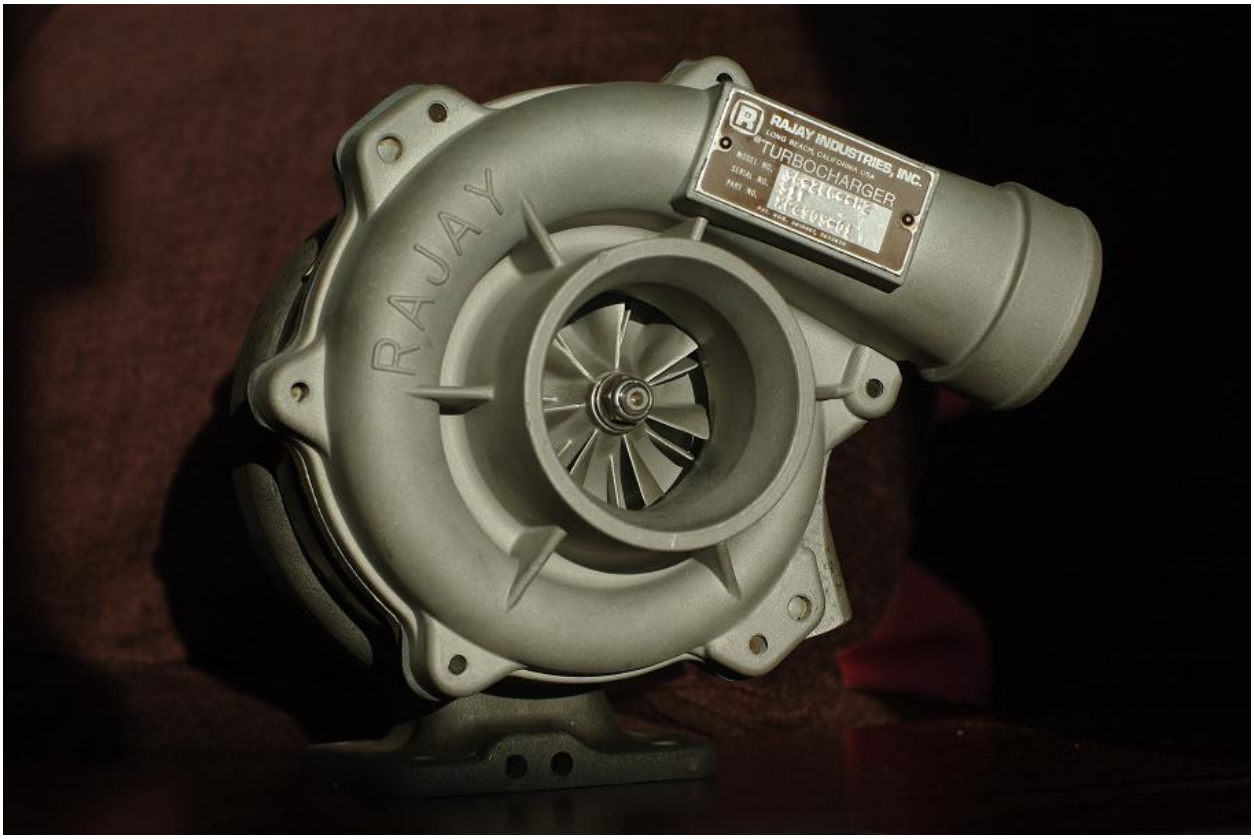
Corvair/Rajay Turbocharger Primer II: Generational Differences



Part 2: Corvair (TRW) and Rajay 300-Series turbo evolution, interchangeable parts, non-interchangeable parts.

By: Nick Williams (Miniman82)

Index

DISCLAIMER!

First and foremost, I am not a turbocharger technician. I am not ‘qualified’ per se to work on these things, and much of what I have learned has been through actual hands-on experience with these units, what I have read in various technical manuals and via telephone conversations with those who are qualified in the industry. None of the information contained herein shall be used in conjunction with any sort of aviation maintenance, and I am not liable for any damages you may experience by following my advice. This is only a basic guide, for the layperson. This primer should be used to gain insight as to how these units operate, how they are built, and how to service them with respect to automotive applications from my point of view. That said, there is some good information here. I haven’t found this collection of information anywhere else, so soak it up and use it for your enjoyment.

