GM Lockup Converters

Inside...
700R4 and 4L60E Torque Converters

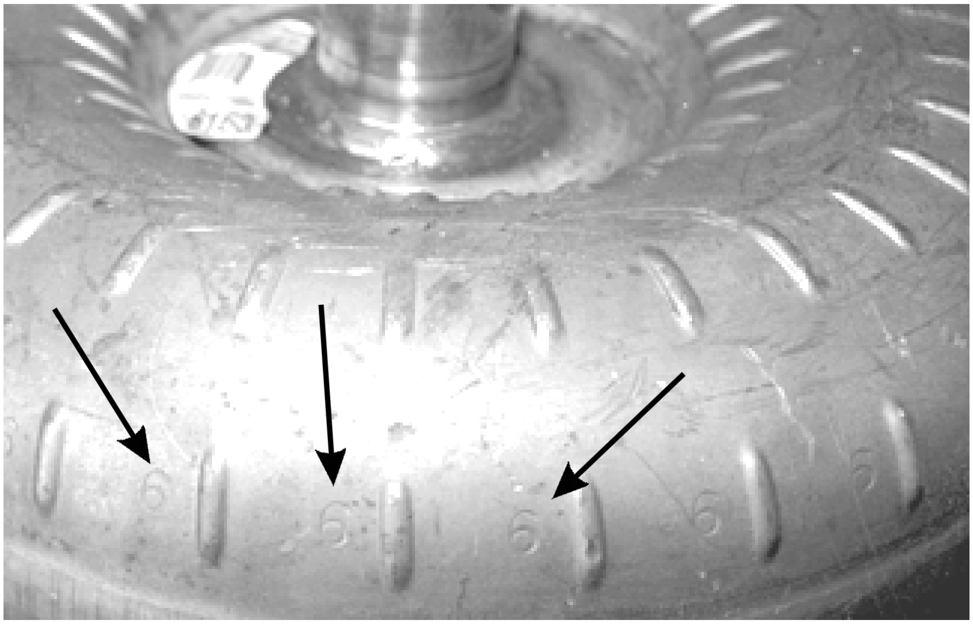
by Doc Frohmader

Early on a lot of us knew the 700R4 as an 'overdrive TH-350'. In terms of size and capacity they aren't all that far apart, but the mysteries and agonies of the overdrive and lockup took some time to thrash through. I can still recall when local transmission shops would either refuse to work on them at all or refuse to warranty them. In the first year of production at least 43 upgrades were made to just the valve body. They were frying like dropped eggs on a steel street in august.

There were lots of individual reasons why they had trouble. Some had to do with a new technology and failures not anticipated by the engineers, some had to do with the fact that most people who bought them had no clue how to drive them, and some had to do with being a bit too light or having components made of the wrong materials. Of all the problems, though, one was a consistent and persistent problem that remains to some degree to this day.

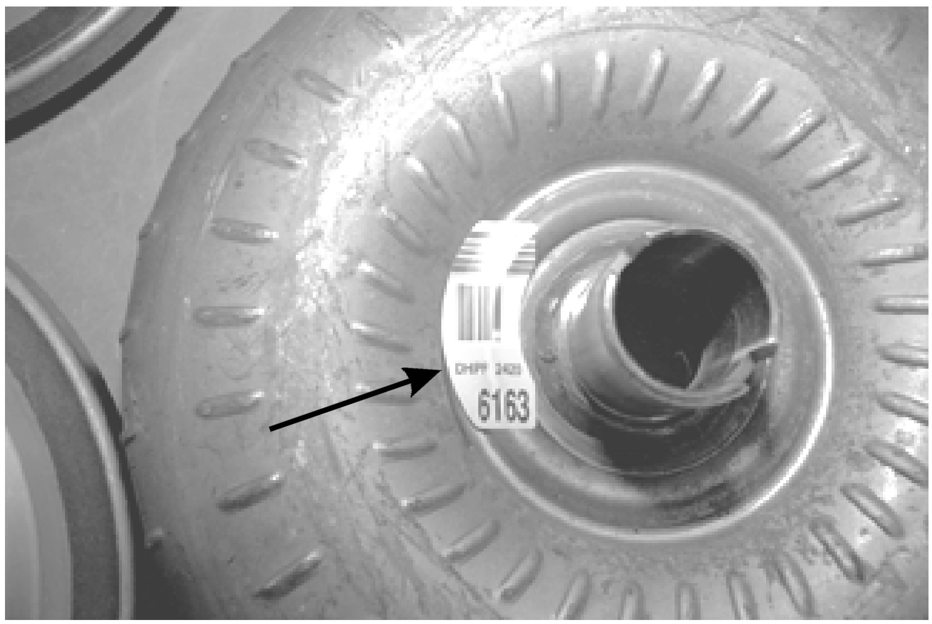
We still have problems with converters. They are found unbalanced, out of round, with too much hub run-out, poor or damaged clutch materials and/or damaged contact surfaces, bad bushings and/or bearings, having incorrect internal clearances, loose turbine fins, and incorrect total height - and that's just the 'new' or 'rebuilt' ones. Actually some 'rebuilts' are no more than washed out and repainted used stuff. Others are opened and the worst of the bad parts swapped for others and welded back together. Some get new parts but they are of poor quality. A vast majority are not well balanced or are out of spec. When converters fail, they throw debris throughout the trans and pretty well thrash the works.

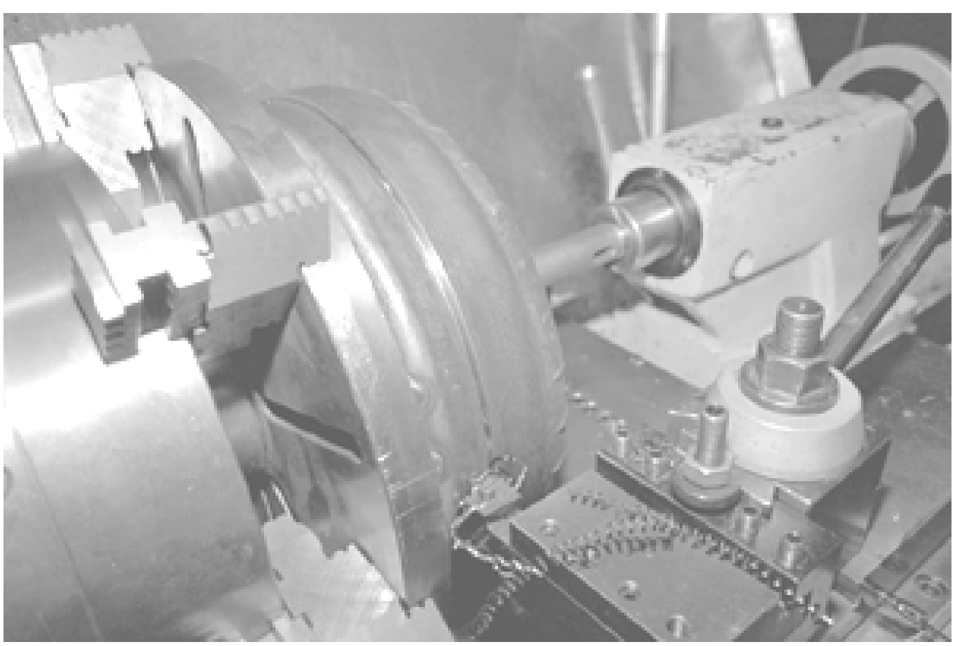
Price alone won't help you either for guarantees. I've seen 50-dollar parts-house converters that worked well and high dollar high performance units turn out to be garbage. On the other hand, there will always be a 'no free lunch' clause to deal with. What I mean is you can't reasonably expect a throw-down converter for el-cheapo prices. The best protection is to know who you are dealing with and know what to look for. If you can't be sure what you are getting, maybe it's best to move along to another source.



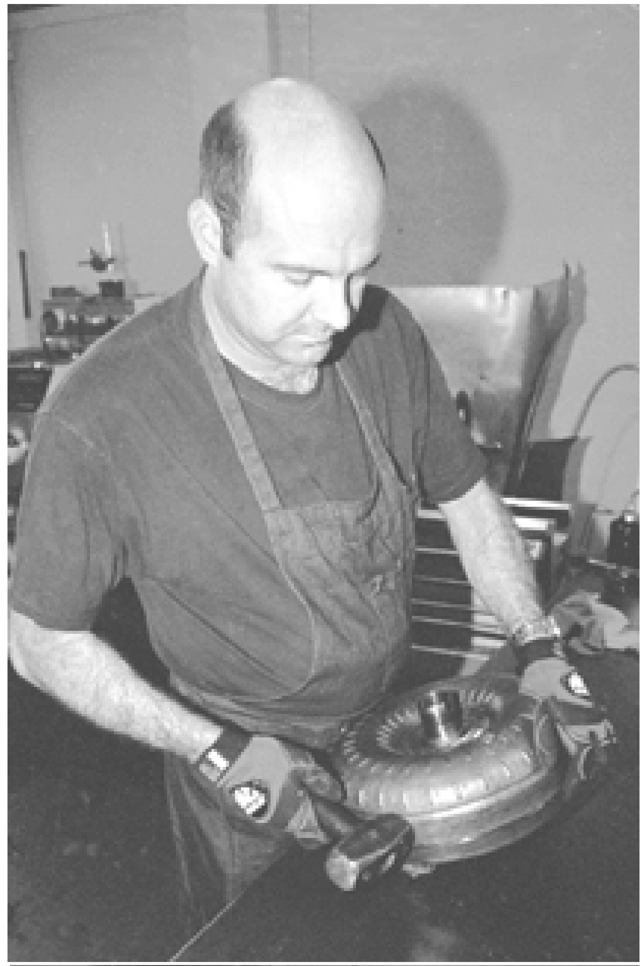
The stamped numbers in many converters tell you details about stall speed and impellers. See sidebar #1

The code tags have a four-digit letter code which provides more detailed information. See sidebar #2





The converter is cut apart in a lathe which cuts away the weld holding the halves together.



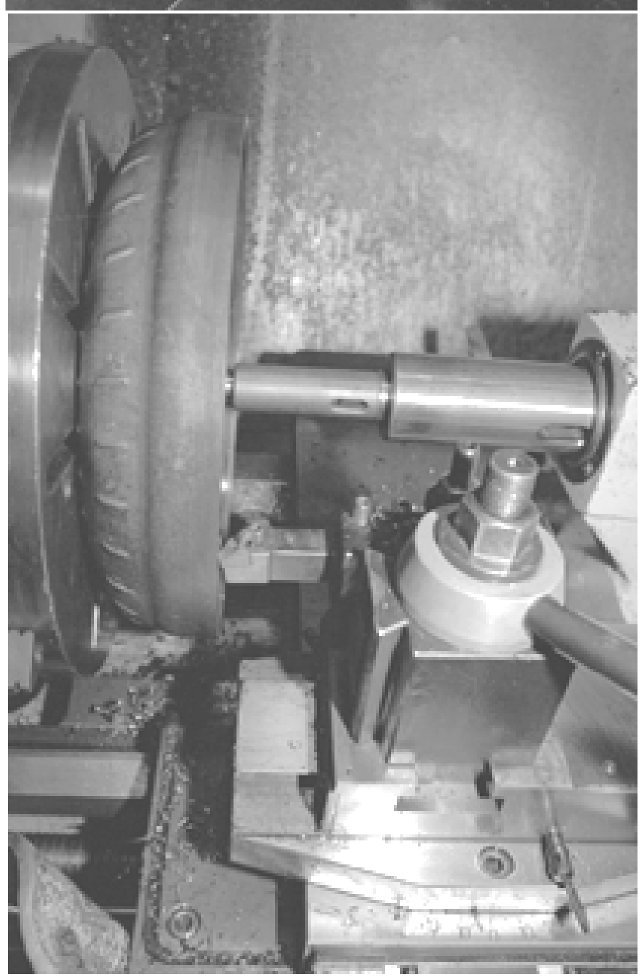
William has just the right touch to pop the converter apart without beating it up. The hammer splits any remaining weld material.

