Steering Toe-Out Adjustment

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Steering toe-out adjustment

To prevent rapid tyre wear and to provide good handling, one of the key adjustments on the front end of a Traction is the toe-out of the front wheels.

The Traction manual is not especially helpful in describing how to measure toe-out. It simply advises the owner to "use a gauge of the type commonly sold in the trade." It doesn't give any details of such a gauge, but the general idea can be deduced from the instructions for this operation.

Seventy years ago there were no tyre and front end specialists equipped with today's electronic gauges and a good many Tractions would never have been serviced by a Citroen specialist. Therefore, if one is prepared to spend the time it should be possible to check and adjust toe-out, and achieve the required accuracy, using simple techniques. If one is uncomfortable about doing the job at home, a modern front end alignment shop can measure toe-out quickly and extremely accurately.

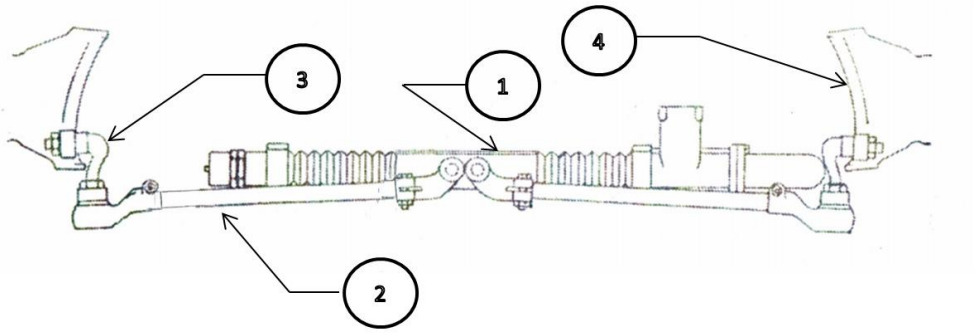
This document is broken into five parts:

1. Terminology
2. Some basic theory about steering geometry, and why it is relevant to measuring toe-out
3. Some simple ways to measure toe-out
4. Making steering adjustments on a Traction
5. Tyre wear patterns
6. Summary of procedure

Part 1: Terminology

The workshop manual and the spare parts manual use different words to describe the same component. To add to the possible confusion, the words used by Citroen are sometimes different from those commonly used for equivalent components on other makes of cars.

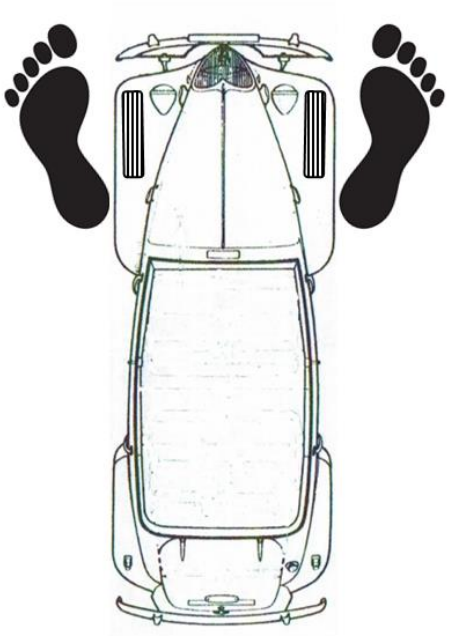
The following sketch and table explains some of the differences in the names used for the parts of the steering system.



Item no.	Workshop manual	Spare parts manual	Common automotive term
1	Steering rack	Steering housing	Steering rack
2	Track rod	Steering side rod	Tie rod
3	Steering arm Steering lever	Track rod lever	Steering knuckle (made as a single component)
4	Swivel	Swivel housing	

Part 2: Some basic steering theory

What is meant by the term “toe-out”? Surely the front wheels point straight ahead when the car is pointed straight ahead? Well … no. Or at least probably not! The Traction manual says the front wheel should toe out 0 – 2mm at the front, measured at the inner edges of the wheel rims. This sketch illustrates what toe out means. The wheels point slightly outwards at the front when there is toe-out.



Toe-out of front wheels

In the section of the workshop manual dealing with toe out, the manual doesn’t specifically mention some important starting points before making checks and adjustments:

- Tyres must be at the correct pressure. (If the procedure for measuring and adjusting caster angle has been followed immediately before measuring toe out, tyre pressures should be OK).
- The car is on the ground and the suspension is settled.
- The steering wheel is pointing the car straight ahead.

