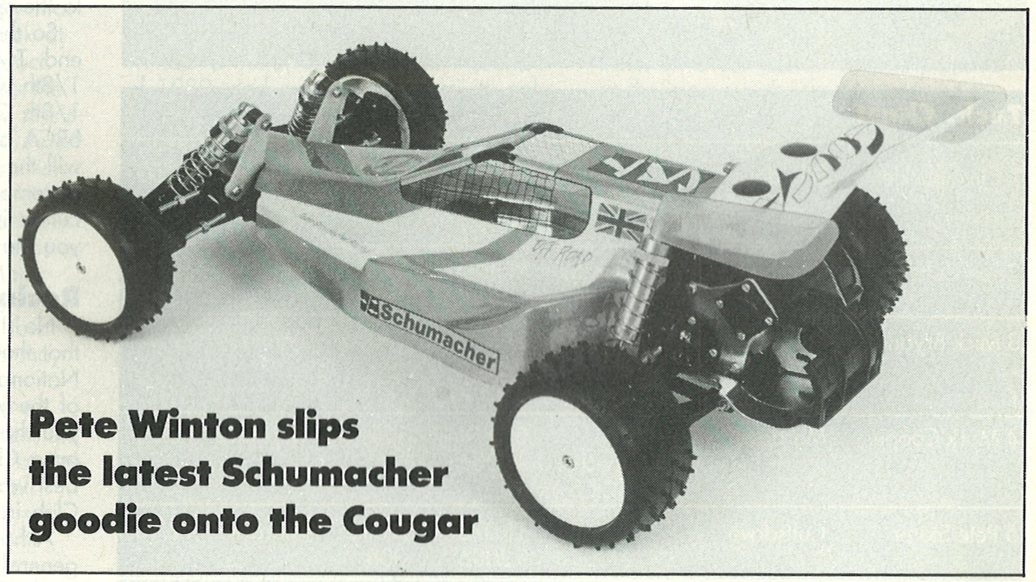
Give-Em the Slip!

New Hexagon drive super diff unit – now even smoother!

I 990 will be the year of the slipper clutch. For some that is stating the obvious, but remember you read it here first. It all goes back way before the 10th Off Road World Champs in Australia last year, but on the slippery St. Ives circuit, the slipper clutch came of age.

What is a slipper clutch? We must first separate the two words. A clutch is a mechanism for disconnecting and reconnecting two shafts. Often, one or both of the shafts are moving and, depending on the application, there are different types of clutch available. Perhaps the best known form of clutch is that used in road cars, where a mechanical clutch is used to disconnect the engine from the gearbox, or a fluid clutch is used in automatic gearboxes. The word slipper merely describes the action of this type of clutch, in this case to allow one shaft to slip relative to the other. The two shafts never become fully disengaged like a manual car clutch, they slip relative to each other more like a fluid clutch. There is always some torque transmitted from one shaft to the other when the clutch is slipping.

Why use a slipper clutch? Basically to stop wheelspin under acceleration. If the motor produces too much torque for the rear tyres to transmit to the track, they lose grip and the wheels spin. This is most unwelcome when accelerating out of a corner, as it tends to push the rear of the car away from the corner and can lead to a complete loss of control which wastes precious track time. A properly adjusted slipper clutch will limit the torque fed from the motor to the rear wheels, reducing wheelspin and making the car easier to drive.



Pete Winton slips the latest Schumacher goodie onto the Cougar

In order to understand the principles involved, we need to delve into the properties of that universal force, friction. Friction is the physical force which ensures that we can walk, cars can be driven, and things stay where you put them. Friction is the way two surfaces act on each other to stop them sliding. Walking along the High Street on a dry sunny day is easy. The friction between the soles of your shoes and the pavement is high. Walk the same route on an icy day and the friction is very much lower, often low enough for you to lose grip and fall over. There are two types of friction, dynamic and static. Dynamic friction is the friction between two moving surfaces, and static friction is the friction between two non-moving surfaces. The most important difference between dynamic and static friction is that one needs greater force to overcome than the other.