You see, the failure of a converter remains one of the most common failures of the 700R4/4L60E. It still has the same devastating result on the rest of the trans. The cost of such failures often run well over a grand and if you compare that to a quality converter, it's well worth whatever the converter costs. Hey, the trans is only as good as the weakest part!

That's the place I was this last spring when I was fighting still again with a vibration problem I was convinced had its origins in the transmission. The unit had been rebuilt in front of me and I was as certain as I could be it was right. Still, my old 700R4 had a cyclic vibration driving me up a wall. I had no confidence in the truck, was sure it would sooner or later fail and leave me stranded, and I could feel my wallet heating up from overuse. I mentioned this to Greg Ducato at Phoenix Transmission while working on another project and he told me to drag my butt into the shop with the converter and he'd school me. Not one to turn down a challenge to my limited brain power, I did just that. The resulting experience made me realize the difference between the junk and the primo stuff and I had to share it.

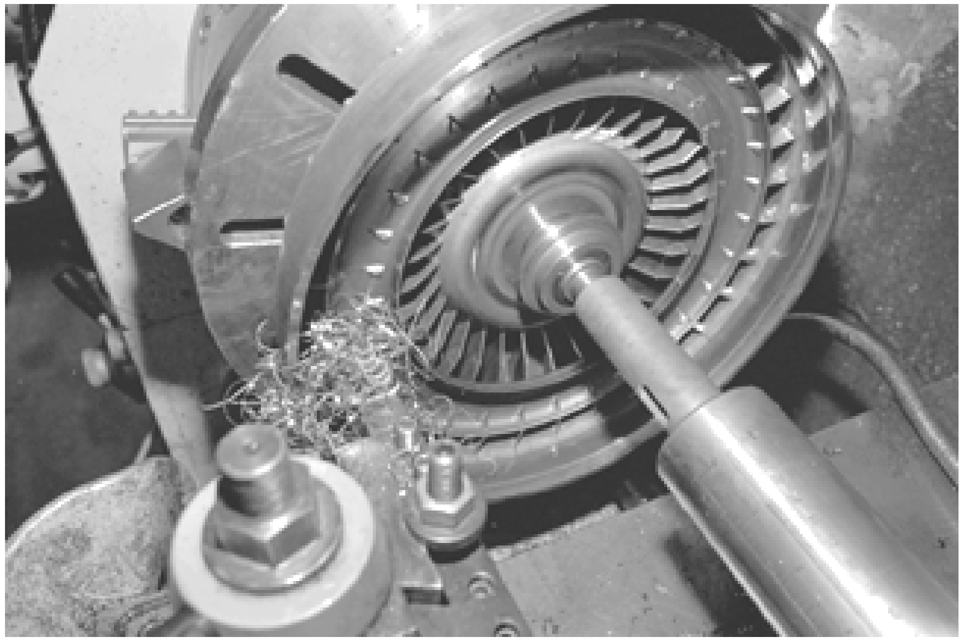
Good, Bad, and Ugly

The converter that is not completely disassembled is a mass of uncertainties. I don't care how good you think you are at jiggling and shaking and sniffing and probing, there's too much inside that can go wrong. For that reason Greg tears every one down to components. Granted, he prefers using 'virgin' cores - those not screwed up by the amateurs - but you can tell a lot about what is inside by two basic items. First, there is a stamped number around the housing which corresponds to the stall speed or fin angle (see sidebar).

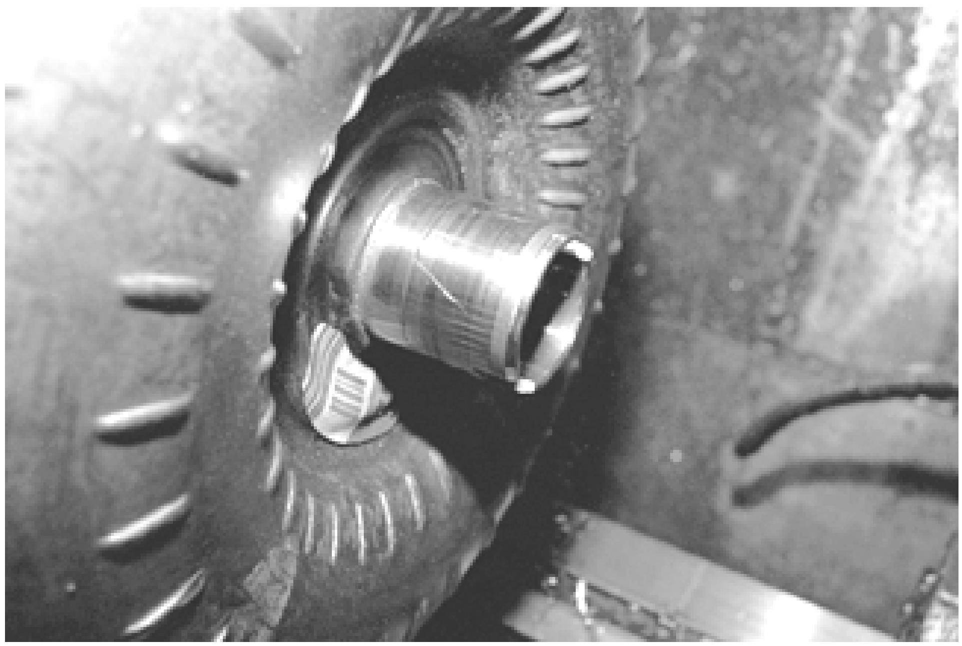


The front edge of each half is trimmed so it is clean and even and will allow the parts to fit precisely.

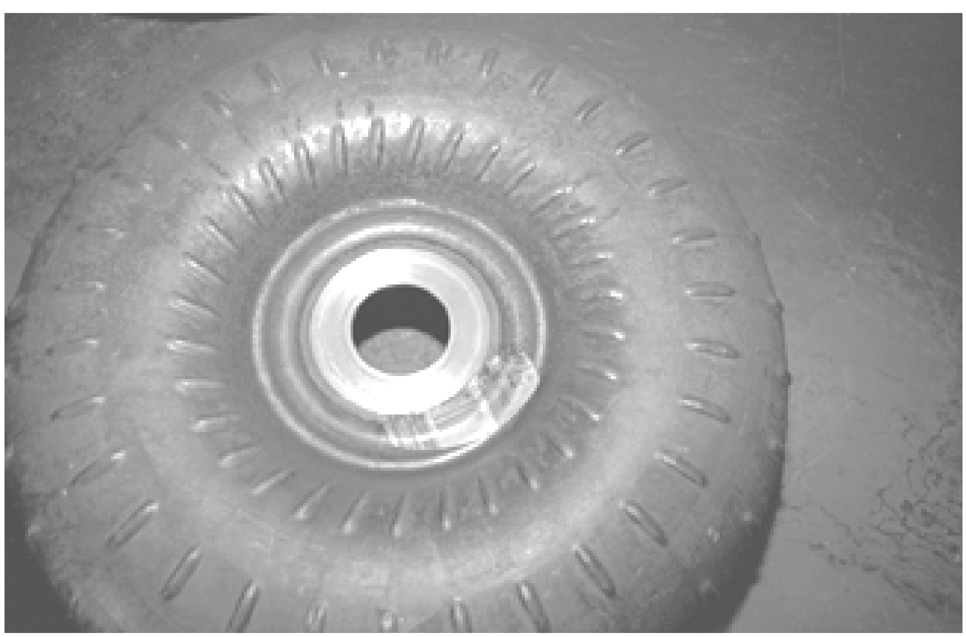
The front half is also turned to clean weld debris and deepen the shelf cut so the halves can be assembled at the correct height later.

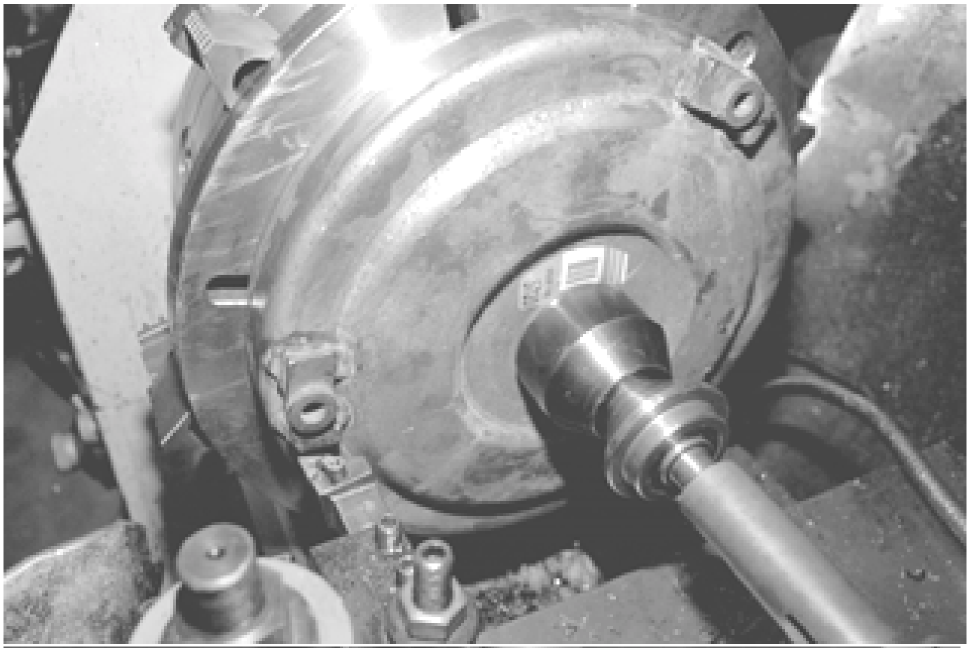


A damaged hub. Rather than try to repair or re-cut the hub, Phoenix will remove it and replace it with a new hardened hub.

