Automatic Transmission Basics

PART ONE

Last month, we looked at some of the ways liquids act when the pressure is on. Our presentation was admittedly very basic, but no apologies are offered, because no matter how many pumps, valves, and scroggins we put together to make these liquids work for us, the individual components and the principles behind them remain constant. The more things change, the more they stay the same.

This month, let's add some more pieces to the puzzle and start to look at the basic components in an automatic transmission. Traditionally, an automatic transmission has needed the following sub-systems to operate:

- **A hydraulic system.** This includes a pump to move fluid, control valves to regulate the direction of flow and control pressure, and a torque converter.
- **A set of planetary gears.** Planetary gears provide different gear ratios.
- **A set of friction linings.** These linings are used to either hold or release different members of the planetary gearset. They are found in clutch assemblies or bands, and since they are applied or released by hydraulic pressures, they are commonly called *reaction members.*
- **Load and speed sensors.** These sensors are often included in the control valve section. We'll look at these as a separate category, however, since the addition of computers has changed the nature, but not the basic task of these sensors.

The Torque Converter

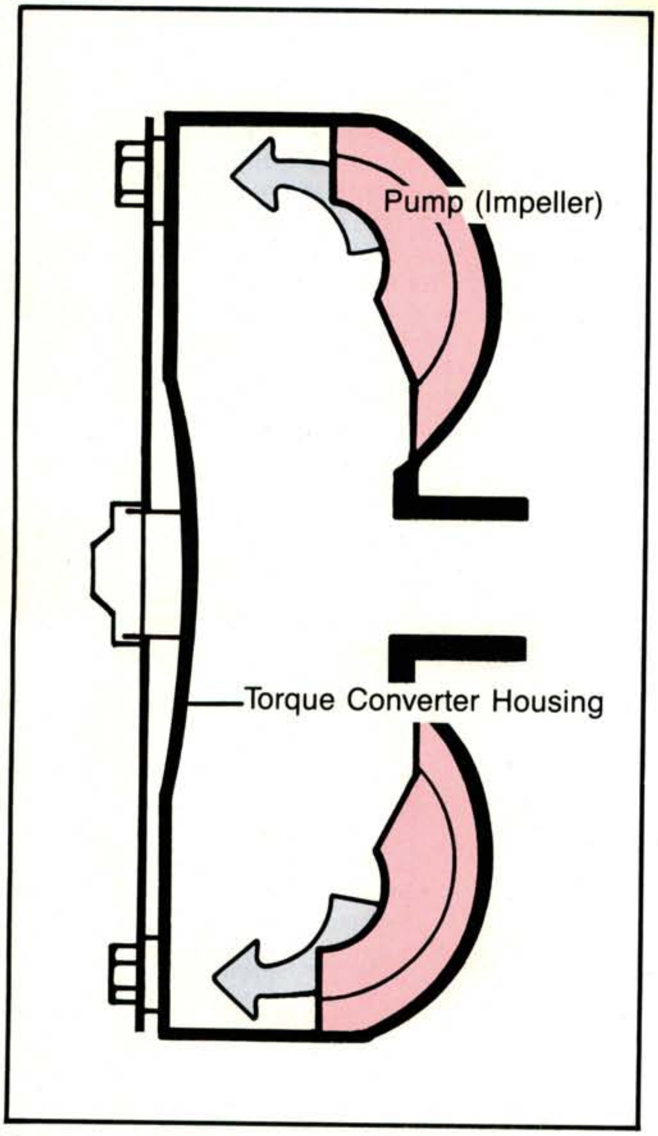
Since we've already gotten a little flavor for pumps and valves from our look at hydraulics, let's move on to the torque converter. There have been countless descriptions of torque converter operation over the years. But since the main components of the torque converter don't actually touch one another, most descriptions include diagrams trying to show the flow of the liquid that transmits the force between those parts. Most have confused me.

Maybe a couple of simple house fans will help clear things up.

