HOME ALIGNMENT OF

PORSCHE 914

FOR COMPETITION OR STREET

Complete Step by Step Guide to Alignment

How to adjust:

Tools Required:

Spool of thread
Car jack & four jack stands
One-inch tape measure
Straight-edge ruler (accurate to 1/32")
Carpenter's level or plum bob
Metric sockets and wrenches
And a flat and level work place

By Ray Scruggs

Ray's suggested 911 specs:

	Street	Competition
Height (from rocker lip)	10 ¾" Front 11 ½" Rear	½ to ¾ inch lower in front than rear
Front Camber	–0.5' to –1'	-2' to –3' (-0.5 to –1 more than rear settings)
Rear Camber	-0.5' to –1'	-1.75' to –2.5' (Varies due to rim width and tire stiffness)
Castor	middle of range	forward – wide tires middle – narrow tires
Front Toe	-1/8"	+1/8"
Rear Toe	0 to –1/8"	0" to –1/8" (use toe-in if too much power-on oversteer)
Tire Pressures	30 psi – front 30 psi – rear	Check with manufacture & do temperature studies

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By Ray Scruggs

You can align your own car. It just takes time (a lot of time at first) and a few tools. Give yourself a full day to a day and a half the first time you do your own alignment. After you've done your first complete and successful four wheel alignment you should be able to do the same type of full alignment in about 4 to 6 hours. Follow up adjustments to your alignment after lowering or changing camber specs can be done in less than 2 hours. The time it takes to do a complete home alignment is about 50 percent longer than an alignment shop could do because of the nice alignment racks and measuring tools they use. But a home alignment can be just as accurate and save $400 - $800. So what's your time worth?

Not only do you save money, but you also gain the knowledge of the dynamics that make a car handle and ride well.

Before you begin your first alignment, sit back and read through this to get an overall understanding of the concept of four wheel alignments.

The worst that could happen is that you give up and drive your car to a professional alignment shop.

Camber, caster, and ride height adjustment affect toe-in, therefore do toe last.

Accurate alignment is most easily done on a level surface. If you don't have a perfectly level surface, you will need to have a nearly level and nearly flat surface. But in addition, you will need to drive the car around and park in the reverse position on the same non-level surface and re-measure – then average the measurements together for overall rake and camber on each end or side before and after each adjustment.

A. Level and Rake Car

Rake changes effects handling due to weight distribution: less rake induces under-steer, more rake induces over-steer.

A-1. Adjust tire pressures to manufacturer's recommended pressures all around. Level and rake to where you want it.

Disconnect anti-sway bars to avoid any pre-loading of the suspension while leveling the car. Once the car is leveled reconnect the sway bars. If they have adjustable drop links, adjust the length so that they do not cause any loading (twisting) of the sway bar when a driver is sitting in the car and the car is on a level surface.

The overall rake should be about ¾" or so, whether stock height or lowered. At the top of the rocker panel there is a lip that attaches it to the body above. Using stock tire height, I set the front about 9 ¾" to 10 ¼" and the rear 10 ½" to 11", so the overall rake is about ¾" or so. Drive the car around the block each time after re-adjusting the height to settle the suspension (you may need to repeat this a few times).

A-1a. To adjust the height of the front end, turn the bolt on the rear end-cap of the torsion bars. If the adjustment of the bolt does not give you enough adjustment range, then with the front jacked up, remove the bolt and pull the cap off the back end of the torsion bar and rotate it one spline in the direction that gives you the range you need. You will probably need to settle the car a few times to get an accurate ride height.

A-1b. If you want to adjust the rear height to be lower you must have after-market adjustable rear spring perches, or buy after-market lower springs, or cut the stock springs (cutting springs is not recommended due to possible uneven changes in spring tension rates).

Note: The Porsches of this era were still hand made. The chassis were never perfectly level - at least I have never measured a chassis within ¼" of level. ½" side-to-side variation from level is not uncommon when measuring the height of the corners from level ground. Level the car to a measurement that is close to level, slightly higher on the driver's side to compensate for static spring sag with a driver's weight. A visually level car is what's important before beginning any camber, toe, and corner-balance adjustments.

B. Camber

Negative camber compensates for car body roll and tire roll-under during cornering. While hard cornering, without any negative wheel camber, the tire's inside edge roll up, lessening the tire patch size (the surface contact between the tire and pavement).

For competition I want to maximize the cornering tire patch with extreme negative camber. More negative camber allows lower tire pressures without causing the inside edge to rollup, and the tire patch is larger. However, the wider the tire the less camber or caster is necessary for an optimum tire patch. Stiffer tires also require less negative camber and castor angles.

