DAMPERS

by Darren George

I have a BEng Honours degree in Mechanical Engineering from the University of Greenwich. I have been involved in club racing all my life as my grandfather was Dr Tony Goodwin's mechanic, and my step father raced in various saloons and sports car series. My step brother is a former Formula Firster and now races Eurocar V8's, I was his race engineer in Formula First in which we came second in the National Championship. We both raced 100cc karts during our teen years.

After leaving Uni I went to work for Dynamic Suspensions, as a damper designer. During my 2 1/2 years there I rose to handle F1 car and Ford World rally car damper designs. I also looked after many R&D projects for F1, Rally and Touring Cars. Exactly one year ago I joined John Barnard's company B3 Technologies and my responsibilities now include the design of brake and suspension components for the Prost Formula One team, as John is an exclusive design consultant to the team.

I am now in the process of building a Locost to race in the 750MC championship in 2000. hopefully I will be able to design my own dampers for it.

It's a bit of a huge task to do "handling with dampers" but here goes..... The dampers I refer to here would be deemed 3 way adjustable mono tube type. A lot of the adjustable dampers on the market are only one or two way adjustable. In two way adjustable dampers you usually have the ability to change low speed compression and low speed rebound damping. In one way adjustable you usually have the ability to change only rebound damping (some are fixed to adjust both rebound and compression in a fixed ratio together). In three way adjustable dampers we can change both low speed rebound and compression independently of each other, along with high speed compression.

Firstly a few generalities about suspension principles.

One of the main aims of a good suspension setup is to minimise something known as **Contact Patch Load Variation.** It's quite self explanatory, we are seeking to keep the load on the tyre (through its contact area) at a constant level. A tyre generates cornering force proportional to the amount of vertical load it has on it. The more load, the more cornering force available. This is up to a point and it has diminishing returns as it is not a linear relationship. As the tyre generates traction based on vertical load it will seem obvious that for a well balanced and optimumly setup car to maintain this load with the minimum of vertical load variation. Hence Contact Patch Load Variation.

If we imagine a spring with a mass dangling from it, and we extend the spring and let the mass bounce it will take a fair amount of time to come back to rest. The vibrations will be "damped" but only lightly, the damping in this case coming from internal spring friction and the drag of the mass passing through the air. If we now imagine this spring and mass system to be a corner of a car reacting to an input like hitting a kerb, we can see that the Contact Patch Load Variation would be very high. The tyre would alternate between high levels of vertical load (high cornering/tractive force) and low levels of vertical load (low cornering/tractive force). The result is obviously a reduced amount of cornering/tractive force for the period that the corner is oscillating.

The role of a damper is therefore to control the vibrations of the suspension to maintain the lowest possible contact patch load variation.

The tuning of a suspension system involves springs, dampers, anti-roll bars etc... The best handling car has the best compromise of all these components. The results are totally dependent on the compromise of the total system. Dampers can play a significant part of this system. You can't, though, take them totally in isolation.

If for a moment we assume we have a perfectly damped car, then we change springs and go stiffer in the suspension, we may end up with a faster lap time, but, unless we re-tune the dampers to match the new springs we will miss out on some of the potential of the new setup.

The message here is that springs and dampers go together and we must take account of this if we are to tune the car to its full potential.

The advantage dampers have, is that adjustable versions, are usually easy and quickly adjusted. This can have very dramatic results in the car's handling. So knowing what to adjust, and when, can be a big advantage to the competitor.

Dampers are not like springs. The load created by a damper is totally dependent on the speed of the damper's shaft. A spring's load is dependent only on the amount of displacement. Therefore for a competitor it's important to realise that when a car is being tuned they think carefully about what area of the system is likely to make an improvement.

If you are in the middle of a long high speed corner, on a smooth circuit, then the dampers will not contribute very much to the contact patch load. On the other hand the springs will be compressed on the outside of the car, and the roll bar will be twisted, and thus adding a large proportion of the contact patch load.

