Porsche 928 Alignment Instructions

If I've made a mistake (technically or typographically), or omitted something, please let me know. This is based on my personal experiences, understanding and opinions. All of which are limited.

General description:

This is primarily intended to aid in performing an alignment on the 928 without the aid of a professional alignment rack and equipment. Even if you have your car aligned by a professional, it's worth understanding what's being done and what's unique to the 928 that the average alignment shop might not know.

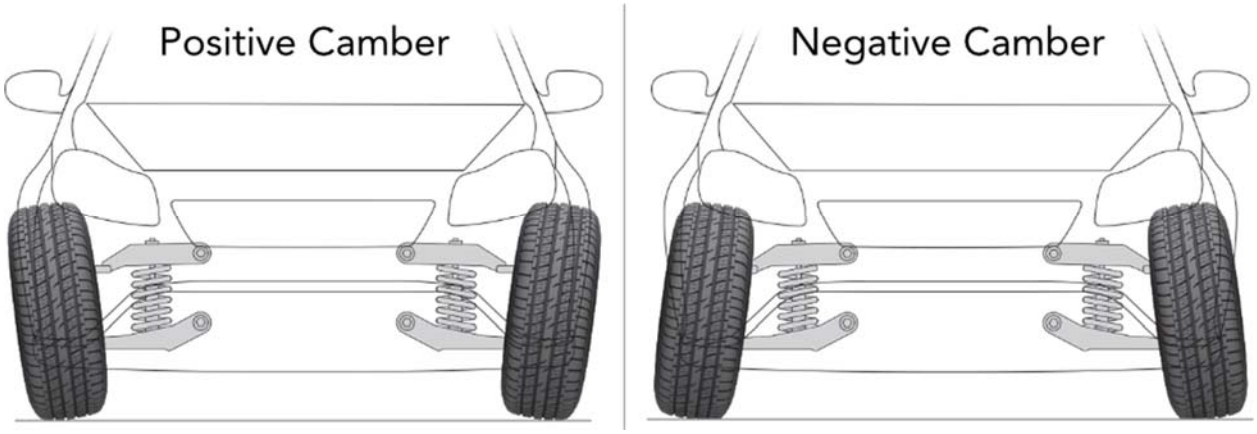
A vehicle's alignment is orientation of the wheels relative to the frame/unibody. The primary purpose in the alignment settings is to affect how the car handles. That includes how well it holds a straight line, pulling to the left or right, how much it's affected by ruts and grooves in the road, how well it turns in corners, and how much traction the tires get under acceleration. The alignment also affects how the tires wear. An alignment can make the difference between a pleasantly stress-free drive and a nerve-rackingly exhausting drive.

Primary components:

There are three main aspects to an alignment: Camber, Caster and Toe

1) Camber:

Camber Description:
This is the tilt of the wheel relative to a vertical plane. If the top of the wheel leans in toward the center of the car, that is negative camber. If the top of the wheel leans out away from the center of the car, that is positive camber. Not all cars have camber adjustments for both the front and rear, but the 928 does.

