Adjustment of the Wheels

A. General

The correct positioning of the four road wheels of the car relative to each other and to the surface of the road is the decisive factor for good road-holding qualities, satisfactory steering, and normal tire wear. Model 190, like all our other passenger models, has independent front and rear suspension.

The values indicated for the wheel adjustments on Model 190 are the result of extensive tests and represent an optimum with regard to road holding qualities and steering characteristics.

If irregularities occur in the car's steering characteristics, road holding qualities, or tire wear, it must be borne in mind that factors other than wheel adjustment play a part.

The following conditions must be fulfilled:

a) Correct tire pressure

b) Good tread on tires (as evenly worn as possible)

c) Perfectly balanced wheels

d) Springs which are functioning perfectly

e) Shock-absorbers which are functioning perfectly

f) Steering assembly units and wheel bearings with a minimum of play.

Since the position of the moving car relative to the road surface is dependent on road conditions, speed of travel and loading and consequently varies at all times, values for wheel adjustment are given for the cars when normally loaded and also when in curb condition.

Car in Curb Condition = Car in working order, with oil and water + full fuel tank + spare wheel + tool kit, but without passengers and luggage.

Car Normally Loaded = Car in curb condition + 6 × 65 kg load on the seats + 45 kg luggage in the trunk.

The car should be loaded with sandbags. The sandbags should not weigh more than 22 kg as heavier sandbags are awkward to handle.

Distribute the sandbags on the individual seats so that at both the front and the back there is 3 × 65 kg; in doing this, adjust the front seats to the central position (do not put the sandbags on the floor of the car).

Distribute the weight in the trunk compartment evenly (45 kg).

If the fuel tank is not full, additional weights must be put in the trunk to compensate for this (1 liter fuel = 0.750 kg).

Measurements for cars which have been involved in an accident or cars where irregularities in the road-holding qualities or tire wear are observed, should be carried out with the vehicle in both curb condition and loaded condition.

When carrying out routine checks it is generally sufficient to take measurements with the car in curb condition.

The measurement and the evaluation of the measurement requires expert knowledge and experience. For this reason only specially trained mechanics should be permitted to carry out this job.

B. Terminology and Methods of Adjustment

a) Camber

Camber is the term used to designate the angle which the wheel plane forms with a line drawn at right angles to the road surface. If the wheels are inclined outward at the top the camber is said to be positive (+) and if the wheels are inclined inward at the top the camber is said to be negative (—) (Fig. 40 — 3/1).

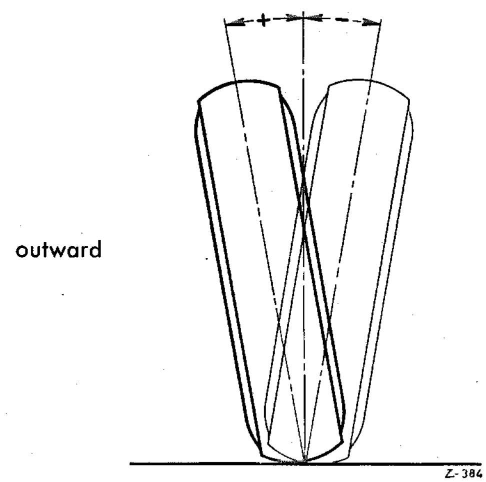


Fig. 40 — 3/1

Front Axle

The front wheels are adjusted to a positive camber. Positive camber together with king pin inclination ensures stable and smooth steering. With the low-pressure tires which are in general use today, the front wheel camber must not be too great, because this causes increased wear at the outside shoulder of the tire. The camber at the left and the right should be as nearly identical as possible. If there is a considerable discrepancy between the left and the right, the car tends to veer to the side at whichever wheel the camber is greatest. Camber is adjusted so that the least possible variation in camber results when the springs are fully depressed, with the car in normally loaded condition.

A camber of $\pm$ 0° to + 1° is permissible with the car in normally loaded condition, and a camber of + 0° 20′ to 0° 40′ should be aimed at. The difference between the camber at the right and the left should be as slight as possible; however, a maximum difference of $\pm$ 0° 30′ is permissible.

Adjustment of camber is carried out by turning the eccentric bolt (7) (Fig. 40 — 3/2). To do this, first back out the hexagon screw (13) and the lock washer (12) and remove it together with the locking plate (11). After unscrewing the hexagon nut (10), camber can be adjusted to the prescribed value with the aid of an SW 19 box wrench.

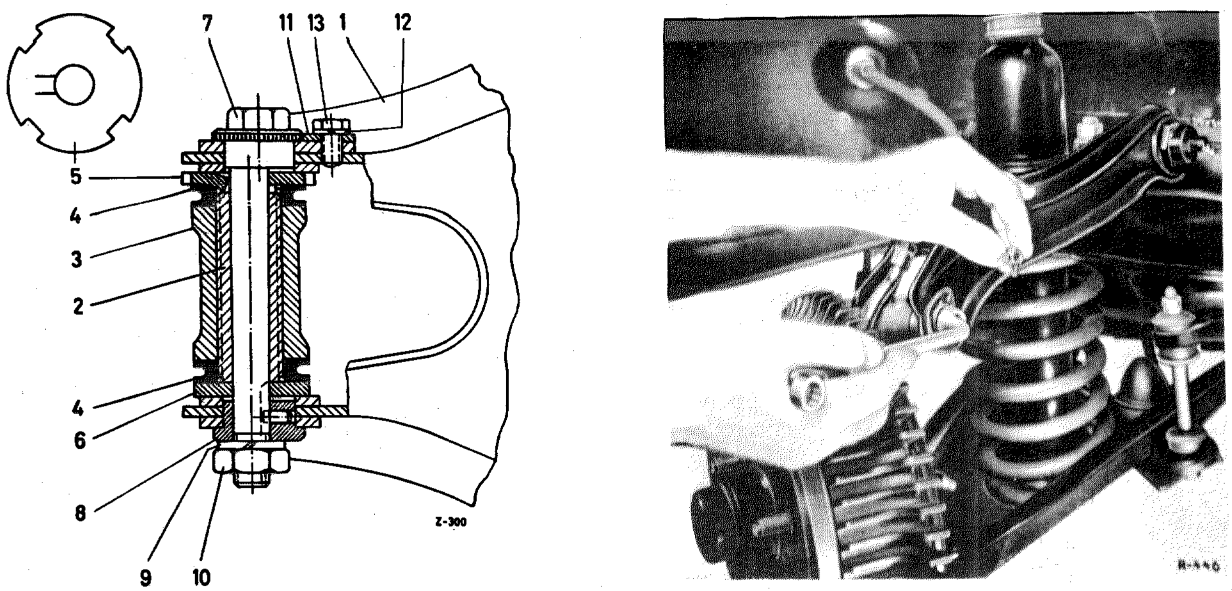


Fig. 40—3/2

1 Upper left control arm
2 Threaded bushing
3 King pin
4 Sealing ring
5 Adjusting washer for caster adjustment
6 Washer
7 Eccentric bolt for camber adjustment
8 Eccentric bushing
9 Lock washer
10 Hexagon nut
11 Locking plate
12 Lock washer
13 Hexagon screw

From the neutral position an adjustment of ± ½° is possible. **If in special cases the camber adjustment is not sufficient to achieve uniform camber at the left and the right, pivot pins can be installed on the upper control arms, whose fixing bores are offset ± 2 mm compared with the standard version.**

Offsetting the bores by —2 mm yields an alteration in the camber of approx. —½°; offsetting by + 2 mm yields an alteration of approx. + ½°. Pivot pins are obtainable as part No. 120 333 03 30 for the shorter version and as part No. 120 333 04 30 for the longer version.

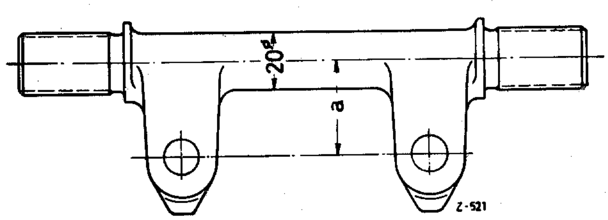


Fig. 40—3/2a

a = 35 mm standard version
a = 33 mm shorter version
a = 37 mm longer version

Rear Axle

The rear wheel camber varies according to the load, since the axle tubes swing about a common fulcrum. Variation in camber is, of course, less in the case of the single-jointed swing axle than in the case of the twin-jointed swing axle.

The rear wheels also assume a negative camber with increasing load.

It is advisable to adjust the rear wheel camber with the car in curb condition. In consequence of the difference in length of the axle tubes when the car is standing in a horizontal position, the camber is greater at the right than at the left. With the car in curb condition the difference amounts to approx. 0° 15′, and with the car in normally loaded condition to approx. 0° 30′.

