

SAM WALKER

# MC-9 CRUSADER II



# MAINTENANCE MANUAL

January 1989

**NOTICE:**

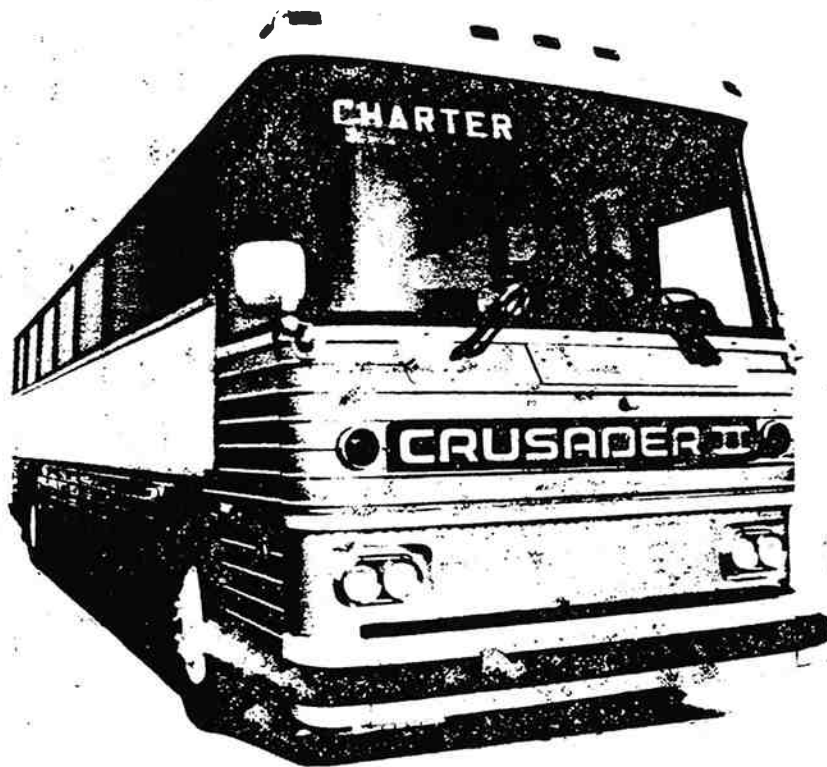
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# MC-9 CRUSADER II

## MAINTENANCE MANUAL

January 1989



**MOTOR COACH INDUSTRIES INC.**  
PEMBINA, NORTH DAKOTA, U.S.A. 58271-0349  
**MOTOR COACH INDUSTRIES LTD.**  
WINNIPEG, MANITOBA, CANADA R3G 0J8  
MANUFACTURERS OF INTERCITY COACHES



**TRANSPORTATION MANUFACTURING CORPORATION**  
ROSWELL, NEW MEXICO, U.S.A. 88202-6670  
MANUFACTURERS OF INTERCITY COACHES, TRANSIT BUSES & ROBOTIC TRAILERS

*Power Steering Oil =  
10W-40 Engine Oil*

*740 OIL  
= Detroit 11*

*Oil Types  
= page 10-3*



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# MC-9 MAINTENANCE MANUAL

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# MC-9 MAINTENANCE MANUAL

## INTRODUCTION

This manual contains operation, maintenance and overhaul information on MC-9 Model Coach. Information in this manual pertains to standard and commonly used optional equipment.

Vehicle operation from the driver's standpoint is contained in a separate operator's manual. Detroit Diesel engine information is found in a separate service manual. Allison transmission information is contained in the appropriate vendor service manual which, like the engine manual, is supplied separately.

*All information contained in this manual is based on the latest product information available at time of publication. We reserve the right to make publication changes at any time.*

## HOW TO USE THIS MANUAL

This manual is divided into major sections in the sequence shown on the section index. All major sections are divided into sub-sections containing descriptions, operation, maintenance, replacement, overhaul and specification information on related systems and components. A section index appears on the first page of each major section.

## PAGE AND ILLUSTRATION NUMBER

Manual pages and illustrations are numbered consecutively within each major section.

## SPECIFICATIONS

Service data, torque limits and tolerances are listed at the end of most sections under the heading "Specifications." Manufacturer's model or part numbers are provided where applicable for component identification. Detail service part numbers must be obtained from the MC-9 Model Parts Manual.

## SERVICE INFORMATION BULLETINS

Service Bulletins are issued, when required, to supplement or supersede information in this manual. Information in the bulletins should be noted and filed for future use.

## CUSTOMER SERVICE

Universal Coach Parts of Northlake, IL and Motor Coach Industries, Ltd., Service Parts Division of Canada, know your coach best and are interested in your complete satisfaction. Both offer genuine factory parts for this MC-9 Model and all other TMC/MCI Coach Models.

Service departments in both Roswell, N.M. (U.S. service) and in Winnipeg, Canada (all Canadian service) stand ready to serve you. Their addresses are:

Transportation Manufacturing Corporation  
Service Department  
P.O. Box 5670 (R.I.A.C.)  
Roswell, N.M. 88202-5670

Motor Coach Industries, Ltd.  
Service Parts Division of Canada  
1149 St. Matthews Ave.  
Winnipeg, Manitoba, Canada R3G0J8

**Proper maintenance is important to the safe and reliable operation of the MC-9 Model coach. The service procedures recommended and described in this manual are effective methods for performing service operations. In some instances, the use of special tools is recommended. These tools should be used when and as recommended.**

**Various WARNINGS, CAUTIONS and NOTICES are contained in this manual. They should be read carefully to minimize the risk of personal injury or the possibility that improper service methods may be used which could damage the coach and render it unsafe. It is important to note that these cautions and notices are not all inclusive. We could not evaluate and advise users of all conceivable ways in which service may be done or of the possible hazardous consequences of each way. We have not attempted to do this. Therefore, anyone who uses a service procedure or tool not recommended by the manufacturer should first satisfy himself that neither his safety nor vehicle safety will be jeopardized by the particular method he selects. REFER TO PAGE ii FOR CAUTIONARY INFORMATION PERTAINING TO WELDING.**

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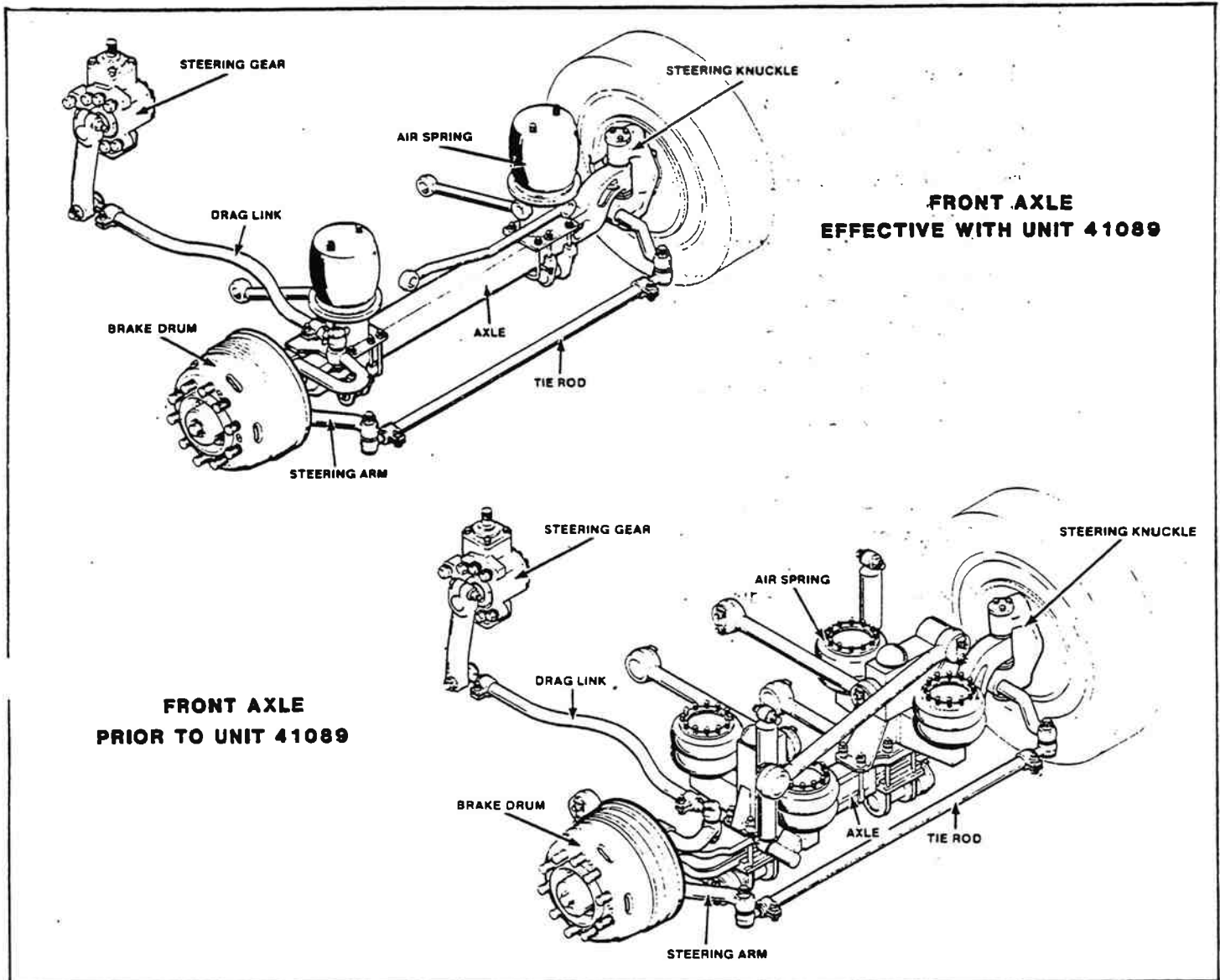


Figure 1-1. Front Axle Assemblies.