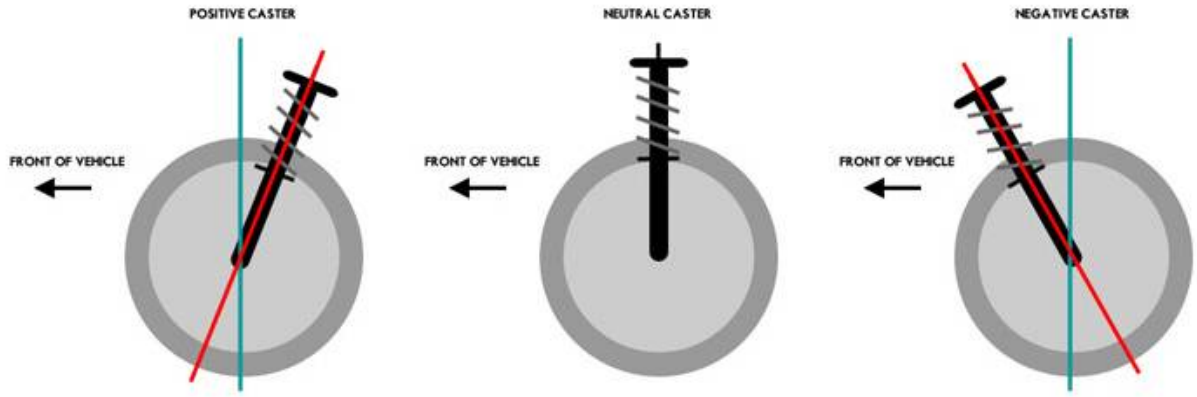


Camber Effect:
Any camber (positive or negative) decreases traction for straight line acceleration. The more camber, the less the traction. Negative camber improves cornering. More negative camber will also cause the car to want to turn more, and follow the grooves and ruts in the road. Wider tires and wheels with larger offsets exacerbate this effect, but it can be offset with less negative camber. Most cars have negative camber.

Camber Measurement:
With the wheels pointed straight ahead, the angle of the wheel relative to a vertical plane is measured.

2) Caster:

Caster Description:
This is the tilt of the wheel relative to the steering pivot point. If you visualize a wheel with a strut that is straight up and down, that would be a neutral (or zero degree) caster setting. If the strut is angled forward, pushing the wheel backward toward the rear of the car, that is negative caster. If the strut is angled backward, pushing the wheel forward to toward the front of the vehicle, that is positive caster. You can also visualize it in terms of ball joints, if the wheel has upper and lower ball joints. Just visualize the top ball joint in relation to the lower ball joint. If it is more forward, that is negative caster; if it's more rearward, that is positive caster. Normally, caster only applies to the front wheels on a car since they are normally the only ones that can be turned left to right.



Caster Effect:
Positive caster causes the steering to return to center/straight much easier. It also makes the steering heavier and harder to turn. Conversely, negative caster makes the car follow the contours of the road, and it turns easier. Wider tires or wheels with offsets that push the wheel further out will produce an effect similar to negative caster. This can be offset by increasing the caster during an alignment.

Caster Measurement:
The caster is measured by taking a camber measurement (see previous section) with the wheels turned in one direction, and then another measurement with them turned in the opposite direction. The degree that you turn them must be the same (e.g. 20 degrees left, 20 degrees right). You can then calculate the caster from those measurements. The formula is:

((Camber with front of wheel pointed toward middle of car) - (Camber with front of wheel pointed toward outside of car)) * (Degree multiplier)

The degree multiplier used depends on the degrees that you take the camber measurements at. For 20 degrees, use 1.5. For 15 degrees, use 2.0. For 10 degrees, use 3.0. The larger the degree that you're able to use, the more accurate the measurement will be. This will get you very close to accurate. The most important thing is to set the caster to the same on both front wheels. For reference, a closer approximation can be calculated:

Caster = ((180 / Pi) / (Degrees turned to inboard – degrees turned to outboard)) * (Camber to inboard – Camber to outboard)

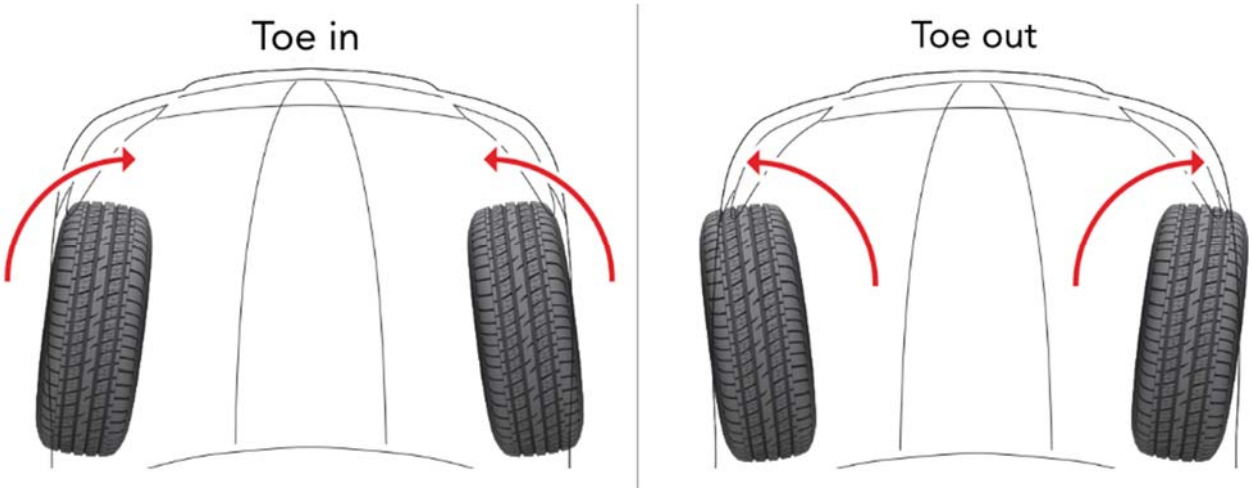
To determine whether the caster is positive or negative:

(Camber of wheel when straight) < (Camber when front of wheel turned outboard) = Positive Caster

(Camber of wheel when straight) > (Camber when front of wheel turned outboard) = Negative Caster

3) Toe:

Toe Description:
This is the angle that the wheels point, relative to the frame/unibody, when the steering wheel is pointed straight ahead. If the front of the tires point toward the center of the car, it is "toe in" (positive toe). If the front of the tires point toward the outside of the car, it is "toe out" (negative toe). For cars with solid rear axles, it's called the "thrust angle" in the rear. For the 928, it's "toe", both front and rear.



Toe Effect:
The greater the positive toe, the more stable the car will feel when going straight and the more it will favor returning the steering wheel to center. Wider tires and larger offset wheels will have the effect of reducing the positive toe, which can be countered with greater positive toe.

Toe Measurement:
The angle of the wheel, with the steering wheel pointed straight ahead, is measured relative to the frame/unibody. The reference is achieved by comparing the position of the track width of the front wheels vis-a-vis the rear wheels. For example, if you draw a line on the ground on either side of the car, from front to rear, that is the same distance from the rear and front hubs on both sides, then you now have a frame of reference to measure the toe angle against.

Methods:

There are several ways to collect alignment measurements. With some creativity, you can come up with more variations. These are the most common methods:

1) Alignment rack with computerized laser measurement equipment.
The car is driven onto a four post lift that has turn plates under each wheel. The turn plates allow the wheels to move without resistance as adjustments are made. Frames are attached to each wheel with either lasers that hit a stationary target placed in front of the car (and sometimes hit targets on the other wheels), or the frames have targets that stationary lasers hit. A computer collects readings from these lasers to determine toe and camber. Caster is still measured by turning the wheels left and right, but the computer automates the data collection and calculation. This is the fastest and easiest way to get the alignment measurements. Basic inexpensive systems start at around $4,000, without the lift and turn plates. With a lift and a more advanced system, it can easily cost more than $20,000.

2) Ground markings and trash bags.
Trash bags or thin plastic cutting boards with a little bit of oil in between them can be used in place of turn plates. Paper, metal plates, cardboard or tape can be placed next to each wheel to take toe measurements. Camber can be measured using a level gauge and caster can be measured using angle marks on the ground.

3) String method.
A string is run along each side of the car. They are placed at the same height as the wheel hub and carefully positioned so that they are parallel to each other and parallel to the car's frame/unibody. Toe is measured by measuring the distance from the string to the front and rear lip of each rim. Camber and caster can be measured with a level gauge.

Tools used:

The approach described here uses the string method. The tools used make things much easier, but are not necessary in order to perform an alignment. You can substitute other tools (homemade or otherwise) for any of the tools described here.

The string system used is an earlier version of this:
https://www.smartracingproducts.com/smartstrings

The string used is 1mm elastic cord:
https://www.amazon.com/gp/product/B01LZQM2AH/

The electronic camber gauge used is this:
https://www.smartracingproducts.com/smartcamber

The turn plates used are aluminum with a 1 ton capacity each:
https://www.amazon.com/gp/product/B0758Z612B/

The toe measurement gauges used are these:
https://advancedracing.com/product/dream-stick-as-targets-pair/

The measurement tool used to setup the strings is this:
https://www.amazon.com/gp/product/B01FTT46ZQ

Porsche tool 9116 - This is a bolt with a tapered end that locks the steering rack in the center position. It's cheap and saves a lot of aggravation. 928sRus.com has it.

