Wheel Alignment Basics Explained

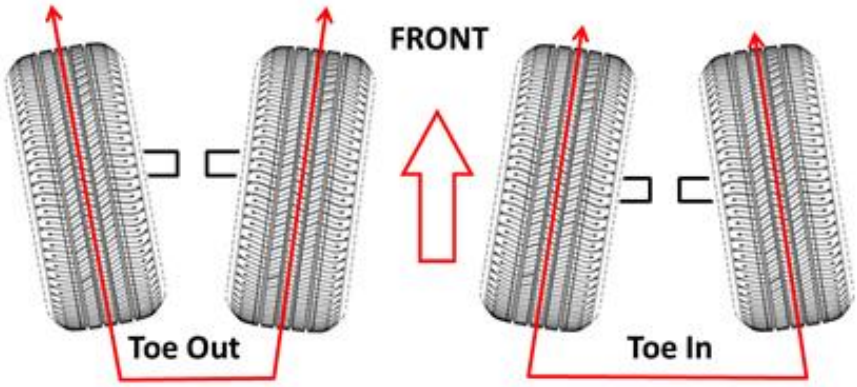
Joe Fisher

This brief article is not meant to teach someone how to align the front steering/suspension but to explain the three basic specifications that are set during a standard wheel alignment. It was explained to me by an old-timer back when *I wasn't* an old-timer. This article is not vehicle specific and the basics can apply to all cars. I will not get into four-wheel alignment (as required for C2 Corvettes) in this article.

Toe-In, Toe-out:

"**Toe**" is a condition where the fronts of the tires are either pointed in toward one another, or pointed away from one another in a horizontal plane measured in a fraction of an inch. If your toes are pointed toward each other then that is **toe-in**, if they are pointed away from each other then it is **toe-out**. So, if your tires are pointed inward you have a toe-in condition and if pointed outward then you have a toe-out condition. Normally, you want **1/16" to 1/8" toe-in**. A misadjusted toe setting will cause rapid tire wear and will sometimes cause tire squeal. If they are severely out of specifications the vehicle can become "darty" and the tire tread will become feathered.

Fig. 1

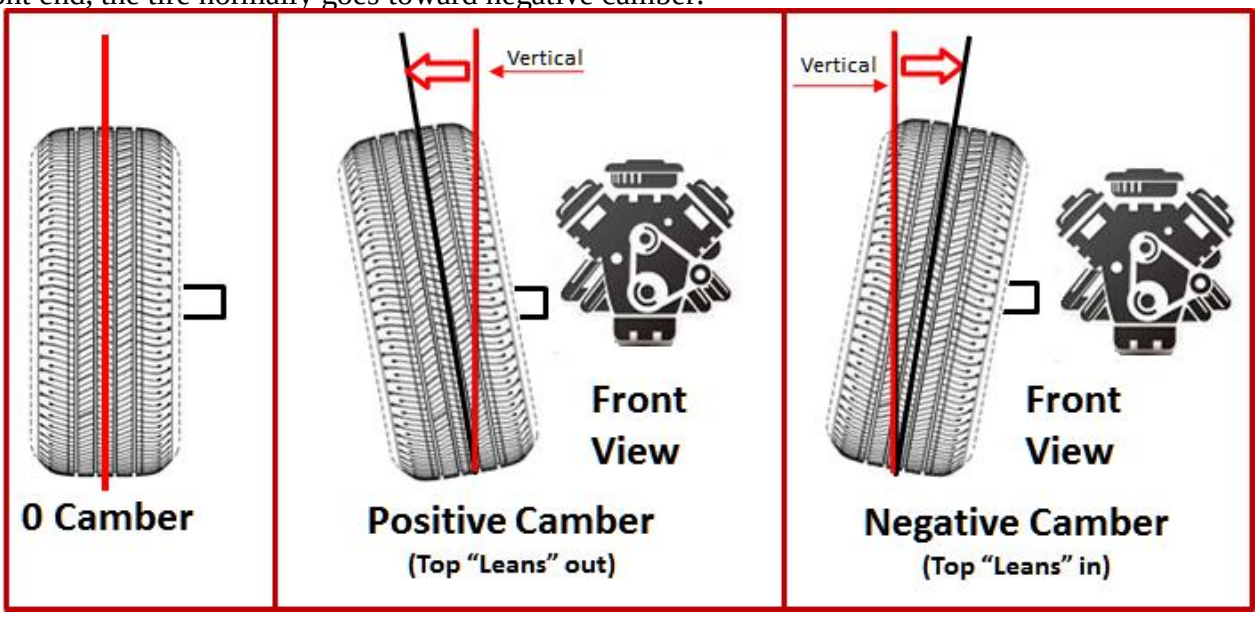


Camber:

"Camber" is the tilt of the top of the tire, in a vertical plane **toward or away from the engine**; it is measured in degrees. If the top of the tire is tilted outward, it is called **positive camber**, if it is tilted inward, that is **negative camber**.