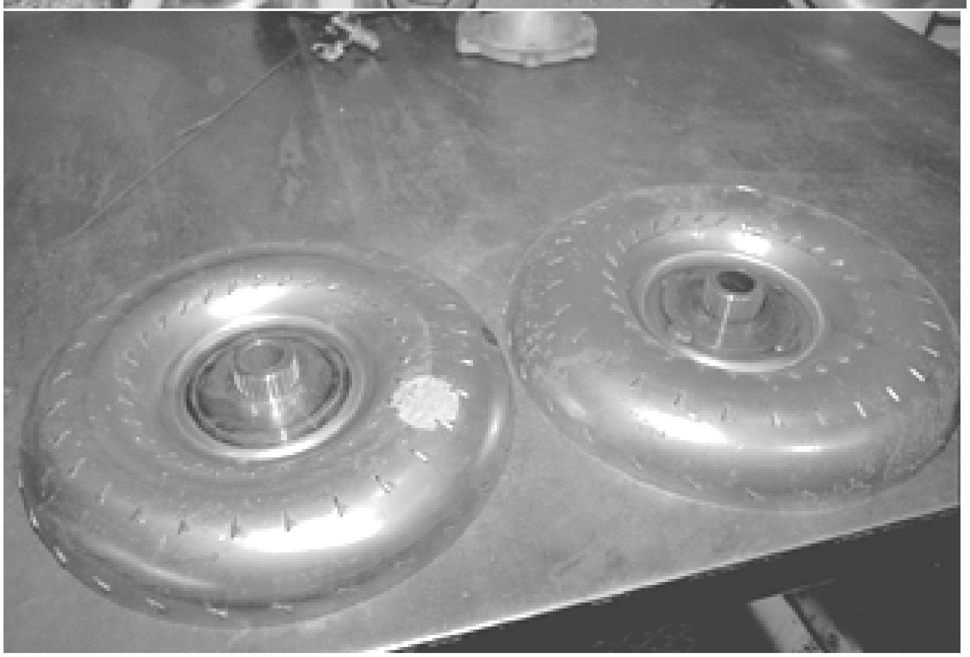


The hub mount surface must be turned flat and smooth or it could end up defective.

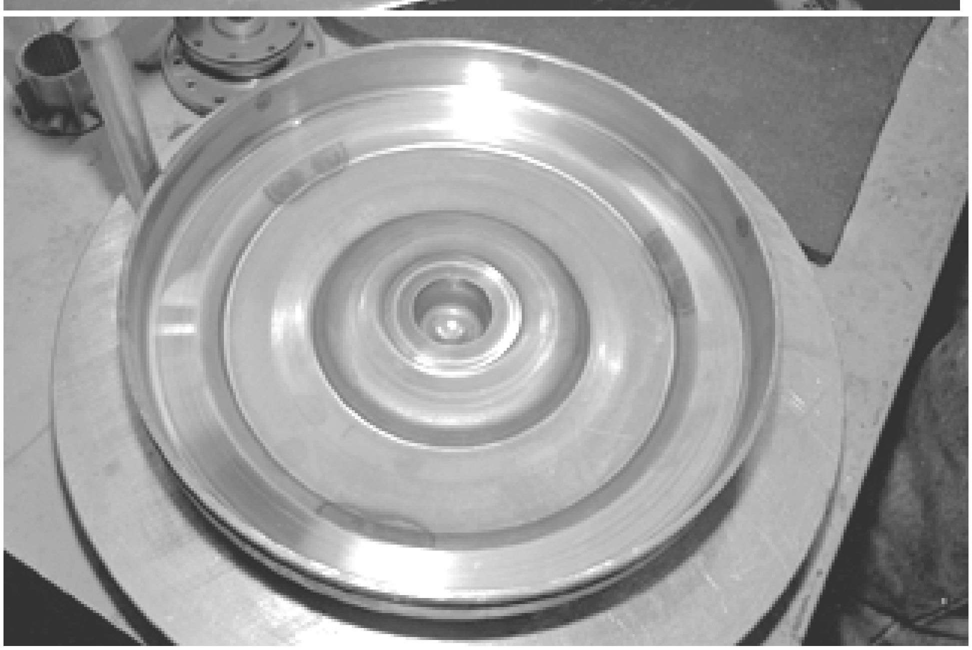




The front half is flipped over and the mounting lugs are trued. You'd be surprised to find how many of these are crooked, beat up, or stripped.



The turbine on the right is an early multi-part unit with spot-welded hub. The one on the left is the late-style one-piece with full-perimeter welded hub that is the preferred part.



The clutch rides on the front half of the converter cover. The contact area must be smooth, clean, flat, not burned, and not grooved or it gets chucked out. There is no effective and economical repair for damaged parts.

The new hardened hub sets on the converter housing in a special jig. The housing rests flat and the conical fitting locates the hub in the dead center.

Second, many will still have the bar-coded GM sticker near the hub which gives very specific information if you know how to read it (see sidebar). Greg tries to start with the most appropriate cores for the specific application.

After draining the converter, it goes to the lathe where the original weld is cut through. This allows the front and rear halves to be separated and turned to prepare them to go together again in a nice tight slip fit. As happens, the core we built also had a worn input hub so the rear housing was chucked up, the old hub cut off, and the housing turned flat. The bad hub will be replaced with a hardened hub and fully welded again.

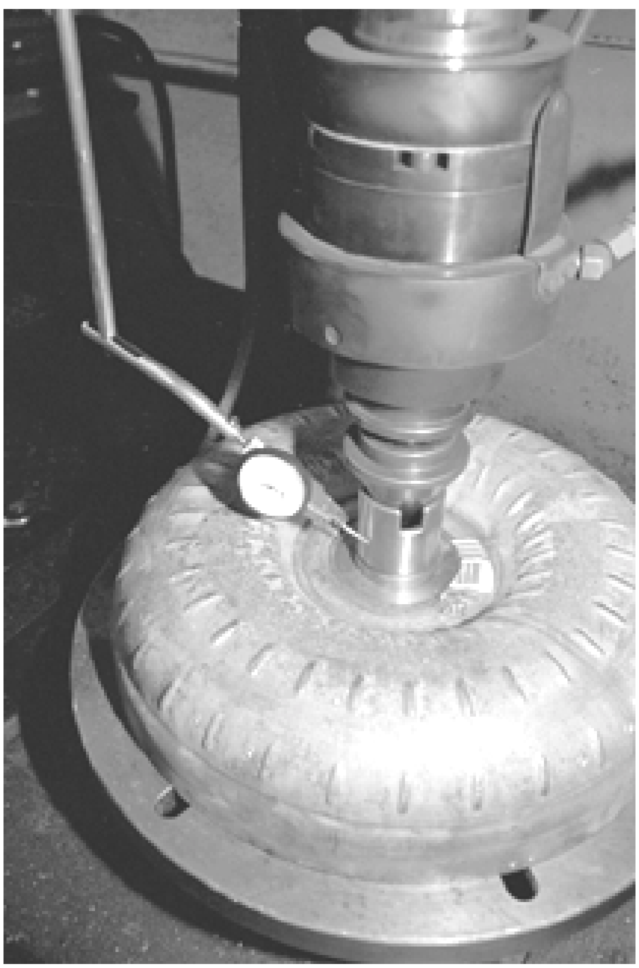
The other half also gets attention. The threaded lugs are checked for damage, re-welded as needed, and then the housing is chucked up in the lathe jig to true the lugs. This makes sure all are in the same plane and at right angles to the centerline. It's a common source of run-out in any converter.

If the clutch contact surface in the front half is in good repair or it can be cleaned up with light abrasive, the housing inspection and prep are nearly done. If the clutch surface is in bad shape, Greg discards it. To cut it down could weaken it.

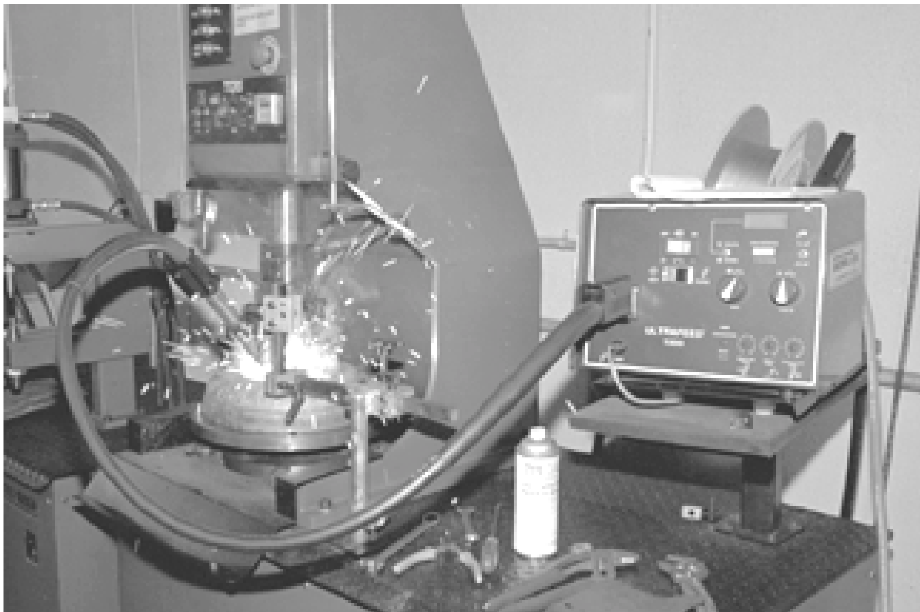
The remainder of the internal parts are thoroughly cleaned and all are inspected. There's a lot to learn about the condition of the converter and where potential problems could lie by taking a careful look at the parts before any are discarded.

Sub Assemblies

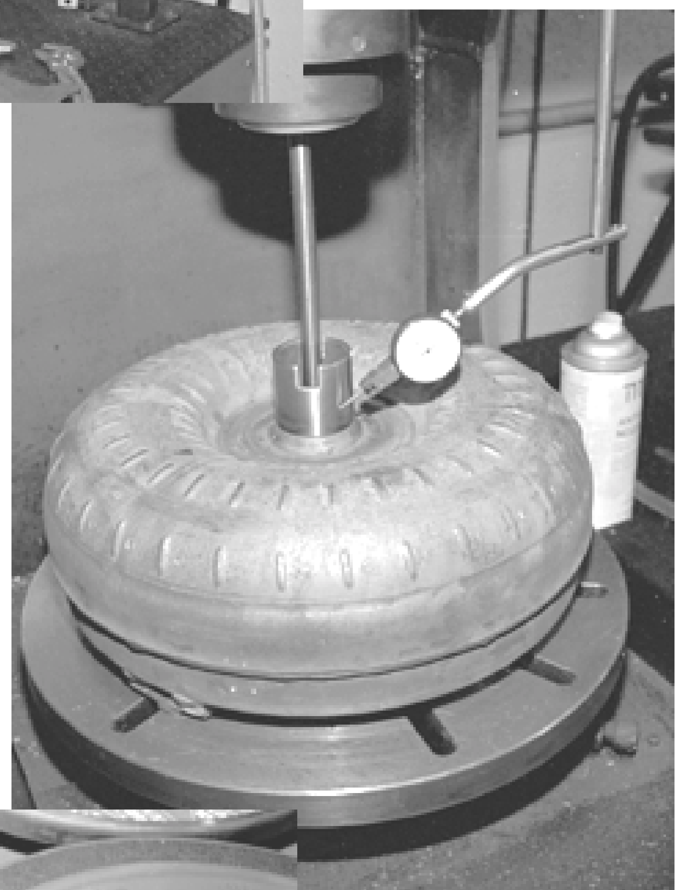
One of the first steps is to replace the hub. I can understand why some of the fast and dirty builders don't do this. It takes a good piece of equipment operated by someone who knows something about machining and measurement.



Minute adjustments are done according to a dial indicator. The hub must be indicated to have no more than .001 inch of run-out.



