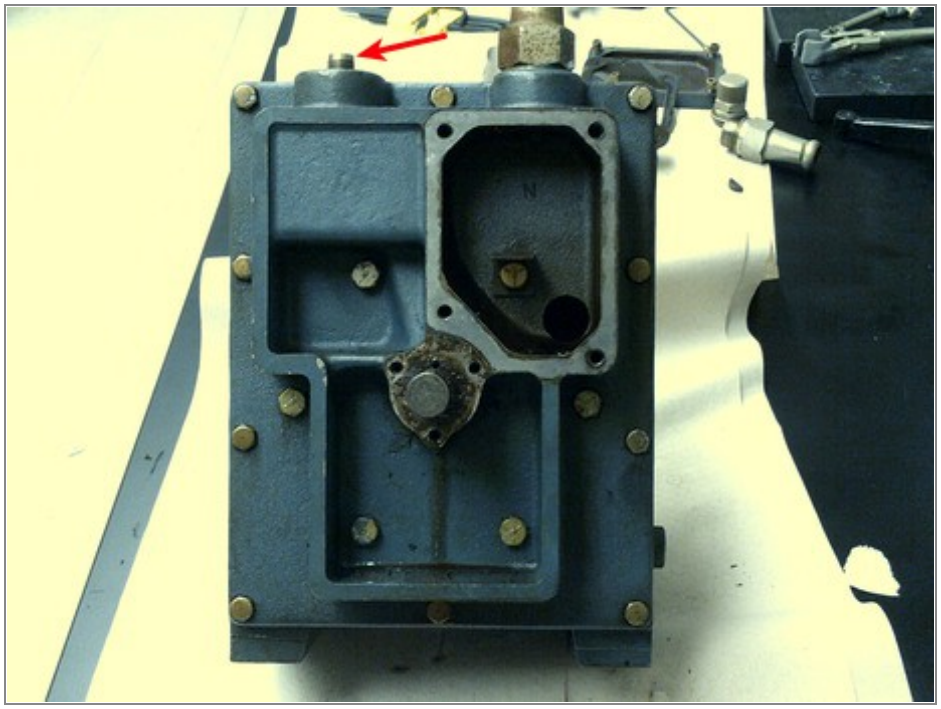
Step 2
Large end plate disassembly

- Remove the intake gasket.
- Remove the intake filter.

Step 3
Large end plate disassembly

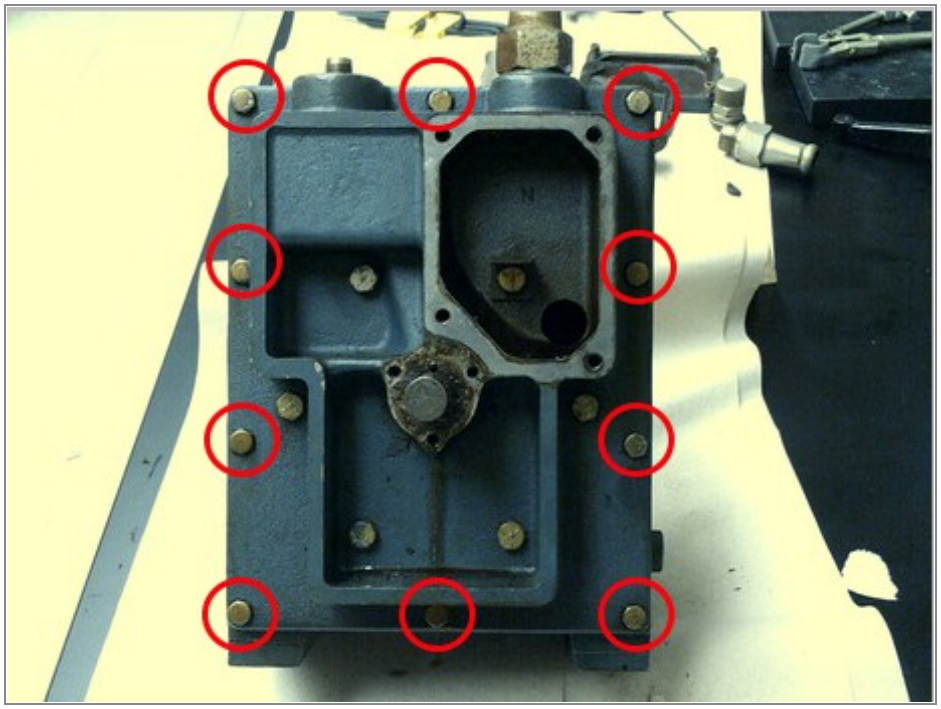
Remove the shaft seal





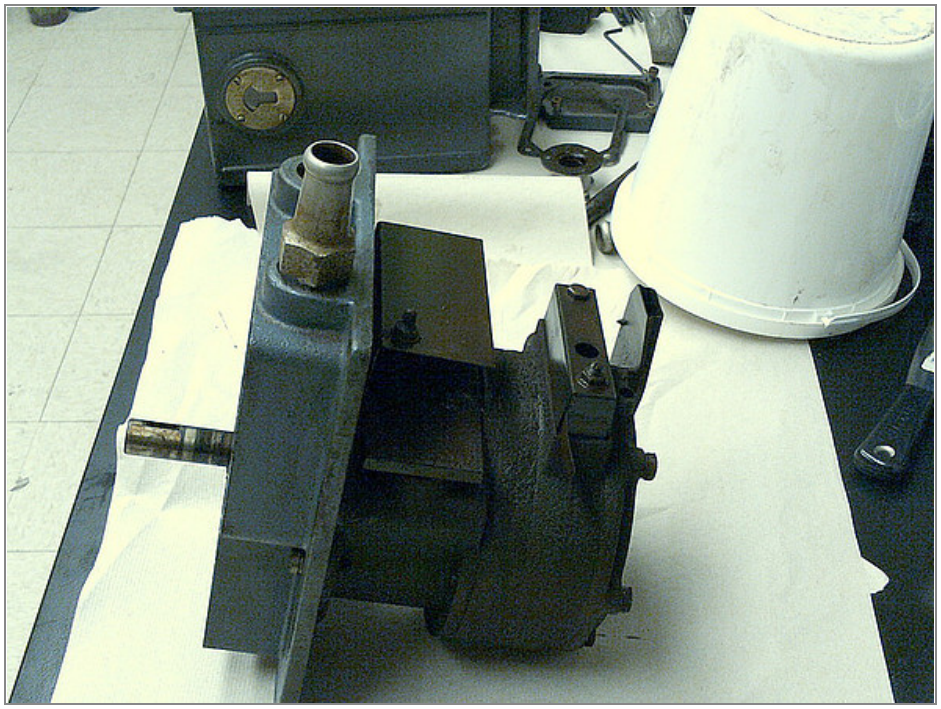
Step 4
Large end plate disassembly

Remove gas ballast from the oil case.



Step 4 (cont.)
Large end plate disassembly

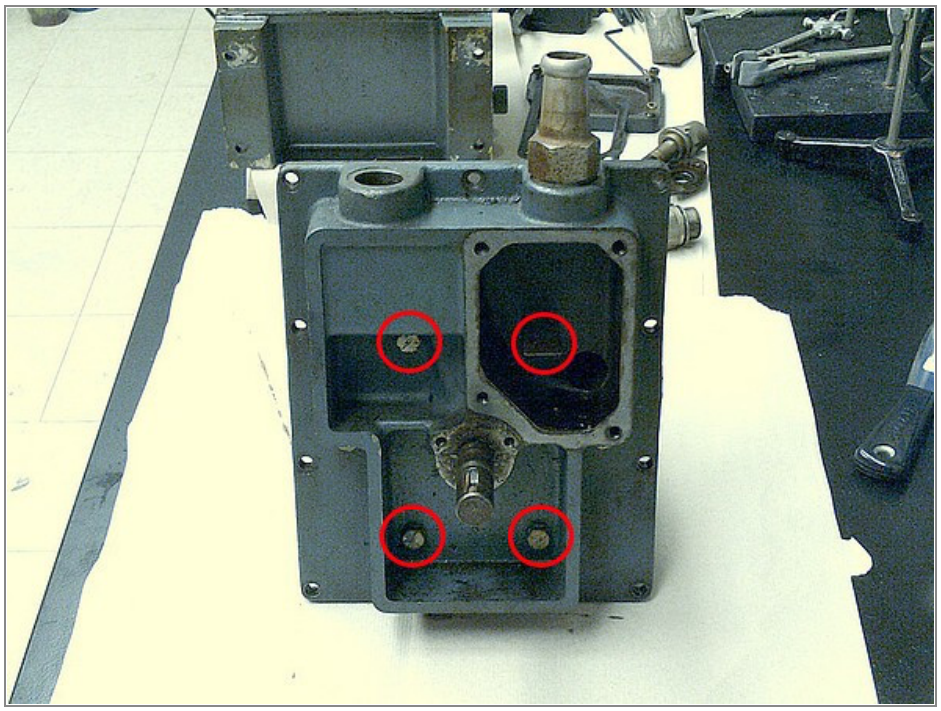
- Remove 10 perimeter hex nuts securing the large end plate to the oil case with a wrench.
- Lift and seperate front end plate from oil case.



Step 4 (cont.)
Large end plate disassembly

Side view of large end plate and exhaust stage assembly

Step 5

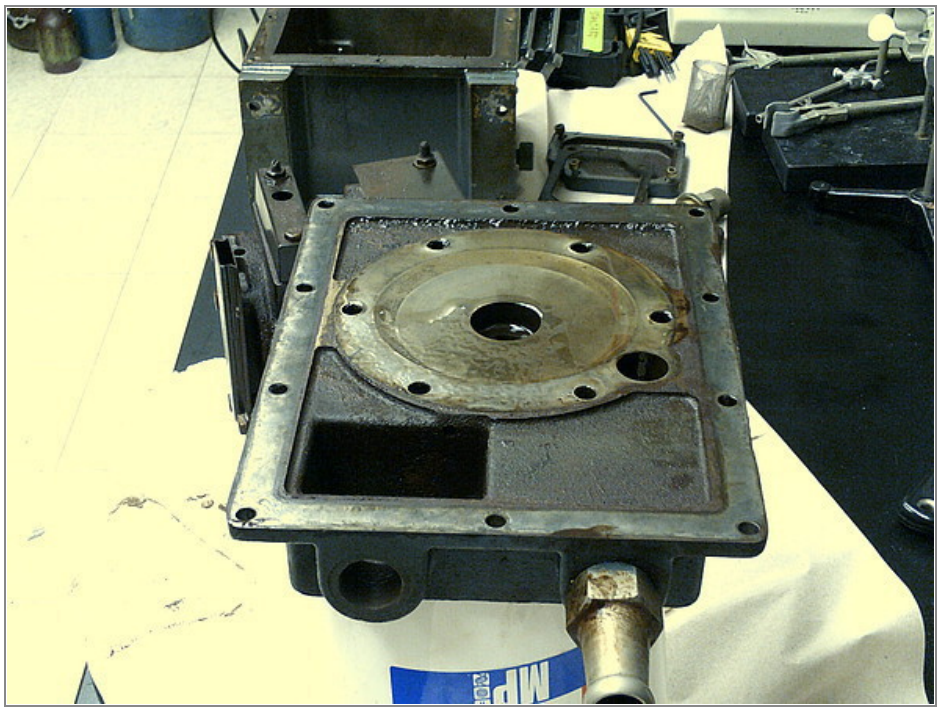


Large end plate disassembly

Remove 4 remaining hex nuts securing exhaust stages to the large end plate using a socket wrench.

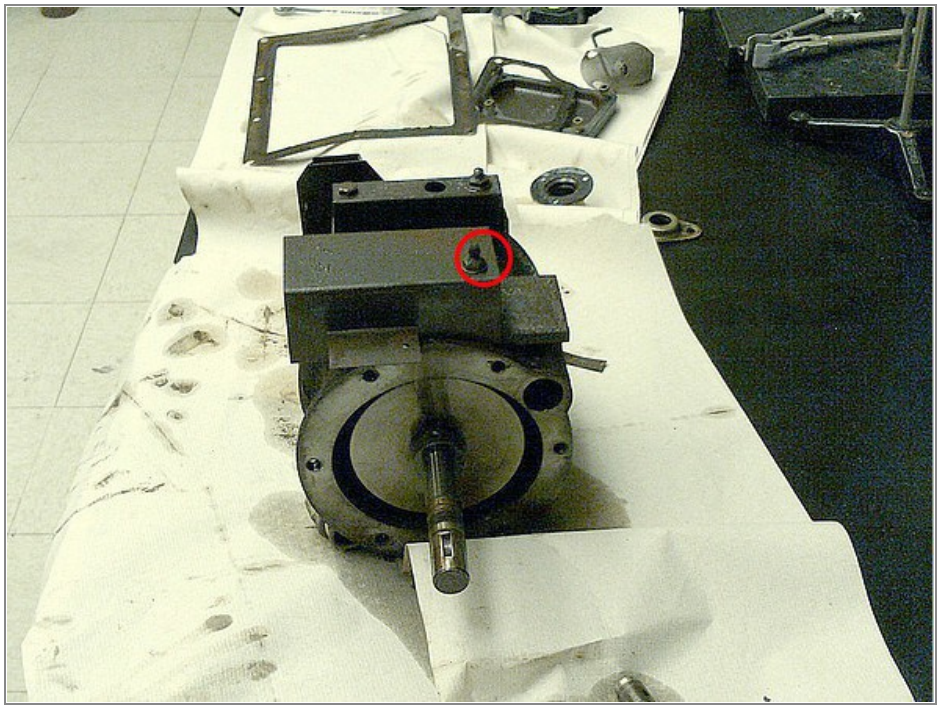
Step 5 (cont.)
Large end plate disassembly

We used a bucket with a hole in the bottom to hold the shaft and front end plate in place. The exhaust stages were then lifted and seperated from the front end plate. You should probably have an assistant for this part. We chose to do it this way to avoid damaging the pressure plate on the small end plate.



Step 5 (cont.)
Large end plate disassembly

The backside of the large end plate. The ports for intake, exhaust, and shaft are now visible.

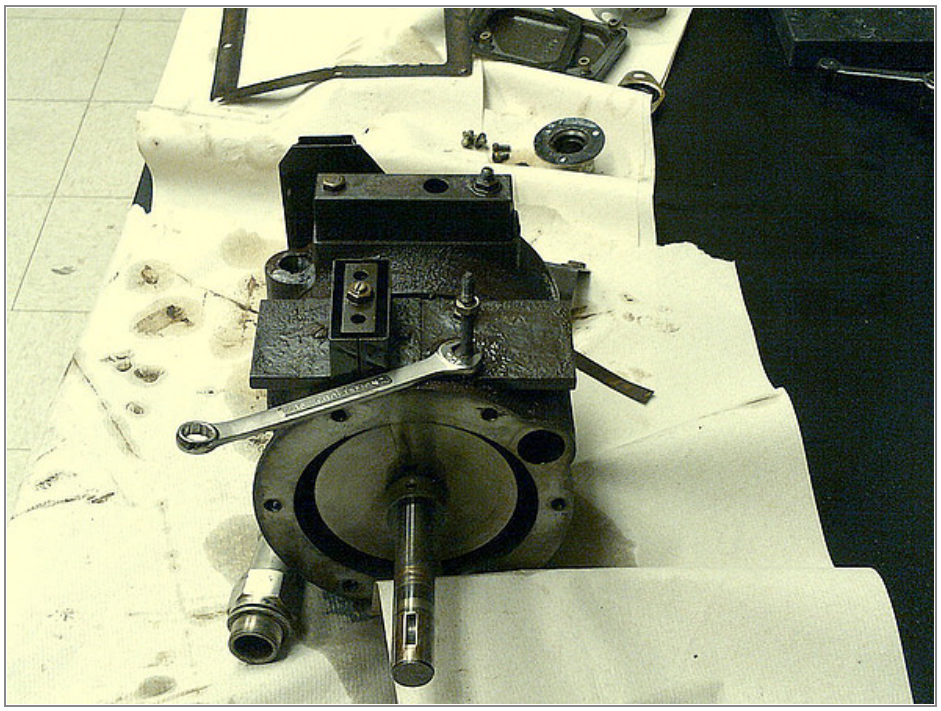


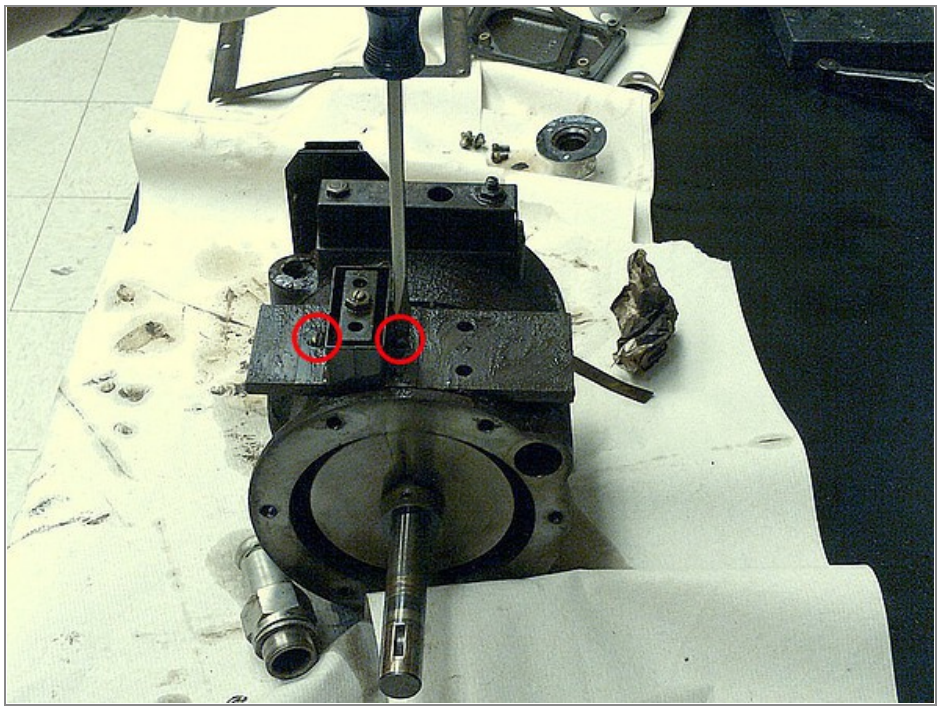
Step 6
Exhaust stage disassembly

Remove the nut securing the exhaust baffle with a wrench.

Step 7
Exhaust stage disassembly

Remove the nut securing the baffle post to the stage.



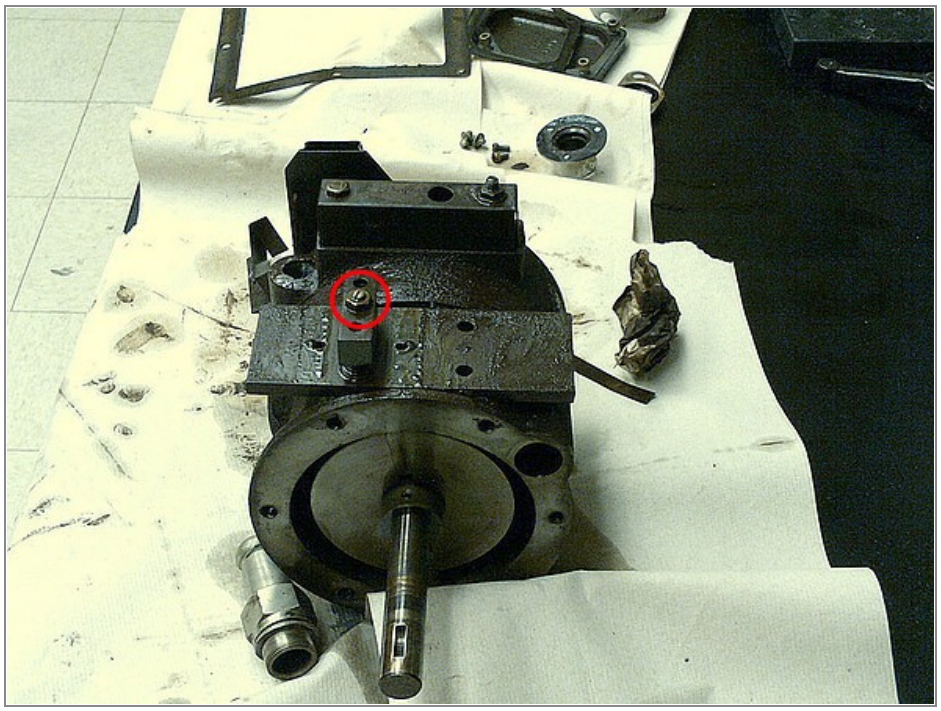


Step 8
Exhuast stage disassembly

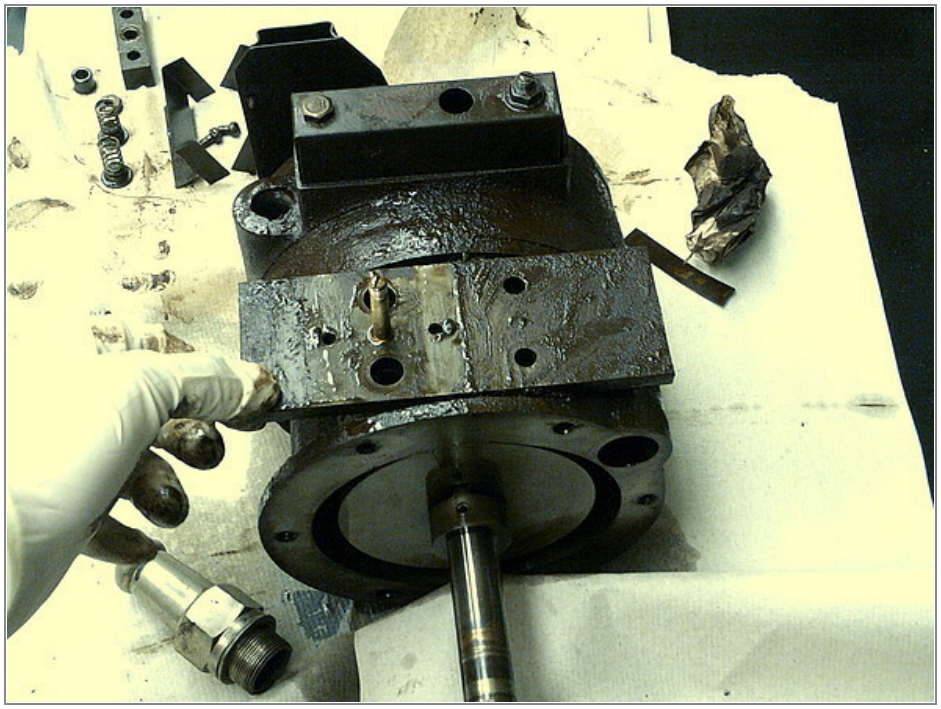
- Remove the screws securing the exhaust valve cover.
- Remove exhaust valve cover.

