Ecological 4 Wheeling Adventures
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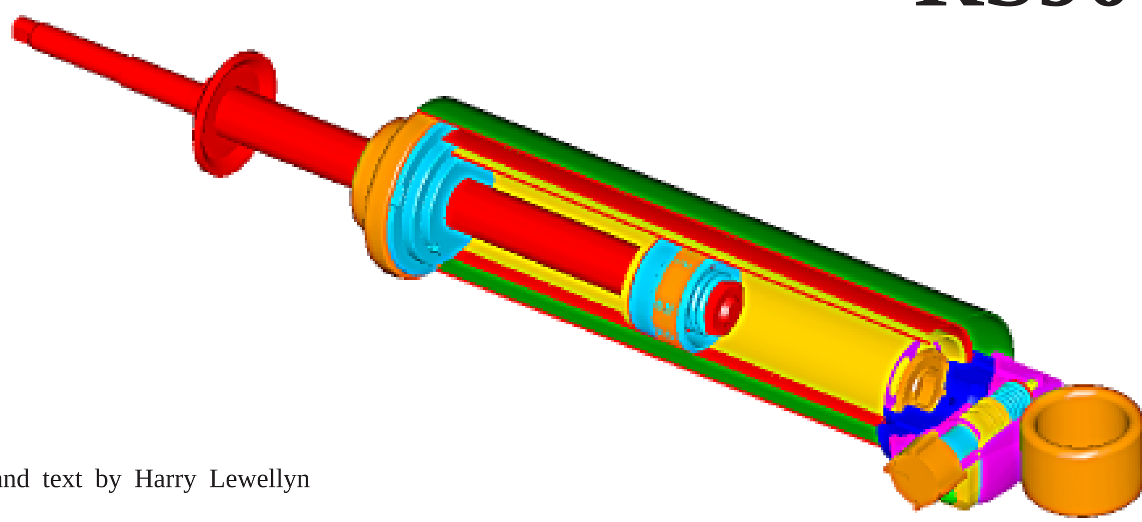
FOURWHEELING ACADEMY

RS9000X



Photos and text by Harry Lewellyn

Shocks are second only to tires regarding product questions. I typically recommend Rancho 9000s. I've been using them since about 1991. Those who have traveled with me always get the "Rancho commercial" about the time we hit a long annoying stretch of washboard road. I announce that I can significantly improve my ride by adjusting the shocks to max soft from the cab, while underway! Some even report they can hear the difference on the radio. I suspect the vibrating message really sinks in after a few teeth rattling miles.

This article recaps and supplements several past shock articles. I will present a little shock history, what they do, describe how they work and reveal Rancho RS9000X details. According to Bill Johnson, director of engineering for Rancho Suspension, "The RS9000X isn't simply a case of raising the bar in terms of self-adjustability and control; this new shock completely changes the rules for on- and off-highway performance driving." "There is no other shock in the world that delivers this level of driver-tuned precision and comfort over such an extreme range of environmental conditions."

In my new column, GETCHABACK, I'll describe how to diagnose shock problems and discover failures (see page 7).

SUMMARY

Properly tuned and operating shocks are important for comfort and safe handling. Rancho RS9000X shocks, with remote cab adjustment offer a means to "tune" your shocks for varying trail conditions.

HISTORY

Long ago, automotive engineers understood the need for shock absorbers and started the evolutionary process that has culminated in modern hydraulic shocks.

Take your flattened hands, press them together (hard) and rapidly rotate your palms back and forth in opposite directions. Feel the heat and notice it takes some force to rotate them? Henry's model "A" used Houdaille disk shocks. Housed in one little cylindrical unit, with an arm on a central shaft, alternate friction disks rubbed together to dissipate stored spring energy (described below) in the form of heat. Things evolved from there and, on some of the oldies, you could add oil, adjust the shock rate or

See **SHOCK**/p2

In this Issue

SHOCK, from page 1

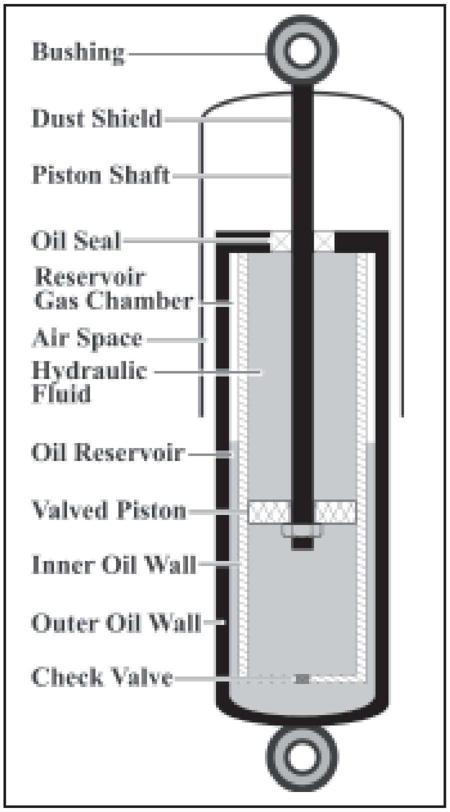


Figure 2 *Twin-tube shock and parts*

compensate for wear. Enter the hydraulic shock.

