Cycle

September 1981 • $1.25

Turbo Preview Honda CX500

HONDA GL1100 INTERSTATE

Suzuki's 16-Valve GS750EX
Versatility Made A Virtue

Rear Suspension Techno
Single-Shock Systems

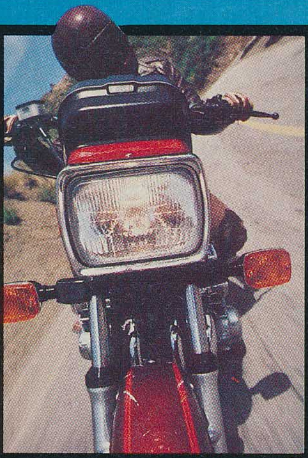
Yamaha IT465H Enduro
Off-Road Skywalker

0 14024 14277 09

Cycle®

September 1981 Volume XXXII No. 9

pg.62



pg.32

pg.86

Road Tests

Features

Special Feature

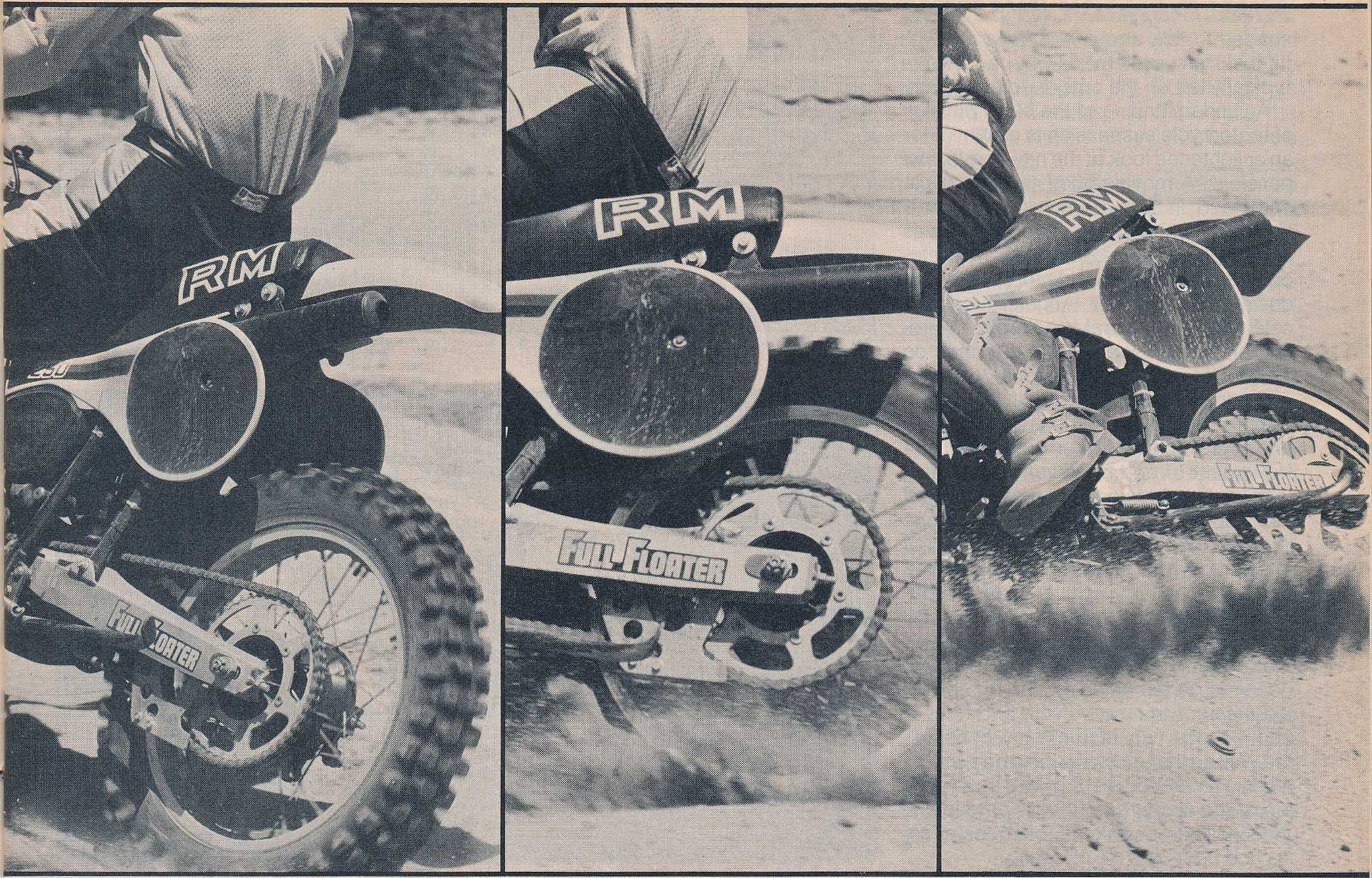
Technical

Competition

Departments

This Month's Cover: Although he's hidden behind the GL-crest, DDC, America's answer to Mighty Mouse, played a starring role in Robin Riggs' captivating photo of Honda's GL1100 Interstate. In order to position the giant Gold Wing emblem, Riggs nailed Daniel's shoes to the wall at the appropriate level, inserted DDC into the shoes, and epoxied the shield to his helmet top. Then, threatening DDC with a bare 220-volt line, Riggs told Daniel to stand up *very* straight. Presto. And click. The test begins on page 20.

CYCLE (ISSN 0574-8135), published monthly at One Park Avenue, New York, N.Y. 10016, by Ziff-Davis Publishing Company—Richard P. Friese, President; Selwyn Taubman, Treasurer; Bertram A. Abrams, Secretary. Second-class postage paid at New York, N.Y. 10016 and at additional mailing offices. Authorized as second-class mail by the Post Office Department, Ottawa, Canada, and for payment of postage in cash. One-year subscription rate for U.S. and possessions $13.98, Canada $18.98, all other countries $21.98. POSTMASTER send address change to *Cycle*, Circulation Department, P.O. Box 2776, Boulder, Colorado 80302. Please allow at least eight weeks for change of address. Include your old address, as well as new—enclosing, if possible, an address label from a recent issue.



SINGLE-SHOCK SYSTEMS

Where They're At, Where They're Going

By Steve Hunter

