

— Technical Topics No. 11 — Racking Your Brains

By Richard Treacy
(Switzerland)



1981 Silver Spirit, ASB02325, on 'The Red Centre Walkabout'. Photograph by Patty Aiosa.

Introduction by Bill Coburn (ACT)

David Neely, our Editor, kindly gives me fairly free rein in these pages, which makes for an easier life but there is the ever present danger that I will be regarded by some as 'The Oracle'. I am not and never will be.

What I try for is to coax mechanically challenged owners to actually think beyond the ignition keys in their cars. For the more adventurous I try to encourage them to 'have a go' and lastly to make available to the World's owners whatever information I can find in the hope that their task of preserving the few remaining cars left on the planet, is made a little easier.

And so Richard Treacy produces this very timely article on his experience with steering racks in late SY and SZ cars. Timely because two SZ cars on the recent Darwin Safari suffered incontinence in this very assembly. This is a continuing problem but along with a host of other foibles our cars are inclined to spring on us, is just one more to discuss ad nauseum at our various gatherings

Finally, I always recall a mechanically challenged medical practitioner advising me at one of our gatherings that the very best soporific he could prescribe for an insomniac patient was a few chapters of a Rolls-Royce workshop manual. But then if you are trying to explain detail it is hard to flavour it with a little light hearted banter. Given that most owners do not lie awake at night wondering about their steering rack, I have therefore taken the liberty of inserting the odd picture with caption that may help to retain your attention.

Silver Shadow II and SZ cars have wonderful steering. Truly marvellous. That is until they leak that horrible hydraulic fluid. The naturally-aspirated cars are not so bad in this regard, but still unacceptable, however it seems that the added heat of the cross pipe to the turbocharger on the Turbos, especially with right hand drive, makes them just that bit worse. That pipe runs parallel to the steering rack, and a small fibreglass shield is all that helps to keep that cherry-red heat away from the rack.

So it was. I replaced the rack assembly on my 1987 right hand drive Turbo R, BSH20037, in year 2000. That will be that for another decade I thought with confidence. Rather than fooling around with it myself, I had bought an exchange rack UR27336 from the leading specialist supplier in the UK in the knowledge that they need setting up with great care. I figured that the additional time and cost would ensure a very reliable result. Oh no. In mid 2002 the fluid level again started to deplete, so I knew that I was in for more trouble. Sure enough, fluid soon started spilling from the overflow at the centre of the rack, so I installed yet another exchange rack hoping that the last one fitted was just a Monday job.

By way of explanation, the two rubber bellows at the centre of the steering rack assembly, named convoluted seals, are only dust boots and should not contain any oil at all. If the fluid starts depleting, it slowly fills the bellows until they finally overflow. If you leave it to someone else

to top up the fluid, you may never know that there is trouble in there until it is all too late. Otherwise, when your knowledgeable roadworthiness tester jacks the front, then zips the wheels from lock to lock, a puddle appears beneath.

There is a simple check for a suspect rack. In the main housing on the lower protrusion for the pinion and towards the rear of the vehicle, there is a grub screw drain plug. Remove it with an Allen key. If any sizeable quantity of red fluid comes out, then you have troubles. If gear oil comes out, then the rack is an early type and has been mishandled during assembly, shipping or fitting: the rack tube may be refilled with gear oil through the blanking plug above and forward of the pinion in-situ in this case. Many a vehicle's rack is drained by this method before sale to disguise a leaking rack during the warranty period, so beware. Having said that, it will let you cheat through a roadworthiness test, giving you time to consider the options.

So I bought and fitted yet another nice new rack. So far so good. That one was leak-free afterwards, but only until March 2004. Horror. NOT AGAIN! Fluid was suddenly depleting, and finally it started to spill out yet again.

I pulled out the steering pump and had it bench tested. What a horrible job it is to remove and refit a steering pump on a 20,000-series car! No defects were present there. Darn it. This was becoming decidedly silly.