If we have a car that understeers or oversteers in long smooth high speed corners, we will not find very much improvement by changing dampers. We should be looking to change the roll bar or springs to cure the problem. On the other hand, if we are experiencing problems on the entrance to a corner just after turn in, then dampers might help us. The car's body is rolling, the outside wheels are rapidly moving into the body and the inside wheels are rapidly moving into rebound and thus the dampers will be generating a fair proportion of the contact patch load. Thus, a change in the damping values may alter its reaction to the turn in.

So the first thing to consider when tuning a suspension is what are likely to be the major contributing factors to the contact patch load at the point we are interested in.

Another generality I like to work with is that the softer end of the car will be working the best, and the stiffer end of the car is the end that will have the understeer/oversteer. If we are experiencing some understeer then it is due to the front being proportionately stiffer than the rear, and vice versa for oversteer.

So now we can see that we can slowly figure out which part of the system needs tuning. If we have high speed/smooth corner understeer, then we should be tuning the springs/roll bar at the front of the car. The first thing I would try here would be to soften the front springs or roll bar and get driver feedback on the improvements. We could conversely stiffen the rear springs or roll bar. We are looking to "balance" the apparent stiffness of each end of the car.

Back to dampers. There are two directions for damping. They are compression and rebound. Compression is the condition when the damper shaft goes into the damper body and conversely rebound is when the shaft exits the damper body. In most suspension set ups, compression is when the wheel moves up relative to the body and rebound is when the wheels move toward the ground relative to the body. Due to the internals of a damper, rebound and compression can be different if we so wish (and very often do). A basic rule of thumb is that rebound damping on circuit cars is approx. twice the compression damping. On road cars this can be as much as 4/5 times higher in rebound than compression.

The dampers generally have two ranges of operation in each direction. Low speed and high speed. Speed here refers to shaft speed and not car speed. Low speed is the range that will control the transient movement of the car, such as, rolling, braking etc.. High speed controls the inputs like hitting kerbs or pot holes.

From the point of view of circuit racers, low speed damping is by far the most important area. We race on smooth circuits (usually) and so the potholes and kerbs are a small proportion of what work the damper has to do.

It is usually relatively easy for most of us to imagine what compression damping might do for us. Rebound is harder to imagine. Rebound could be considered a little like an anti-roll bar. When we roll the car into a corner the outside wheel wants to move up and the outside wheel wants to drop down. So if you imagine a stiff rebound damper, it will resist the outside wheel dropping and therefore the car's body roll angle will be less than a softer rebound damper.

Another general rule to keep in mind - the compression damping controls the motions of the wheels and the rebound damping the motions of the car's body.

If we are in a long corner and the car is oscillating across the track towards the outside I would first look at stiffening the low speed compression damping all round. If the phenomenon appears to be confined to one end of the car then I would make the same change only at that end of the car.

If we have a car that is reluctant to turn in sharply or understeers/oversteers on turn in, then it is more likely to be the low speed rebound that needs addressing.