A poorly adjusted Camber setting will cause the tires to wear on one edge only. If you ever saw a car that has a raised front end, the tire normally goes toward negative camber.

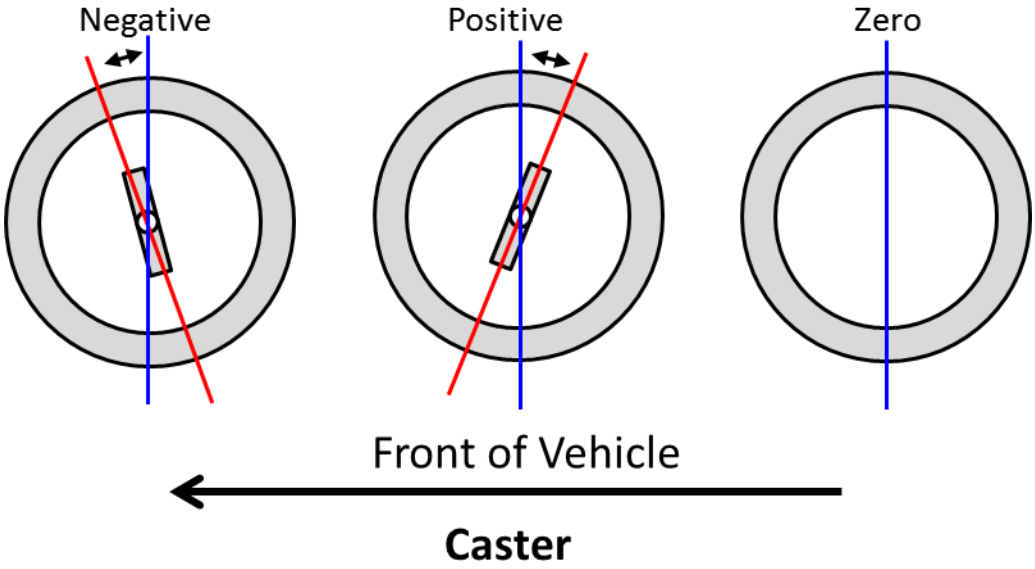
Fig. 2



Caster:

"Caster" is the most misunderstood part of an alignment. If you draw an imaginary line through the upper and lower ball joint and measure it in degrees (from the vertical), you are determining the caster setting.

Fig. 3

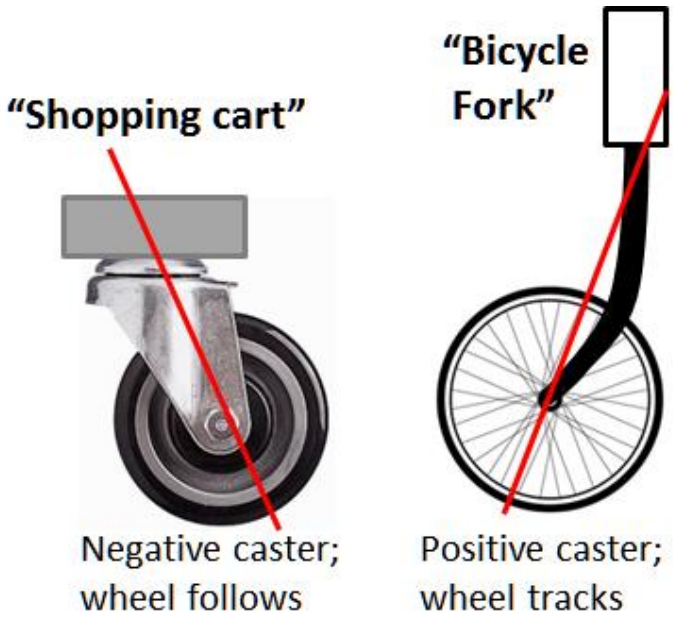


Some analogies to describe positive and negative caster:

Picture a shopping cart's front wheel (below left), the wheel's axle lies behind the pivot and, when you push the cart; the wheel always follows. This is called **negative caster**.