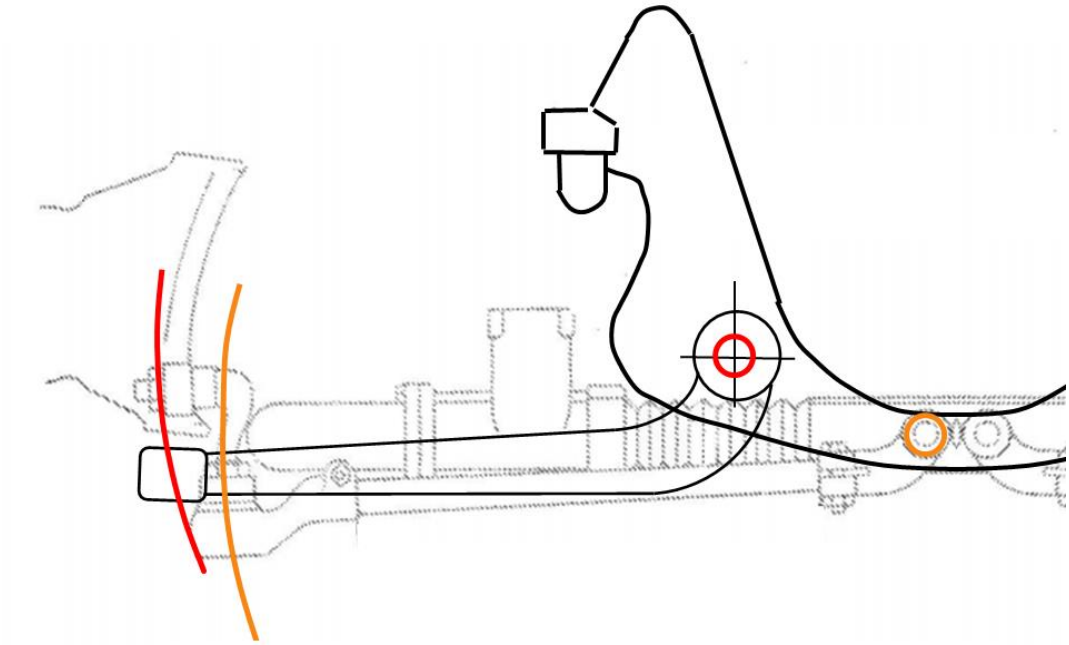
Here is an explanation of why the last two of these conditions are important:

Bump steer

Although adjustments to toe out are made when the wheels are off the ground, measurements are made with the vehicle on the ground. Why? Would it not be more convenient to measure and make the necessary adjustments while the wheels off the ground? Unfortunately, a characteristic of the front axle geometry called bump steer means that the car must be on the ground when toe out measurements are made.

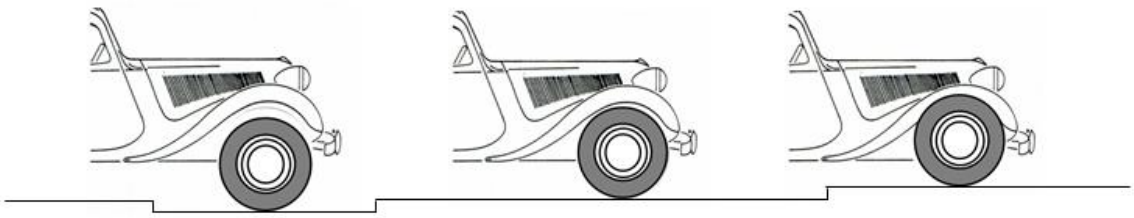
The geometry of a Traction's front end, as the car moves up and down on its suspension, is complex. The upper and lower link arms and the track rods all move in arcs. The lengths of the various linkage parts are different, and the points around which they move are different, so things don't move in straight lines, and they don't move in parallel. As the lower link arm moves up or down when the car hits and recovers from a bump, the track rod pulls or pushes on the steering arm, causing the swivel housing to rotate. As a consequence, toe-out changes. This is known as "bump steer", and it is a common problem with rack and pinion steering systems. In the Traction front end design, the shorter length of the upper link arm goes some way towards compensating for this effect as the wheel goes up. However, the whole set-up is a bunch of compromises. The simplest and best approach to making adjustments on the front end is to follow the manufacturer's instructions.