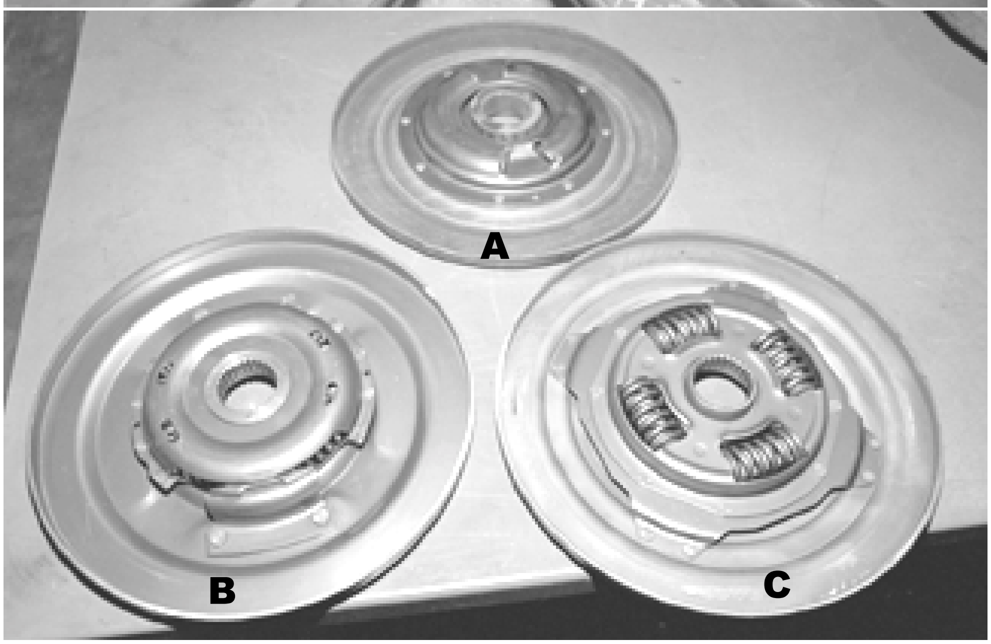
The entire jig is part of a welding rig. The turntable rotates and a perfect, consistent weld is made around the hub. This robot welding is far better than can be hand-done.



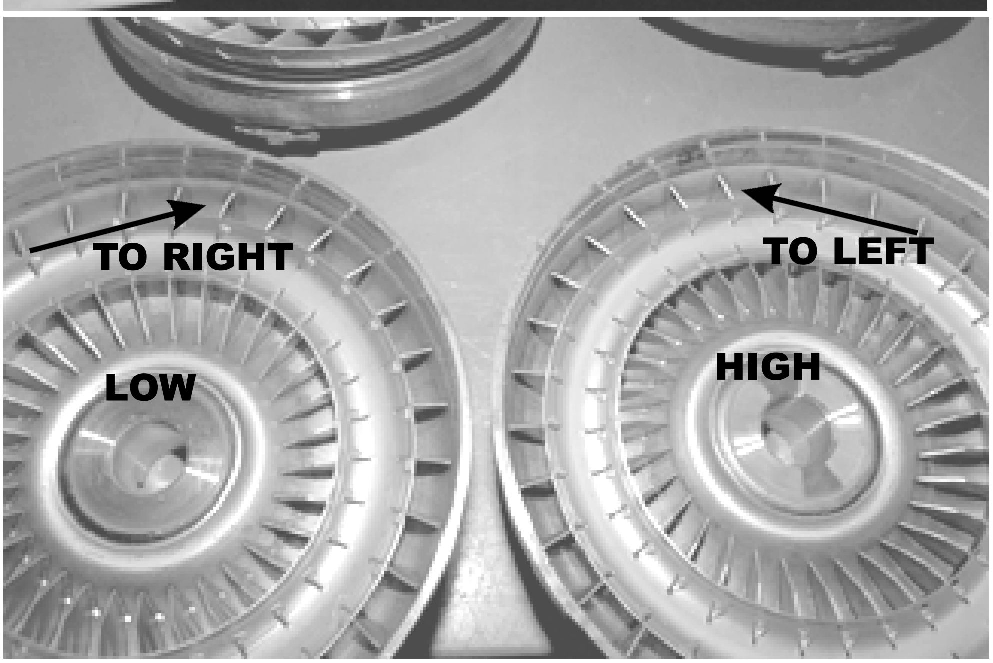
It's not enough to know the hub was within spec before the weld. It is re-checked afterward to make sure nothing was moved or distorted. Attention to such detail is what makes a great converter.

On the right is the woven carbon fiber clutch used in 1998 and later severe duty units. On the left is the carbon composite clutch which is a durable and heat-resistant material used in most applications 1992-98.

On the left is a paper faced clutch which is only good for the lightest-duty applications and which Phoenix never uses in its converters. On the right is the Kevlar material Greg bonds to upgrade or replace worn facings.



The common clutch damper units. (A) is the early HD damper, (B) is the late HD and performance damper, and (C) is the standard car and light truck unit.



Blade angle is the way stall speed is determined. The low stall impeller fins angle to the right for less aggressive fluid movement. The high stall unit on the right has blades angled to the left which really increases fluid pressure against the stator.

The housing is located in one side of the machine jig where a conical support positions it. On the other side a second conical fixture locates the hub so it is exactly on the centerline when the cones are pressed together. From there, William Buxton uses a dial indicator setup to check and correct run-out on the hub. When run-out is determined to be no more than .001, the hub is welded on with an automatic welder to ensure a clean, precise, and evenly-heated weld all around the hub.

Next Greg determines which clutch and damper unit he'll use. There are four types of clutches to choose from. First is the paper clutch. This is the low-end of performance and used only in low-performance applications and light vehicles. Second is the carbon composite clutch. This is a good quality material used by GM and it stands up well to most uses. Third is the Kevlar clutch which is a high-heat material and a common replacement material for higher performance converters. It was not used in OEM units. The toughest is the carbon woven clutch material used on extreme duty 1998 and later units. It was used especially where the trans was expected to cycle often between lock-up and non-lockup conditions. In many cases it's an over-kill.

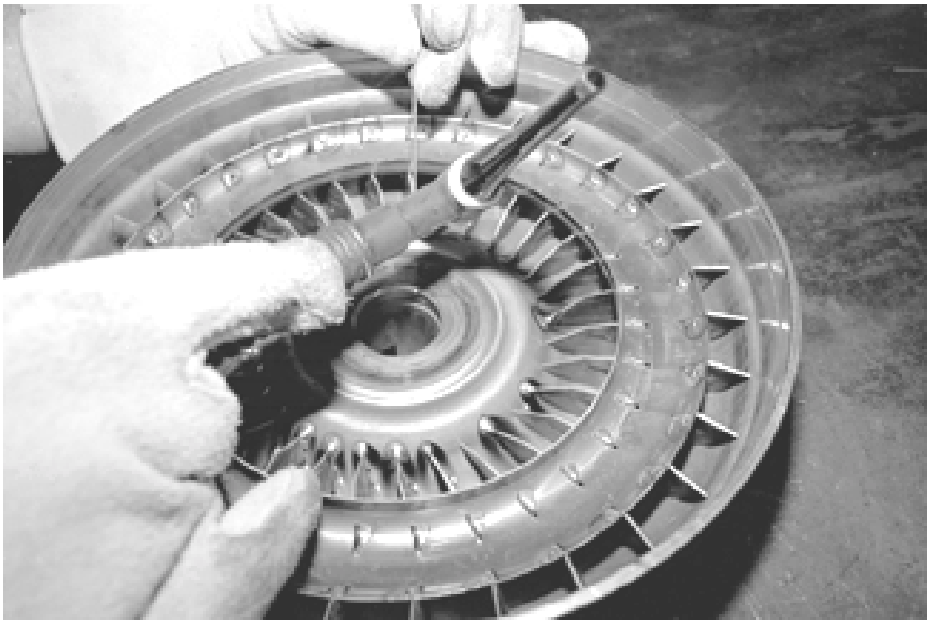
The clutch dampers come in three flavors. First is the early HD performance unit which is found in high performance and some diesels prior to 1992. The second is the late HD performance unit used in nearly all 1992 and later 700R4 and 4L60E's. The last is the standard car and light truck unit used in most 1980-91 GM lockups like the 350,200, etc. These parts are designed to cushion the application of the clutch much the same as a dry clutch plate works. For this application we used the late style HD because it is intended for truck use and trailer towing.

By the way, the clutch material is renewed by removing and cleaning off the old material and replacing the clutch material with a pre-cut section of the appropriate material. The new clutch is positioned on the clutch damper so it runs true and inserted in Greg's 'easy-bake' oven. Actually this special oven cures and bonds the clutch material to the damper at about 400 degree and under pressure.

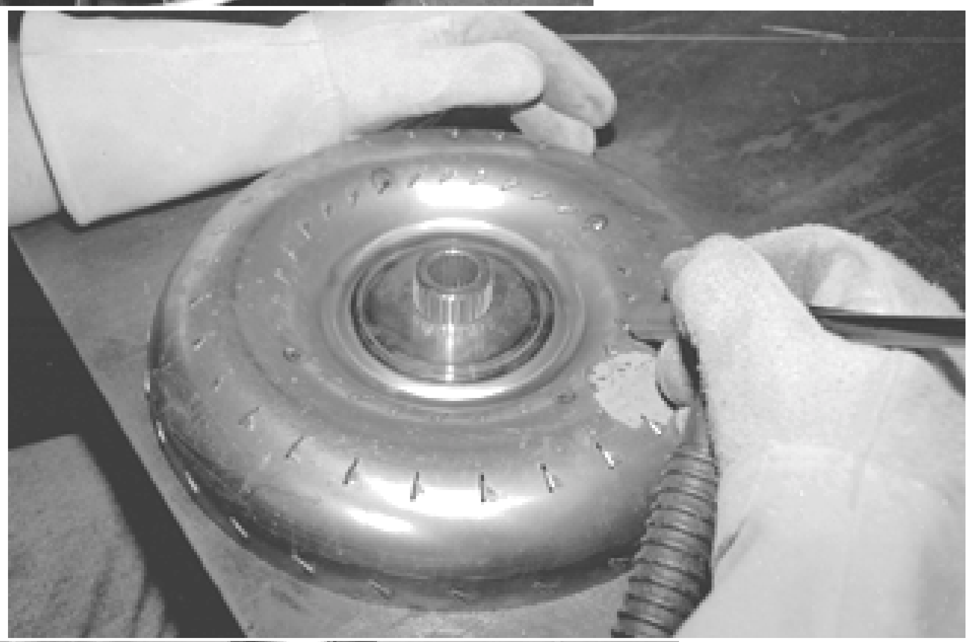
In addition to altering blade angle as required, William deftly uses a punch and hammer to tighten every fin prior to welding. More important small details.

Next up is the impeller. Impellers have fins which are critical for a couple of reasons. The impeller and stator are connected by fluid to transfer energy between engine and trans so the angle and direction of the impeller fins affects the stall speed. The more aggressively the fins angle into the fluid flow, the lower the stall speed. It's designed-in slippage under power. As noted before, there are several different pitches from GM to choose from and then there's modified fins. Greg can alter the fin angle to develop just about any stall speed you need.

While stock-type converters or low-performance units are less likely to have a problem with fins loosening or breaking off under hard use, Greg spot welds each fin using a silicon-bronze and a TIG welder. This insures the fins won't go loose and fail when you put the hammer down on a healthy engine or under heavy load. Welded fins also reduce flexing under hard loading so there is less likelihood of metal fatigue, vibration, or erratic function.