Now, picture a bicycle fork (below right), its wheel axle is in front of the pivot point and, when you ride your bike and take your hands off the handle bars, the wheel tracks straight. It wants to stay forward – this is **positive caster**.

Fig. 4



Now, draw an imaginary line through the pivot point and the axle and imagine the axle is the lower ball joint and the pivot is the upper ball joint. In the case of the shopping cart (left), the line slopes front to back which is negative caster, and on the bicycle (right), it goes back to front which is positive caster.

If the upper ball joint is directly above the lower, you have **zero caster**. If the upper ball is more toward the rear of the car than the lower you have positive caster.

Keep in mind that negative caster wants to "follow" and positive caster wants to "track". Thus the car will "pull" toward the side that has the lesser amount of positive caster.

This is why my mentor always told me to put ½ degree more positive caster on the right side then left to help counteract the crown in the road which wants to pull the car towards the curb.

Caster causes the car to pull to one side if all else is set up OK.

Also, I had cars with **too much negative caster which caused the steering wheel not to center itself** after making a turn.

C-1 Corvettes use a pivot pin (see figure below) that is threaded on each end and has an eccentric in the middle to adjust the camber and caster. It is held into the knuckle support (7) by a clamp bolt (3). Each control arm bushing (2 & 5) is threaded over each end of the pivot pin (4) as they are threaded into the control arm (1). As the bolt is turned, it moves the upper knuckle support forward and rearward to adjust caster and also moves the spindle in and out to adjust camber.

The ST-12 (**1953-1962 Corvette Servicing Guide, Section 3 – Front Suspension**) goes into more detail on this adjustment (See below).

Fig. 5

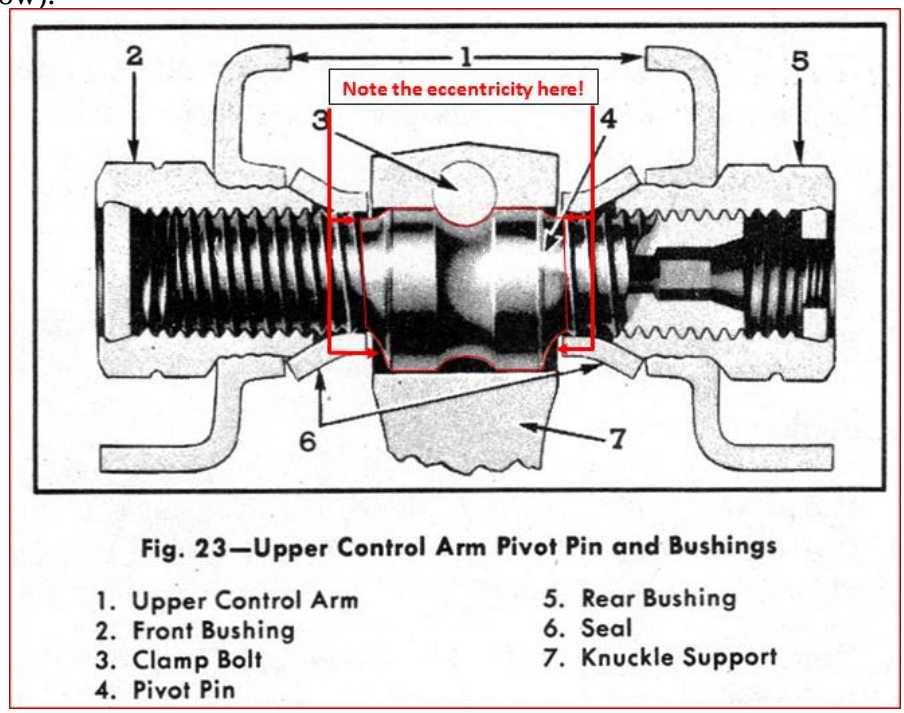


Fig. 23—Upper Control Arm Pivot Pin and Bushings

1. Upper Control Arm
2. Front Bushing
3. Clamp Bolt
4. Pivot Pin
5. Rear Bushing
6. Seal
7. Knuckle Support

Fig. 6

REMEMBER: You must remove the grease zerk to get to the Allen wrench insertion to make the adjustment. Also, the clamp bolt at the top of the spindle support must first be loosened or you can't turn the pin to make the adjustment.