Step 9
Exhaust stage disassembly

- Remove nut securing the valve block.



- Remove valve block and valves.

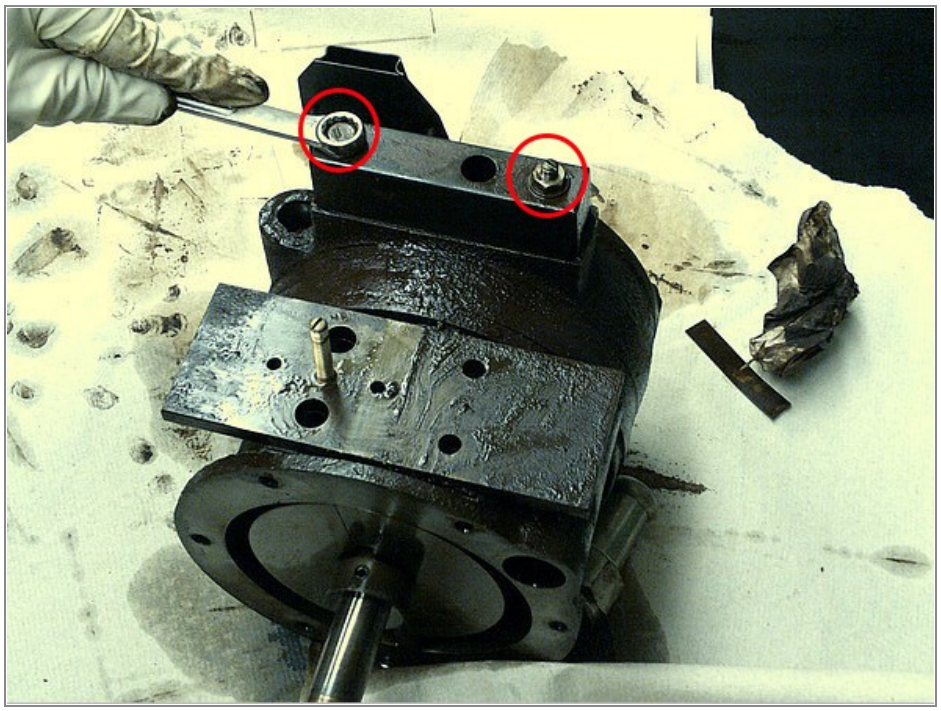


Step 10 (older models)
Exhaust stage dissassembly

An Aside. The exhaust valves for the first stage are mounted to a plate on early models (~<1975). There are two metal gaskets between this plate and the first stage (shown in Step 43). Rebuild kits for late model pumps do not include these gaskets, because this plate is integrated into the stage. At this point it lifts off of our model, but I'll leave it in place here.

Step 11
Exhaust stage disassembly

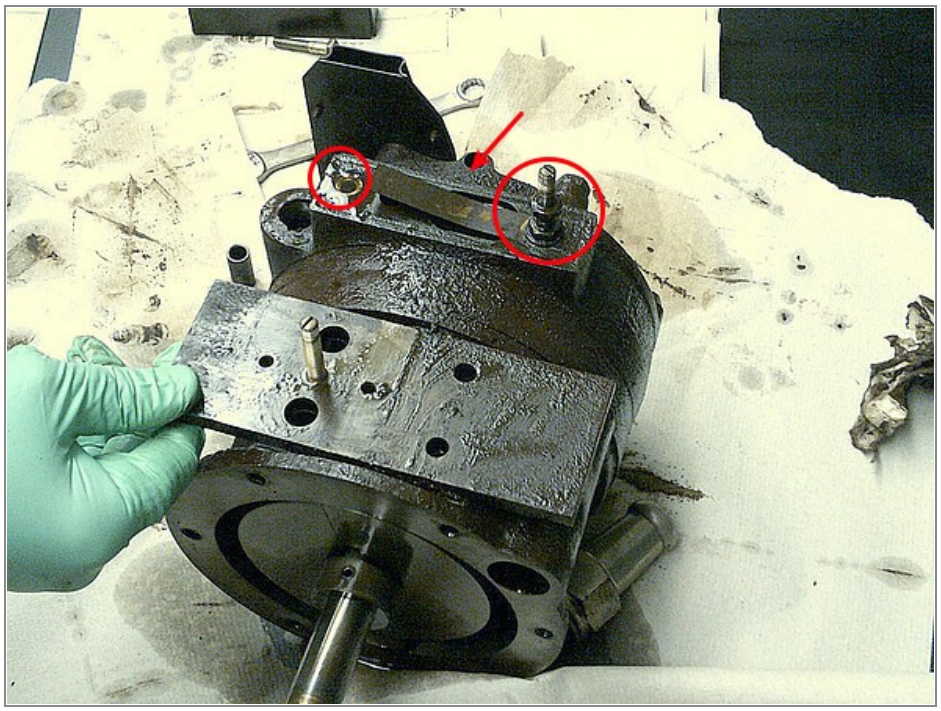
- Remove the two nuts securing the shields for the 2nd stage exhaust valves.

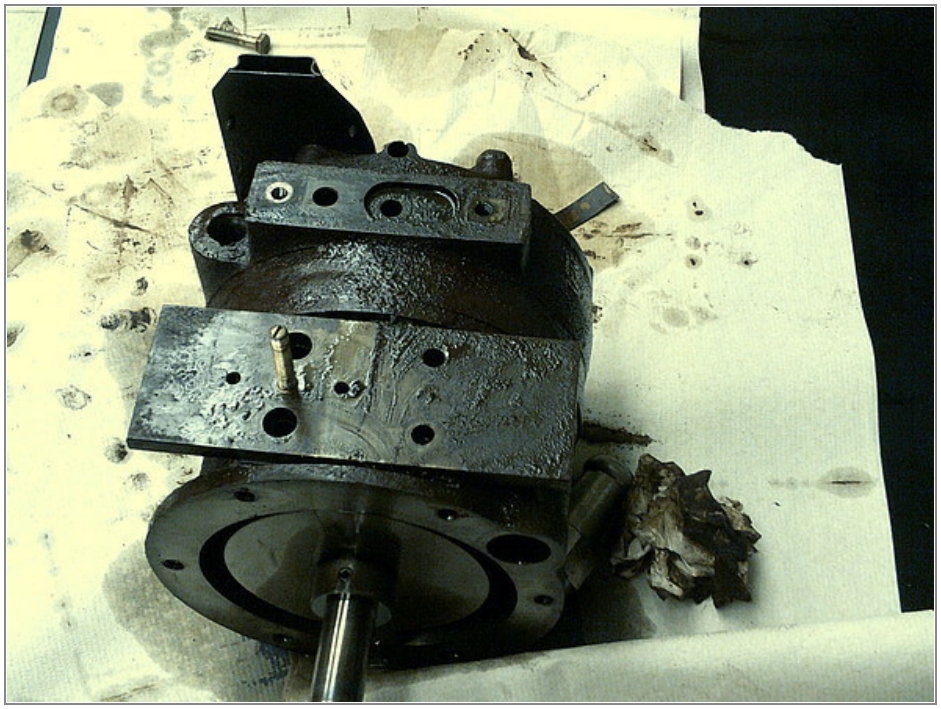


- Note: the upper exhaust valve for our second stage was broken! There it is off to the right.

Step 12
Exhaust stage disassembly

Remove steel screw and valves.





Step 12 (cont.)
Exhaust stage Disassembly

First and second stage valves have been removed at this point.

Step 13
Exhaust stage disassembly

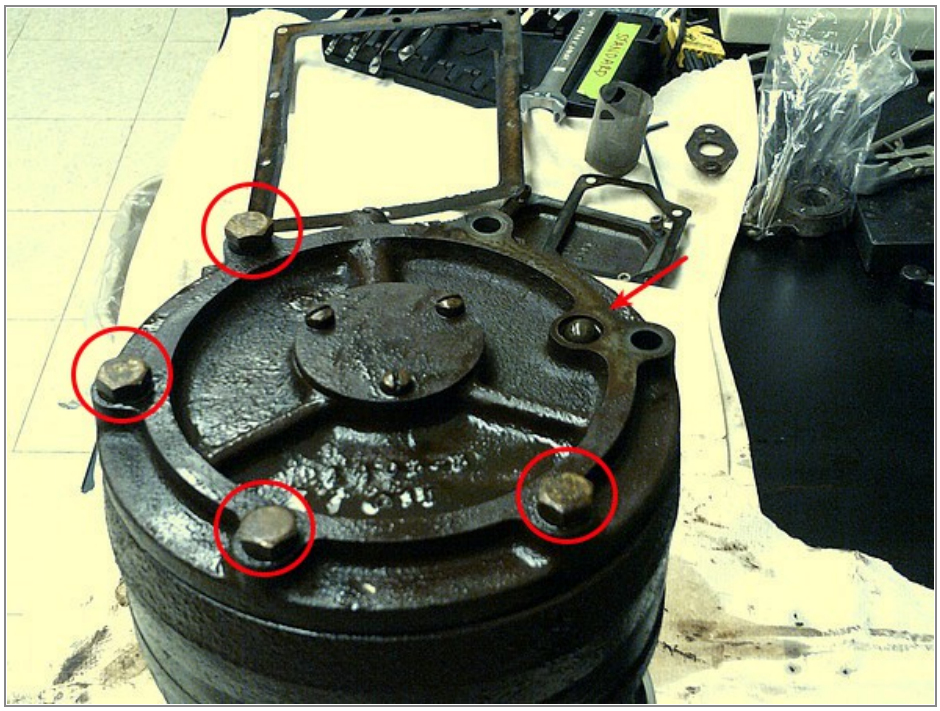
- Remove the 5/16" Hex bolt that is securing the pressure relief valve cover to the small end plate.
- Remove screws securing the valve cover.

Step 14
Exhaust stage disassembly

- Remove the hex bolt located inside the valve cover, and remove valve and cover.

Step 15
Exhaust stage disassembly

- Remove the steel ball, and 4 hex bolts.

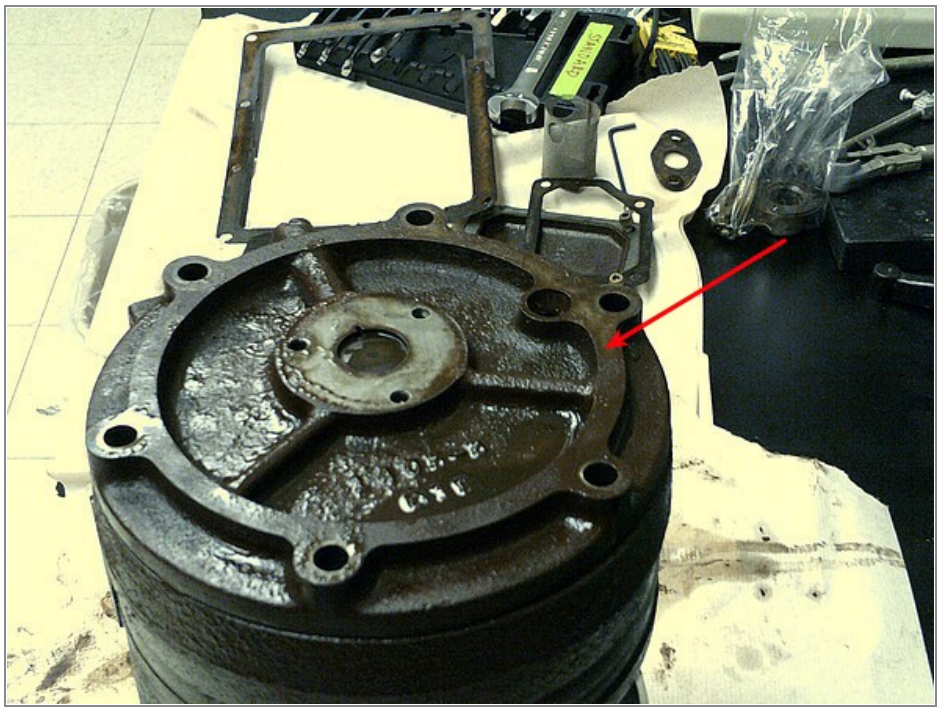


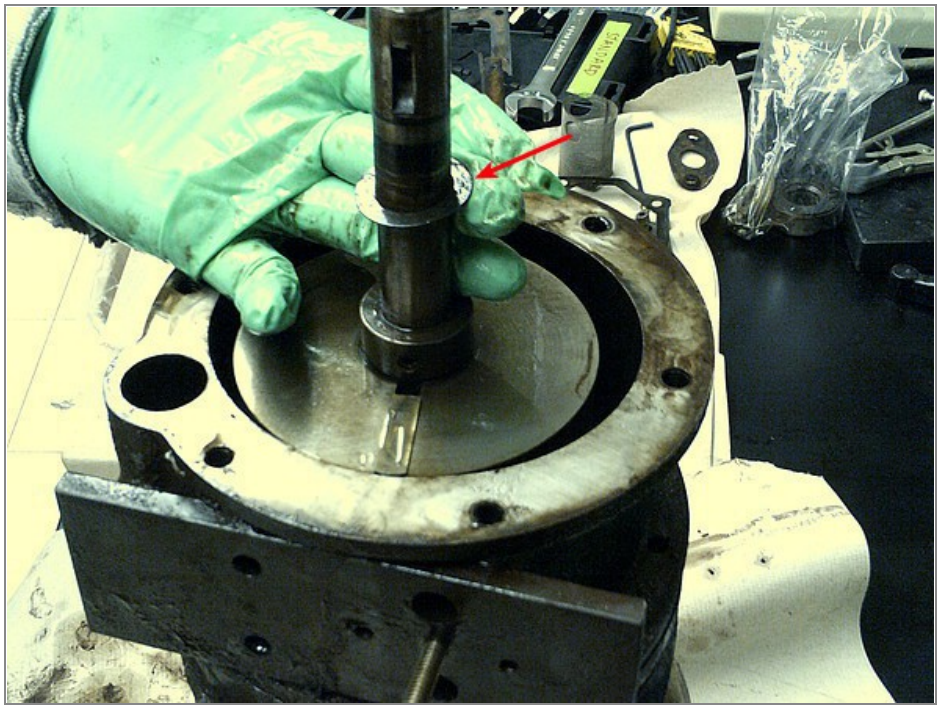
Step 16
Exhaust stage disassembly

- Remove the end cap.

Step 17
Exhaust stage disassembly

- Remove the small end plate

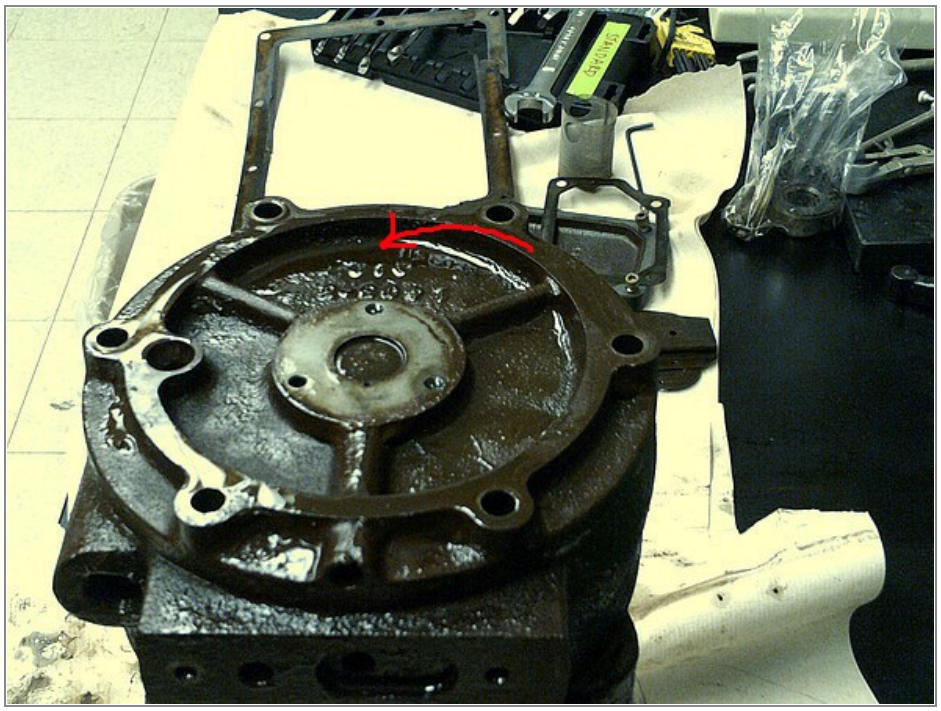


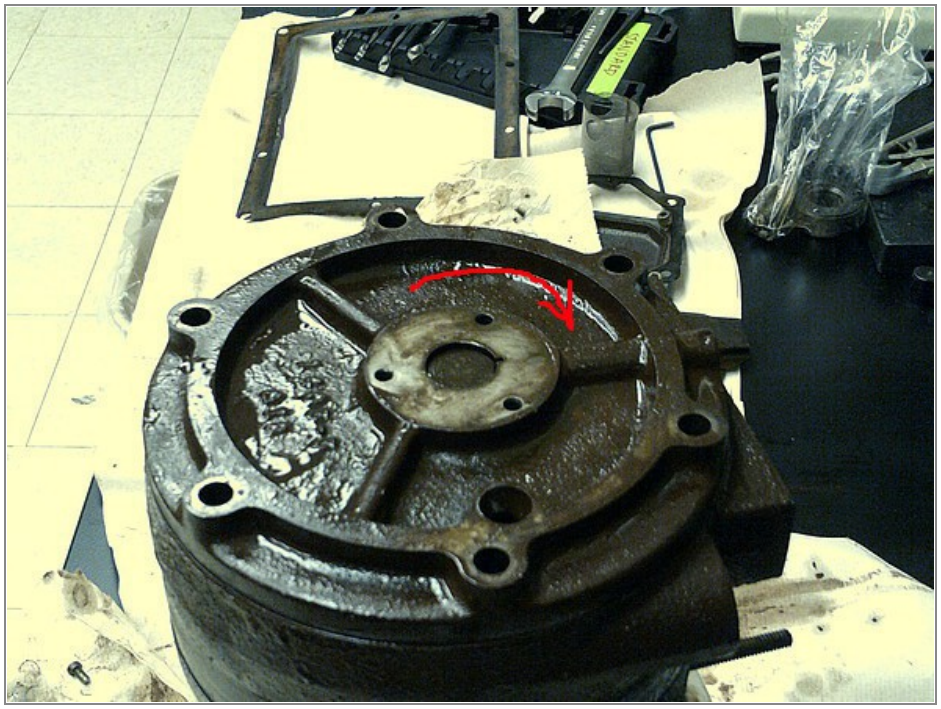


Step 18
Exhaust stage disassembly

We had to skip removing the end plate for a minute, because it would not come off easily and we were very frustrated. We flipped the stages around and removed the thurst washer.

