Showa blues: Some investigations into a Showa front fork .

When I bought my Monster 900 in 2002, I was terrifically satisfied with the way everything worked (OK, by most things, at least….). Since my reference was my modified Yam XS650 / 860, I suppose anything else would have been really serious ...
After a while, however, I felt the suspension was maybe not that great, the forks beeing first in line.

Mod #1: RaceTech Gold Valve.
I had heard that Öhlins made a shim kit for Showa USD forks with 20 mm cartridges, but I could not find anyone to tell me if it would fit in "my" forks.
However, I was informed that RaceTech made a shim kit that fitted, even though my bike did not show up in their catalogue. As a side, Monster 900-2002 does not show up in hardly any accessory catalogues since it is the only model year with the new frame, old 900cc engine, and 5.9 ECU. Not worth the trouble for most producers, so you have to know what fits where (or take a chance, which I did).

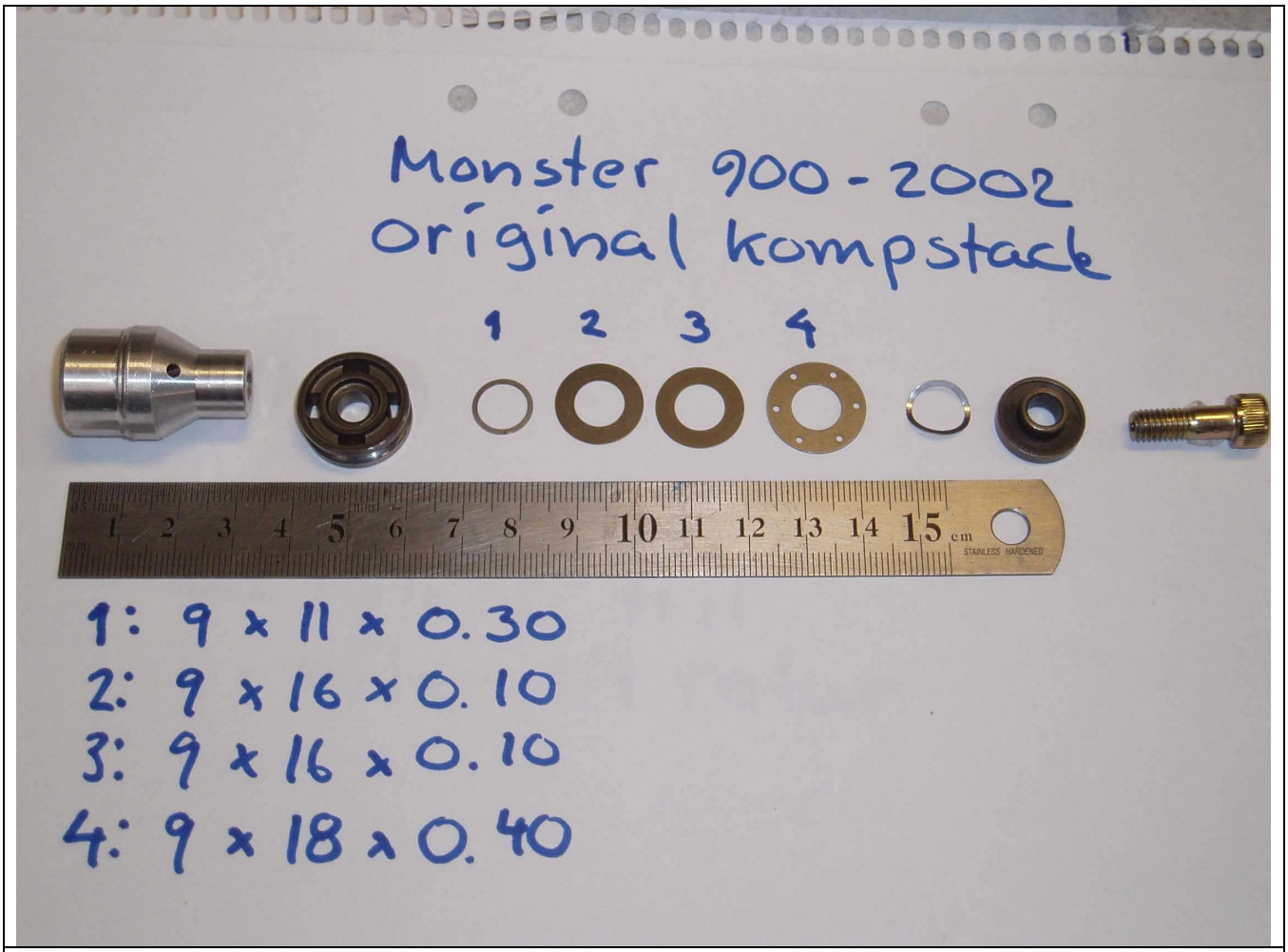