Fig. 7

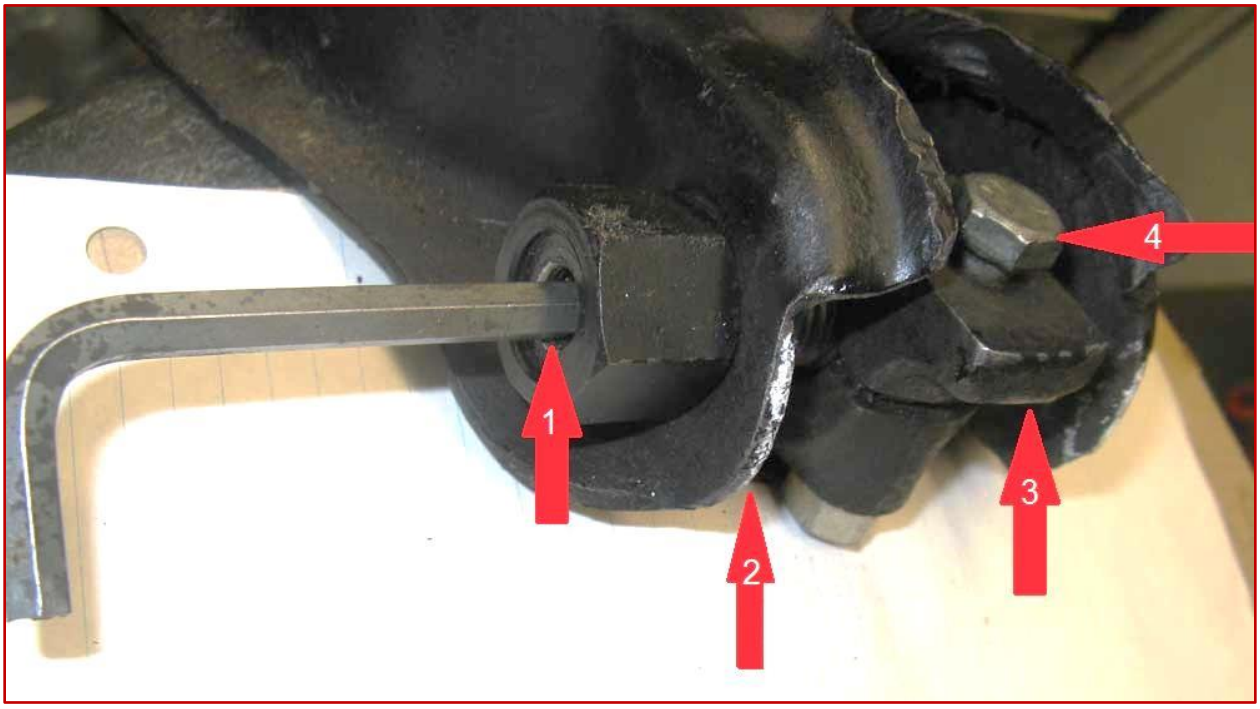


Fig. 8

Here is the upper control arm with the bushings and pivot pin installed.

1. Grease fitting hole were the Allen key is inserted to turn the pivot pin.
2. The control arm.
3. Knuckle Support (#7 in ST-12 drawing above)
4. Clamp bolt (#3 in ST-12 drawing above)

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Diagram from the ST-12 (Front Suspension 3-3) illustrating the various terms regarding wheel alignment.