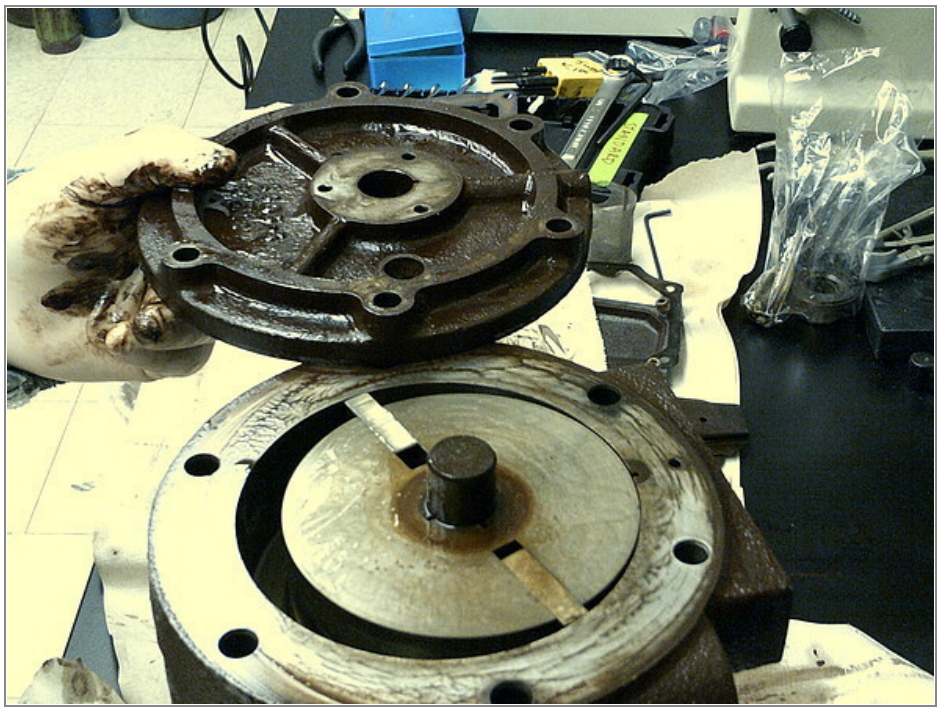
We revisited the endplate. Argh..





ARGH..

With the end plate removed, we can see the second stage rotor.

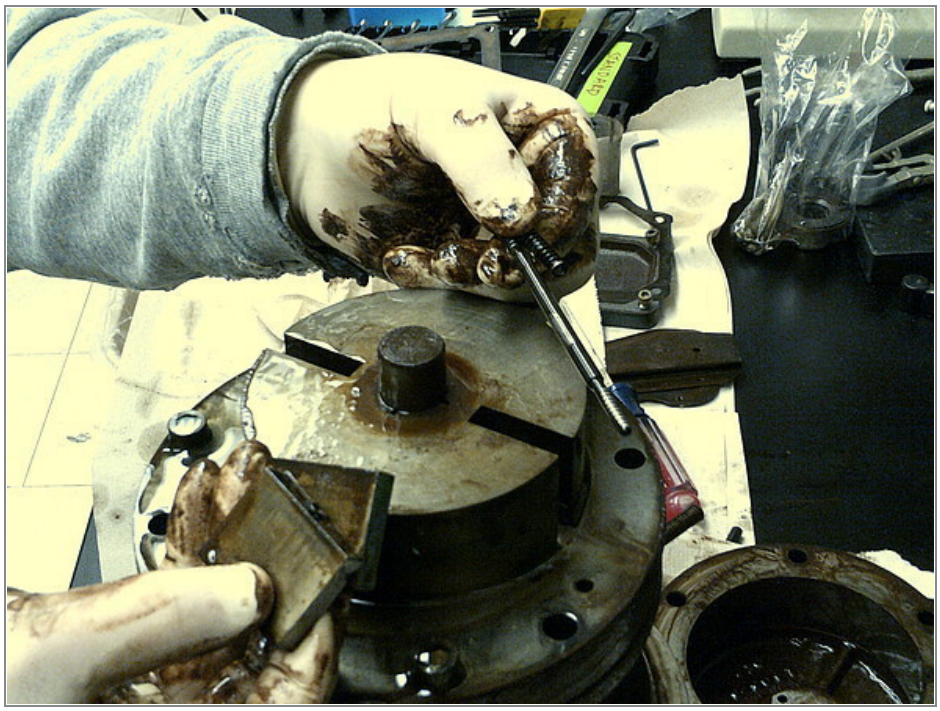


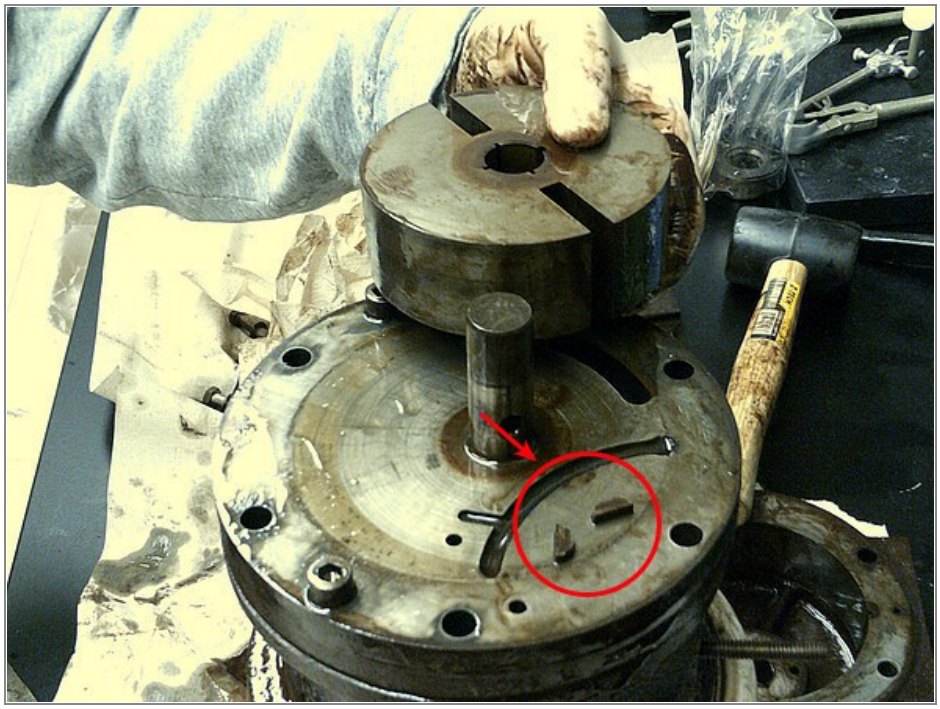
Step 19
Exhaust stage disassembly

Remove Exhaust Ring

Step 20
Exhaust stage disassembly

Remove small vanes, vane springs, and vane spring holder.





Step 21
Exhaust stage disassembly

Remove woodruff keys and exhaust rotor. Do not destroy or discard the woodruff keys, as we discovered that the new keys didn't fit well into older model shafts

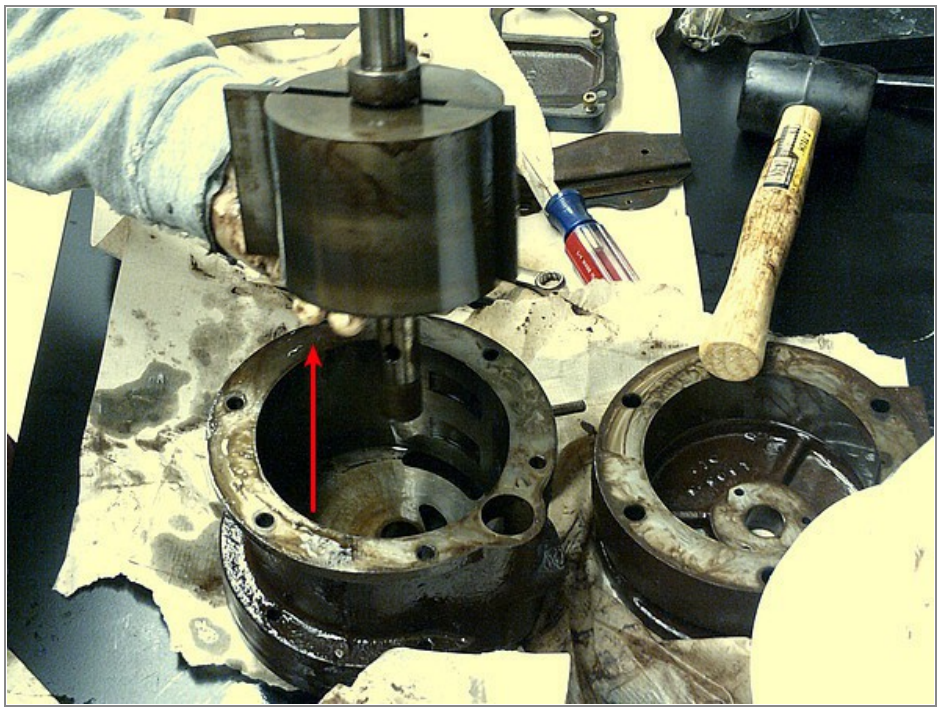
Step 22
Exhaust stage disassembly

Invert the exhaust body to reveal the intake rotor (first stage).

Step 23

Exhaust stage disassembly

- Remove intake rotor
- Remove large vanes, vane springs, and vane spring holder,
- Remove shaft

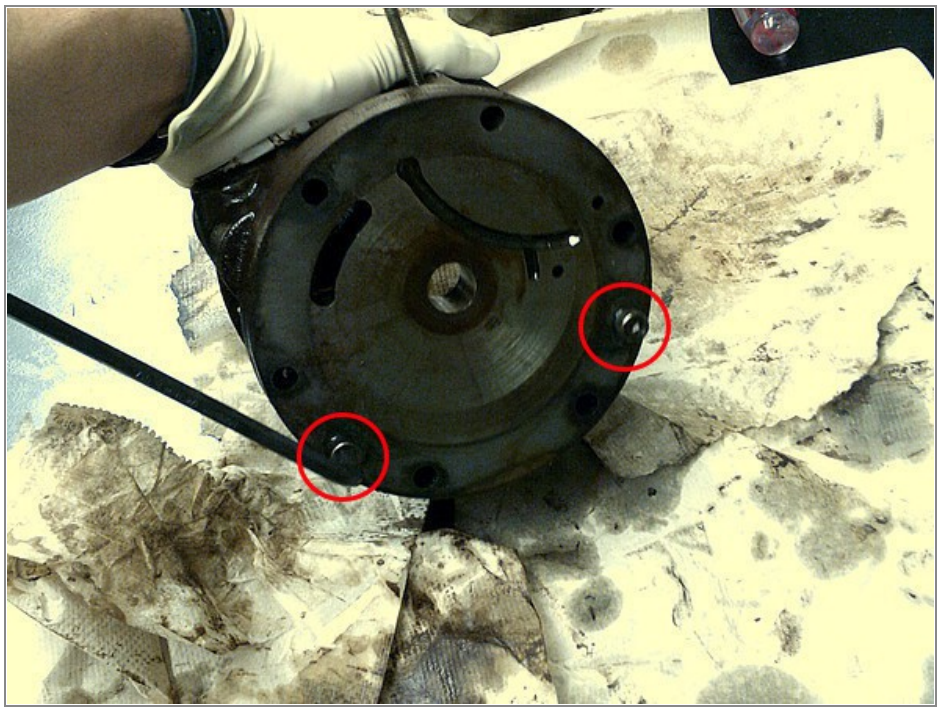


Step 23 (cont.)

The first stage and shaft, in all their glory.

Step 25
Exhaust stage disassembly

- Remove hex head screws
- Remove center plates



Step 25 (cont.)
First center plate

Step 25 (cont.)
Second center plate

Step 26
Cleaning

Dunk the intake ring into pet ether.

Go to disassembly

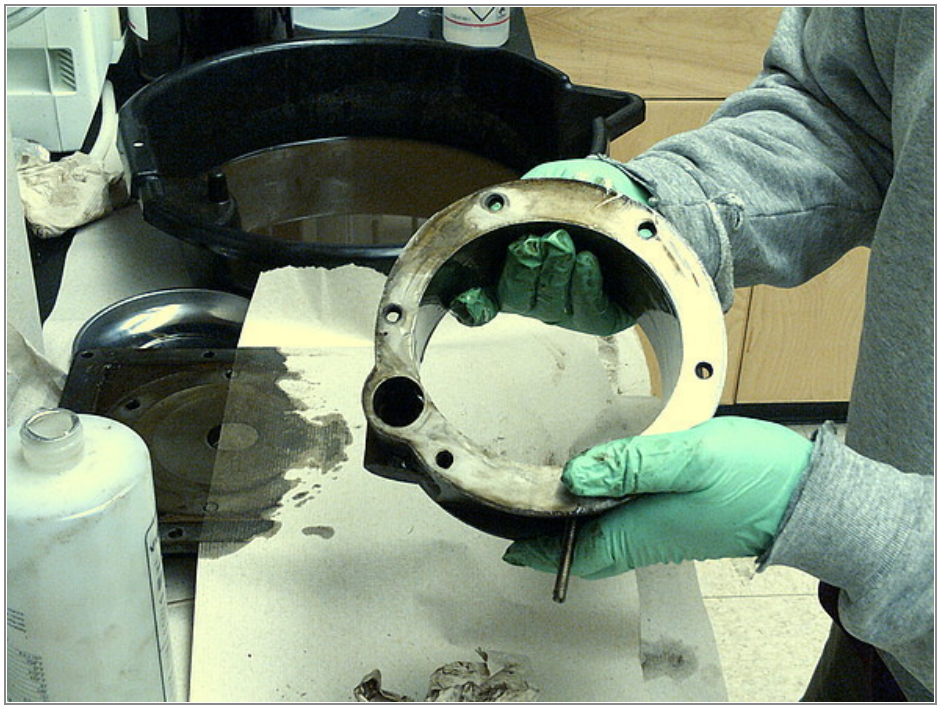
Go to reassembly

Cleaning

Use a copper brush to remove debris and gunk.

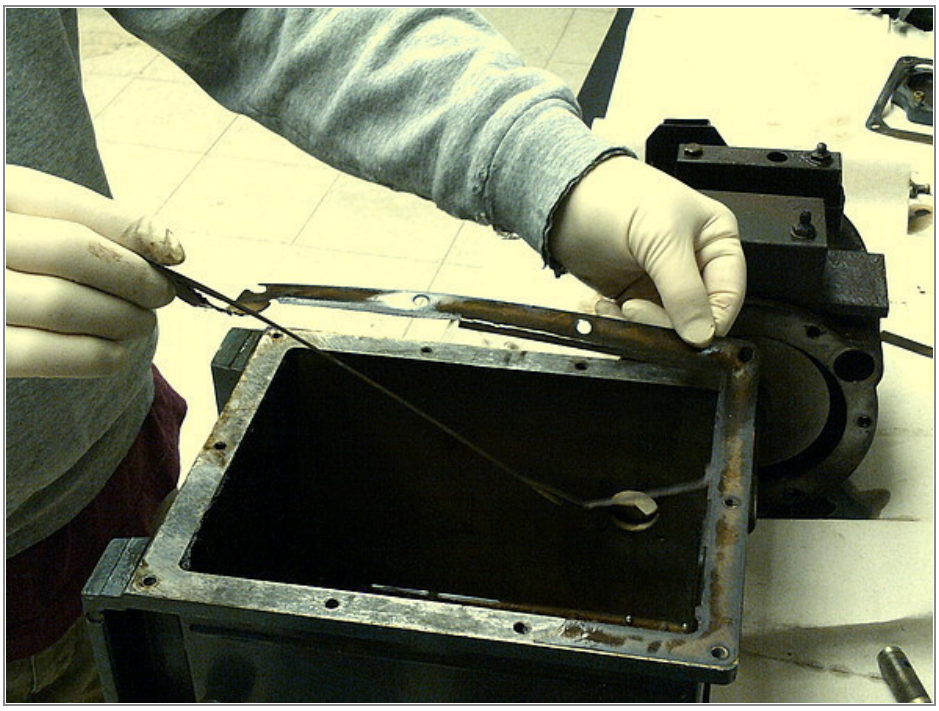
Give parts a nice petrol bath to remove oil.

Immediately rub parts with clean pump oil to prevent oxidation.



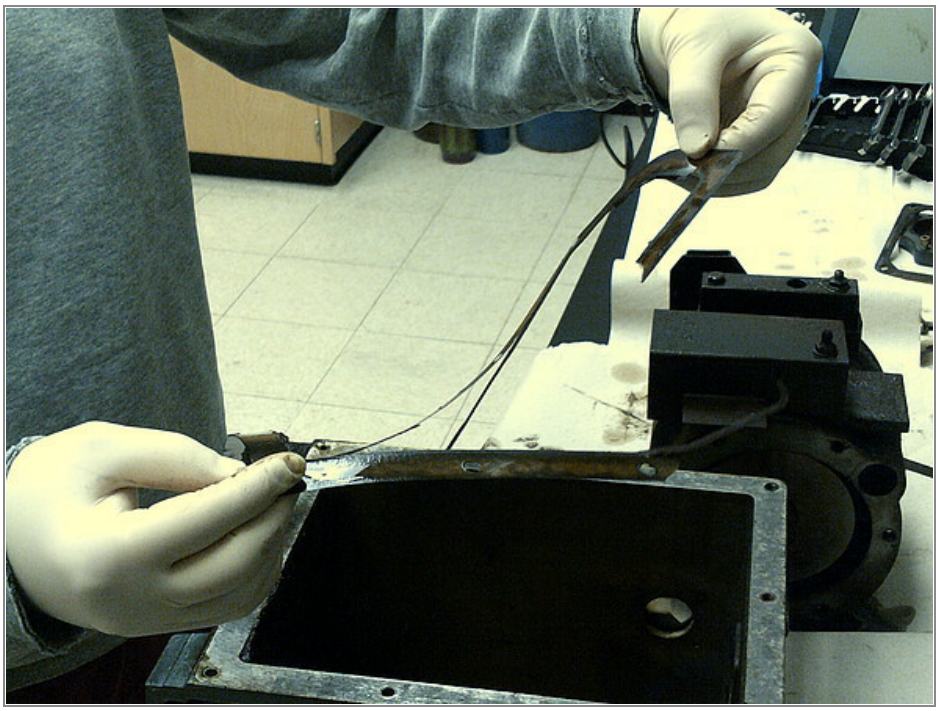
Like new.

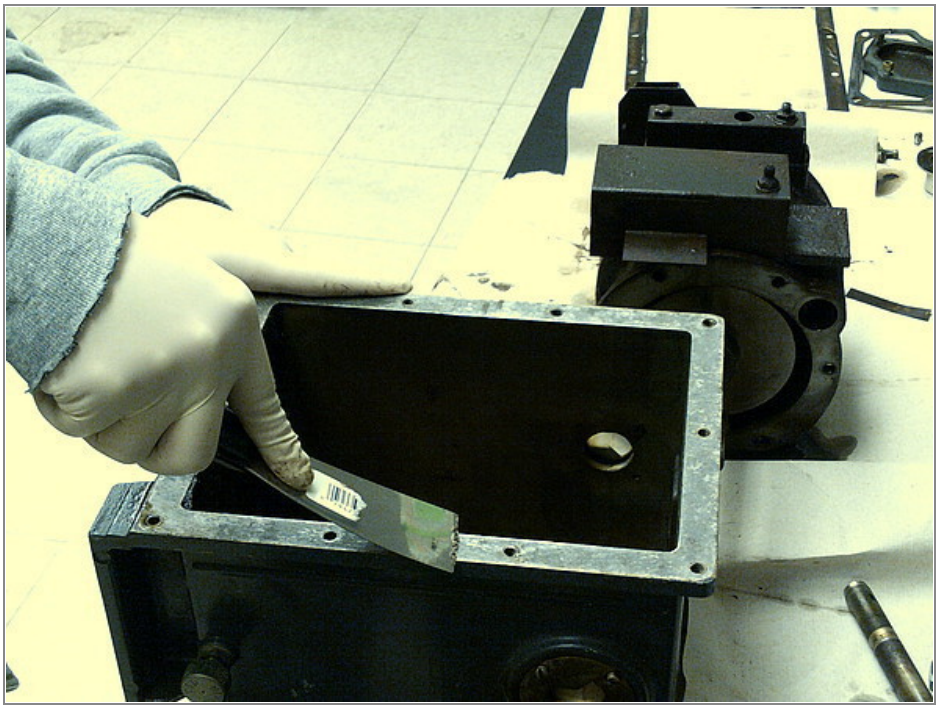
Use steel wool to clean all gasket mating surfaces, such as in this example of the intake filter cover.



.

This one had the texture of a thin tortilla chip.