Imagine what happens when one does fall over on an icy day. We tread carefully along the pavement until suddenly one foot loses grip. It seems impossible to stop the foot sliding, and we either fall over or manage a passable imitation of a tightrope walker. While the sole of the shoe is stationary relative to the icy surface, it takes a reasonable force to get it moving. However, once it is one the move, sliding across the ice, it takes less force to keep it moving. This is why it seems to slip away from under us whatever we try to do to stop it. Static friction is operative whilst our feet are firmly planted on the ice, but when they slide, dynamic friction comes into play. Static friction needs a greater force to overcome it than dynamic friction, it is in effect a higher level of friction. We racers see this phenomena most often on the track when our tyres lose grip.

A car coming out of a corner uses friction to keep the tyres gripping the track. The contact area between the tyre and the track is between two stationary surfaces. Although the car is moving, the tyre revolves, constantly presenting new rubber to the track. At any instant in time the tread of the tyre touching the track is stationary relative to the track; in other words the tyre is not sliding across the track. However, if the forces acting on the tyres, through cornering and acceleration, overcome the static friction, the tyre will start to slide. This is manifested by the back of the car sliding round, often without stopping until the car is facing the wrong way!! The forces of cornering and motor torque we have built up in the tyre to start it sliding are way in excess of the force we need to keep it sliding. To stop the slide, we remove the motor torque, and reduce the cornering forces, by simply closing the throttle and to balance the car, we may also apply some opposite lock to the steering. Often, no matter how quickly we release the throttle, or apply the opposite lock, the forces cannot be reduced sufficiently, or quickly enough, to restore static friction whilst the car is travelling forwards, and the car spins right round. The car only stops sliding when the forces are reduced to a level where dynamic friction is no longer overcome, and the tyres stop sliding relative to the track – static friction is restored.

Static friction operates when the car is not sliding, and dynamic friction operates when the car slides. Because the force required to overcome static friction is higher than the force required to maintain dynamic friction, the car continues to slide until the forces are reduced way below the level at which the slide started.

One of the most common ways we see this in action is when a road car tries to make an emergency stop in the wet. The car slows down quickly while the tyres have grip (static friction), but as soon as the wheels lock up the tyres skid (dynamic friction) and the rate of slowing down reduces rapidly – the car carries on at apparently unabated speed, usually into the car in front!! Correct driving technique teaches one to release the brake pedal momentarily which reduces the force on the tyres and gets them rolling again (static friction restored), and then brake again. Anti-lock braking systems (ABS) carry out this process electronically and very quickly, but the principle remains the same – restore static friction so that the maximum forces stopping the car are in play.

What has all this to do with a slipper clutch? We are trying to stop the rear wheels (on a 2WD car, where this unit is most effective) being fed too much torque from the motor so that the static friction forces between tyre and track are not overcome. The friction between the tyre and the track we normally call grip, so we are in effect trying to stop the tyres at the rear of the car losing grip.