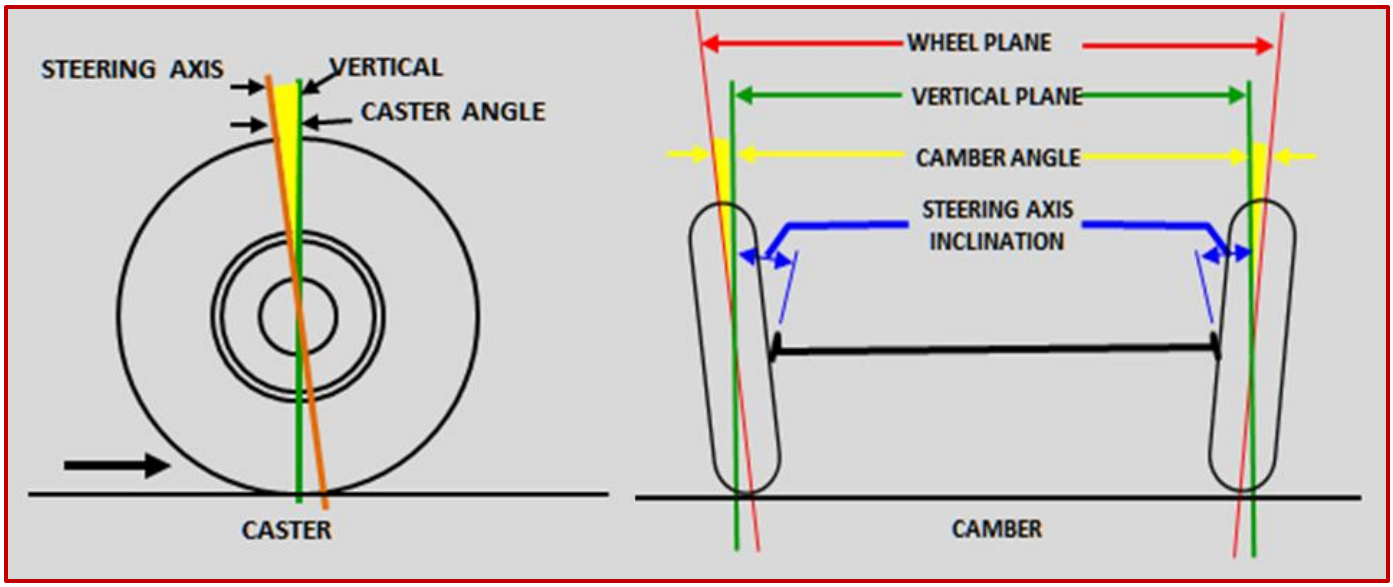

Fig. 4 – Caster and Camber Diagram (ST-12 Manual)

Specifications from the ST-12 Service Manual:

SECTION 14

SPECIFICATIONS

FRONT SUSPENSION
(Section 3)

Front Springs
Make and Type ..... Chevrolet, Coil

Shock Absorbers
Make and Type .... Delco, Direct Double-Acting
Location .... Mounted vertically from lower control arm through coil spring into front suspension crossmember

Stabilizer ..... Bar Type, Link Mounted

Front End Alignment
Curb Height—1953-1962
Caster ..... 2° ± ½°
Camber ..... ½° ± ½°
King Pin Inclination ..... 3½°-4½°
Toe-In (Per Wheel) ..... 1/16"-⅛"
Toe-Out on Turns
Inner Wheel ..... 20° ± 2°
Outer Wheel ..... 24° ± 2°

Vehicle Height
1953-1962—Std. Springs ..... 11" ± ½"
1957-1959—H.D. Springs ..... 8¾" ± ½"

Torque Specifications—Ft.-Lbs.

Tie Rod Clamp Bolt Nut	3-12
Spindle Nut .. See Front Wheel Bearings—Adjust	
Lower Control Arm Pivot Bolt	100-200
Lower Control Arm Shaft Bushing	85-100
Lower Control Arm Pivot Bolt Lock Nut	90-120
Lower Control Arm Pivot Bolt Bushing	150-170
Upper Control Arm Pivot Pin Lock Bolt Nut	30-35
Upper Control Arm Pivot Pin Bushings	30-40
Upper Control Arm Shaft Bushings	30-40
Stabilizer Bracket	17-22
Shock Absorber	4-6

Some Corvette Forum comments from John Hinckley & Duke Williams re: C1 wheel alignment:

SWCDuke

"If you believe the wheel alignment of your car is satisfactory now, the only thing you need to do with radials is reduce the front toe-in to about 1/16" total.
The instructions for this should be in your ST-12 shop manual."
Duke

See ST-12 Info below.

JohnZ

"When you do take it to the **alignment** shop to make sure it's correct, be sure and take your ST-12 manual with you, as I guarantee there will be NOBODY there who even knows where the adjustment is or how to get to it (take an Allen wrench with you, as they won't have one of those either). Also, don't let them center the steering wheel with the tie rod adjusters - C1 steering wheel centering is done at the drag link between the pitman arm and the "third arm", not at the tie rods (they won't know that either). There is also a steering gear "high-point centering" procedure to do before the steering wheel centering adjustment is made, which they also won't know about. All of this is explained (with photos) in the ST-12. As Duke said, don't use the "book spec" for toe-in, as it's for the old bias-ply tires - **with radials you want between zero and 1/16" total toe-in."**

Here is the information from the ST-12 referred to by Duke above:

ST-12 3-3

Caster

–is the amount in degrees of the backward tilt from the vertical of the knuckle support and kingpin (fig. 4).

