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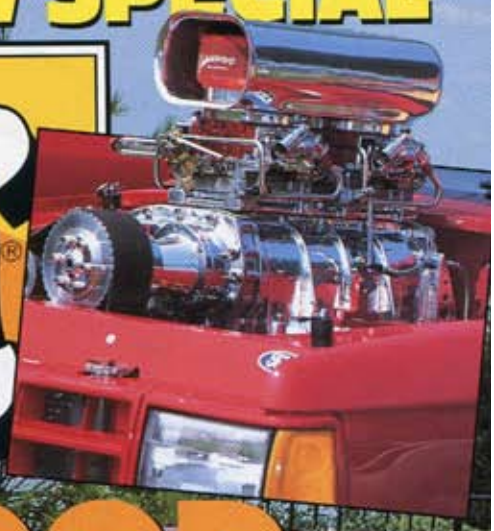

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TECH HOW TO:

THE PROGRAM

Bomb-proofing Ford's E4OD

BY GORDON TARBELL

Jim Galatioto, the star of this segment of *Truckin'*, has almost 30 years of experience in working on automatic transmissions. He has devoted much of his career to developing new parts to improve the performance and longevity of automatic transmissions and valve bodies, and as a long-time fan of Ford products, has done extensive development work with the C4 and C6 units, among others.

While the main focus of his business is building transmissions for the racing world, he long ago realized that many of the concepts essential in that realm also held great benefits for the truck market. Many truckin' folks have discovered this, too, and automatic equipped trucks of all shapes and sizes, including motor homes, have limped into (or have been towed to) ATO Performance Transmission, his Rancho Cordova, California facility.

Therefore, it was only natural that he would turn his attention to the Ford E4OD transmission after it became available. In fact, it wasn't out for too long before he had his first chance to work with one.

"The first one I worked on, in 1990, had a broken overdrive planetary," he said. "It was on a commercial truck, and it was just out of warranty. Since then, we've had them in for such things as blowing the snap rings off of the overdrive clutch piston, broken gears, worn-out pumps, blown-out seals, worn-out overdrive sprags, and broken rear sprags. We've had vehicles with the forward clutch rings wiped out from the center support bouncing around.

"They'll come in with all the clutches fried, because the transmission ran too hot for too long. We've seen them come in with the overdrive input shaft broken off, sheared right off, due to an earlier design which had a weak shaft.

"We also find a lot of premature bushing wear, and premature thrust washer wear. The damage caused by overheated fluid alone can be catastrophic, and for a variety of reasons these transmissions, as built by the factory, have a tendency to run hot.

"What we have developed here over the years is an upgrade that addresses this problem, and virtually all of the others we have ever encountered. There is always a reason for a transmission failure, and once that reason is found, we've usually been able to devise a solution.

"Just about everything we do to upgrade an automatic transmission satisfies two requirements: Minimize heat and facilitate the movement of the fluid with the system."

Friction, of course, is the main cause of heat, and much of ATO's efforts have been devoted to minimizing unwanted friction within the transmission as much as possible. Galatioto went on to describe the ways he has been able to accomplish this.

"One of the main things we've done is make changes to improve converter feed circuitry. Converters like fluid, and if you run them low on fluid they start to run hot. By having a system that would allow a greater flow of fluid under demand, when it needs it, it cuts down on the heat.

"Also, the factory likes to use thrust washers wherever they can, mainly because they're a whole lot less expensive than anything else. When you're building a million of something, that may seem to be an important factor. But thrust washers are by their very nature friction and heat generators, and the ones used in the E4OD are bronze washers with a babbit coating.

"This is the same material that is used in rod bearings. However, unlike in that application, the babbit used in the thrust washers isn't hardened. It's relatively soft, and before too long there can be serious, unwanted metal-to-metal contact, which is not a good situation.

"This is especially true with the rear planetary of the E4OD," Jim says. "The standard helical cut of the planetary gears and the sun gear preloads the gears and keeps them from whining, but results in a 'screwing' effect, where the planetary is being forced onto the thrust washer. With a heavy load situation, as with a heavy truck, or when there is a lot of torque output, like with a turbo diesel or pulling a hill in overdrive, the planetary is actually 'screwing down' on the thrust washer with tremendous pressure.

