John Z.

Rebirth of a Renault Tranny

Or how to build a racing 395 transaxle

by Mike Schlicht –Vice Prez

This is the first in a series of articles about the Renault transaxles used in the Europa. The main focus is on what it takes to race prepare the 395 variant which was used in the Renault R17's. Most of the information except that pertaining to the shift mechanisms is applicable to the 365 transaxle as well. This first article will talk about some basic transaxle stuff. In the next article I will go into what it takes to retrofit the 395 into a Europa. Subsequent articles will go into the details of doing roll pins, modifying synchros, changing gear ratios and fixing a few known problems.

A little history;

Lotus first used a Renault transmission in the S1 Europa. The Europa at that time was Renault powered so the choice was obvious. Later when the Twincam version of the Europa came out the Renault transaxle was retained. Along the way the transaxle went through several versions. Starting with a side shift 4 speed and ending with a rear shift 5 speed (365). The basic internal design stayed about the same with only the shift mechanism including the rear cover changing significantly. Various final drive and gear combinations where tried. By the time the Twincam came along the split housing had gotten stronger mainly by using more ribbing. Rumor has is that the improved housing was for the Twincam but my sources in Renault indicate that this was not so. During the late 60's and early 70's Renault was using this transaxle in rally cars. At the 95 Lotus convention at Laguna I had a chance to talk extensively with some of the guys from Renault who where there to support the Renault powered F1 cars that where there for the Historics. Several facts came to light:

1. The turbo powered Rally cars where putting out over 200 HP and 200ft/lb of torque! The cars would regularly get several feet off the ground and then come down hard with the engines redlined!

Occasional U-joint and drive shaft failures would result but they never saw a stubaxle or internal gear failure! After a little prodding they admitted that the input shaft extension (the part that actually goes into the clutch) would sometimes fail but this was considered almost a normal thing as it is designed to be the weak link in the transaxle.

3. It was not uncommon for the cars to finish a race or stage with holes in the casing, gear and pinion faces badly scored but still running! The transaxle was not considered a high priority item in keeping the cars running. The term used by the French was "bullet proof". They just laughed when asked about the supposed "weaknesses" of the transaxle.

By 1995 I had been racing with a 395 Renault transaxle for over 5 years and had experienced no significant failures. This is not to imply that all was perfect, just that the basic design and materials would easily work with engines of up to 260HP and 160ft/lb of torque. This does require a slightly different 1st and 2nd gear tooth design than found in a stock 395 (stub tooth). With less HP (200) you can go a little higher with torque, maybe 200ft/lb. It turns out that the actual instantaneous torque that the engine puts out can be much higher than the average torque. In a typical street car with a light (26lb) flywheel/clutch and rubber engine mounts the peak torque is typically 150% of the average. In my racecar with a low mass low weight flywheel/clutch (12lb) the instantaneous torque is about 300% of the average. This works out to a peak torque for a stock Twincam of 165lb (110 * 1.5) and 474lb (158 * 3) for my car, 2.87 times as much.

Besides limited slip and pinion wear, all of the problems that I have experienced have to do with shifting and the synchro springs. Jeff at JAE has told me about problems with first gear failures when drag racing a ell tuned Europa Twincam. I have used a stock transaxle for years Autocrossing (drag-race starts), without any problems. I suspect that the transaxles that failed where not maintained properly. If the stub axles are not shimmed correctly the spider gears will wear abnormally eventually shedding small bits of metal. Additionally, I have almost never seen a transaxle that had the ring and pinion backlash setup correctly. If this is way to loose (the norm) the pinion will wear abnormally eventually shedding small bits of metal. If any of these bits get between the gear faces it will damage the gear teeth. If this goes on long enough a gear will fail! First gear being closest to the final drive will usually get the most damage.

Transaxle design highlights:

The basic layout of the transaxle is very conventional for a street transaxle. There are two shafts that carry the gears, the Input shaft and the Pinion shaft. As it implies the pinion shaft also ends in the final drive pinion which together with the ring gear and spider gears makes up the final drive unit. Overall a

Transaxle is the most efficient way to package a complete drivetrain and the Renault transaxle with bell housing weighs only about 95 pounds. The Shaft spacing is 70mm or 2.756". This is actually considerably less than all of the other transaxles that I have seen for this power range and contributes to both the lightweight and much lower rotating mass.

In my opinion the lower rotating mass more than makes up for the slight disadvantage posed by using synchros verses dogteeth in shifting. The following is a real world example of why I like synchros:

You are heading for turn 2 at Laguna when making an inside pass on someone that you have been chasing for several (eternal) laps. You are coming into the end of the straight at about 125-130mph, you go way to deep into the corner and stand on the brakes, the car initially pulls down at near 3 G's but as the brakes heat up and the car slows they start to lock up (oh-shit!), at this point you are modulating the brakes for all you are worth to save Y O U R L I F E, you leisurely pull the shifter back and to the left, step on the clutch, apply a little back pressure to the shifter and wait a second or two for that reassuring clunk as the synchro does it's J O B and the transaxle drops into second gear, while you are still modulating the brakes for all you are worth to save Y O U R L I F E, just on the off chance the Lotus achieves the miraculous and slows down enough WHILE STILL ON THE PAVEMENT to make the corner, (oh yea, wasn't I passing someone way back there?!! God, what a lousy pass, I'll have to apologize to him after the race for almost hitting his car at least once never mind running him off the race track!), finally get off the brakes, blip the throttle and let the clutch out, accelerate smoothly just clipping the apex and out of the turn (phew!), check the rear view mirror to see if the poor slob is still there and not flipping you off (what? what's this, he is giving me the thumbs up for a good pass, YEA!).