In the air, take your vertically flattened hand and move it rapidly from left to right in front of you. That's easy. Now picture your hand immersed in water and move it. Wouldn't it harder to move? The fluid creates more friction. This is the principle of the modern telescoping hydraulic shock, which started to appear in the late twentys and early thirtys. In it's simplest form, a trapped hydraulic fluid restricts movement. This is achieved with valves of various designs. Figure 2 shows a modern twin-tube shock. Most original equipment shocks are of this type.

Now, before I go any further, understand that virtually all modern shocks do their job via oil. Air shocks and high-pressure gas shocks are just refinements.

WHAT SHOCKS DO

Your 4X needs some kind of system to soften the ride. Let's call it the "ride system" and divide it into two primary parts: 1) the suspension part (springs) and 2) the stabilization part (shocks). For the purist, there are at least two more stabilization components that are part of a ride system: the sway or anti-sway bar, and the Panhard rod. I'm neglecting both for this article. A properly designed ride system must delicately balance the suspension part <u>with</u> the stabilization part. It must also take into account the application be it race or pleasure.

The springs suspend (support) the body from the wheels and allow them to move up and down, somewhat independently. This reduces the harshness of holes, bumps, rocks and other obstacles that would otherwise make for a very uncomfortable ride.

Springs come in various forms: coil, leaf, torsion bars and air bags. Regardless, all types suffer the same drawback: When compressed or stretched, they store energy.

Shocks are the stabilization part. Their job is to perfectly absorb (see CRITICAL DAMPENING below) the stored energy and eliminate rebound. Without shocks, hit a bump and the tire goes up, the spring compresses, then tries to get back to "normal," but overshoots it (rebounds). This stretches the springs storing more energy. The spring again seeks normal and again overshoots it. The result: The vehicle continues to bounce for some time after the original bump. Obviously, this constant bouncing is uncomfortable and down right dangerous. Bouncing cars are hard to control. Automotive engineers realized the need for spring "dampeners" and added shock absorbers. The friction of the Houdaille disks and the fluid movement in a modern shock do this.

WHAT SHOCKS DON'T DO

For the record, with the exception of high-pressure gas shocks (minimal) and air bags (significant), standard shocks <u>do not</u> support or lift the vehicle. Old or new, the level of your 4X is set by the springs, not the shocks.