-Nick

Section 1: Preface

Welcome back to another exciting installment of my primer, covering the Corvair (TRW) and Rajay turbocharger. It's been more than a couple years coming, and now I finally found the time to get this information out to you- the end user. This go-around, we will delve into the generational differences across all series of turbos, which parts can be used/interchanged between them, and what parts you must not use together. Armed with this information you will be able to identify which parts go with which series of turbo, and you should also be able to tell what is what at a glance. My hope is that the more you know, the less trouble you will have with your unit. Also it should make less work for me, because I've seen some jacked up turbos since I started rebuilding them!

First off you'll recall that in the previous installment, we talked about some of the history behind this line of turbocharger. We will now build upon that knowledge, and get right to the nuts and bolts of what the units looked like at every point in their production history. I have chosen to break this information down from one generational change to the next in roughly chronological order (oldest to newest), so as not to confuse the reader.

The final installment of this primer will consist of a complete rebuild, from teardown to inspection and rebuild. I will show you the correct tools, how to use those tools, and what to look for so the unit works like it should when you go to put it back on the car. Some of this information is already out on the interwebs, so I'll collect it here so you have a reference at your disposal and don't have to go searching for it. Many of you will find this invaluable, because I have taken instructions and clearances straight out of the Rajay manual and blended in my own insight to make things easy. For example, the Rajay manual has a somewhat confusing mathematical table to calculate compressor impeller to housing play- I'll clear all that up into one simple step for you!

So sit back, take all of this in and let it digest. Then get out there, and get those vintage Rajay turbocharged vehicles back on the road! You owe it to yourself, and to the posterity of these turbochargers. There are fewer of them around still working year after year, and that to me is a shame.

Section 2: The Early Years

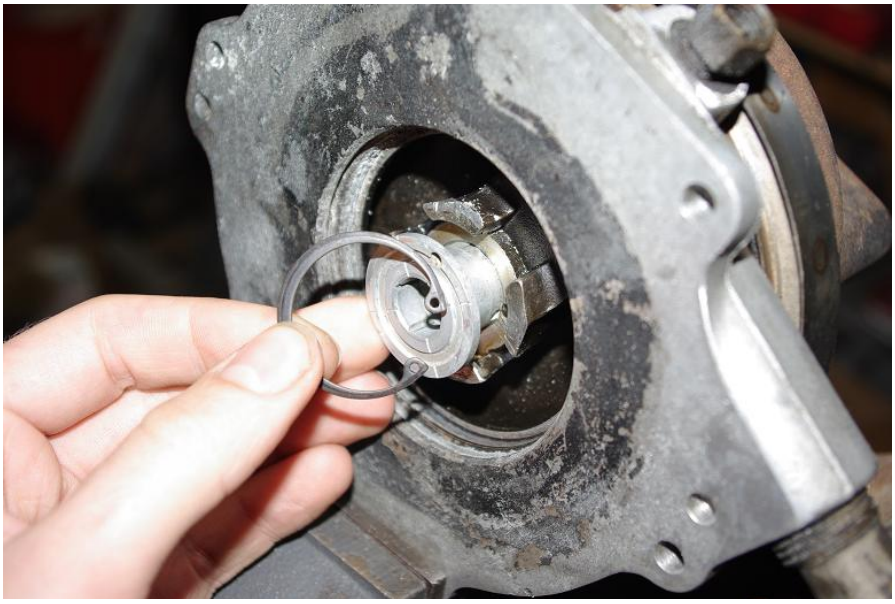
TRW gives birth to a turbocharger!

Imagine if you will the year is 1962, and the largest auto manufacture in America approached you saying they want to turbocharge an already revolutionary vehicle with one of your units. Exciting would hardly be the word if you worked for TRW back in those days! Turbocharging was not a new concept then, but its application to a production passenger automobile was. Oldsmobile had done just that with their Jetfire, so naturally Chevy wanted to respond with their own turbocharged engine. The hot compact market was heating up! Certainly turbocharging an engine was an idea that was outside the box for Detroit, and suddenly we had 2 turbocharged vehicles in the same model year- one of which had a rear mounted air cooled engine. Thus in 1962, the turbocharged Corvair Spyder came to be.