I did a little research, and found that in 1989 a new rack design, UR70708, was introduced. It has secondary wiper seals on the rack shaft to pre-clean the bits before the main seals hold the fluid pressure. Great I thought, so I bought one. These wiper seals must have been the solution I figured. This rack has cast mounts unlike the earlier fabricated ones, and needs a conversion kit RH3034 with special brackets and sundry items, and a revised longer lower column link UR70827 (Bentley) or UR71398 (Rolls-Royce). The mounts on these racks are slightly wider apart and lower in the chassis than on the earlier type, and the adaptor brackets accommodate the variation. Especially for Bentley cars, the lower link is stiffer than those for the Rolls-Royce cars.

In it went. Great. Until October 2004. AGAIN AGAIN. Depleted fluid was followed by leaks soon after. Yet again, I bought an exchange rack, this time a UR71818 from a 1997 model. This third and final design incarnation from about 1992 onwards has a useful external backlash adjustment rather than using shims on the spool valve. That's applaudible, but I was suspicious of why such a young rack was on the exchange programme. This time I fitted a system fluid filter for good.

As an aside, all racks before 1992 were filled in the tube encapsulating the rack and pinion with gear oil as the gear lubricant, not to be confused with the steering fluid. Later racks and all rebuilt racks should be filled with at least 35g of bespoke constant velocity joint grease smeared evenly across the rack teeth and with a dab into the pinion's lower bronze bushing in the main housing. The change to grease is important, unknown to most rebuilders, and it is poorly documented. Gear oil works fine in service, but a rack inverted during shipping will lose all its lubricating oil from the rack tube into the bellows cavity. Do you trust your shipper to keep it upright?

March 2006. Oh no, more fluid loss. The fluid again commenced to deplete, and finally it started to ooze out from the backlash adjuster grub screw, the breathing point on late racks. This caused a stir at the supplier and his subcontractor in the UK, the world's largest supplier of reconditioned steering

racks for these cars. It emerged that they are truly fed up with these racks, and also that in desperation the major US rebuilder has recently slashed its lifetime guarantee to just 12 months for Rolls-Royce and Bentley only. I discovered also that the volume of exchange rack sales worldwide is of epidemic proportions. This time, there was no way I would suffer the time and costs of customs, repairs and shipping of a lousy replacement rack, so I decided I would do it all myself and find out what really is going on here. Out came the rack, and I stripped it down rather easily. Next was to analyse the bits, and I feel we are some way to solving the matter.

Neither the rack tube nor the rack shaft itself are shown fully in any documentation I have ever seen. The shaft has one solid end and one floating end. The seal on the floating end finds its own position in the tube and seals just fine. On the fixed end, sometimes called the free end, it relies entirely on its split (scarfed) PTFE (Teflon) bearing as it is called, but it is actually a bushing, to keep the Nitrile main seal central against all those substantial steering forces. This bushing is also referred to as a PTFE seal in the literature, but it is certainly not a seal. If there is any slack in the bearing, that allows an off-centring of the shaft, so that the seal is squashed to one side and will leak. On observation, the PTFE bearings both had no gap whatsoever on mine. The minimum specified is 0.25mm or 0.010" when aligned in the bore. As any engine rebuilder knows with piston ring gaps, a wide ring gap is preferable to a narrow gap. The lack of any gap meant that the moving PTFE bearings were jammed into the tube, and could only wear quickly on the outside to compensate. Also, the inside diameter was too large as the bearing was expanded by having no gap, so the resulting slight sloppiness means that the rack shaft could have been slightly offset from centre on a random axis.

This appears to be the root cause of our problems, as just a few thou off-centre allow leaks. Gapping is a simple task, using 420 grit paper on a flat surface. Measure the gap in the shaft tube bore using a feeler gauge in exactly the same manner as you would a check a piston ring gap, although the gap in the PTFE bearing is at 45 degrees.



Above: The leaked fluid drain grub screw.