● WE'RE NOW WITNESSING THE SECOND Great Leap Forward in motorcycle suspension, and like it or not, from here on we're all going to have to become pretty good vehicle dynamics engineers if we have hopes of buying, tuning, racing, or testing bikes intelligently. Each of the Japanese manufacturers now offers a single-shock rear end on its full-sized motocrossers, and the competition between the various systems is as hot in the four-color ad pages of the magazines as it is on the world's motocross tracks.

The ads are packed with the kind of Wilshire Boulevard techno-speak that sets teenaged hearts pounding and throttle fists clenching—including such grandiose but sometimes cryptic phrases as progressive damping, speed-sensitive valving, rising-rate response curves, tapered-wire progressive springs, 30-position adjustable rebound damping, nitrogen-charged remote reservoirs, bellcranks, pushrods and Heim joints.

In one sense it's remarkable that the new wave of suspension thinking took so long to arrive. The basic dual-shock and swing-arm system has been with us for over 60 years. The direct-mounted cantilever swing-arm system used today by Yamaha is a newcomer; it was first used about 25 years ago on HRD Vincents.

Shock absorbers, wheel travel measurements, and frame design have come a long way since the advent of long-travel motocross bikes in 1974, but the basic designs haven't moved a micron until these last few years. It's undeniable that motocrossers work better every year, but for the most part the advances have been incremental tuning refinements and not the kind of design breakthroughs we're seeing today.

Most engineering advances in racing machinery come from factory racing team efforts—and the realities of running a race team do not lend themselves to radical design changes or long-range design development. Factory racing departments justify their existence by winning races. Developing radically new systems during a racing season tends to steal time from vital fine-tuning and race machine preparation—and often results in broken bikes and lost championships.