For a well-balanced 914 I like slightly more negative camber in the front end. More front camber than rear compensates for the greater lateral g forces in the front under braking and turn-in, and front grip when unweighted during acceleration while cornering.

For strictly street use, use very little negative camber for more comfort, highway driving directional stability, and longer tire wear. Extreme negative camber, if not used in competition, will cause the tires to wear out at the angle of the camber, thus shortening the life of the tires slightly. Extreme negative camber will cause the car to be jumpy side to side over bumps (not very relaxing on long tours). Also negative camber will exaggerate any tendency a car has to pull to one side due to corner balance problems.

My technique of cambering the wheels is by using a carpenter's level to measure the difference off plum of the top of the rim compared to the bottle of the same rim. A plum bob or weighted string could be used if a good level is not available.

To calculate the camber in degrees: multiply the inch measurement off plum by 4 for 15-inch wheels, or 3.75 for 16-inch wheels. (Example: ½" x 4 = 2 degrees).

B-2. Front Camber:

B-2a. Camber and caster are adjusted by loosening and moving the mounting bolts at the top of the strut.

B-2b. To increase negative camber, slide the top strut mounts toward the center of the car and tighten the mount bolts. Use a large flat screwdriver to pry the mounts over. (This may be easier to do if the front end is raised off the ground and prying the mounts over from underneath in the wheel well. But you will again have to resettle the car to measure the camber.)

B-2c. Measure the camber by placing a carpenter's level plumb up against the fender lip and across the wheel hub. Measure the lower and upper distance between the level and the rim. That measured difference should be the same for both front wheels. Maximum negative camber should result in a camber measurement of at least ½" in at the top (2 degrees negative, which is good for competition). For high tire mileage street use, measure and set camber to 1/8" in at the top (1/2 or .5 degree negative).

B-3. Rear Camber:

Rear camber is adjusted by removing or placing shims in the outside suspension pickup points. Rear toe-in will be effected by camber changes, so finish your camber changes before adjusting rear toe.

B-3a. Jack the car up in the rear and place on jack stands for safety. Loosen the three mounting bolts on each side. Remove the rear outer bolt on each side.

B-3b. First count the number and note the thickness of shims in each side.

B-3c. Assuming the camber measurement to begin with is the same side to side, for maximum negative rear camber remove all the shims out of the side with the fewest number of shims. Then remove the same number and combination of thick and thin shims from the other side. (Max camber may be too much for stiff or wide tires.) On a straight 914 lowered for competition, max rear camber is 2 ¾ to 3 degrees negative.

B-3d. Lower the car off the jack stands and drive it a short distance to settle the suspension down. Park it and be sure the car is level and make your camber measurements with the same technique as in the front. Again the measurements should be very close to equal on both sides of the rear. (If not on a level surface remember to park in the reverse direction and measure again then take the average to obtain the true level measurements.)

B-3e. Jack the car up and change the shims as necessary if there is more than 1/8" difference side to side. Perfect is best.

A. Caster

Caster is the measured angle the front struts are angled back from vertical. The adjustment range is very small but significant on a Porsche. Generally the greater the castor the better the straight-line directional stability is, but the slower turning and heavier the steering effort is. Greater castor also increases the progressive rate of increasing wheel camber as the wheels are turned towards lock.

For competition with no extra wheel offset (using wheel spacers or offset wheels), loosening and moving the upper strut mounts all the way back will increase straight line stability and maximize effective camber in turns. If the wheels are offset or extra wide the steering effort increases and you may want to set the castor more central or even forward in the range if you have a very wide track and wide tires.

For street use the caster should be set in the middle of the range.

B. Toe

Finish your front-end camber and caster adjustments before setting front and rear toe.

My system of toe alignment uses a string technique. I use a white thread for greater accuracy.

a. Level and rake the car as described above in Section A.

b. Set up four jack stands at the four corners of the car. They should be 2-3" away from the sides and a foot or so to the front and back. Tie the string (thread), at the level of the hubs, along both sides of the car between the jack stands. I start at one corner tying off the string to the stand then trailing the string around the front or back two stands to the last stand where I tie it off, the sides are what's important.

c. Measure and align the string with a straight ruler (accurate to 1/16") to be 2" away from the hubs of the rear wheels and 2-5/8" (approximate stock difference) away from the front hubs, depending on spacers, etc. Check for parallel alignment of the string on the two sides of the car and adjust the jack stands until the distance across is within 1/8" and the string is 2" out from the

rear wheel hubs and equal distance away from the front wheel hubs. (After setting the strings parallel, note the measurements of the distance the string is away from the hubs for future reference, so you don't have to measure across the car again, its tedious to do alone.)