## FRONT AXLE ASSEMBLY

### DESCRIPTION

Effective with unit 41089 the front axle assembly is a tubular type of Reversed Elliot design. Axle construction consists of a tempered seamless steel tube with forged steel king pin ends. On units prior to 41089, the front axle is a forged steel drop center I-beam type. King pin ends are integral parts of the axle center. See figure 1-1.

Steering knuckles have grease fittings in both king pin bosses for lubrication of the knuckle bushings. The bushings are of the "Steer" type on all models after September 1986. Prior to that, the bushings are bronze. Covers and plugs prevent dust and moisture from entering bushings and serve as seals.

The brake shoe spider is doweled and bolted to the steering knuckle. Dowel pins are also used to locate air suspension mountings.

The two steering knuckle assemblies are connected to each other by a tie rod. Tie rod is threaded at each end and held in position by clamp bolts. Right-hand and left-hand threads are provided on the tie rod to facilitate toe-in adjustment. Stop screws installed at each end of axle center limit turning angle of front wheels.

On the tubular style axles, to detect development of fatigue cracks, approximately two quarts of diesel fuel are installed in the hollow tube section. Any axle which leaks should be replaced.

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## WELDING CAUTION

Since welding is a procedure which may be carried out either as allowed (explicitly or implicitly) by instructions in this manual or carried out by an independent decision of the coach owner/operator, the following information pertaining to welding should be read before beginning any welding procedure. The prohibitions and requirements contained therein must be followed during the welding procedure.

1. Welding must be done only by a qualified and experienced person.
2. Adequate ground contacts and barriers must be positioned as required to protect components (wiring, brake lines, hydraulic lines, etc.) from damage due to heat, contact by weld splatter arcing or other potentially damaging events associated with welding.
3. On any coach, turn battery switch to "OFF."
4. For coaches equipped with a battery equalizer, after performing step 3 above:
  - a. Disconnect the ground at the equalizer.
  - b. Disconnect the battery leads.
5. If coach has ATEC or DDEC, remove the ATEC/DDEC power control fuses.
6. Any applicable welding instructions or prohibitions given by a procedure must be heeded.



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Steering knuckles are bushed in the upper and lower pin bosses so that they may turn freely about the pins. Bushings are grooved on the inside to allow grease to flow uniformly to high-pressure areas. Grease fittings are installed at both upper and lower king pin bosses.

On the earlier MC-9 front axles the tapered steering knuckle pins are drawn into the axle center by tightening the nut at the upper end of the pin. On the later MC-9s a straight type knuckle pin is used. The straight type pin is held in place by draw keys in the knuckle.

Wheel bearings, air suspension, steering and brake parts which are mounted on the front axle are described in the applicable sections of this manual.

## LUBRICATION

Periodic lubrication according to the recommendations in the lubrication section of this manual should be carried out. Points which require lubrication are the steering knuckle pins, tie-rod ends and drag link ends. These are provided with grease fittings for pressure lubrication.

## MAINTENANCE

Periodic inspection of the front axle assembly should be made to see that all bolts are tight and that no damage or distortion has taken place. Suspension support stud nuts, U-bolt nuts, tie-rod arm and steering arm nuts, and stop screws should be checked and tightened if necessary to the torque specifications shown at the end of this section. Attention should also be given to the condition of the steering knuckle pin and bushings. If excessive looseness is found at this point, the bushings and pins should be replaced.

The axle manufacturer recommends that the bronze or "Easy Steer" king pin bushings be replaced when the range of side-to-side tire movement reaches .030 inch or when the bushings are worn to a maximum of .010 inch on their diameter.

**NOTE: These measurements are made with the wheel bearings tightened on the spindle.**

With new bushings installed, the range of side-to-side tire movement should not exceed .010 inch maximum. Refer to Figure 1-2.

Looseness in the steering linkage under normal steering loads is sufficient cause to immediately check all pivot points for wear, regardless of accumulated mileage. Steering linkage pivot points should be checked each time the axle assembly is lubricated. If any indication of lateral movement is found, cross tube ends should be removed for inspection. Looseness at the steering linkage pivot points can be visually detected during movement of the vehicle steering wheel.

Steering knuckles, king pins, and bushings may be replaced without removing the axle from the coach.

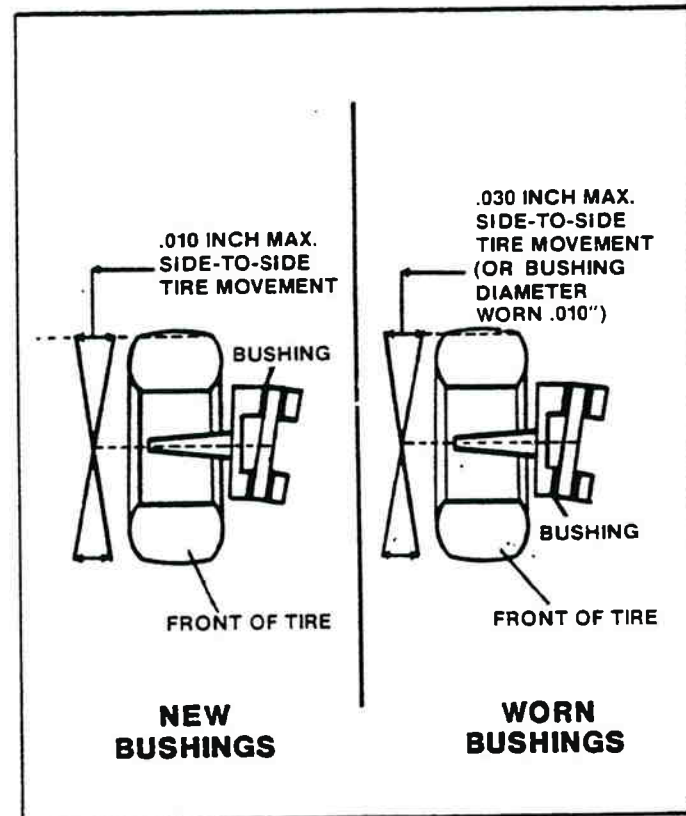


Figure 1-2. Side-To-Side Tire Movements With New And With Worn King Pin Bushings.

If extensive overall work or straightening of the front axle center is necessary, the axle should, of course, be removed.

**WARNING: Do not attempt to repair, remove or reinstall front axle with the vehicle supported by jacks only.**

### FRONT AXLE REMOVAL (Prior to unit 41089)

To remove the entire front axle assembly first block the rear wheels to prevent the vehicle from rolling. Raise the front end of the coach with jacks until the bottom of the coach body is approximately 18" (457.2 mm) from the floor. Block the body in this position as indicated in Section 3 under Coach Jacking Points.

**CAUTION: Do not raise the body in such a way that the entire weight of the front axle will hang on the suspension bellows assemblies. Damage to the bellows may result.**

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1. Remove tires and wheels from axle. See Section 15.
2. Exhaust air pressure from the suspension air tank by opening the drain cock at the bottom of the air filter.
3. Disconnect the height control valve link, and pull down on height control valve arm to exhaust air from the front inner beams.
4. Disconnect the hose from the front brake chambers.
5. Disconnect the steering drag link.
6. Disconnect both ends of all radius rods as outlined in this section under Radius Rods.
7. Remove nuts from all bolts attaching air springs to the bracket assemblies.
8. Remove shock absorbers as outlined in this section under Shock Absorbers.
9. Lower the axle assembly on jacks until air spring bead ring bolts are cleared of the suspension supports. The axle can now be carefully removed from under the vehicle.

Reinstallation of the axle assembly is the reverse of removal. Make sure that air springs mounting pads on axle towers are clean.

### FRONT AXLE REMOVAL (Effective with Unit 41089)

To remove the entire front axle assembly first block the rear wheels to prevent the vehicle from rolling. Raise the front end of the coach with jacks until the bottom of the coach body is approximately 18" (457.2 mm) from the floor. Block the body in this position as indicated in Section 3 under Coach Jacking Points.

**CAUTION: Do not raise the body in such a way that the entire weight of the front axle will hang on the suspension bellows assemblies. Damage to the air springs may result.**

1. Remove tires and wheels as detailed in Section 15.
2. Exhaust air pressure from the suspension air tank by opening drain tank at bottom of the air filter.
3. Disconnect the height control valve link, and pull down on the height control valve arm to exhaust air from the front inner beams.
4. Disconnect the hose from the front brake chambers.
5. Disconnect the steering drag link.
6. Disconnect both ends of all radius rods as outlined in this section under Radius Rods.