The early TRW units will be the focus of section 2, since they spawned the turbochargers that are still being produced to this day. While the first units may look more or less the same on the outside compared to a modern one, there are in fact some distinct differences between them. Let's have a look at the unit from the Corvair.

As you can see in this partially disassembled unit, there is only one oil feed and drain port on the bearing housing. Since there is no way to rotate the compressor housing relative to the bearing housing, the turbo can only be installed in one position- with the drain pointing down. Doing otherwise means oil cannot gravity drain back to the sump; it will back up inside the turbo, and the result will be oil pushing past the turbine seal and a cloud of burning oil. The turbine housing however can be rotated relative to the position of the bearing housing, so as long as the drain points down the exhaust can enter at any angle.

As you can see the compressor cover has a triangular inlet flange, making it specific to the Corvair installation. This has not stopped shadetree mechanics in the past from adapting it to other engines though, from sand rails to motorcycles. Note the provision for a PCV line, tapped into the inlet.



Bearings in the early units were retained via snap ring, which went into grooves cut into the bearing housing. To make up for manufacturing tolerances, a shim goes between the underside of the bearing and the housing to take up any slop. Notice the round shape on the rim of the bearing, and the fact that it is pinned to the bearing housing to keep it from rotating. Later bearings had 'ears' which went into slots in the housing to keep it from rotating. Take note of the holes drilled into the bearing as well, to admit oil. Some bearings had them in different positions and cannot be interchanged, as we shall soon see.

Above is the carbon seal plate, with carbon seal installed. Later models of turbo did away with the snap ring which held the bearing into the housing, and the carbon seal plate gained raised tabs on it to press against the bearing to hold it into the housing. These later carbon seal plates are easily identified, the raised tabs are located around the carbon seal. The Corvair carbon seal plate has a thin outer O-ring, which sits in a groove on the periphery. Later plates used a thicker O-ring, so the periphery has a sort of ledge or lip to it instead of a groove. These changes will be shown in the next section.

The last characteristic defining these units from later ones is the area where the turbine seal goes, which has a straight edge to it. Because of its blunt edge the hard metal turbine seal will often get hung up on it on installation, even when using the correct suppressor ring that is supposed to keep the seal compressed as you install it. What often times will happen is the seal then gets pinched between the turbine shaft and bearing housing, bending the seal and usually gouging the housing in the process. Great care must be taken with these housings to keep the seal from doing damage when the shaft is installed- DON'T FORCE IT! This is a design flaw which would be corrected in the next iteration.

At this point, it's worth mentioning which core parts are common across all units and all years:

1. Turbine shaft/seal and heat shield spring
2. Compressor impeller, spacer and shims
3. Mating washer
4. Compressor and turbine paper gaskets

That's it! You could say the turbine and compressor housings are common as well, since technically they do interchange. But for ease of understanding, I'm leaving them out because like with the Corvair they are sometimes specific and there are too many variations to include here. In other words they fit, but you might not like using some of them because of their unique inlet or outlet flange for example. There were compact turbine housings with 3-bolt triangular

inlets for use on motorcycles, T04 style inlet flanges like the one on the Corvair, V-Band inlets which saw aircraft duty, and marine housings which weighed a freaking TON because of the water jackets cast into them. On the outlet side the Corvair had either a flat gasket or doughnut seal depending on year, and the later units had round 4-bolt outlets (Rotomaster style). Aviation destined units had V-Band outlets. For the most part the compressor housings had 3" round inlets, the Corvair was the only one to have a bolt-on intake for attaching a carburetor. Those housings with round inlets you see on popular auction sites, with bolt holes in them? Those were machined housings which were custom made for specific applications, usually motorcycles. They always began life as a round inlet, to which a hose would normally be attached.

