Justering af Camber vinkel på IRS modeller

Næstformanden fik efter 8 års „hårdt arbejde", endelig sin TR 6 klar til det Europæiske træf i september. En af de sidste ting, der skulle bringes i orden inden afgangen til Svendborg, var indstillingen af baghjulenes camber.

De fleste TR ejere med en IRS model vil nikke genkendende til problemet, men har åbenbart opgivet at gøre noget ved det med det resultat, at de fleste biler kører rundt med alt for stor (negativ) camber på baghjulene.

Fabrikken har ikke indbygget nogen justeringsmulighed, men da der gennem tiderne har været anvendt 3 forskellige beslag til ophæng af de bagerste svingarme, er der alligevel lidt „spillerum" ved at bytte rundt på beslagene.

For ikke at i blinde at skulle forsøge sig med de 36 mulige kombinationer, prøvede jeg mig frem på Internettet, for at se om ikke andre havde været i den samme situation.

Det er UTROLIGT, hvad man kan finde i cyberspace !

Den følgende artikel er hentet fra en Amerikansk TR club „Buckeyes Triumph" og behandler i alle detaljer netop dette problem.

I det følgende gengives artiklen i sin helhed på originalspoget og uden yderligere redigering (husk alt er i tommer). Skulle der være uklare punkter, hjælper jeg gerne med en uddybning; jeg har været gennem det hele selv !

TR250 & TR6 Steering & Suspension Adjusting Rear Suspension Camber

By Nelson Riedel

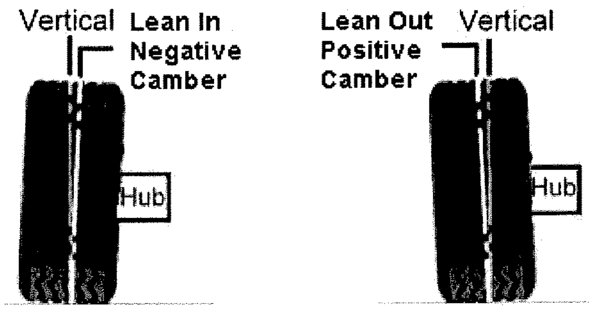
There are three aspects of the TR4A, TR5/250 and TR6 Independent Rear Suspension (IRS) that can be adjusted:

1. The toe-in alignment.
2. The rear wheel camber.
3. The height of the rear of the car.

The design incorporated a toe-in (wheels point in or out) adjustment capability through the use of shims between the trailing arm brackets and the frame. I leave the toe-in adjustment to the alignment shop where I have it done as part of a 4-wheel alignment. My only contribution is to provide plenty of spare shims for both the front and rear suspension.

Neither ride height nor camber adjustment capability was incorporated into the design so one should not expect the alignment shop to be able to fix such problems without a little assistance. The following describes how I adjusted both the camber and ride height in my garage without the use of any special equipment. I suspect any alignment shop can do the same thing if furnished with the necessary parts.

The concept of camber is illustrated in the following sketch The most common camber misalignment is excess negative camber, where the top of the wheel leans in toward the car.



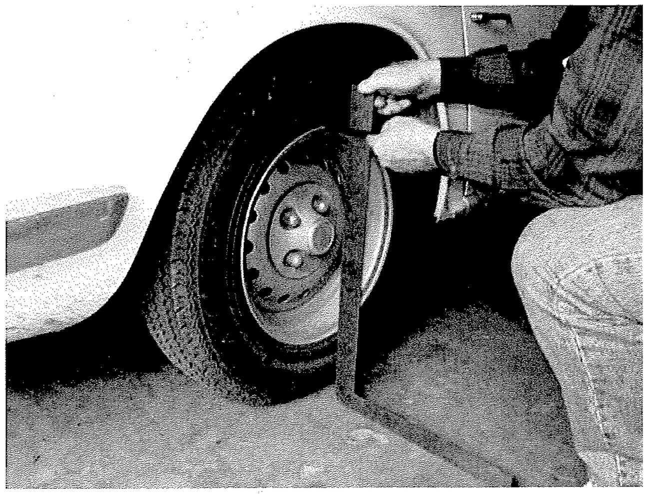
I can think of five possible causes of excess negative camber:

1. Severely sagging or broken frame.
2. Worn out trailing arm bushes.
3. Broken trailing arm mounting brackets.
4. Weak or too short replacement springs.
5. Misalignment of the trailing arm mounting brackets or frame cross member to which they attach.