7. Remove nuts from all bolts attaching air springs lower bead rings to the axle tower.

8. Remove shock absorbers as outlined in this section under Shock Absorbers.

9. Lower the axle assembly on jacks until air spring bead ring bolts are cleared of the suspension supports. The axle can now be carefully removed from under the vehicle.

Reinstallation of the axle assembly is the reverse of removal. Make sure that air springs mounting pads on axle towers are clean.

### STRAIGHTENING AXLE CENTER - Before Unit 41089

The earlier MC-9 front axle center is a steel forging, heat treated for strength and resistance to bending and torsional strain. If the center is bent or twisted less than approximately 5 degrees from the original shape, it may be straightened. However, it is recommended that this work be done only by mechanics who are thoroughly familiar with such operations and where the proper facilities are available. Parts which are distorted more than approximately 5 degrees from the original shape must be replaced, since such distortion exceeds the elastic limit of the material causing fractures which may result in failure under ordinary operating conditions.

**CAUTION: Do not attempt to straighten front axles with tubular style axle centers. Never apply heat to a front axle forging. Front axle should be straightened cold only.**

## STEERING KNUCKLE

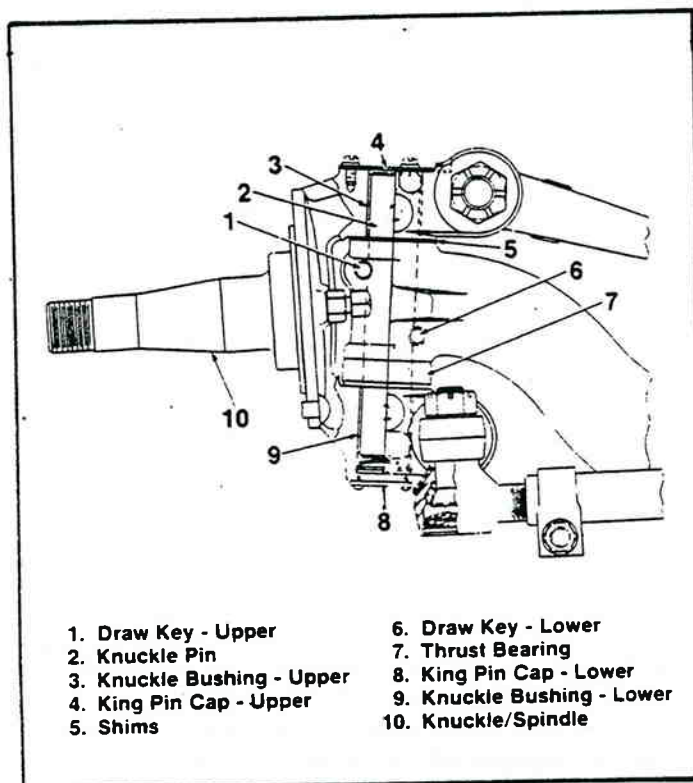
### DESCRIPTION

Later MC-9 coaches have front axles with straight knuckle pins. The earlier MC-9 models have axles with tapered knuckle



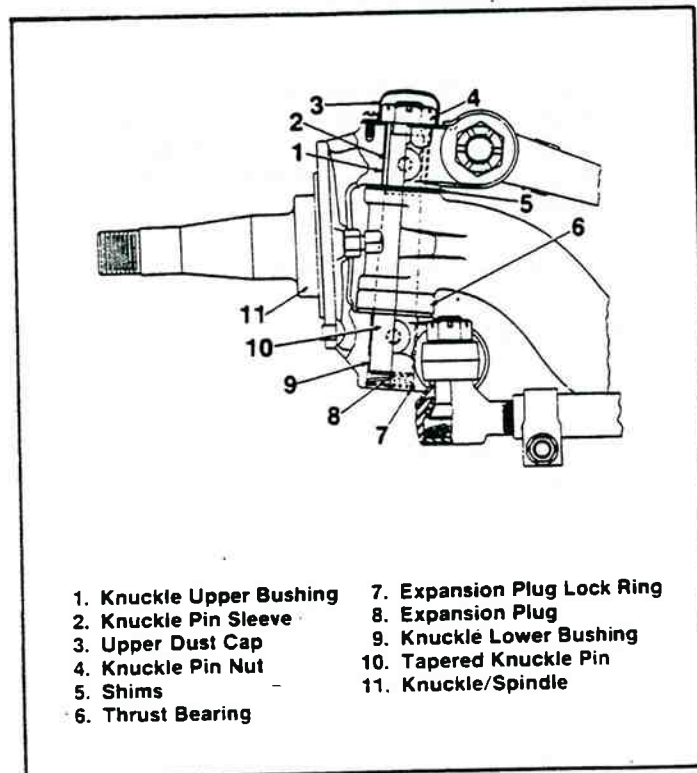
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pins. Figures 1-3 and 1-4 show the steering knuckle construction of the two different axles.



- |                            |                            |
|----------------------------|----------------------------|
| 1. Draw Key - Upper        | 6. Draw Key - Lower        |
| 2. Knuckle Pin             | 7. Thrust Bearing          |
| 3. Knuckle Bushing - Upper | 8. King Pin Cap - Lower    |
| 4. King Pin Cap - Upper    | 9. Knuckle Bushing - Lower |
| 5. Shims                   | 10. Knuckle/Spindle        |

Figure 1-3. Steering Knuckle (Later MC-9)



- |                          |                             |
|--------------------------|-----------------------------|
| 1. Knuckle Upper Bushing | 7. Expansion Plug Lock Ring |
| 2. Knuckle Pin Sleeve    | 8. Expansion Plug           |
| 3. Upper Dust Cap        | 9. Knuckle Lower Bushing    |
| 4. Knuckle Pin Nut       | 10. Tapered Knuckle Pin     |
| 5. Shims                 | 11. Knuckle/Spindle         |
| 6. Thrust Bearing        |                             |

Figure 1-4. Steering Knuckle (Earlier MC-9).

## STEERING KNUCKLE REMOVAL

1. Block the rear wheels to prevent the vehicle from rolling. Jack up front of coach so that tires clear floor. Block up securely at this position and remove jacks. Refer to Section 3. Coach Jacking Points.

**WARNING: Do not attempt to disassemble or perform knuckle repair with vehicle supported by jacks only.**

2. Remove front wheels, hubs and bearings as directed in Section 15.

3. Remove brake chambers and brake shoe hardware from steering knuckle. Detach brake shoe spider from knuckle and remove spider, camshaft and slack adjuster as an assembly.

4. Remove drag link and tie rod from steering arm. Refer to Steering, Section 11.

5. Remove nuts from steering arms and drive arms out of steering knuckles.

**NOTE: It is not necessary to remove steering arms unless service or inspection is necessary.**

6. Upper and lower knuckle pin covers are present on the newer style axles with straight type knuckle pins. The original MC-9 axle, with the tapered knuckle pin, has a cover on the top of the pin only. Remove the capscrews from the cover(s) and the gasket(s) beneath the cover. See figure 1-5.

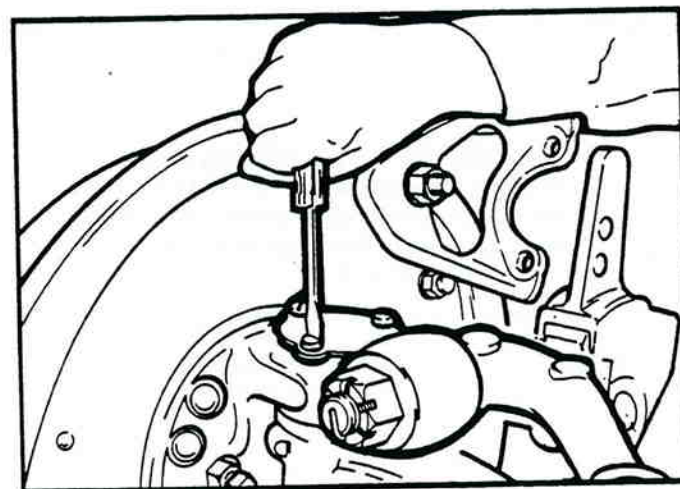


Figure 1-5. Removing Knuckle Pin Cover.

The tapered type knuckle pin has an expansion plug and lock ring at its lower end. Remove the lock ring with a pair of snap ring pliers. Dislodge and remove the expansion plug with a small drift.

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7. The straight style knuckle pin is retained in the knuckle by means of threaded draw keys at the top and bottom of the knuckle. Remove the draw keys as follows:

a. Loosen locknut on key and turn it out to the end of the threads. The end of the nut should be flush with the draw key end.

b. With a brass drift and a hammer, firmly strike the end of the nut to loosen the draw key.

**NOTE: Failure to strike the draw key squarely may result in a damaged key, causing removal difficulties.**

c. Remove the nut and key from the axle center.

The tapered style knuckle pin is retained in the knuckle by a nut on the threaded upper end. Remove the knuckle pin cotter pin and nut. Refer to figure 1-6.