While the above adds up to a significant investment, it's possible to achieve the same results using some PVC pipe tapes to the bumpers, elastic cord, a cheap camber bubble gauge, and a ruler. The tools make it easier and faster, but they are not necessary.

Steps to setup, check and adjust the alignment:

Ride height should be adjusted and the suspension settled prior to performing an alignment.

Alignments should be done in the following order:

1) Rear Camber (-0.83 to -0.50)
2) Rear Toe (0.083 to 0.25)
3) Front Camber (-0.67 to -0.33)
4) Front Caster (3.50 to 4.00; see note in specs table)
5) Front Toe (0.083 to 0.167)

Adjusting the camber will affect caster and toe, and adjusting the caster will affect toe, so it is important to do them in the correct order and recheck the settings for all of them when you're done.

The factory specifications are:

Item	Specification (Minutes/Seconds)	Specification (degrees)
Rear Camber	-40' +/- 10'	-0.83 to -0.50
Rear Toe	+10' +/- 5'	0.083 to 0.25
Front Camber	-30' +/- 10'	-0.67 to -0.33
Front Caster	N/A	3.50 to 4.00 (up to 1990) 4.00 to 5.00 (1991 and on, can be applied retroactively to 1986+)
Front Toe	+15' +/- 5'	0.083 to 0.167

A critical factor that is specific to the 928 is that the suspension must be fully settled prior to performing an alignment. If the car is raised off of its wheels, the suspension will be extended and the alignment will be off. Do not attempt to do an alignment if the suspension is not settled. If you're using a four post lift, you can settle the suspension by pulling the car down by 60 to 70mm from the stabilizer bar and holding it there for 1 minute. Or, you can drive it for approximately 100 miles. This is not common with other cars, so alignment shops may lift the car off of the wheels, which will invalidate the alignment.

First, you need to set things up. If you have access to a four post lift, I recommend cutting some boards to place on the lift between the turn plates to make it easy to get the car into position. If you do not have access to a four post lift, then you can achieve the same result by stacking three boards together, each end cut at a 45 degree angle and staggered, so that you create your own ramps that you can drive the car onto. Leave a cut out for the turn plates. This will give you enough height to slide under the car to make adjustments.

Below, you can see homemade wood ramps used for performing an alignment on the ground. This allows the vehicle to be driven into place and not require resettling of the suspension, while providing enough clearance underneath to make adjustments. The cut-outs in the longer ramps provide a place for the turn plates to sit.

Here is a four post lift being leveled. The wood block has a mark on it that is checked at all four corners:

Rechecked with the vehicle on the lift at working height:

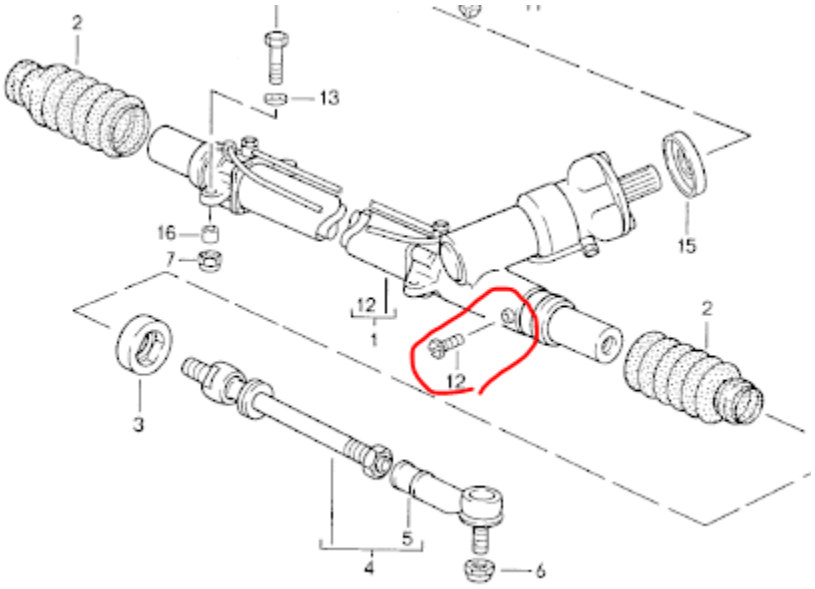
The turn plates with ramps to make it easy to drive on and off:

The vehicle on the turn plates with the string jig setup and camber gauge mounted:

It's best to do this on level, flat ground. If you're using a lift, make sure that the lift and car are perfectly level at the height that you'll be performing the alignment at. You can do the alignment if things aren't level, but it makes calibration of the camber gauge a little more difficult.

Before making any adjustments, you may find it useful to take the current measurements. You can compare them against your driving impressions to see if there is an obvious problem or a direction that you want to move things in to correct a problem.

First, you need to locate the steering rack centering hole. You'll find the hole for the centering bolt on the front of the steering rack on the driver's side. It should have a black plastic plug in the hole. Remove the plug and look in the hole. You should see a divot. If not, turn the wheels left/right until you see the divot and it is centered in the hole. Install the bolt and move the tire left to right a little bit as you do so, to make sure that the bolt is seated in the divot.



Next, setup the string jig and center it on the car by eye. I like to hang the front hooks off of the headlight cross tube. I hook the rear one to the lip of the tool compartment with the tool panel removed. Since you'll need to leave the rear hatch open, you should either hook up a battery tender or disconnect the battery.

Mount the toe gauges to the wheels, with the measurement gauges just below the height of the center of the wheel hubs.

Tie a loop in the end of the elastic cord and slide it onto one of the string jig poles. Stretch it out to the other end of the car and pull it tight enough that there is no sag. Cut it and tie another loop and slide it over the string jig pole. Make sure that both ends of the cord are settled into the matching grooves in the pole at either end of the car. Repeat this for the other side of the car.

Now, it's time to get the strings parallel and equidistant. Starting at the back of the car, measure from the string to the center of the toe gauge directly in front of the hub (or to the hub itself if you don't have toe gauges). Take a measurement from both sides, and then slide the string jig pole left or right until the measurements are the same. Repeat for the front, and then recheck the rear. Repeat the process until the rear measurements are the same as each other, and the front measurements are the same as each other. The measurements will be different front to rear, but must be the same left to right.

Getting the string setup perfectly is critical to the toe measurements, so make sure that you get it right. Take your time.

Now, you're ready to take measurements. The order that you take the measurements in doesn't matter, but to make it easy we'll do it in the same order that the adjustments should be made.

1) Remove the front turn plate locking pins if you haven't done so already.
2) Install the steering rack centering bolt.
3) Camber: Mount the camber gauge to each wheel in turn (start with the rear) and record the measurements. A bungee cord will help the gauge stay on the wheel. Be sure to calibrate the camber gauge to match the level of the surface that the car is sitting on.

4) Remove the steering rack centering bolt

5) Caster:
   a. With the camber gauge mounted to each front wheel, turn the wheel so that the leading edge is point 20 degrees outboard, record the camber measurement.
   b. Then, turn it so that the leading edge is 20 degrees inboard and record that camber measurement.

      For example, if you were doing the left front wheel, turn it left first, and then to the right.

      When you are using the degree markings on the turn plate to measure the angle, make sure that you turn it until the 20 degree mark is point straight out, perpendicular to the side of the car.

      Also, the tire can roll on the turn plate, which will move the camber gauge out of the vertical plane. Make sure that you keep the camber gauge vertical and do not let the tire roll when you turn the steering.

      This can be done by one person turning the tire by hand, but is easier with a second person sitting in the car and turning the steering wheel.

      To calculate caster: (1st reading - 2nd reading) * 1.5
      For example, if the first reading is 1.70, and the second reading is -0.9:
      (1.7 - -0.9) * 1.5 = 3.90.