To achieve optimum road-holding qualities the rear wheel camber should be adjusted to approx. + 1° 30′, with the car in curb condition.

With the car in normally loaded condition, the camber at the left is from —2° 30′ to —3° 30′, and at the right from approx. —3° to —4°. The relatively high tolerances with the car in loaded condition arise because of the tolerances in the rear axle suspension and because of the rubber buffers which extend the action of the springs.

Care must be taken to ensure that, when the car is in normally loaded condition, the camber never reaches a greater negative value than —4° since otherwise the upward spring deflection is too small and moreover there arises the danger of increased wear at the inside shoulder of the tire. Before the measurements are taken, the rubber buffers must be checked to ensure that they are in perfect condition. The camber of the rear wheels is adjusted by turning the spring plate (5) (Fig. 40 — 3/3). The spring plate can be turned to four notch positions; turning the spring plate one further notch causes an alteration of wheel camber of approx. 0° 10′. If it is not possible to adjust the camber sufficiently by turning the spring plate (5) an attempt may be made to adjust the camber to the specified value by adding or removing compensating rubber rings (9). (For further details see Job No. 32—5).

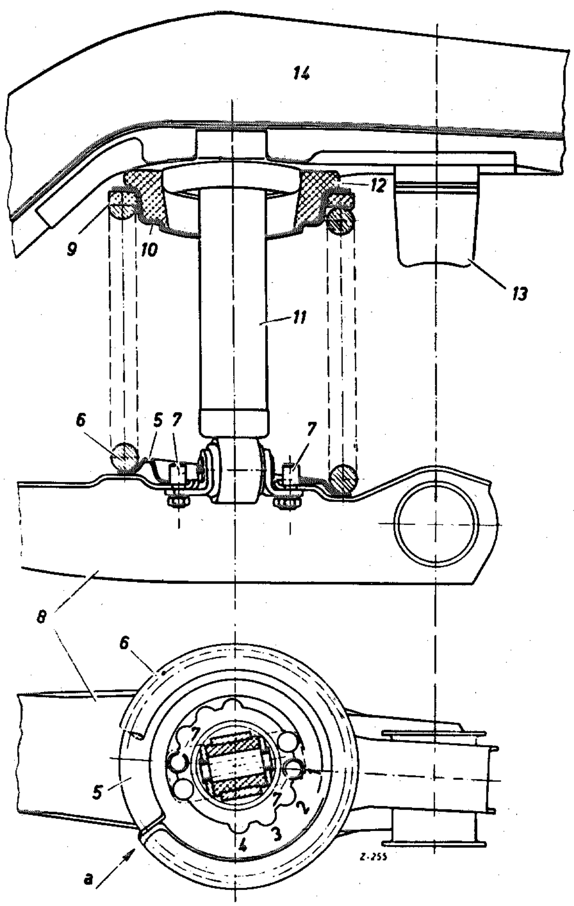


Fig. 40 — 3/3

1—4 Notch position
5 Lower spring plate
6 Spring
7 Cheese head screw
8 Torque arm
9 Compensating ring
10 Upper spring plate
11 Shock absorber
12 Rubber mounting
13 Rubber buffer stop
14 Chassis base panel
a = distance between the end of the spring and the heel of the spring plate

b) King Pin Inclination

The term king pin inclination designates the angle which the king pin forms with a line drawn at right angles to the surface of the road. This is measured by producing the center line of the king pin to meet a line drawn at right angles to the direction of travel and to the surface of the road.

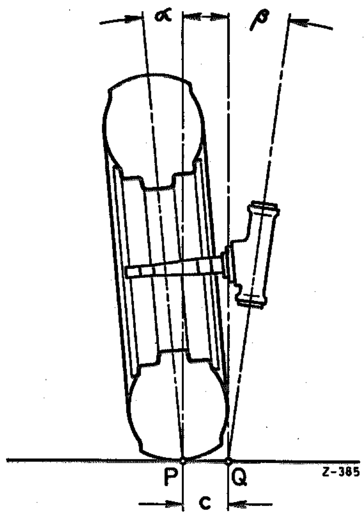


Fig. 40—3/4

a Camber in degrees
b King pin inclination in degrees
c Effective rolling diameter in mm
P Point of contact of the tire with the surface of the road
Q Point of intersection of the center line of the king pin and the surface of the road

The sum of the camber and the king pin inclination is constant, due to the design of the king pin. For this reason when the camber is adjusted, the king pin inclination is automatically adjusted as well.

c) Rolling Diameter

The term rolling diameter (rolling circle diameter) designates the distance (c) between the point of intersection (Q) of the center line of the king pin and the surface of the road and the point of contact (P) of the tire with the surface of the road (see Fig. 40—3/4). The rolling diameter is critical for ensuring easy steering action at low speed, e.g. when parking, since the tire describes a small arc when the steering is locked hard over. The contact surface in modern low pressure tires is so large that steering would be very heavy if the tire had to turn more or less on the spot when parking.

d) Caster

The term caster designates the angle which the axis of the king pin forms (when "produced" upward and rearward) with a line drawn at right angles to the surface of the road (Fig. 40—3/5). To measure this, the central axis of the king pin is produced to intersect with a plane parallel to the direction of travel and at right angles to the surface of the road.

The point of contact S of the tire with the surface of the road thus lies behind the point of intersection R of the axis of the king pin and the surface of the road.

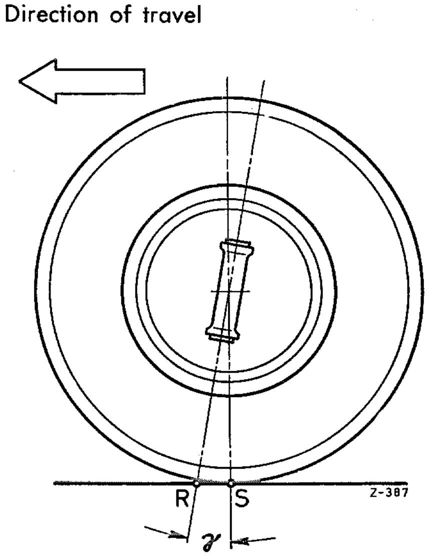


Fig. 40 — 3/5

γ Caster
S Point of contact of the tire with the surface of the road
R Point of intersection of the axis of the king pin and the surface of the road

Caster facilitates stable steering and automatic return of the road wheels to the straight-ahead position after cornering. The effect of the caster achieved by the angle of the king pin is the same as with the action of an ordinary dinner-waggon.

The magnitude of the caster angle is dependent on the loading of the car. In Model 190 the caster, allowing for all tolerances, is 2° 30′ to 4°, according to the loading of the car. The caster should be as nearly identical as possible between the right and the left. A discrepancy of approx. ½° is, however, permissible.

Caster can be adjusted by turning the threaded bushing (2) (Fig. 40 — 3/6).

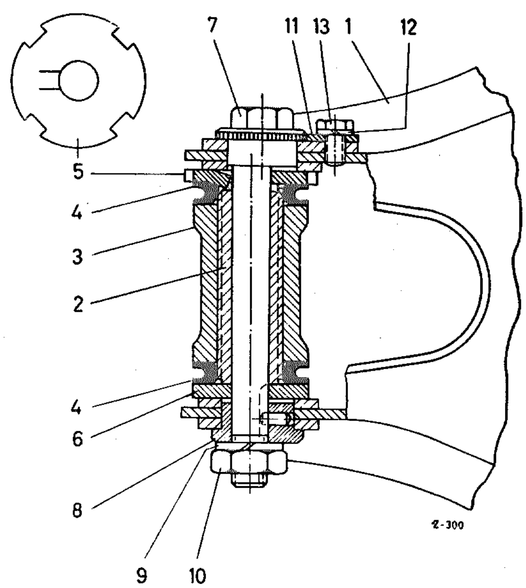


Fig. 40 — 3/6

1 Upper left control arm
2 Threaded bushing
3 King pin
4 Sealing ring
5 Adjusting washer for caster adjustment
6 Washer
7 Eccentric screw for camber adjustment
8 Eccentric bushing
9 Lock washer
10 Hexagon nut
11 Locking plate
12 Lock washer
13 Hexagon screw

After the hexagon nut (10) has been unscrewed, the threaded bushing (2) can be turned by turning the adjusting washer (5) with the aid of Special Wrench 180 589 00 05 (Fig. 40 — 3/6).

When the threaded bushing is in the neutral position, an adjustment of 1.5 mm in both directions is permissible. This allows a variation in caster of $\pm 0^\circ 20'$. A greater amount of adjustment is not permissible, since on the one side the rubber ring would be crushed and on the other it would no longer make a perfect seal.