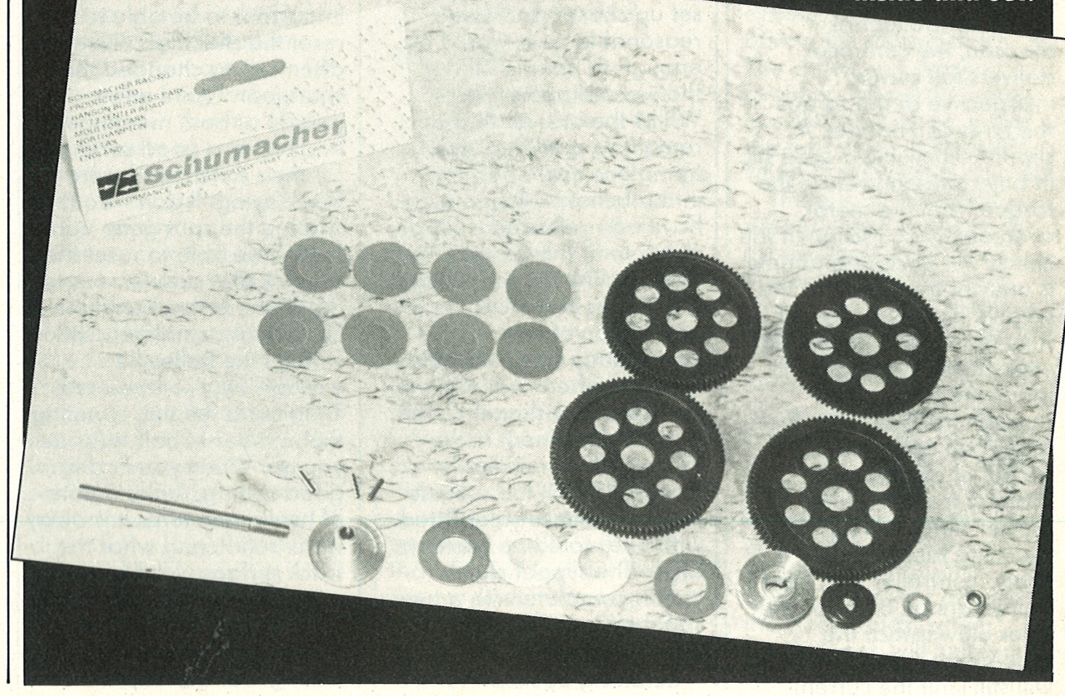
How does the slipper clutch work? Using friction!! Basically, the slipper clutch is two mating surfaces which can slip, one relative to the other. One surface is fixed to the spur gear (which is attached to the motor directly through the pinion) and the other surface is connected to the gearbox input shaft, and hence to the rear wheels/tyres. Applying a force on the two plates (in this case squeezing them together) increases the friction allowing drive straight from the motor to the gearbox. However, when the torque of the motor is sufficient to overcome the static friction between the surfaces, they they will slip. Using an adjuster, we can vary the force squeezing the plates together and so change the amount of torque the clutch will transmit before it slips.

If the clutch is correctly set, then the motor torque we are trying to feed to the rear tyres will cause the clutch to slip before the rear tyres lose grip. This means that, however heavy handed we are with the throttle, the slipper clutch will help prevent wheelspin, and therefore stop too much torque going to the rear wheels which might make them slide. In effect, as those at the Australian World Champs found out, it becomes more difficult to make the car spin coming out of a corner, and so makes it easier to drive.

Those keen students of friction should by now be saying "Aha, but if dynamic friction (when the clutch slips) is less than static friction, then the clutch will go on slipping until the torque is reduced". True, but one of the properties of a dc electric motor is that it produces less torque as it speeds up. The act of the clutch slipping allows the motor to speed up, reducing its torque output. "But", we hear you say "when the clutch stops slipping there will be a sudden jolt in the system because the restoration of static friction allows higher torque to be fed instantly to the rear tyres". True (you are a clever lot aren't you?) True except for the wondrous properties of a substance called Polytetraflouroethylene or PTFE. Discovered by NASA, it was used to coat the outside of spacecraft to reduce friction on re-entry to the atmosphere, and subsequently became a household name in non-stick frying pans. Good though it is for aerospace and culinary applications, it has one other magic property. The more slip against a PTFE surface, the higher the friction. Additionally, the difference between levels of static and dynamic friction is much lower than for other conventional materials.

Using PTFE in the clutch means it will start to slip more progressively, and will continue to transmit a relatively even level of torque to the gearbox whilst the clutch is slipping. As the speed of the car increases, the torque difference reduces until the clutch stops slipping and moves gently (with PTFE) back to

The components of the Schumacher slipper clutch – a must for slippery surfaces inside and out.



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static friction. This process can happen in the twinkling of an eye!!