Section 3: The First 370 Series Explained

After the Corvair was all done in 1969, it seems TRW had no further use for turbochargers and sold the lineup to Rajay Industries. Rajay would take over development for the next 13 years, and some interesting things would be tried in order to get more performance and economy from the units- some changes were good, others were not. Principle in the design changes were modifications to the bearing housing, so the turbos could be installed in many applications instead of just one.

The first thing to be changed was the fact that the original unit only had one feed and drain port for oil. Units now featured 3 inlet passages, spaced 120 degrees radially around the bearing housing. Drains were offset from each feed line by 60 degrees. Now all you had to do was get the compressor pointed where you wanted it, pick the drain that was closest to perpendicular with the ground, and plug the unused holes. Simple! This made the job of orienting the turbo for your application much easier, but since the compressor still could not be rotated relative to the bearing housing (a glaring oversight I'm sure), it was possible to have the drain line tilted at some small angle and not perfectly perpendicular to the ground. Because of this Rajay state that the drain may be oriented at up to 45 degrees from vertical centerline in their manual, but common sense tells me to get as close to vertical as possible to avoid issues. Oil could be fed from any of the 3 inlet lines regardless of which drain was used, just plug the unused ones.

Shown below, the first model 370 bearing housing.

You can see a drain line with AN fitting in it, and one of the plugged feed lines right above. The redesigned bearing with ears can be seen interlocking with the housing to keep it from rotating, as well as the revised shim which snaps around the ears. Because the carbon seal plate was now used to retain the bearing in the housing, the shim had to be moved from the back side of the bearing to the front. There was only one thickness of shim: .010", where before there were a few different ones to choose from. Structurally the bearing housing is pretty much the same, aside from having the bearing bore supported at three places instead of one as with the last version. This had more to do with having 3 oil feeds rather than correcting for any weakness in the housing, they had to give the oil a place to travel.

This is the revised carbon seal plate. You can see the raised tabs which press against the bearing, keeping it in the housing. Also the thicker O-ring seal, and altered plate edge. Gone is the groove for the O-ring to sit in, so it can be tricky to get the O-ring to sit properly on the plate during install. Use petroleum jelly around the plate to hold the O-ring in place, it helps. This revised plate still uses the same style carbon seal as before, it can be removed and the internal O-ring replaced as needed during rebuilds. This plate is not interchangeable with the earlier style one, it is specific to the 370 Series.

Let’s zoom in closer now, and have a look at the bearing. If you look close, you can see that the surface the shaft rides in has some small holes in it. These are direct feed oil passages for the bearing; there are four of them at each end of the bearing, and they line up with channels machined into the bearing bore in the housing. You may think this is a good idea at first, but it needlessly complicated the design and production of the bearings and housings. The next generation solved this by going back to the original design which was simple (no holes), cost effective and worked well. In short- it was an unnecessary change. See the hole at the top of the front face? Yep, it’s the same hole for the locating pin as the last bearings had! No idea why it’s still present on this version, when the ears are there keeping it from turning and it wasn’t backwards or forwards compatible… Just an oddball item.