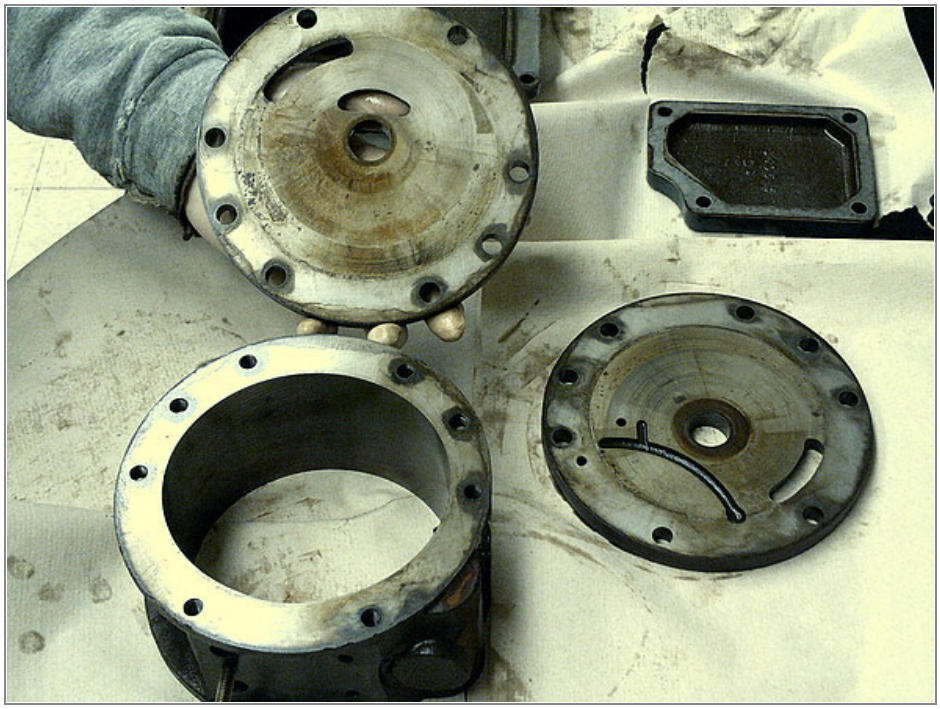
Use a putty knife to remove any left over gasket, but avoid gouging or scratching the mating surface with the blade edges.

Our rebuild kit did not come with window gaskets for our model pump, so we avoided removing them from the case.

Use steel wool to clean the metal frame of the window, and a paper towl to wipe down the glass.

A magnificent scene.

Another satisfying picture of cleaned parts.



Step 27
Reassembly

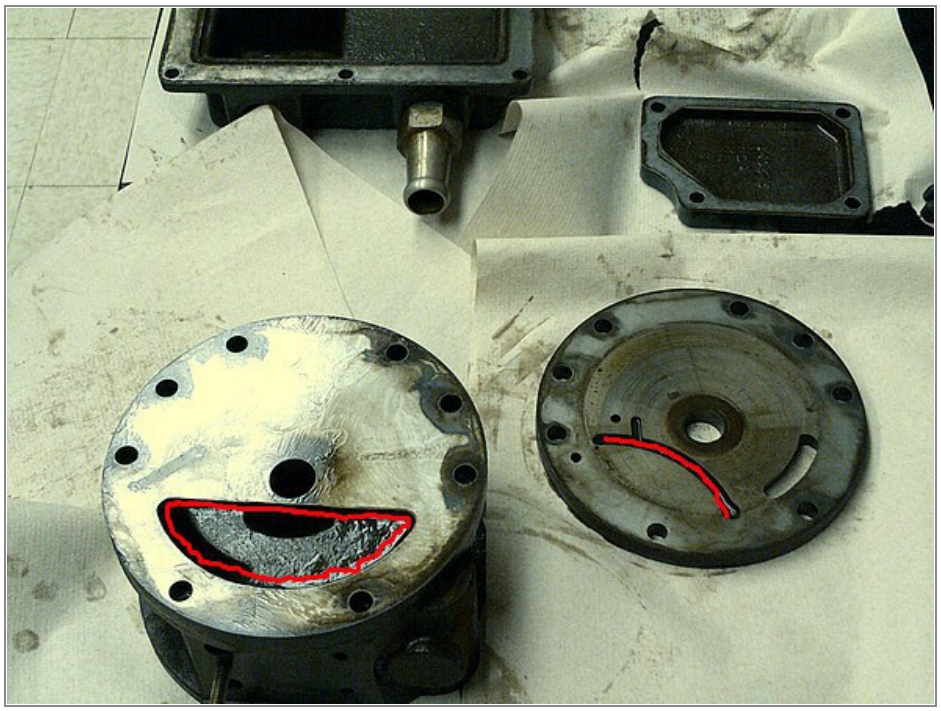
- Place the intake ring on the table, so that the intake side is face down.
- Place the first center ring onto the intake ring. The large relief should face towards you.

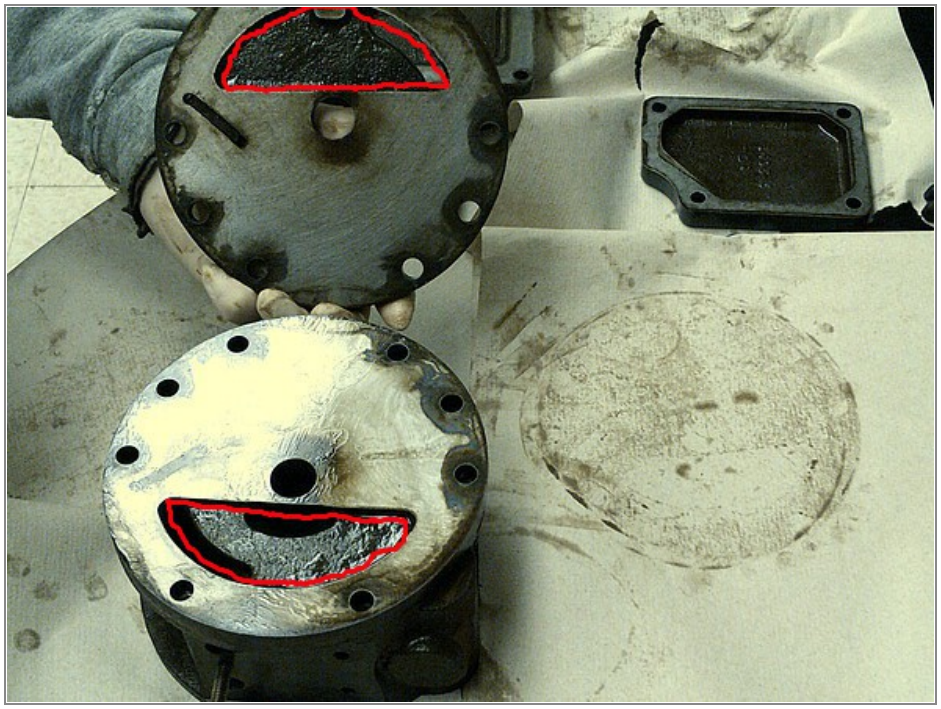
Go to disassembly

Go to cleaning

Step 27
Reassembly

Place the second center ring on top of the first, with the small relief facing outward and the large relief facing inward.



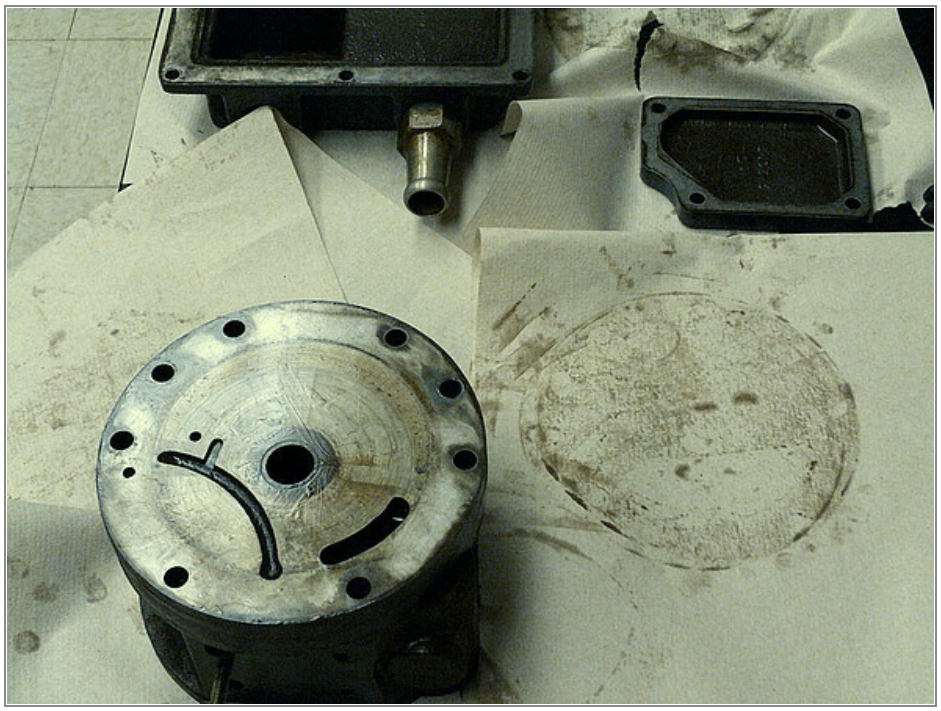


Step 27 (cont.)
Reassembly

Note: the center piece in late model pumps is machined into a single part, as opposed to the two pieces found in our pump.

Step 27 (cont.)
Reassembly

Note: the center piece in late model pumps is machined into a single part, as opposed to the two pieces found in our pump.

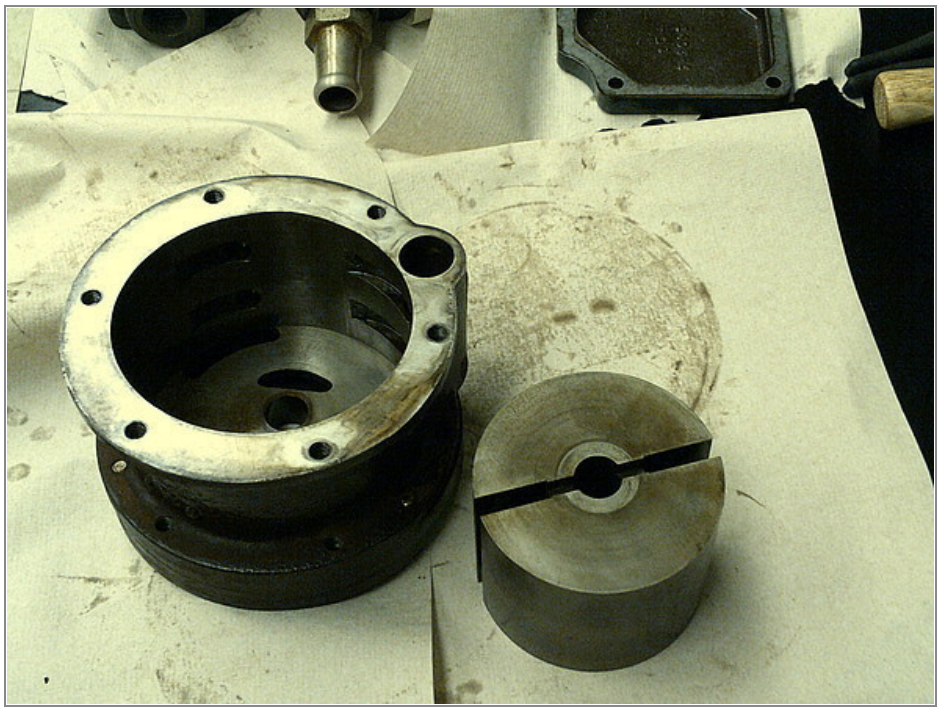


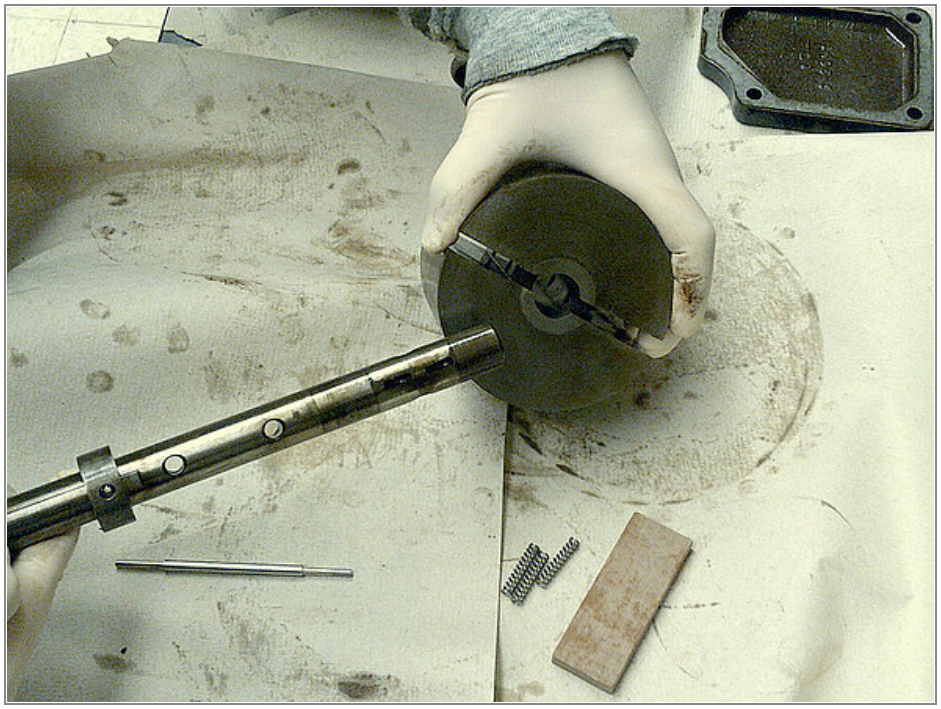
Step 28
Reassembly

Put then two hex head bolts into the center rings to join them to the intake ring, but do not tighten them down. A turn or two will suffice.

Step 28
Reassembly

Flip the assembly in preparation for adding the first stage.





Step 28
Reassembly

- Assemble shaft
- Assemble vane spring holders, vane springs, and vanes

Note: Replacement vanes are phenolic vanes instead of metal. These replacement vanes form superior seals with the ringed exhaust chambers.

Step 28 (cont.)
Reassembly

Vane spring post goes in first.

Step 28 (cont.)
Reassembly

Vane springs go onto posts

Step 28 (cont.)
Reassembly

The stage is ready for the vanes

Step 28 (cont.)
Reassembly

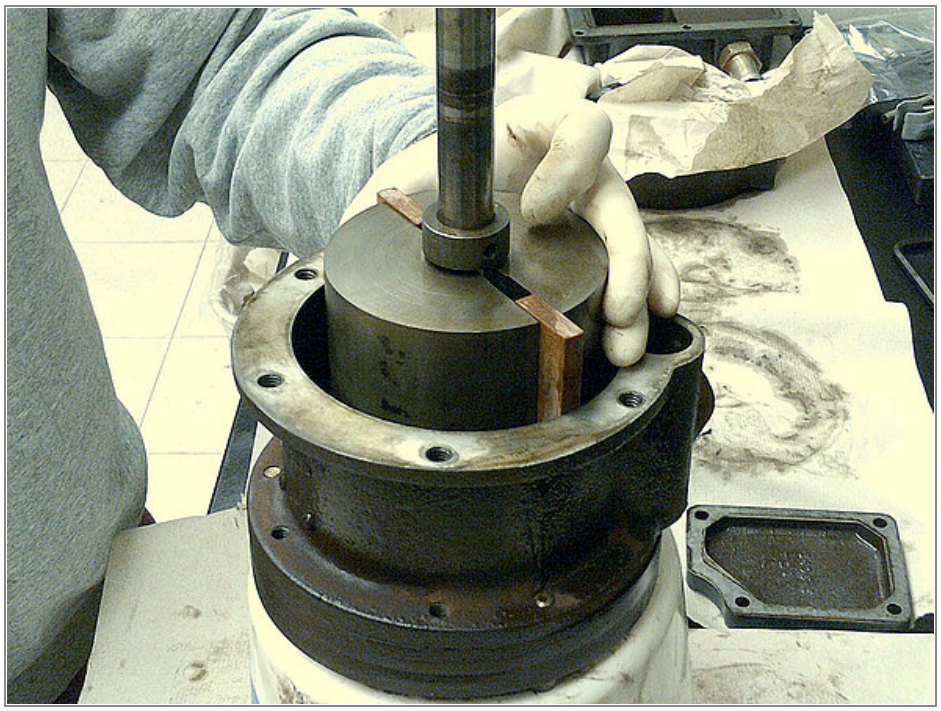
In go the vanes.

Step 28 (cont.)
Reassembly

Make sure the vanes are springy.

Step 29
Reassembly

Drop the stage in with the shaft collar facing out. We used an inverted bucket with a hole in the bottom to hold the other end of the shaft in place.

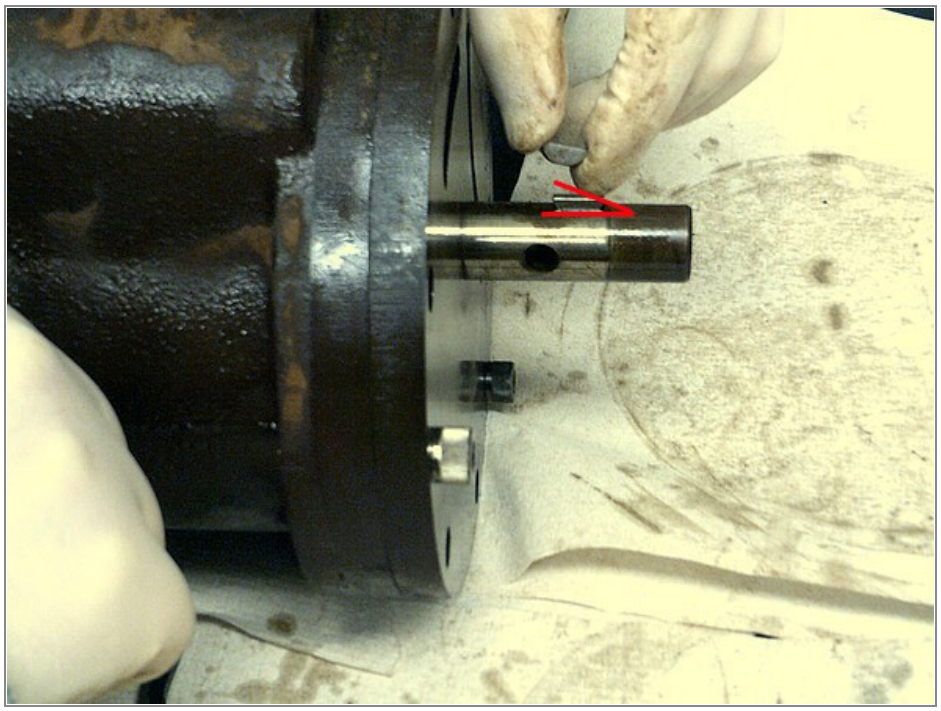


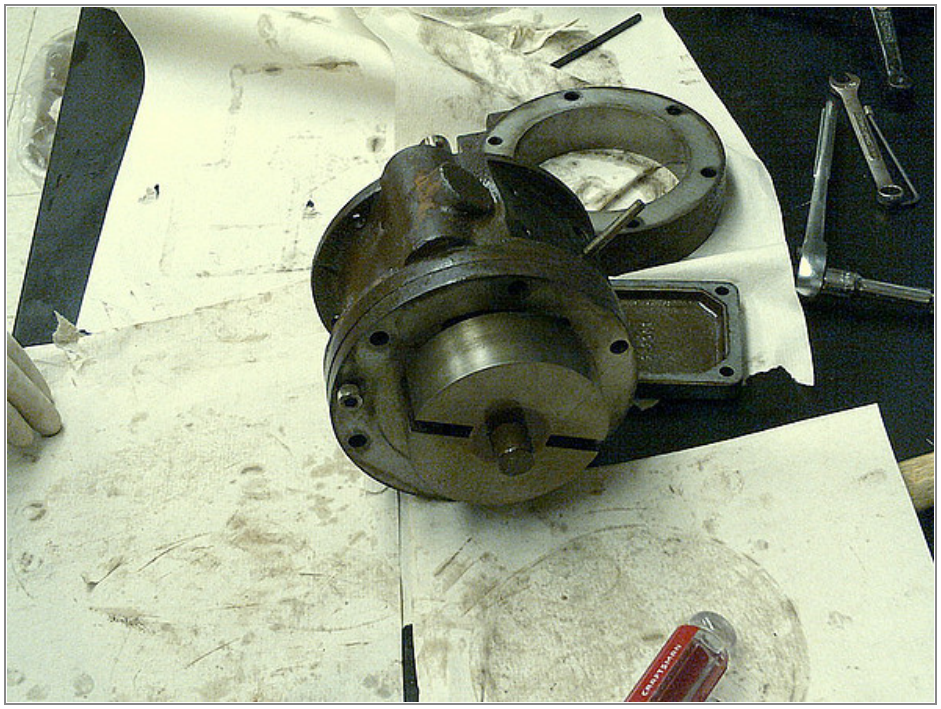
Step 30
Reassembly

Tighten the two hex bolts down.

Step 31
Reassembly

Add woodruff keys to the shaft. You may have to angle them to better accept the second exhaust rotor.



