Brakes

By Bob Williams (Vice-President), Torque of the Town, 4/2006

My condolences to the family of Peter Brock. His sudden death gives us all reason to pause and reflect on our own driving and mortality. In the words of club member Roy Jessop, 'live life to the full, enjoy every day and skid sideways into heaven with your wheels spinning'.

I continue with my open invitation to any club members who have some interesting technical stories or problem solutions to contribute them to this column. My scribbling is a simple introduction to the subject in the hope that it might be entertaining and at least a little bit informative. I hope to provide a bit of an insight into this technical stuff.

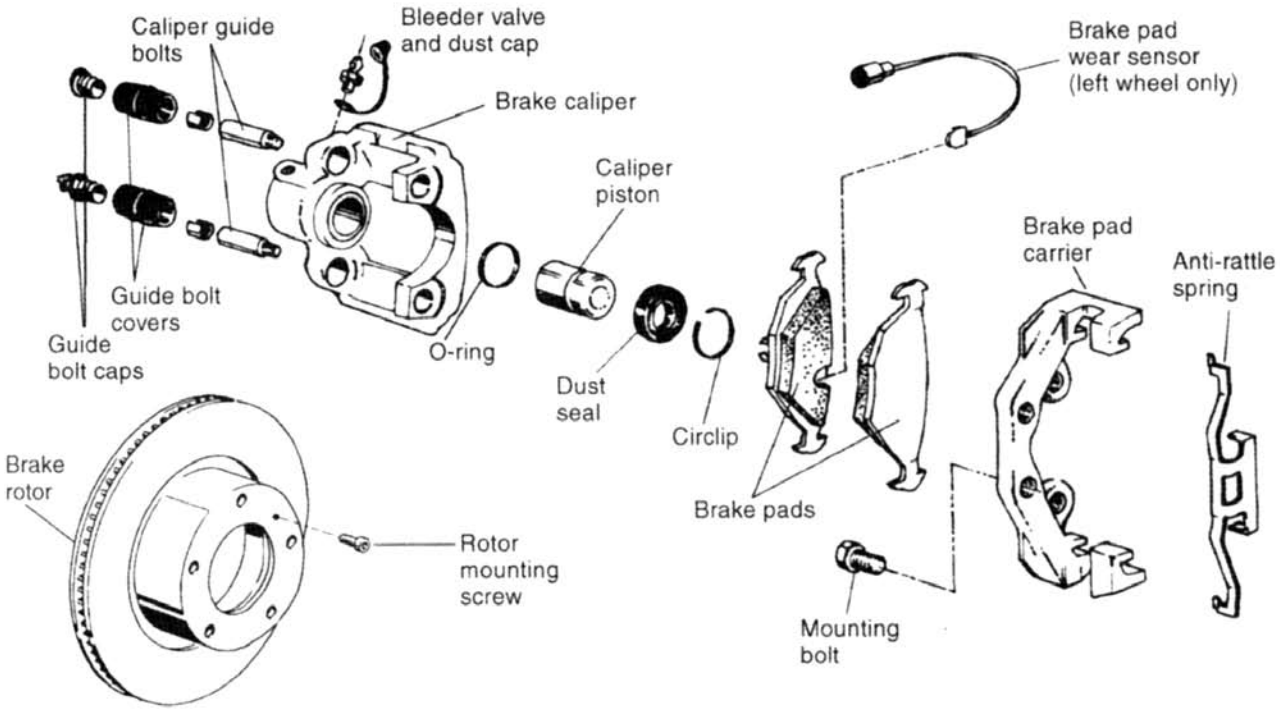
The brakes are the most important part of your car. If the engine fails you just don't go and that never hurt anyone. If the brakes fail, the loss of a controlled stop can be deadly.