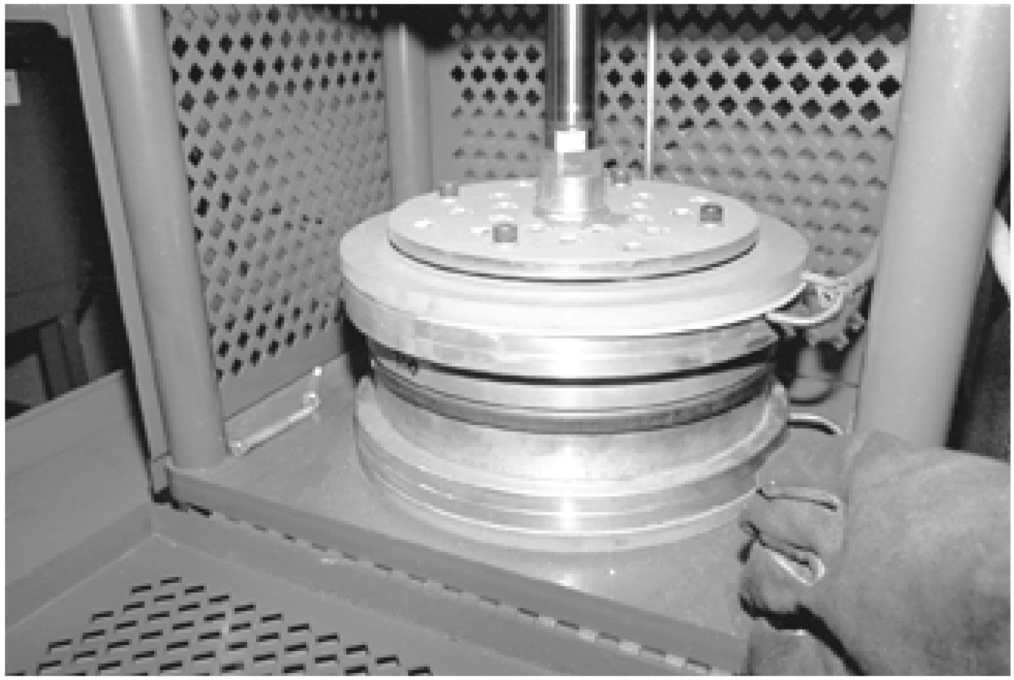


Each and every fin is spot-welded with a TIG machine by hand. Greg says it's important not only to weld each one, but make sure each weld is exactly the same and holds well. It takes skill and practice.



Yep, both sides! Greg is careful to make the spots very small and stagger the welds to keep heat soaking down. Production converters don't get this because it takes too much time.

No, Greg isn't making lunch - he's setting a clutch in the bonding oven. The Kevlar clutch material is glued to the plate, making sure it is centered and in it goes.



High pressure and 400 degrees make the bond permanent and help the clutch hold up under high-torque loads.

SIDEBAR #1 - converter body stamped codes

Most converters will have a number or letter stamped regularly around the outside of the housing. You can get a good idea of what you have from these stamped codes. Although the stall speeds are quoted, these vary depending on the performance level of the engine, vehicle weight, and gearing. It's good for comparisons.

#4 - 1211 rpm
diesel engines

#5 - 1611 or 2025 rpm
two different stators were used which changed stall

#6 - 1397 rpm
typical 5.0L and 5.7L unit

#7 - 1654 rpm
used in V-6, 5.0L, and 5.7L

#C - 2075 rpm
a #7 with brazed fins and high-stall stator
used in 1996 4.3L jimmy, Blazer, Bravada

#H - 1397 rpm
a #6 with brazed fins
used in 4.3L, 5.0L, 5.7L

#K - 1211 rpm
a #4 with brazed fins
used in diesels

#L - 1654 rpm
a #7 with brazed fins

Sidebar #2 - Bar code or tag decoding

GM used bar-codes and tags on many torque converters. A lot of detailed info is on them if you know how to read them. The first digit of the four is application. The second is stall speed and impeller type (brazed or non-brazed). The third is the type of clutch and dampers used. The last is mounting lug type.

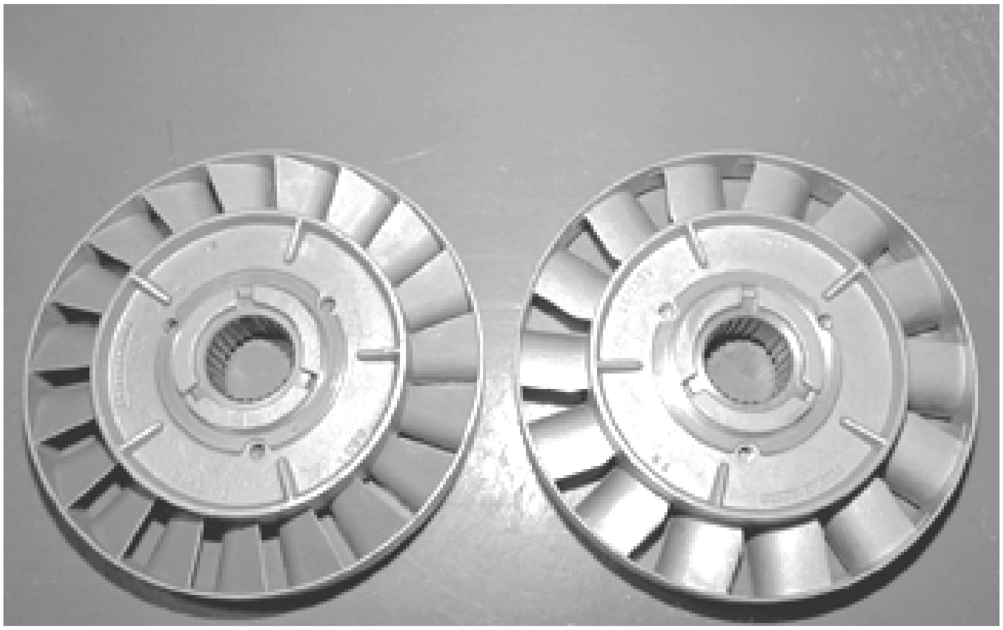
First Digit:
B=250C and 350C trans.
C=200C, 2004R, pre-1985 700R4, and 325-4L trans
D=1985 and later 700R4 trans

Second Digit:
B=2025 rpm
C=2075 rpm, brazed impeller
E=1654 rpm
F=1611 rpm
G=1397 rpm
H=1397 rpm, brazed impeller
K=1211 rpm, brazed impeller
L=1654 rpm, brazed impeller

Third Digit:

These are confusing to most people and relate to internal valving and capacities that won't do you much good without some detailed tech experience. On the other hand, if the digit is a G, H, or L the unit has the high-end woven carbon clutch.

Fourth Digit:
C= 3 round lug gas engine
D= 3 round lug diesel engine
E= 6-lug gas or diesel engine
F= 3 square lug gas or diesel late style
G= 3 square lug gas or diesel late style



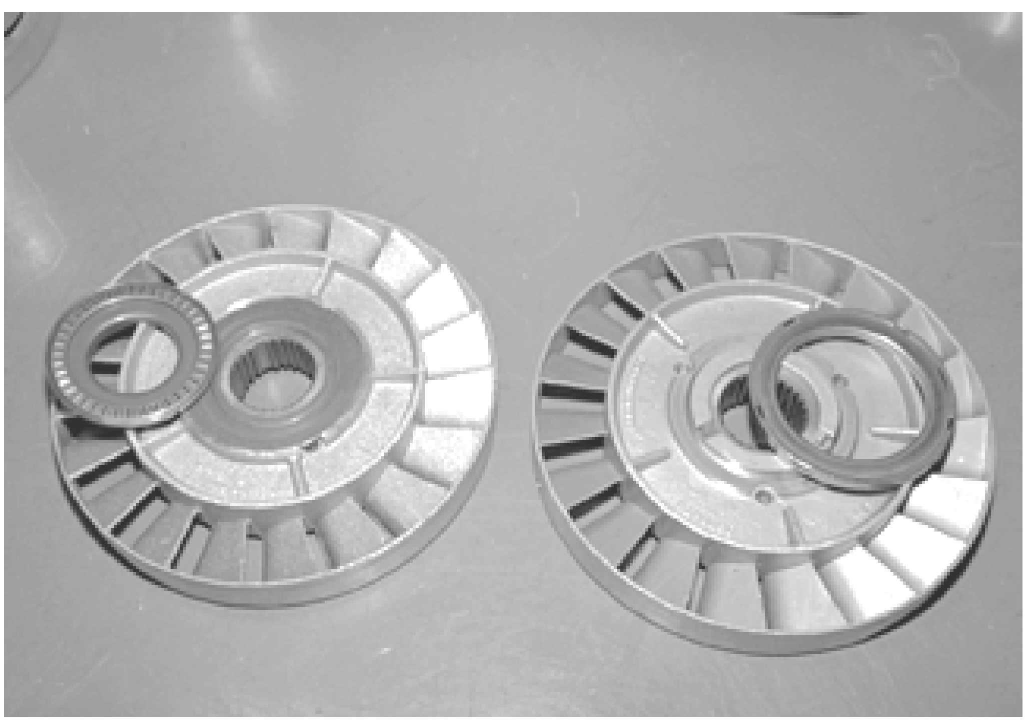
The stator on the Right is the rare high-stall part used in a very few 4.3 liter S-10's and turbo cars but never in the Corvette or Camaros