Having the vehicle on the ground when making toe-out measurements provides a consistent reference point, and eliminates errors which would be caused by bump steer.



The lower link arm and the track rod move on different arcs

Bump steer causes this to happen, as the car is moving up and down on its suspension:



Wheel down → increased toe in

Nominal ride height → 0 – 2 mm toe out

Wheel up → increased toe out

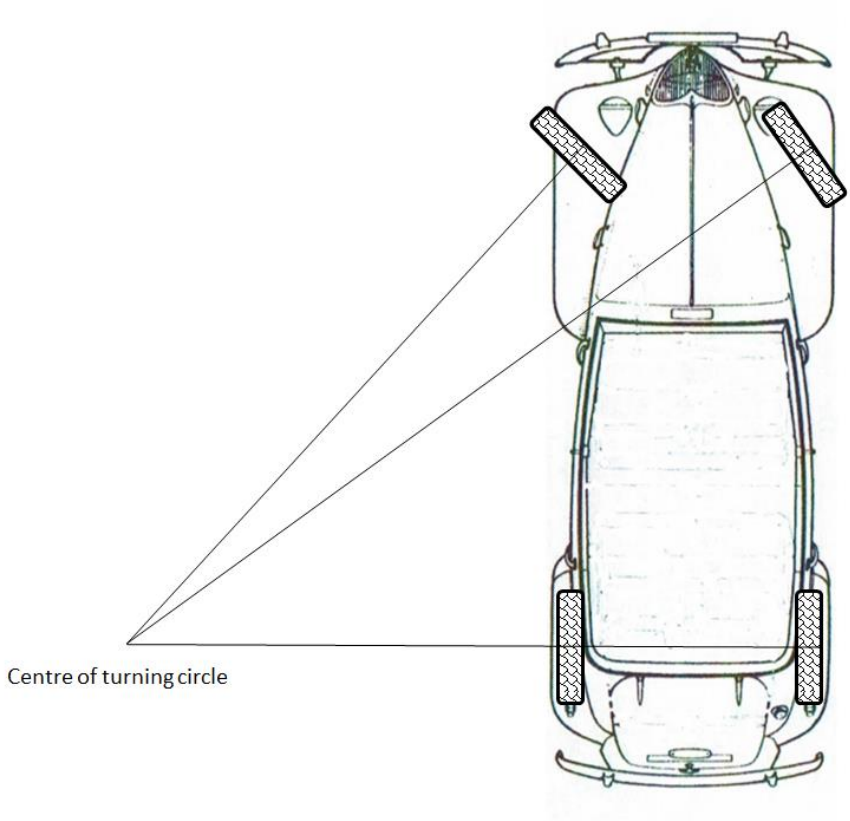
Ackermann steering geometry

Why does the car need to be pointed straight ahead when measuring toe out?

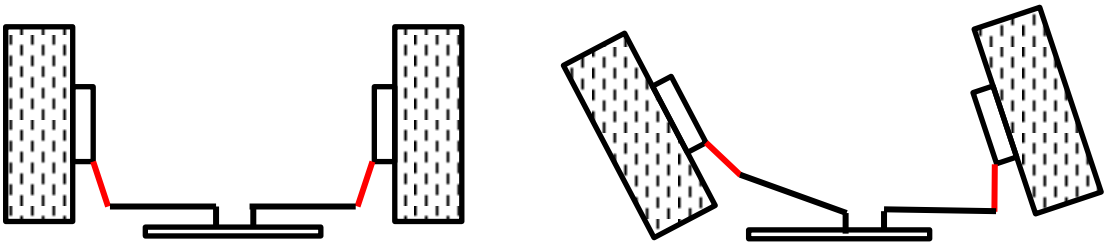
In 1817 a German wheelwright called Georg Lankensperger devised a steering system for horse-drawn carriages. Lankensperger's agent in the UK, Rudolph Ackermann, filed for a patent and he has gained all the credit for the system for the last 200 years. It hardly seems fair!

Actually, there is some evidence that Erasmus Darwin, the grandfather of Charles Darwin, had also invented such a system as early as 1758, after being injured when his carriage tipped over. Either way, what we know today as Ackermann steering is not a product of modern automotive design.

The geometry described in Lankensperger's design causes all the wheels of the vehicle, when it is turning, to follow a circle centred on the same point.