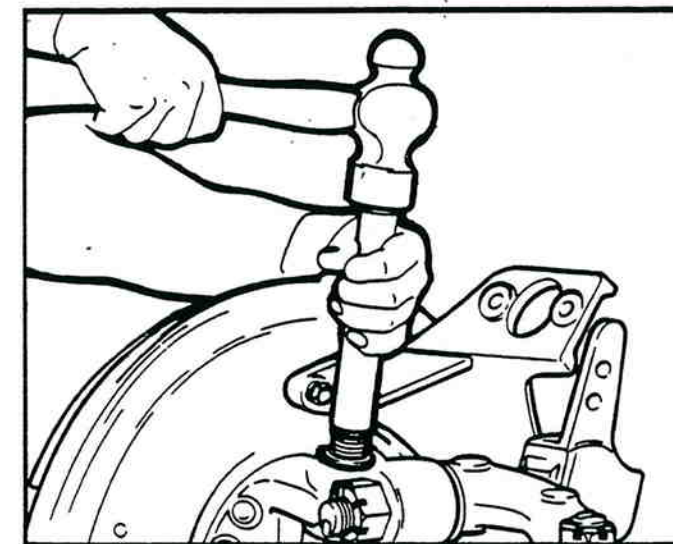


Figure 1-8. Removal of Tapered Style Knuckle Pin.

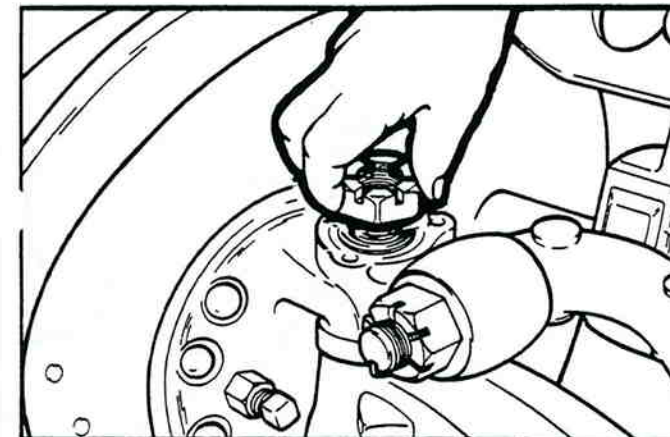


Figure 1-6. Removing Nut From Top of Tapered Knuckle Pin.

8. The knuckle pin, straight or tapered, is removed from the knuckle by tapping it out using a **bronze** drift. See figures 1-7 and 1-8.

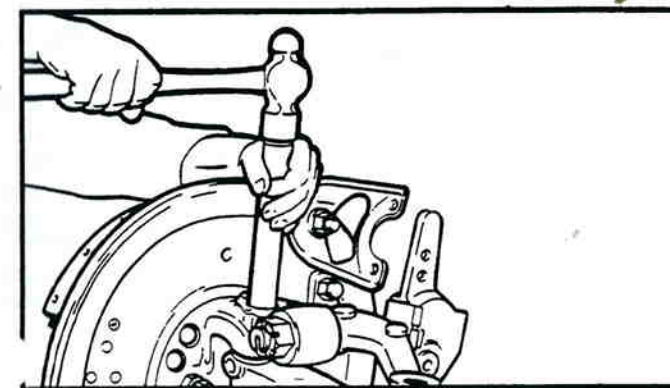


Figure 1-7. Removal of Straight Style Knuckle Pin.

The following precautions and procedures will allow the pins to be removed with minimum danger of personal injury or damage to the knuckle pins and bushings.

a. Straight type knuckle pins may be removed through either the top or bottom of the knuckle. Tapered pins can only be removed through the bottom of the knuckle.

b. **Do not** strike the knuckle pin directly with a steel hammer. The pins are made of hardened steel. Personal injury can result from flying chips and splinters and, in the case of the tapered style pin, the threads on the upper end will be damaged.

c. If the bushings are not to be replaced, precautions must be taken not to damage them with the bronze drift. Grind off any flaring on the end of the drift which will contact the pin. Wrap tape around the drift 1/16" thick for the first inch from the end of the drift. This is especially important when the bushings are of the "Easy Steer" type used with the straight type knuckle pin.

9. If servicing the straight pin type knuckle, lift off the knuckle assembly, thrust bearing and shims. If servicing the tapered pin style knuckle, remove the knuckle pin sleeve, and lift off steering knuckle, thrust bearing, spacing washers, and backplate assembly. Refer to figure 1-9.



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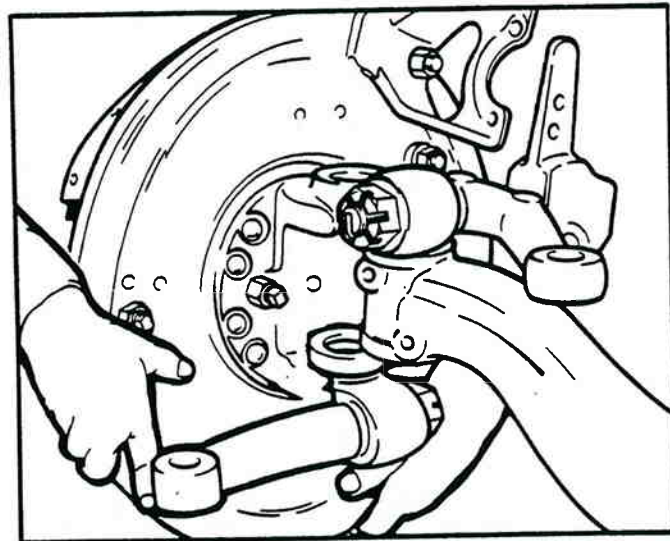


Figure 1-9. Removing Steering Knuckle From Axle.

If seal is being installed in a knuckle which has bronze bushings:

1. Place steering knuckle bottom side up in a vise equipped with soft metal protectors. Position upper knuckle boss (top end down) between jaws of vise and lock securely.

**NOTE:** Seals must be oriented as shown. Reversal of a seal will prevent purging of grease.

2. With the top end of the knuckle held firmly in this position, place the seal over the knuckle counterbore, with the rubber lip facing up.

3. Using a suitable sleeve and a bronze drift, tap the seal into the knuckle until it bottoms against the bushing or counterbore. See figure 1-11.

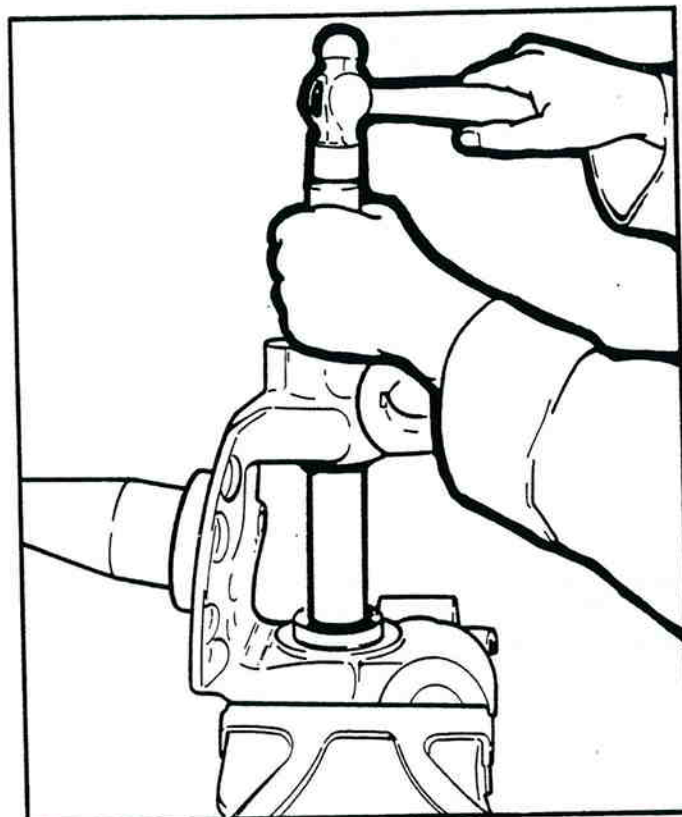


Figure 1-11. Installation of Grease Seal (Bronze or "Easy Steer" Bushed Knuckles).

## STEERING KNUCKLE SEALS

Inspect the grease seals for tears, rips and deterioration. Do not remove the seals from the steering knuckle unless replacement is necessary or if the knuckle is to be rebushed. If seal is to be removed, pry it out with a screwdriver. Refer to figure 1-10.

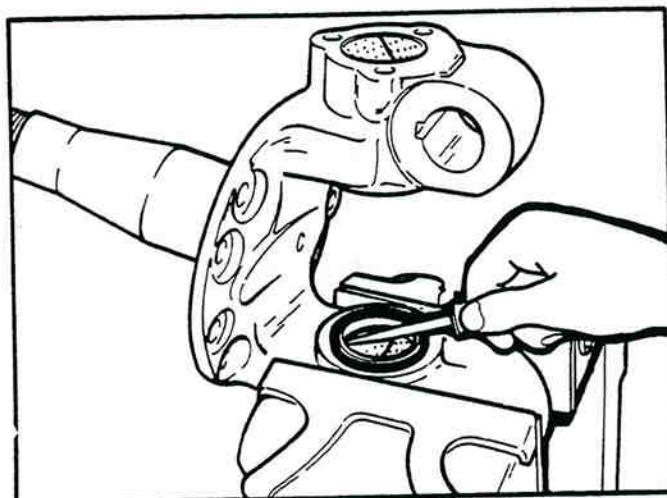


Figure 1-10. Grease Seal Removal.