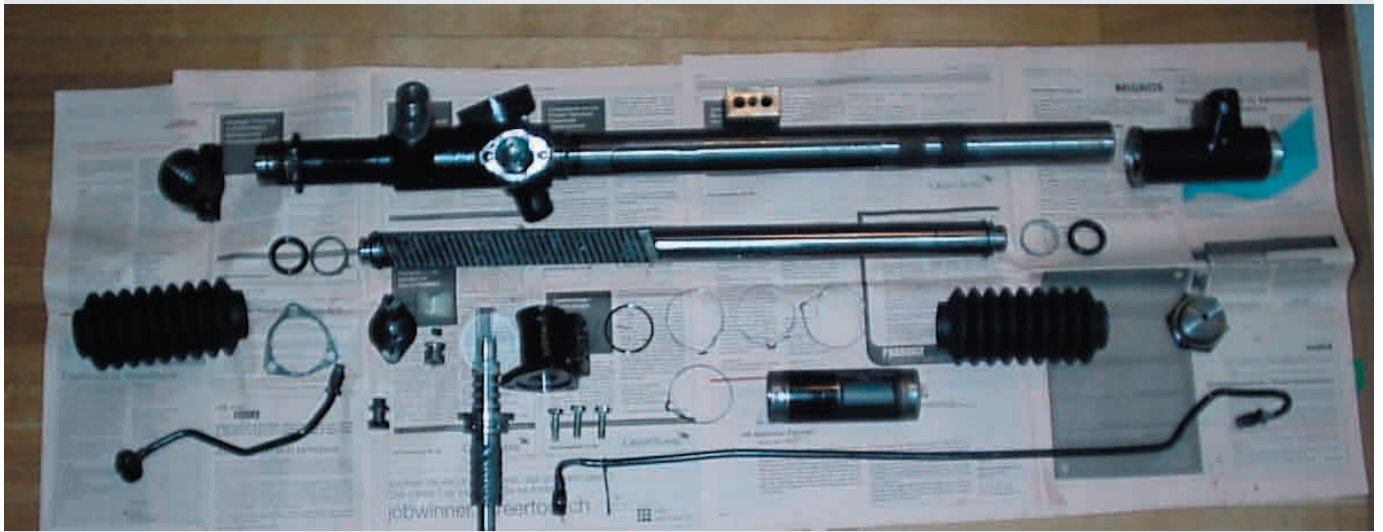
Above: The late-type rack, showing the cast mounts integral with the aluminium end housings and the external backlash adjuster. Early types have their mounts fabricated and welded to the end-housings.



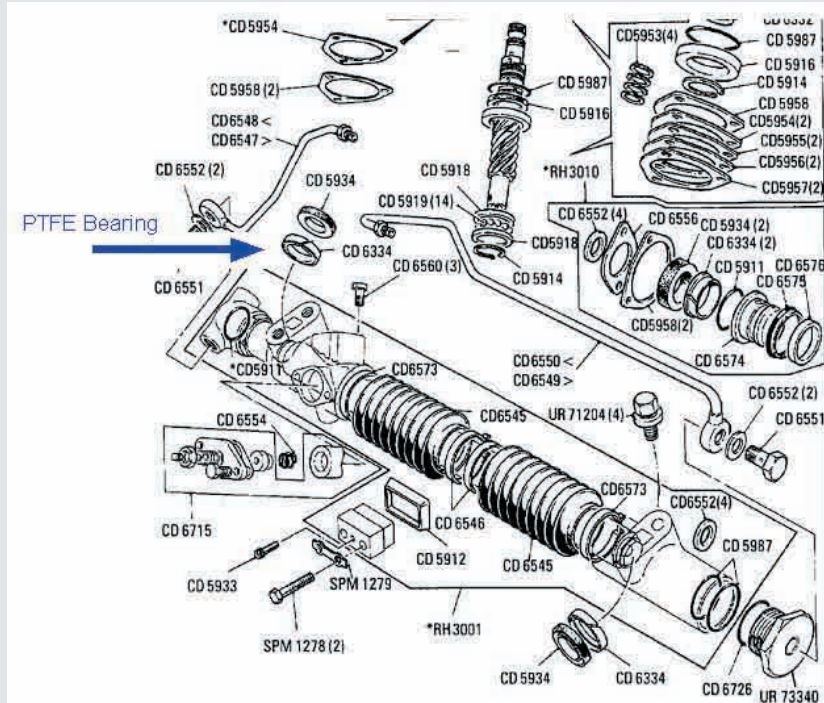
Above: A seal kit from Crewe.

Below: End view of the main seal in-place.