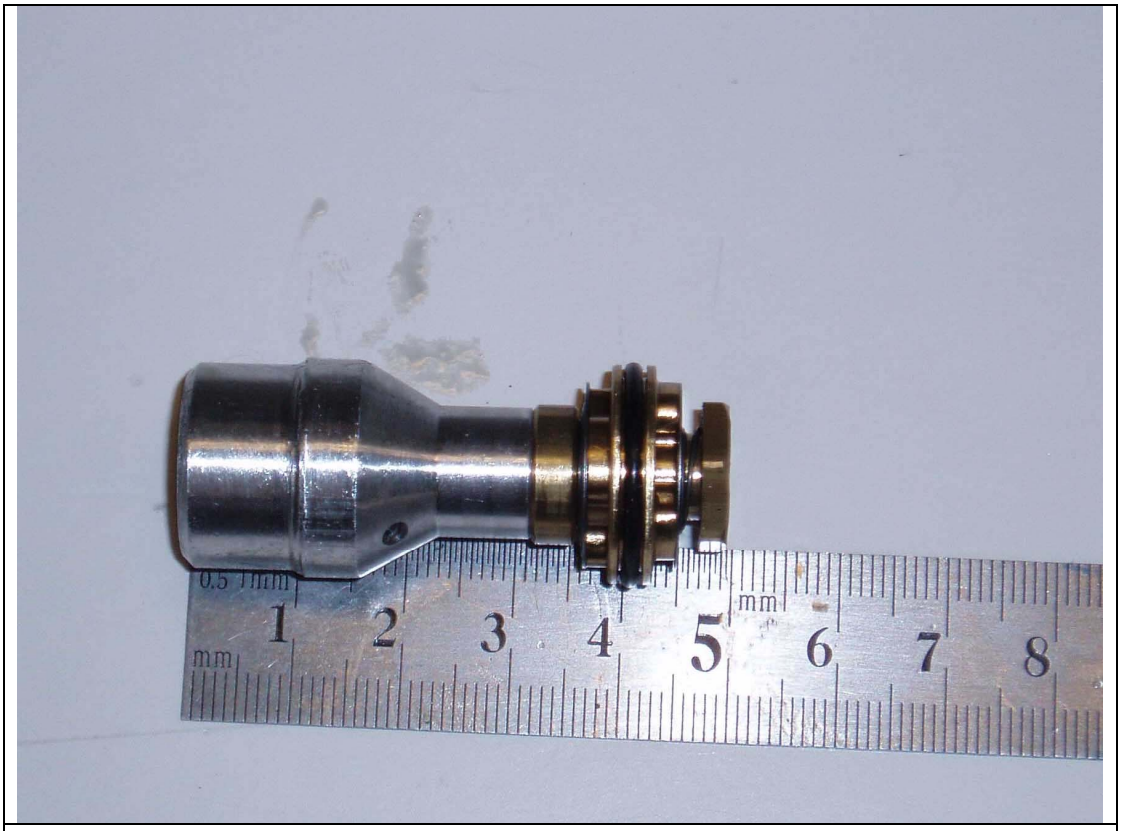


Fig. 1: Showa stock compression valve holder with piston and shim stack.
Please note that all the shims are on top of the damper piston. When damper oil enters the cartridge (when the fork is on the rebound stroke) all shims act as a single shim and are governed by the spring shim to the right of shim #4); all shims lift from the piston and allows oil to enter the cartridge.
When the damper oil is forced out thru the shim stack by the forks compressing quickly, the big shim is forced down onto the outer ridge of the piston. Simoultaneously the oil pressure acts on shim #2 and #3 thru the holes in shim #4; this causes shims #2 and #3 to bend away since their edges are not supported by the ridge on the piston, allowing damper oil to leave the cartridge through the ports in the damper piston.
I have no idea how well this might work, but it does look more like an emergency release valve rather than a "proper" shim stack intended to control the high speed damping.