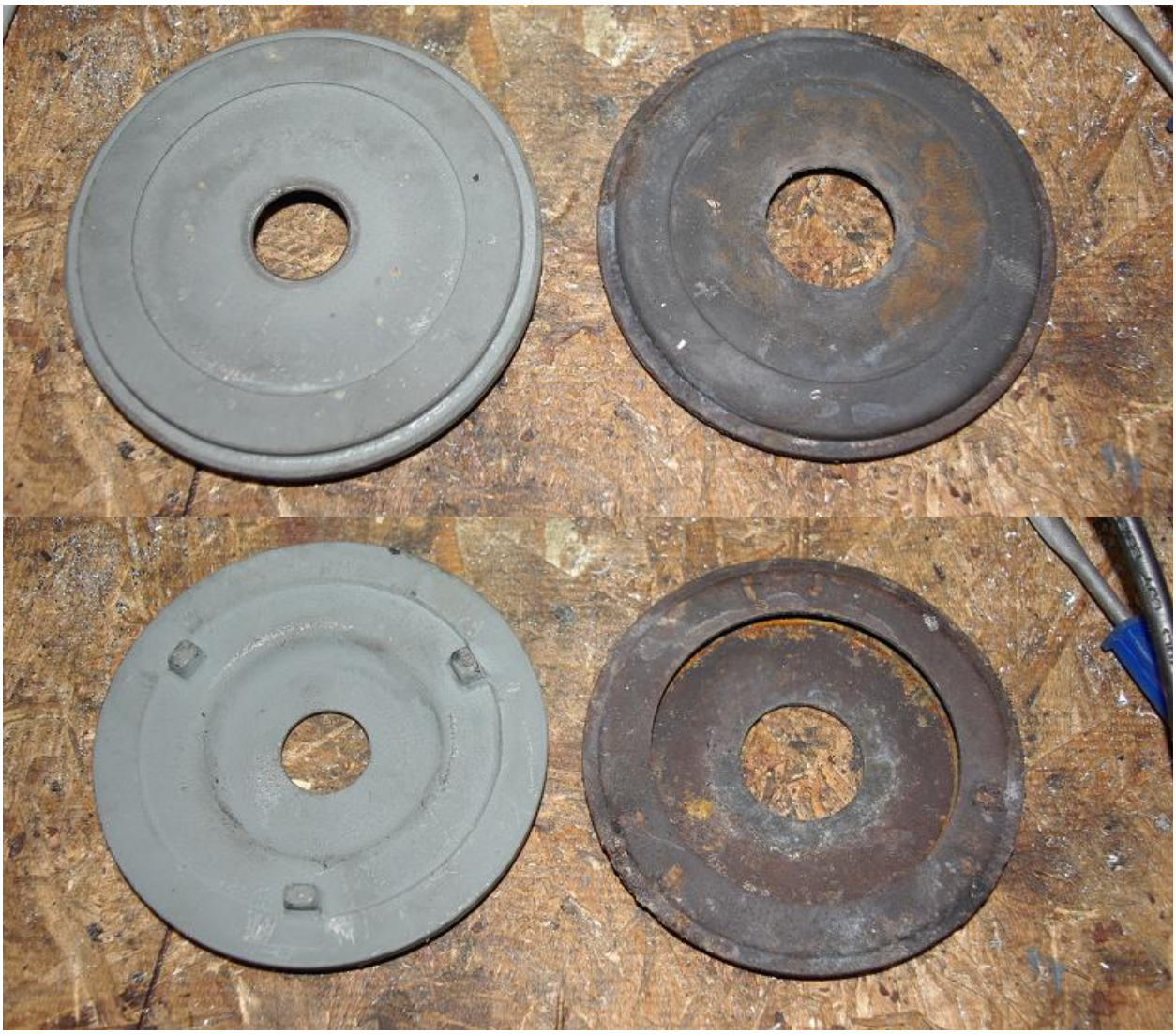
A side view of the same bearing. Large holes are oil drains, small ones are the direct feeds to the journals.

Here's a view of the bearing bore for the bearing with direct oiling. You can see 3 grooves machined into it, the first two are pressure fed with oil and the final one is a drain for the turbine side. The hole you see between the oiling grooves is also a drain, which lines up with corresponding drain holes in the bearing. Why Rajay felt it was necessary to drain oil away from a pressure fed bearing is beyond me, it wouldn't have mattered one iota were it not there at all. Like I said before much of this is needless changes, as they were attempting to get the design right.

These parts are not interchangeable with the previous version or the one after, making them sort of one year only deals. The end result of using this bearing with any other housing or vice versa will be no oil to the bearing, leading to starvation and failure. This happens because of how the passages are done, they don't line up with anything but the correct parts so be sure which ones you're working with!

This is a shot of the turbine side of the housing, so you can see the change that was made to the turbine seal bore. A slight chamfer was added, to aid in installation of the turbine and its seal. Now the turbine can be installed easily without the plastic suppressor ring, and you don't have to worry as much about the soft aluminum getting jacked up by the sharp turbine seal. Not saying you can just go jamming the thing in there, you still have to finesse it home. But it's a whole lot easier than it was before. Finally, one thing they got right!