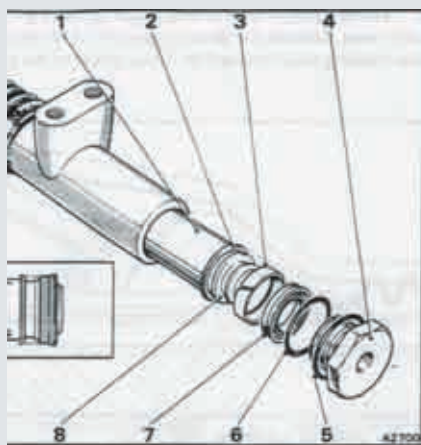




Richard points out that diagrams of the assembly do not show either the body or the rack as spares. The picture at the top showing the whole thing dismantled includes these two bits being the largest components in the assembly. Only the body is shown in ghost outline in the spares diagram below.



Left: The rack seals and PTFE bearing arrangement.



NZ-17 Assembly of free end components

- 1 Rack bar
- 2 Wiper seal
- 3 PTFE seal (also sometimes called a PTFE bearing, but it is really a PTFE bushing)
- 4 Blanking plug
- 5 Blanking plug 'O' ring
- 6 Tube 'O' ring
- 7 Oil seal
- 8 Bearing carrier

Relaying this observation to the suppliers has caused an even bigger stir. After a few days and a few conference calls, they had changed their methods, no longer fitting the PTFE bearings without gapping them first. PTFE bearing gapping has not been the industry standard until now, even though the manuals specify it quite clearly.

On doing the final assembly of the rack unit, the factory workshop manuals are mostly correct but there are a few very important exceptions where the manuals are daft. The early workshop books explain how to fit the

fixed-end main seal, after fitting the PTFE bearing, through the centre tube slot. This is a sure way to damage both the seal and the bearing alike. Hence, later books state that the special tool RH12214 is required to fit both seals onto the rack shaft after the rack shaft is in its central position. Again, this cannot do any good for the seal as the tool squashes the seals to a fraction of their working size. Neither method makes sense. Best is to fit the floating-end PTFE bearing, then the floating-end seal. Slide the shaft into the bore until the fixed-end lip protrudes from the other end but such that the wiper seal (where fitted) does not pop out and be exposed to any damage. With a roll of celluloid from an overhead slide to protect the new seal and PTFE bearing from the end cap's thread, fit the fixed-end bearing and seal to the rack shaft, lubricate it all with Dexron and push the rack shaft gently to near the centre of its tube. The rest is mainly the refitting of the spool valve and adjusting the gears' backlash by the book.

The last tip not mentioned in any literature is vital. At the end of the rack assembly, furthest from the pinion and spool valve, there is a large retaining cap and the oil pipe. That is at the left-hand-side of a right-hand-drive car. The pipe union and rack end cap should be left only firmly hand-tight until the rack is tightened down onto the subframe of the car fully. Finally, tighten the cap and also the pipe union. That way any misalignment will be eliminated, and stresses or distortion minimised as a consequence. If you buy a reconditioned rack or have your own repaired, be sure that you loosen

the pipe and cap before the final tightening of the rack to the subframe, and lastly retighten them.

The next phase in this development is to source a superior main seal (heavens, it's just a standard 1" x 1.5" type) to make the package complete. I am truly hoping that, together with the industry, we shall find a permanent solution to rack leaks once a better seal is sourced, although we may have the solution already cracked with correct PTFE bearing gapping. We are working on developing a greatly improved main seal, possibly simply one with a spring expander.

Watch this space.

Here Richard is gapping the PTFE bearing. You of course know that P.T.F.E. is a convenient way of referring to Polytetrafluoroethylene! (Try saying that quickly when you are a few sheets into the wind!) You know it as Teflon, a non-stick coating for your saucepan. It was first produced commercially after the last war.