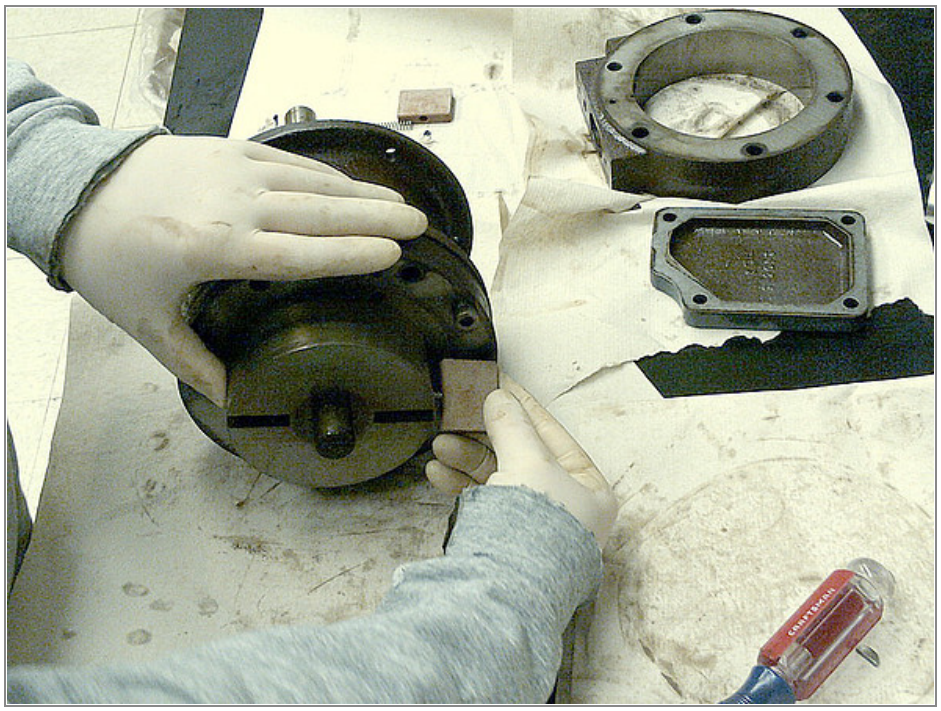


Step 32
Reassembly

Add exhaust rotor

Step 33
Reassembly

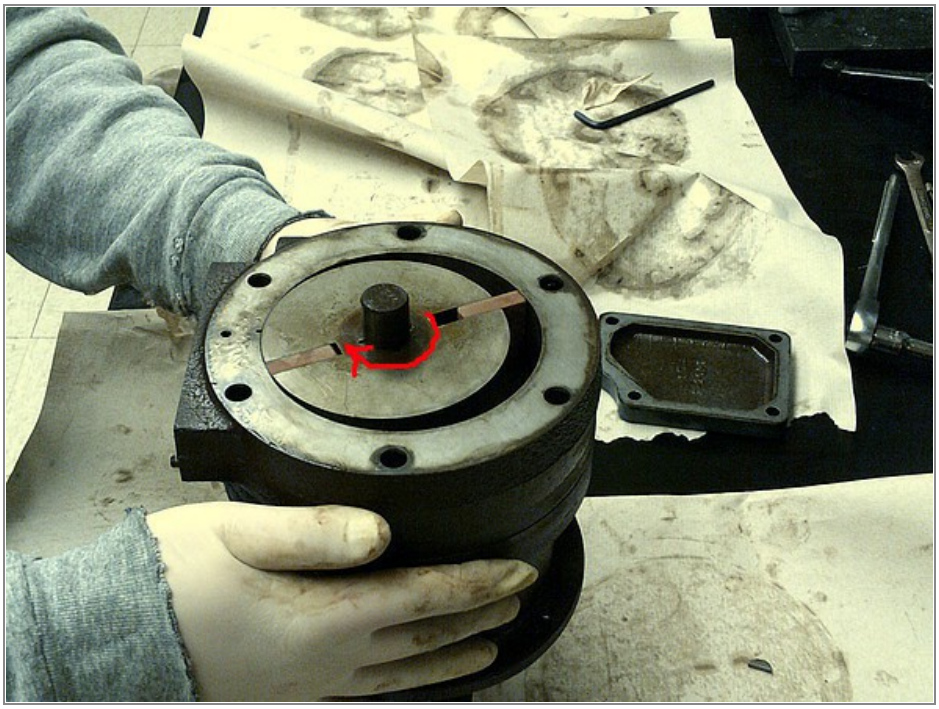
Add vane spring post, vane springs, and vanes to the exhaust rotor.



Step 33 (cont.)
Reassembly

Step 34
Reassembly

Add exhaust ring

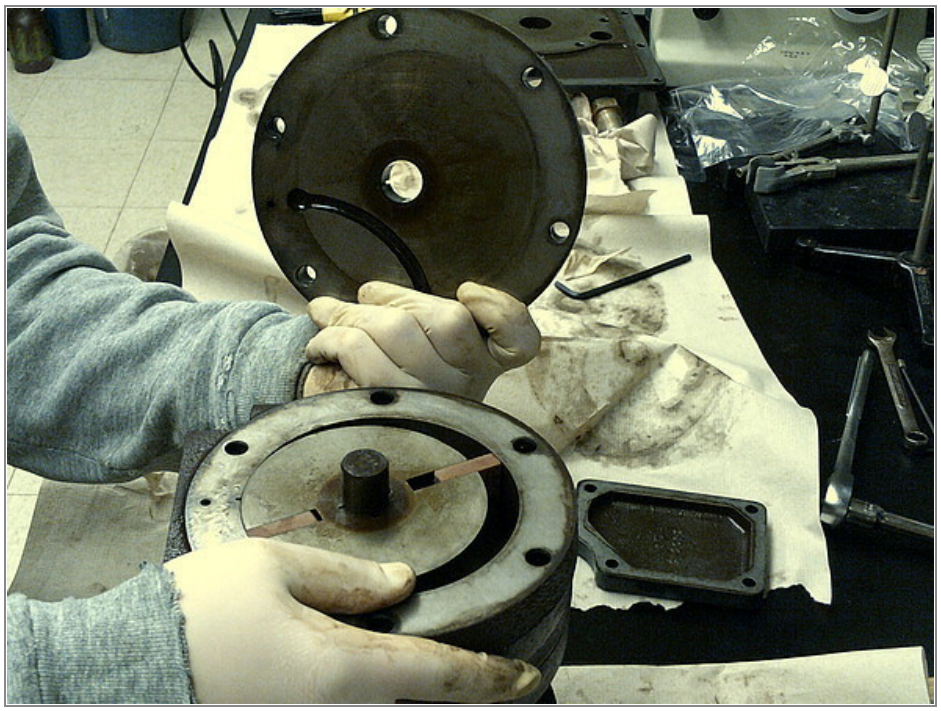


Step 35
Reassembly

Turn shaft to ensure that rotors can freely move and are not bound.

Step 36
Reassembly

Add small end plate.



The stages are now assembled.

Step 37
Reassembly

Secure the pressure release tube and valve in place by partially screwing in a hex bolt on to the end plate.

Step 38
Reassembly

Place the rest of the hex bolts in, but do not tighten them.

Step 39
Reassembly

Do not forget to insert the steel ball and place the valve over it.

Step 40
Reassembly

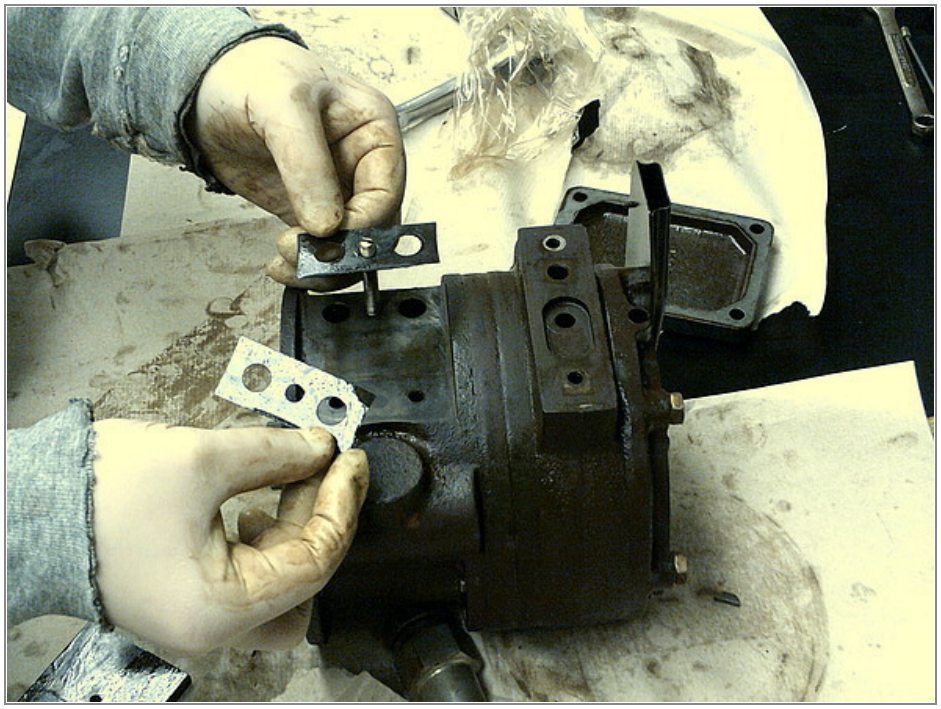
Torque bolts evenly, except you will remove this bolt once all bolts are secured.This bolt will be used to secure the pressure relief cover.

Step 41
Reassembly

Secure bolt and secrews into the pressure relief cover.

Step 42
Reassembly

Secure the end cap to the end plate with screws.

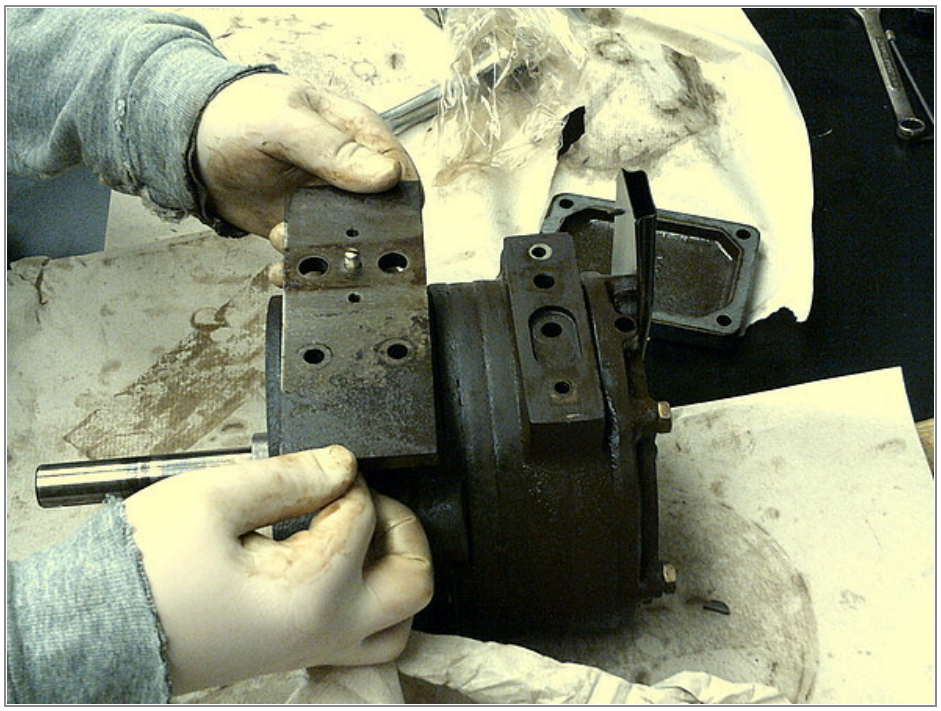


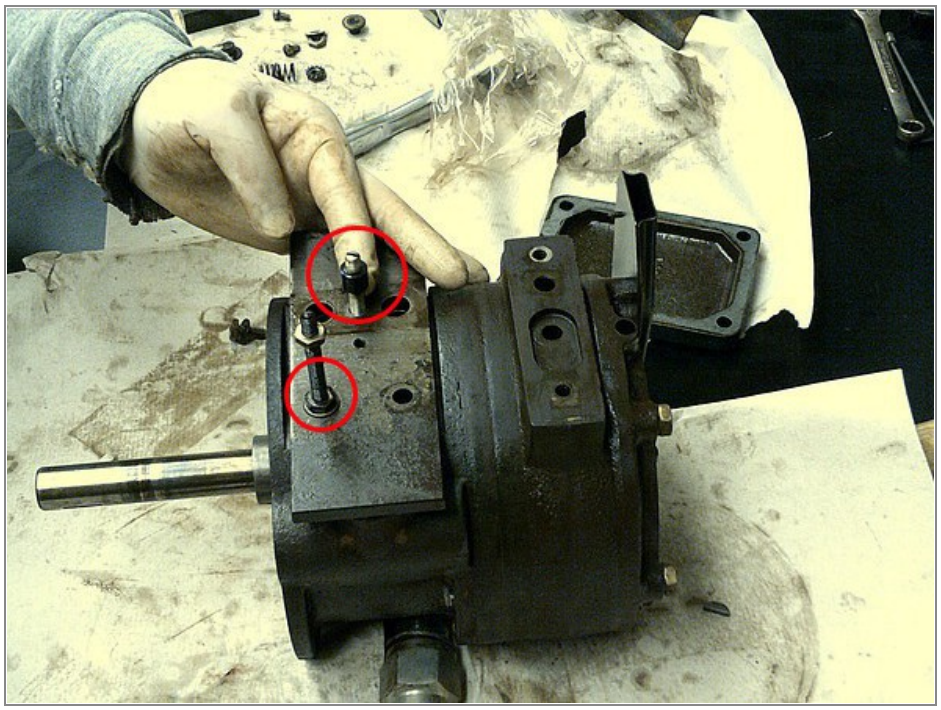
Step 43
Reassembly

For early models (pre-1975), there are two gaskets that sit below the mounting plate for the intake valves. We cleaned the original parts, because the rebuild kit does not come with these gaskets.

Step 44
Reassembly

Add the mounting plate.



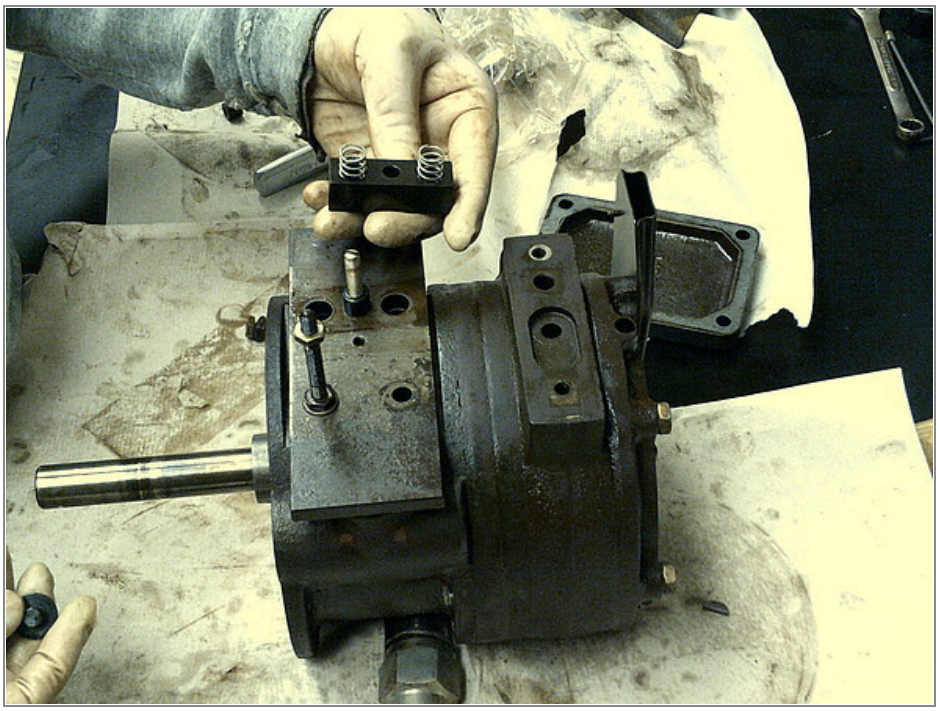


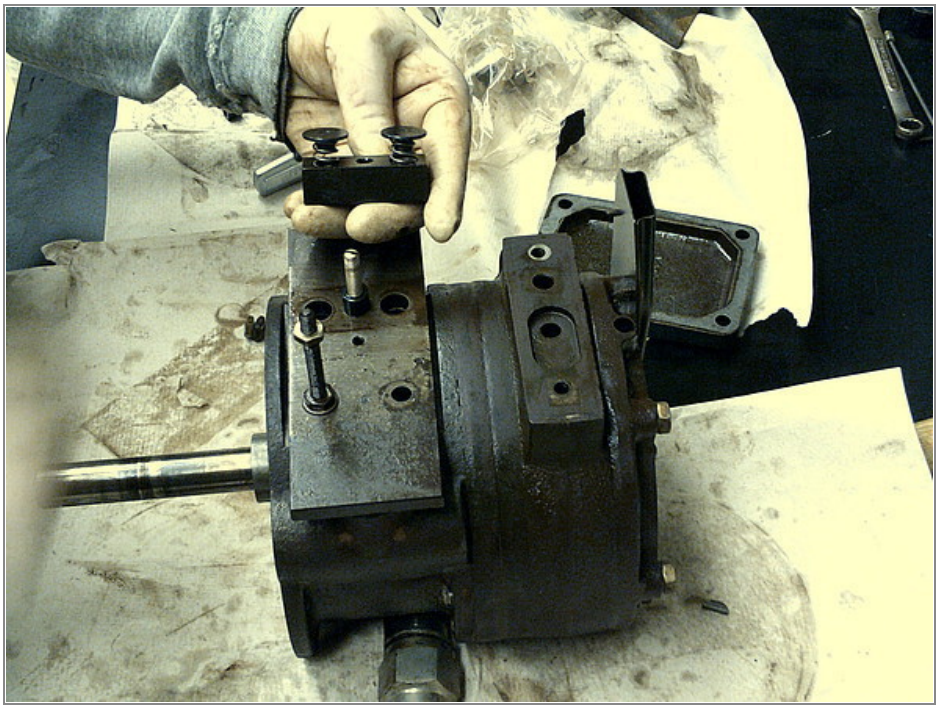
Step 45
Reassembly

- Add valve spacer.
- Add hex nut used to secure baffle plate.

Step 46
Reassembly

Assemble valve spring, valve block, and valves onto valve spacer.



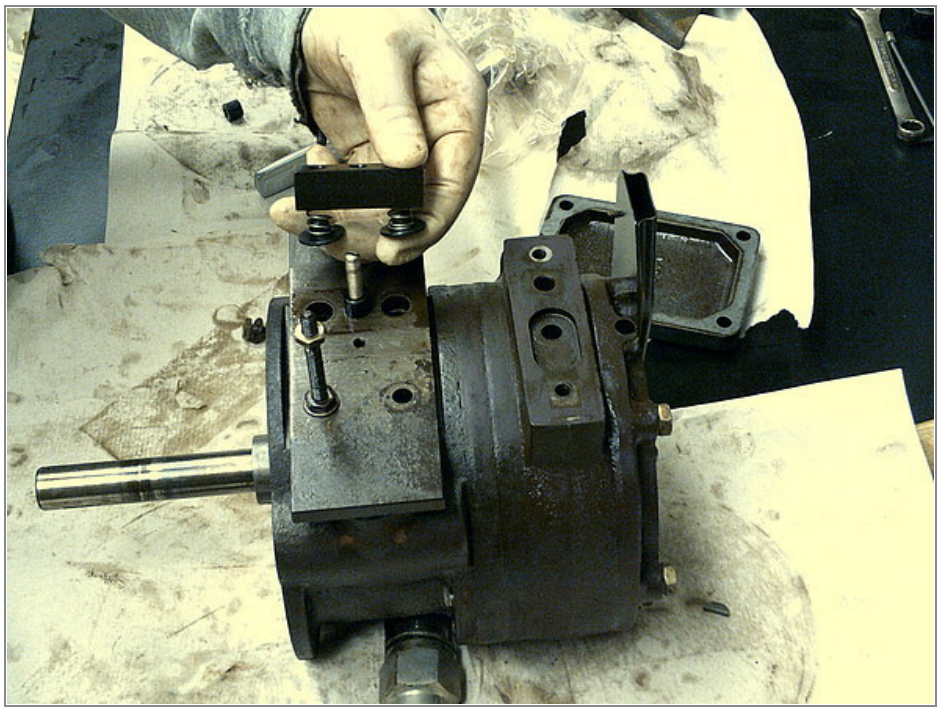


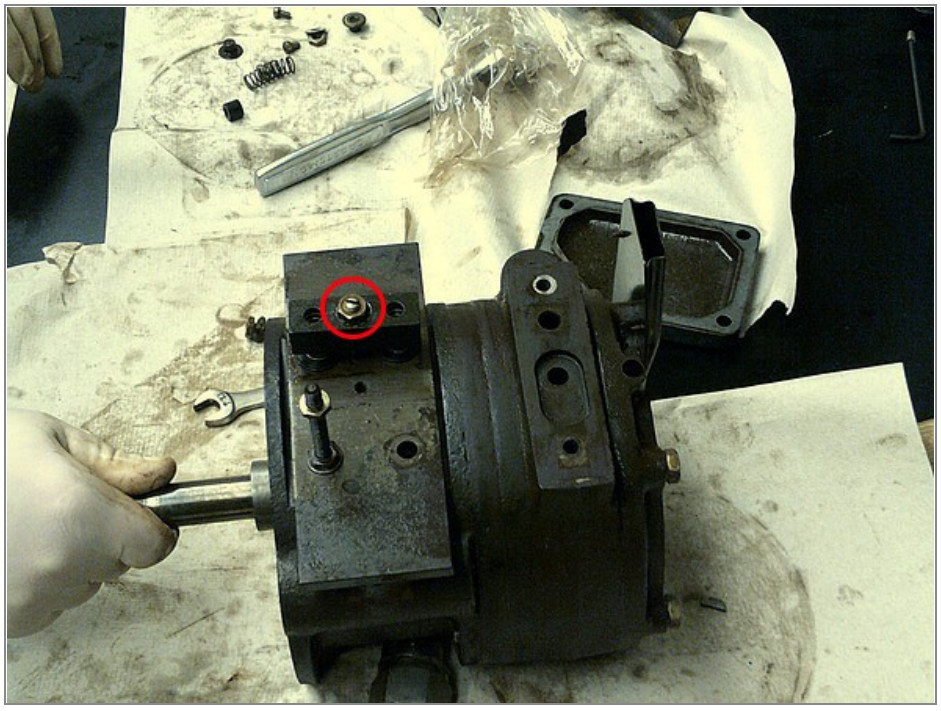
Step 46 (cont.)
Reassembly

First exhaust valve assembly

Step 47
Reassembly

Secure valve mounting plate if you have one.