Having got my RaceTech kit, I disassembled the forks and got the cartridge out. With the Ducati Workshop Manual´s warning in mind (”Do not dissassemble the cartridge”), I started the drill press, and with slightly increased heart rate I proceeeded to drill out the dimples intended to prevent this very action.
As it turned out, it was no big deal, and the RaceTech stuff fitted without problems.
RaceTech supply their kit with a several of the biggest shims, and you are supposed to adjust the number of these shims to suit your weight and driving style. The number is determined by consulting a program on RaceTech´s homepage; in my case it turned out to be the second softest option, or C32 as RaceTech call it.
As it turned out the next summer (no riding in winter in Sweden), it did work better than stock, but not a whole lot. Which leads to mod #2:



Figur 2. Showa stock compression valve holder with RaceTech damper piston and shim stack.

Mod # 2: RaceTech Gold Valve (2:nd go).
To cure what I felt as a harshness over small, sharp bumps, I tried removing one of the two biggest shims. I did notice an improvement, and I could run the compression adjuster at about 3 clicks out from closed without things beeing to harsh. In retrospect, I´m sorry I did not try closing it entirely, but I thought you were not supposed to do that. Anyway, the forks were maybe not that bad with compression and rebound adjuster both about 3 clicks out.
By this time I had started to read some litterature on the subject, and I had tried to follow the advice to “dry swim” the suspension thru the adjustment range to feel for the change it makes.
On the rebound side, the effect was very noticeable, but on the compression I could not really feel any difference at all, no matter where the adjuster was. I assumeed this was due to me not knowing what to feel for (true), beeing to light / not strong enough to be able to compress the forks quickly enough (possibly true), or probably both, so I did not proceeded with that line of investigation at the time.

The story could have ended here, had I not tried to find some lighter springs for the forks. For various reasons the spring change ended up with me having disassembled the forks completely again. As the forks were disassembled anyway, I figured I could just at well get the best there supposedly was: an Öhlins shim kit; which by now was known to physically fit the Ducati Showas.

Modification #3: Öhlins kit.

With the Öhlins kit installed, the fork initially felt quite OK. However, having tried to dial in the compression damping to get the right amount of dive during hard braking things started to feel strange. No matter what I did, I got the same amount of dive. Strange…

I tested in all ways I could imagine: Max braking from the same speed on the same piece of road and different compression damping settings: Exactly the same suspension dive.

Driving on a piece of bad road on the same line with the same speed but different settings: Exactly the same amount of suspension dive.

Additionally, the feel of the fork was not OK on that piece of bad road; the front wheel felt as if it was constantly in limbo somewhere between the road and the air above the road. It simply did not feel right.

Fig. 3. Showa stock compression valve holder with Öhlins damper piston and shim stack.
Please note that the shim stack for the high speed damping is on the underside of the piston. Barely visible is the shim and spring shims för the return flow control on the top side of the piston; this controls the oil flow into the cartridge on the fork rebound stroke.
Please also note the arrangement of the oil channels in the piston: Every second one is open on the top and is sealed off at the bottom by the shims there, every second one is the other way around.In this way, any oil not passing thru the needle valve must pass thru a shim-controlled passage on its way into or out of the cartridge.
The O-ring simply seals off the piston against the cartridge wall and prevents any oil from short-circuiting into or out of the cartridge.

To get at reference, I checked with a friend who had the same Öhlins kit installed on his 999. Different settings on the comp adjuster yielded positive changes in suspension feel and travel; doing the same on my Monster 900 fork gave no discernible effect at all.

However, the rebound adjustments worked very well on both forks; close the rebound adjuster and the forks all but locked up on the rebound stroke.

At about this time I came across a very distressed friend during a track day; he´d had the same Öhlins kit installed on his 900 SSie and was very unhappy with the results. Since his symptoms were 100% identical to mine, we realized we had some kind of a general problem here, nut just me having a set of whacky forks, or me beeing whacky, for that matter. We had no idea what the problem was, but henceforth we pursued this problem pretty much together.
Öhlins also did not know what the problem might be; they simply sell a shim kit for “20 mm cartridge type forks” and do not know the details of all such forks on the market. They leave it up to the skill and knowledge of the person who does the work to assure a good result.

At this time it turned out I had the opportunity to buy an Öhlins R&T fork for my Monster. Very extravagant for that bike, maybe, but I had sold my old trusty XS650 / 860 with assorted parts and that almost covered the Öhlins forks. This is irrelevant for this story, but it meant I could experiment with my Showa without parking the Monster.