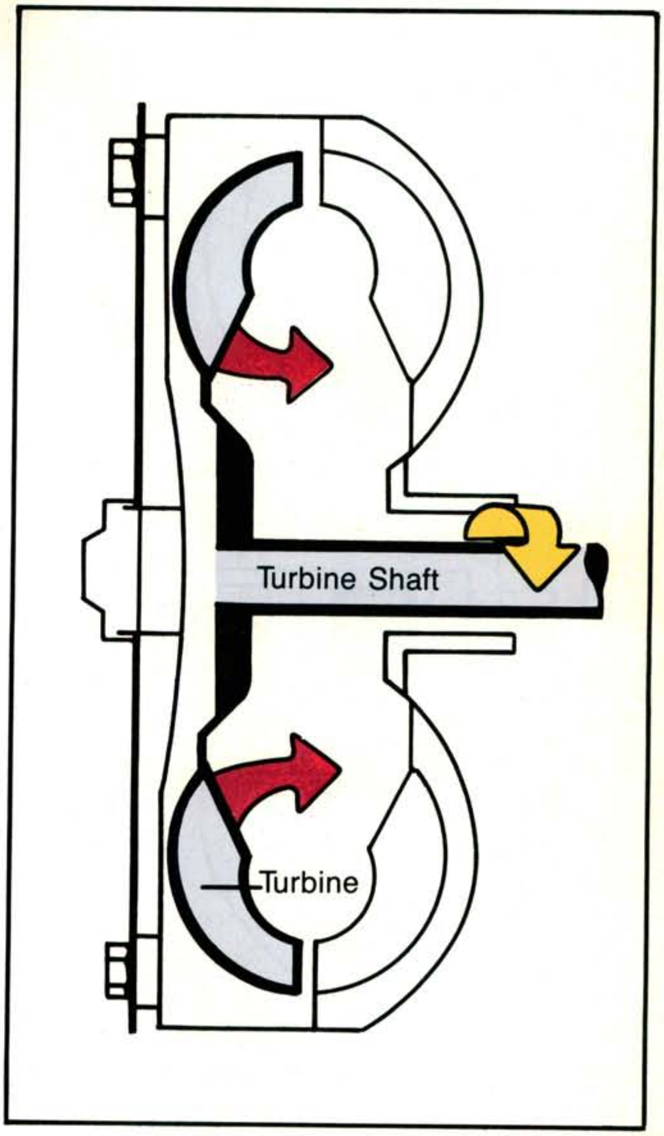
Place two small fans face to face on a table. Turn on the fan at the left. Go ahead, turn it on to its high speed setting. The air it blows will turn the fan at the right like the wind turns a windmill.

Now turn that same fan to its very lowest speed setting, so it just barely turns. The fan at the right may not turn at all now, since the amount of air hitting its fan blades won't overcome the friction of the motor shaft. The fans are pretty inefficient in our "air converter."

Let's redesign the fan blades and put the fans inside a closed, liquid-filled housing. Let's reshape those blades to act more like tapered scoops that will catch that liquid and fling it toward the other fan like a spinning, major league curve ball. This looks more efficient already.



Our pump, or impeller, catches fluid inside the converter housing and flings it in the direction shown. The combination of centrifugal force and the shape of the fan blades sends the fluid spinning.



If we add a turbine attached to a turbine shaft, it will turn as the fluid from the pump strikes its blades. This causes the turbine shaft to turn, transmitting force to the transmission.

Now we'll connect one fan to the engine. The fan blades are located away from the engine, facing back toward it. The fan blades themselves are welded to the converter housing. As a result, the housing and the pump blades will turn at engine speed. We'll call this part the *pump*. Some folks call this an *impeller*, but the term pump will do for our purposes.

Now we'll add the driven fan. Installed in the converter housing opposite the pump, this fan will be called the turbine. It's fan blades are not welded to the converter housing. It is connected by a turbine shaft to the transmission. As the pump drives the turbine with the force of liquid thrown against the turbine blades, that force is transmitted to the transmission.

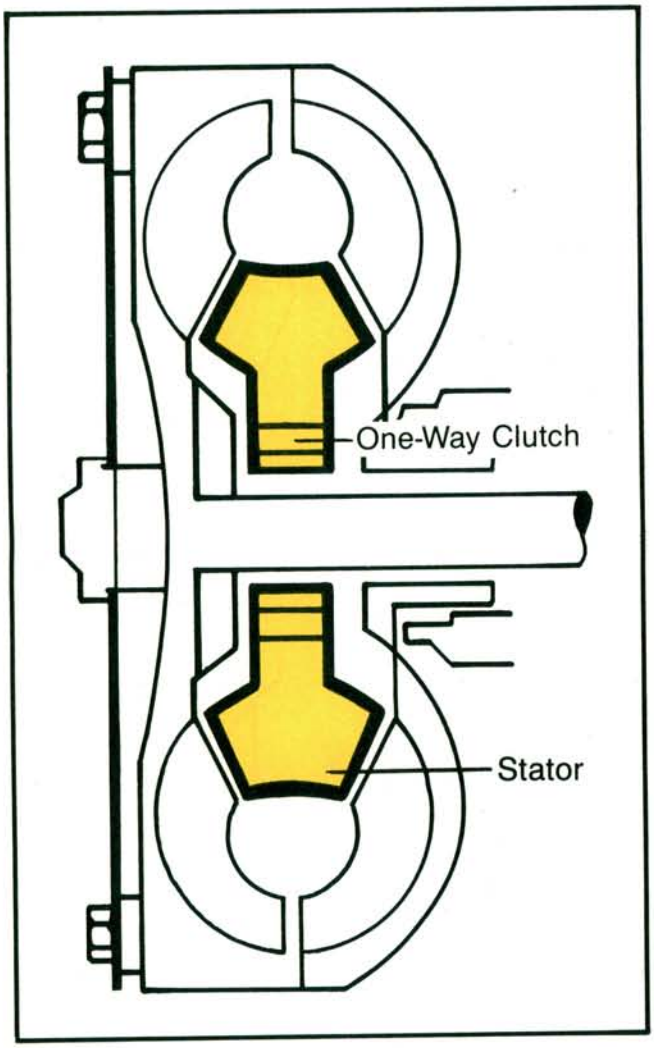
We have made a fluid coupling.