A further limited adjustment of caster can be made by turning the upper control arm pivot pin one turn to the right or to the left from the neutral position. To do this it is necessary to take off the front wheel and remove the shock absorber. Then use Spring Tensioner 120 589 01 31 to compress the front spring so that the upper pivot pin is not under load and can be screwed off the front axle support.

e) Toe-in and Toe-out

The term toe-in (or toe-out) designates the difference in the distance between the wheel rims, at the front and at the rear of the wheels. Measurement for this is taken at a point level with the wheel centers, with the wheels set in the straight-ahead position (Fig. 40 — 3/7).

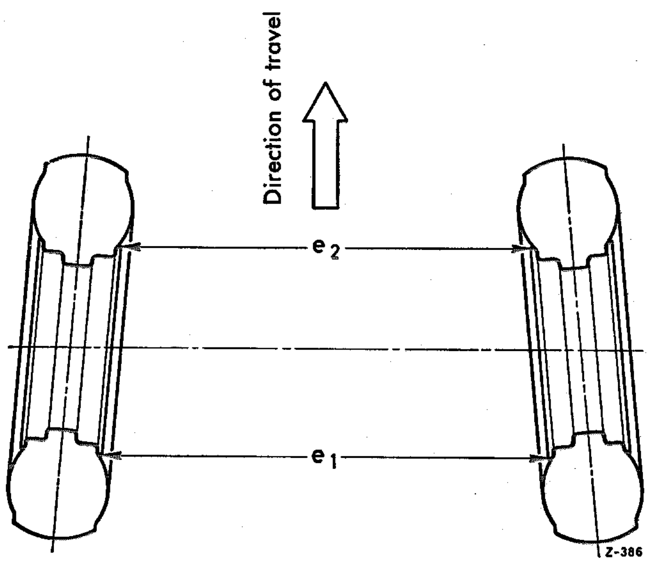


Fig. 40 — 3/7

$e_1 - e_2$ = toe-in (e_1 larger than e_2)
$e_2 - e_1$ = toe-out (e_2 larger than e_1)

Front Axle

Toe-in counteracts the tendency of the front wheels to spread — a tendency caused by the camber. Furthermore, owing to the slippage, lateral forces are brought into play which allow the vehicle to maintain a steady course.

Without toe-in, it is only with a greater angle of "yaw" that lateral forces come into play, so that the car would not maintain a steady course when travelling straight ahead. However, toe-in must not be excessive. If this is the case, considerable tire wear results. Toe-in for Model 190 is 0—2 mm.

When measuring toe-in, the front wheels must not be pressed toward each other at the rear. Toe-in must be measured with the car in normally loaded condition.

Toe-in can be altered by adjusting the lengths of the two tie-rods. To do this, the locking plate (3) must be tapped up, the hexagon nut (4) unscrewed, and the lock ring (2) must be tapped off the cone of the tie-rod tube (1) (Fig. 40 — 3/8).

Note: The tie-rod end on the left side of the tie-rods (seen in the direction of travel) has a left-hand thread. For purposes of identification the two tie-rod tubes have a milled edge on the left side.

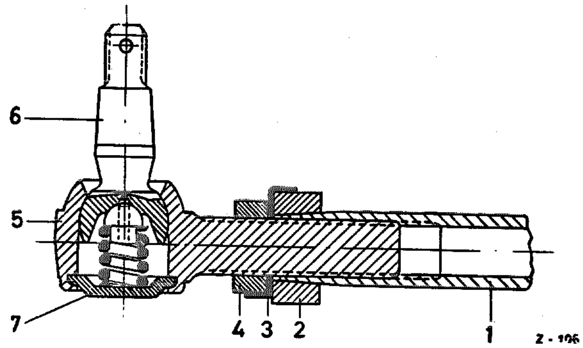


Fig. 40 — 3/8

1 Tie-rod tube
2 Lock ring
3 Locking plate
4 Hexagon nut
5 Ball head
6 Ball stud
7 Plug

The toe-in can now be adjusted by turning the tie-rod tube (1).

To adjust the toe-in, set the wheels in the straight-ahead position and lock them by means of Center Fixing Screw 186 589 00 23. Toe-in must be distributed evenly between the left and the right wheel. If an optical axle gage is not available, the front wheels must first be lined up parallel to the rear wheels, with the aid of Wheel Base Measuring Gage 136 589 07 21. In the absence of a gage, this alignment can be carried out with the aid of a straight-edge or simply visually.

The wheel base measurement at the left and the right must be equal.

After adjusting toe-in, press the lock rings (2) onto the tie rod tubes (1), tighten up the hexagon nuts (4) and tap over the locking plate (3). When tightening up the hexagon nuts (4), care must be taken to ensure that the ball-heads always rest against the ball pin in the direction of rotation of the hexagon nut. This ensures that the tie-rods are free to turn as required when the car is in motion. If they are incorrectly installed, the danger exists that the tie-rods will bend when the car is being driven. **For this reason it is necessary to carry out a check after adjusting toe-in, by turning the tie-rods to ascertain whether the tie-rod heads can turn to the full extent.**

Rear Axle

Toe-in at the rear axle should be nil. It is not normally necessary to measure toe-in at the rear axle; if, however, rear wheel tire wear is excessive, toe-in at the rear axle must be measured. If the toe-in or toe-out is found to exceed 2 mm, the fault may be bent axle tubes, bent torque arms or faulty seating of the step bearings supporting the torque arms. In the latter case, the rear axle mounting bolt will no longer be perpendicular to the road surface, as in the original design, but will be inclined forward or backward. In this case there will be considerable variation of toe-in, when the springs are fully depressed, and increased tire wear will result.

f) Track Angularity Differential

It is a known fact that when the front wheels turn about a definite angle, the lock of the outside wheel is less than that of the inside wheel, since the outside wheel has to describe an arc of greater diameter. The difference between the angle subtended by the tangent of the arc of the outside wheel and that of the inside wheel is designated the angle of track angularity differential (Fig. 40—3/9).

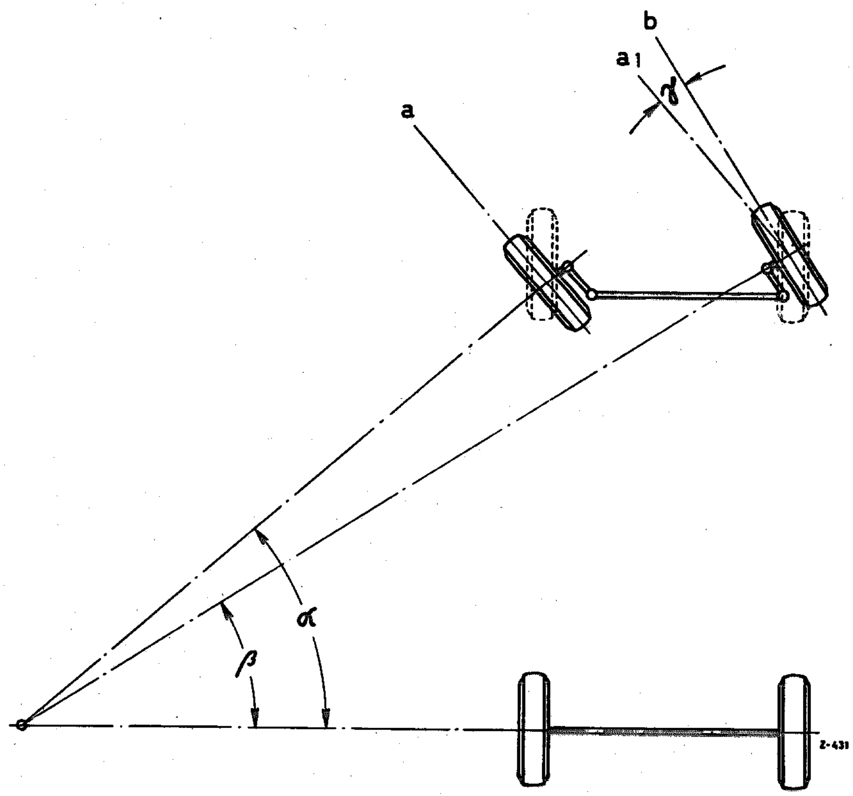


Fig. 40—3/9

a_1 = Parallel to a
γ = Track angularity differential
α = Angle of lock at the inside wheel
β = Angle of lock at the outside wheel

The track angularity differential for Model 190 at an inside wheel lock of 20° is —2° 30′.

In evaluating the track angularity differential, it must be borne in mind that the value indicated is determined geometrically. When the car is in motion considerable slip angles are generated independently of the radius of the curve and speed of travel, so that the track angularity differential most favorable for normal travel can only be ascertained by road tests. Deviations from the value specified are not critical for the behavior of the vehicle and especially not for tire wear. The track angularity differential should nevertheless be as nearly identical as possible on the left and the right locks.

g) Pivot Point Distance

Toe-in should remain constant when the front wheel springs are fully depressed. This is achieved in practice with sufficient accuracy by appropriate relative positioning of the ball pins on the steering gear arm or the steering relay arm, and on the steering knuckle arms (pivot point distance).