What´s wrong?
In order to get numbers for comparison of compression damping performance, a suspension dyno or similiar would have been handy. Lacking that, I improvised a back-yard mechanics version, for lack of a better name I called it the ”Bump test”. A picture says more than 1000 words... More sweat than finesse, but at least it´s a method (not endorsed by Öhlins, I might add).

Fig. 4. Bump test.

The suspension travel is measured after each “bump test”, presumably it should be less if the compression damping is high. The method is to “bump” a number of appropriate combinations of compression and rebound adjuster settings, and measure how much I can compress the fork with the help of an O-ring on the slider and a steel ruler.
The result is a graph like the following:

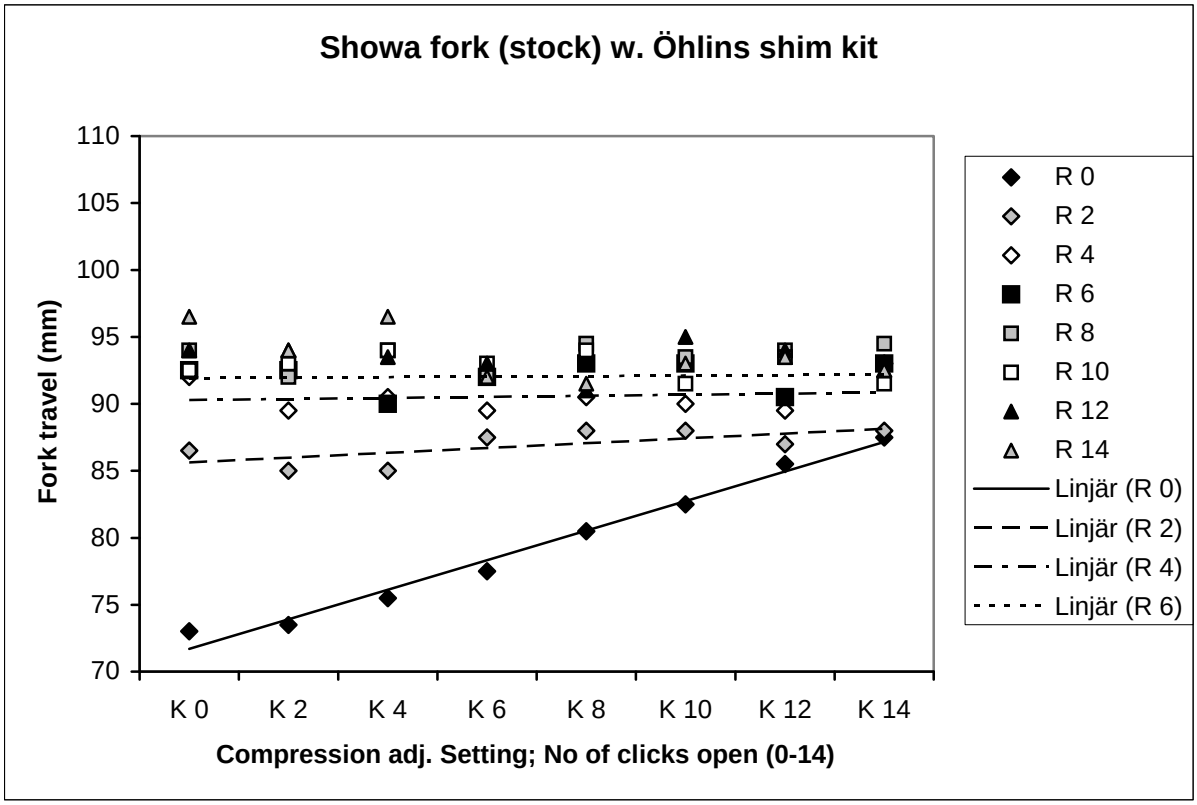


Fig. 5. Bump test graph from a Showa fork with Öhlins kit installed.
Each point K0, K2 etc. is one comp adjuster setting, with K0 completely closed, K2 2 clicks open, etc.
Each curve R0, R2 etc. is one rebound adjuster setting, with R0 completely closed, R2 2 click open, etc.
Since the bump test is not that exact, the results are shown as the measured points, with some trend lines added to show the general behaviour.