A slipper clutch using PTFE is, like an ABS system in a car, a simple way of reducing the possibility of tyre slip, and so maintain a grip on the track surface. The more slippery the track surface, the more useful a slipper clutch becomes. There are other ways of limiting motor power. Many new speed controllers (Laser, Nosram, Schumacher) are fitted with an electronic device to limit the current flow to the motor during acceleration. This has the same effect as a slipper clutch, but it has one theoretical disadvantage. Since it operates by limiting the current flow at low motor speeds, the motor is running in the area of its least efficiency. When the slipper clutch operates, the motor accelerates to a higher speed, nearer its maximum efficiency. Although the current drawn by the motor may be the same in both instances, the motor is making more efficient use of that current in a slipper clutch application. I repeat, that is theoretical. One certain practical advantage is that the slipper is dependant on torque, whereas the speed controller uses a simple timing device to delay the application of full current. After the time delay in the speed controller has elapsed, the controller delivers full current irrespective of the torque the tyres can handle. A slipper clutch will always slip in any condition where the torque from the motor overcomes the friction in the clutch. An obvious example is uneven tracks where the wheels leave the ground. As they do so, they speed up, whereupon landing shock loads are transmitted through the gearbox. These loads can cause the car to go out of control on a slippery track, but the slipper clutch will slip thus reducing these loads – a speed controller with time delay cannot. Perhaps the killer blow is that the time-delay speed controller will still limit the current when the cells are down on power. In this condition, the motor cannot produce as much torque as with fresh cells. The slipper clutch will not slip with the reduced motor torque, so it will give you maximum acceleration.

Believe Me!

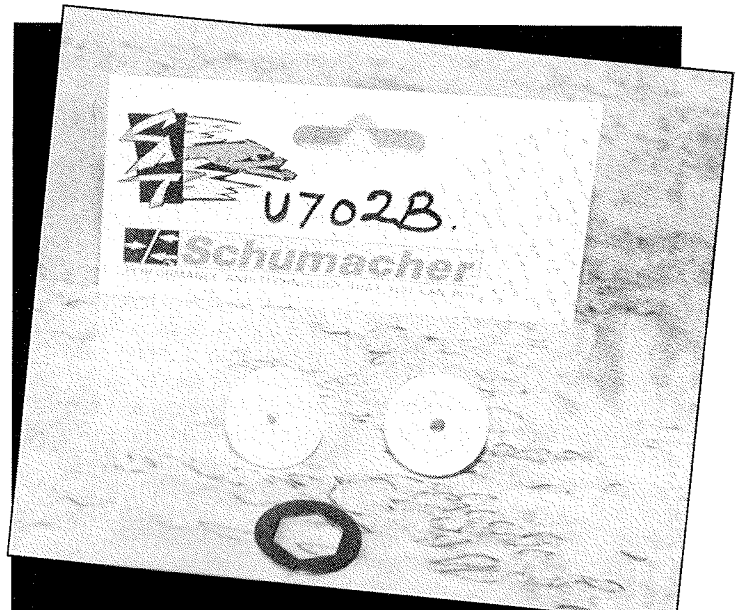
Readers who have got this far will be either bemused, disbelieving, or argumentative. The bemused and the disbelievers will now benefit from specific advice, and the argumentative can put pen to paper and write to us here at the magazine!

For the bemused, there is no need to worry about the theory of a slipper clutch. We try to explain a little about the way things work since knowing the theory can often help people make maximum use of the product. The vast majority of racers have enormous fun with their R/C cars in blissful ignorance of the complexities involved. There is nothing wrong with that, but there is also nothing wrong with trying to improve your knowledge.