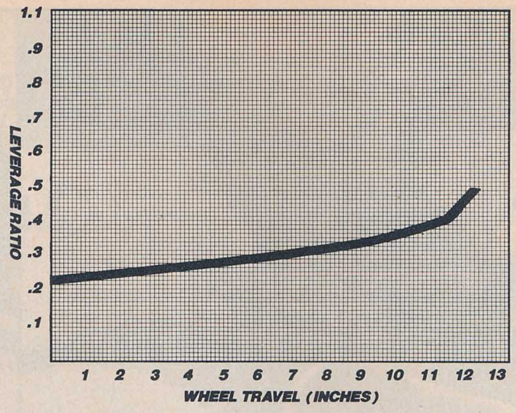
Racing people are best at making motorcycles work better than the intent of the original design. It's not supposed to be their job to design them as well, but the accelerating pace of motocross suspension refinement often left them no choice. This year's crop of motorcycles, however, shows how quickly things have changed. The engineers are being forced to do some fast catching up to design machines capable of satisfying the demands of racers and enthusiasts. There are very few genuine motorcycle suspension experts—and as you will see, even in some of this year's single-shock systems there exist serious design deficiencies that could have been easily avoided. In defense of the designers, the deficiencies of some of the new systems may be due more to legal restraints than to any lack of ability in the respective engineering departments. A motorcycle company, however, can seldom be persuaded to talk about what's wrong with its trick new system, or why, and we're typically left on the outside to speculate.

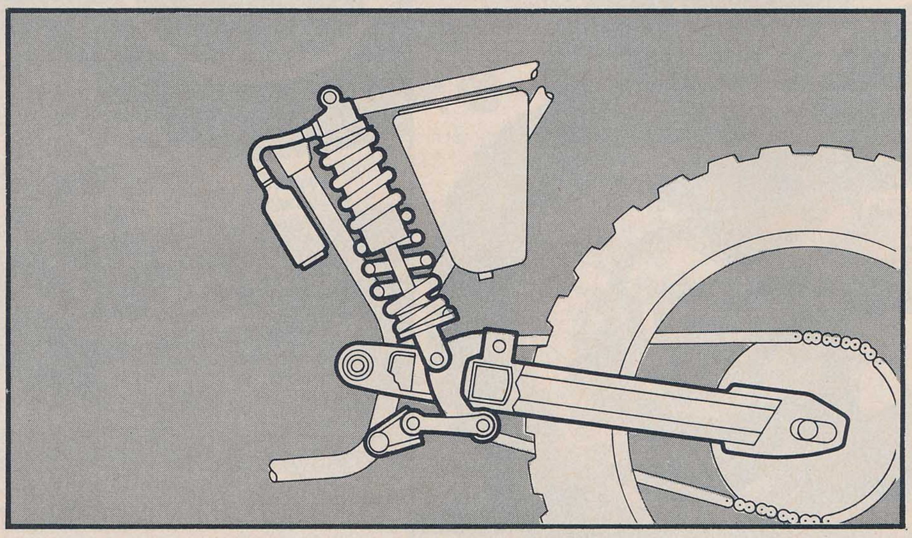
An understanding of the basic physics of motorcycle suspension is essential for an enlightened look at the new-wave suspensions. A moving body (a motorcycle and rider, in this case) will travel in a straight line at a constant velocity unless acted upon by some outside force. Motocross is a game of outside forces—some desirable, some not. Acceleration, deceleration, and lateral acceleration (turning) are all caused by forces acting on the motorcycle at the control of the rider.

Bumps are also outside forces, and with no suspension at all, the motorcycle and rider would be forced to deal with the full impact of abrupt elevation changes; this would act to keep the motorcycle off the ground most of the time. As anyone who has ever found himself at the end of a set of whoops with no suspension travel left can tell you, this tends to separate the rider from the motorcycle.

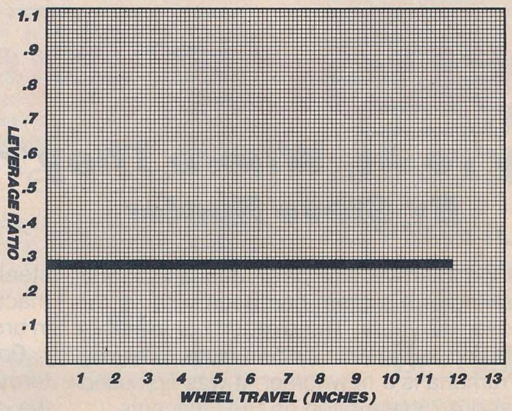
The amount of energy generated by a motorcycle and rider hitting a given bump depends on the height of the bump and the mass of the motorcycle and rider—and if those two factors stay constant, the energy that must be absorbed is constant. The energy won't go away; it's the job of the suspension to dissipate it with the smallest possible effect on the chassis and rider.