I attempted the above scenario in the same place once with a "crash" box and it crashed several times, loudly! I have talked to a few well-known drivers that in private admitted to the same reluctance to try and use heal and toe techniques while they are "braking to save their life". I have driven various racecars with both types of engagement mechanisms and if properly done they can both be made to shift quickly. A synchro transaxle will be more temperature sensitive and in my car the shifting is quite stiff (slow) until the transaxle gets up to temperature which only happens on the racetrack. I will go into more detail on the ins and outs of synchros in a later section.

The five-speed transaxle has 5th gear reversed in that the synchro gear is on the input shaft. This is actually quite clever as it makes the design of the shifter setup simpler. When taking a transaxle apart it's obvious that the 5 speed was a derivative of the 4 speed. 5th gear is outside of the main case, tucked inside the rear cover. In a stock transaxle 5th gear is the only interchangeable gear and for racing can be changed without removing the transaxle from the car. Due to interference with the shifter

selector pivot the ratio that I now use for 5th (1.25 instead of a typical .86 overdrive) is about as high a ratio that will fit.

The final drive ratio in the 365 and 395 is 3.777. Other ratios are in theory available but I have not been able to find any that are a drop in. For reduced gear load a higher ratio like 4.11 would be better. However this puts more load into the pinion which is not a good idea from a wear standpoint. In the racecar, besides the limited slip the pinion is the only part that shows any wear when using Red Line 80W140 synthetic oil. My guess is that a 4.11 ratio would not last more than about 25-50 hours in my car. In addition a 4.11 ratio will require larger input shaft gears slightly increasing the rotating mass. As I have found out the 3.777 ratio is about the best overall compromise.

The 365 as used in the Europa is a rear shifter. Unfortunately what this really means is that eventually it will become a "no shifter". Years ago I did a stress analysis of the shift rod that comes out of the cover. It turns out that there is a lot of side load on it and the simple and too short bushing used to hold it will wear out in short order. Since it is the lowest part of the transaxle it will also leak oil forever! While it is obvious that the case has provisions for a rear shifter, somehow I can't believe that Renault actually designed the rear cover that way unless they did it under duress?

The 395 transaxle on the other hand is more like the early Europa, a side shifter and in my opinion a much better way to go. Not only does it work more smoothly and doesn't wear, it is spring biased like a "modern" transaxle. In neutral the shifter is held between 3rd and 4th gears by a spring arrangement. In racing this means less than on the street but I find it still helps if for no other reason than it tells me if the shift mechanism has gone out of alignment or is broken.

The final drive stub axles that come out of the differential are splined. The inboard U-joint yolk is held in place on the spline with a roll pin. In true Lotus fashion the drive shaft does double duty and is part of the upper link of the rear suspension. This means that the roll pins (as well as the U-joints) always have some side load on them. There are many misconceptions regarding the often-maligned roll pins. If setup correctly they will last a long time, but not forever! In the later Europas the roll pin is a single one. The good ones are made of 0.04" thick steel rolled about 4 times such that there is only a 0.05" diameter hole in the middle. I have seen cheaper ones that use thinner steel where the hole is about 0.1" diameter. Don't use them! In my opinion the roll pins are at the center of one of the most critical areas of the cars performance!

With tight tolerance U-joints, high quality roll pins, correctly shimmed stub axles with some roll pin "preload" and above all else tight fitting yolks on the stub axles, the rear suspension can be made to work very well even with 11 inch wide tires. I add about .1 degree of camber to compensate for the slight play in the U-joints. I also use taper roller bearings in the uprights but that is the subject for an other article.

The standard differential is an open type with 2-spider gears in the 395 and 4 in the 365. While the 2-spider setup will work on the street it will wear out quickly on the track! Do not use it. The 4-spider diff will work on the track but it too will wear out. It took about 25 hours in the racecar to wear the 4-spider diff to the point where small pieces started braking off of the worn edges! Quaife makes a Torsen type limited slip. It works quite well. Like all Torsen diff's it too will wear out the worm gears! At the last race of this past season the Quaife (with about 25 hours on it) would suddenly start to slip when the engine was at peak torque. It felt as if the clutch was letting go, the engine would just race up and down with the car going down the straight. I am still checking into this "problem" and may get an answer from Quaife before the next article.

I have driven the racecar only once with a locked diff. To say that it acted strangely is putting it mildly. With 11 inch wide tires and 220HP the car would "ratchet" around turn 11 at Sears effectively picking the front of the car off the ground! I spent an afternoon flogging the car around Sears Point and only got to within 2 seconds of my normal times. Even though there are people using locked diff's at the track they are all on much heavier cars. I have never seen a high HPmid-engine formula car with wide tires that used a locked diff that wasn't a bear to drive (they did it because they had to). Several Atlantic drivers have told me about what it was like when the limited slip locked up and the car became unpredictable. Some drivers admitted crashing the car.

I don't recommend locking the diff in the Europa if you have wide race tires and or a lot of HP. In vintage racing with narrow tires and about stock HP it will work. It took a while before my lap times improved with the limited slip and even then I would say that at Sears point it is worth about .75 seconds and at Laguna Seca it is only worth about .5 seconds. The biggest improvement to the cars performance was totally unexpected. With the open diff the racecar would exhibit tremendous inside wheel spin coming out of slow (1st and 2nd gear) corners. The acceleration was spectacular, the car was quite stable but the engine was using up lots of gas, tires and dumping large amounts of heat into the cooling system. Without the inside wheel spin the water temp was 15F lower, the oil temperature was 25F lower and the rear tire wear was cut in half! In tire wear alone the limited slip paid for itself in 2 years.