D-1. Front Toe:

I like to set the toe to 1/8" overall toe-out in the front for competition, for more responsive turn-in to corners. But on the street toe-out is harsh over bumps so I like 0" to 1/8" toe-in on the street for a smoother ride.

D-1a. Turn the steering so that one wheel is lined up with the string by measuring the distance from the wheel rim (not tire) so the rim is parallel with the string. Check often to be sure the hub of the wheel remains at you predetermined measurement from the string.

D-1b. Go around to the other front wheel and now measure the difference, if any, of the distance between the rim measurements from the string. This difference is you overall toe. (If there is no difference you have 0" toe, if the difference in the forward rim measurement is greater than the rearward rim measurement you have measured overall toe-in, and visa-versa for toe-out.

D-1c. Adjust toe-in by loosening the tie-rod end clamps and twisting the center section (they are like turnbuckles). ¼ turn on the tie-rod on one side equals approximately 1/8" overall toe adjustment. You can adjust tie-rods without jacking the car up by turning the front wheels full lock one way or the other. (You may need to use large channel-locks if the tie-rods are frozen tight.) You may want to center the steering wheel by using a combination of turns of the tie-rods, on both sides. Be sure that the inner tie-rod couplers to the steering rack are flat (allowing free vertical travel) and the outer tie rod ends are centered in the joint, so the wheel travel does not bind the joints and wear them out prematurely.

"Turbo Tie-Rod Ends" are worth their cost for improved handling feel and ease of adjustment. (Adjusting one full turn on one side equals just over 1/8" overall toe.)

D-1d. Repeat steps D-1a through D-1c until your overall toe is where you want it. Don't tighten the tie-rod ends until you're sure the toe is set where you want it.

D-2. Rear Toe:

Under acceleration or braking there is a dynamic toe. Acceleration pushes the rear wheels forward and drags the rest of the car after, braking pulls the wheels back and the rest of the car hangs on. Because of the angle and play in the suspension pickup points, acceleration dynamics causes more toe-in, braking causes more toe-out.

D-2a. With the strings lined up accurately on both sides of the car, measure the difference between the string and rear rim, forward and behind the rim's hub, for each rear wheel. Write down the existing toe, in or out, in fractional inch measurements on each side. (You will be jacking the car up to adjust the rear toe, which will change the toe angle as the suspension travel changes, so its very important to write down the static, at rest, toe.)

After noting down the existing toe, determine the amount of final toe you want, and calculate the fractional inch changes you will need to make on each side to result in you final settings.

D-2b. Jack the car up in the rear and place on jack stands for safety. Raise the string height to the raised hub height. (The strings do not have to be perfectly aligned to the car at this time because the measurements you now need are for relative alignment changes to the fixed string positions.) Note the distance the strings are away from the front and rear hubs so you can reset the strings in case they get bumped during your adjustments.

D-2c. On each side with the wheel jacked up, measure the difference between the front of the rim and back along the string as you did before with the car on the ground, and note the difference.

D-2d. Loosen the adjustment bolts enough to be able to move the trailing arm outward (more toe-in) or inward (more toe-out) and move it in the direction of change you want. Now the tricky part: After moving the trailing arm and rim, measure the differences from the string to the rim (front and rear of rim). The measurements (between front and rear of the rim) will be less in difference if you adjusted for increased toe-in, and measure greater in difference for decreased toe-in (or increased toe-out), than the first raised rim measurements. The DIFFERENCE in rim distance from the string is what matters, not the measured inches. Adjust and re-measure as needed until the raised difference in rim distance from the string changes for more or less toe as desired.

D-2e. Tighten the adjustment bolts and lower the car off the jack, and drive it around the block to settle the suspension. Set up your strings again, parallel, along the sides of the car and measure the rear toe. If you kept your head straight and adjusted accurately in the right direction while the wheel was raised you should be good (within 1/16" on each side is OK, perfect is better but not worth repeating).

Repeat D-2a through D-2e if not within 1/16" desired toe. More than 1/16" difference in toe side to side will cause the car to noticeably "crab" (and look strange to drivers following on a straight road) and corner differently turning right vs. left.

C. Corner Balance

The true sign of a well weight balanced car is that after alignment it does not pull right or left while driving down a flat straight road.