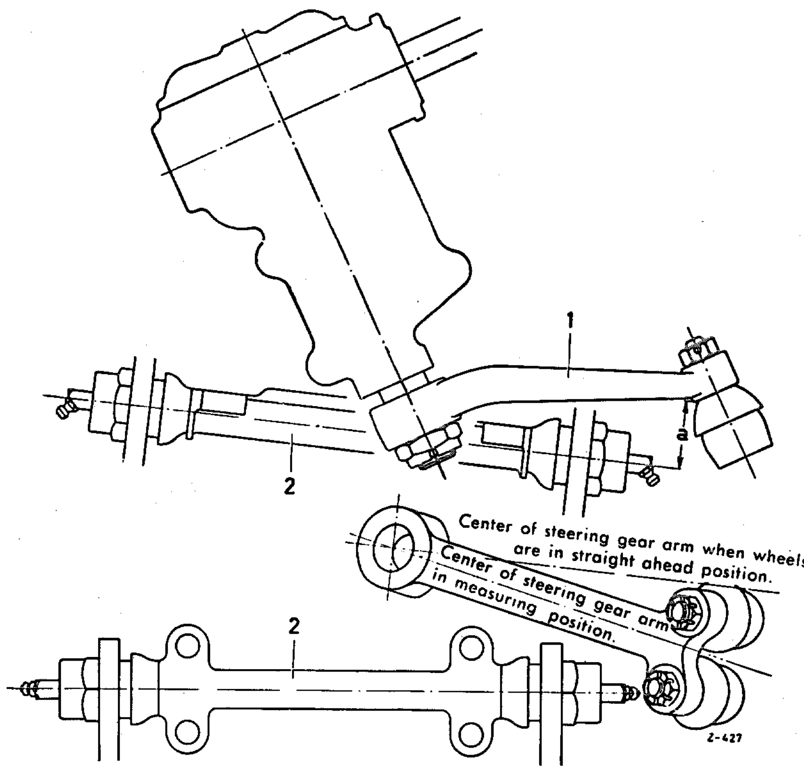


Fig. 40—3/10

1 Steering gear arm
2 Lower control arm pivot pin
a = 34 ± 2 mm

Larger variations in the pivot point distance manifest themselves in variation between toe-in of the wheels with the vehicle in curb condition and toe-in in normally loaded condition. This leads to considerable tire wear and tread defacement on the circumference of the tire.

If, when checking, a variation greater than 2 mm is discovered between the toe-in of the vehicle in curb condition and the toe-in in fully loaded condition, the pivot point distance must be checked.

It is normally sufficient to check the positioning of the ball pins on the steering gear arm and on the steering relay arm. Since in practice the central point of the ball pin cannot be measured, the distance a between the inner pivot pin on the lower control arm and the lower edge of the steering gear arm and steering relay arm must be checked (Fig. 40—3/10). When measurements are taken, the steering must be set in the measuring position. In the measuring position the extension of the pivot pin must be aligned with the measuring spot on the steering gear arm or steering relay arm (Fig. 40—3/10).

If the distance deviates from the prescribed distance, a = 34 ± 2 mm, the steering gear arm must be replaced. If a replacement is not available, the steering gear arm may be straightened cold: **In this case it is essential to carry out a careful check for cracks before reinstalling.**
The steering relay arm can be adjusted for height (see Job No. 46—11, Note: Paragraph 9). The steering gear arm and the steering relay arm must be at the same level when the vehicle is traveling straight ahead, i.e. the tie-rod must be horizontal. A deviation of up to 2 mm is permissible.
If, when the vehicle is in curb condition, the toe-in varies by more than 2 mm from the toe-in when the vehicle is in normally loaded condition, despite correct positioning of the steering gear arm and the steering relay arm, the cause is probably a bent steering knuckle arm. If this is the case, replace the steering knuckle arm.

h) Wheelbase

The term wheelbase designates the distance between the central points of the front and rear wheels (Fig. 40—3/11). The wheelbase at the left should be as nearly identical as possible with the wheelbase at the right. Differences of up to 5 mm between the wheelbase at the left and the right are permissible.

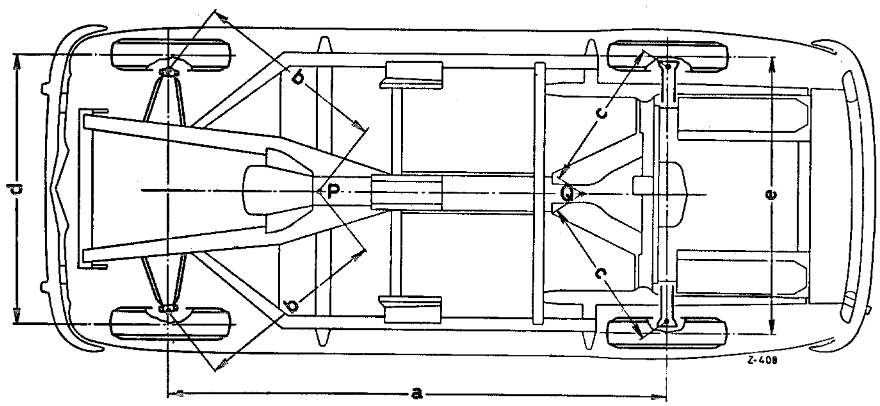


Fig. 40—3/11

P Check bore for front axle positioning distance
Q Check bore for rear axle positioning distance
a Wheelbase
b Front axle positioning distance
c Rear axle positioning distance
d Front axle track
e Rear axle track

i) Axle Positioning Distance

To facilitate adjustment of the front and rear axles, two check bores (P) and (Q) have been made on the chassis base panel along the longitudinal axis of the vehicle (see Fig. 40—3/11). By measuring from these check bores, the position of the front and rear axle can be checked (axle positioning distance b and c). In the case of the front axle a difference of up to approx. 5 mm is permissible. The axle positioning distance cannot be adjusted on the front axle. But a small correction is possible by turning the front axle support, after unscrewing the fixing screws.
Where greater deviations are found, check whether the front axle support is properly fitted, and whether the step-bearings for the front axle support are correctly positioned. Use chassis base panel gage to check the step bearings (see Job No. 61—1, Section B) and use the checking fixture designed for this purpose to check the front axle support (see Job No. 33—8).
A difference of 2—3 mm between the left and the right is permissible on the rear axle. It is possible to carry out a correction by adjustment of the cross strut (see Job No. 35—1).

k) Rear Axle Misalignment

The axle tubes of the rear axle must be perpendicular to the longitudinal axis of the vehicle. If, however, the rear axle becomes turned about the mounting bolt, this results in misalignment and a maximum value of 0° 20′ is permissible (Fig. 40—3/12).

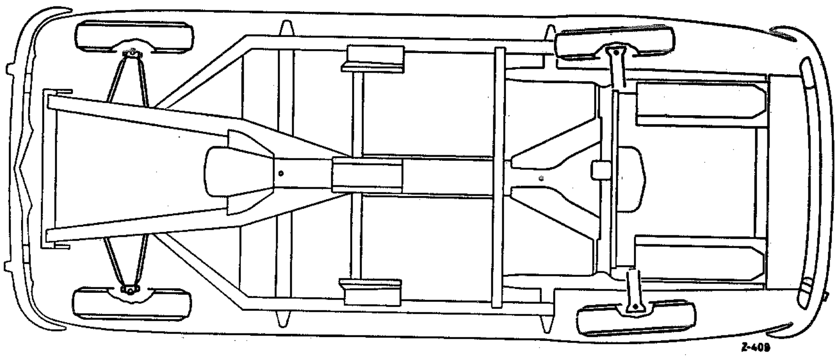


Fig. 40—3/12

If the misalignment is in excess of this value, considerable tire wear results. The rear axle can be straightened by adjusting the cross strut.

l) Lateral Axle Displacement

The term lateral axle displacement refers to the lateral offsetting of the rear axle, relative to the longitudinal axis of the vehicle.
An axle displacement of up to 20 mm is not normally a disadvantage when the vehicle is in motion. If considerable lateral axle displacement is present, the car will veer to the left (with engine pulling) and to the right (with car "driving" engine) or vice-versa, depending on whether the rear axle is offset to the right or to the left. It is usually unnecessary to correct this.