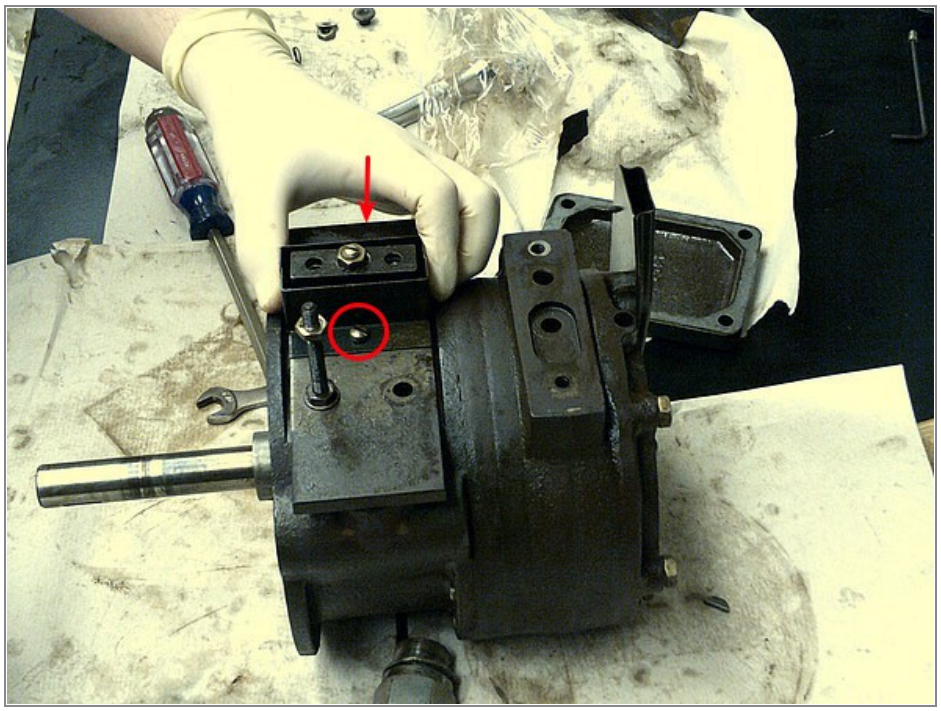


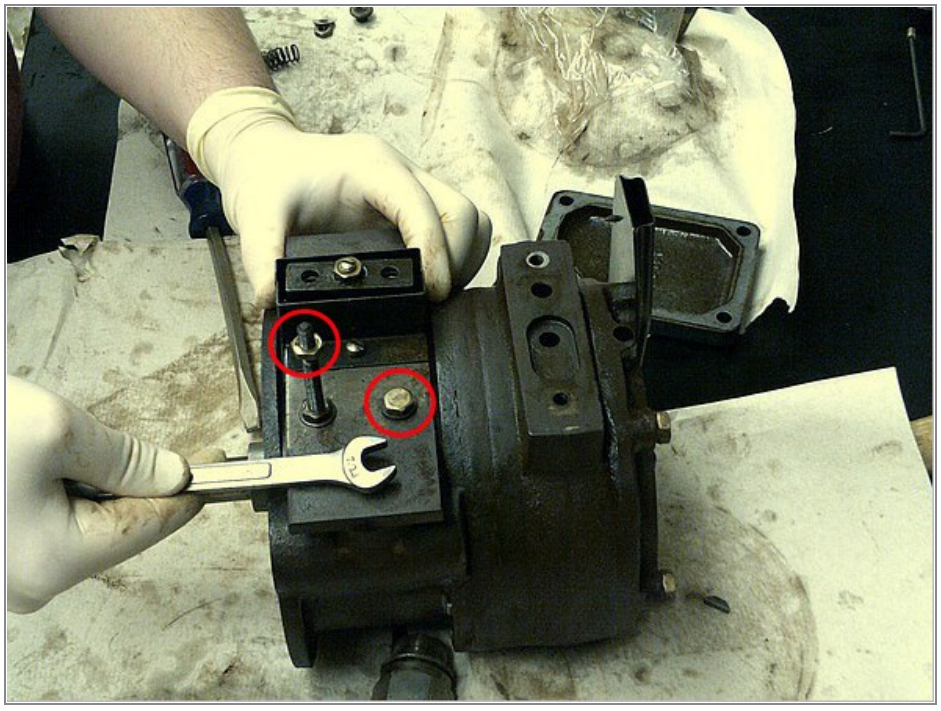
Step 48
Reassembly

Secure valve assembly with a screw post

Step 49
Reassembly

Secure valve plates



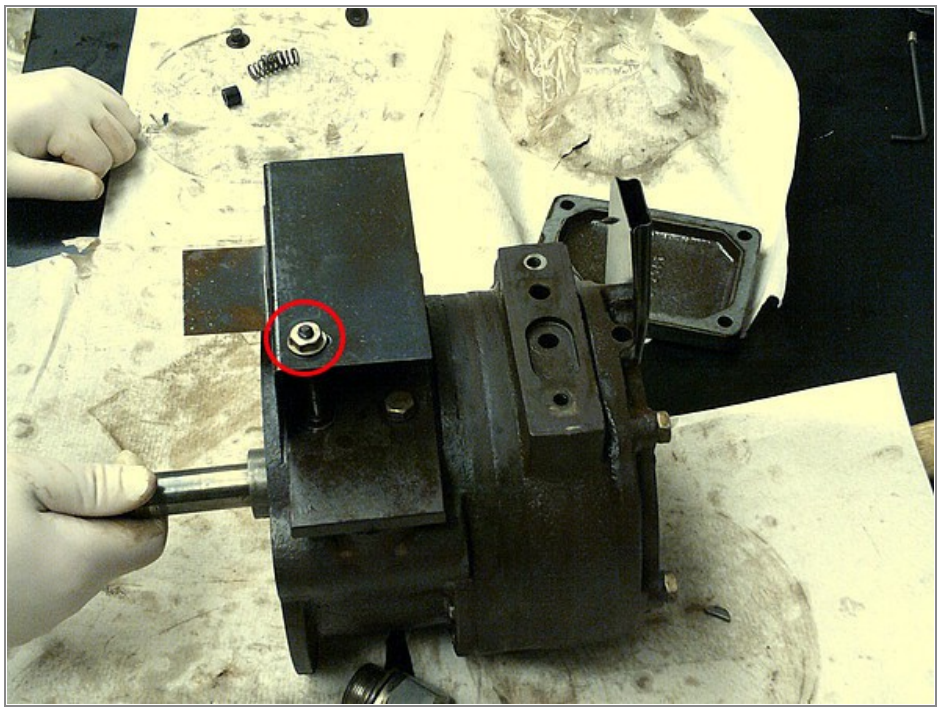


Step 50
Reassembly

Secure valve mounting plate and adjust second hex nut the screw post used to set the height of the exhaust valve cover.

Step 51
Reassembly

Secure baffle in place with a nut on to the screw post.

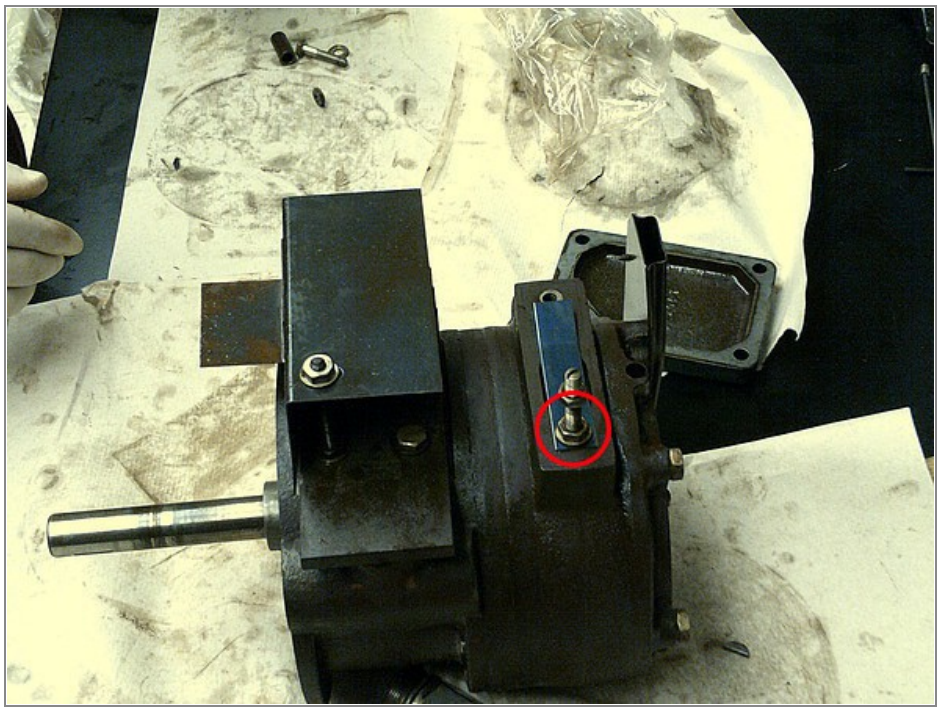


Step 52
Reassembly

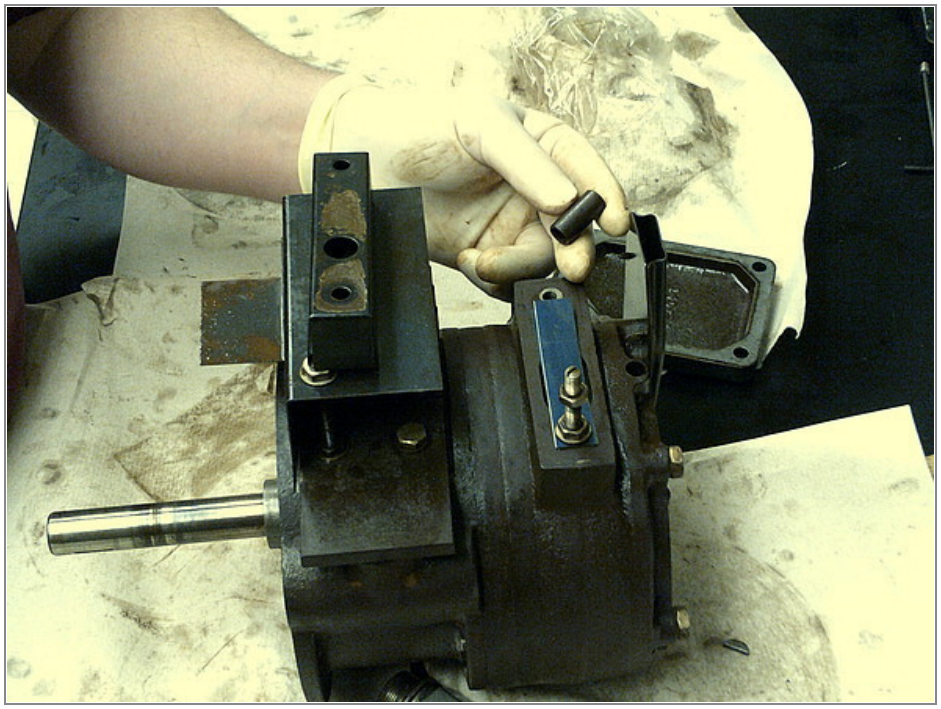
Prepare the lower and upper exhaust valves for the second stage.

Step 53
Reassembly

Secure valves in place with the



screw post and hex nut.

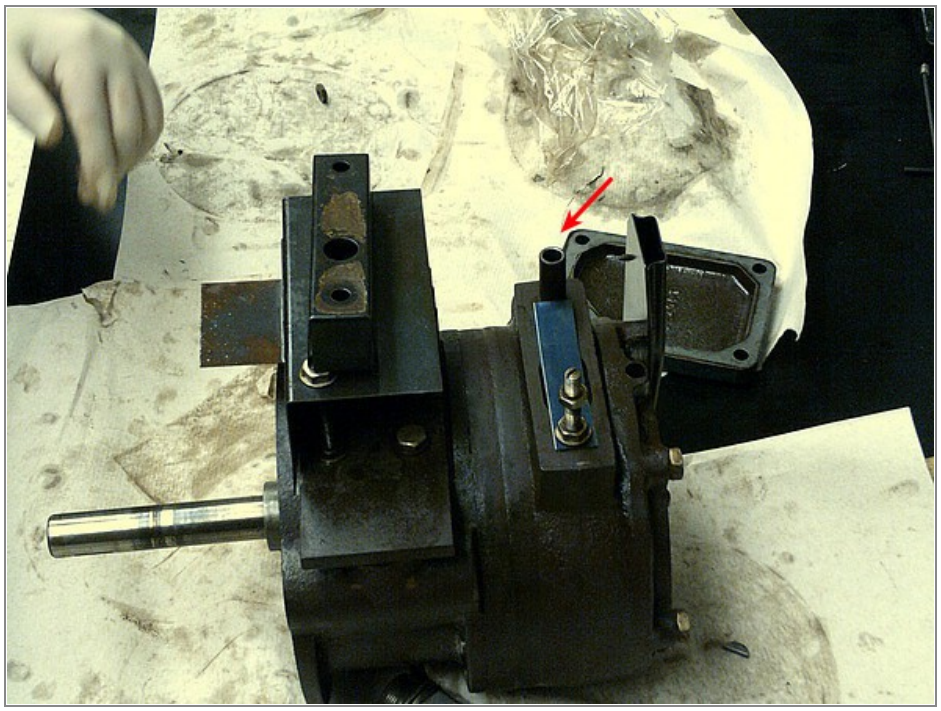


Step 54
Reassembly

Add a spacer for the second screw post.

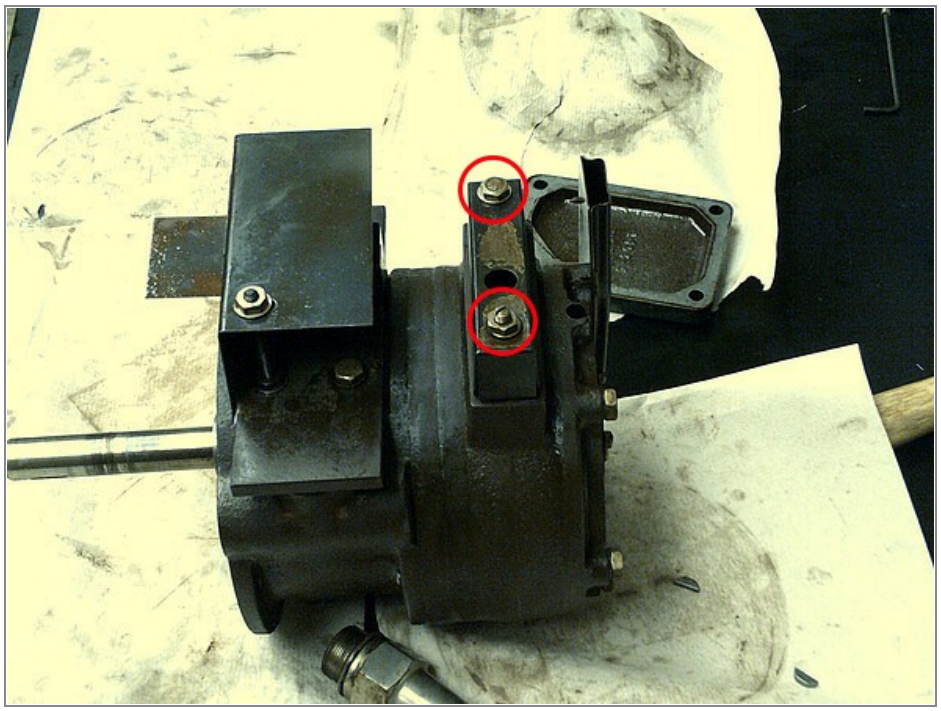
Step 54 (cont.)
Reassembly

Add a second screw post



Step 55
Reassembly

Secure the second baffle in place at both posts with appropriate nuts.

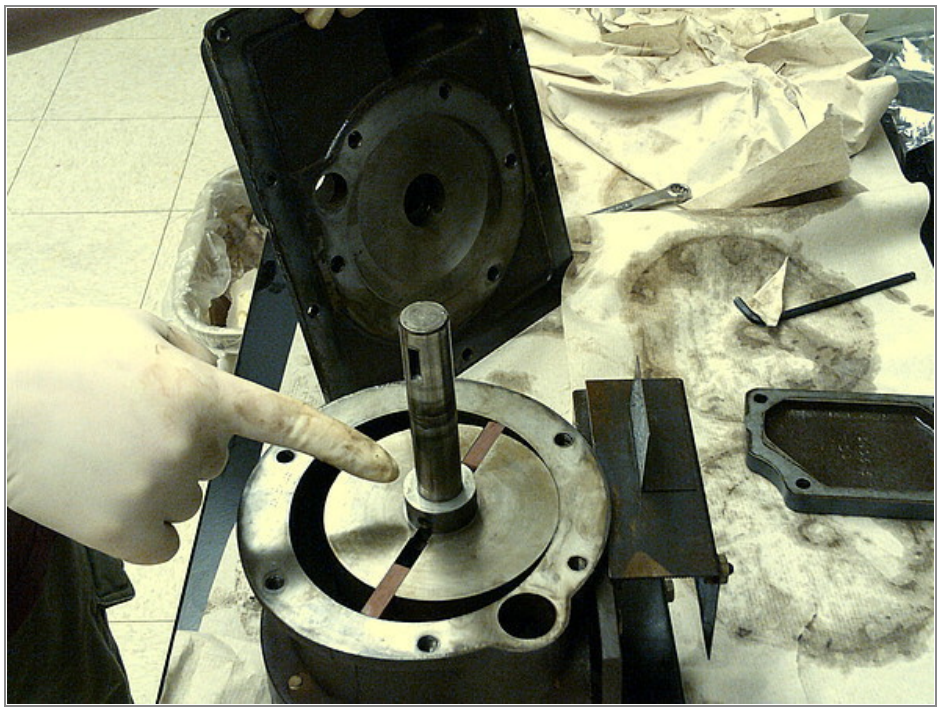


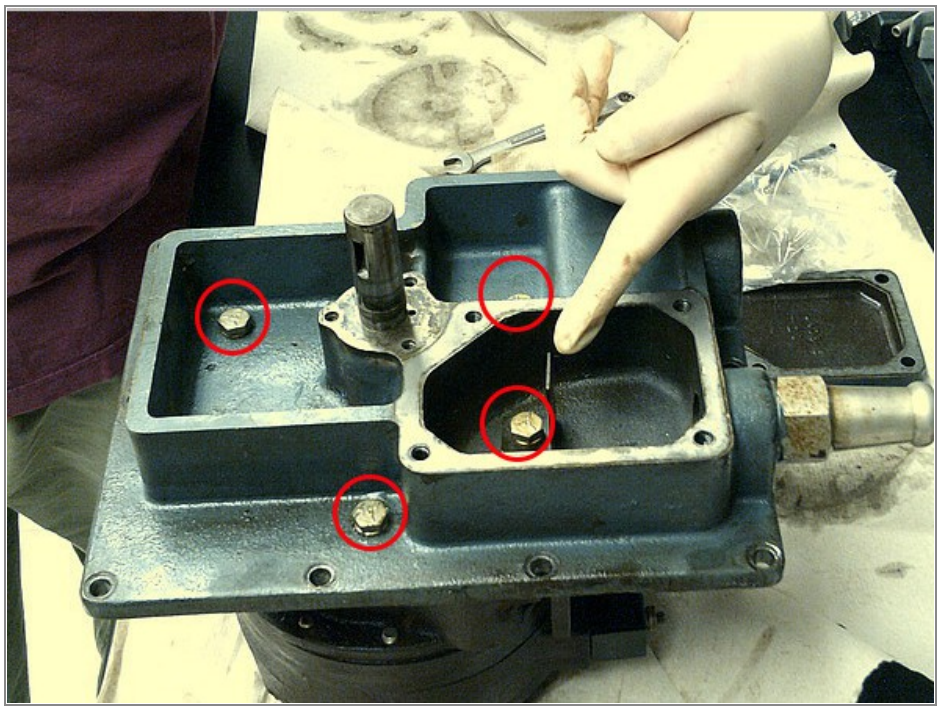
Step 56
Reassembly

Thrust washer. Do not forget this part!!