6) Install the steering rack centering bolt.
7) Remove the camber gauge if mounted.
8) Toe:
   a. Mount the toe gauges on each wheel. A bungee cord will help the gauge stay on the wheel.

   b. Note the distance between the two measurement points on the gauge. Be precise.

c. Next, note the reading on the leading and trailing measurement gauges. Be precise and take the measurement in 32nd's of an inch.
To calculate toe: Arctangent(((Leading - Trailing)/32)/Measurement distance)

For example, if the measuring distance is 19", and the leading edge is 2 32nds, and the trailing edge is 1 32nd:

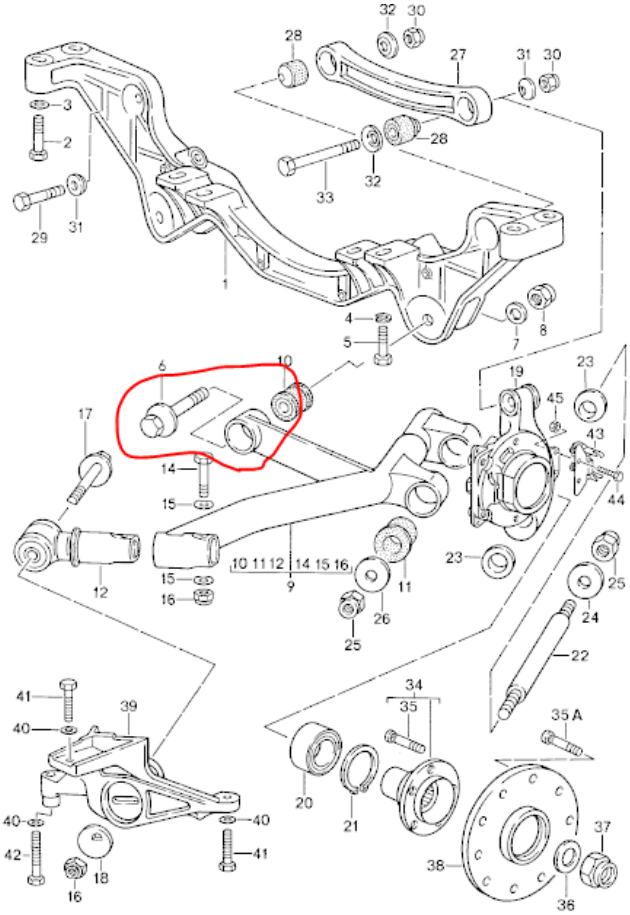
Arctangent(((2 - 1)/32)/19) = 0.094236

Don't worry about the calculations. I've put them here for reference, but I've also provided a spreadsheet that does all of the calculating for you. Just take the measurements, plug them in, and you'll get the results.

Now that you know how to take the measurements, you're ready to adjust the alignment.

REAR CAMBER:

1) Install the steering rack centering bolt if it's not already installed.
2) Remove the toe gauges if they are mounted.
3) Mount the camber gauge to each rear wheel in turn. Be sure to calibrate the camber gauge to match the level of the surface that the car is sitting on.
4) Remove the locking pins on the rear turn plates.
5) Adjust the Camber.
   a. This is adjusted with a bolt with an integrated eccentric washer on the rear control arm link. It's accessible under the car on the inboard end of the control arm.