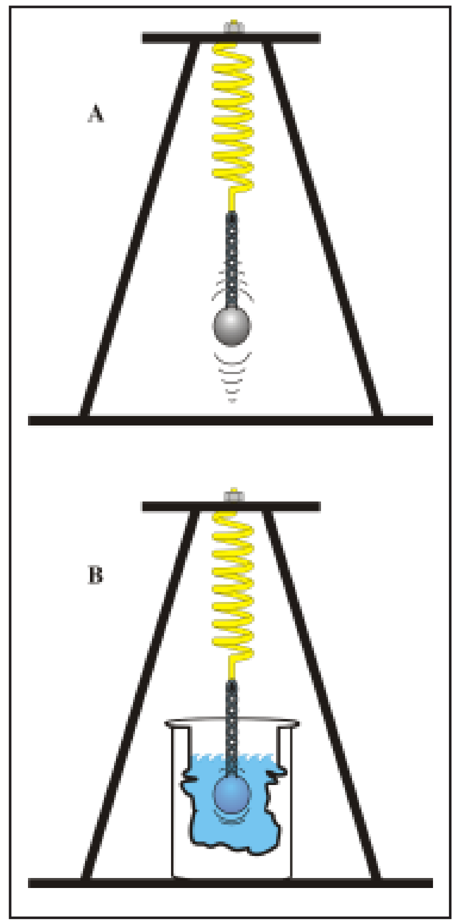


Figure 3 *Hydraulic shock principle*

Managing Editor: Harry Lewellyn
Copy Editor: Jenna Kane

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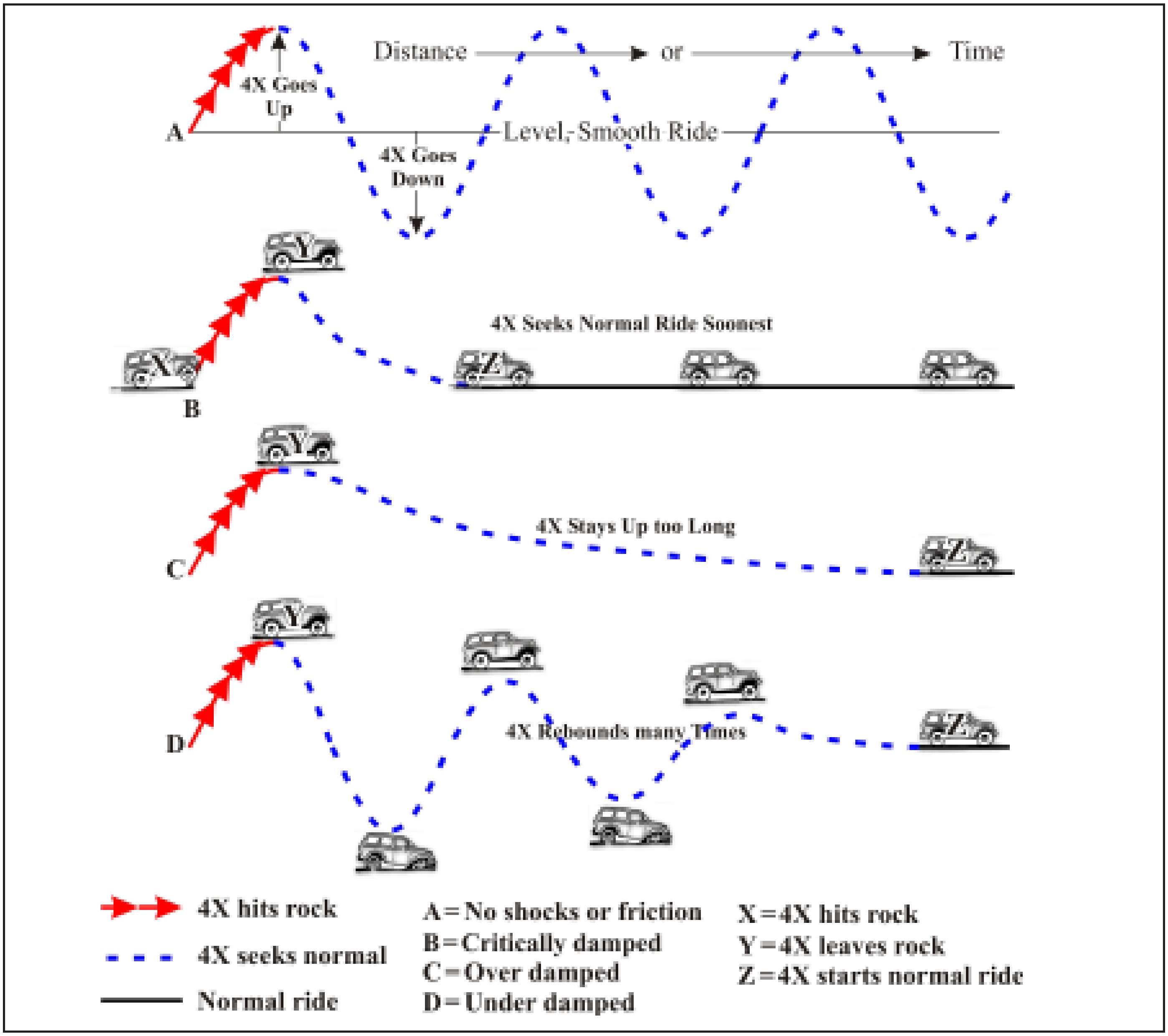

Figure 4 *Various dampening actions*

HOW SHOCKS WORK

Figure 3A shows a weight suspended from a coil spring. Pull the weight down and quickly let go. Can you see the weight bouncing up and down for some time? This rebound becomes progressively less and less and eventually stops. Pull the weight harder and it will bounce longer; Less and it will stop sooner. Without shocks, vehicles will bounce and bounce after a bump.

The only reason the weight quits moving is because of friction. Something uses up the energy stored in the spring and the momentum. In the case of Figure 3A, the resistance (friction) of the weight moving in the air and to a very minor extent, internal friction of the spring itself dissipate the stored energy. Both eventually bring the weight to a complete stop. Submerse the weight in oil (3B) and it should be obvious the movement stops sooner.

SHOCK VALVES

Figure 2 is a cutaway view of a simple twin-tube shock. The 4X body is attached to the top, and the bottom connects to the suspension part closest to the wheel. As the two move independently, the valved piston moves through the hydraulic fluid, just like your hand swishing through water. The rate of movement is the job of very complicated, multiple, progressive, load- and velocity-sensing valve systems. Suffice to say some of what you pay for shocks goes into the research, development, patenting and manufacturing of these sophisticated valves.