Step 56 (cont.)
Reassembly

Did you remember the thrust washer?



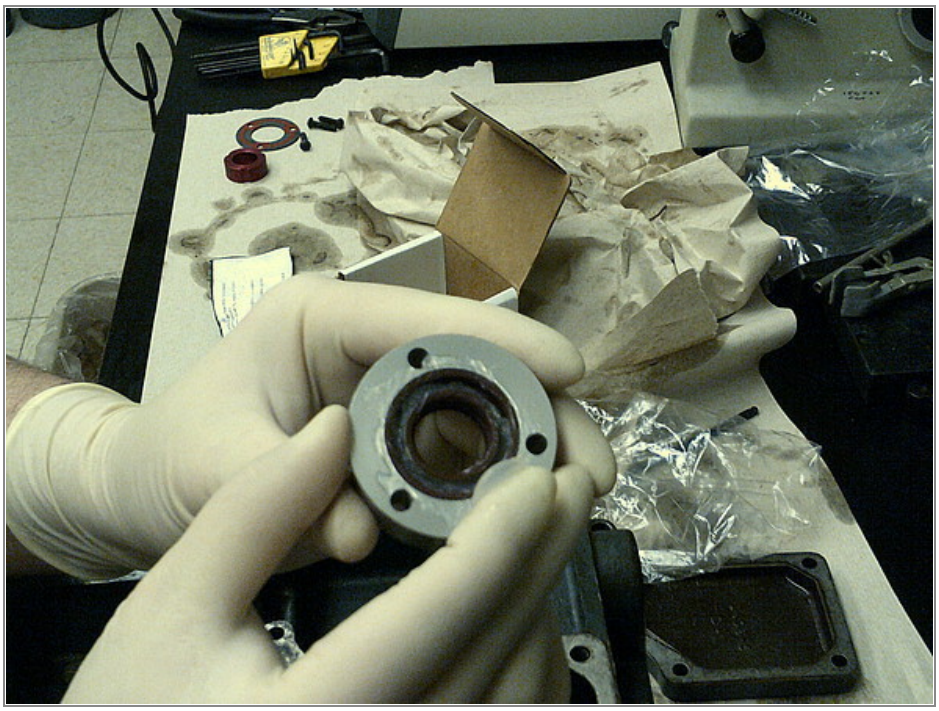


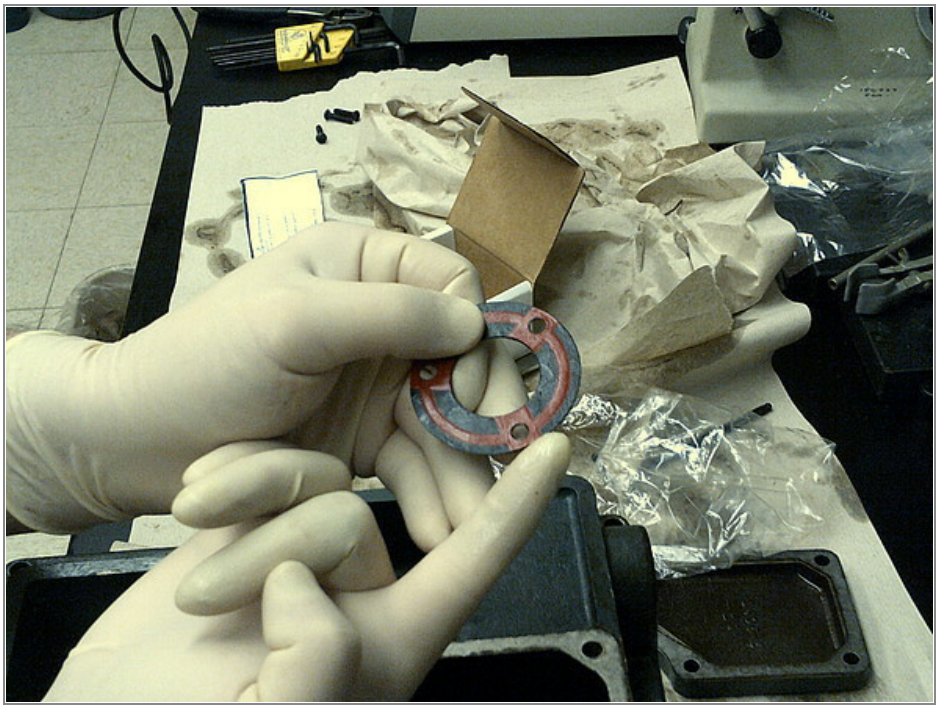
Step 57
Reassembly

Secure the large end plate and filter bracket to the exhaust stages with 4 bolts.

Step 58
Reassembly

Pack the shaft seal with silicone grease



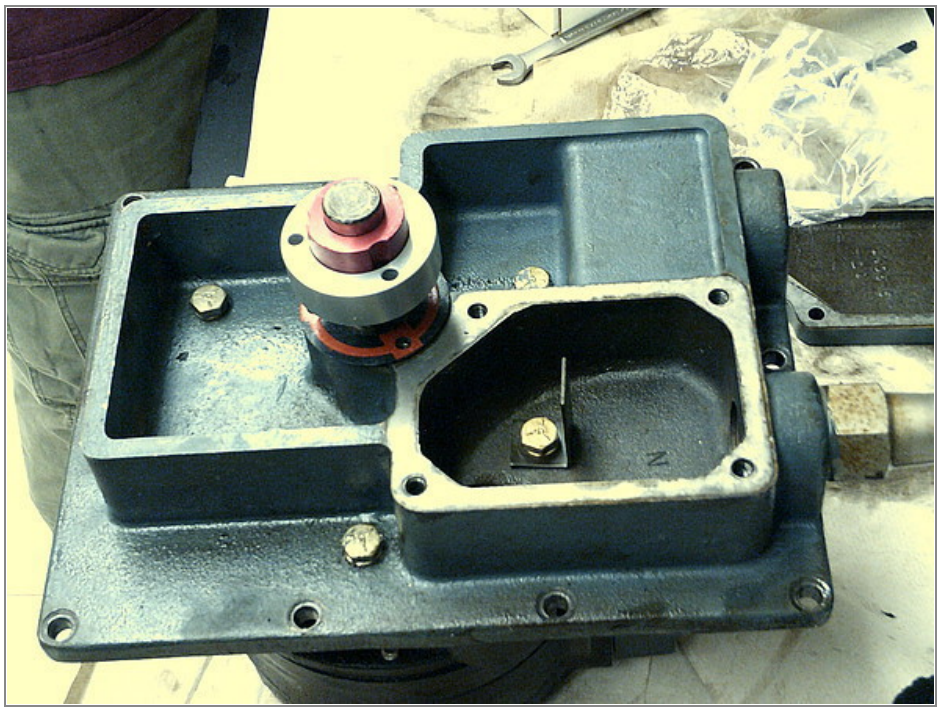


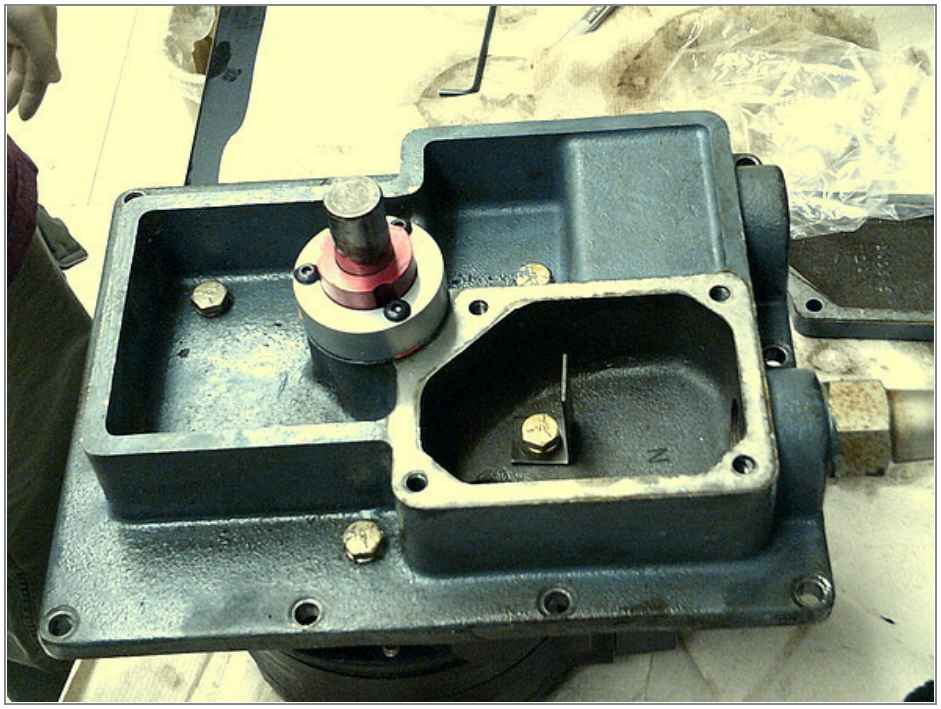
Step 59
Reassembly

Grease the shaft gasket.

Step 60
Reassembly

Use the alignment tool to secure the shaft seal in place.



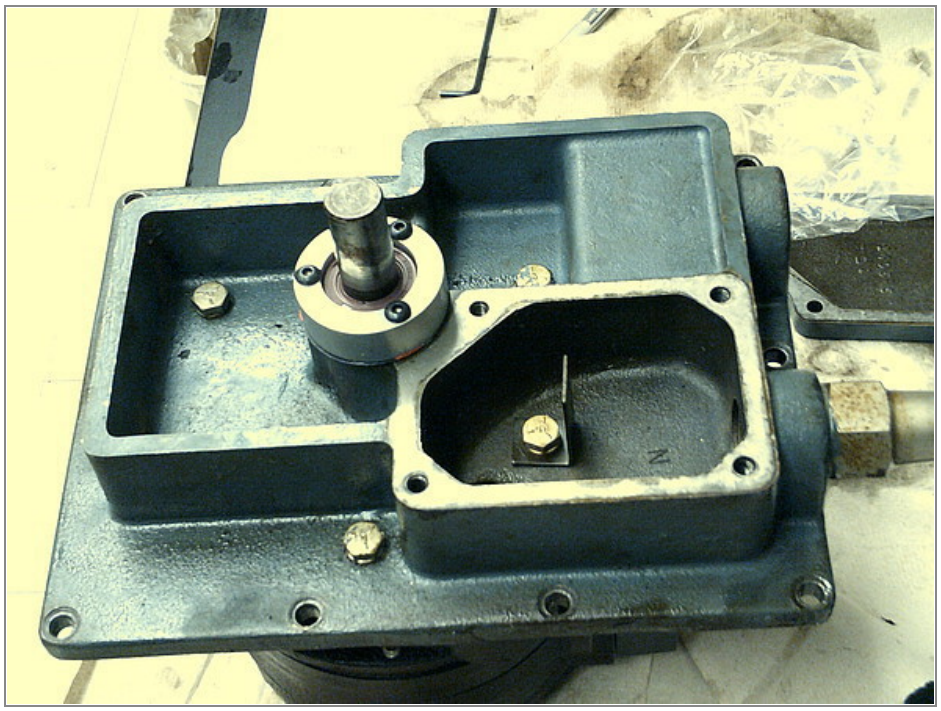


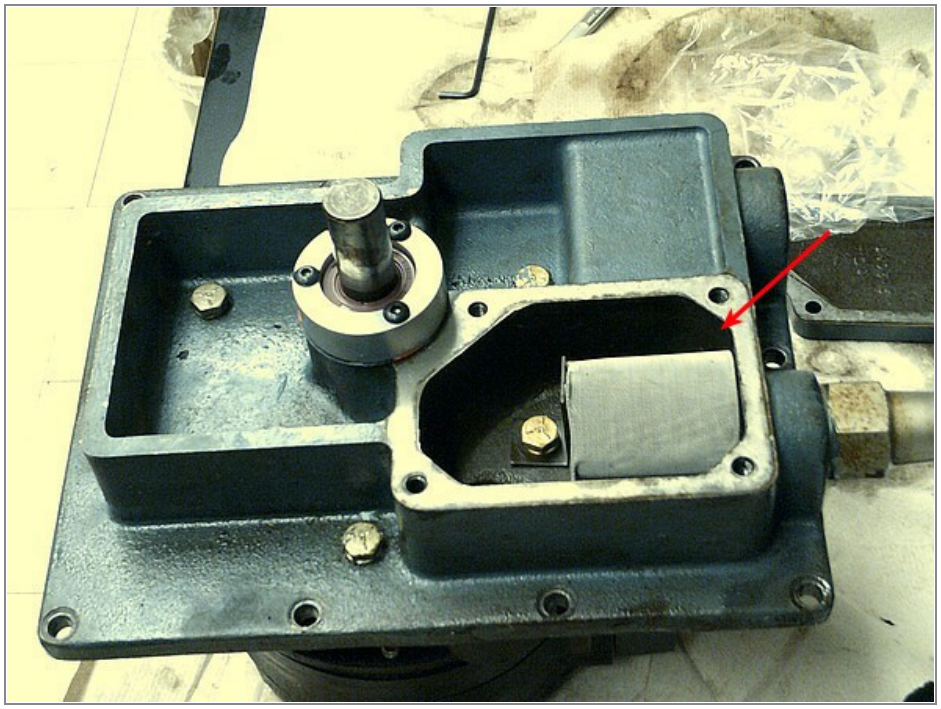
Step 60 (cont.)
Reassembly

Shaft seal in place.

Step 60 (cont.)
Reassembly

Remove the alignment tool.



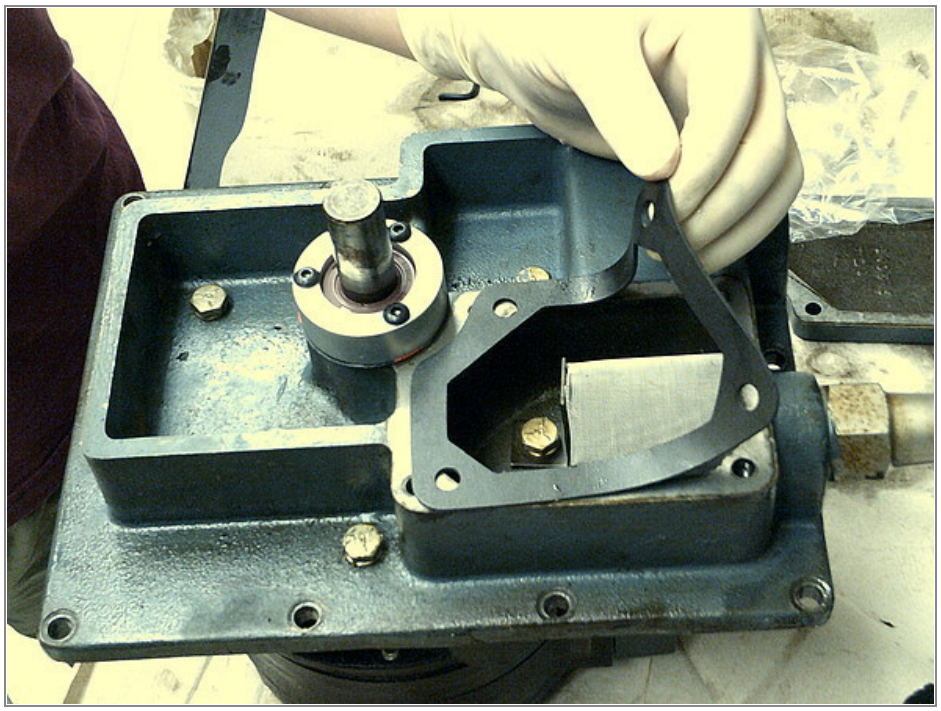


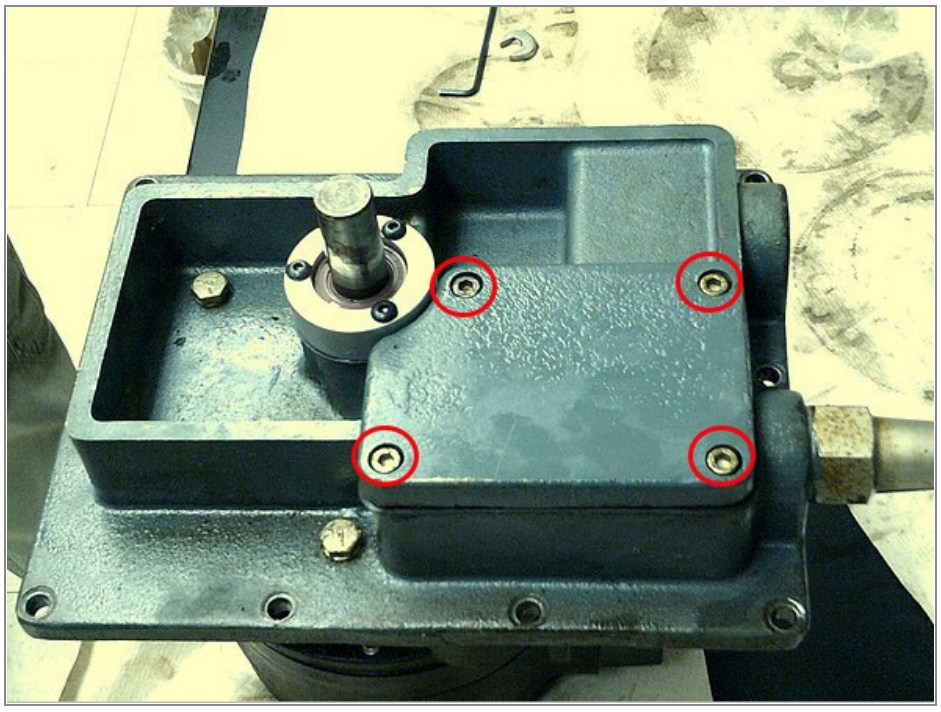
Step 61
Reassembly

Replace the intake filter.

Step 62
Reassembly

Replace the intake cover gasket.





Step 63
Reassembly

Replace the intake cover, and secure it with four hex head screws. Remember to apply torque evenly and inspect the gasket.

Step 64
Reassembly

Replacing the gas ballast seal. A

picture of the oil case with the gas ballast seal removed.

Step 64 (cont.)
Reassembly

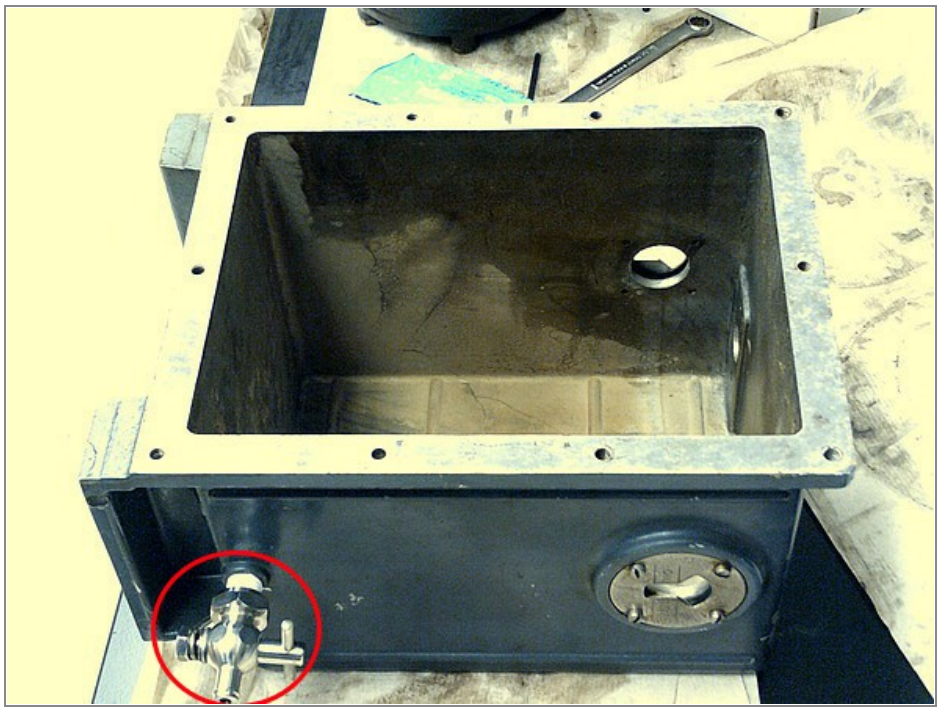
Pack the new gas ballast seal with silicone grease. The gasket off to the side is original, and we did not have a replacement. We made sure not to tear it when we removed it from the oil case.