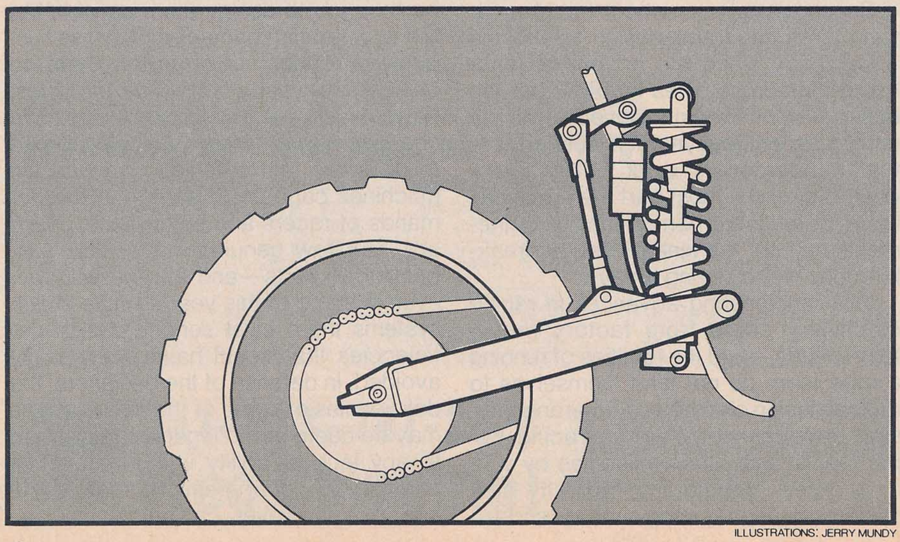
1981 HONDA CR250R PRO-LINK





1981 KAWASAKI KX250 UNI-TRAK





ILLUSTRATIONS: JERRY MUNDY

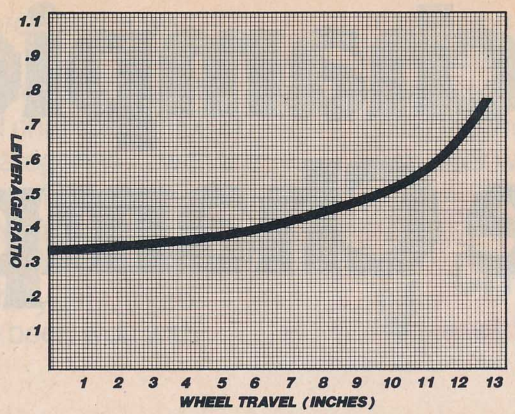
Springs are used to hold the motorcycle up against the force of gravity and to maintain full suspension travel, but springs don't absorb energy—they only store it for a short period of time. Hydraulic dampers are used to dispose of impact-energy by turning it into heat and dissipating it into the atmosphere.

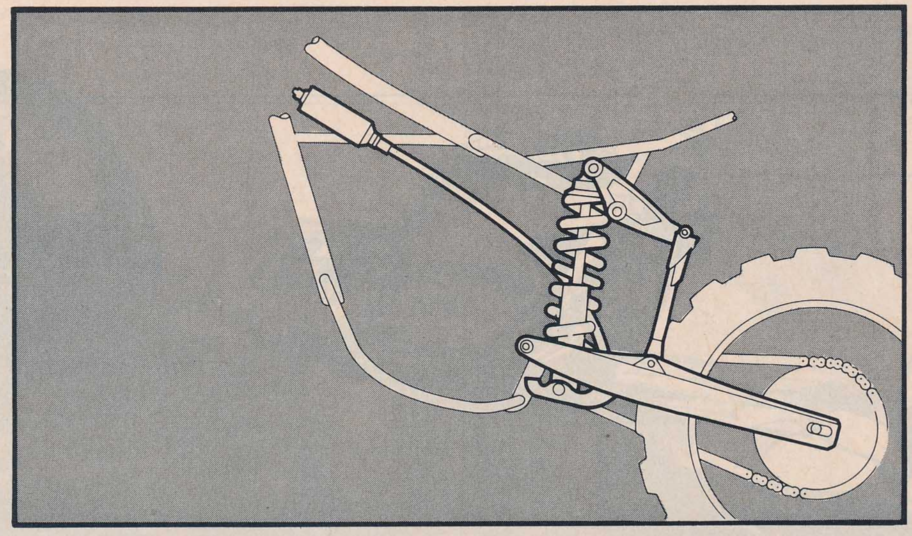
Inside the dampers, hydraulic fluid is forced through a system of openings. The energy required to move the dampers is related to the viscosity of the oil, the size of the orifice, and the relative speed between the two. All other factors being equal, damping force increases as the square of the relative velocity between the oil and the orifice. Because of this, a shock absorber with a single orifice properly matched to its spring at slow suspension speeds would become impossibly stiff at higher speeds. Modern shocks have six to eight spring-loaded speed-sensitive blow-off valves inside to overcome this; half are used on the compression stroke, half on the rebound.