C. Wheel Adjustment Values

vehicle loading	Front axle							Rear axle						Wheelbase permissible difference in mm
	Camber	Toe-in in mm	Track angularity at 20° lock of inner wheel	Caster	King pin inclination	Pivot point distance in mm	Axle positioning distance permissible difference in mm	Camber left	Camber right	Toe-in or Toe-out in mm	Center position permissible deviation in mm	Axle positioning distance permissible difference in mm	Permissible misalignment up to	
curb condition	0° to 1°*	0–2	–	2°50'* to 4°	5°20' to 5°40'	34±2	5	approx. +1°30'	approx. +1°45'	0±2	2	3	0°20'	5
normally loaded	0° to 1°*	0–2	–2°30'*	3°10'* to 4°10'	5°20' to 5°40'	34±2	5	–2°30'** to –3°30'	–3°** to 4°	0±2	2	3	0°20'	5

* This value should be as nearly identical as possible at both sides the maximum permissible difference is 0°30'. The ideal value for front wheel camber = 0°20' to +0°40'.

** At the rear wheels a variation in camber of approx. 0°30' if the car is in loaded condition, and of 0°15', if the car is in curb condition, is normal. (The variation in camber at the left and the right arises from the design of the single-jointed swing axle, since the connecting pin of the axle halves lies outside the longitudinal axis of the car. For this reason right wheel camber is greater than left wheel camber).

Car in curb condition = Car in working order, with oil and water + full fuel tank + spare wheel + tool kit, but without passengers and luggage.

Car normally loaded = Car in curb condition + 6 × 65 kg load on the seats + 45 kg luggage in the trunk.

Front axle track	:	1430 mm
Rear axle track	:	1470 mm
Smallest turning circle diameter	:	approx. 10.7 m
Smallest track circle diameter	:	approx. 10.0 m

The smallest **turning circle diameter** is understood to be the diameter of a circle described by the circumferential extremities of the turning vehicle with the steering at full lock.

The smallest **track circle diameter** is understood to be the diameter of the circle described by the outside front wheel (center of tire) when turning with the steering at full lock.

Note: When too great a negative camber is present, particularly in the case of vehicles with special bodies produced by other firms, it is advisable to check the permissible axle load after weighing the vehicle in fully loaded condition, with a full fuel tank and all equipment (see Job No. 32 — 0 and Job No. 40 — 0, Section B). This is carried out by weighing the vehicle on a platform scale twice; the first time with only the front axle on the scale, and the second time with only the rear axle on the scale.
As a check the complete vehicle can then be weighed.

D. Tire Wear

Irregular and extreme tire wear occurs if the wheels are incorrectly adjusted. In many cases it is possible to detect incorrect wheel adjustment without the aid of any measuring device, purely by reference to typical tire wear diagrams. The following diagrams show some such tire wear phenomena and give in each case the cause.

a) Tire Wear Diagrams

(The arrow indicates in each case the direction of travel)

Excessive toe-in

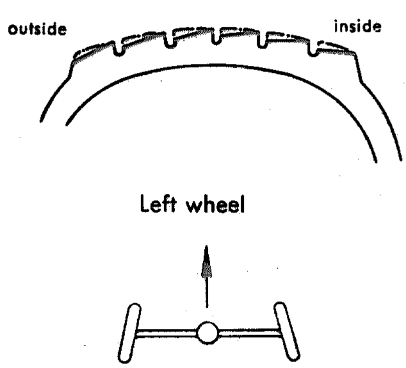


Fig. 40 — 3/14

The fault can occur at both the front and the rear axle.

Excessive toe-out

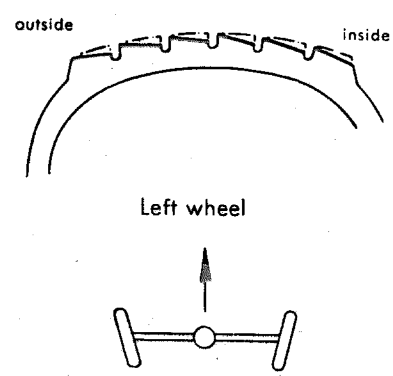


Fig. 40 — 3/15

The fault can occur at both the front and the rear axle.

Rear axle misalignment

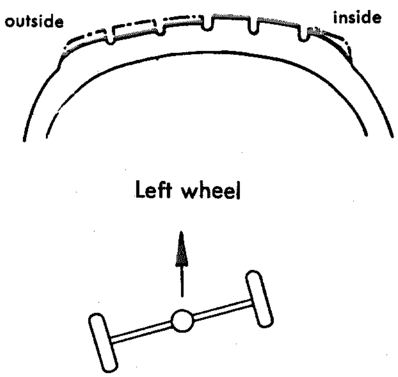


Fig. 40 — 3/16

The rear axle has misalignment but neither toe-in nor toe-out.

Front axle misalignment

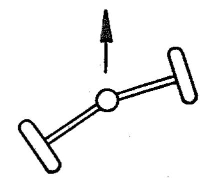


Fig. 40 — 3/17

A tire wear diagram results which is a combination of Fig. 40 — 3/15 and Fig. 40 — 3/16.

Wear at the Shoulder

Fig. 40 — 3/18

This tire wear pattern occurs even when driving mainly on freeways or national highways and does not indicate the presence of an adjustment error nor insufficient tire pressure.
The same fault occurs, however, when the vehicle is driven under normal conditions with insufficient tire pressure.
Wear at one shoulder, i.e. the outside shoulder, can occur on the front wheels when camber is excessive. If the tire is not seated firmly on the rim and can thus "wander", wear at the shoulder is especially likely to occur.
Wear at one shoulder occurs less frequently on the rear wheels, since the camber alters constantly when the car is in motion owing to the swinging of the axle tubes.
A certain tendency to wear at the inside shoulder can appear if the vehicle is driven constantly when heavily laden. Here too, perfect seating of the tire on the rim is important. It is therefore important that the interchanging of wheels as recommended is carried out in order to obtain even wear of all tires, including that on the spare wheel.

Flat surfaces

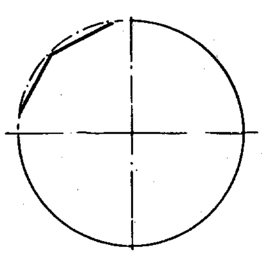


Fig. 40 — 3/19

a) Static or dynamic unbalance, or static and dynamic unbalance.
b) Excessive out-of-round at the rim.

Saw-tooth wear at the outer ribs

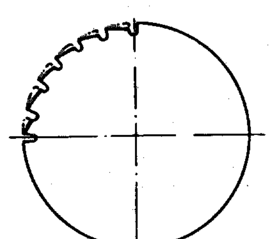


Fig. 40 — 3/20

Saw-tooth wear at the outside ribs is conditioned purely by the type of tread. This type of wear occurs only on front wheels.

In addition to incorrect wheel adjustment, defective shock absorbers can also be partly reponsible for uneven tire wear. If the shock absorbers are defective, the wheels tend to bounce on rough roads. This causes increased general wear and under certain circumstances uneven tire wear along the circumference (polygonal wear).

b) Judgement of Tires

If the tread of a tire is no longer clearly distinguishable along the whole of its surface, the tire is no longer safe. Depth of tread must be a minimum of 1 mm at the most worn point on the tread.

E. Preparation for Measurement

a) When measurements are taken, the tire wear on the left and the right wheels should be as nearly identical as possible. It is not permissible to measure with one very worn tire and one new tire. In such cases it is advisable to use special "measuring wheels", i.e. wheels with new tires, which are used only for this measurement work.

b) The tire pressure should be checked and, if necessary, corrected.

Tire pressure front	1.7 atmospheres
rear	1.8 atmospheres

c) The play in the steering units should be checked (see Job No. 46 — 3). Worn parts should be replaced or repaired.

Note: If an optical axle gage is used, the check for excessive play can also be carried out with this gage.

d) If parts of the front or the rear axle assemblies (e.g. springs or axle halves) or complete assemblies are replaced before the measurement is carried out, it is essential to make a road test beforehand. This is necessary because the sudden stresses which occur whilst the vehicle is in motion cause the replaced parts to alter their position again, so that the measurements taken would be inaccurate.

e) The wheels must be able to settle into position freely whilst under load. This is best done by allowing all four wheels to stand on ball-bearing skid plates. For the front wheels, plates are required which are free to move in all directions; for the rear wheels, it is sufficient to use plates which move laterally. If such plates are not available the car can, if necessary, be measured on fixed plates. The plates used should, however, be "neutrally" positioned under the wheels. The car should also be pushed and rocked to and fro sufficiently before measurement is begun.

It is sufficient to have a level surface if measurements are taken with an optical axle gage.

F. Measurement Charts

Always record all measurements on a measurement chart, which should be kept with the car's papers. This serves to establish whether measurements have altered, e.g. as a result of colliding with the curb when parking or because of an accident.