Jim Galatioto of ATO Performance Transmission Products examines some of his modifications to the components of the Ford E4OD automatic transmission.

ATO's improvements to the E4OD start right at the beginning of the front pump. A groove is machined into the cover to enable a locking seal retainer (right) to replace the crush-fit factory front seal, eliminating a potentially major hazard.

It'll start to get hot, it'll turn blue, and start chafing off metal.

"What we have done is to replace most of the factory thrust washers with needle bearings. These bearings are better able to handle the thrust loads in the trans, and eliminate the friction and heat buildup problems common to the washers. To maintain the proper endplay and hold the bearings in place, we machine down the surfaces that the bearings ride on to precise tolerances."

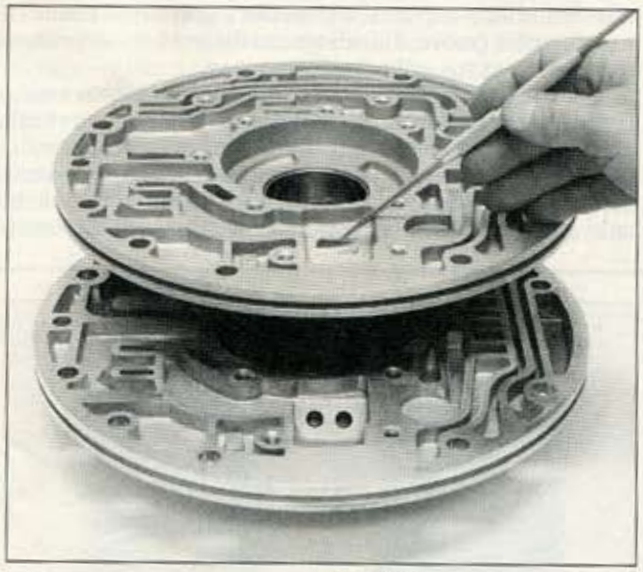
When asked about the longevity of the bearings, Galatioto said, "The bearings can take more load, and more heat, with less friction and will last longer than the thrust washers."

Needle thrust bearings also replace thrust washers on both sides of the front planetary, and on the parking gear. "We've seen E4OD cases that were ruined because the thrust washer on the parking gear got hot and tried to adhere to the surface of the gear," Galatioto said. "Once it starts spinning, it doesn't take too long to chew through the back end of the case, and then the case is junk."

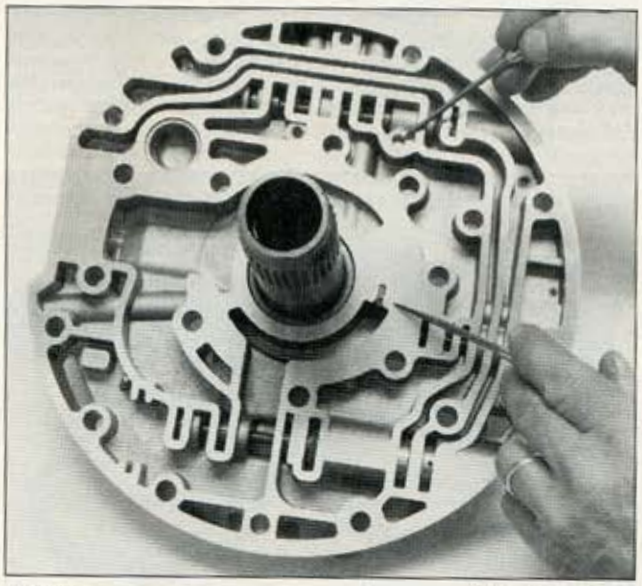
One other new bearing finds its way into an ATO rebuild. The overdrive input center shaft is machined to accept a roller bearing where it passes through the center support housing, which is bored out to achieve a slip-on fit. This cuts down on the premature wear of the case bushings, and solves a host of related problems.

"In the E4OD," he said, "you have two case bushings. The main shaft comes through the case bushings, and the sun gear is riding on this shaft. The sun gear in turn supports the high clutch drum, the forward clutch drum, the front planetary, the rear planetary, the front ring gear, and the rear ring gear. That's a lot of mass. The high clutch drum rides up over the back of the center support housing, but the high clutch drum can't support the rest of those mechanisms.