The curve ”R0” (completely closed rebound adjuster, symbol ”black diamonds”) shows that with the rebound adjuster completely closed there is a reaction to how the compression adjuster is adjusted: The more clicks it is open, the more I can compress the fork. However, the rebound is incredibly slow with closed rebound adjuster, no way it would be possible to use the fork like that.

With the rebound adjuster opened up anything at all, this changes rather dramatically; already 2 clicks opened (curve R2, grey diamonds, corresponding to about 0.3 mm of needle lift) results in a completely flat curve. I can compress the fork an equal amount no matter what the comp adjuster is set at.

Having messed so much with the forks by now, I knew pretty well how it was designed, but I could not understand how it was supposed to work. In desperation I sent a sketch of my Showa forks to my suspension supplier; maybe he could enlighten me.
His immediate comment was “this is not how it looks”. After some confusion we realised: he had never seen a Showa fork like mine, so he did not understand what I meant, and I had never seen a ”normal” Showa, so I did not understand what he meant.
Having realized this, we also quickly came to the same conclusion: It looks like this, and it can not work properly.

The key difference is in how the rebound circuit is designed.
On a ”normal” Showa (or any other fork I´ve seen since) the needle for adjusting the rebound damping is situated in the bottom of the damping rod, within the damper cartridge. A rod connects it with the adjuster screw in the fork top nut so it can be adjusted from outside the fork (see fig.6 below):

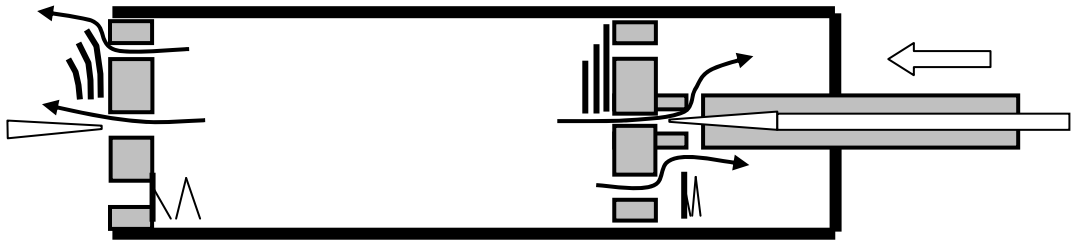


Fig 6. Working principle of a "proper" damper cartridge: Piston, damper adjuster needle, shim stack and backflow valve with suspension compressing.
Please note that the damper oil can only leave the cartridge via the compression damper assy (to the left) when the forks compress.

On the Monster and SSie 900 / 2002 forks, however, the rebound adjuster needle is situated on the top of the damping rod, outside the cartridge, see the next illustration:

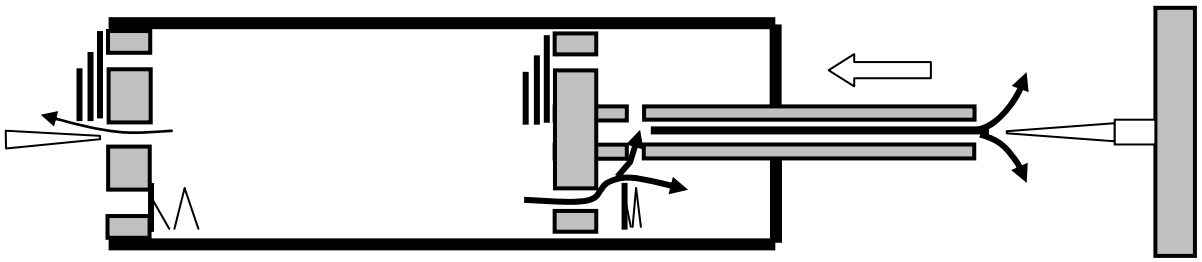


Fig 7. Working principle of a Monster / SSie damper cartridge: Piston, damper adjuster needle, shim stack and backflow valve with suspension compressing.
Please note, that on compression the oil will take the path of least resistance, mostly leaving the cartridge via the open rebound adjuster on top of the damper rod.

This means that the damper oil displaced by the damper rod as it enters the cartridge (and to some extent, the damper piston pushing the oil in front of it) when the fork compresses, and which should pass the compression valve assy to damp the forks compression movement, is instead short-circuited out of the cartridge via the open rebound adjuster.
Since the oil flow volumes involved are very small, a click or two of rebound adjuster opening is sufficient to render compression (low speed) damping essentially inoperable.