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4. Repeat this procedure by reversing the knuckle for the lower seal.

**NOTE:** In the absence of a suitable driver, do not tap the seal in with a hammer. Set the seal in the opening and cover it with a rigid flat metal plate. Tap the plate with a hammer directly over the seal until the seal is flush with the machined surface. Do not drive the seal any further.

If the seal is installed in a knuckle which has "Easy Steer" bushings:

1. Follow instructions 1 and 2 for above bronze bushed knuckles.

2. Using a suitable sleeve and a bronze drift, tap the seal into the knuckle bore until it is flush with the machined surface as shown in figure 1-12.

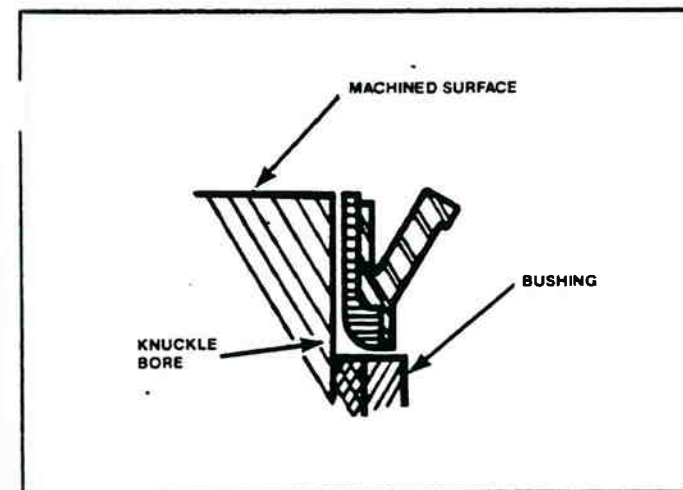


Figure 1-12. Grease Seal Installed in Knuckle With "Easy Steer" Bushings.

## STEERING KNUCKLE BUSHINGS

The earlier MC-9 front axles have bronze steering knuckle bushings; the later MC-9 front axles have Rockwell "Easy Steer" bushings.

The tool shown in figure 1-13 should be used when removing or replacing the bushings. The tool shown in figure 1-14 should be used to size the bushings.

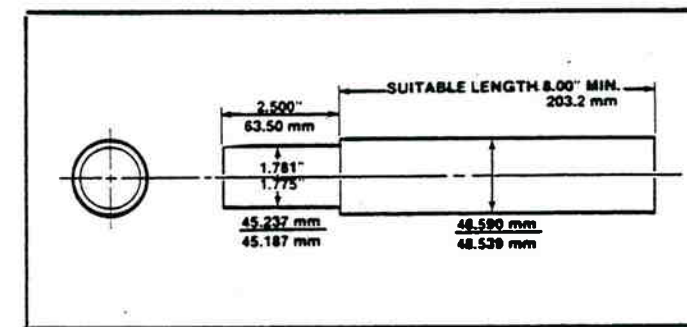


Figure 1-13. Tool - King Pin Bushing Removal & Installation.

These tools may be used with either type of bushing, but the diameter of the cutting surface of the reamer will vary, depending on whether the reamer is used on bronze or "Easy Steer" type bushings.

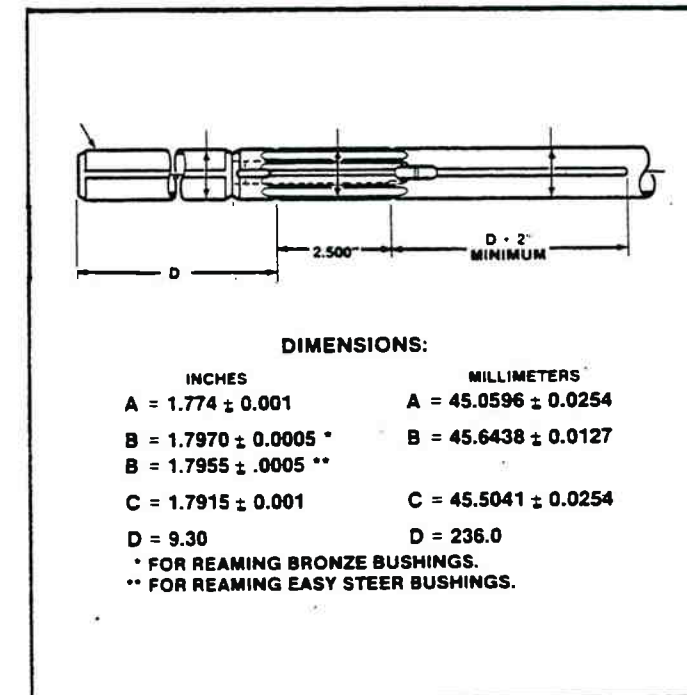


Figure 1-14. Reamer - King Pin Bushing.

The tools can be made from round steel bar stock. A reaming tool (part number 20-312) for the "Easy Steer" type bushings may also be purchased.



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## STEERING KNUCKLE BUSHING REMOVAL AND INSTALLATION

The tool shown in figure 1-13 and a press of at least 5-ton capacity is required to remove or install the bronze bushings in the earlier MC-9 front axle knuckle, or to remove or install the "Easy Steer" bushings in the front axle knuckles of the later MC-9 models.

Before beginning the removal or installation of the bushings, fix the steering knuckle firmly on the bed of the press to avoid knuckle slippage during the bushing removal or installation.

To remove the bushings, insert the tool's pilot end into the bore of the bushing and press the bushing from the knuckle.

The procedure for installing the bushings will vary, depending on whether the bushing is of the bronze or "Easy Steer" type.

To install bronze bushings:

1. Align grease holes in bushing and in knuckle. The circumferential grease groove should be positioned toward the end of the king pin.
2. First press bushing into knuckle approximately  $\frac{1}{8}$ "', relieve press pressure and check alignment of tool and bushing.
3. The bushing can now be pressed in until it is .135" to .165" from the inside machined surface of the knuckle. This applies to both upper and lower bushings. **Do not install seals until after the reaming operation is complete.** Refer to figure 1-15.
4. Using the reamer shown in figure 1-14, finish the bushings to 1.7965-to-1.7975 -inch diameter. The bushings must also be in line with each other to within .001 inch. Refer to the sizing procedure described later in this section.

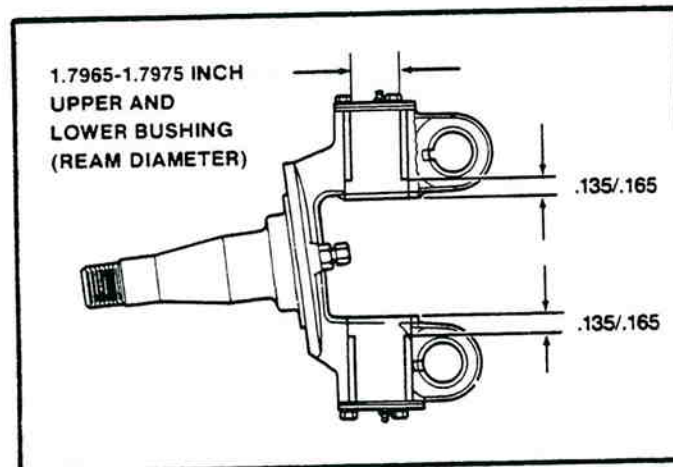


Figure 1-15. Bronze Bushing Installation.

To install "Easy Steer" bushings:

1. Press the upper bushing approximately  $\frac{1}{8}$ " into the knuckle and relieve the press pressure. Check alignment of tool and bushing.
2. The bushing can now be pressed to the desired depth of 0.477 inch to 0.507 inch from the top of the machined surface. See figure 1-16.
3. Place the knuckle bottom side up and repeat step 1.
4. Press the lower bushing in to a depth of 0.412 to 0.442 inch from the bottom machined surface. See figure 1-16. **Do not install the grease seals until the reaming is completed.**
5. Using the reamer shown in figure 1-14, finish the bushings to 1.7950-to-1.7960-inch diameter. The bushings must also be in line with each other to within .001 inch. Refer to the sizing procedure described later in this section.