A measurement chart has been drawn up for use throughout all our branches and workshops and is suitable for use with all our models (see Page 40—3/23). The measurement charts can be obtained from the Central Service Department.

On the back of the measurement chart are listed the adjustment values for all our passenger models.

G. Measurement with an Optical Axle Gage

Measurements should be made wherever possible with an optical axle gage. We recommend for this purpose the Exacta-Gage manufactured by Müller (Heilbronn). When using this gage, the makers' instructions should be observed. However, the method – which is recommended by several of the firms marketing optical gages – of pressing the front wheels in toward each other at the rear, is not permissible for our cars. The correct method is to measure toe-in with the vehicle loaded and the wheels "rolled", not pressed in. The term "rolled" means that before measurements are taken, the car should be forcibly pushed to and fro and rocked by hand, so that the wheels can settle into a position of minimum stress.

H. Measurements with Mechanical Gages

For smaller workshops we have developed a number of mechanical gages, with which measurements can be made which are in general sufficiently accurate for practical purposes.

As is the case with an optical gage, measurement should be commenced at the rear axle, since all further measurements or adjustments are dependent on both the correct positioning of the rear axle relative to the longitudinal axis of the vehicle and the camber of the rear wheels.

a) Rear Axle Center Position and Axle Positioning Distance

The axle is in **center position** when the connecting pin, which is the fulcrum of the two axle halves, is parallel to the longitudinal axis of the car at a certain distance from it.

Use Master Gage 180 589 08 21 to check the axle for center position. The gage should be placed against the two torque arm mountings on the chassis base assembly (Fig. 40—3/21). If the center position is correct, the measuring pointer on the gage points to the center of the hexagon head of the connecting pin for the rear axle suspension (permissible lateral divergence 2 mm).

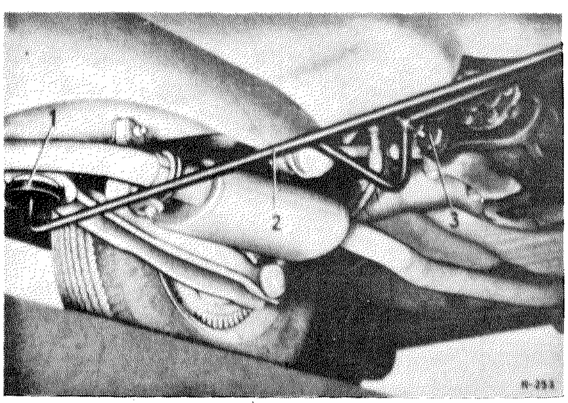
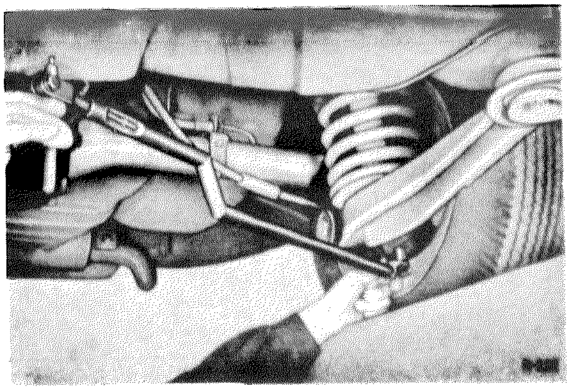


Fig. 40—3/21

1 Cup on torque arm mounting
2 Master Gage 180 589 08 21
3 Connecting pin hexagon screw

After checking the rear axle for center position, the axle positioning distance should be checked. The axle positioning distance should be measured with the aid of Master Gage 180 589 08 23. A measurement should be taken from the check bore on the chassis base to the torque arm fixing screw bores in the bearings of the two support tubes at the rear axle (Fig. 40—3/22).



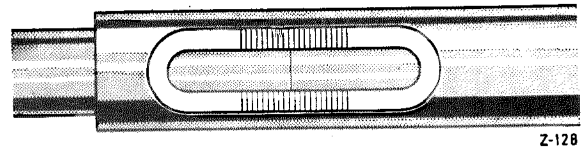


Fig. 40 — 3/22

For reasons of uniformity, measurement should always be taken first at the left side. The difference in distance (+ or —), as compared with the left side, should be entered on the measurement chart (permissible difference 3 mm). Lateral divergence from center position and rear misalignment can be corrected by adjustment of the cross strut.

b) Rear Wheel Toe-in (Toe-out)

Rear wheel toe-in or toe-out should be measured only if uneven tire wear occurs. If possible it should be nil, although divergences of up to ± 2 mm are permissible. The method of taking measurements is described in Section h) – Front Wheel Toe-in.

c) Rear Wheel Camber

Correct adjustment of rear wheel camber is particularly important for vehicles with independent rear suspension, in order to achieve optimum road holding qualities. Camber should therefore be measured both with the vehicle in curb condition and also in loaded condition. Measurement of camber is carried out with Camber and Caster Gage 180 589 02 21 (Fig. 40 — 3/23).

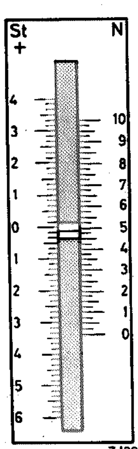
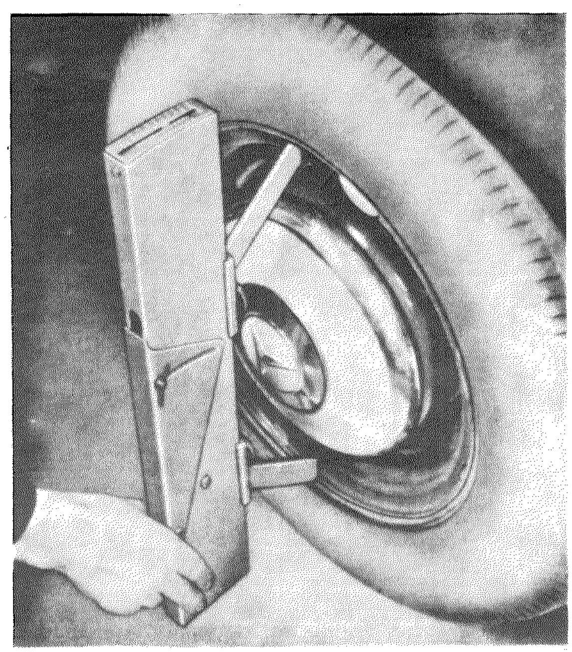


Fig. 40 — 3/23



Care must be taken to ensure that the measuring surfaces are brought into definite contact with the extreme edge of the rim and that the camber gage is held perpendicular, so that the measuring pendulum can swing freely and does not stick. The camber amount can be read off the left-hand scale on the gage (one graduation = 10′).

To counteract possible rim run-out, an average measurement should be taken by measuring at two opposite points. To do this proceed as follows:

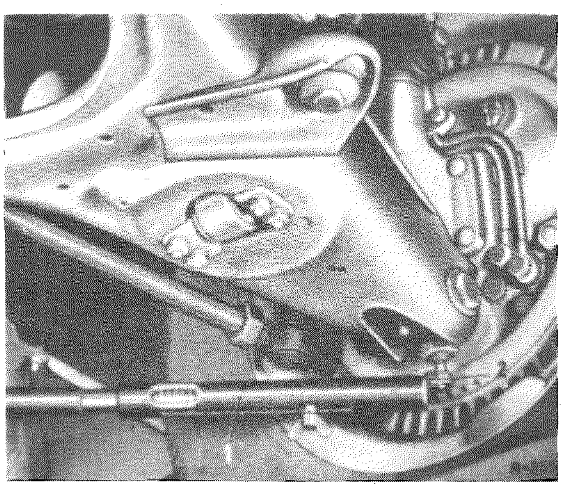
1. Place the gage in position and read off the amount of camber. (Example: + 1° 30′.)
2. Make a chalk mark where the upper tip of the gage touches the wheel.
3. Move the vehicle (in the direction of travel) until the chalk mark is at the bottom of the wheel.
4. Place the gage in position again and read off the amount of camber (Example: + 1° 50′).
5. The actual amount of camber is the mean of the two values read off the gage.

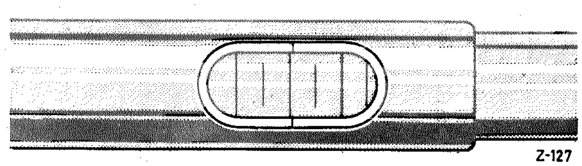
Example: $\dfrac{1^\circ 30' + 1^\circ 50'}{2} = \dfrac{2^\circ 80'}{2} = 1^\circ 40'$

The correct camber amounts are given in Section C.

d) Axle Positioning Distance for the Front Axle Halves

Use Master Gage (1) 180 589 02 23 to measure the axle positioning distance of the front axle halves; measurement should be made from the check bore in the chassis base assembly to the centering bores in the two king pins (Fig. 40 — 3/24).