With the Öhlins kit assembled, fork action is if anything worse that stock. Presumably this kit is designed to work with the pressure increase caused by the damper rod entering the cartridge that you´ll get with a normal rebound circuit (as per fig.6).

Well, what to do about it?

Once we realized this, the solution suggested itself: modify the forks to move the rebound damping adjuster needle down inside the cartridge.
How to accomplish this in a practical manner did not suggest itself quite as easily, but having considered and dismissed several proposals, the simplest method also appeared to be the best (and cheapest): Modify existing hardware as far as possible, design and manufacture what new parts are necessary.

With the help of my friends contacts, we arrived at a practical solution, consisiting of the following:

- Disassemble the rebound circuit damper piston holder from the damper rod;
- Machine a hole along the length of this piston holder;

- Manufacture a new rebound adjuster needle;
- Manufacture a rod to connect the rebound needle (now down inside the cartridge) with the adjuster screw in the top of the fork leg top nut;
- Assemble the forks again.

Mod #4:Öhlins kit + modified rebound circuit.
With the forks modified as per above, we got the bump test results below:

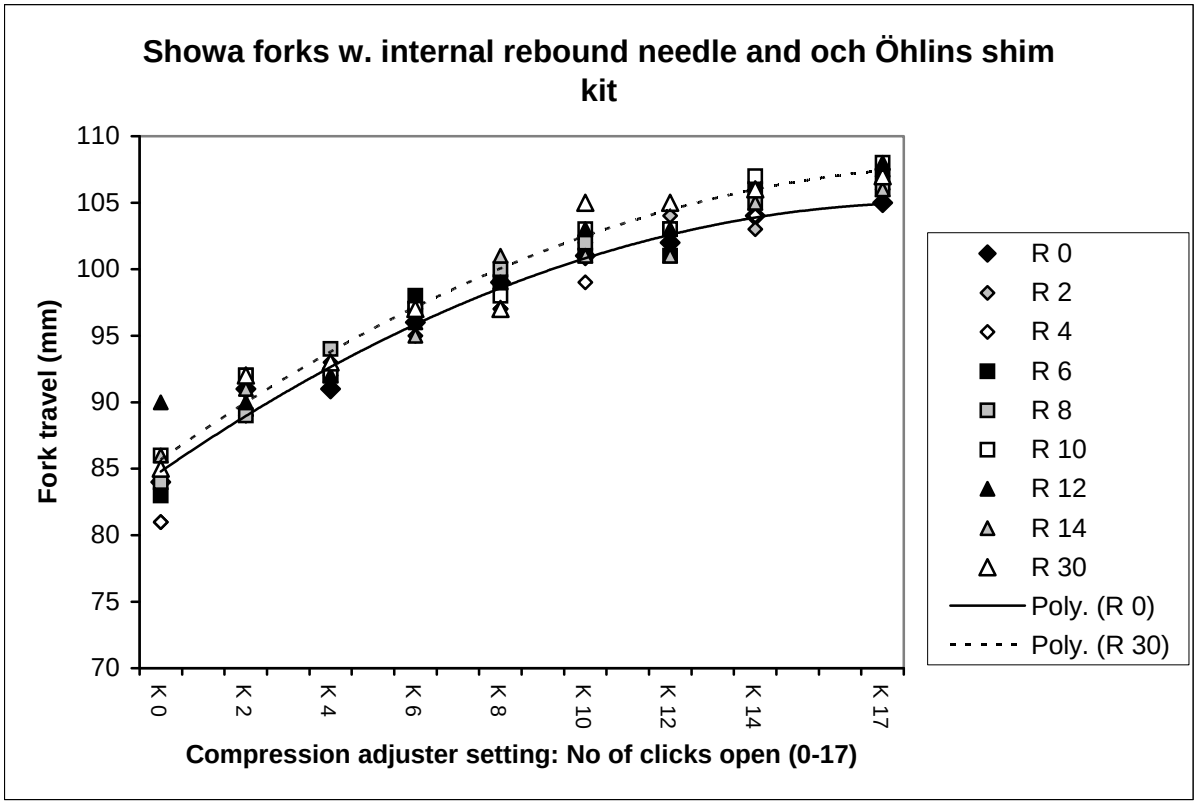


Fig 8.Bump test diagram for Showa with Öhlins kit and modified rebound damper circuit.
Please note that the adjuster needle has a different taper to the stock one; hence the different number of clicks.