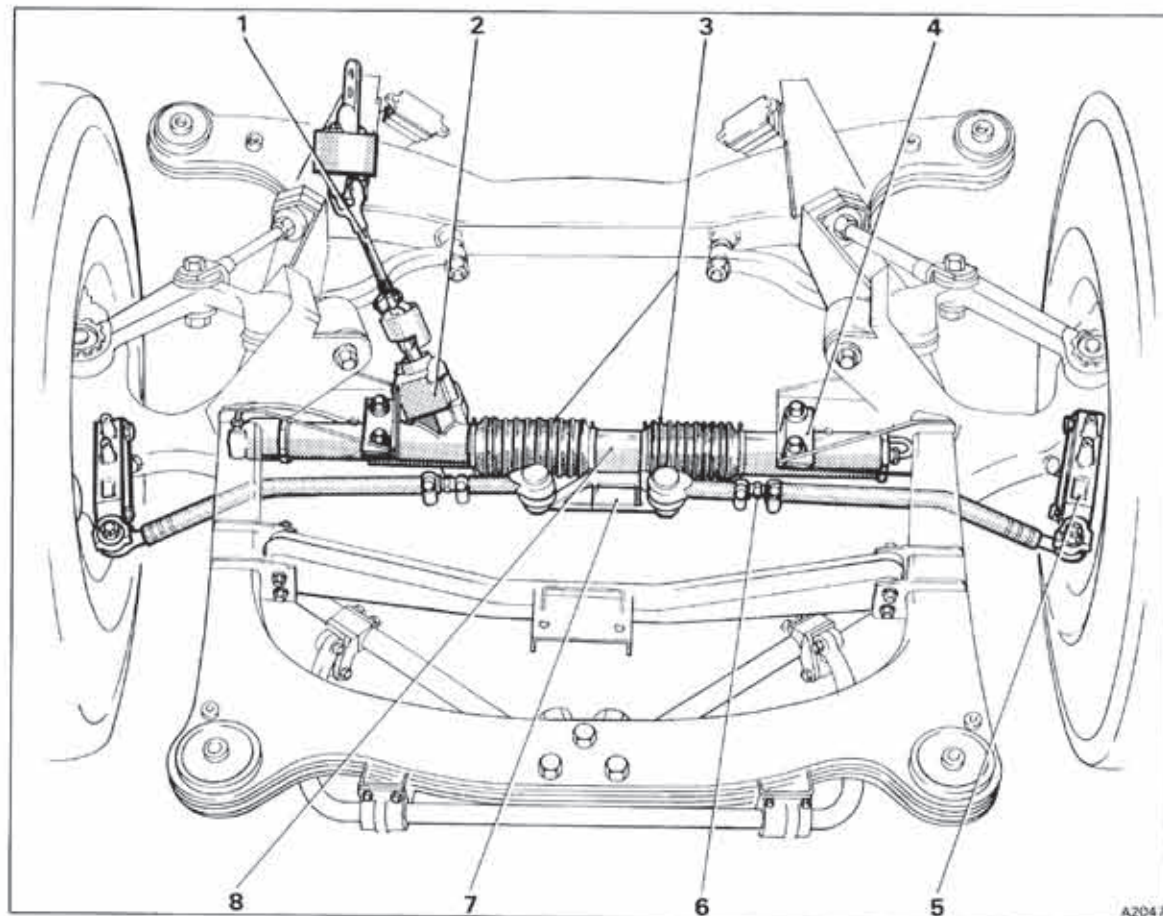
PTFE has the lowest coefficient of friction of any solid material. It melts at 327 °C, but its properties degrade above 260 °C so one wonders just how hot that power steering oil does get in your Turbo Bentley motoring at 160 mph across the Kalahari Desert!

My reference points out that PTFE is ideal for bearings and bushings due to its low frictional properties. The writer further notes that UHMWPE wears better – what was that you say - God you have to be told everything? UHMWPE is ultra high molecular weight polyethylene, which apparently sits very happily with mineral oils.

Finally, lest we be declared insensitive to the environment and our fauna, a 1973 study found that a 4-hour exposure to the organic products of butter in an uncoated pan were 100% toxic to parakeets at 260°C! I assume the writer was referring to the butter and Teflon at 260 degrees and not the parakeets!



If you whipped the whole front sub-frame assembly out of your Spirit and tossed the engine out, this is what you would see. Note that the mountings (4) are well inside the frame to minimise the 'moment' a writhing sub frame has, to distort the steering rack. This is an area that many specialists maintain is the root of the problem. The sub-frame is flexibly mounted to the body at its four corners and together with the entire front suspension forms one unit. Of particular note are the mounts for the upper control arms of the suspension which are mounted right above the mounting points of the steering rack. The frame must surely be pushed and pulled by the various components leaving the poor rack hanging on like grim death to this writhing structure and at the same time trying to keep enough structural integrity to let the various power steering fluid seals retain their integrity!