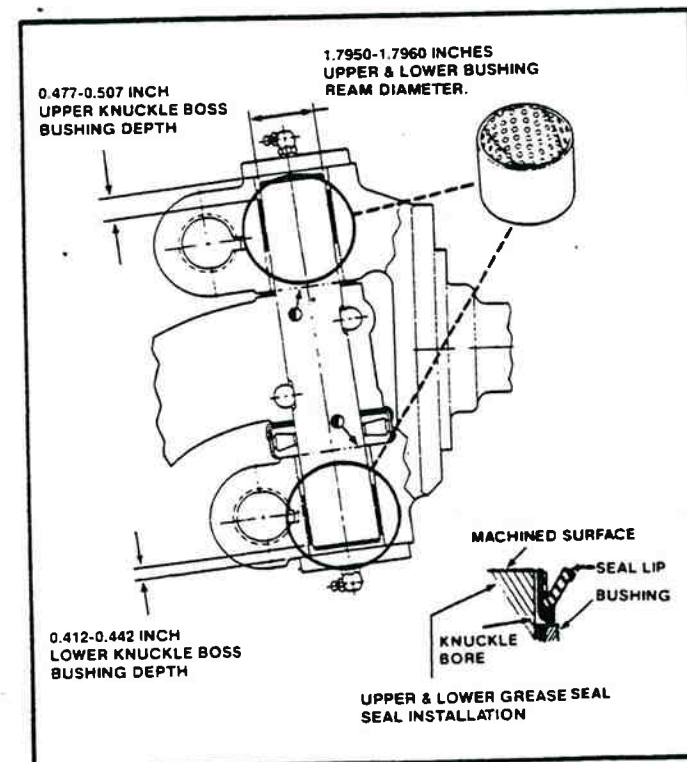


Figure 1-16. Easy Steer Bushing Installation and Grease Seal Installation.

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## SIZING NEW BUSHINGS

There are several methods of sizing the bushings but the only method which will give accurate size and alignment of the bore is reaming. Honing and burnishing do not provide good bushing bore alignment. Easy steer bushings are made of too resilient a material for them to be sized with a burnishing ball or bar.

The recommended procedure for reaming the bushings is as follows:

1. Position the knuckle in a vise with soft metal shims to protect the knuckle. It is preferable to have the king hole vertical.
2. Gently slide the reamer pilot through the upper bushing until the reamer cutters begin to engage the upper bushing. See figure 1-17.

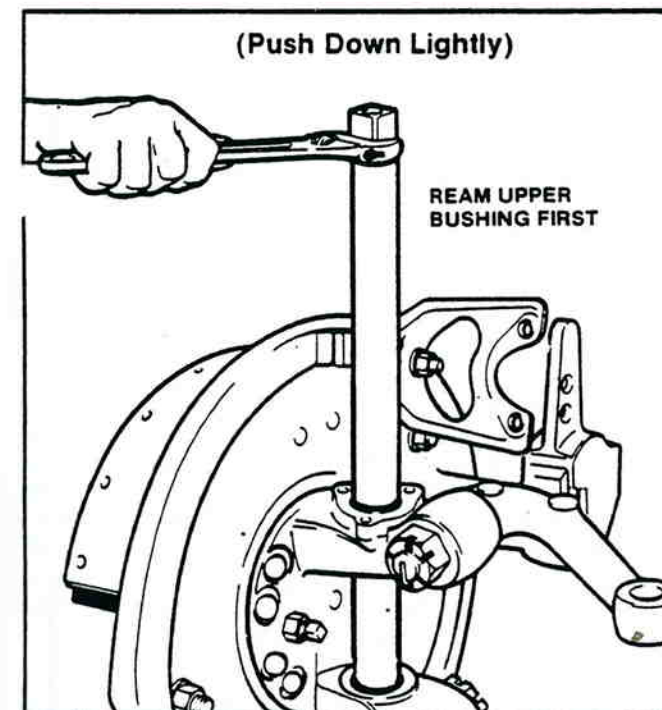


Figure 1-17. Size Upper Bushing.

3. Begin rotating the reamer and applying a light downward pressure with your hand at the same time. Do not force the reamer by applying too much downward force. The reamer can be rotated at any speed but should be done smoothly.

4. After the reamer sizes most of the upper bushing, support the reamer so that it does not drop to the bottom bushing as it completes the cut.

5. After the upper bushing has been sized, gently slide the reamer through until it engages the bottom bushing. See figure 1-18. Repeat steps 3 and 4 for the bottom bushing.

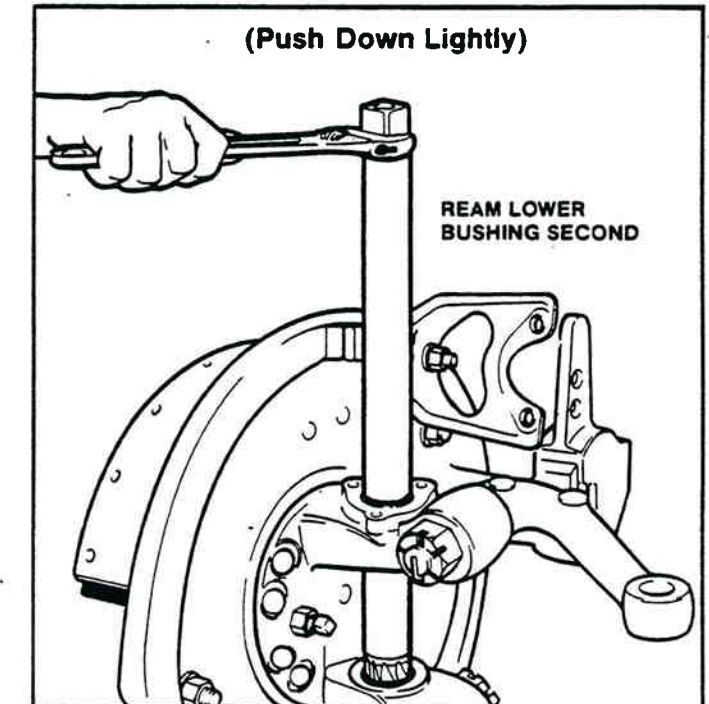


Figure 1-18. Sizing Lower Bushing.

6. Slide the reamer out through the bottom. If the reamer must be pulled back up through the bushing, do so only while rotating the reamer in reverse. Any other way will damage the bushings.
7. Clear bushing debris from bores before installing seals.

## GREASE SEAL INSTALLATION

After the reaming operation is completed, install the grease seals. See the procedure as described earlier in this section.



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## REASSEMBLY - AXLE CENTER TO STEERING KNUCKLE

### THRUST BEARING INSTALLATION

The earlier MC-9 front axle does not have a seal at the thrust bearing under the steering knuckle. The later MC-9 front axles have a seal at the thrust bearing.

**NOTE:** Some of the thrust bearings used in front axles have the word "TOP" stamped on the flat face of the bearing retainer. The stamped word "TOP" should not be used for bearing installation purposes. Refer to the following instructions for proper bearing positioning.

Prior to putting the thrust bearing in the axle center-knuckle assembly, if the bearing has a seal, assemble the bearing and seal by holding the bearing so that the opening between the bearing cage and the retainer is up. Then snap the seal securely over the opening. See figure 1-19.

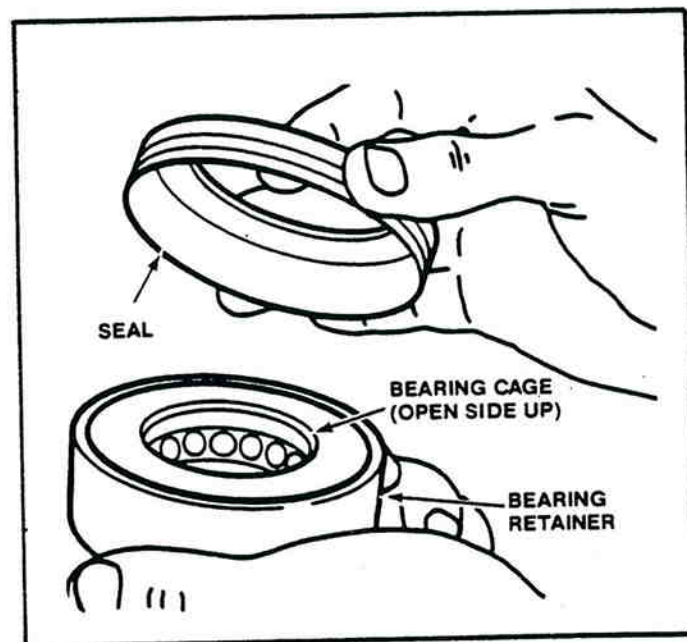


Figure 1-19. Bearing And Seal Assembly.

The assembly of the axle center and knuckle now proceeds as follows:

1. Position and support the steering knuckle assembly on the axle center.

2A. Thrust Bearings With Seals — With the seal positioned on top of the thrust bearing, slide the bearing and seal assembly between the lower face of the axle center and the upper face of the knuckle yoke. See figure 1-20.

**NOTE:** The thrust bearing must be seated on the upper face of the lower knuckle yoke. The seal must cover the opening between the bearing cage and retainer. Always install the bearing and seal assembly in the axle with the seal on top. See figure 1-20.