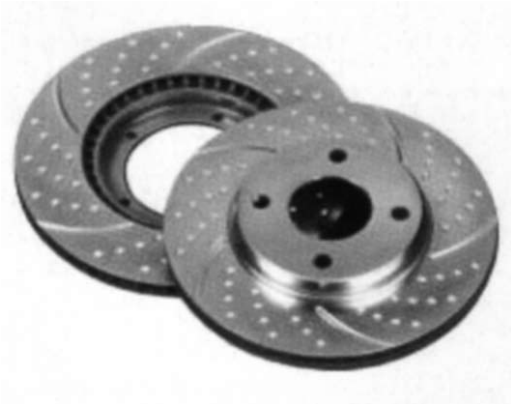
The brakes in our cars have been developed since the horse and buggy used "woo dobbin" as the brakes. Even many horse-drawn vehicles had a lever with wooden blocks that rubbed against the steel wheels.

I wish to start my brakes story at the 2002 (BMW not year). In the 1960s most cars had drum brakes. The 2002 was quite revolutionary with drum brakes on the rear and disk brakes on the front. All BMWs since the 2002 have had disk brakes on all wheels. After 30 years most car manufacturers have now progressed to this brake arrangement.

Drum brakes are where a cast iron cylinder, the drum, is bolted with the wheel to the hub. The drum therefore rotates with the wheel. There are two brake shoes inside the drum with the same curved shape as the inside of the drum. These shoes are attached to the car via a pivoting mechanism. When activated these shoes push out against the inside of the drum and the resulting friction retards the rotation of the drum and the car stops. The shoes are made of a friction material that is softer than the cast iron of the drum so it wears out first. Drum brakes have an advantage in that they tend to be self-energising and are relatively easy to apply. That means, you don't need to push the brake pedal very hard to stop the car. The problem with drum brakes was that if you applied them hard three or four times in a row, the heat build-up from the friction resulted in the brakes fading and the force on the pedal needed to stop the car greatly increased.

This is all about the physics of the situation, – 'energy can

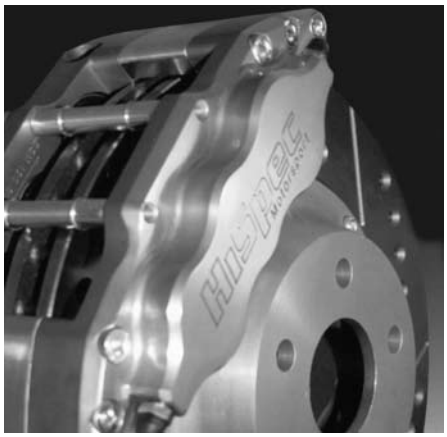




neither be created nor destroyed, just changed in form'. The kinetic energy of the motion of the car is converted to heat energy in the brakes. This heat has to be dissipated. Drums with fins were invented in an attempt to dissipate the heat to the surrounding air. These are heavier than drums without fins and that resulted in other problems in the suspension.

Brakes were originally activated mechanically. A lever or pedal, pushed or pulled a rod that pushed or pulled the brake shoes against the drums. This is cumbersome and heavy, especially where the wheel is moving up and down as the cars suspension operates. Cable mechanisms are needed to allow for this wheel movement. Hydraulic activation was invented and by the 1960s all cars used hydraulic activation. The brake pedal pushes a piston in a hydraulic cylinder. This forces brake fluid down a pipe to a slave cylinder in the wheel. When force is applied, the slave cylinder piston pushes out forcing the brake shoes against the drum. The advantage here is the pipe can be a flexible hose and can then easily allow for the movement of suspension and steering. The hydraulics also allowed for the mechanical advantage required so that reasonable movement and pressure on the brake pedal is translated into small movement and high pressure on the brake shoe.

As hydraulic systems were developed, the power booster appeared. I can remember my father-in-law always had a power booster fitted to his EJ then HD Holden. Both these cars had drum brakes all round. He believed that his brakes, because of the power booster, were better than everyone else's. I tried, without success, to explain that because it took less pedal pressure to apply the brakes didn't make them better brakes, just easier to apply. The invention of power boosting is all about taking low pressure from the engine manifold and using it to assist with pushing the brake pedal.



Power boosting made the disc brake a practical possibility. Without power boosting the brake pedal for disc brakes requires a great deal of force to stop the car. Just about all cars now have power boosting. The downside of this is that the car is very hard to stop if the engine is not running and the store of low pressure in the brake booster is exhausted.