Also note the there is a small ledge on the area around where the seal goes, where before the entire area was flat. I suppose this was done to provide material for the chamfer, but it also meant a change to the turbine heat shield. Previous ones had a smaller hole in them, and were made of cast iron. New style ones are two-piece stamped steel, spot welded together. They cannot be used with the previous version bearing housing (they lack the locating tangs on the back side and aren't deep enough), but were carried over to the new versions from here on out. Next picture is a shot of the revised heat shield, with original Corvair cast style one on the left for comparison.



Section 4: The Second (improved) 370 Series

I suspect that after much fussing over how exactly to go about feeding the bearings with oil, Rajay finally caved and went back to the way it was before- yay, no more needless complications! Apparently someone in the engineering department pulled their head out of their hind quarters, or more likely, had it pulled out *for* them by the guys over in accounting for increasing the cost of production unnecessarily! Either way, with the second installment of the 370 series, we were finally heading towards a unit that made sense. Simple bearing system, easy to produce housings, but you STILL CAN'T ROTATE THE DAMN COMPRESSOR HOUSING! I mean really, how many chances do these guys need? All jokes aside, this is a really good unit. Tough as nails, easy to adapt to your application, cheap/plentiful parts, and they are easy to rebuild. This section is short because the only thing different is the bearing and bearing housing, so refer to the below pictures.

Ah, now this is the future! It's pretty much the same thing as the original Corvair bearing, just with ears and no locating hole. This bearing is backwards compatible with the original Corvair/TRW stuff with a few simple mods, all you have to do is drill a hole for the locating dowel and grind the ears off along with a little extra outside material to make it fit. So don't pay an arm and a leg for 'Corvair specific' bearings, you can get these ones cheap usually. This is also the bearing all future units would use, so it would appear that the original design was good enough to start off with.

A side view of the bearing. As you can see, the oil feed holes have returned to their original Corvair positions and there are no drains.

This is the bearing bore of the housing used with the above bearing. No more pointless and complicated oil channels and return holes, just a simple and easy to produce casting. All other parts were carried over from the last one, just a different bearing and housing.