Frame problems are common for these vehicles, especially those that have been driven in the presence of road salt. Much of the frame is covered with oil from the always-present leaks and not prone to rust in those areas. However, the oil usually doesn't coat the fame cross members to which the trailing arms mount. If the frame is not solid, it must of course be repaired.
The factory apparently realized there was a camber problem as early as '69-'70 because they made available a spacer to put between the bottom of the springs and the trailing arm and also redesigned the brackets.

Fortunately, the camber can be adjusted by manipulating the configuration of the trailing arm mounting brackets and through the use of the spacers under the springs. As mentioned earlier, these same adjustments also affect the ride height so the two adjustments must be treated together.

Measuring Camber: The first thing I did is determine if the camber is misaligned and if so, how much and in what direction. (Remember, if it isn't broke, don't fix it — or, don't treat a well patient cause you might make him sick.) All that is needed to get a rough measure of the camber is a flat surface such as a garage floor, a large square and a ruler, preferably calibrated in tenths. The next photo shows these tools in action. (Notice the clean hands, almost like a surgeon.)



First and most important, all tires must be inflated to equal pressure and the car must be pushed with no driver or passenger straight to the place of measurement. If the car had been turned or worse, the back end jacked up and then put back down, the suspension will not be at equilibrium because the bottom of the tires are restrained from moving in an out by the floor. The same goes for any load on the suspension from driver or passengers.

Next, the square is set on the floor and positioned near the tire with the vertical side of the square aligned with the centre of the hub and as nearly vertical as possible. Oh, forgot to mention to remove those wheel trim rings.
Next, measure and record the distance between the square and lip at the top of the wheel. Then, without moving the square, measure and record the distance between the square and lip at the bottom of the wheel. Next, subtract the measurement at the top from the measurement at the bottom. If the two measurements are equal, then the camber is zero, great! If the difference is negative (top measurement larger then the bottom measurement) the camber is negative; the top of the wheel is leaning in. A positive difference indicates a positive camber; the wheel is leaning out. I take three sets of measurements for each side. If the computed difference varies more than ten percent on one side I keep taking the measurements until I get consistency. One more measurement that is needed is the diameter of the wheel between

the points where the other two measurements were takes. My wheels measured 16 1/8 inches. The subsequent calculations work only if the diameter and the other measurements are in the same units (inches, feet, millimetres, furlongs, etc). I also measure the height of the lip of each fender (both front and back) directly over each wheel at the same time I take these measurements.

Computing: All that is needed now is a little trigonometry to convert the measurements to the camber angle. For those of you that remember more about the young women in your trig class than small angle approximations or worse yet, took a woman's studies class rather than trig, I'll help you out:

1. The tangent of an angle in a right triangle is the ratio of the opposite side to the adjacent side.
2. The tangent of a small angle (5 degrees or less) can be approximated by the radian measure of the angle.
3. The radian measure of an angle can be converted to degrees by multiplying by 57.3.

It follows then that the camber angle is related to the measurements taken above by:

Camber Angle =(57.3 degrees) X (difference between top & bottom)/(dia.)

Example, if I measure 2.3 inches at top and 1.8 inches at the bottom, then the difference is:

1.8" – 2.3" = -0.5", and the camber angle is:

(57.3 degrees) X (-0.5") / (16.125") = -1.8 degrees

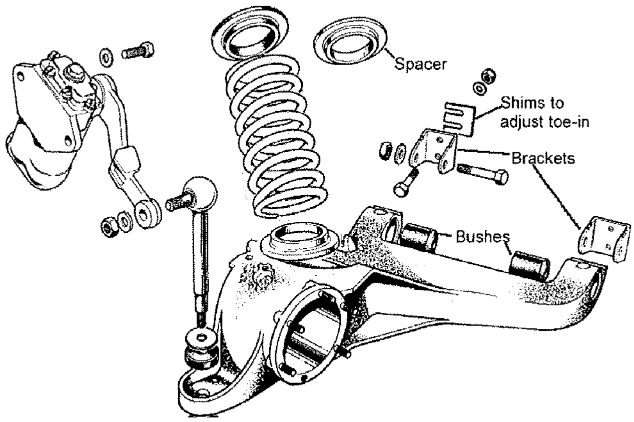
This wheel should have a noticeable lean in. If I do the measurements and computations and the results don't match what I observe (such as wheel leans in and I compute a positive camber or the wheel that leans in the most seems to have a smaller computed negative camber, etc) I consider that:

1. I made an error on slide rule or calculator,
2. The floor isn't very flat,
3. The square isn't square,
4. If none of the above, I might consider having someone drive me to an optometrist or psychiatrist

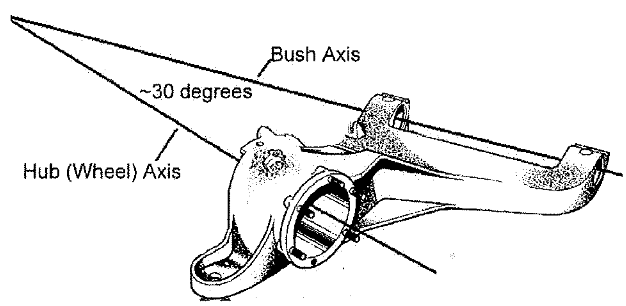
The correct rear wheel camber is from +1degrees to –1/4 degrees. If my camber is in this range, I go worry about something else. Once I decide to do something about the camber, I use the following sequence:

1. Renew the rear suspension bushes.
2. Deal with any spring issue
3. Alter the bracket configuration.

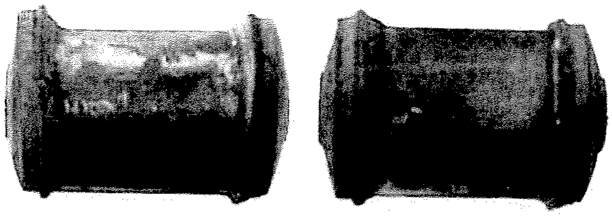
The following sketch from TRF catalogue shows the rear suspension components.



If you look closely at the sketch you'll see that the axis of the bushes is not parallel to the axis of the hub that fits in the round cylinder with the studs protruding. The next sketch shows this more clearly. Because of the ~ 30degree angle between the bush axis and wheel axel, as the trailing arm moves up and down the camber changes. For example, when load is added like people getting in, the back of the car goes down and the camber changes in a negation direction. A slight positive camber with no load will give a nearly vertical wheel under moderate load.



Bushes: The standard bushes are made of rubber with metal sleeves in the middle. After years of use, the sleeves tend to migrate to one side of the bush. Since the forces on the inside and on the outside bushes are different, the amount of sleeve movement can be different enough to cause several degrees of negative camber. The next photo shows a pair of bushes removed from the trailing arm on my '70TR6. Notice that the sleeve on the left has migrated to the top more than the one on the right.



If the bushes are more then ten years old I'd suggested replacement before doing anything to adjust the camber. The standard bushing as well as uprated rubber and poly bushes are available. I installed new standard bushes on my '76 about 18 months ago at the same time I replaced the frame rear cross members, that part of the frame to which the trailing arm brackets attach.

Springs: The next thing I looked at was the springs. Recall that I mentioned measuring the height of all four fenders at the same time the camber was measured. There are two things to consider:

1. Is the back too high or too low?
2. Is one side too high or too low?

Jay Welch in his TR6 Shop Reference Data (on the BT Website in the technical area) lists the fitted length of the standard spring as 8.61". I measured the fitted length of the springs on my '76 as follows:

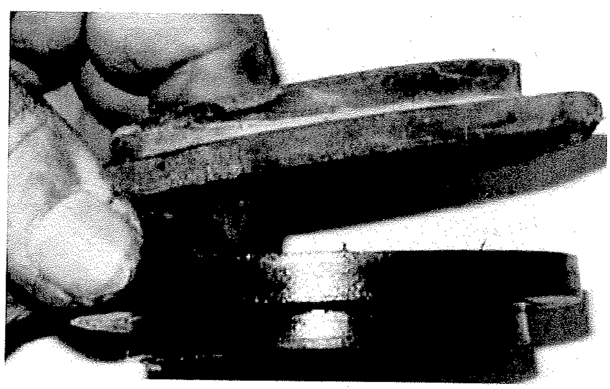
1. Measured fender height.
2. Put floor jack under trailing arm in area of rear axel.
3. Jack up trailing arm and removed wheel.
4. Lowered jack so that height was same as in 1.
5. Used steel rule to measure from bottom of spring to near mid point and made mark on spring.
6. Measured from top of spring to mark in 5.
7. Added measurements from 5 & 6 to get fitted length.