Disc brakes are an arrangement where a round cast iron disc is bolted with the wheel to the hub. The disc is usually called a rotor. A brake caliper, bolted to the suspension, straddles the rotor. The rotor is slowed by applying force so that it is squeezed between two brake pads in the caliper. Activation is by hydraulic pistons applying the squeezing force. The brake pads are friction material like that on the shoes in the drum brakes. The front brakes on the 2002 were disc brakes with each caliper having four pistons arranged in two pairs.

It is relatively important that the brakes work every time the pedal is pressed. To make this happen, car manufacturers build in two separate hydraulic brake circuits. If one brake circuit springs a leak the other circuit applies force to the remaining brakes on half of the wheels. In the 2002 the front calipers had two sets of pistons, one set operated from one hydraulic circuit the other set from the other hydraulic circuit. The 2002 even had two power boosters, one for each circuit. Race cars often have calipers with 2, 3 or even 4 pairs of pistons. The larger the caliper and the larger the brake pad the better. The limit again is can they fit inside the wheel and can the suspension handle the unsprung weight.

The hand brake or parking brake is an independent mechanical brake arrangement that operates on the back wheels. If all else fails the handbrake might stop the car.

The larger the rotors the better. Just look into the front wheels on your car. The rotor is the big round shiny silver disc. Large rotors almost fill the space between the hub and the wheel rim. Modern cars have 17", 18" or even

19" wheels. This allows for larger rotors. The first rotors were a solid disc of cast iron. The problem was they overheated when squeezed. At night after some spirited driving they could be seen glowing red and they were prone to warping. More modern rotors are ventilated. That is they are two flat disks of cast iron separated by cast iron spacers with an air gap. As the rotor spins, air is sucked through the gap between the two surfaces to keep them cool. Some rotors have grooves or holes to improve braking and cooling. Some rotors like those on the M3 have cast iron disks but the centre is aluminium to keep the weight to a minimum. The latest innovation is to make the rotor out of carbon ceramic. They are large flat dinner plates, expensive yet but the way of the future. They tend to look mottled black.

The disc pads are available in a range of friction materials. Nice soft materials have the advantage of requiring low pedal pressure to stop and they reduce wear on the rotors. Their problem is that they tend to overheat if driven spiritedly and wear out quickly. As the material is hardened the brakes operate better under extreme conditions but wear out the rotors. Replacement rotors can be expensive. I remember the day when a Valiant Charger was presented to WRA with noisy and badly shuddering brakes. When we removed the front wheels, we found that the pads were just backing plates with no friction material at all and the ventilated rotors were worn through to the spacers between the disks. Don't let this happen to you. Each rotor has a wear thickness limit stamped on the rotor. When it wears down to the limit, replace the rotors. It is your life.

The best development in brakes in recent years has been ABS (Anti-lock Braking System). If you leap on the brake pedal in an emergency without ABS, the wheels lock and the car slides straight ahead and does not stop in the shortest possible distance. You have little or no control over the direction of the slide. Result, you will unfortunately likely hit the target. Really talented drivers remove their foot then replace it to get the wheels rotating to stop the slide. This is not a natural reaction and is quite hard to accomplish. With ABS the electronics detects that the wheels have stopped but the car has not so it oscillates the brakes allowing the wheels to rotate and stop. This results in a car that stops in a shorter distance and is still controllable during the crash stop.

It is important that every driver who has ABS (and that is just about all of us now) tries out the ABS to understand just what it feels like and how you can still control the car in an emergency stop. When it is raining, please take your car to a deserted stretch of road. At 60 km/h land on the brakes hard. You will feel the oscillation as a pulsing on the brake pedal and you can still steer the car. Please practise. It has been reported that if you don't understand the operation of ABS, some drivers in an emergency are frightened by the oscillating effect and take their foot off the brake pedal with disastrous results. Please practise.

The next development in braking is DSC (Dynamic Stability Control) or DSP (Dynamic Stability Program). These are topics for discussion in a future Technical Stuff.

Remember, if you want to go fast, make sure your brakes are the equivalent of your thrust. Hot up the brakes before you hot up the motor. Look after your brakes and they will return the favour over and over again. Enjoy life in the fast lane and good motoring.