

## Brakes: How Do They Work?

by Lynn Bennett

You start your British twin motorcycle, slip it in gear, and zoom to the end of the block where you are suppose to stop. Then in a moment of panic you forget where the rear brake pedal is: left or right? Am I on my Ducati (right) or one of my several British bikes (left)? But not all is lost, you think. I'll just stop with the front brake. But when you pull it the bike only just perceptibly slows. At the last minute the bike stops, a few feet beyond the limit line. Why didn't the front brake adequately stop the bike? Well, if you understood how brakes work maybe you'd know and be able to fix the problem. So here is what I know about brakes. And the above scenario actually happened, to me.

### Types of Brakes:

For Brit bikes produced in the 1960's, 70's, and into the 80's three types of brakes were used: single leading edge drum brake, double leading edge drum brakes, and disc brakes. The classical drum brake includes a cylindrical surface (brake drum) located inside the wheel hub, about 7 inches in diameter whose inner surface is the working surface. Internal brake shoes, part of a cylindrical surface with friction material attached to the outer curved surface, expand to touch the hubs brake drum. Springs, usually strung between the shoes, return the shoes to their at rest position away from drum contact.

Disc brakes use a flat circular plate (sometimes dished on its' inner center to accommodate mounting to the wheel hub) attached to the hub of the wheel. A caliper, which is mounted to the motorcycle frame (at swing arm for later bikes) or front fork, pinches a pair of pucks onto the outer edge of the disk. The concept is to cause friction between the shoe or puck and the drum or disk. That friction is turned into heat. The limit of the braking is affected by the ability of the friction material and the drum or disk to get rid of the heat. Disk brakes, since they have more area of the disk to which to transfer the heat, tend to be more fade free than drums. Disk are also helped by the fact that the disk is exposed to the air flow, not stuck inside the wheel in a confined area which has little or no air flow as in a drum brake.

### Single Leading Edge Drum Brake:

As stated above the drum brake includes the drum and two brake shoes. The shoes are situated on a brake backing plate that is attached to the frame via a central hole for the axle and a brake stay or bar. The stay is attached to the backing plate at one end, close to the edge so as to maximize the mechanical advantage, and to the frame or forks at the other end. The stay transmits the force of braking into the non-rotating part of the bike. As the force can get to be pretty high the stay must be pretty robust. In some front fork drum brake installations the stay is replaced by a cast on lug on the baking plate and a welded or cast on receptacle on the fork leg. But the purpose is the same: transfer the braking force to the non-rotating part of the bike. The brake shoes are attached to the backing plate such that one end is free to rotate (pivot) while the other end rides on a wedge shaped device, the fulcrum. The fulcrum allows the shoe to be wedged over against the inner surface of the brake drum. Pivot on one end, fulcrum on the other. Physically most Brit bikes use a single pivot bolt for both shoes with each shoe including only half or less of the pivot hole. Usually only a single fulcrum, double sided, is used against the ends of the shoes to move them against the brake drum.

For the so called "leading shoe" the wedging action started by the fulcrum is reinforced by the wheels rotation. This is called self actuation. As the shoe end touches the drum the shoe's friction material is pulled into the drum by a wedge like action of the rotating drum, since the shoe's other end is fixed at its' point of pivot. The other brake shoe, which

is physically located such that its "leading edge" is actually fixed at the shoe's pivot point, simply drags on the surface of the drum with no self actuation. Hence the name single leading edge brake. Of course when the bike rolls backwards, as in holding the bike on a hill, the jobs of the shoes reverse due to the change in rotating direction. Since we rarely go backwards on bikes, the leading shoe typically wears out much sooner than the trailing shoe. But for the amount of brake area involved the efficiency of that braking is not all that it could be. The self actuation is a big part of braking performance and the single leading edge drum brake throws half of it away. What if both shoes were leading shoes?

#### Double Leading Edge Drum Brake:

For this class of drum brake the shoes are arranged physically so that each shoe has its own pivot and fulcrum. Both shoes are arranged on the backing plate such that for the forward direction of rotation each shoe can present a leading edge to the drum. This usually means a brake actuating arm (part of fulcrum mechanism) at the top and the bottom of the backing plate and two pivot bolts. Both shoes self actuate in the forward direction and neither do in the reverse rotating direction. That means double leading edge brakes have minimal braking (less than a single leading edge brake) while holding a bike on a hill. Consequently, that is the main reason bikes typically only have a front double leading edge brake. The rear is usually a single leading edge brake. I suppose another reason for this is that the front does most of the stopping of the bike, so it should be the most powerful.