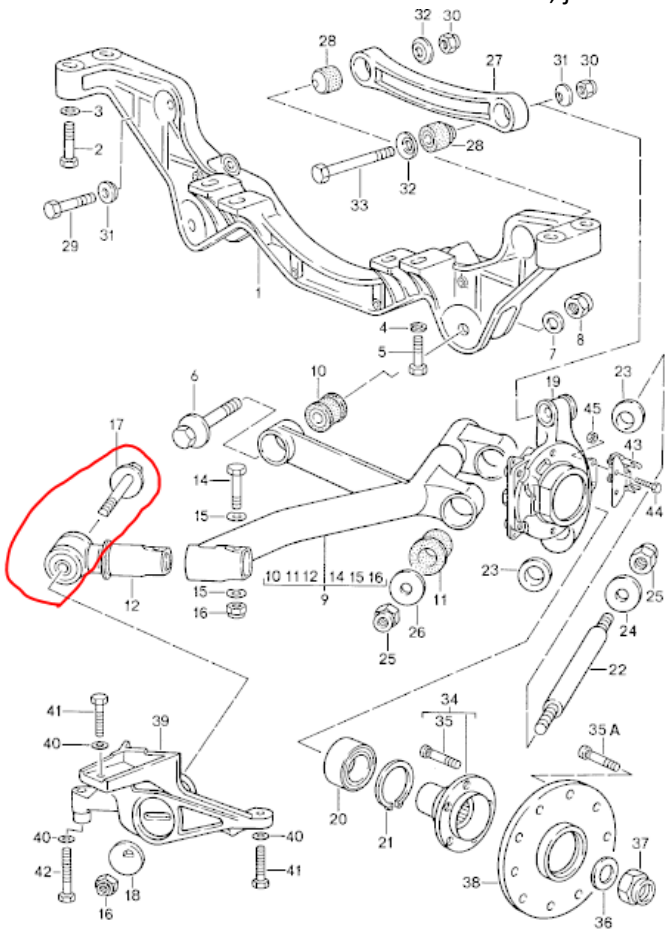


   b. Loosen the nut, which is on the end of the bolt toward the rear of the car.
   c. Turn the bolt head that is facing the front of the car. Turn it no more than an 1/8 of a turn at a time and check the updated camber measurement. As you get closer to your desired setting, turn it in smaller increments.

d. If the channel that the eccentric washer rides in is gouged to the point of not allowing you to achieve the desired setting (common issue), you can string a large ratchet strap between the two opposing control arms and pull them closer to achieve the desired setting.
e. Once you have achieved the desired setting, hold the bolt head in place while tightening the nut to 147 foot pounds.
f. Recheck the camber setting before moving on.

REAR TOE:

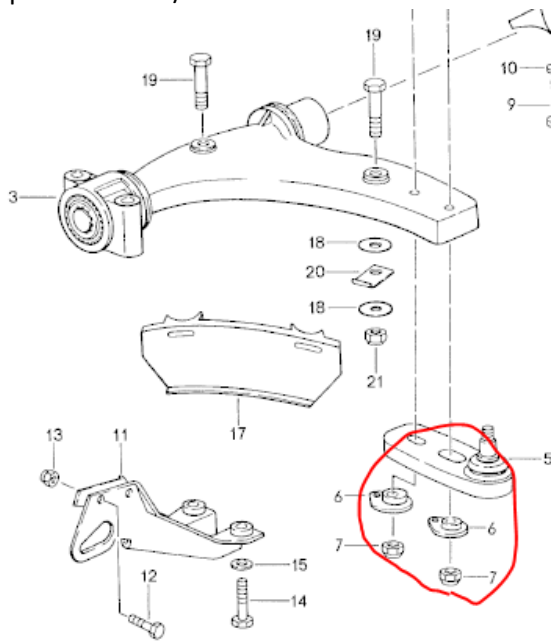
1) Install the steering rack centering bolt if it's not already installed.
2) Remove the camber gauge if mounted.
3) Mount the toe gauges on the rear wheels.
4) Remove the locking pins on the rear turn plates.
5) Adjust the toe.
   a. This is adjusted with a bolt with an integrated eccentric washer on the forward control arm link. It's accessible from the side of the vehicle, just in front of the rear tire.



   b. Loosen the nut, which is on the end of the bolt toward the front of the car (between the link and the body).
   c. Turn the bolt head that is facing the rear of the car. Turn it on very small increments and recheck the toe. Once you have achieved the desired setting, hold the bolt head in place while tightening the nut to 88 foot pounds.
   d. Recheck the toe setting before moving on.

FRONT CAMBER:

1) Remove the front turn plate locking pins.
2) Install the steering rack centering bolt.
3) Mount the camber gauge to each front wheel in turn. Be sure to calibrate the camber gauge to match the level of the surface that the car is sitting on.
4) Loosen both nuts for the camber and caster eccentrics. They are located under the control arms close and are part of the lower ball joint carrier. They each have a hex shaped hole to accept an allen bit/wrench.