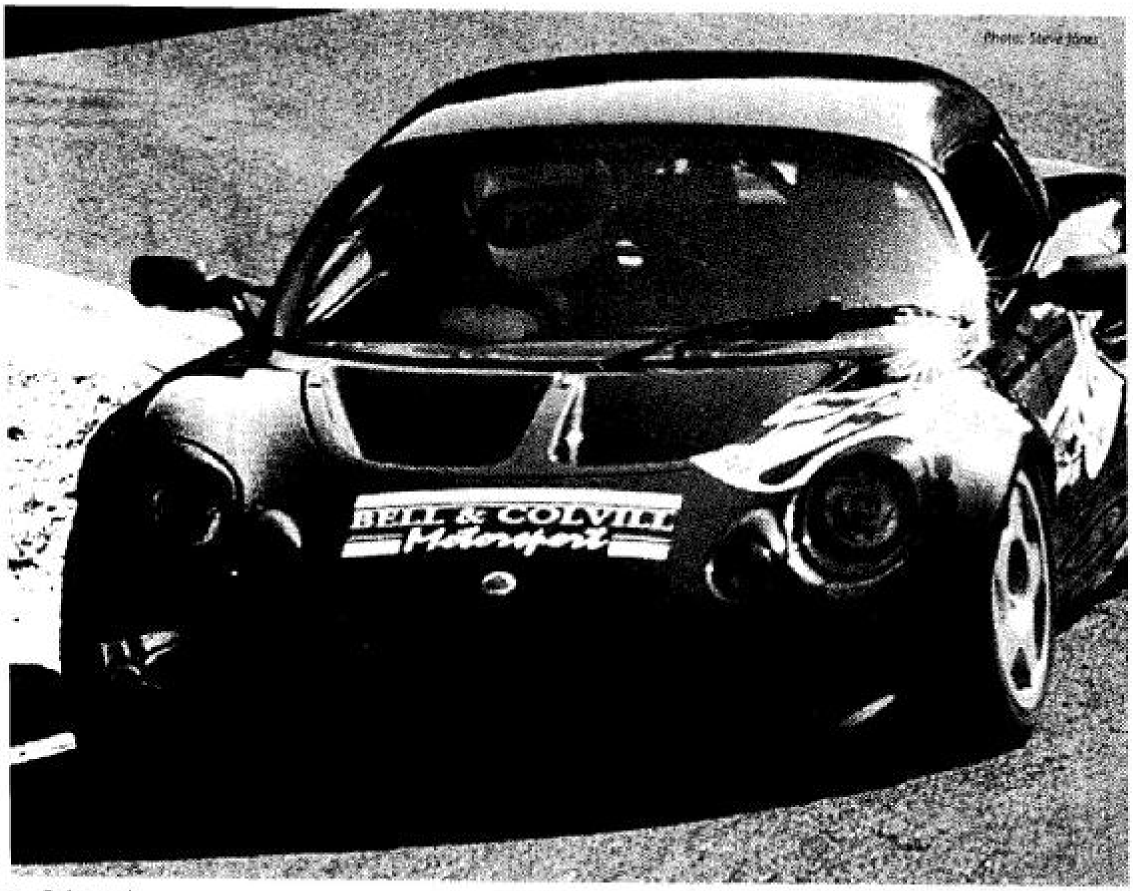
If the car has a predictable bad reaction to being kerbed then the high speed compression damping might need looking at (soften!!). On this point it is worth pointing out that although we treat low speed and high speed ranges as being distinct areas that can be treated in isolation, in the real world this isn't totally true. If we make a high speed damping change then chances are the low speed will change slightly too, and vice versa, so consideration must be made. If we soften the high speed compression damping then the chances are that the low speed damping will soften to a lesser extent as well, and so the low speed adjuster may want stiffening slightly to compensate.

As a case study it is worth taking a look at the Bell and Colvill Lotus Elises of Tasha Bell and Philip Gladman, running in Road Sports. These cars run on three way adjustable Dynamic Suspensions dampers. I was responsible for the initial setup for these cars and the damper design, and since then have remained personally involved in the development of the cars. Philip was 1998 Road Sports championship outright victor and this year they have both won their respective classes.

The development of these cars last year revolved mostly around the suspension, in particular the dampers. The initial damper valving was calculated by Dynamics, and we haven't moved from this initial setup enough to warrant a re-valve. Dampers of this nature have a vast range of adjustment and you can make radical changes to the car's handling within the range of adjustment.

For each circuit and for every weather condition we will slightly change the dampers settings to give the best compromise handling we can achieve in the allotted testing time. On circuits that are long and fast with few slow speed corners we might run with more rebound damping all round to keep the car tight and inspire driver confidence. On more twisty circuits we might soften the rear rebound to improve the drive out of the slow corners, (rebound damping like anti-roll bars at the rear kill slow speed traction). At Oulton Park with its gentle rises we stiffen rebound all round and soften the compression to keep the car tight under the driver as the car goes light over the bumps.

During wet weather we will soften the dampers off completely in an effort to get the maximum compliance and feel for the driver in the difficult conditions.



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