DAMPENING FACTOR

Regarding valves, you hear about dampening factor or shock ratio. This refers to how much shock action there is on the <u>up</u> versus <u>down</u> stroke of the piston. 50/50 means equal up and down action. 80/20 refers to 4 times more

See **SHOCK**/p4

SHOCK, from page 3

action on the down stroke than on the up stroke. In most shocks, down travel is stiffer than up travel. Too much up travel resistance is like very rigid springs.

Without getting into too much detail about sprung vs. unsprung weight, a shock must balance its friction force against that of the spring's stored energy and the momentum of the unsprung weight. Less unsprung weight is an advantage to the high performance racecar, but for the average unpaved traveler, it can be neglected.

UNSPRUNG WEIGHT

Unsprung weight is the tires, wheels, brakes, and (now it gets hard) other suspension and components such as the lower "A" arms and McPherson struts, axles, and finally the axle housings and differentials in the case of solid axles. Simply put, unsprung weight is all the weight connected to the "bottom" of the spring. Technically, the bottom portion of a shock is unsprung weight and the top is sprung weight. Nit-picky, huh?

CRITICAL DAMPENING

Critical dampening is the ideal balance between shock action and spring rebound. It perfectly absorbs all of the stored energy on the first rebound. Figure 4A (page 3) shows the theoretical world of no friction or shock where, after the first bump, the 4X continues to bounce forever. B is critically damped, C is under damped and D is over damped. Picture your rear rides the exaggerated waveform: vertical scale is intensity of bump and the horizontal scale is time or distance traveled.

Under damped means the 4X takes a couple of rebounds to settle. Over damped means it takes too long to settle. In most circumstances, you want smooth ride/maximum control as fast as you can get it.

Highway bump intensity falls into a relatively moderate range and can be handled fairly easily because they are not too extreme. What complicates dirt road damping action is the extent and frequency (variability) of the bumps: washboard versus hoop-dee-doos versus intense drops and rises. As you will see in the next issue, this is where the RS9000X excels!

Critical damping is a thing of beauty. It's that feeling like you know something is going on between you and the trail, but somehow, the effects are minimized. The bumps come and go with the passing of the road. You don't carry the bump along with you.

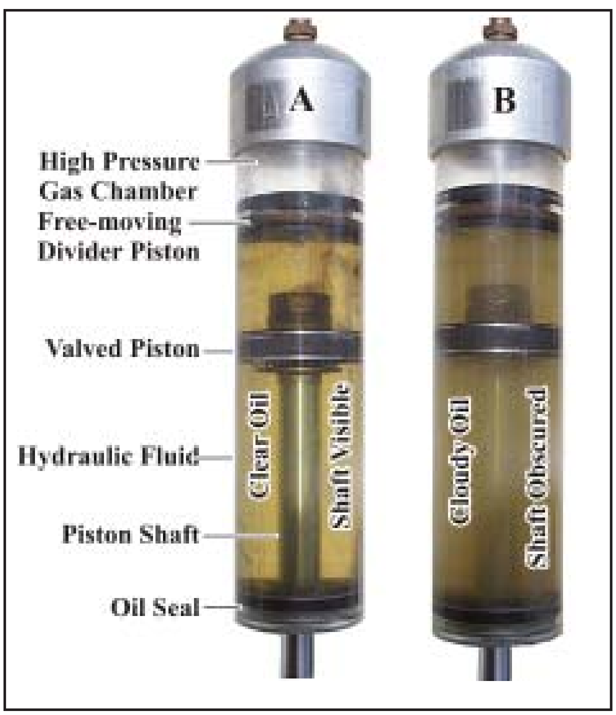

Figure 5 *Cavitation clouds the hydraulic fluid. (right)*

HEAT

Shock piston movement creates the slowing action, but along with this comes performance-degrading/component-deteriorating heat. You felt the heat when yon rubbed your hands together simulating the disk shock. Heat thins the oil and makes it less effective. Racers understand this, hence the trend toward multiple shocks. More shocks reduce the heat per shock and maintain better overall shock action. But most of the "clean and easy" set don't need multiple shocks and actually suffer by using them. We typically don't drive long and hard enough to heat shock oil, and besides, some multiple shock systems are inadequately designed. They look good, but produce a poor ride.

Since the heat starts where the dampening action takes place (at the piston), it must be carried away through several layers of "insulation." Referring to Figure