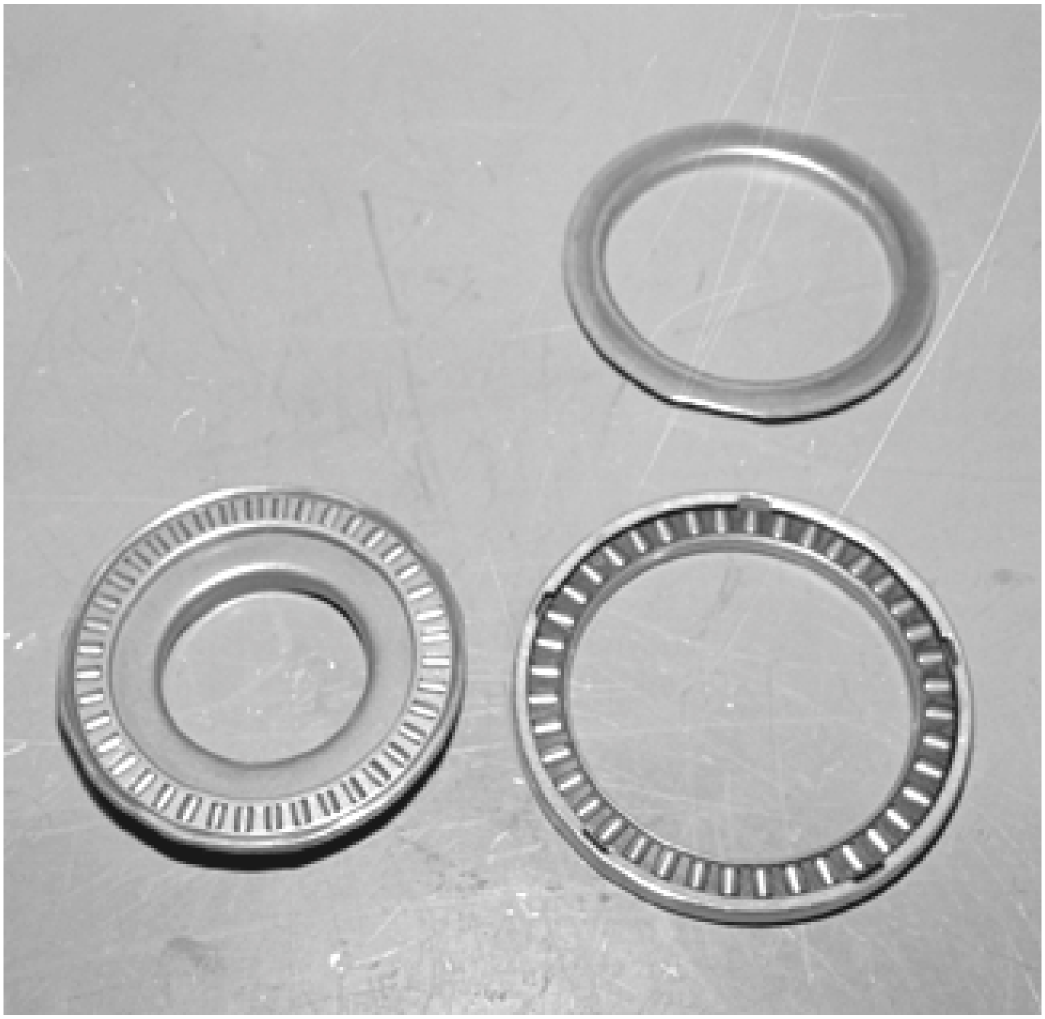
Stators

Stators make a big difference in how a converter functions in terms of stall speed for example, but I found there's more to it. First off, the early units used a smaller bearing which had a separate staked-in race. The preferred stator used a large one-piece enclosed Torrington-type bearing which is much stronger and less likely to fail. This is an optional upgrade Phoenix uses on all 300+ hp applications but one that might be a good idea if you are putting it behind a high-performance engine, a heavy vehicle, plan to do a lot of towing, or foresee a lot of miles on it. It's another one of those options that depend on comparing the cost to the benefit and you have to be the judge of that.

Next there's the high or low-stall aspect. In truth, there are only two basic styles according to Greg. The first is used in almost everything and is the standard low-stall unit. The second is somewhat rare and was used in a few 4.3 liter S-10's and turbo'ed cars like the Grand National Buicks as a factory special. Contrary to myth, these were never used in Camaro or Corvette units. The High-stall unit has fewer blades and therefore allows more driving fluid to bypass the fins and offers less area to be pushed against.

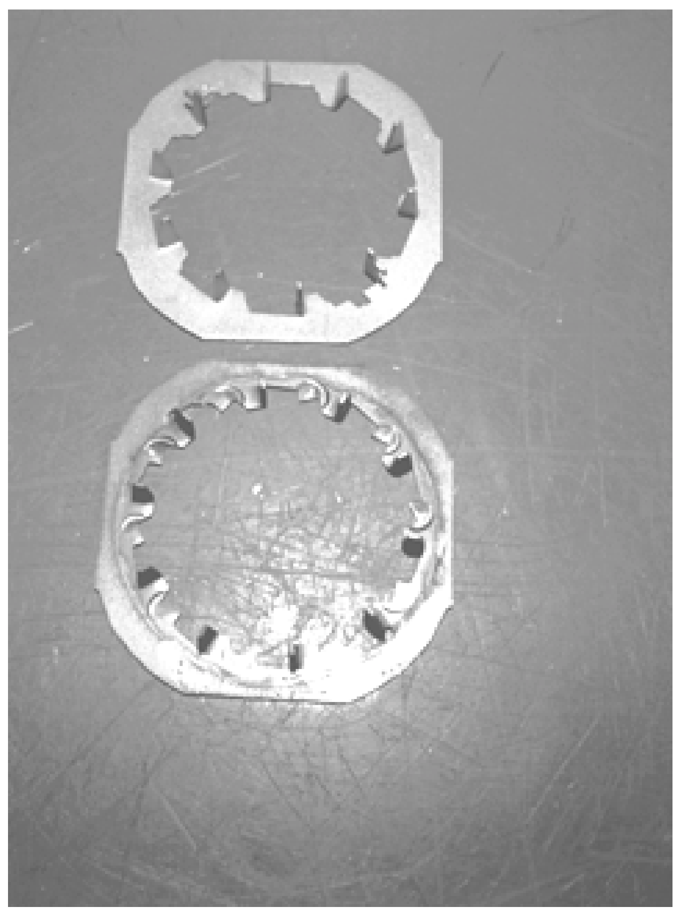
The stator on the right is the late-style part with the large one-piece enclosed Torrington bearing. The other is the early style with the small Torrington with separate staked-in race. The right choice is obvious.





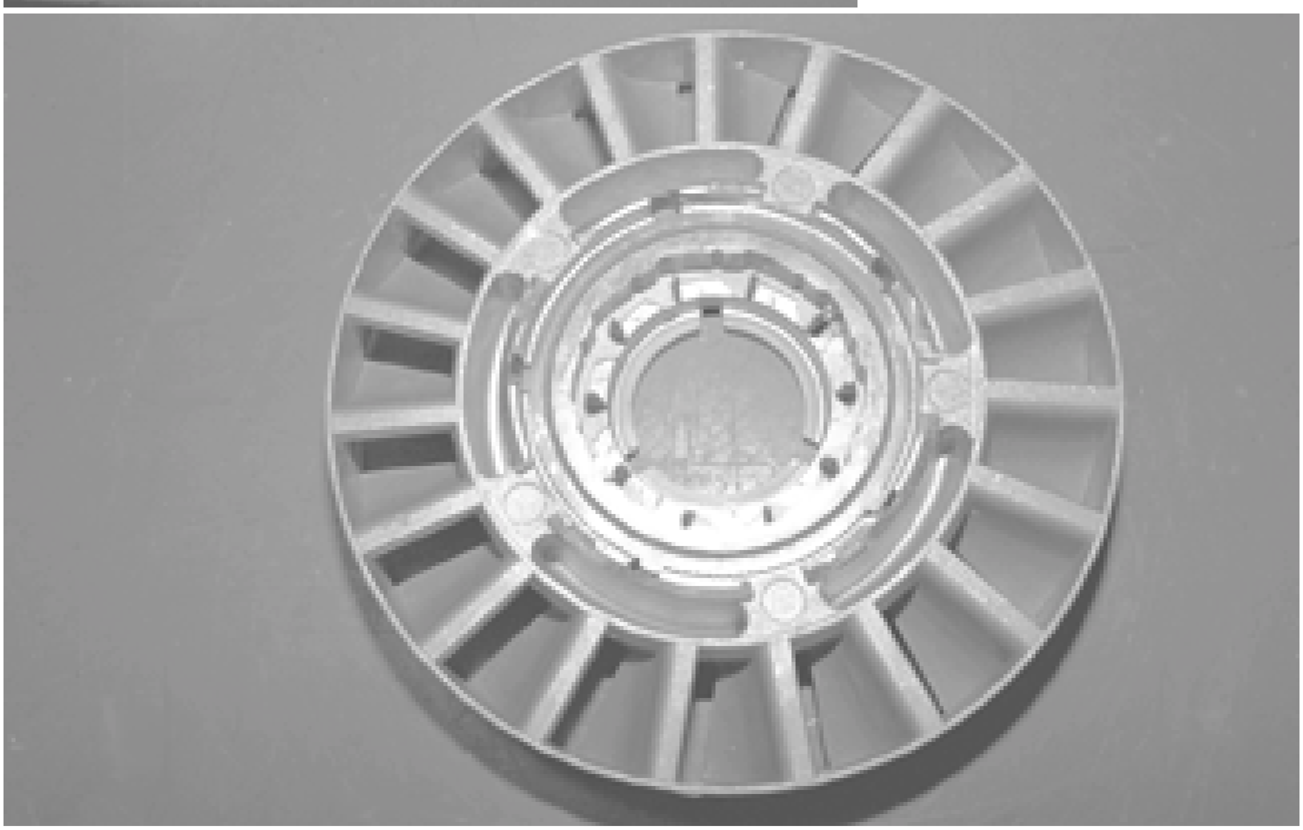
The large bearing (opened up for the picture) not only has more bearing rollers but more contact area to spread the contact energy across. Less friction and less heat buildup.

For the most part, the stall speed is determined by the pitch of the turbine in these converters. As you may recall from last month, there are some serious differences and Greg can also tailor the turbine pitch to change stall speeds to suit your specific application.



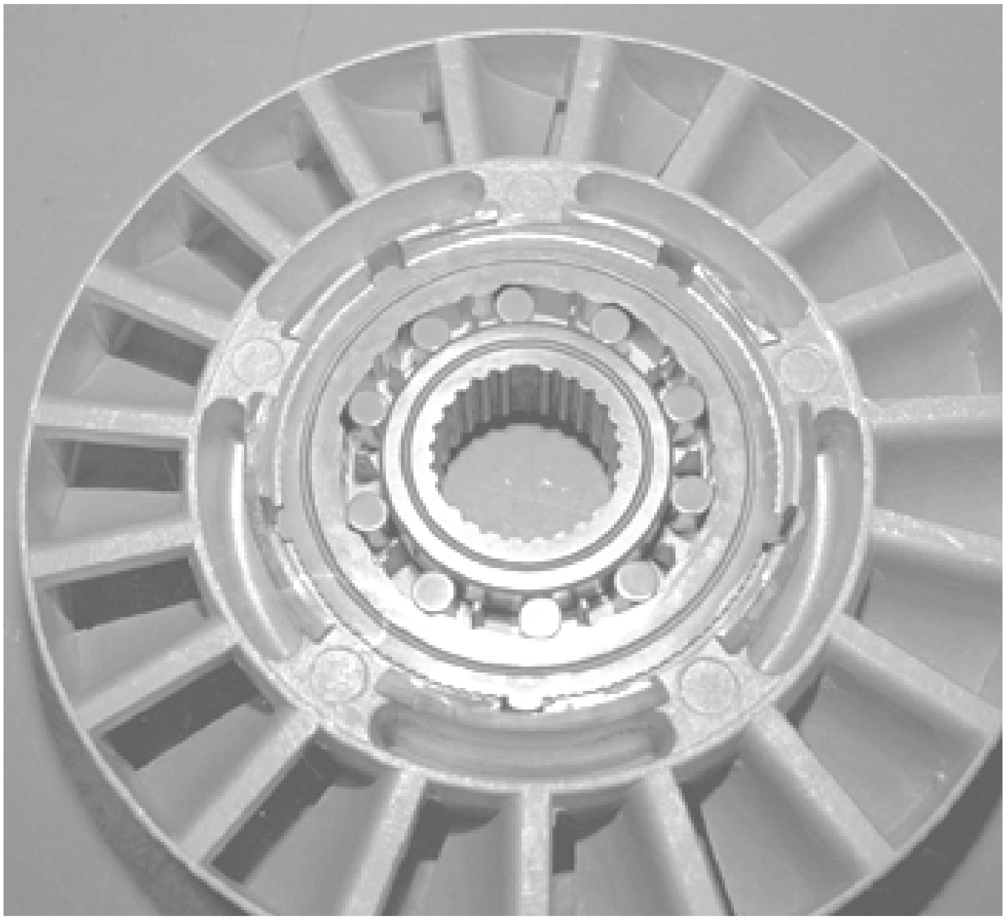
The Sprag cage on the bottom shows the kind of extreme wear that can cause trouble. The cage aligns both rollers and springs for correct function.