Hidden Benefits

To the disbelieving we can only say this – try it. Although I fully understand the benefit of a slipper clutch, I confess to being very sceptical about using one. Surely a reasonable competence with the throttle allied to a properly set up chassis and some reasonable tyres would be enough to handle all but the worst slippery tracks. Whilst the answer to that remains a qualified 'yes', trying one converted me into a believer. Schumacher have now released a slipper clutch to fit the Cougar and Procat. With the many high grip tracks in the UK, a new generation of tyre compounds now available, land the inherent stability of a 4WD car; a slipper clutch is of dubious merit in the Procat. However, for the Cougar (2WD) the success suggests that any car fitted with one would be easier to drive. The slipper clutch comes complete with a new spur gear, and a new gearbox layshaft.

Referring back to the



Plastic diff update parts for standard diffs.

instructions, the new layshaft was fitted to the Cougar gearbox. The actual clutch assembly is quite straightforward, and no problems were encountered during assembly. Slipper clutches can only be set on a circuit, so no attempt at adjustment was made on the bench, except to ensure that the gearbox and differential were properly adjusted and free running.

We used the clutch at the Chesham Off-Road Club, and at the Stafford EFRA Grand Prix. The nature of the surfaces at the two events were so different, that we learned a lot in a very short time. It is very important to be able to reset the clutch accurately after having changed the spur gear. Quite a few people at both meetings had found a good setting for their clutch, and were then saying "I don't want to change the spur gear 'cause I won't be able to reset the clutch". Our answer was to do up the locknut until the clutch was completely solid, with all the Belleville washers fully compressed. Then undo the nut, counting the number of half turns as you go. When you find a good setting, make a note of how many turns it is away from 'solid', and what the track surface was like.

At Chesham there was a lot of grip, and the track maintained that grip throughout the day. Chesham is always slightly bumpy, and here we noticed the first 'slipper' benefit. Obviously, if there is enough grip the slipper could be set at solid. However, we backed the nut off about half a turn, so that when the spur gear and one wheel are held stationary, turning the other wheels makes the clutch slip before the differential slips. We found that this had two advantages.

No Shock

The first was that when the car travelled at speed over the bumps, or accelerated over bumps, the slipper clutch took all the shock loads instead of the diff. Thus the car remained in a straight line over the bumps and was much less prone to being thrown from side to side in this situation. The second was that the differential remained free and smooth all day since it was not slipping over the bumps (this creates a noise often mistaken for belt slip) causing the balls and thrust washers to wear prematurely.

At Stafford the situation was similar in regard to the bumpy nature of the track, but there were also some very slippery turns to negotiate. We backed the nut off about one turn, and found this helped a little. When we got to about 1¼ turns, the car could be accelerated hard out of the slippery turns. However, once we got the car onto the track for a race, the slipper setting was OK for the slippery bits, but left us with absolutely no accleration out of the grippy turns, just a motor screaming its head off!! Returning the slipper to about ¾ of a turn away from solid gave the right balance, but meant care on the very slippery turns (just like a standard set-up), but much more confidence in the rest of the track.

Two points are apparent. Unless the track has equal grip all the way round, the slipper clutch is of limited benefit in trying to make the car easier to drive out of corners. If the track has a lot of grip, and is bumpy, the slipper clutch (set to slip before the diff slips) will make the car easier to drive, and save wear on the diff. If the track is of low grip all the way round, then correct setting of the clutch will make the car much easier to drive.

There are a number of points to note. Firstly the Schumacher slipper clutch is quite easy to adjust, the combination of Belleville washers (which must be in accordance with the instructions and remain unaltered) is designed to give a straight relationship between the amount the nut is tightened, and the amount of slip. Secondly, the skill of the driver materially affects the setting of the clutch. The less your skill, the more slip you allow, and hence the easier the car is to drive. Lastly, the amount of slip you allow (set) in the clutch must take account of the grip around the total length of the track.

Get a Grip

If the grip is even around the whole length of the track, then one setting will be of equal benefit everywhere on the track. However, on tracks where grip varies in different corners, a setting is required which suits the majority of the track. One must be aware that a clutch set of minimise wheelspin in a slippery turn will not maximise acceleration in a grippy turn. A measure of judgement is required to decide which corners are most important for a fast time, and which are not. The clutch must be set to maximise acceleration out of the turns which, in the majority, have the same level of grip, and are key to a fast lap time. One slippery turn should not dictate the setting of the clutch for the whole track when that means losing time out of the turns with higher grip because the clutch slips on its 'low-grip' setting.