Section 5: All Good Things…

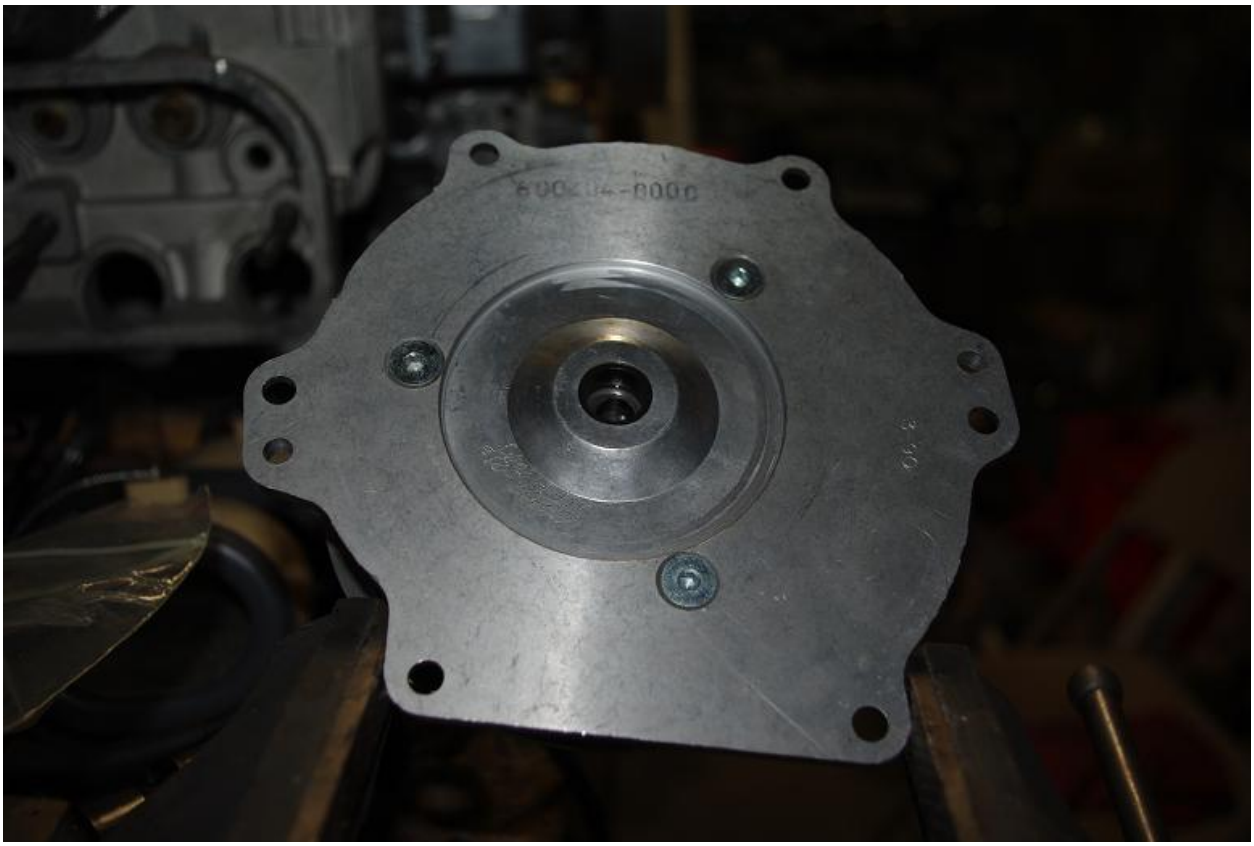
The 300 Series makes its last stand

In 1982, Rotomaster took over development and manufacturing of the 300 Series turbocharger from Rajay. When they did, one last change happened to make the turbo truly universal-clockable compressor housings!

FINALLY!

In order to make this happen the bearing housing had to be made in two pieces, so it was completely redesigned to the one most people are familiar with. The bearing was still retained by the carbon seal plate as with the last one, but the carbon seal plate had actually become the front cover for the bearing housing now- it could be called a backing plate in Garrett speak. The carbon seal was also redesigned at this point, now being made completely of carbon instead of being a steel holder with carbon impregnated onto it, and it was retained by a spiralock retaining ring to the front plate vice being press fit like before. Gone were the multiple oil feed and drain lines from the 370; since you could clock this version at any angle they were no longer necessary, so all you get is one feed and one return. One final minor change was the compressor housing is now secured to the front plate via countersunk allen screws, vice the previously used hex headed bolts. These changes form what became known as the 310 Series, below is an assembled 310 Series turbocharger.

The outward appearance isn't dramatically different from any of the others, but the inside has definitely changed. Shown below is a bare NOS center section. No more round carbon seal plate, it has morphed into a backing plate retained by a trio of allen screws.



Removing the plate reveals the bearing in the other half of the housing. Note that there are many tapped holes to receive the backing plate fasteners; this is how the compressor housing is able to rotate around the bearing housing, just point it where you need it and bolt it down.

On the reverse side of the backing plate is the new style carbon seal, retained by its spiralock ring.

Zoomed in…

Section 6: The Clipped Fin Turbine

At some point in the 80's or 90's (I haven't found any documentation to pin down when exactly it happened), a slightly modified F flow turbine shaft appeared on the scene. It had what is known as 'clipped fins', where a slight amount of the turbine exducer was removed. This has the effect of slightly increasing turbine flow, making it something in between a full bladed F flow and an E flow turbine. I find these turbines quite often in aviation units, which leads me to believe it was something that grew out of the aviation industry. Perhaps they felt the additional flow was beneficial, or maybe they wanted to limit the amount of turbine blade exposed to exhaust heat to avoid cracking to improve reliability. Whatever the case these can be used in any TRW or Rajay unit, but its effect on boost response is a bit of a grey area since there isn't a lot of automotive experience with these shafts. On the left is a stock TRW/Rajay made F flow turbine, on the right is one with clipped fins. I can say that the quality of these turbines is very high, and the blade thickness is very consistent unlike some of the earlier stuff. You will also notice a spot to place a socket wrench on the end of the turbine, which makes it very easy to properly torque the compressor impeller nut during assembly.