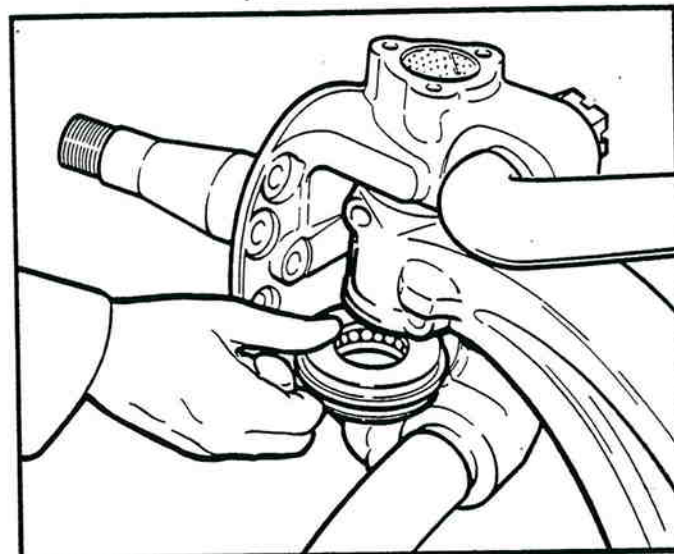


Figure 1-20. Installing Knuckle And Seal Assembly.

2B. Thrust Bearings Without Seals — With the open side of the thrust bearing facing down, slide the bearing between the lower face of the axle center and the upper face of the lower knuckle yoke. See figure 1-21.

**NOTE:** The thrust bearing must be seated on the face of the lower knuckle yoke. The bearing should always be installed in the axle with the closed retainer face up and the cage face (with the opening) down. See figure 1-21.

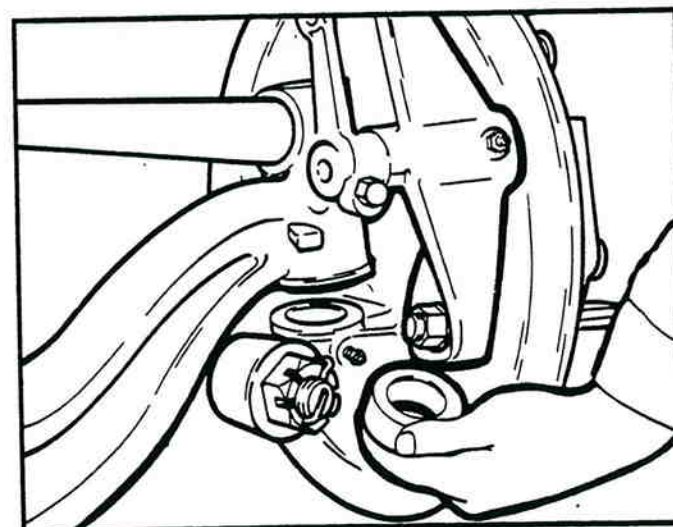


Figure 1-21. Installing Thrust Bearing (No Seal).

# MC-9 MAINTENANCE MANUAL

3. Shim the knuckle and axle assembly. Shims are positioned between the upper axle center face and the upper knuckle yoke. See figure 1-22. Shims are used to limit the vertical movement of the knuckle with respect to the axle center and king pin. Some clearance in this area is required, however, to allow grease to purge from the upper bushing area. Carefully inspect shims, new or used, to be sure none are kinked, bent or torn. Discard any that are damaged. Select a quantity of shims to obtain as little vertical end play as possible. Lift the knuckle in position and slide the shim pack between the axle center boss and the knuckle upper yoke.

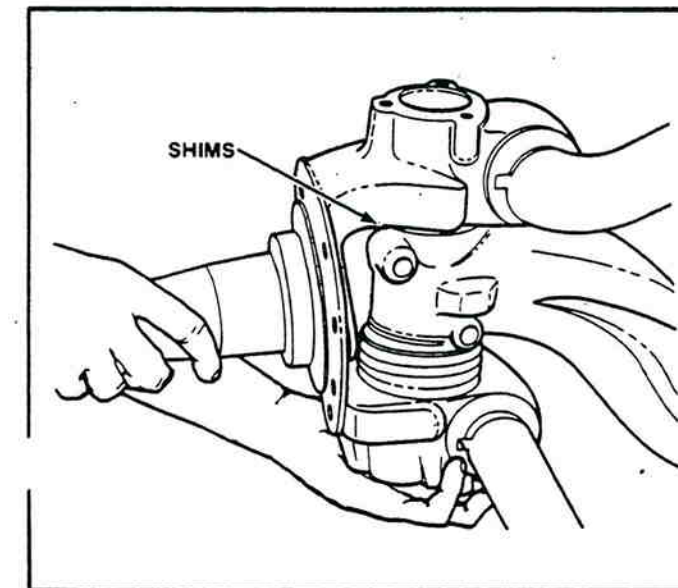


Figure 1-22. Shimming Axle And Knuckle.

Alignment of the king pin hole in the knuckle and axle center is now required for king pin installation. While looking down through the king pin hole, shift the knuckle to align it with the axle center. Now align the shims to be flush with the axle center around the entire circumference of the king pin hole. The shim alignment can only be done through the upper bushing. Any protrusion of any portion of the shim will prevent the king pin from passing through and result in a damaged shim.

**NOTE:** Shims are delicate and sharp. Extreme caution should be exercised while aligning shims so as not to cut fingers or bend the inside diameter of the shims. Damage to the shims during this entire procedure requires disassembly and replacement of the damaged parts.

4A. To install the straight type king pin:

a. Smear clear chassis grease on the bottom half of the king pin and insert it slowly into the top of the knuckle. King pins are marked with the Rockwell logo, part number and the word "TOP" on the top end of the pin. Rotate the pin to align the draw key slots with the draw key holes in the axle. Slowly push the pin through the bushing, seal and shim pack. The pin should slide through the shim pack freely. Any resistance greater than a

hand push indicates misalignment. Remove the pin and realign the components. After the pin is inserted through the shim pack, a brass hammer may be used to assist in installation. Care must be taken not to dislodge the lower grease seal as the king pin enters the lower knuckle yoke.

b. Center the king pin in the knuckle to equalize the distance from the top and bottom surfaces. For knuckles with a bottom welsh plug arrangement, increase the bottom gap to allow for assembly of the welsh plug and snap ring.

c. Lightly tap the draw keys into position, flat side toward king pin; do not firmly seat them until after the end play measurement. Install the lower draw key from the front side and the upper draw key from the rear. Assemble so the wedged ends of the two keys contact the king pin and torque to restrict pin from moving while the end play is measured. The procedures for end play measurement and for seating the draw keys will be found later in this section.

**NOTE:** Never install both draw keys from the same side.

4B. To install the tapered type king pin:

a. Smear chassis grease on the tapered section of the pin and insert the pin from the bottom of the knuckle.

b. Smear chassis grease on the inside and outside of the king pin sleeve and insert it into the upper bushing bore over the king pin.

c. Install king pin nut, and torque only enough to seat the king pin for end play measurement.

d. Measure end play according to the procedure which is given later in this section and adjust if necessary.

e. Torque nut to 350-390 ft. lbs. (475-529 Nm) and install cotter key. If the cotter hole does not align with the nut castellation, advance the nut. Do not back the nut off.

5. Measurement of knuckle end play:

**NOTE:** A procedure for measuring end play with axle installed on coach and with wheels and tires installed can be found later in this section.

**NOTE:** The use of shim gauges (feeler gauges) for measurement of clearance tolerances on steering knuckles is not recommended. These will not give an accurate reading of end play. Use only a dial indicator.

**NOTE:** End play is the free movement of the steering knuckle up and down along the axis of the king pin. Some end play is required to prevent binding of the knuckle while turning and to provide a passage for grease to purge during bushing lubrication. Excessive end play can cause interference between the king pin and end caps or retainers.



# MC-9 MAINTENANCE MANUAL

a. With king pin caps off, turn the knuckle to the straight ahead position. Take a rubber mallet and repeatedly strike the top draft of the knuckle as shown. This will shift all of the components down and remove grease layers so an accurate reading may be taken (figure 1-23).

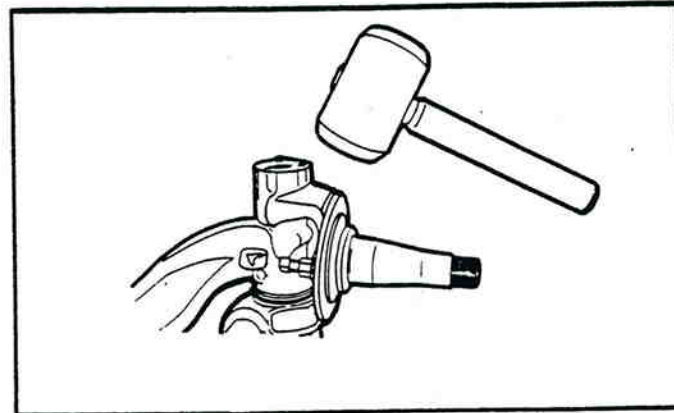


Figure 1-23. Striking Knuckle.

b. Attach the dial indicator with a "C" clamp or magnetic base to the knuckle spindle such that the knuckle can be turned freely as shown (figure 1-24).

c. Place the dial indicator plunger on the exposed end of the king pin so that its line of action is approximately parallel to the king pin center line (figure 1-24).

d. Zero the dial indicator.