I was careful to get the end of the ruler inside the lip on the rubber packing pieces when The taking measurements in steps 5 & 6. This measurement is probably subject to an error of 0.1" or so. I measured about 8.6" so it appears that my springs have collapsed little as any. Later when I removed the springs I measured the free length of both to be 11.5". The following table summarizes the starting point for my '76 TR6.

Data for my car		
	Left	Right
Front fender height	28.0"	28.2"
Rear fender height	28.1"	28.2"
Rear spring fitted length	~8.6"	~8.6"
Rear wheel camber	-2.3 deg.	-1.6 deg.

The height was good and the right side was very slightly higher — not enough to consider trying to fix — I wouldn't worry about any difference less than ½ inch. The only problem seems to be the camber.

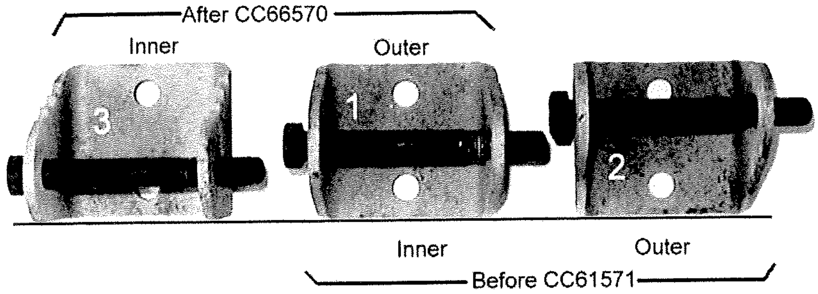
New Packing: When measuring the fitted spring length I noticed the rubber packing pieces at each end of the springs were in bad shape so I decided to replace them first. I purchased the uprated poly packing pieces from TRF. The rubber packing pieces are about ~0.25" thick and the new poly packing pieces are ~ 0.29" thick (photo below)



I decided to install the new packing pieces and measure everything again.

Data for my car		
	Left	Right
Front fender height	28.0"	28.2"
Rear fender height	28.4"	28.4"
Rear wheel camber	-1.6 deg.	-1.3 deg.

height increased and the camber improved because of the thicker packing. The height became equal. I noticed that part of one of the old packing on the left side was not under the spring, which might explain how the height changed more on the left side.



Try Spacers: As mentioned earlier, the factory made available spacers to put under the springs to fix the negative camber problem. I decided to try a set of spacers next. The spacers raise the springs 0.44" and are placed between the spring and the lower packing piece.

Data for my car	New packing pieces	and spaces
	Left	Right
Front fender height	28.0"	28.2"
Rear fender height	29.2"	29.2"
Rear wheel camber	-0.4 deg.	-0.2 deg.

In the accompanying note on Rear Suspension Geometry, the effect of spacers are computed to be:

Camber Angle Change (Spacer)=(Spacer height) X (2.7 degrees)

Ride Height Change (Spacer) = (1.8) X (Spacer height)

The spacer height must be in inches and the resulting ride height change is in inches. The 0.44" spacer raised the height 0.8" and increased the camber (in a positive direction) by a little over one degree, matching the calculated values very closely. The wheels looked pretty good with this setup but I thought the height was too high. I also expected the new poly packing to compress slightly making the camber more negative. I decided to remove the packing to lower the height and work on the brackets instead.

The Brackets: Triumph made three different brackets for the trailing arm as shown in the next photo. The number of notches in the top edges identifies the brackets and is marked on each bracket in the photo. Up to CC61570 a 1-notch bracket was used on the inside and a 2-notch bracket on the outside. Beginning with CC61571 a 3-notch bracket was used on the inside and a 1-notch bracket on the outside.

Brian Lanoway of Winnipeg, Canada (brian_lanoway@standardaero.ca) struggled with and successfully solved this problem. He sent a note to the Triumph list in August 1998. Part of that note is reproduced below with Brian's permission.

It's now taken me 2 years, but I finally think that I've got the camber on both my rear wheels right and I thought the list might benefit from some of the 'science' I've applied to the task. There's been some traffic on the list last spring about this subject, but I haven't seen a comprehensive approach to this yet. I hope this helps.