The difference is very apparent; the curves are pretty much identical no matter what the rebound adjuster is set at. What it works out like in actual use is another matter, but at least the compression low-speed damping adjustment is now basically independent of the rebound setting.

Which forks are affected?
As far as I have been able to establish, all adjustabe Showas with 50mm upper / 54 mm lower triples: 900 SSie, Monster 900, Monster 1000, S4 / S4S, ST2/ST4/ST4S has these forks. It seems that S1000DS has a "proper" set of forks, but with rather ineffective valving. I have not yet checked any of these forks myself, so I can´t know for shure.

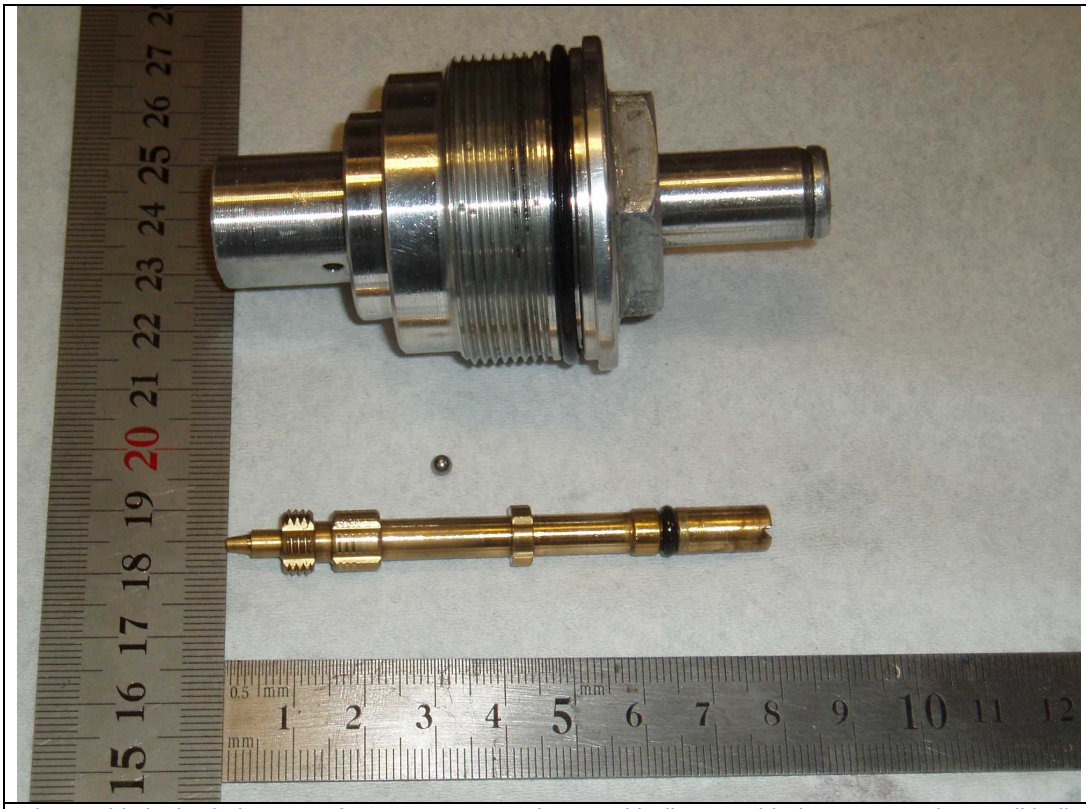


Fig. 9. This is the fork top nut from a "Monster" Showa, with disassembled contents.: The small ball is responsible for the "clicks" you feel when adjusting the damping; it´s backed by a a small spring in the top nut.
The brass screw is normally within the top nut; the pointed end is the needle adjusting oil flow out of the cartridge against an orifice in the top of the damper rod (i.e., in a non-modified fork).