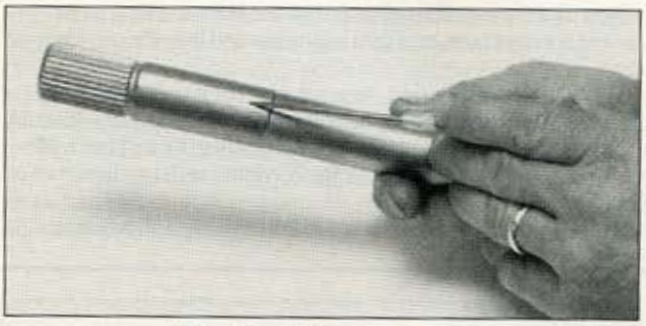
"There is no support where the overdrive input comes in and connects to the forward clutch drum. This puts an extra load on the case bushings and the sun bushings, and they prematurely wear out. In fact, it's not uncommon to see them go away in only 20,000 miles.



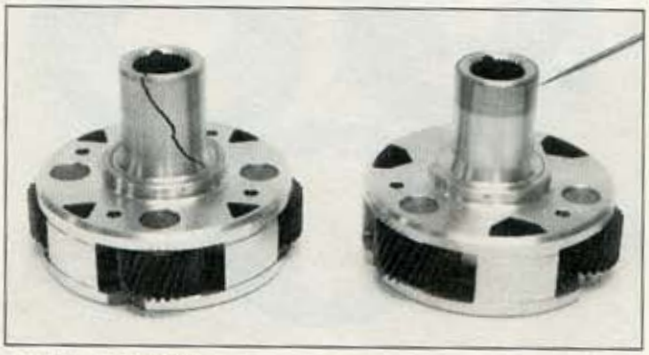
The space between the two pump-suction inlet holes in the front pump cover has been machined out as indicated, resulting in a greatly improved volume of fluid passing through the filter and into the pump.



Two other modifications are made to the front pump. At the top, this passage, used to exhaust fluid from the converter when it locks up, is enlarged from .060-inch to .250-inch, providing for a crisper clutch application and less clutch wear. A small hole is also drilled into the cover (lower pointer) to feed the overdrive sprag assembly with pressurized fluid instead of from the converter-feed circuitry.



The turbine input shaft has four slight slots machined down the length of the shaft, 90-degrees apart, to improve the flow of fluid into the converter, with less restriction, and out of the converter when it locks up. Facilitating this movement helps keep the fluid temperature down.



On the left is a stock overdrive planetary that has suffered a torsional stress crack, a failure that leaves a vehicle dead in the water. An inherent weakness in the E4OD, the planetary, which works off of the turbine input shaft, is made of cast aluminum. ATO machines down the OD of the planetary neck and presses this sleeve, made of 8620 gear steel, into place to eliminate this problem.

Most of the thrust washers used by Ford (left) are replaced by needle thrust bearings in the ATO upgrade, minimizing friction and heat buildup. This is the E4OD's rear planetary, which encounters severe helical-tooth thrust loads.

"What happens next is that the forward clutch drum starts walking off of center, which causes the sealing rings in the clutch drum to start eating away at the inside of the center support housing. Once the ring seal goes away, the forward clutches go away because they have now lost the pressure that causes them to apply, and they soon burn up.

"By adding this bearing to the system, there is now support at the midpoint of the assembly. The case bushings don't have to carry the entire load, and everything lasts longer."

Those rings on the center support housing also receive some attention at ATO. The cast-iron factory rings are replaced by a wider, Teflon ring.

It took Galatioto a lot of research and experimentation, and attempts with dozens of formulations and configurations of synthetic materials, but in 1975 he was able to develop the Teflon seals that he has used ever since. He has found that they are ideal in most transmissions.

"In a cast iron or steel hub, hardened steel or cast iron rings will wear out. There is a lot of friction and heat, and as the ring expands it puts even more pressure on the bore, causing even more friction and heat, and the rings wear and lose their compression fit.

"Teflon is very forgiving. When it gets hot it softens up, and when pressure hits it, it expands and conforms to the bore. It seals much tighter, and with less friction. Plus, this stuff will last a lifetime. I've been using these rings for 20 years, and they have never failed me.