This is achieved primarily through the design of the steering arm, as shown here:



The steering arm is a carefully designed component, to permit Ackermann to work. It isn't shaped just to prevent the steering system components from hitting the tyre!

Ackermann developed his theory when carriages were fitted with narrow wheels with steel rims, and sometimes they didn't even have springs. The theory is not entirely accurate when dealing with today's motor vehicles, but it is useful to explain the general principle.

Why isn't the theory completely accurate? Pneumatic tyres distort somewhat as the vehicle is turning. The higher the speed, the sharper the turn, and the wider the tyre, the greater is the distortion of the tyre. The distortion results in the tread of the tyre not pointing in exactly the same direction that the wheel hub is pointing. Furthermore, as the vehicle is turning, the outer side of the car sinks a little on its suspension, and bump steer comes into play. It all gets very complicated, very quickly!

If the theory isn't 100% right, why is the general principle relevant to setting toe-out on a Traction? Toe-out increases as the car is going around a corner. To have a consistent point of reference for measurements, the car needs to be aimed straight ahead.

Part 3: Ways to measure toe-out

Needless to say, instructions on measuring and adjusting toe-out assume that there is minimal or no play in ball joints, ball pins, bushes and silentblocs. It is advisable to make measurements after driving the car forwards to take up play as would happen when the car is being driven.

Operation 149 in the workshop manual says:

"At the height of the wheel centres, measure the distance between the inner edges of the wheel rims at the front. Chalk mark the points measured. Rotate the wheels half a turn and measure the distance between the same two points now at the rear."

To be less open to misinterpretation, it would be better if the manual said "drive the car forwards, or push it backwards, so that the chalk marks are at the rear, and measure the distance between the same two points."

This is an important instruction. We are aiming for toe-out of 0 – 2mm, measured at the rim. Small distortions of the rim are possible due to manufacturing variances, seventy years of parking knocks, previous wheel weight attachment, and other such reasons. Measuring at the same location on the rim eliminates errors due to such distortions.

A gauge which fits under the car and can be located against the inside edges of the wheel rims is not easy to use, especially when measuring the chalk marks when they at the rear position. There are many other ways to measure toe-out. Here are two of the easier ones.

1. Gauge which uses the outsides of the rim as measurement points.

This type of gauge is not difficult to make. One side has a fixed stop, and the other side is used for the measurement.

2. Tyre scribe method

Rather than measuring on the rim, this method uses lines marked on the treads of the tyres as reference points. A nice advantage of using this method is that the diameter of the tread is about 675mm, whereas the diameter of the wheel is about 430mm. Therefore, instead of working to a specification for toe-out of 0 – 2mm measured on the rim, one can use 0 – 3mm measured on the tread. This gives a bit more comfort about achieving a result within the tolerance range.

Jack up each wheel and mark a line on the tread while rotating it. A fine tipped felt pen works OK, because the tip has a bit of flexibility to run over depressions in the tread pattern. Do not move the pen while rotating the wheel. Then lower the car to the ground and push it backwards to settle the suspension.

A gauge similar in concept to that used in method 1 can be used to measure the distance between the lines on the tyres. Alternatively, some duct tape can be used with a string and a plumb bob. If the string is placed on the line marked on the tyre, and the plum bob is slowly lowered until the point puts a dent in the duct tape, it is easy to measure, on the floor, the distance between the lines at both the front and back of the wheels.

Gauge to measure between scribed lines on tyres

Tyre scribe method

A couple of comments on other methods:

Any technique which uses the tyre wall as a measurement point is open to error caused by branding and other such lumps and bumps in the rubber.

Some Traction wheels have a hub cap mounting bar in the centre of the wheel. It is difficult to measure toe-out using straight edges or string lines against the tyre walls on this type of wheel.

Part 4: Steering adjustments on a Traction

There is a sequence in which adjustments of the front end should be made:

1. Set heights under the hull, by adjusting torsion bars
2. Set weights on each wheel, by adjusting the torsion bars. (This could change the heights).
3. Adjust caster angle
4. Adjust toe out
5. Adjust steering lock
6. Check wheel camber (which is not adjustable)

If rebuilding the steering, the workshop manual advises to have a distance of 563 mm between the ball pins on the steering rack and the corresponding ball pins on the other ends of the track rods, with the same amount of thread engaged in the inner and outer sockets of each rod. This dimension provides a good starting point toe-out adjustment, and the load on the fine pitch threads is shared evenly among them.