Soft springs work better than stiff springs in storing the required amounts of energy in a manageable fashion, but wheel travel must be sufficient to give sufficiently high bottoming resistance. If you halve the spring rate (measured at the wheel) of a suspension system, you must double the available travel to give the same effect at the maximum foreseeable impact.

This year's factory motocrossers have

1981 SUZUKI RM250X FULL FLOATER





between 12 and 13 inches of suspension travel, front and rear, and it seems unlikely that bikes can get much taller without some kind of built-in stepladder to help the riders climb on board.

Until this year, suspension engineers faced a serious design dilemma. Motocross suspension has to be exceedingly soft for maximum traction over small ripples and stutter bumps. It also has to be stiff enough to prevent bottoming through the most violent bumps and sky-jump landings. Set up your suspension for the ripples and watch your riders eat it in the whoops. Stiffen the system enough to accommodate monster bumps, and control and traction go away in slow sections.

Two-spring, three-spring and progressive spring combinations help some, but it is now clear that the wheel rate change that spring combinations can produce will not be enough to solve the problem completely. Besides, progressive springs need progressive shock absorbers for predictable suspension action—and progressive shock absorbers are exceedingly expensive to build. With six to eight essential pressure-sensitive valves inside already, it would be very tough to add travel-sensitive valving to match highly progressive springs. Travel-sensitive dampers *do* exist and are used primarily in jet aircraft landing gear—but seeing them on motorcycles is a long way off.

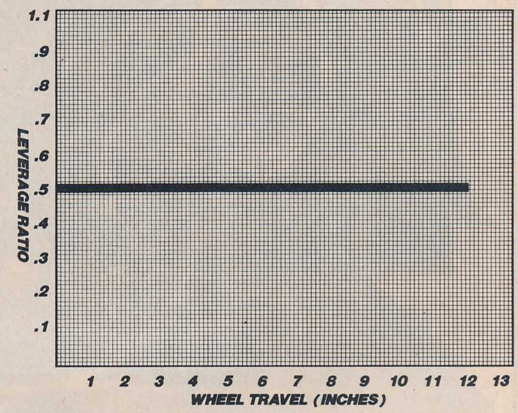
Rising-rate suspension geometry is the answer—a system of bell-cranks and linkages that gives soft initial rates and near-infinite final rates independent of the spring and damper. The technology has existed in Formula One cars since the early 1970s, but it's taken till now to see it in motocross.

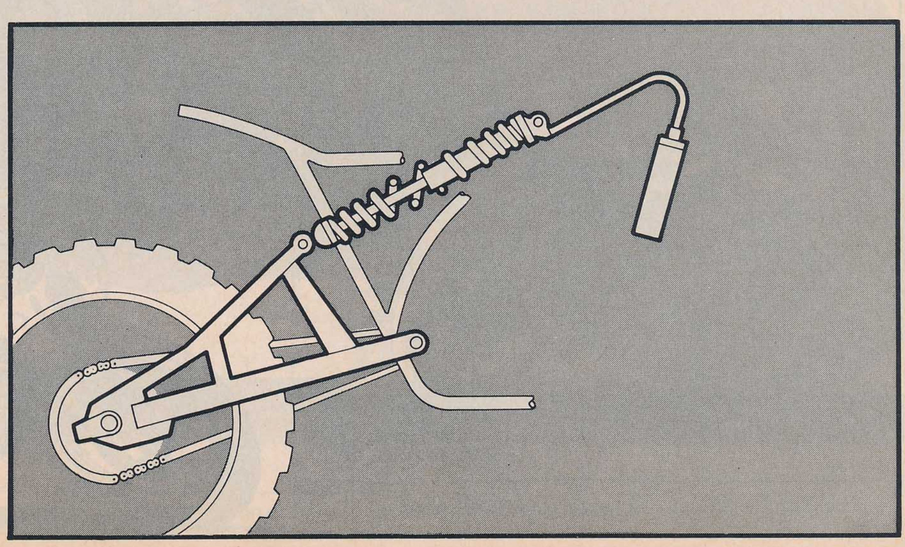
It's possible to achieve limited rate rise with a properly arranged conventional two-shock system, but the maximum rate increase is about 20 percent, not nearly enough to obviate the need for progressive springs (and the non-existent—for motorcycles—progressive dampers).