Photographs courtesy of Richard Treacy.

Above: Richard Treacy gave up when his third exchange rack expired and decided to overhaul the thing himself. Kits are available for the do-it-yourselfers but as cavalier as I am I would avoid the task particularly as removing and replacing the things is not the most enjoyable of tasks.

Eventually very light cars were able to adapt a toothed shaft meshed with a gear, the latter being driven by the steering wheel through the steering column. The former pushed and pulled the wheels from one side to the other pivoting to achieve steering. This light, quick and very positive steering was impractical for heavier cars unless they were to be driven by Sumo Wrestlers.



At Left: The little oil cooler under the radiator of the Spirit seems to be a token effort at trying to keep the internal fluids at a reasonable temperature.

But eventually hydraulic power was applied to the system and the wrestlers were no longer required. If you doubt me put your Shadow on a gentle slope, switch off the engine, release the brake and try steering it!! In fact we had a

local near accident with a late Spirit whose engine had the happy knack of cutting out for no particular reason. It did this on a roundabout while being driven by, shall I say a fairly substantial lady and she just managed to get the car to safety and stop. A mere slip of a gel would I suggest be in major trouble! For reasons we mere mortals are not privileged to know, the Factory designed their own rack and pinion steering which has been a source of trouble from the day the first Shadow II went on the road. And it is still a problem!



At left: One reason I do not remove and replace racks for recreation is the small task of trying to hold the unit which must weigh some 40 lbs while you are trying to thread the pinion shaft onto the end of the steering column and then start at least two of the 4 large bolts that secure it to the sub frame. The plastic tie strap seen poking out on the right of the picture is my method of loosely supporting the thing while you swear and grunt. The large straps are adjustable and are more than adequate to take the weight.

As I mentioned, a contingent from the Australian Club is wending its way to Darwin following the very successful Federal Rally in Orange. Included are no less than two SZ cars both of which are leaving a trail of oil from their leaking racks! There have been three

iterations of these assemblies, the last in the early nineties. They never fail as such, they simply leak. Repairers are apparently limited in the range of seals they can use and most of them will tell you that the seal technology is in the historical category. Then there is the general design in that the whole structure is bolted rigidly to the front sub frame on which is mounted the entire front suspension. Obviously this frame flexes with the various loads placed on it and if it flexes so must the steering rack. Surely it is asking a lot of a seal to keep high pressure oil in its rightful place when the shaft on which it is trying to seal is writhing around like a demented rattlesnake!

If all that were not enough consider an exhaust pipe running alongside of it which in the case of a roaring turbo would be a glowing cherry red. Despite attempts at shielding, the oil in the steering system would have to be, at times, the hottest in the whole car despite the pathetic little oil cooler strapped to the front of the sub frame.