"Some transmission builders don't like using Teflon rings. They probably had the same difficulties I had with the wrong material, but I just wouldn't give up until I found the right stuff.

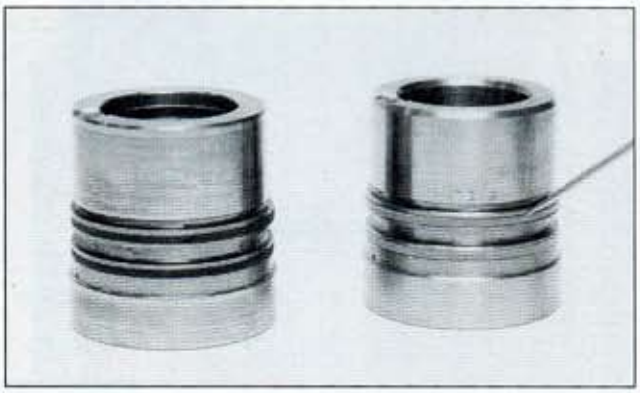
"Also, it is common to apply air pressure during the transmission assembly to feed the clutch pack and watch it apply and release. When Teflon rings are used, an incredible amount of air leaks past them, and it probably gets the builders worried. But automatic transmissions operate with fluid, not air, and in this particular fluid environment the Teflon rings are awesome.

The input shaft seal also gets changed, but in a different way and for a different reason. The factory uses a crush-fit seal on the front pump housing, but the different rates of heat expansion between the aluminum housing and the steel seal retainer can be a major problem. It is not uncommon for the assembly to heat up to the point where the integrity of the crush fit is lost, and the seal could blow out the front of the trans. This not only leads to a rapid release of all the fluid, but it is possible that the fluid could be ignited on its way past the exhaust system, leading to more serious troubles than a non-functional transmission.

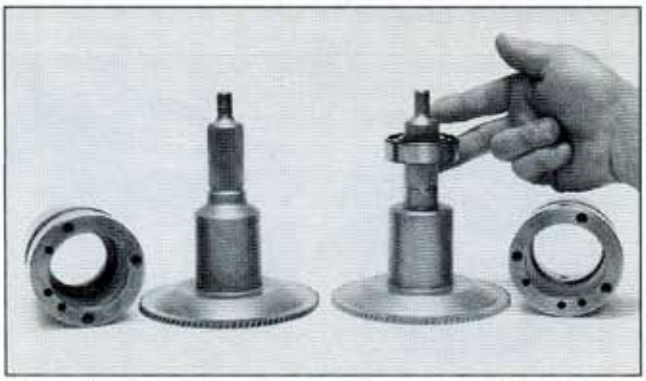
To cure this tendency, ATO machines a ring around the outside diameter of the pump neck, and installs a snap-fit seal retainer that locks into this groove. This eliminates the problem, and makes the replacement of this seal a simple operation.

The front pump cover goes through three more operations before it is put back in place. "The design of the converter feed circuitry causes problems with overheating of the converter," Galatioto said. "To help counteract this design flaw, the material between the two pump suction inlet holes is removed, resulting in an oval opening that enlarges the suction inlet volume by around

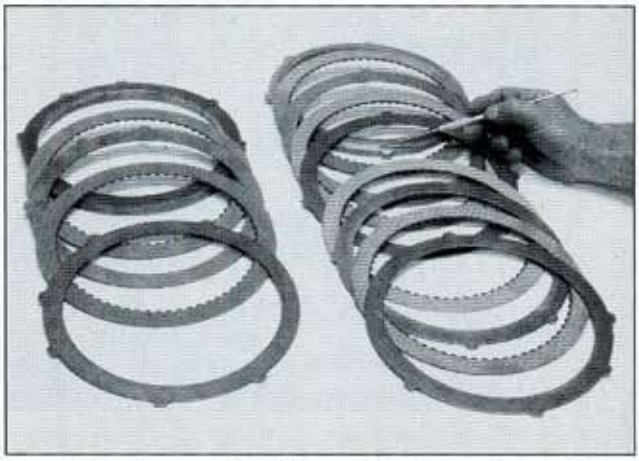
Shown here is the machining performed on the front planetary to create the clearance and register to hold the new thrust bearing in place. In the foreground is the stock thrust washer that is replaced.