The simplest single-shock rising-rate system (and perhaps the one with greatest long-range potential) appears to be a cross between the Kawasaki and the Suzuki systems being marketed this year. It consists of two struts mounted to the swing arm which actuate the single, near-vertical, inboard-mounted shock absorber through a carefully designed bell-crank. In the initial inches of wheel travel the swing arm is acting on its end of the bell-crank at nearly a 90-degree angle, giving it maximum leverage. At the same time the bell-crank is acting on the shock at an acute angle, and the net result is a very soft wheel rate; that is, the wheel moves a relatively large distance for a given increment of spring and shock absorber travel. As the wheel rises, the angle of the swing arm on the bell-crank decreases just as the angle of the bell-

(Continued on page 100)

1981 YAMAHA YZ250H MONO-X





SINGLE - SHOCK *Continued from page 43*
crank on the shock nears 90 degrees. This stiffens the suspension dramatically as travel increases, because the wheel moves a shorter distance for a given measure of spring deflection.

The Kawasaki, Suzuki and prototype Yamaha "Link 5" systems are all variations on this basic strut and the bell-crank idea, though all vary from it in some respects. By juggling the angles between the various moving pieces in the system, especially the dimensions of the bell-crank, an astute designer can come up with almost any response curve he desires. The question then becomes: What kind of curve works best for motocross?

A look at the response curves of the two systems available today that in fact produce significant rate rise—the Suzuki and the Honda systems—reveals two similar but distinct design philosophies.

The Suzuki system yields an accelerating curve with the last bit of wheel travel about 2.2 times stiffer than the first. The Full Floater has a number of other design features to recommend it. The bits in the system are quite light; the shock absorber and bell-crank are both aluminum alloy. Its swing-arm struts are mounted a respectable distance back on the swing arm; this helps prevent the swing arm from twisting under severe side loads. A swing arm is quite strong in the vertical plane but very prone to twisting, especially when acted upon by the relatively long lever arm of the rear wheel. Suspension experimenters speak of watching massive box section swing arms contort while spinning the nuts on adjustable strut rods.

The design feature that sets the Full Floater apart from the others is the positioning of its shock mounting points. Both the top and bottom of the Suzuki's shock attach to the swing arm, whereas the Honda's and Kawasaki's shocks bolt one end to the frame. With the Suzuki, this *does* increase the rate rise of the system, all other things being equal, but that could be easily achieved with modifications in the bell-crank dimensions.

On the negative side, the swing-arm shock mount contributes to unsprung inertia in the system—the entire shock must move with the swing arm, though positioning the shock so close to the swing-arm pivot minimizes this effect.

The Honda Pro-Link system uses an altogether different configuration to achieve its rate rise, and it may be that the shape of the rate-rise curve is determined more by minor limitations in the Pro-Link design than any in-depth research on the perfect response characteristics for motocross. The system yields the same softness-to-stiffness ratio as the Suzuki, 2.2 to 1, but the curve shows a nearly linear rate rise until the wheel is in its last two inches of travel, and by that time the rubber bottoming bumper on the shock absorber shaft is already starting to send the actual wheel rate toward infinity. The performance of Pro-Link-equipped motorcycles is entirely predictable. Testers report a plush, soft and well-controlled ride for most of the range of travel, and the sensation of rather abrupt bottoming when the system's rate-rise kick-up is reached.