Z-127

Fig. 40 — 3/24

1 Master Gage 180 589 02 23
2 Feeler inserted in the centering bore in the king pin

A difference of 5 mm between the left and the right halves is permissible. The axle positioning distance of the front axle halves cannot be adjusted. A slight correction is possible by removing the fixing screws on the front axle support and turning the support.

If greater divergences are found, a check should be made to see whether the control arms are bent, the front axle support is defective or the step-bearings for the front axle support are incorrectly positioned. Use the chassis base panel gage (see Job No. 61 — 1, Section B) to check the step bearings, and the specially designed checking fixture to check the front axle support (see Job No. 33 — 8).

e) Front Wheel Camber

As with the rear wheels, use the Camber and Caster Gage 180 589 02 21 to measure the front wheel camber. To counteract possible rim run-out, an average measurement should be taken as before (see Section c) Rear Wheel Camber).

f) King Pin Inclination

King pin inclination cannot be measured by mechanical means. It is determined by the design of the steering knuckles and can only be adjusted together with the camber.

g) Caster

The amount of caster is fixed by the design of the car. The adjusting mechanism serves merely to remove slight differences in left and right wheel camber.

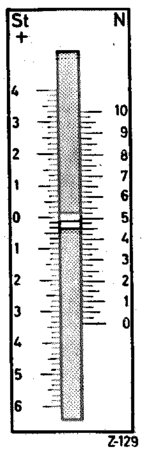


Fig. 40 — 3/25

Caster should be measured (as was the case when using the optical axle gage) by measuring the difference in camber amounts of the front wheels when set at a left and right lock of 20 .
There are two scales on Camber and Caster Gage 180 589 02 21. The left-hand scale gives the camber amount in degrees and minutes and the right-hand scale enables easier measurement of caster to be made. The figures on this right-hand scale, however, do not give the actual caster or camber amount. The caster must be calculated from the difference between the readings taken when the wheels are over at left and right lock (Fig. 40 — 3/25).

When taking measurements proceed as follows:

aa) Set the left wheel in the straight-ahead position; place a rule or draw a chalk line parallel to the road wheel at a distance of 200 mm from it.

bb) Pull out the 20° angle guide of Gage 180 589 02 21.

cc) Place the gage horizontally against the wheel. Now turn the wheel to the left until the rule or chalk line is parallel with the angle guide on the gage (Fig. 40 — 3/26).

dd) Now place the gage against the wheel rim, set it exactly to the vertical position, and read off the value shown on the right-hand scale (one graduation = 15′). Example: 7° 45′ (Fig. 40 — 3/27).

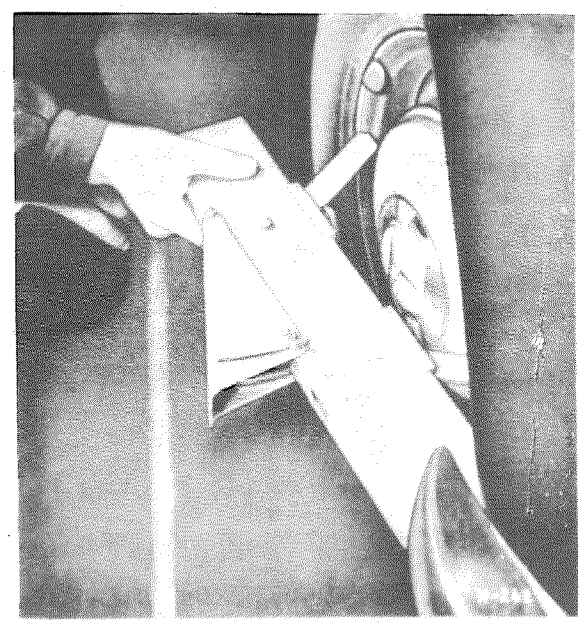


Fig. 40 — 3/26

Measurement at the right wheel

ee) Place the gage horizontally against the left wheel, this time with the gage turned to point in the other direction (i. e. turned through 180°). Now turn the road wheel to the right until once again the rule or the chalk mark is parallel to the angle guide on the gage when in the horizontal position.

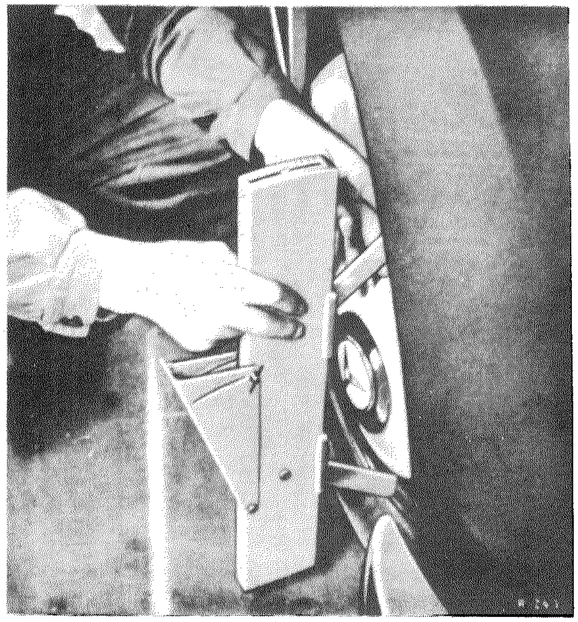


Fig. 40 — 3/27

ff) Place the gage in position as described under point dd) and again read off the value indicated.
Example: 4° 15′.

gg) **The difference between the two values is the caster.**

Example:

Left wheel

Reading at 20° left lock	= 7° 45′
Reading at 20° right lock	= 4° 15′
Difference left wheel caster	= 3° 30′

Note: It should be noted that left wheel caster must be greater when at left lock than at right lock, and right wheel caster must be greater at right lock than at left lock, since the car is designed to have positive caster.

If negative caster is found, there must be a major defect in the front axle (e.g. bent control arm etc.).

hh) Measurement at the right wheel should be carried out in the same way.

h) Toe-in of Front Wheels

The toe-in must be measured at the height of the horizontal diameter of the wheel and with the steering in a straight fore-and-aft position. For this purpose, Center Position Check Screw 186 589 00 23 must be screwed into the steering housing cover instead of the closing plug. When this is done, care must be taken to ensure that the point of the screw enters the centering bore in the steering shaft arm. The toe-in must be equally distributed at the left and right wheels. To ensure this, use should be made of Wheel-base Measuring Gage 136 589 07 21 in order first to line up the front and rear wheels so that they are parallel. If this equipment is not available, the alignment can be made with the aid of a straight-edge or it can be sighted out.

The toe-in must be measured with the vehicle normally loaded. When measuring the toe-in, the front wheels must not be pressed together at the rear.

Measurement is made by means of Track Measurement Gage 000 589 05 21. When measuring, the following procedure should be adopted:

aa) Set the distance between the rims at the front wheels at the rear on the gage. Fix in this position. (Fig. 40 — 3/28).

bb) Make a chalk-mark on the wheel at the point at which measurement is to be made.

cc) In order to obviate any difficulty which might be caused by rim run-out, measurement should be made at two places and the average taken. The vehicle should therefore be moved in the direction of travel a half-turn of the wheels so that the chalkmark is now at the front.

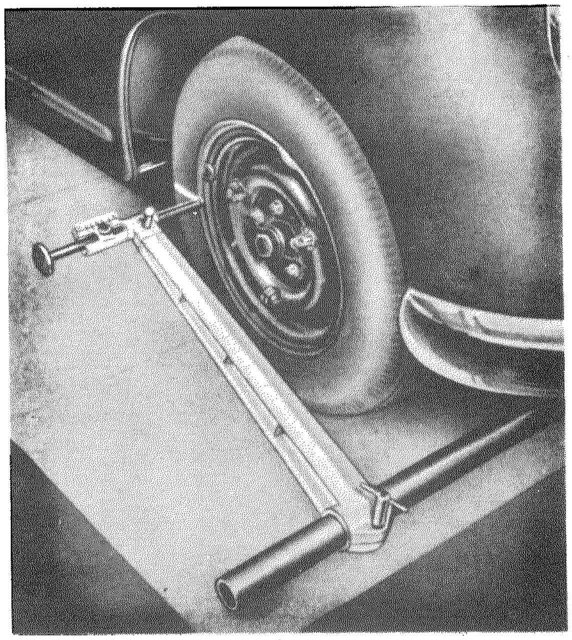


Fig. 40 — 3/28

dd) Now set the distance between the rims at the front on the gage and read off the difference between the distances at the front and at the rear. This measurement is the toe-in of the vehicle in mm.