Special-formulation Teflon rings replace the stock, cast-iron sealing rings on the center support housing. Virtually frictionless, the Teflon rings provide positive sealing, better heat resistance, and long life. When the OEM rings wear out, the pressure used to apply the 3rd gear piston drops, resulting in slipping and burned clutches.



The overdrive input shaft neck is turned down so this roller bearing can be installed on the shaft. With the center-support housing (right) bored out to accommodate this bearing in a slip-fit, the entire rotating assembly will now have much greater stability.



By machining the rear surface of the overdrive clutch pack assembly as shown on the right, ATO is able to double the number of clutches and clutch plates used in the E4OD from two to four, greatly increasing the clamping force.

75%. Removing this restriction helps the converter get all the fluid it needs, when it needs it. To expedite the removal of the fluid when the converter goes into lock-up, the transmission's .060-inch bleed hole is opened up to a full .250-inch. This results in a more crisp, but not harsh, shift as the clutch is quickly applied."

Galatioto explained the benefits. "When you are driving an E4OD and lift off the throttle, the converter disengages by way of the throttle position sensor. When you get back on the gas, the converter kicks back in. If you are in traffic, that poor converter is working awful hard, going on and off.

"The material on the clutch disc is only 5/8-inch across, and about .030 thickness. There is not much there, and if you have the clutch apply real slow, especially in a diesel, it glazes, burns the lining, and dies prematurely. By having the clutch apply quickly, you minimize the slippage and get better lift out of it, plus better performance."

The final modification to the pump is the drilling of a small hole in one of the high-pressure fluid passages, to provide increased lubrication to the overdrive sprag assembly. This sprag has a washer on both ends, and these washers are also drilled with six holes apiece to keep the moving parts immersed in fluid.

To improve the clamping power of the clutch packs, extra clutches and steels are incorporated wherever possible. The pressure plate for the overdrive clutch pack is machined down to double the number of clutches, from two to four, while the same procedure performed on the coast clutch pressure plate adds another clutch and steel to that pack.

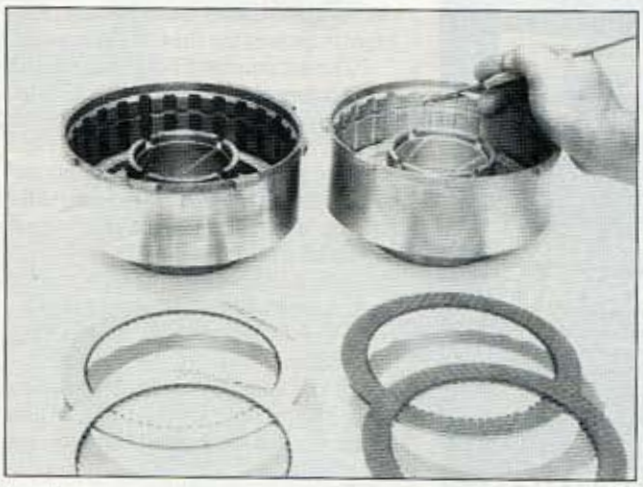
The third-gear clutch pack, which also is used for reverse, gets another disc and steel to bring that total to five. To get it to fit, an extra groove is machined into the inner surface of the clutch hub, while a bit of material is shaved off of the clutch mating surface. ATO also replaces the stock Borg-Warner clutch discs with those from Raybestos, which have more friction and heat-resistant clutch material.

To remedy one of the more dramatic weaknesses of the E4OD, the neck of the overdrive planetary is machined down to accept a reinforcing collar of 8620 billet gear steel. This planetary, made of cast aluminum and not particularly beefy or strong, is driven by the turbine input shaft, and can split apart under heavy torque loads. When this happens, the vehicle stops in its tracks.