First some background. Last year, I installed new trailing arm up-rated rubber bushings, springs and rubber spring packings, only to find that the rear camber was still excessive - with the driver's side sagging more than the other. This spring, I mixed and matched the trailing arm brackets - using the same mirror-image combination on both sides – the net result being the proper camber on the passenger side with some sag still remaining on the driver's side. Finally, I remixed the brackets on the driver's side alone to get that right. I now have both sides at the proper camber angle - primarily through using various trailing arm bracket combinations.

Since there are 36 possible trailing arm bracket combinations with the one notch, two notch and three notch brackets - either in the 'up' or 'down' positions, I measured the bracket and trailing arm geometry, applied some trigonometry, and then created a table to determine the range of camber adjustment possible using the 36 combinations.

I've had several discussions with Brian and as a result revised his original table to account for several additional variables. (That exercise is documented in the accompanying note on Rear Suspension Geometry.) The resulting table is shown below. The camber angle and ride heights are relative between bracket configurations. Also note that the negative camber angle DECREASES as you go down the table. By the way, 3U means positioning the bracket with the three notches up, etc.

Relative Camber Angle and Ride Height for Various Trailing Arm Bracket Configurations		
Bracket Configuration Outer-Inner	Total Camber Angle (Degrees)	Ride Height (Inches)
3D-3U	-4.5	0.0
2U-3U	-4.0	-0.1
1D-3U	-3.4	-0.1
3D-2D	-3.3	0.1
1U-3U	-2.8	-0.2
2U-2D	-2.7	0.0
2D-3U	-2.3	-0.3
1D-2D	-2.1	-0.1
3D-1U	-2.1	0.1
3U-3U	-1.7	-0.3
1U-2D	-1.6	-0.1
2U-1U	-1.5	0.1
2D-2D	-1.0	-0.2
1D-1U	-0.9	0.0
3D-1D	-0.8	0.2
3U-2D	-0.4	-0.3
1U-1U	-0.3	-0.1
2U-1D	-0.2	0.1
2D-1U	0.2	-0.1
1D-1D	0.3	0.1
3D-2U	0.4	0.3
3U-1U	0.8	-0.2
1U-1D	0.9	0.0
2U-2U	1.0	0.2
2D-1D	1.5	-0.1
1D-2U	1.6	0.1
3D-3D	1.7	0.3
3U-1D	2.1	-0.1
1U-2U	2.1	0.1
2U-3D	2.3	0.3
2D-2U	2.7	0.0
1D-3D	2.8	0.2
3U-2U	3.3	0.1
1U-3D	3.4	0.1
2D-3D	4.0	0.1
3U-3D	4.5	0.0

Brian suggested that it's best to change only one bracket per trailing arm at a time which makes sense. I started with the standard later 1U outer 3U inner configuration. The inner bracket bolt was installed with the head toward the inside and I didn't know if I could get the inside bracket off easily so I decided to try to correct the problem by changing only the outside bracket. (The configuration shown in the manuals has the bolt head toward the inside. In the future I'm going to assemble them with the inner bolt head to the outside and the outer bolt head to the inside to facilitate changing the bracket configuration.)

The 1U-3U configuration has a relative camber of -2.8 degrees. Moving down the table then next entry with the 3U inner bracket is the 2D-3U configuration that has -2.3 degrees relative camber. That is an increase of 0.5 degrees—not enough. I needed between 1.3 and 1.6 degrees to get to zero camber (the spacer had been removed). The next entry down with the 3U inner bracket is the 3U-3U configuration that has -1.7 degrees relative camber. This is an increase of 1.1 degree. I would have liked a little more increase, but the 3U-3U configuration is the combination with the greatest positive camber with the 3U inner bracket. So I tried that. The results were:

Se tabel

Data for my car	New packing pieces	and 3U-3U brackets
	Left	Right
Front fender height	28.0"	28.2"
Rear fender height	28.5"	28.5"
Rear wheel camber	-0.3 deg.	-0.0 deg.

This was a slightly greater camber increase than expected and very close to the +1 degrees to −1/4 degrees specification. The road height increased slightly rather than decreasing as predicted from the data in the table. The ride height increase is due to a small second order effect explained in the Geometry note. These results above are barely acceptable. I'd be much happier with the left at about + 0.6 degree and right at +0.3 degree since the left side load is nearly always more than the right side load. I decided to run it for a few weeks and then measure it again.