The Pro-Link system is basically sound in execution, with incredibly strong (and heavy) forged chrome-moly steel link pieces and a very massive steel-bodied Showa shock absorber. Honda had some trouble keeping shocks in one piece on the first production motorcycles, but the early manufacturing difficulties they encountered appear to be under control at this point.

The position of the shock and link pieces is consistent with a low center of gravity and short polar moment arms for the motorcycle's significant masses. In other words, the weight is packed low and toward the center of the motorcycle, and that's good. Seemingly, Honda hasn't incurred much of a weight penalty with the new system. Their CR450R weighs within four pounds of the conventional dual-shock 490 Maico.

The other two systems offered for sale, the Kawasaki Uni-Trak and the venerable Yamaha Monocross system, do not offer significant overall rate rise. The Yamaha system is a direct-acting design; the shock absorber is connected directly to the swing arm, as in a conventional two-shock system. The Yamaha's response curve shows a slight rate rise, but not enough to affect performance significantly. The Monocrossers make up for their lack of trick geometry with expensive truly progressive tapered-wire springs; there is no spring manufacturer in the United States capable of producing them at this writing.

Yamaha has been working with the Monocross system for more than six years now, and the development shows. With its progressive spring, massive DeCarbon-type damper, and nearly infinite adjustability, the system still has some races left in it.

The Monocross system, however, has all kinds of basic design problems. First and foremost is the shock absorber position, as high in the chassis as it could get, perched over a hot engine and shielded from cooling air by the fuel tank. Yamaha has attacked the cooling problem with a huge remote reservoir strapped to the front downtube, but the lack of rate rise and its height bode ill for its future.

Indeed, Yamaha is quite aware of the design limitations of the traditional Monocross, and they've been experimenting with a radically different system. They call the setup the "Link 5," and we've had early glimpses of it on the factory motocross bikes. Link 5 is similar to the Kawasaki or Suzuki systems, but the shock absorber angles toward the steering head in traditional Yamaha fashion.

More important, Yamaha employs a bell-crank and linkages to produce mechanically progressive springing. An examination of photos of the Link 5 in use on the National circuit reveals that Yamaha has in fact designed a setup with some rate rise, but data and exact response curves will have to wait until we can measure some hardware and until Yamaha settles on a particular version of the system.

The Kawasaki system is a paradox. Kawasaki's works racers use a bell-crank that differs from the production unit, and the factory edition gives them a luxuriously smooth response curve. An aftermarket manufacturer, Rising Rate Designs, also markets a bell-crank replacement kit that does the same for a stocker. But for reasons that may have as much to do with patent laws as Newton's laws, the Uni-Trakers that Kawasaki sells have a flat response curve.

Kawasaki uses a very slightly progressive spring to compensate for the lack of rate rise in its system, but its effect is almost negligible. The results are quite predictable: harsh suspension response at full extension, and minimal protection from bottoming at full bump. Brad Lackey suffered with the deficiencies of this system during the 1979 Grand Prix season; with the spring dialed up for the faster, rougher sections, he chattered his teeth out in the ripples and stutter bumps. He often blamed himself, or the shock absorber, but in fact the geometry of the system was the culprit. Other than the deficient bell-crank dimensions, the Uni-Trak system appears to have as much potential as any of the other systems.

With all this new-wave single-shock design and development work going on, is the old two-shock system to be considered dead and buried?

Not at all. Motorcycle building is as much a process of careful and thoughtful development as of wild new ideas, and the new crop of systems may take quite a dose of fiddling before the better two-shock systems can be counted out.

Husqvarna's Ohlin-equipped motorcycles are generally acknowledged to feature the best two-shock system going, and it is very, very good. It has the proper geometry for maximum rate rise (equal distances from the swing-arm pivot to each of the shock mounts), very nicely thought-out shock and spring rates, and it's very light. *Cycle*'s testers liked its performance as well as they liked the Honda's—and that's saying something.

With position-sensitive dampers, and some kind of air-spring combination to replace the present spring-only configuration, the two-shock system might well keep up with the new high-tech single-shock systems for quite a few years.

There's one thing that is sure, though: we're in for a long and exciting ride as motorcycle engineers spin out these new-wave and well-executed old-wave systems. And that can't be bad. ◉