Corner balancing is the process of raising and lowering opposing corners of the car so the car remains level, raked, and aligned as before but the spring pressure is increased and decreased at the corners in order to balance the weight on the wheels at all four corners so that the car drives straight.

Professional corner balancing makes use of four very accurate heavy-duty scales under all four tires to measure corner weight. Or another tool is a lever that lifts each wheel rim, with a gauge to measure the weight lifted; this is a very inaccurate tool but does show gross imbalance. The home technique is just as effective:

E-1. Once the care is leveled, raked, and aligned with even camber, castor, and toe, then drive it out on a level section of freeway. If the steering wheel pulls off center and the car will not drive straight, you may need to adjust for corner balance.

E-2. Before beginning the corner balance process be sure that there are not other factors causing the car to pull to one side. Other factors that cause a car to pull include: the surface of the test

drive was not level; cross winds; a sticky brake caliper or parking brake; dry or sticky steering gears and bushings; uneven tire wear or tire pressures; anti-sway bar preload; worn tie-rode ends, ball joints, suspension bushings, or wheel bearings.

If you determine that none of the above is a factor causing the car to pull consistently in one direction, then proceed with corner balancing.

The front of the 914 is adjustable by raising and lowering the front corners with the turn bolts at the back end of the torsion bars. The rear must have after-market adjustable spring perches in order to raise or lower the rear corners. Without the adjustable rear spring perches you will only be able to raise the rear corners with washers above the top of the upper spring perch.

E-3. If the car pulls to the right, it means that there is more weight on the left-front and right-rear tires than the other corners. And opposite if the car pulls to the left.

E-4. To correct the weight, if the car pulls to the right, raise the left rear spring (if adjustable) and right front torsion bar, and lower the right rear and left front, vice-verse for a pull to the left.

E-5. Drive the car around the block to settle the car. Be sure the car is level and raked as before. This process is rather tedious but necessary. The drive the car on the flat freeway to check the steering pull. Repeat the process until the car doesn't pull. (A slight pull to the right is better than to the left for safety reasons.)

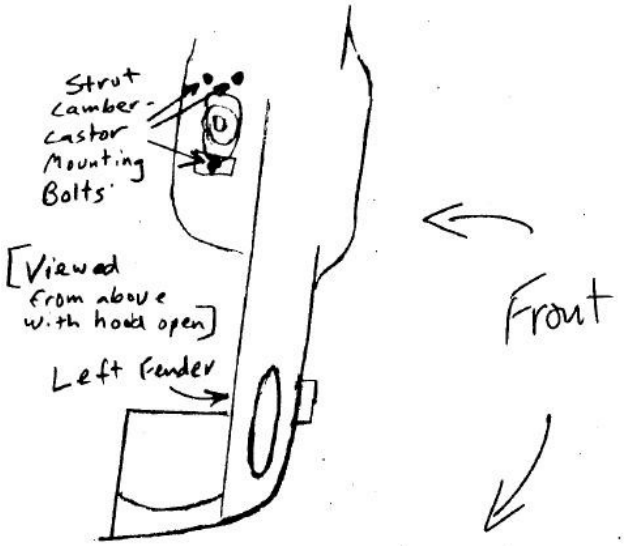
Final Note:

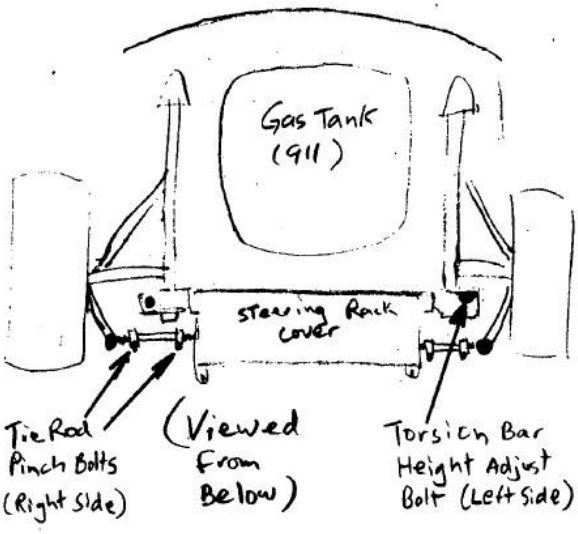
Lowering or raising the car will affect camber and toe-in.