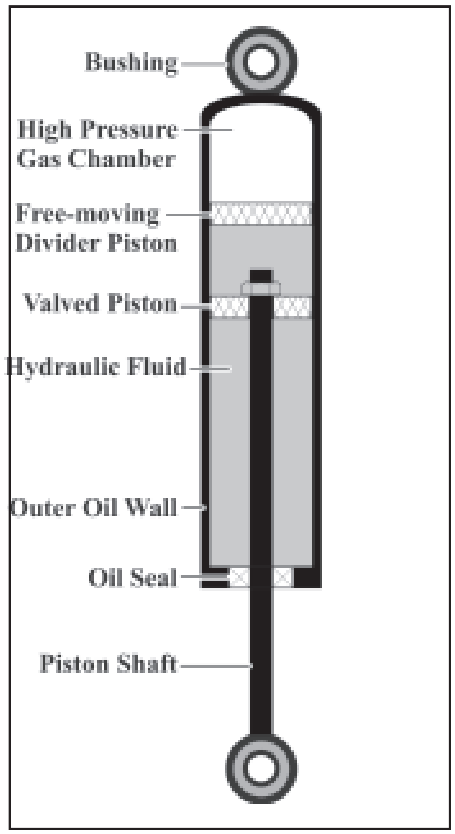

Figure 6 *Mono-tube shock*

2, note there are three metal layers (inner oil wall, outer oil wall and dust shield), two oil areas (piston area and reservoir) and one air space (space between the dust shield and outer oil wall) on conventional shocks. This slows heat dissipation, which results in poor or erratic dampening action and an increased likelihood of internal component failure. Needless to say, this is not very efficient and it certainly reduces service life.

CAVITATION

A rapidly moving piston not only thins the oil, but also liberates trapped gas from the slippery stuff. This "outgassing" action is an effect of cavitation and takes place on the backside of the fast moving piston, whatever direction the piston is traveling. This low-pressure side literally sucks the air out of the oil. Actually, cavitation is similar to opening a shaken-up soda. You reduce the internal pressure to atmospheric pressure by opening the can and it bubbles over. The piston is now moving through foamy oil at best (see Figure 5). This is not as good as unaerated oil for shock action! This is where high-pressure gas shock shine.

GAS SHOCK

Gas shocks are also known as mono (only one oil tube) or high-pressure gas shocks. Referring to Figure 6, note there is a high-pressure gas chamber above the oil and the free moving, divider piston. I mean high pressure! 15 to 25 times atmospheric (220 to 367 pounds per square inch) is typical. At this pressure, cavitation is non-existent. Plus one for the mono-tube. High pressure is what gives gas shocks their "spring" action, but it contribute to rollovers as I will report in a future article. Minus a big one for monos!

Regarding heat, note there is only one outer oil wall between the heat producing piston and the cooler world of ambient air. This results in better heat dissipation, hence better shock action and longer service life. Plus two for the mono.

Also note the mono-tube can be mounted either end up. The twin-tube must be mounted shaft up to allow the oil reservoir to function properly.

But the single oil chamber wall and exposed piston shaft are vulnerable to rock damage. A single dent or deep scratch to either of these critical components and it's all over. Most shocks take a vicious beating, particularly at the lower end. Minus two for the mono.

Re-enter the twin-tube. The added layers that reduce heat dissipation actually protect the sensitive piston shaft and inner piston area of a twin-lube. Some twin-tube brands have gone a step further and eliminated the dust cover all together to increase heat dissipation, but this exposes the piston shaft.

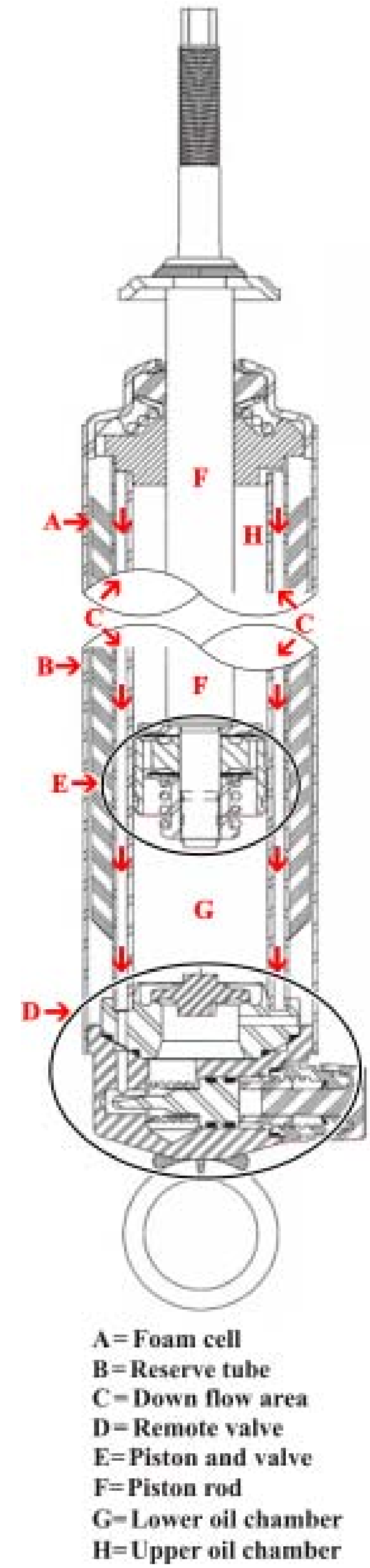

Figure 7 *Rancho 9000X*

AIR SHOCKS

The air shock should not be confused with a gas shock. Air shocks have a bladder that provides lift. This is a "helper" spring and is completely independent of the hydraulic shock portion. The shock portion could take on any of the above configurations, but to date, I've only seen the conventional twin-tube construction.

