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Horst of a Different Color: The History of the Horst Link / Four-Bar Linkage

In our last Advanced Suspension Seminar in Portland one of our students brought up the impeding expiration of the US Patent on the Horst Link rear suspension design. Currently held by Specialized (and licensed to other manufacturers), the Horst Link is considered by many to have revolutionized full-suspension mountain bikes when it was released in the late 1990s, and continues to be used extensively on everything from cross-country race bikes to full-on downhill rigs. As we approach the potential release of this design into the wild, we'd like to take a look at what distinguishes the Horst Link, and why this design turned the full-squishy mountain bike world on its head.

Austrian engineer and motocross legend Horst Leitner has never been a stranger to innovation. His motorsports company, ATK, was responsible for countless developments in motorcycle suspension, transmission and braking during the 1980s. Leitner moved his family to Southern California, which in the 1990s was a locus for the then-infant sport of mountain biking. Leitner decided to take what he had learned from motocross and apply it to the engineering challenges posed by this new two-wheeled sport. **AMP Research** was born. Within short order AMP Research released a slew of new products: A linkage front fork, the first hydraulic/cable actuated disc brake, and the "Horst Link" (also called the Four-Bar Linkage), a dramatically different rear suspension design.

Before we delve into the specifics of the Horst Link, let's first look at why designing an effective rear suspension for bicycles has historically been so problematic. It comes down to the effect the chain force has on the suspension, and the peculiarities of a meat-based power plant. A motorcycle produces power consistently, and only has to contend with a single front and rear sprocket. This allows the motorcycle engineer to position the pivot of the swingarm such that suspension movement is isolated from the force the chain produces under tension. The bicycle and its rider are a different animal.

The way in which human beings produce power on a bicycle is in pulses. As much as we like to think we pedal in perfect circles, there is a definite ebb and flow in power output. This, in turn, creates cyclical tension on the chain. Problem One.

I like to grind a single speed up a 10 mile fire road climb as much as the next person, but for most practical off-road applications gears are a necessity. As you shift throughout the cassette and the chainrings, the angle of the chain changes. This alters the "chain force vector", which is a fancy was of saying "where the chain wants to pull things." With single-pivot designs (where the rear axle is part of the main swingarm), the location of the pivot relative to where the chain enters a given chainring is critical. The path that the rear axle traces as the suspension compresses is a simple arc on single pivot bikes. Whether the arc goes up and back or up and forward is a function of the pivot location. If the pivot is above the chainring you're on, chain force wants to pull the rear wheel down, locking out the suspension. If the pivot is below a given chainring, chain force wants to pull the wheel up, compressing the suspension. Both scenarios result in a significant amount of pedal-induced bob, and make the suspension behave strangely under power. Problem Two.

The third challenge was how to isolate suspension action from braking forces. Many early full-suspension designs suffered from what is called “brake jack”, or a stiffening up of the suspension when the brakes are applied. This is especially pronounced when braking through technical terrain, an obvious disadvantage for mountain bikes. Problem Three.

Enter the Horst Link. Horst realized that in order to create a rear suspension design that isolated suspension movement from chain force (and the related effects of braking), you had to de-couple the rear axle from the main swingarm. What Horst did, essentially, was to give the swingarm a wrist. By placing a pivot slightly in front of, and slightly below, the rear axle, Horst’s design allowed for an axle that no longer had to follow a simple arc. It can track virtually straight up and down as the suspension compresses, minimizing the effect of chain force (and, consequently, brake jack) on the rear axle. The patent geeks among you can view the original patent application and associated drawings **here**.

Via the good folks at Tenerife-Training.net

AMP Research utilized the Horst Link (also called the “Four-Bar Linkage”) on their bikes for several years before selling the design to Specialized Bicycles. Specialized incorporated the design into their FSR (Future Shock Rear) line of full-suspension bicycles, and it has been the foundation of their off-road product line ever since. Because of the advantages of the design, other manufacturers have paid Specialized licensing fees to use the Horst Link on bikes destined for the U.S. market. Smaller manufacturers, or those unable or unwilling to pay licensing fees have had to come up with innovative work-arounds, some of them very successful. But the patent is set to expire, potentially by the middle of 2013. Whether this opens up the Horst-Link floodgates remains to be seen. What is certain, however, is that Horst Leitner will be remembered as a true innovator. A pioneer who identified a challenge and set out to overcome it. Four cheers to Horst.

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