It's a Set-up

Setting the clutch is easy. Place the car upon the surface you want to set the clutch to handle. Stab open the throttle. If the wheels spin, reduce the force on the clutch by undoing the nut a small amount. Stab the throttle again. Keep doing this until the wheels spin momentarily, and the car takes off in a nice straight line. You will probably hear the clutch slip, the motor note rises but the car does not accelerate. It is not necessary to eliminate all the wheelspin, since in the turns the car is normally moving when you accelerate thus helping keep the tyres gripping the track. You will quickly find the best way of setting your clutch to suit your driving style. We found that any setting using more than 1½ turns away from 'solid' may look great in testing, but was a waste of time on a mixed surface track since the car was just too slow out of the grippy turns.

Remember that the slipper clutch setting is dependant on the amount of torque the rear tyres can take before they lose grip. The amount of torque the motor produces, or the gear ratio the motor is using, are largely irrelevant to the setting. It is of paramount importance to reset the clutch if the driven tyres are changed (all four on a Procat, the rears on a Cougar) since different tyres give different levels of grip, and thus affect the amount

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of torque that can be fed to the track from the motor. Tyre choice remains the same as before, find a set that gives as much grip as is practical for the conditions, irrespective of the use of a slipper clutch. Remember that if you set the clutch correctly, you should always feel that you have the right tyre choice, since the car is easy to drive. Remember to look around at the tyres people are using who do not have slipper clutch to make sure you are using the best type for the conditions!

It may be stating the obvious, but don't forget to re-adjust the slipper clutch if the track conditions change during the day. A slippery, dirt circuit can become a very grippy proposition after a shower of rain. Do remember that cars must never be tested whilst racing is in progress. However sure you are that no one is on your frequency, and however far away you go from the track, switching on your transmitter in the pit area is highly anti-social and potentially very dangerous. Just ask yourself how you would feel if someone did it and ruined your race/car/health?

No Spin

The slipper clutch need not be set to prevent ANY wheelspin, although it can. Setting the clutch so that the car drives in a controlled manner, including slides and wheelspin if you can handle it, is the objective. A slipper clutch will not make the car travel any faster round the corner, nor in a straight line. It may have a limited beneficial or adverse affect on run times (duration) depending on many factors. The slipper clutch helps control. By removing some of the risk that you will lose control of the car under acceleration, your increased confidence will be the major factor that improves your lap times.

Always remember that the slipper will not allow you to stab open the throttle in the middle of a turn, and rocket on to the next straight without any problem. It only works properly if you drive properly, and when it works it helps a great deal in keeping the rear of the car in line. That is the beauty of it, a simple device which can help keep you pointing in the right direction and maximise your enjoyment of racing 2WD cars.

Lastly a slipper clutch makes you slow off the line. In a standing start, cars without a slipper will move off ahead of you no matter what you do. However, they could storm off sideways, whereas you should remain in a straight line. This will require skill and patience in picking your way through the qualifying traffic, but the benefit will show later on in the race.

A slipper clutch only affects that cars' performance when the throttle is on. It has no effect on understeer, either going into, or out of, a corner. If you have a handling problem which occurs when the throttle is steady, closing, or closed, don't blame the slipper clutch. The clutch only helps in avoiding wheelspin under acceleration, either out of the turn or on the straight, when the throttle is opened.

There is no doubt that a slipper clutch makes a car, especially a 2WD car, easier to drive. The club lunatic will not suddenly become a Jamie Booth, but if he does pass you on occasion with his slipper in place, you'll know why! Devices will soon appear for the RC10, Losi JRx2, Ultima and Astute. They are not instant performance-enhancing goodies you must buy, but another device in the war against the clock which, when properly set, will help you win the war.