MONO-FLOW

The Rancho RS9000X is a mono-flow or tri-tube shock and, like its predecessor, it is fully adjustable from the cab. But the new shock significantly increases the precision of tuneable compression and rebound dampening through nine, rather than five, metered settings. The RS9000X also features Rancho's exclusive 15-stage, velocity-sensitive valving for enhanced stability and traction.

The RS9000X has a 16-mm-diameter hardened and double-chromed piston rod (F), 32-mm-diameter piston with Teflon band and an all-new rod guide design that reduces friction and improves flow for enhanced ride comfort (E).

Complimenting the RS9000X is the RS99700 in-cab remote control kit. It permits adjustment of the front and rear RS9000X shocks independently, while the vehicle is in motion.

Most shocks achieve valving at the piston only. In contrast, the mono-flow design does virtually all of its valving in the body of the shock. Most of this is in the stationary housing (D) and not the moving piston. The piston provides minimal control at low and medium speed displacement rates. The external valve comes into play at very high displacement (bad bump at high speed) rates.

Figure 7 shows a 9000. The tri-tube (mono-flow) name comes from conventional pressure and reservoir tubes plus a third, down (mono-flow) area (C). Note the valve area (D) at the bottom of the housing. The down flow gets its name because oil always flows in the same direction, down as drawn. Follow along as the shock compresses and re-

see **SHOCK,** page 7

GETCHABACK SHOCKS

By Harry Lewellyn

Here I offer several tests you can conduct to assess the condition of your shocks and a field fix or two.

ON 4X TEST

At home conduct a bounce, or rock and roll test. One at a time, stand near each corner of both bumpers (this may take two of you on full-sized, stiffly sprung rigs). Now carefully, like a kid in a swing, develop a pumping, bouncing action until the vehicle has reached the limits of your weight and energy, then quickly jump off at the bottom of the last down cycle. A safer way is to grab the highest point of the car, rock vigorously, and observe the number of bounce cycles.

Immediately count the number of times the car takes to cycle to a still. For the “pump and jump” method, it takes athletic-like coordination since you will most likely still be airborne while counting! The other alternative is to use a friend and assign a “jumper” and a “counter”. A perfectly tuned and working ride system (critical dampening, see Figure 4, page 3) will come to rest in one cycle. More than one or two “up, then down” cycles indicate fatiguing or faulty shock components (shocks, bushings, mountings). The only other reason for continued bounce is low tire pressure. Eliminate this variable by firming up the tires before you perform the test.

OFF 4X TEST

With an unmounted shock you can check the action as shown in the photo. First move it up and down in short strokes (upper photo), then move it full stroke (lower photo).

In a vertical position as shown, rapidly cycle it several times through the middle one-half to one inch of movement. If you hear a gurgly sound, you can bet air (gas) and oil have mixed and rendered it useless.

In the full displacement test, if the shock moves easily, and that’s hard to qualify (quantify) without experience, the shock is bad. Even in their weakened state, most off-road shocks are pretty tough to move.

FAILURE INSPECTION

Physical failure is simply a matter of crawling under a properly supported and braked car and looking for: 1) missing shocks, 2) broken or missing bushings (both top and bottom), 3) oil leaking out of the shocks (faulty seals), 4) dented metal housings or covers, 5) bent shocks, 6) scratched or bent piston shafts, 7) shocks in two pieces, and finally, 8) broken mounts on the vehicle itself. Grab each shock and shake fiercely to check for hidden damage. The last two items in particular need manhandling since under some circumstances, high-pressure gas shocks can extend themselves and appear OK.

REPLACEMENT

Shock replacement is usually easy. Depending on the type of mounting, somewhere between two to four bolts per shock and the same number of minutes and you’re done. But beware of high-pressure gas shocks. Leave the compression bands on a new shock in place until it is secured at both ends on the car! Besides being capable of knocking out your teeth, once expanded, some of these puppies are impossible for the average backyard mechanic to install.

FIELD FAILURE

If you carry a pretty broad selection of bushings, as I do, simply replace failed bushing. You could also try using various spare hose as replacement bushings, but my experience shows this usually leads to follow-on failures.

Regarding complete shock field failure, consider removing it, worry not, and replace it when you get home. With anti-sway bars and the way they work, one side’s shock shares some of its action with the other side. Remove both shocks and you’re in for a bouncy ride.

Here’s to reliable shocks on the trail.

SHOCK, from page 5

bounds. For simplicity of explanation, we'll assume piston movement only. As you well know, in the real world, both piston and housing move.