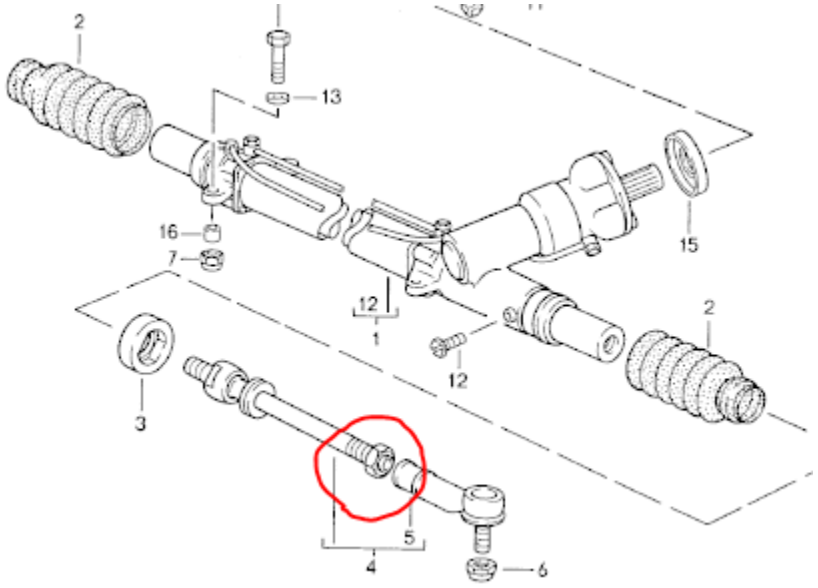
5) Adjust the camber.
   a. If you have aluminum ball joint carriers (which you should upgrade to steel if possible): the camber eccentric is closer to the center of the car.
   b. If you have steel ball joint carriers, the camber eccentric is closer to the wheel.
   c. Using a hex bit and ratcheting wrench, turn the eccentric in very small movements, rechecking the camber with each adjustment, until you achieve the desired setting.
   d. Do not tighten the nuts until you finish adjusting the caster.

FRONT CASTER:

1) Remove the front turn plate locking pins.
2) Remove the steering rack centering bolt.
3) Mount the camber gauge each front wheel in turn. Be sure to calibrate the camber gauge to match the level of the surface that the car is sitting on.
4) Loosen both nuts for the camber and caster eccentrics. They are located under the control arms close and are part of the lower ball joint carrier. They each have a hex shaped hole to accept an allen bit/wrench.
5) Adjust the caster.
    a. If you have aluminum ball joint carriers (which you should upgrade to steel if possible): the caster eccentric is closer to the wheel.
    b. If you have steel ball joint carriers, the caster eccentric is closer to the center of the car.
    c. Using a hex bit and ratcheting wrench, turn the eccentric in very small movements, rechecking the caster with each adjustment, until you achieve the desired setting. Do not tighten the nuts until you finish rechecking the camber.
6) Recheck the camber. If you have to make camber adjustments, recheck the caster. Continue repeating this process until both measurements are correct.
7) Tighten the camber and caster nuts to 88 foot pounds.

FRONT TOE:

1) Remove the front turn plate locking pins.
2) Install the steering rack centering bolt.
3) Mount the toe gauges on the rear wheels.
4) Loosen the jam nut on the tie-rod. BOTH tie rods are NORMAL threads. Turn the jam nut counter clockwise to loosen it. The tie rods are located just to the rear of the lower front control arms and can be accessed from under the car.



5) Adjust the toe.
   a. Turn the tie rod in very small increments and check the toe measurements with each change.
   b. When done, tighten the jam nut and recheck the toe.
6) Recheck the camber and caster. If they are no longer at the desired settings, reset them and then recheck/readjust the toe. Continue repeating this process until both measurements are correct.

Reference material:

The Porsche 928 Work Shop Manual has procedures, specifications and photos in section 44 "Wheels, Tires, Alignment".