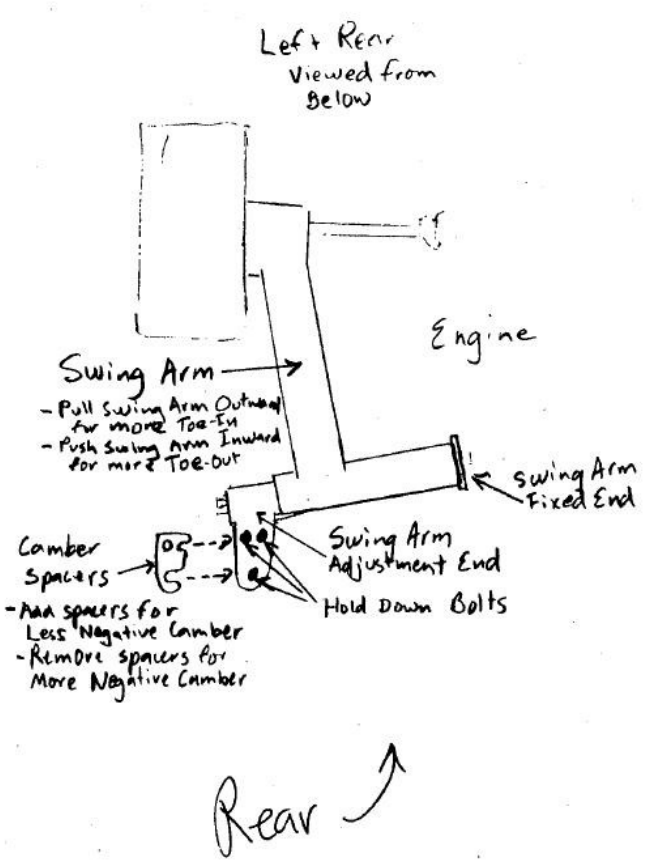
It should not be necessary to realign the rear because the toe does not change significantly when raised or lowered 1" or less. Rear camber changes to more negative when lowered, less negative when raised.

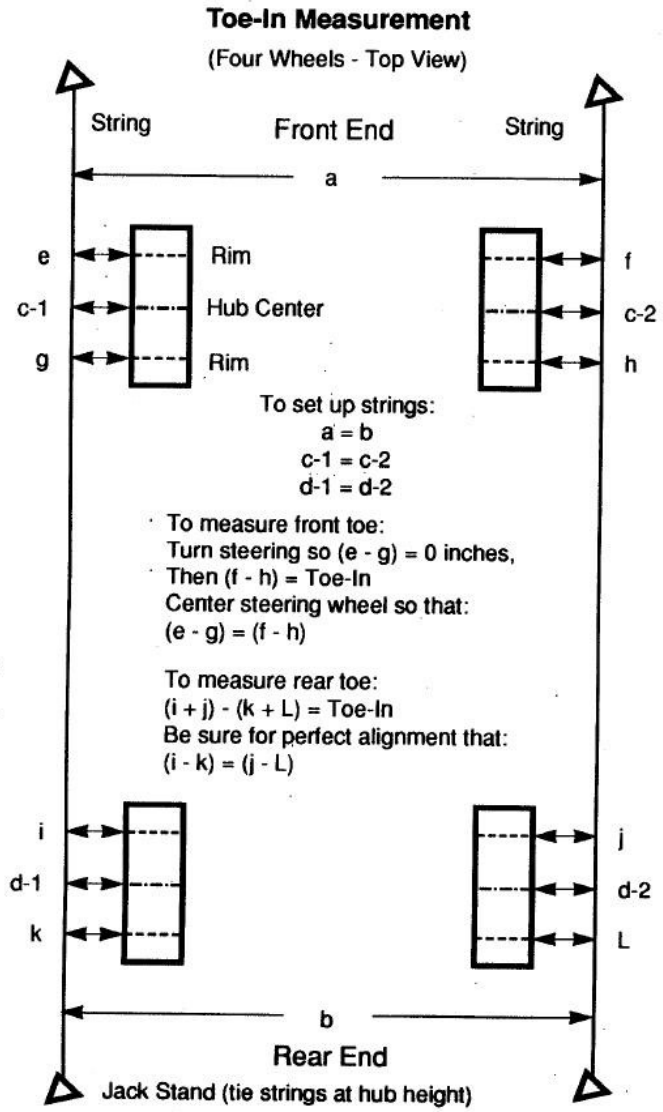
In the front the camber and toe change. Like the rear the camber becomes more negative when lowered, etc. Toe changes significantly. Lowering the front causes more toe-in, raising causes toe-out. With a previously well aligned car, if you raise or lower the car later you definitely need to re-adjust the toe in front.

F. Illustrations









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