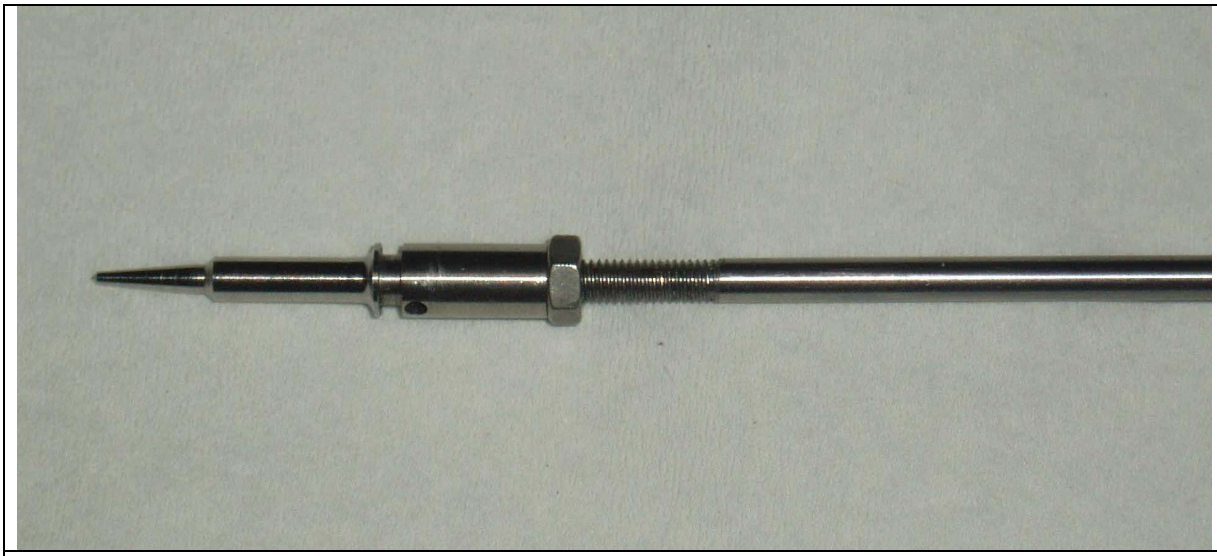


Fig. 10. Rebound adjuster needle. This replaces the pointed tip of the brass needle in fig.9, and is now situated down in the bottom of the damper rod, within the cartridge. The rod (Ø 3 mm för reference) connects the needle with the brass adjuster screw in the top nut (see fig.9), so that the rebound damping can be adjusted. The needle in the picture is the one we had made, the corresponding part of the "Hyper" Showas looks slightly different (much blunter needle).

Technical update 2011:
The modification described in this article requires the help of someone with specialized machining competence. I´ve modified maybe 8 or 10 or so forks according to this article, and so far all have worked great (I use 2 of them myself, one beeing a track day bike used by a lot of people).

Fig. 11: Track bike (900 SSie) with modified Showa forks and a few other tweaks (cosmetics not one of them....)

On the last few forks I´ve modified, I have used a shim kit from the british company K-Tech.It has the advantage that the rebound adjuster needle and shim stack/ shim stack holder come pre-assembled with the kit; hence, the machining competence needed for the modification is greatly reduced.
It does require, however, that you do manufacture a new cartridge rod and a few other bits and pieces, so machining competence is still required.

Also, the K-tech kit needs a little more room inside the cartridge which I found out when doing the forks of a MY2000 M900 recently; due to the dimensions, the cartridge bottomed out on full compression before the fork tubes did. This is obviously not a very desirable condition,and required a lot of fiddling and machining to compensate, finding a mm here and a mm there.
Anyway, if there is interest, I´ll do a piece on this modification as well next time I do a fork modification.

Disclaimer:
The opinions found in this feature are fully my own (even if I´m not alone in having them), and I´m fully convinced the results are valid in principle; in an actual case results may vary due to tolerances etc.

As for the function of the forks concerned, I have no doubt in my mind about the correctness of the contents of this article; however, I´m just a backyard mechanic (OK, and a mechanical engineer by profession) trying to solve a problem I happened to stumble upon.

If anyone wishes to follow the example described in this article, feel free to do so, but it´s all on your own responsability and down to the knowledge and skill of the people you decide to cooperate with (and / or your own, of course). As I´ve discovered, there are several versions of fork internals in Showa forks looking externally identical, so you need to take care.

If you, however, choose to go this route, I´m convinced you´ll be very satisfied with the results. Riding both this conversion and my Öhlins regularly, the ony real advantage of the Öhlins is the BLING factor. Maybe if you´re much faster than me that would be different, but so far everyone riding the modified forks are happy with the results. I will use a set of modified ST4S Showas for my track bike eventually (still a garage project), so I´ll put my money where my mouth is.

Text: Torbjörn.
Illustrations, co-thinking & more: Petrus.