The cage sets in the bottom of the stator after the stator is checked for damage or cracks.



The Sprag cam sets over the top of the cage to retain it. The cam must be in perfect shape or it will rapidly fail.

The Sprag inner race is next. It must seat in the stator fully and without play. It is a hardened part that takes a lot of stress so it is always closely inspected and replaced for even minor wear.

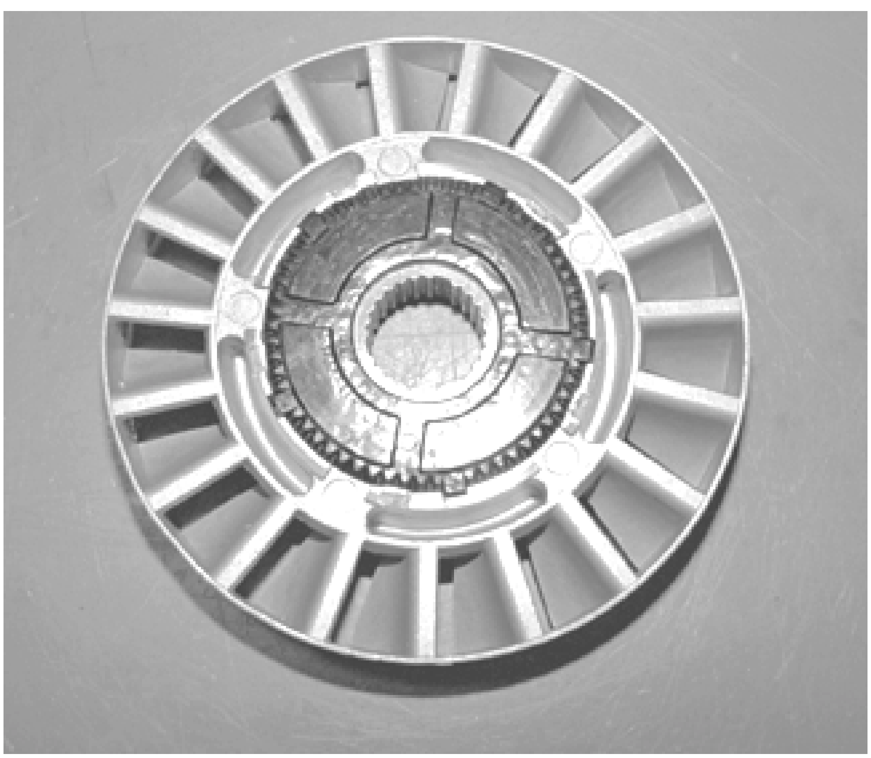


You can see how the rollers fit into the cam. They require correct clearances so any wear is a death warrant.

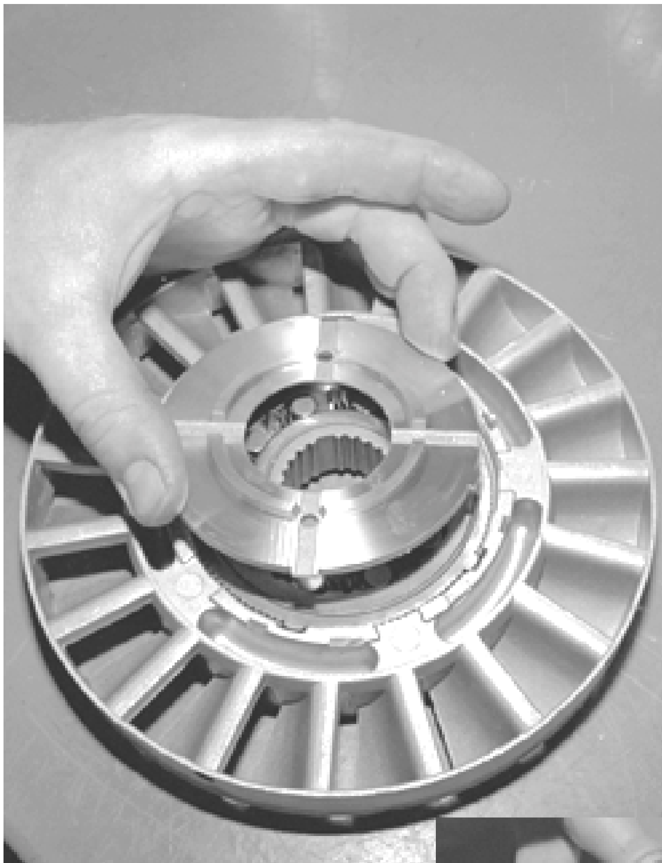
The accordion-like Sprag springs keep the rollers pressed to one side until the rollers and cam are engaged and return the rollers. Broken, damaged, or compressed springs won't do.

Inside the stator hub a Sprag unit is located. A Sprag is a type of one-way clutch and takes a lot of abuse. It keeps the engine from free-wheeling when you lift the throttle and helps multiply torque on acceleration. At the bottom is a Sprag roller cage which keeps the rollers and springs in alignment and provides a place for the rollers to rub that's tougher than the aluminum stator. This is one of those parts that always gets thoroughly inspected and replaced if the y show wear. The same goes for the Sprag inner race, and the rollers and springs (most are replaced). These can make a big difference in how long the Sprag works right, and the cost of the parts is not all that high. It surprises me that some builders will forego a couple bucks in new parts, making minimal extra profit but a lot more failures. Unfortunately the whole transmission industry is infected with too many of these hacks.

Not all components require upgrade, though. For example, GM units use a phenolic washer on the back of the stator and it works fine in many applications. Phoenix prefers a Torrington bearing and spacer conversion in their performance units. The conversion requires an aluminum plate machined to the stator and the new bearing which rides against the turbine. For serious performance this is a real asset, but for the vast majority of streetable vehicles the phenolic washer will last and perform perfectly.

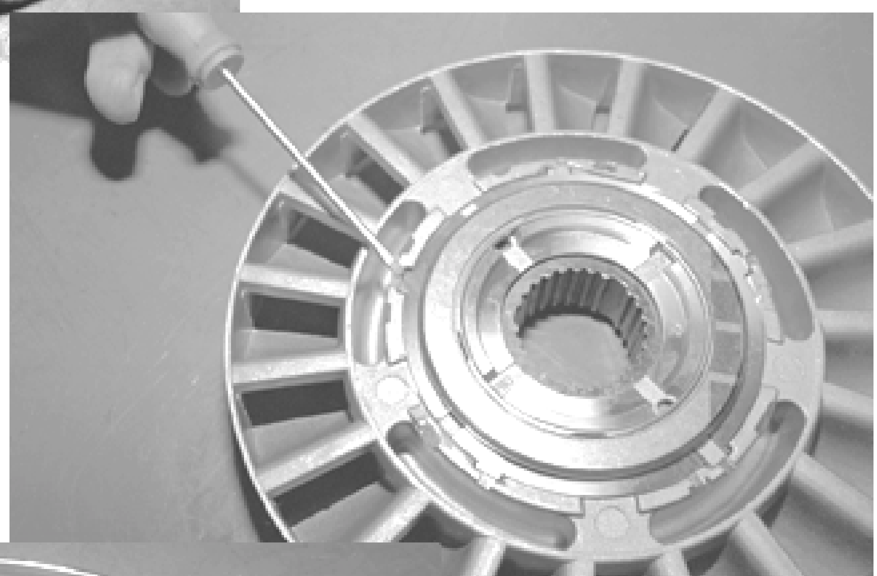


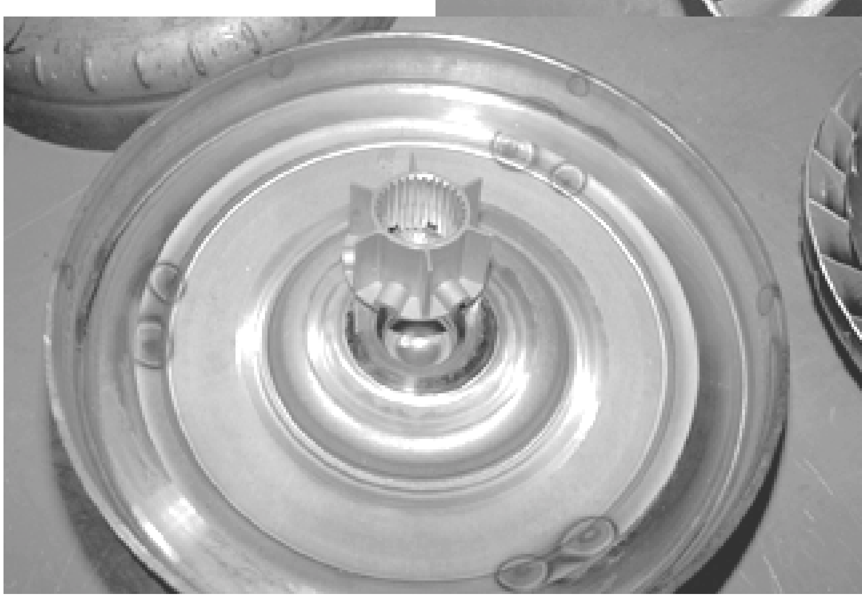
A phenolic spacer is used in stock stators and work well in most cases.



An aluminum spacer is installed instead of the phenolic spacer for high performance or severe use.

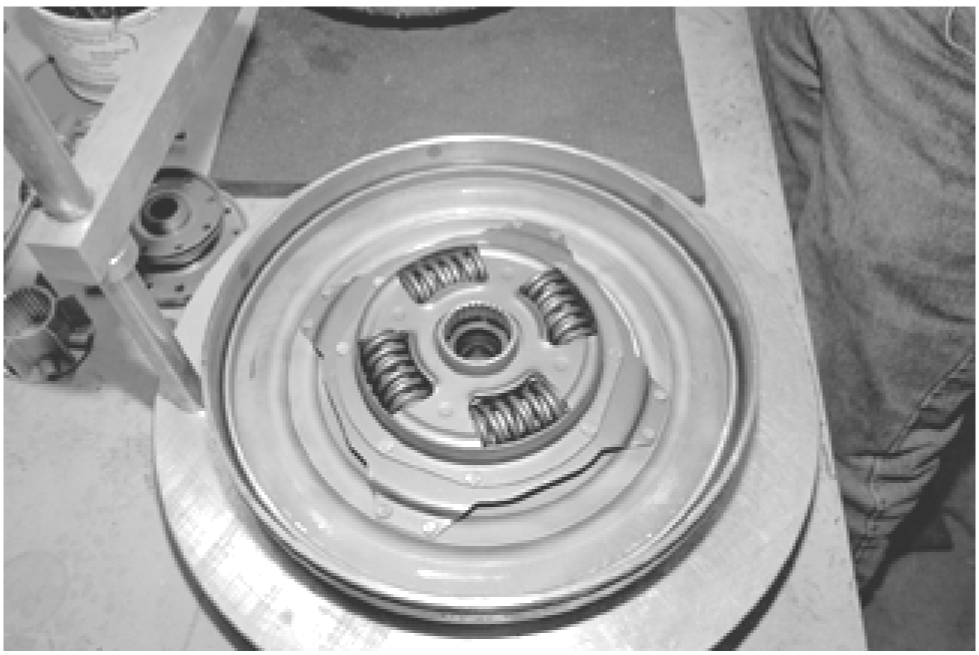
The spacer is staked into the back of the stator to keep it from moving in and out.