#### Drum Brake Maintenance:

Drum brakes should be cleaned whenever the wheels are off the bike, like at tire changing time. They can be blown out with air to remove the brake dust but some of the old bikes have asbestos lining, which can cause cancer. Use common sense when doing this. The pivot point(s) needs to be cleaned and the pivot re-greased, but minimal is much better than liberal. The fulcrum(s) and the shoes fulcrum contact point should be cleaned and every so lightly greased. Do not soak the friction material in solvent or oils. That ruins the friction material and possibly could start a brake fire (never seen this on a bike but it happens to trucks all the time). Brake Clean Spray is the best solvent for any cleaning of the shoes or their parts. Use a very coarse sand paper to remove the shiny surface on the friction material, called glaze. Again watch out for the asbestos dust. Ideally the brake drum should be "turned" as we used to do in cars but doing it at home is extremely difficult. I have made it a habit when I rebuild wheels (relace) to use my lathe to resurface the drum. I made up special mandrels to hold the hub through the axle hole on the good bearings for absolute centering. Do not take off too much material or the shoes will not get full contact with the drum. Just skim the surface to remove the surface irregularities and to square up the surface (drums tend to wear bell mouthed). Ideally the shoes should be "arched" or sanded on a machine to get the right radius on their surface to match the new radius of the turned drum. There are at least two vintage motorcycle brake shops in Southern California that offer this service.

Brake adjustment is pretty straight forward for single leading edge brakes: adjust until brakes are just short of dragging as the wheel is spun by hand. Double leading edge brakes require that both shoes touch and exert pressure on the drum at the same time in order that the shoes equally share the brake load. Some of the latter examples use a single cable threaded through both fulcrum arms on the backing plate so that the two fulcrum levers give exactly the same force to the shoes. Earlier versions of double leading edge brakes use a series of links with adjustment turn buckles. For these hold one shoe up against the drum with its fulcrum lever while adjusting the other fulcrum lever using the linkage, to the point where its shoe too is just touching the drum. Then adjust the common (to both leading shoes) adjustment as with the single leading edge brake until

the brakes are just short of dragging as the wheel is spun by hand or to the point where you like the free play before brake contact.

#### Disk Brakes:

As vintage motorcycles go disk brakes are new. As described above disk brakes literally pinch the disk to stop the bike. Except in the very early days of disk brakes, disk brakes are hydraulically actuated devices. A master cylinder, made up of a lever connected to a piston, provides hydraulic oil under pressure to the caliper assembly through a rubber hose. The caliper is a hydraulic device that squeezes a puck on each side of the disk using the hydraulic pressure from the master cylinder. The caliper can be made in several different ways, all equally effective. The caliper can have one fixed puck and one piston actuated opposing puck. Or it can have a piston actuated puck on each side. Or it can have the single piston on each side replaced with multiple (2 or 3 or ?) pistons. The possibilities are endless, it seems. The caliper assembly can be fixed to its' mounting point while the disk is made to float. Or the disk can be fixed to the hub and the caliper made to float on pins or ways. Or both can float. All possibilities have been tried over the years.

The design of the hydraulic system leverages is critical to the feel of the brakes. The size of the master and caliper pistons (total area) determines the feel of the brakes and how much effort is required to stop the bike. Swapping components from other bikes can give you bad, good, or great brakes.

The caliper pistons are actuated by the hydraulic pressure and are retracted, after hydraulic pressure subsides, by the piston's rubber seals (no return springs). The pucks, which obviously are actuated by the pistons, are only a few thousandths of an inch from touching the disk when the brakes are not actuated. When pressure is applied the pistons move in their bore sliding the seals on the piston's wall. The seals are so designed that when the pressure is relieved the seals pull the piston back that few thousandths of an inch. This design makes the system self-adjusting. But when new pucks are installed the pistons must be moved back in the bore to make room for the thicker pucks. If during the life of the pucks you have been adding hydraulic (brake) fluid as the pistons slid out and the system volume increased, this pushing of the pistons back in will require removal of some of the systems brake fluid at the master cylinder reservoir. Disk run-out is critical; that is, a disk that is bent and moves to push the disk pucks with their associated pistons in and out of the caliper piston bores. Such run-out makes the hand lever modulate or can make moving the motorcycle around by hand a challenge as the disk alternately drags and is free. A dial gauge should be used to check the run-out if it is suspect. Refer to the shop manual for tolerances. Replace the disk, if necessary, to eliminate the condition.

#### Brake Stay Attachment Points:

No matter the system type the rear brake stays must be tied somehow to the non-rotating part of the moving bike. The easiest and least expensive approach is to tie the end of the stay to the swing arm, for instances. It can be a long stay or a lug on the brake backing plate fitting into a notch on the swing arm. The result is the braking acts to jack the suspension down in the rear. The force of braking tends to lock up the suspension from traveling in response to a bump input. A bump encountered during braking can cause the rear of the bike to hop as the suspension is nearly frozen by the brake force applied by the stay. The bike tends to squat as the stay tries to rotate the swing arm down at its front. The design solution is to connect the end of the brake stay directly to the frame through a rotating connections, bypassing any connection to moving suspension components. The wheel can travel in response to a bump as the braking force is transmitted to the frame directly. Few Brit bikes use this approach for the brake stay but some Brit racing bikes have incorporated such a design over the years.

### Conclusion:

Well, there you have it: single leading edge drum brakes, double leading edge brakes, and disk brakes. What was my solution to my little scenario? I replaced the Gold Star style single leading edge drum front brake with a latter model double leading edge drum front brake. What a difference! The bike actually stops with the front brake used alone! Success!