On compression, the piston and check valve (E), and piston rod (F) move down. Oil freely passes through the piston check valve from the bottom fluid chamber (G) to the top fluid chamber (H). But note the piston rod now occupies additional upper chamber space. As the piston moves down, the rod takes up more and more space in H. Also recognize the check valve (I, Figure 8) in the valve area is closed, meaning all of the oil in the lower chamber must move to the upper chamber. It doesn't fit, so the excess, piston rod-displaced oil, finds its way to the top of the down flow and eventually to the adjustment valve (D). The oil moved down.

On rebound, the up-moving piston check valve closes, so the upper chamber area displaced oil also finds its way to the top of the down flow for a trip to the adjustment valve (D). Again, the oil moved down.

Regardless of piston direction, the oil moves the same direction in the down flow area. So we now have oil moving through the valve area on both the compression and rebound strokes. How is adjustment achieved? It is simpler than you think. See Figure 8.

Remember oil is always flowing in the direction of the arrows. As it reaches the spring loaded (K) check valve (J), it either moves through the low speed relief groves (not identified) or displaces the check valve against the spring. Follow the check valve spring to the outside adjustment knob (L) and you can probably take it from there. Change the spring tension and you change the valving. Remotely put air pressure at the knob end to change the spring rate and you've achieved remote shock adjustment. Class dismissed.

When you're on the outside looking in, it looks pretty simple. But from Rancho's point of view, they took a very complicated, patented design, spent big bucks, a year and a half of research, development and testing, followed by additional upgrades and bingo, the simple design.

From my perspective, they really paid attention to detail. They worked with DuPont for the special plastic fittings, Zytel®. They also made the system pretty much failsafe. Break off any part of the manual or air adjustment system and you're still safely and securely operational in the low shock-rate mode.

SELECTING SHOCKS

Selecting the right product is tough. Celebrities, slick ads and price (high or low) don't always mean the correct product for you. So many products make so many contradictory claims, you don't know what to believe or buy. I may sound like I have all the answers, but here's where I draw the line. We all have different requirements, so there is no absolutely perfect, common denominator solution for all people or cars, but the RS9000X comes close. Just as with driving skills, let Professor Posterior (your seat-of-the-pants experience) assist. I take a practical approach.

- Talk to others, particularly those who have your exact desired after-market product on the same make of 4X.
- Get a test ride and make your own decision.
- Short of that, talk to others that are using your potential choice.
- Snoop around other vehicles and ask the owners how they like what they've got.
- Inspect your failed part and assess the failure modes. Let that aid the selection process.
- Look for a 100%, no strings attached, lifetime guarantee. I really make out on these.

All of this comes together to improve your chances of success when making any after-market product selection.

Good luck with your product selection and here's to smooth trails.