We repeat, even though these two fans don't touch each other, if the force of the liquid thrown from the engine-driven pump strikes the blades on the transmission fan, it will turn, just like our air fans did.

When the engine idles, the force sent by the pump is weak, just like it was with our air converter. It doesn't have enough force to turn the turbine fan on the transmission. As a result, we can sit at a stop light with the car in drive and our foot on the brake without stalling the engine.

Now we're using that inefficiency we found in our air converter to our advantage.

If we step on the gas to accelerate, the pump speeds up with the engine. Our spinning fluid flow is forceful enough to move the scoops on our transmission fan, or turbine, causing it to turn.



The stator sits between the two fans, making sure that fluid is directed back to the pump at the proper angle so it will work with the pump instead of against it.

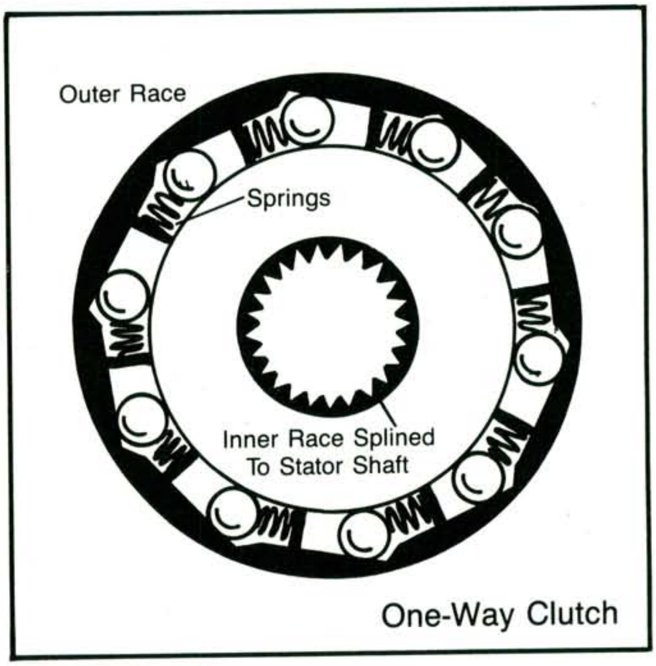
Direct and Redirect

The bad news is that when we put our fans in that closed, liquid-filled housing, we made a problem for ourselves. Quite simply stated, the force of the liquid returning to the pump from the turbine can actually start to work against the pump. It's striking the pump blades at the wrong angle. The turbine is being driven by the force of the liquid. But when it gets turning fast enough, it starts acting like a pump too. To paraphrase Gary Cooper, "This town just ain't big enough for two pumps."

The good news is that we can put this to our advantage with the help of a fluid traffic cop called a stator. You see, when the turbine starts acting like a pump itself, we just need to put all that energy to good use. We can use the force of the fluid returning to the pump to our advantage. It just needs a little guidance, that's all.

Our traffic cop sits between these two warring pumps. It's a kind of a fan too, and it makes that fluid take a turn for the better, helping the two fans work as a team. Instead of allowing the returning fluid to strike the pump at an angle that would slow the pump, it bends that flow of liquid a little. Now the fluid strikes the scoops or fans at an angle that actually helps the pump turn. The force generated by the pump boomerangs and comes back to it in a form that multiplies its own ability to force fluid.

Eureka! We have torque multiplication. We have a torque converter. We have force that just doesn't disappear, but comes back again to help make even more force. Apparently two pumps can live in this town if they work together.