NOTE: Before adjusting caster and camber angles after complaint of excessive tire wear or poor handling, the front bumper should be depressed and quickly released to allow car to return to its normal height.

Camber

–is the amount in degrees that the front wheels are tilted outward at the top from a vertical position (fig. 4).

When a wheel is tilted too far out at the top, hard steering or wander will be experienced and tires will show excessive wear on outside shoulders.

Reverse camber or a wheel that is tilted too far in at the top will result in excessive tire wear on the inner shoulders.

Unequal camber may result in unstable steering, wandering or unequal tire wear.

The caster and camber adjustments are both performed by turning the upper control arm pivot pin with an allen wrench placed in allen wrench hole in rear end of pivot pin after lubrication fitting is removed from rear bushing. This pivot pin is threaded into the front and rear bushings in the control arm and the steering knuckle support is held centrally located on the pivot pin, which is $\frac{3}{32}$" eccentric, by a clamp bolt which indexes with a groove in the pivot pin. With this construction, change in caster is slight for a full range of camber adjustment.

Procedure for adjustment is to turn pivot pin (fig. 5) until the travel of pin threads in bushings gives an exact caster setting, then turn pivot pin less than ½ turn in direction required for camber adjustment. The direction depends upon the position of the eccentric. The maximum amount of thread travel during camber adjustment is about ¼ of the available caster adjustment so that caster and camber can be brought within limits on the first trial. Refer to Specifications, Section 14, for caster and camber settings.

ST-12 3-4

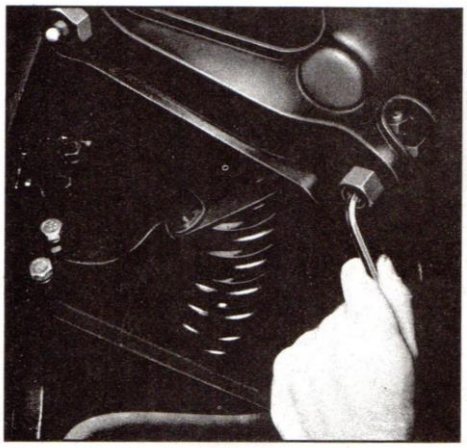

Fig. 5—Adjusting Caster and Camber

Toe-In

–is the amount in fractions of an inch that the wheels are closer together in front than at the rear. The purpose of toe-in is to insure parallel rolling of the front wheels, to stabilize steering and prevent side slipping and excessive wear of tires. A slight amount of positive toe-in is desirable to offset the small deflections due to rolling resistance and brake application which tends to turn the wheels outward.

Toe-in can be adjusted by loosening the clamp bolts at each end of the left hand tie rod and turning the left hand tie rod to increase or decrease its length as necessary, until proper toe-in is secured. Refer to Specifications, Section 14, for toe-in settings.

Before locking the clamp bolts, make sure that the tie rod ends are in alignment with their ball studs. If the tie rod is not in alignment with the studs, binding will result. Lock the clamp bolts at each end of the tie rod by tightening to 8-12 ft. lbs.

Check wheels for straight ahead position with steering gear on high point. If wheels are not straight ahead with gear on high point, adjust steering connecting rod as outlined in Section 9, "Steering."

Kingpin Inclination

–is the amount in degrees that the tops of the kingpins are inclined toward the center of the vehicle (fig. 4).

From the definitions of "KINGPIN INCLINATION" and "CAMBER," one being the inward tilt of the kingpins and the other the outward tilt of the wheels, it is evident that one cannot be corrected without changing the other. For this reason these two factors of front wheel alignment must be considered together. The correct kingpin inclination should be 4° plus or minus ½°.

If a check shows that the camber is incorrect and the kingpin inclination is correct it indicates that the steering knuckle is bent and must be replaced. If the kingpin inclination is incorrect the knuckle support must be replaced. If a new knuckle support is installed it is necessary to re-adjust both caster and camber.

Cornering Wheel Relationship

Cornering wheel relationship or toe-out on turns, is determined by the angle of the steering arm and is not adjustable. If this measurement does not fall within the limits (inner wheel 20° ± 1°, outer wheel 24° ± 1°), it will be necessary to replace the steering arm on the wheel side that does not fall within limits. See this section for steering arm replacement.

It is recommended that major service operations on the front suspension be performed on a hoist which will allow the control arm to swing free.