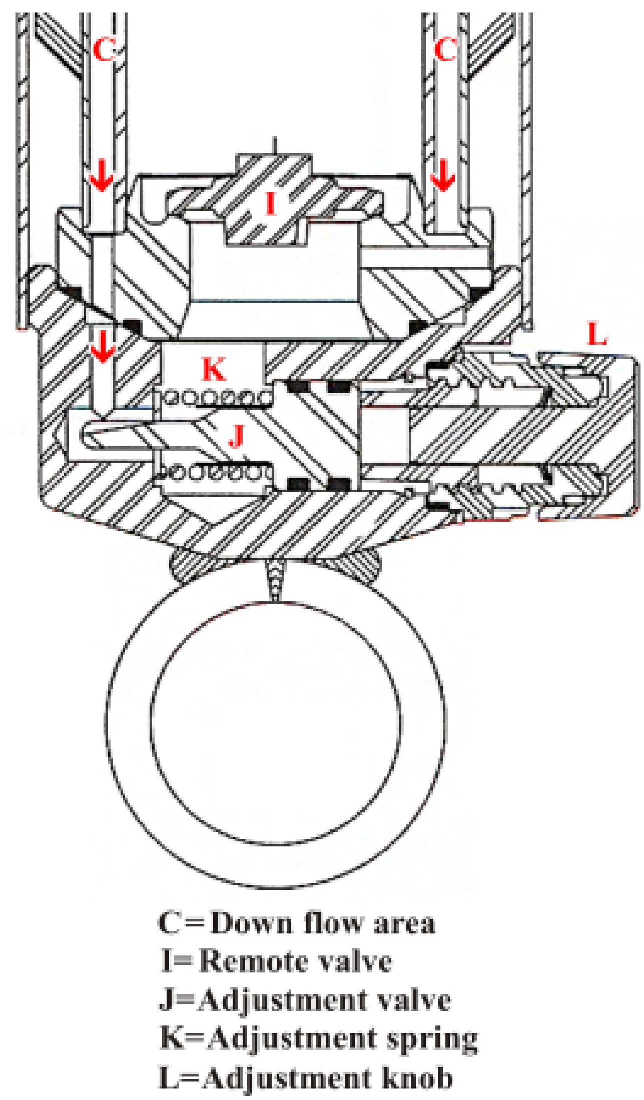

Figure 8 *Rancho 9000X adjustment valve*

2003 Coming Events

EVENT	DATE	REMARKS (See Bonus Issue N/L /p# for more info)*
By God, to Bodie (C/H)	September 13 to 15	Historic California ghost town tour /p31
Golden Leaves & Trails (C/H)	September 20 to 22	Historic California tour /p32
Introducing the HAMMERS! (C)	October 24 to 25	An EXTREME Rock Crawling skills class
Death Valley II (C)	October 17 to 20	4WD camping mini-vacation /p32
Copper Canyon Mexico (H)	November 7 to 18	See Mexico's Barranca del Cobre up close /p27
2004 • • • 2004 • • • 2004 • • • 2004 • • • 2004 • • • 2004 • • • 2004		
Death Valley I (H)	January 23 to 26	Furnace Creek Ranch-based backcountry tour /p23
Pinion Mountain (C)	February 14 to 15	Roughie, camping, skills trip /p23
Truckhaven (C)	February 28 to 29	Roughie, camping, skills trip /p24
Baja Whales & Rock Art (H)	March 5 to 11	Great intro to Baja — Open to 2WDs /p25
Lunch in Lucerne	March 20	One-day rock art/botanical/geologic high desert tour /p24
Borrego Boondoggle (H)	March 26 to 28	Get acquainted with the Anza-Borrego state Park /p25
Lucerne Sand session (C)	April 3 to 4	Learn the skills of driving on sand /26
Mojave Expedition	April 10	One-day tour of the historic Rand Mountains /p26
Copper Canyon Mexico (H)	April 16 to 27	See Mexico's Barranca del Cobre up close /p27
San Felipe Sand Blast (H)	May 14 to 17	Experience the extreme Sea of Cortez low tides /p27
Piute Passage (C)	June 5 to 6	Historic California tour /p28

(C)= Camping trip (H)= Hotel-based trip = Schedule subject to change
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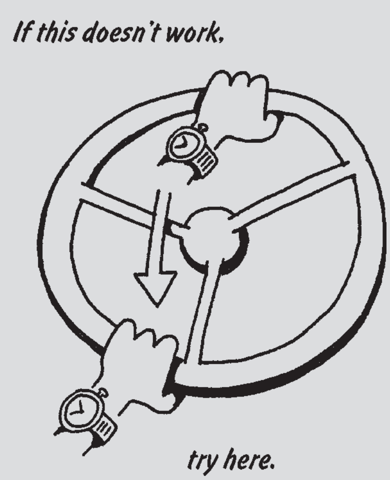
TRAIL TIP

REVERSE STEERING HINT

Some folks have a hard time steering backwards. Page 209 of SHIFTING Into 4WD offers this simple hint:

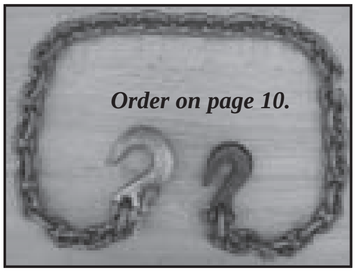
REVERSE STEERING HINT

If you always seem to get backing up wrong, safely try this. See if it works for you. Move your steering hand from the top of the wheel to the bottom. This reverses your steering action and may make things come out just perfect for you.



COYOTE CHAIN

Your buddy is stuck.
You are free, but you can't connect...



The Coyote Chain is your solution!

Attach the **slide hook** (left) directly to the 4X frame or use it as a choker to cinch up on anything, including the downed tree blocking your trail.

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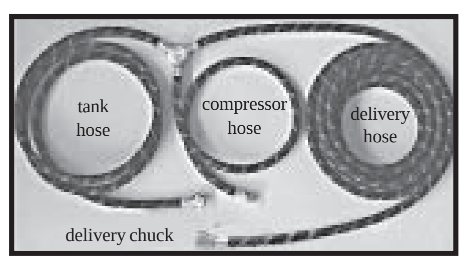
UNLIMITED AIR: With an AR, you have air with *or* without a compressor.

SIMPLE TO USE: Connect the AR's screw-on valve stem chuck to any inflated tire. Use the custom lock chuck at the other end to air up.

INNOVATIVE DESIGN: Connect a compressor to the valve stem at the end of the 3-way manifold and you continuously replenish the source-tire while you fill the others.



QUALITY CONSTRUCTION: The AR is 22-feet long, has brass fittings, including a screw-on chuck, a valve stem and a new lock chuck. ***Order on page 10.***

NEWSLETTER REPRINTS

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