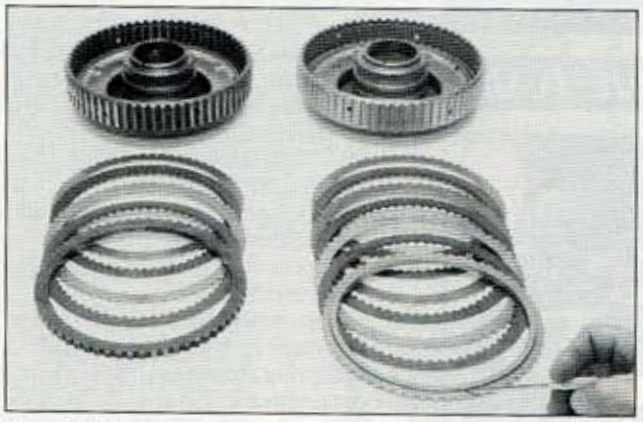
This sleeve fits onto the planetary with a compression fit, with the sleeve being heated and the planetary subjected to freezing temperatures before the collar is pressed on. Acting as a girdle, this sleeve gives the leading part of the neck substantial strength and rigidity, and prevents any cracks from forming.

The turbine input shaft itself gets a bit of a massage, with four shallow slots being machined down the length of it. These help improve the flow of fluid to and from the converter. "The longer the fluid stays in the converter, the hotter it gets," says Galatioto. "Remember, one of the main goals is to get the fluid into the converter as quickly as possible, and then get it back out and through the cooler and back into the system."

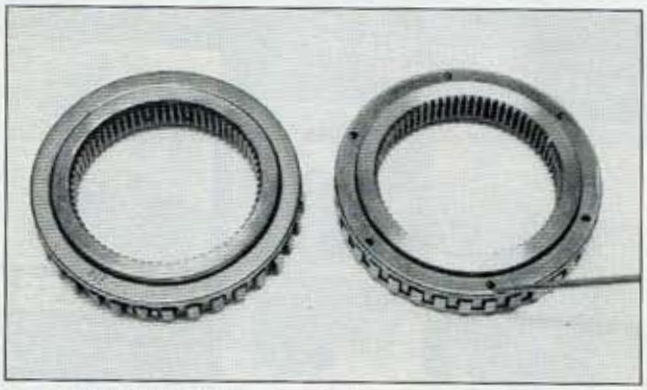
The final stage in the ATO upgrade involves the accumulator body. Galatioto has performed some impressive magic on the modulated accumulator assembly. His redesign of this system allows the elimination of two of the three springs incorporated in



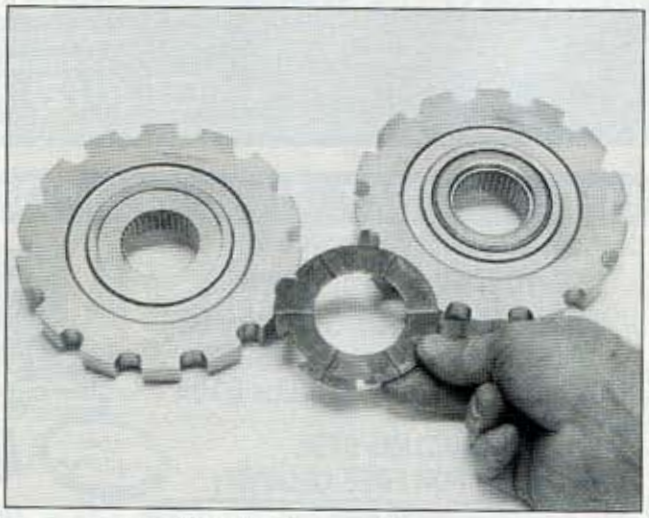
An extra groove cut into the hub for the 3rd gear/reverse clutch pack, combined with a little more machining on the seating surface, allows the installation of one extra clutch plate and clutch disc. Replacement Raybestos clutches are more resistant to heat fatigue.



This cut in the coast-clutch pressure plate makes room for the addition of one more clutch and plate. This assembly is responsible for handling all of a truck's weight under deceleration conditions.



The overdrive sprag, which works off of the coast clutch, has a large washer on either side. Holes drilled into the washer's surface help improve fluid flow through the sprag by over 50%.



The parking gear thrust washer, foreground, is also replaced with a bearing after the gear is grooved for the bearing to fit. ATO's experience has revealed that when the factory washer wears and overheats, it tends to spin and chew up the end of the expensive E4OD case.