Page 67 of the manual shows a gauge MR.3440 to use when assembling tie rods. This is a “nice-to-have” gauge, and given most owners would never use it more than one or two times, it can be regarded as non-essential. Careful measurement with a tape measure will suffice.

If making measurements and adjustments without rebuilding the steering, the length of the two track rods must be the same as each other, to within 1 mm. This can be checked by measuring between the ends of the two sockets. Page 92 of the manual shows another gauge MR 1590, and this is used to check the lengths of the two tie rods are within 1 mm of each other. It can be used either when assembling tie rods before installation in the car, or when adjusting toe-out. Again, it is a "nice-to-have" gauge, and there are other simple ways to check the lengths. For example, a standard tape measure, preferably with a fairly square case, can be used to measure between the two sockets.

If the track rod lengths are not the same, the steering cannot be centred in the rack, and the maximum steering angle on one side of the car will be restricted.

Tools required for adjusting to toe-out:

- 14 mm spanner to loosen and tighten bolts on the sockets
- A footprint pipe wrench or a similar tool to grip and turn tie rods
- A jack
- Means of measuring toe-out

How does one minimise the time to achieve the specification?

Adjusting the track rods – this bit isn't in the manual!

The Citroen manual simply instructs one to turn the track rods. What it doesn't say is which way to turn, and roughly by how much to turn to get toe-out back to within the specified range. Having that information helps to minimise the time required and the number of checks and subsequent adjustments needed. Here are some hints:

Which direction?

The sockets at the rack end have left hand threads. The sockets at the wheel end have right hand threads. Looking from the side of the car:

- To lengthen that side's track rod, rotate it clockwise. This decreases toe-out (and increases toe-in).
- To shorten that side's track rod, rotate it anti-clockwise. This increases toe-out (and decreases toe-in).

How much to rotate?

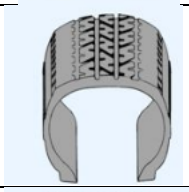
Here's a rough guide, and the logic behind it.

- The pitch of the threads on the track rods is 1 mm. Both ends of the rod are threaded, so one full rotation of a track rod changes its length by 2 mm.
- The distance of the steering arm, from the centreline of the ball joints to the track rod ball pin, is about 120 mm.
- The diameter of the wheel rim is about 430 mm, so the radius is 215 mm.
- Changing the length of a track rod by one turn (2 mm) moves the wheel rim by (215/120) x 2 = 3.6 mm.

- If one side of the wheel moves 3.6 mm in a particular direction, the opposite side moves 3.6 mm in the other direction, so a total of 7.2 mm change in toe, for one full turn of just one of the track rods – or half a turn of each track rod!
- It is clear that this adjustment is sensitive! The entire range of the specification (2 mm) is covered by about 1/8 of a turn of each track rod.

Part 5: Wear patterns on tyres

After making front end adjustments, watch your tyres for unusual wear patterns. They can give early warning that there is an alignment or other problem which needs to be addressed.

Wear on tyre	***Cause***	
Feathered, or saw-tooth, wear pattern across the tyre	Toe-out incorrect	
Wear on inside edge of tyre	Camber incorrect – on a Traction check for worn ball joints or other worn suspension components	
Wear on both edges of tyre	Under inflated tyre	
Wear in centre of tyre	Over inflated tyre	
Irregular, scalloped or spotty wear pattern	Variety of reasons, including out of balance, out of round, worn shock absorbers, other front end wear	

Part 6: Summary of procedure for setting toe-out:

Step 1: Ensure preconditions are met:

- Heights under the hull and weight distribution OK
- Tyre pressures correct
- Track rods are assembled to same length, with equal thread engagement in the sockets.
- Caster angle correct

THEN

Step 2: Drive the car slowly forwards to the place where toe-out measurements will be made. Don't brake hard. Make sure the steering is pointing straight ahead.

Step 3: Measure toe-out. If it is OK, the job is done. If it is not OK, go to step 4.

Step 4: Jack the car up and adjust the track rods. (Refer to part 4 of this document to estimate how far to rotate, and in which direction).

Step 5: Lower car to the ground, drive away a few metres to settle the suspension. Repeat steps 2 and 3.