Note: After adjusting the toe-in, a check must be made to see whether the steering knuckle arm of the left steering knuckle at left lock and the steering knuckle arm of the right steering knuckle at right lock strike against the lower steering knuckle support. The left and right steering locks must be limited by the steering knuckle supports and not by the steering housing (Fig. 40 - 3/29). (For further details see Job No. 33 — 2).

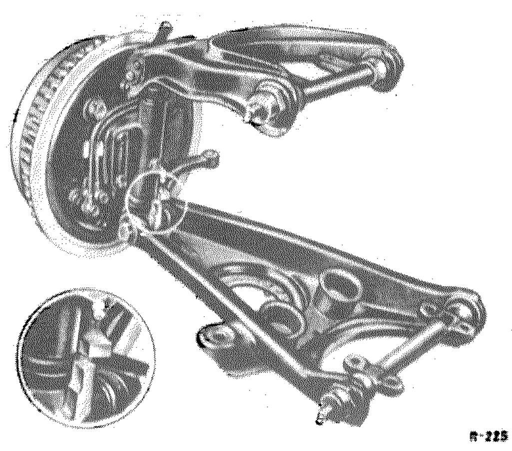


Fig. 40 — 3/29

i) Wheel-base

Measurement of the wheel base is made principally in order to assist in the adjustment of the toe-in of the front wheels. The wheel-base must only be measured when the center position check screw is actually screwed into the steering. Measurement is taken from the center of the rear axle shaft to the center of the front axle stub. Wheel-base Measuring Gage 136 589 07 21 is used (Fig. 40 — 3/30).

1 Centering bore of front axle stub
2 Wheel-base Measuring Gage 136 589 07 21
3 Centering bore of rear axle shaft

Fig. 40 — 3/30

Data Sheet for
Vehicle Measurement

Model: .... Mileage: ....

Chassis No: ....

First Licensed: ....

Owner: ....

....

Branch/Agent

....

....

Measured by: ....

Date: ....

Customer's complaint: ....

Make of tires, front: rear:

Condition of tires: front, left rear, left
front, right rear, right

Tire pressure checking and correction

Front: atm. rear: atm.

				Measurements: Before correction vehicle – curb condition	Before correction vehicle – normally loaded	After correction vehicle – curb condition	After correction vehicle – normally loaded
Front axle		Wheel bearing play in° (with optical axle gage)	left				
			right				
		Axle positioning distance difference from left to right in mm					
		Pivot point distance in mm	steering gear arm				
			relay arm				
		Toe-in or toe-out*	in °				
			in mm				
		Camber in °	left				
			right				
	Caster Measurement	Reading or camber left	at 20° left lock				
			at 20° right lock				
		Caster left	in °				
		Reading or camber right	at 20° right lock				
			at 20° left lock				
		Caster right	in °				
		Track angularity diff. in ° (with optical axle gage)	left				
			right				
Rear axle		Center positioning or lateral divergence	in mm				
		Axle positioning distance difference from left to right or rear axle misalignment	in mm				
			in °				
		Toe-in or toe-out*	in °				
			in mm				
		Caster in °	left				
			right				
Wheel-base difference from left to right			in mm				

* Toe-in = +, toe-out = –. The toe-in must be measured with the wheels settled in their neutral position. They must not be pressed together. The toe-in must be measured with the wheels in the straight fore-and-aft position. At the same time the steering must be in the center position. Toe-in and camber must be measured on an average of two diametrically-opposed points in order to obviate difficulties caused by any rim run-out.
(For further details on vehicle measurements, see Workshop Manual, Model 190, Job. No. 40–3).

Model		Tire pressure front	Tire pressure rear	Normal load capacity of vehicle in kg	Front axle: permissible wheel bearing play mech. in the axial direction in mm	Front axle: permissible wheel bearing play optical in min	Front axle: permissible axle-positioning distance diff. from left to right in mm	Front axle: Pivot point distance in mm	Front axle: Pivot point distance permissible deviation from steering gear arm to steering relay lever in mm	Front axle: Toe-in in mm	Front axle: Toe-in in °	Front axle: Camber in °	Front axle: Caster in °	Front axle: Track angularity diff. at 20° lock of inner wheel in °	Rear axle: permissible departure from center position in mm	Rear axle: permissible axle positioning distance difference from left to right or permissible rear axle misalignment in mm	Rear axle: permissible axle positioning distance difference from left to right or permissible rear axle misalignment in °	Rear axle: permissible toe-in (+) or toe-out (−) in mm	Rear axle: permissible toe-in (+) or toe-out (−) in °	Rear axle: Camber left in °	Rear axle: Camber right in °	permiss wheel-b differer from l to rig in mm
180 180 D	curb condition	1.7	1.8		0.005	10′	5	34 ± 2	2	0 - 2	0° - 0° 20′	± 0° to + 1° [3]	2°50′ - 4°	approx. −2°30′ [4]	2	3	0°25′	±2	±0°20′	approx. +1°30′	approx. +1°45′	5
	normally loaded			6 × 65 + 45									3°10′ - 4°10′							−2°30′ [5] to −3°30′ [6]	−3° to −4°	
190	curb condition	1.7	1.8		0.005	10′	5	34 ± 2	2	0 - 2	0° - 0° 20′	± 0° to + 1° [3]	2°50′ - 4°	approx. −2°30′ [4]	2	3	0°25′	±2	±0°20′	approx. +1°30′	approx. +1°45′	5
	normally loaded			6 × 65 + 45									3°10′ - 4°10′							−2°30′ to −3°30′ [6]	−3° to −4°	
190 SL	curb condition	1.7	1.8		0.005	10′	5	34 ± 2	2	0 - 2	0° - 0° 20′	± 0° to + 1° [3]	3° - 4°	approx. −2°30′ [4]	2	3	0°25′	±2	±0°20′	+0°30′ to + 1°	+0°45′ to +1°15′	5
	normally loaded			3 × 65 + 30									3°30′ - 4°30′							−2°40′ to −3°30′ [6]	−3°10′ to −4°	
219 220 a 220 S	curb condition	1.6	1.7		0.005	10′	5	30 ± 2	2	0 - 2	0° - 0° 20′	± 0° to + 1° [3]	2°50′ - 4°	approx. −0°30′ [4]	2	3	0°25′	±2	±0°20′	approx. +1°30′	approx. +1°45′	5
	normally loaded			6 × 65 + 45									3°30′-4°10′							−3°15′ to −3°45′ [6]	−3°45′ to −4°15′	
300 b 300 c	curb condition	1.7 1.7	1.9[1] 1.7[2]		0.005	10′	2	20^{+1}_{-3}	2	0 - 2	0° - 0° 15′	± 0° to + 1° [3]	2° - 3°	approx. −2°30′ [4]	2	3	0°25′	±2	±0°20′	approx. +1°15′	approx. +1°30′	5
	normally loaded			6 × 65 + 45									2°15′ - 3°30′							−3° [5] to −3°30′ [6]	−3°30′ to −4°	
300 S 300 S c	curb condition	1.8	2.0		0.005	10′	2	20^{+1}_{-3}	2	0 - 4	0° - 0° 30′	± 0° to + 1° [3]	2° - 3°	approx. −2°30′ [4]	2	3	0°25′	±2	±0°20′	approx. +1°15′	approx. +1°45′	5
	normally loaded			3 × 65 + 30									2°30′ - 3°30′							−1°45′ [5] to −2°15′ [6]	−2°15′ to −2°45′	
300 SL	curb condition	2.0	2.2		0.005	10′	2	18.5±2	2	2 - 4	0°15′ - 0°30′	± 0° to + 1° [3]	3°30′ - 4°30′	approx. −2°30′ [4]	2	3	0°25′	±2	±0°20′			5
	normally loaded			2 × 65 + 25									4° - 5°							−3° to −3°45′	−3° to −3°45′	

) Model 300 b.
) Model 300 c.
) As nearly as possible identical on both sides; permissible maximum difference 30′. The ideal is a camber of + 0°20′ to + 0°40′ with vehicle loaded.
) As nearly as possible identical on both sides at left and right lock. Maximum difference 30′. See also Workshop Manual, Model 190, Job No. 40 — 3.
) On models fitted with double-jointed swing axle, the camber is the same at the left and the right; in each case the camber value given for the left is applicable.
) On models fitted with single-jointed swing axle, the difference in camber between left and right is approx. 0°30′ with vehicle loaded. (The variation in camber left-right results from the design of the single-jointed swing axle where the connecting pin of the axle halves does not lie on the longitudinal axis of the vehicle).

Vehicle in curb condition = vehicle in running order with oil and water + full fuel tank + spare wheel + tool kit but without passengers and luggage.
normally loaded = vehicle ready for the road + load according to Table. (The two first figures indicate the load on the seats and the last one the weight in the trunk compartment).