

## Gear Types

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**Baker Drivetrain**

Violence is interesting. Genghis Kahn and his descendants raped and pillaged their way across Asia and Eastern Europe to establish the largest contiguous empire in history. One of their calling cards was to leave a pile of heads in the smoldering remains of the village to let people know that they stopped by. There's something really cool to me about a pile of heads all covered with blood and dripping spinal fluid; death is what gives life meaning. And a good transmission gives meaning to horsepower.

There are three basic types of internal *gear changing systems*—crash box type, dog tooth type, and synchronizer type. There are other less common types but we'll stick with the mainstream designs for now. All three are violent because each time a shift is performed, metal-to-metal contact is instantaneous and abrupt.

### Crash Box Type

The term alone sounds crude and harsh, and it is. Crash box is slang for a gear changing system that is not constant-mesh, the type of gear-changing systems more commonly found in transmissions designed in the first half of the 20th century. One of two mating gears is physically moved in and out to engage (shift into) or disengage (shift out of) the selected ratio. Old 3-speed Springfield Indians used this system in first gear. Downshifting into first while in motion resulted in a characteristic grinding noise. Some modern trucks still use this system. Crafty Springfield Indian owners and seasoned truckers avoid grinding by *matching speeds*. In other words, there is a certain RPM in which there is no relative motion between the gear teeth on the mainshaft and countershaft, so the gear moves right into mesh without any grinding. But *matching speeds* is a hassle if you enjoy aggressive riding. Double clutching is another method.

### Dog Tooth Type

A dog tooth system is akin to throwing a stick into the spokes on a bike while in motion. The result is violent and immediate.

Most motorcycles and racing cars use dog tooth internal gear changing systems because they are simple and take tons of abuse. Dog tooth gear changing systems are constant-mesh, meaning all gears at all times are in mesh. Each pair of gears is comprised of one gear that is free spinning (aka speed gear) and one that is splined or fixed (aka fixed gear) to the other shaft. A gear pair, and the resultant ratio, is selected by locking the speed gear to the shaft via a dog clutch or an adjacent fixed gear. Dog teeth, like the ones shown on my arm tattoo, come in male and female versions. The gear closest to my

elbow and adjacent to the chains has female dogs. The other two gears to the left have male dogs.

But dog tooth systems have an inherent amount of rotational slop/lash. Take the typical male/female dog arrangement. The angular width of the male dog must be 50% or so of that of the female. The inherent rotational lash cannot be "designed out" without sacrificing shift quality. For this reason, you will never find dog-tooth-type systems in production passenger cars because this amount of inherent lash gives rise to "tip-in/tip-out" clunk. This is a bigger deal than you might think on a vehicle with a relatively low HP-to-weight ratio (aka cars). Even with low lash synchronizer systems, automotive engineers spend a lot of time tuning engine mounts and modifying engine control algorithms to minimize clunk so drivers don't spill hot coffee on their crotches.

### Synchronizer Type

A synchronizer is like a little brake. Within a hundredth of a second, it stops the relative motion between a gear and the shaft onto which the gear is spinning, and it does this during each upshift or downshift.

Almost all passenger cars use synchronizers because low lash is required (for the reasons listed above) and the larger price tag of a car can justify the added cost of the synchros. And, boy, they do shift nice and smooth. Synchronizer gear changing systems are constant-mesh, meaning all gears at all times are in mesh. The workhorse part of a synchronizer is called a blocker ring and it can be viewed as a conical female brake pad. Each speed gear has an integral male steel cone. When the blocker ring is pushed against the speed gear's male cone, it synchronizes (thus the name) the speed gear RPM with the shaft RPM onto which it is turning, allowing the synchronizer sleeve to lock it to the shaft smoothly and quietly.

The disadvantage of synchronizers is that they do not hold up to abuse as compared to dog-tooth-type systems. Quite often the friction material from the blocker ring will get smeared off and adhere itself to the male cone if you like to do wide open 1-2 upshifts like I do. This renders the synchro useless, creating an audible crunching sound when that gear is selected. Clutchless upshifts or downshifts are not advised unless you *match speeds* or *double clutch it*.

### In the future

For 95% of the motorcyclists out there, dog tooth systems are the way to go. They are simple, dependable, and take gobs of abuse. Clutchless shifting is possible, provided you are not stomping too hard on the lever because you will bend the shift forks.

It's real hard to hurt the dogs because they are designed for day-to-day abuse in a world of violence. I suppose 5% of the people out there may whine about drivetrain lash, particularly in the higher gears. For that reason, there may come a day when a synchronizer may have to be introduced for the 5th and 6th gear shifting. Or we could just stack the whiners' heads in a pile and forget about them. IW