If you want to eliminate the lock-up, the entire clutch assembly can be replaced with this machined hub/ spacer.

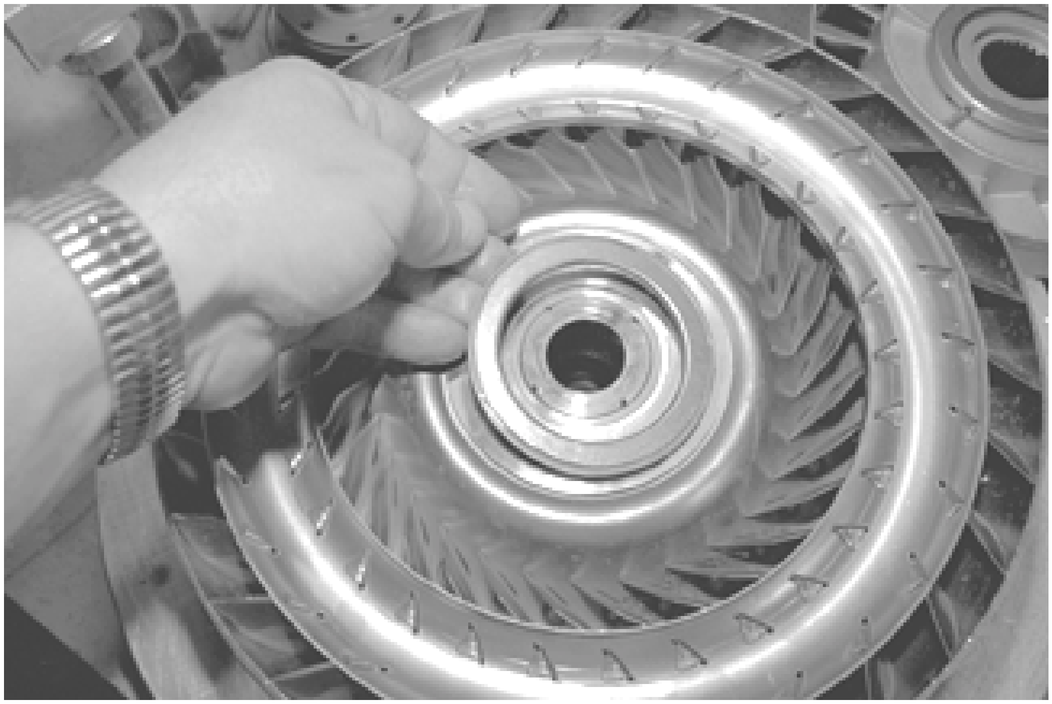
This phenolic insert sets end-play and seals the input shaft to the clutch hub as well as determines overall converter height. They come in various sizes for adjustments.



The late HD clutch damper with the Kevlar clutch face seat in the front half of the converter housing.

The modified and silicon-bronze welded turbine is next in line over the clutch.

This Torrington bearing is the other half of the phenolic spacer replacement. It goes between the turbine and the stator.



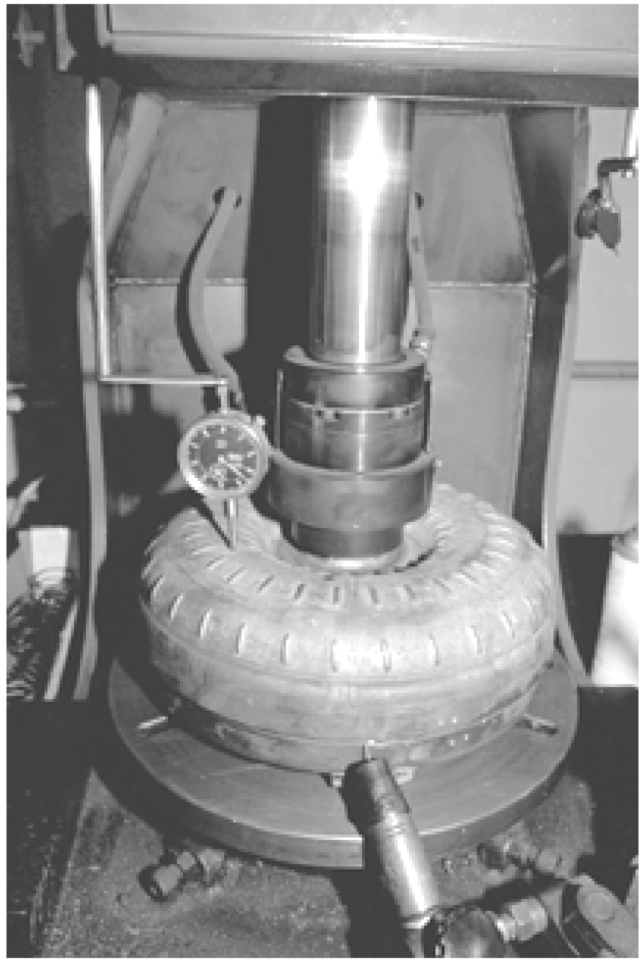
Speaking of conversions, there is a special hub made to replace the entire lock-up clutch assembly to eliminate lock-up. This is sometimes used in off-road or very high performance units where the clutch is either not needed or has the potential to cycle too often or even outright fail do to extreme abuse. In almost every case, a street vehicle performs best with a properly functioning locking converter.

Assembly

Once the sub-assemblies are rebuilt and/or modified, it's time to assemble the converter. One of the first items of concern is a phenolic spacer that fits between the clutch damper and front housing. These are made in selective sizes and are used to set end-play, overall height of the converter unit and also makes the seal between the converter clutch piston and input shaft. Just slapping a new O-ring on it won't make it right. If worn they are junk and may leak around the shaft even with new shaft seals.

A lot rides on the converter assembly having the right internal end-play and having the total assembled height of the converter correct. No matter how good the parts, if the specs are not made right you've still got a load of junk.

This is the complete internal assembly with the stator on top - ready to cover.



The height and run-out are checked I the welding machine/jig before any welds are made. Alignment is critical and can make or break a converter.

For this reason, Greg determines and/or sets the height of the internal components. They have to be within a narrow range to function correctly. This overall height is compared to the to the height of the converter housing to determine the total internal end-play and the final height of the converter. I've stood and watched as another large builder slapped converters together without once checking this, so I can tell you from experience not all are alike.

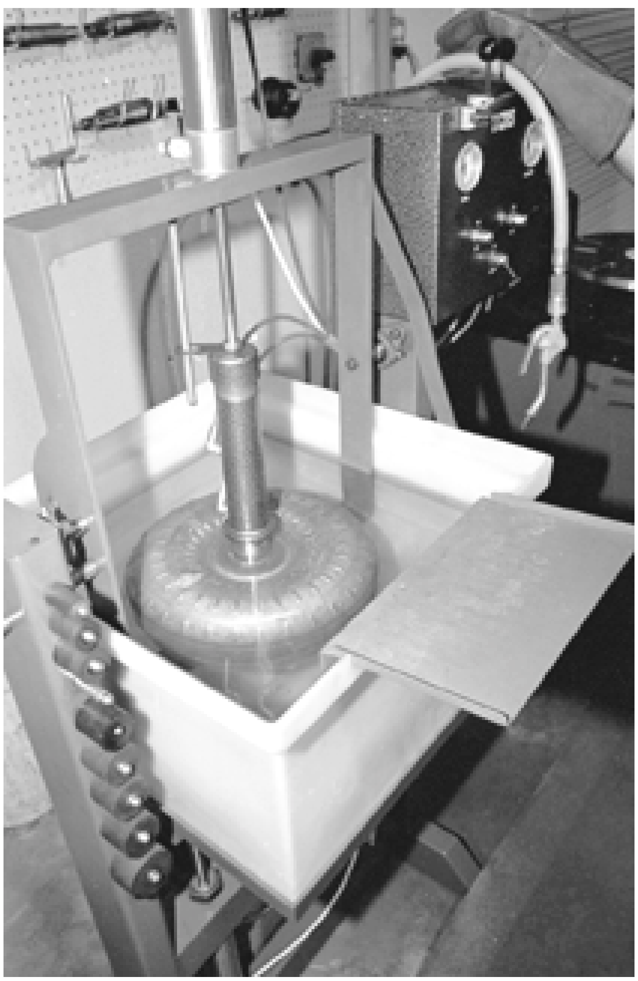
On top of the clutch the turbine unit with the silicon-bronze welded fins, the Torrington bearing for the HD conversion from the phenolic spacer and the assembled stator/Sprag unit are installed. Finally the back half of the converter is slipped into the front half.

From here the converter assembly goes to the welding machine. The machine is also a jig which allows Greg to position the two halves precisely where they must be. The internal over-all end play is set by the total height of the converter housing, so the halves slide in and out to get to this point. You may recall from the first part how William Buxton turned the housing halves so they had a slip-fit so this operation could be completed with concentric housings. Both the height and the run-out is checked and set with a dial indicator before any welding.

Welding starts with a series of alternating tacks which fix the position of the halves and make concentricity easier to retain. When this is done and the specs checked, the entire circumference is machine welded for a consistent weld. Welds are critical for several reasons. First is simple penetration and strength. Second is the need for air-tight welds to prevent leaks or seepage. Finally, irregular welds make balancing harder. If you see welds that look poor, they probably are and you should look for another source.

You don't back-yard a converter. It takes expensive and specialized equipment to get it right, like this welder/turntable/assembly jig made just for converters.

Clean, strong, and very consistent welds are made in the machine welder. Bad welds mean leaks and imbalance problems.



All converters are pressure-tested at 120 psi. Not even the smallest leak is acceptable.

Final Tests

Once the welds are done, the converter is double-checked for run-out and height. After the converter has cooled, it gets pressure tested for leaks at 120 psi. For obvious reasons, even the smallest leak is unacceptable. If a minor pin-hole is found it can be spot-repaired, but if there is more there was a problem with the weld that requires re-opening and re-welding the converter. A visual inspection to seek out any defects or flaws in done and the mounting lug threads are chased.

All Phoenix converters are balanced to zero on a special converter balancer. This is another area where the cheap converters fail. In the last few months I have had some checked and found 20-30 grams of imbalance to be common. The result is increased wear and vibration problems. Greg sees it as not only an assurance the unit will work smoothly and last a long time, but an indication of potential problems. If a converter shows up a large amount out of balance, there is some concern that one of the components is defective.

I installed the converter used to demonstrate for this article in my own truck behind a tuned-port small-block and have to say it works perfectly and is completely smooth and vibration-free. The converter I removed was a parts-house item. I changed only the converter and eliminated an irritating vibration. The converter I removed and took to Greg was checked out and found to be in such poor condition that rather than rebuild it it was tossed in the scrap. It's nice to be able to identify a problem and know it is resolved.

Even details like the threads in the mount lugs are checked and cleaned. Shops that do this kind of quality rarely see failed returns because they pay attention to details. How many times do you want to replace a converter?

That zero on the balancer readout means just what it says. Zero balance is not an option if you want a smooth and durable converter.