The stator has to resist the difference in fluid force between the pump and turbine until those forces equalize. In one direction, the rollers jam tightly in their tapers locking the races. In the other direction, they freewheel, disengaging the races.

I'm Slow But I Get There

The stator has a rough job. In order for him to redirect that flow of liquid, he has to resist the temptation to just get pushed around himself. Engineers knew he had no will power and installed a one-way clutch in him. He has no choice. He has to resist the fluid flow from the turbine when it starts being a problem for the pump.

The turbine really has a lot of nerve. He's a little slow to respond to the force of fluid sent by the pump. Oh, sure, he's turning slower and generating torque as a result. But then he starts feeling his oats and the stator has to keep him in line.

Finally, the turbine gets up to speed. At this point, the one-way clutch relaxes a bit. Both fans are turning at about the same speed, so the forces between them equalize. The stator gets to free-wheel and take a break. At this point, the torque converter acts pretty much like a clutch would. Except for that built in inefficiency we mentioned earlier, the drive ratio is a direct one-to-one.

What a Piece of Work

We ought to stop and admire this torque converter for a moment. It is sloppy and inefficient when we need it to be that way at a stop light. It multiplies torque when the light turns green and we first accelerate. It acts as a direct fluid coupling when we're cruising. And it's truly automatic. Not bad.

If we get fancy, we can install a friction lining that locks-up that torque converter and eliminates that last bit of inefficiency. In this mode, the torque converter really does act like a clutch and the drive really is direct when cruising.

Understanding how the different parts of the torque converter interact is helpful when we try to diagnose torque converter problems. Although torque converters are generally very reliable due to their simplicity, they do fail on occasion. A simple procedure known as a stall test can help us diagnose converter problems and locate the causes of transmission component slippage.

—By Ralph Birnbaum

Stall Test

A stall test measures the efficiency of the torque converter and the ability of internal transmission parts to "hold" under load. If we prevent the wheels of the vehicle from turning, place the transmission in drive, and fully open the engine throttle, we will eventually reach an engine speed where the force generated by the pump can no longer overcome the resistance of the stationary turbine. This is the peak RPM at which the engine can turn with that amount of resistance.

As a result, the condition of the engine is very important in a stall test. If the engine is weak for any number of reasons, it will take less resistance to "stall" it. More than one complaint of poor acceleration or bad transmission performance has been caused by a badly tuned engine.

Altitude changes and high ambient temperatures can also affect stall speed readings. Some manufacturers provide charts showing how changes in engine vacuum at higher altitudes will affect RPM readings. Since engine vacuum affects engine performance, this is an important consideration in the mountains. One manufacturer suggests that engine RPM will be about 125 RPM lower for each additional 1000 meters (3200 ft) above sea level.

Before Starting

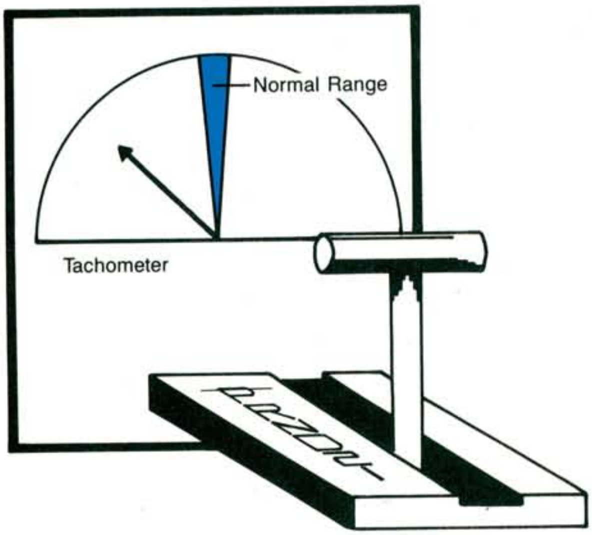
Here are a few more things to consider before starting that may save embarrassment or injury:

- **Check the fluid level and condition of the transmission fluid. Transmission fluid has to be clean and at the proper level for the tests to be valid.**
- **Check main pressure. Is a bad pressure regulating valve, a weak transmission pump, or a clogged pickup strainer the cause of your problems?**
- **Check the throttle linkage. Poor acceleration or performance problems can be caused by an improperly adjusted throttle linkage or cable. If the throttle isn't opening fully, you'll never generate peak engine power.**
- **Make sure you have the proper specifications for the car being tested. Rated stall speeds will vary, even within a given line of cars, and sometimes within a given model year. Don't just check the make and model of the car and stop there. Make sure you use transmission code numbers to properly identify the unit you're working on whenever necessary.**
- **Make the test with the engine and transmission at normal operating temperature. We want to test everything while it's warm, well-lubricated, and working at top efficiency.**
- **Be careful. One of the reasons you test drove the car was to check the brakes. They'd better be working properly before you start. Even with good brakes, make sure you chock the wheels before starting. Never let anyone stand in front of the vehicle.**