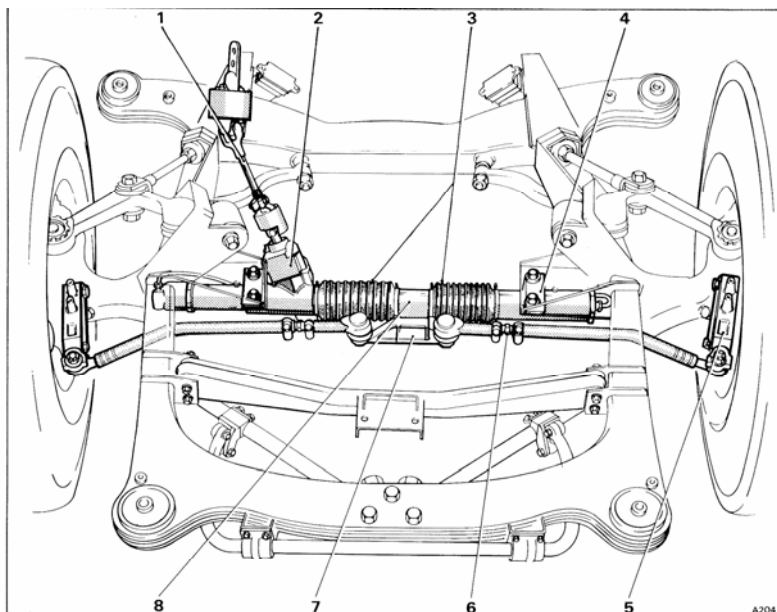


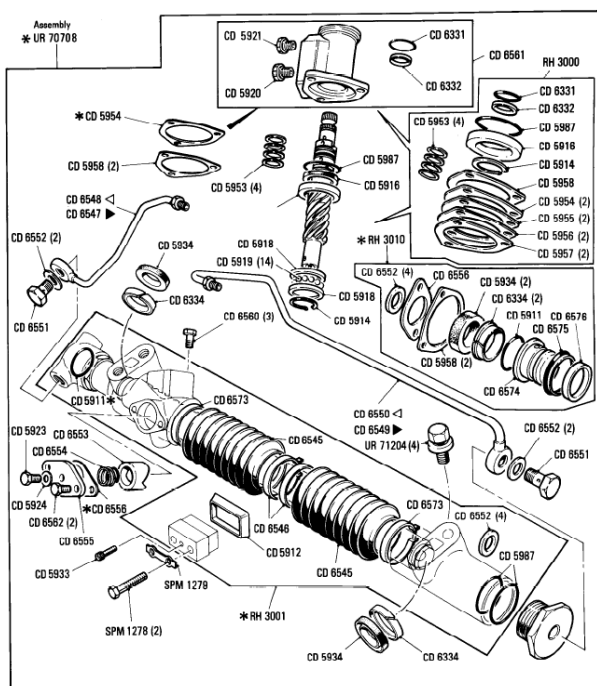
Fig. N2-1 Steering unit mounted in sub-frame

- | | |
|------------------------------------|----------------------------|
| 1 Intermediate link | 5 Side steering lever |
| 2 Spool valve and pinion | 6 Track rod adjuster |
| 3 Convuluted seals | 7 Inner ball joint bracket |
| 4 Steering to sub-frame attachment | 8 Centre tube and seal |

I understand that the largest rack supplier in the United Kingdom last year sold over 200 replacement racks!! So where does that leave us?

Apparently there are a number of people working on the problem particularly in the seal area where most if not all the problems occur. For the moment all the hapless owner can do is keep an eye on the consumption of power steering fluid which should be virtually nil. He can also keep an eye on the convoluted seals on the rack which tend to bake

hard and split. When this happens the rack needs to be removed and sent to a specialist for repair. If power steering fluid leaks from the seals the rack is in clear need of an overhaul.



A closing piece of advice is don't use additives in the hope of sealing off the leaking seals. The seals that are leaking are plastic and won't be affected but other seals will and have been known to expand so much they have damaged components.

At left: The spares schedule lists the consumables, the alternative is buy the whole rack. The Shadow II was the first car to use this equipment and well I remember the hapless Factory Supervisor telling me how there were strikes at the rack manufacturers and the petrol tank manufacturers, just when the model was to be presented to the World! Apparently the Factory yards were strewn with cars sans tanks and racks as they cannibalised them to get sufficient for the presentation. The late Don Appleby of the former York Motors tells of opening the container with the very first Shadow II for

Australia packed therein, to be greeted by this lovely new car standing astride a huge pool of power

steering fluid. Not an auspicious start! If you have succumbed to the additive treatment you would be well advised to overhaul the whole power steering system. Replace all hoses high and low pressure, have the pump overhauled as well as the rack and thoroughly flush the system to remove all traces of the contaminant.



Richard Treacy our Switzerland expatriate now advises he has had it, being on his third exchange rack so has dismantled the latest leaking one himself.

At left: The dreaded spool valve which controls the amount of hydraulic assistance to be supplied to the rack. The splined shaft connects to the steering column. This bit of the assembly seems to require more precision in setting up than a Swiss watch!

He is now consulting with various authorities and hopefully we will benefit from his observations. The opening pictures are of his rack dismantled. My experience? apart from removing and replacing the units, none. But only yesterday I had a call from a friend down the coast who has a leaking rack. I had it professionally overhauled not four years or 90K kilometres ago!!!