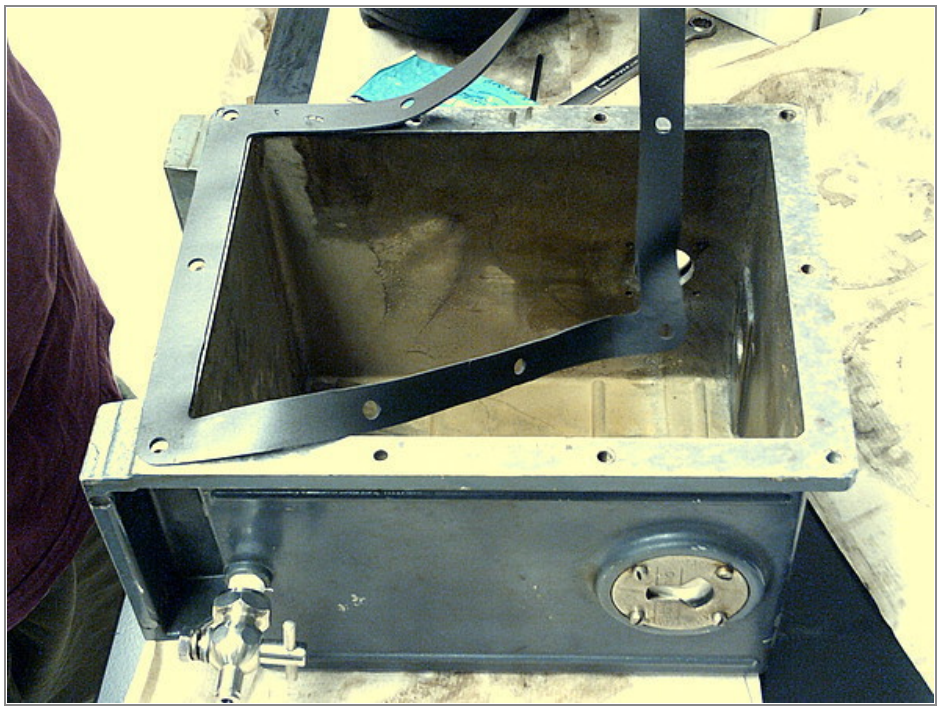
Step 65
Reassembly

Fasten the seal cover with only a few turns, until we are able to insert the gas ballest.

Step 66
Reassembly

We also replaced the oil drain valve. You have to order one in advance, as it is not a standard part in rebuild kits.



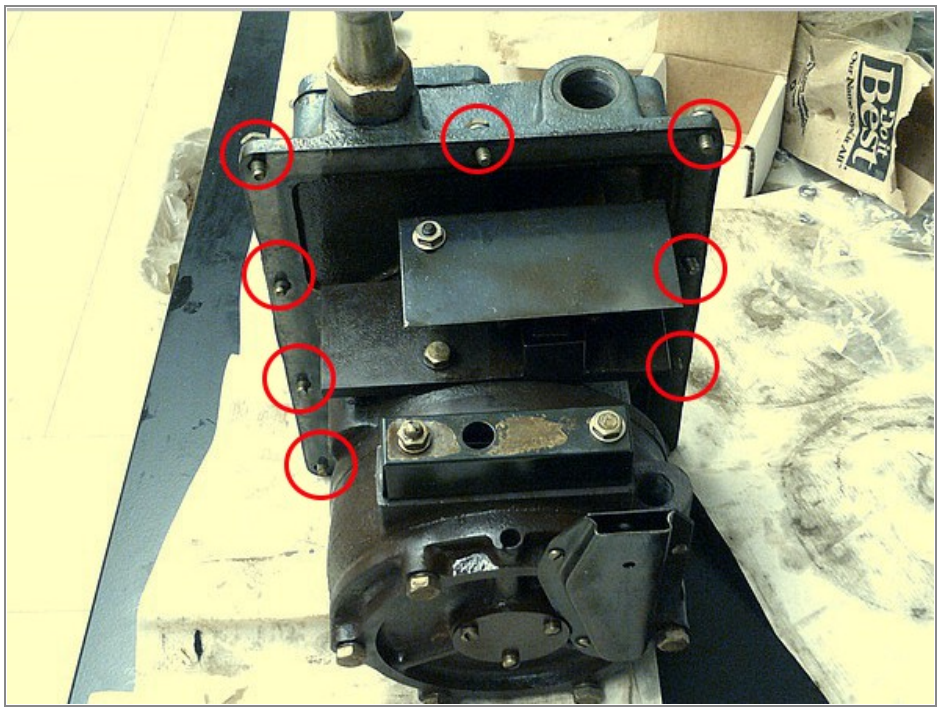


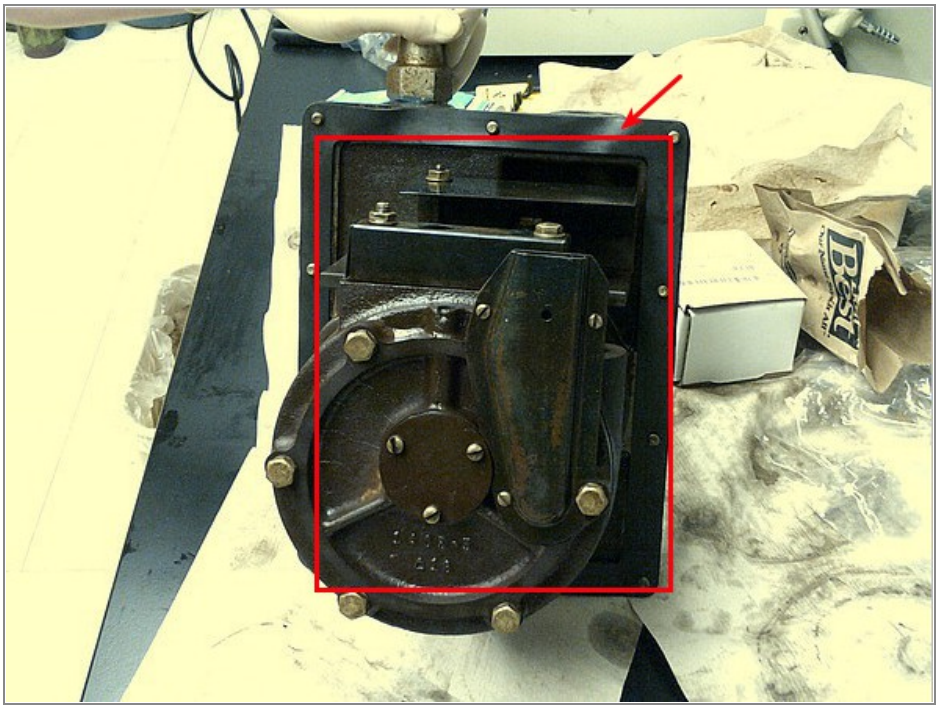
Step 67
Reassembly

Align the gasket with the oil case, in preparation for joining the large end plate.

Step 68
Reassembly

The best method to join the large end plate to the oil case is to put the bolts in place...



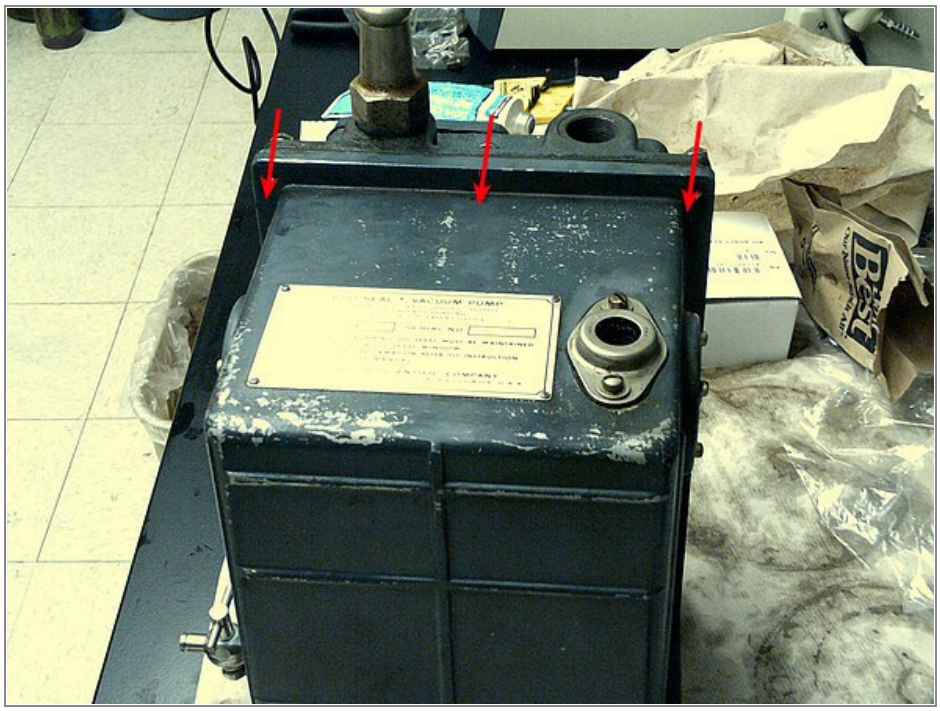


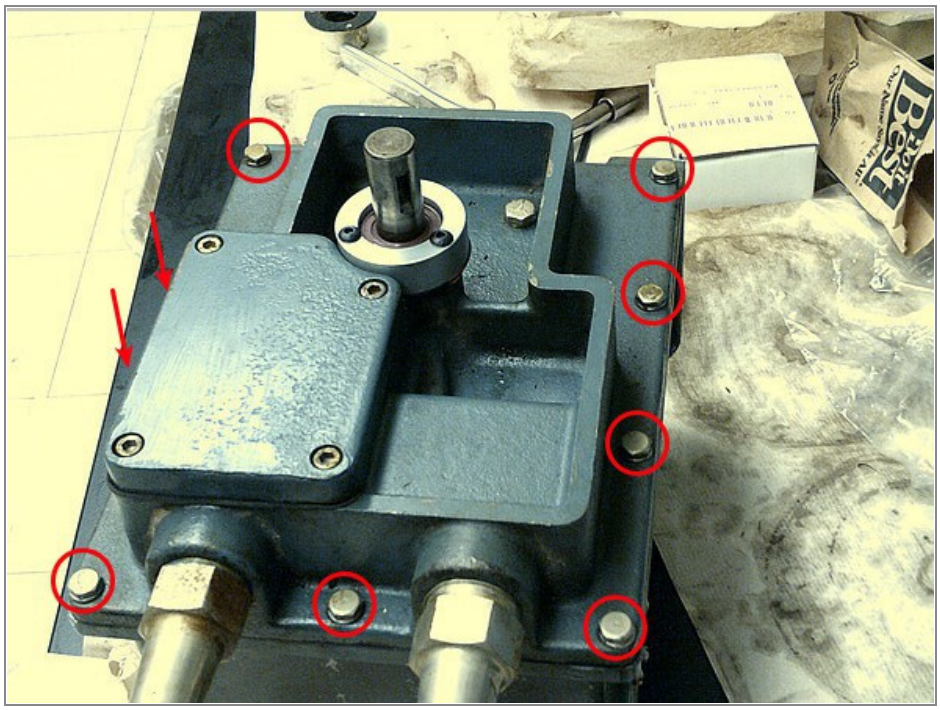
Step 68 (cont.)
Reassembly

and tilt the unit forward. Mount the gasket onto the bolts.

Step 68 (cont.)
Reassembly

Put the bolts into the oil case, but do not fasten them in place.



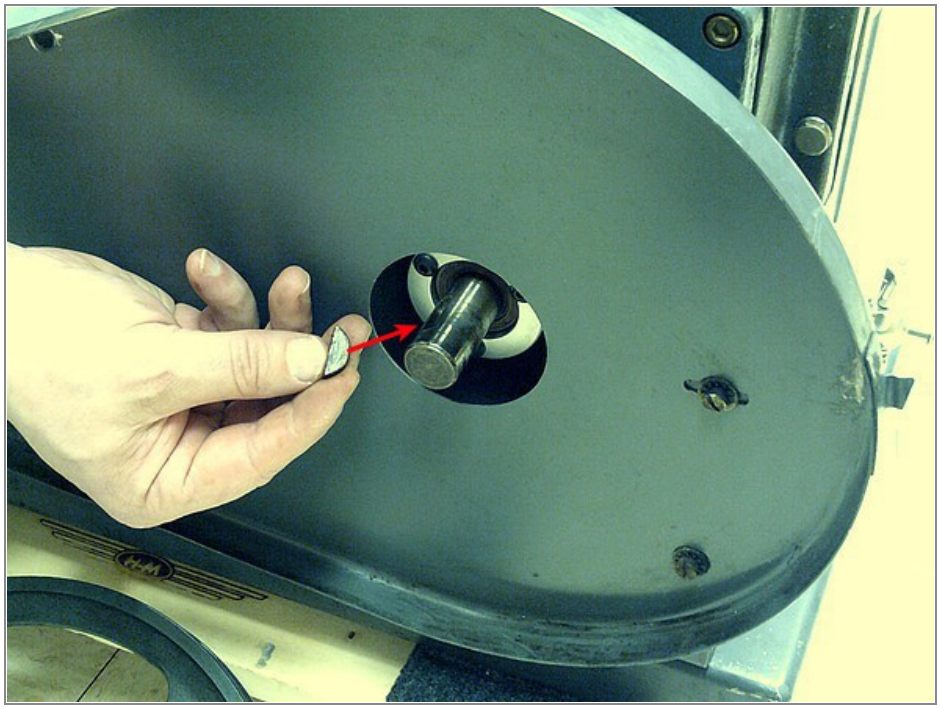


Step 69
Reassembly

Tilt the unit back and secure the bolts in place. Use original or copper washers to ensure a tight fit.

Step 70
Reassembly

Insert the gas ballest and secure the seal in place.

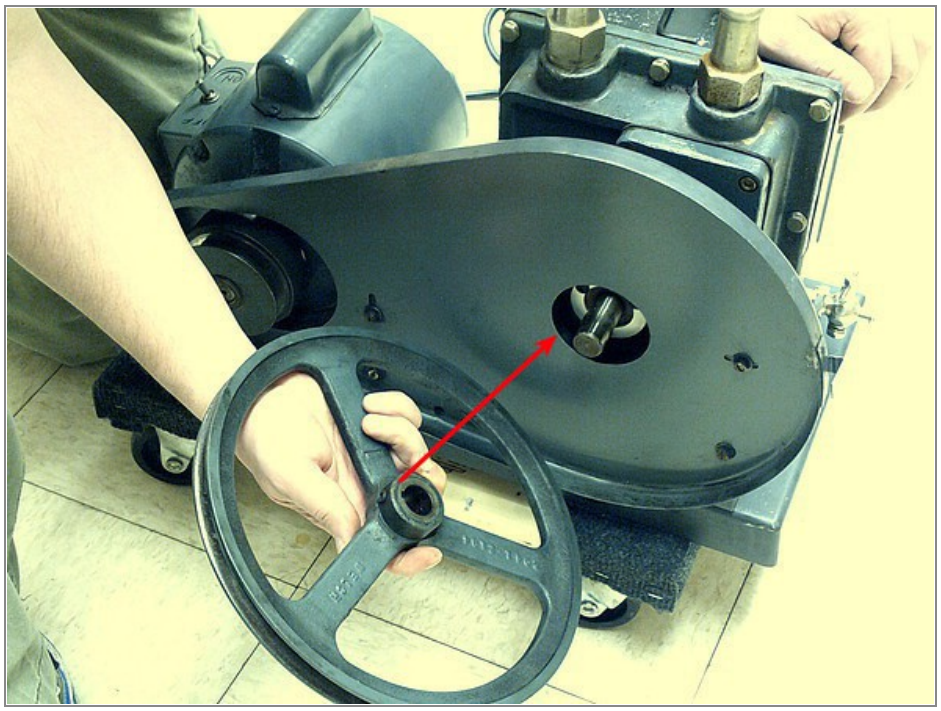


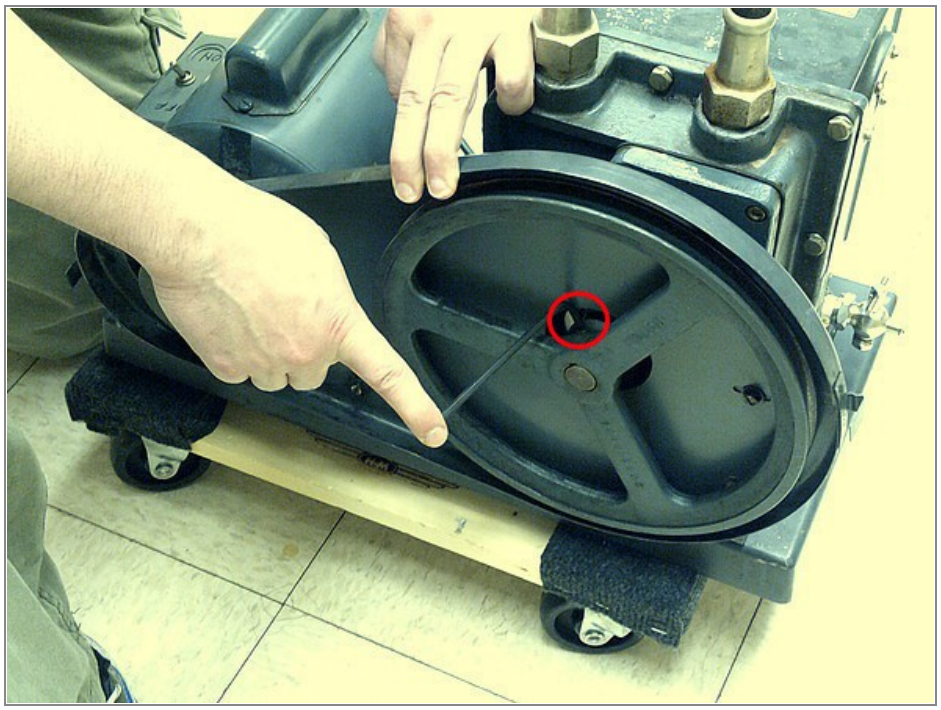
Step 71
Reassembly

- Secure the pump to the base platform
- Secure belt shield
- Replace woodruff keys on the shaft. We found that the original keys fit best on our shaft

Step 72
Reassembly

Replace pully.





Step 73
Reassembly

Secure pully in place with set screw.

Step 74
Reassembly

V-belt replacement. The picture shows a modest deflection in the belt. This suggests that the belt is over tension. The V-belt tension should be just enough, so that the belt doesn't slip during rotation. We adjusted the motor pulley

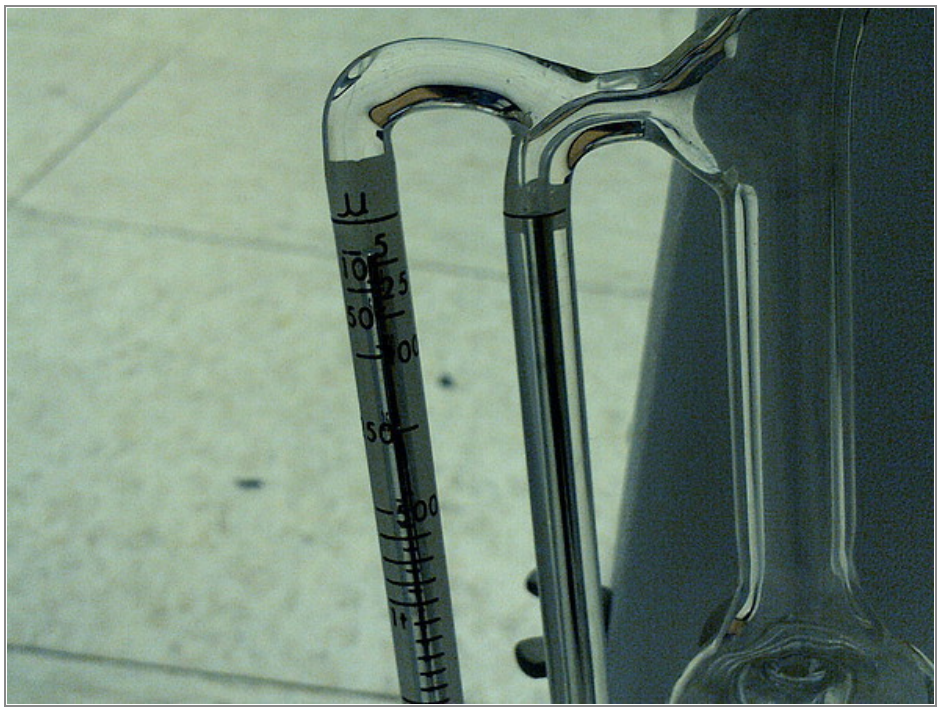
ratio, and thus the belt tension, using a percussive method. We loosened the AC motor bolts, and used a rubber mallet to make minor displacements to the motor position. You should avoid making major adjustments to the motor position unless you have force gauge to properly set the V-belt tension.

Step 75
Reassembly

OIL FILL. We filled the oil case through the intake, atleast twice, manually cranking the oil through the first two stages. This is crucial for getting oil into every void. The rest of the oil capacity was brought to regular level by filling the oil case through the exhaust.

FIN

After a couple of minutes, we



were able to obtain a 5 micron (Hg) or 5 mtorr vacuum as measured using a McLeod gauge. Awesome!

I'd like to thank a certain hand model who wishes to be unnamed, and the boss.

UC San Diego