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The Program

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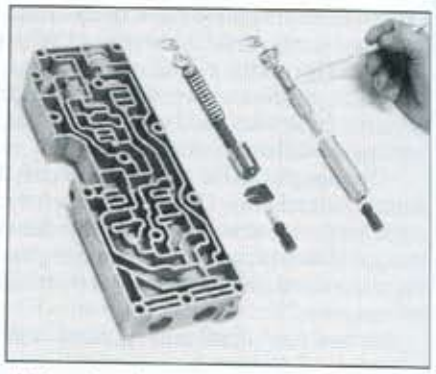

ATO replaces the stock modulated accumulator assembly with one of its own design. Eliminating two of the three internal springs, the remaining spring is tailored for each specific application. The spool valves are also modified to enhance fluid flow and control.

it, and the remaining spring is custom-tailored for each application. The spool valves in the body are carefully replaced with the custom ATO accumulator enhancement kit. The re-timed regulator control valve enhances the converter feed circuitry. Re-timing the converter control valve improves the flow to the converter.

"The accumulator body controls all of the clutch packs," Galatioto said. "It accumulates pressure to soften the hit. What I did was make my own system so I can accumulate the fluid the way I want and control the modulator valve, control the volume of the fluid going thru my system, and make it more progressive.

"When I modify one of these transmissions, I need to know what vehicle it's going into, what the application is, what the weight is, what engine it's getting mated to. I then know what I have to do to make it work right for that truck, to tune it to that suspension, powerplant, gear ratio and weight.

"We always install a new, better-grade converter that is furnace-brazed, with bearings instead of washers, and with the improved clutch lining.

One other trick Galatioto recommends is the use of a marvelous little electronic module from Rostra. This black box can be utilized to control the speed at which the converter locks up, from 30 to 50 mph, in 5-mph increments.

"With a light throttle, the shift schedule of the E4OD is 1st, 2nd, converter clutch lock-up, 3rd, and then 4th. A moderate or heavy throttle changes the pattern to 1st, 2nd, the converter locks up simultaneously with 3rd, and then 4th.

"By installing this box, you could set the converter lock-up point at, say, 45 mph. Driving around town with a light to moderate throttle, it'll go 1, 2, 3, 4, lock-up. If you're on the throttle, it changes to 1, 2, 3, lock-up, 4. The advantage is, you'll never get lockup at a low rpm, which lugs

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This Rostra Lockup Delay Module can be easily installed on Ford trucks to have the E4OD converter clutch lockup triggered by vehicle speed instead of throttle position. It can be set in 5-mph increments, from 30 to 50 mph.

down the motor. The Rostra helps keep the engine well within its torque curve.

A switch can also be installed in the cab, within easy reach of the driver, that is used to manually take the converter out of lockup when conditions warrant. This feature can come in handy, basically providing an extra, in-between gear when downshifting would wind the motor up too high, but staying in the same gear is bogging the engine down.

The ATO shop vehicle is a cherry 1993, 1-ton Ford XLT van with a 460 motor and an E4OD, which received the full ATO treatment after Galatioto had a chance to install a transmission temperature gauge, drive it around a while, and learn its characteristics. Originally, it was easy to hit fluid temperatures of 225-250 degrees, and now it typically runs at 140-145 degrees under the same conditions. It also gets 15.5 miles per gallon on the highway, even loaded with parts.

Jim Galatioto offered another customer testimonial. "I had one fellow come in with a year-old, turbo diesel motor home. He'd heard about our modifications, and wanted to get one done for himself.

"He didn't like the way the stock trans worked at all, so he brought it in. I drove it, and it was a real mush-box. Every time it shifted, it felt like it was gonna take a couple of days to finish the shift, and the engine was off its torque curve when it finally did make it.

"So we did the transmission for him, and a week after he took it home he went on a 5,000 mile trip. He was so impressed with the difference that he called to tell me about it when he got back.

"He said, 'The best way I can describe it is that I've made this trip before, and taking this same hill that I used to struggle to get up at 45 mph, this time I went up the hill and easily passed everything in my way with no problem. The converter temperature stayed surprisingly low, and I even picked up two miles per gallon.' " **TR**

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