The Test

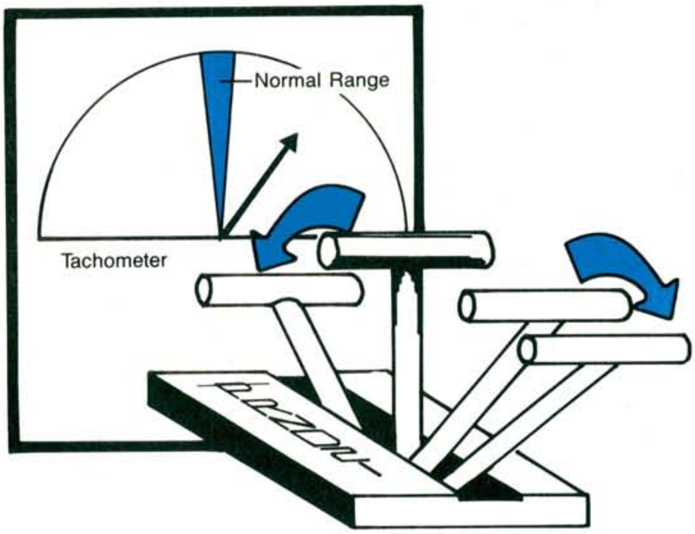
- Warm the engine and transmission to normal operating temperature.
- Attach a tachometer to the engine and place it where you can easily read it.
- Chock the wheels, apply the parking brake, and step firmly on the brake pedal.
- Place the vehicle in Drive.
- With the brakes still applied, gradually open the throttle all the way. When the engine has reached its maximum speed, jot down the figure. Manufacturers' recommendations will vary about the length of time you can run each test, although five seconds is a common figure.
- Give the transmission a break. If you have to repeat the test for any reason, give the transmission a chance to cool down between each test. Place the selector in neutral and run the engine at high idle to let the transmission cooler do its job.
- The stall test can be run to check performance in other ranges as well. By moving the gear selector lever to different positions, we can isolate the causes of internal transmission slippage in specific drive ranges. More on that later when we look at component diagnosis, but for now, we can make some general points about the results of a stall test.

General Observations



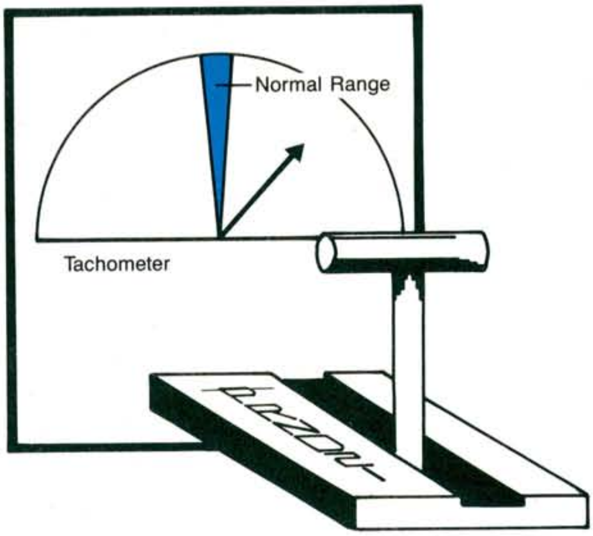
Lower Than Standard RPM Readings

Either the engine doesn't have enough power, or the stator clutch is slipping. Remember your test drive? If acceleration was poor at take off but good at top end, the engine is running properly.



Higher Than Standard RPM Readings In Every Gear

Look for low line pressure, caused by a weak pump, plugged strainer at the pickup, a faulty pressure regulator, or some internal leak causing pressure loss. If it happens in every gear, it has to be something common to all of them.



Higher Than Standard RPM Readings In A Specific Gear Or Gears

For example: If you get higher than normal readings in only one gear, then you know by process of elimination that everything but that particular gear is working properly. Normal stall speed readings in the other gears indicate that the engine, torque converter, oil pressure system, and internal components of the remaining gears are all working properly. Now you can refer to a reaction member application/release chart to determine which components are slipping. (To be continued . . .)