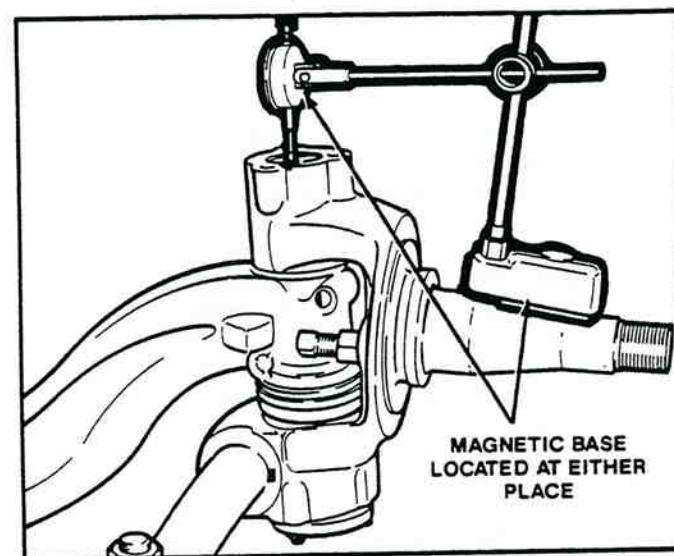


Figure 1-24. Dial Indicator Installation.

e. Measure the knuckle clearance (end play) by using a suitable lever to lift the knuckle while observing the dial indicator. Make a note of the measurement (figure 1-25).

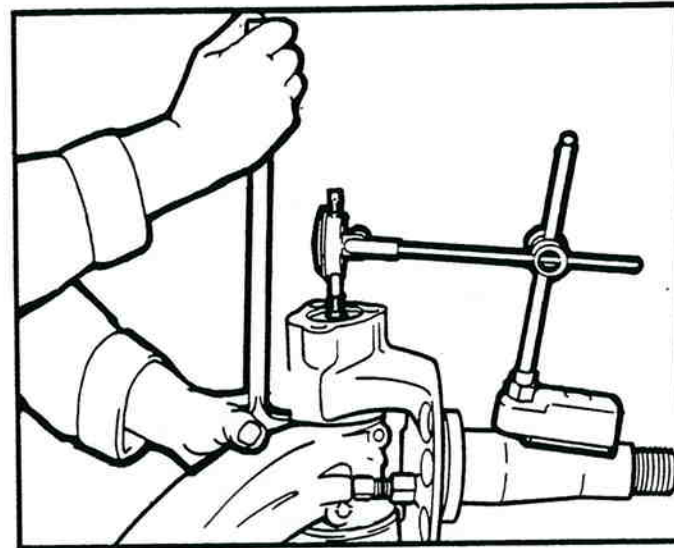


Figure 1-25. Measuring End Play.

A small hydraulic jack under a block of wood can be used beneath the knuckle to provide the necessary lift. Keep lifting the knuckle until the dial indicator reading levels off (figure 1-26).

**CAUTION:** When using a hydraulic jack, be sure that the axle is supported by two jack stands. Raising the end in this manner may cause an axle supported only in the center to tip and fall, causing personal injury.

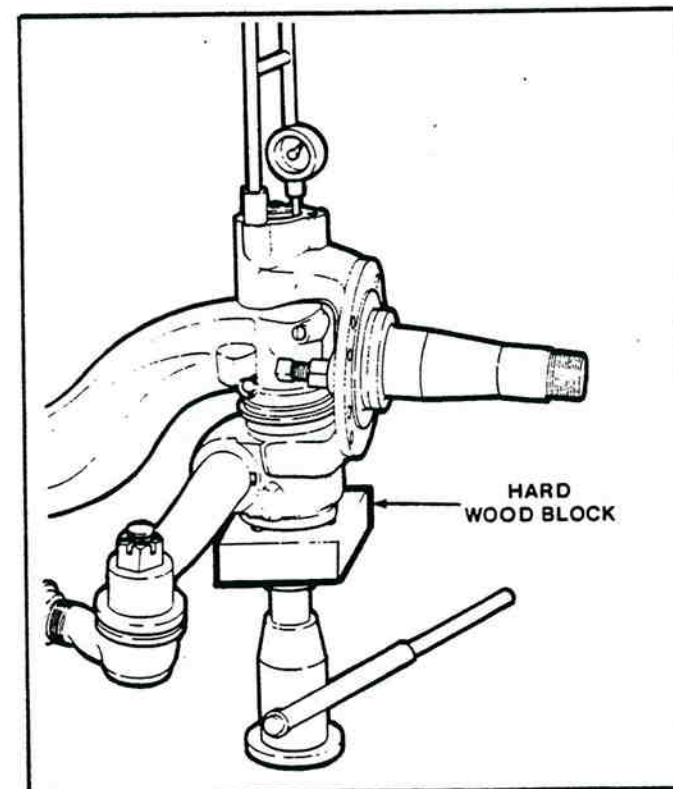


Figure 1-26. Lifting Knuckle With Jack.

# MC-9 MAINTENANCE MANUAL

f. Repeat steps 5a. through 5e. with the knuckle in the full right and left turn positions. This is necessary to be sure that no binding or excessive play is present during turns.

**IMPORTANT:** If binding exists or zero end play is measured anywhere in the full travel of the knuckle, remove shims as required to obtain end play of .001" to .025".

**IMPORTANT:** After measuring knuckle clearance (end play) of over .025", add shims between upper knuckle pin boss and axle center end, as required, to obtain an end play of .001"-.025" (.02-.64 mm) through full range of turn.

**NOTE:** Normal seating of the thrust bearing, seal and shims will increase the end play reading after a short time in service.

6. Seating Draw Keys — The knuckle pins on later MC-9 units are retained by draw keys. After the specified end play is obtained, seat the draw keys firmly with a hammer and drift (figure 1-27).

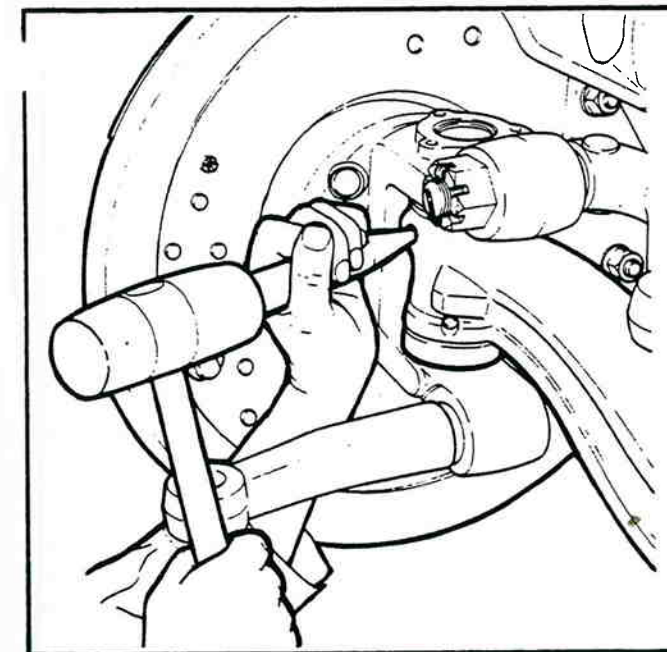


Figure 1-27. Seating Draw Keys.

**IMPORTANT:** Even though they are threaded, the keys must be solidly seated in this manner. The nut torque on the threaded design is only sufficient to hold the key in position and is not adequate to properly seat the key.

Install flanged locknut and torque to 30-40 lb. ft.

7. Securing Tapered King Pins — On earlier MC-9 coaches with drop forged axle centers (which have tapered king pins), the procedure for securing the pin is given in step 4B.

8. Installation of King Pin Caps and Welsh Plugs:

**IMPORTANT:** Before king pin caps and/or welsh plugs are installed, recheck draw keys and king pin nut to be sure the final staking or torquing procedure has been completed. Omission of the final king pin securing steps may result in damaged or broken king pins and axle centers.

A. On the axles of later MC-9 coaches:

1) Align king pin caps and gaskets and assemble to knuckles with capscrews and washers.

2) Gaskets do not have a top or bottom orientation and may be installed in either position.

3) Caps do require orienting the flat side toward the gasket and knuckle. The flat, sealing side contains no numbering or lettering.

4) Torque fasteners to 20-30 lb. ft.

B. On the axles of earlier MC-9 coaches:

1) Place welsh plug into the lower knuckle bore with the rounded (convex) side toward the king pin.

2) Install lock ring.

9. Bushing Lubrication:

A. Grease upper bushing first, then the lower bushing. Use molybdenum disulfide grease. If grease does not flow through the thrust bearing, it will be necessary to raise the knuckle with a jack to close off passage of grease around the thrust bearing. Regrease the lower bushing and thrust bearing, then remove jack.

B. Rotate knuckle lock to lock to help distribute the grease. Note the knuckle will now be noticeably harder to rotate than during the end play measurement. This is normal.

C. Repeat step A.

D. On models using draw keys fill the voids in the draw key holes with grease to prevent corrosion and ease future disassembly.

10. The steering knuckle/axle center reassembly is now complete.



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## MEASURING KNUCKLE END PLAY WITH AXLE, WHEELS AND TIRES INSTALLED

1. Securely block vehicle to prevent rolling.
2. Place a jack under the axle beam as close as possible to the knuckle end being checked and jack the vehicle up until the tire is clear of the floor.
3. Attach a dial indicator to the axle beam with a "C" clamp or magnetic base (figure 1-28).

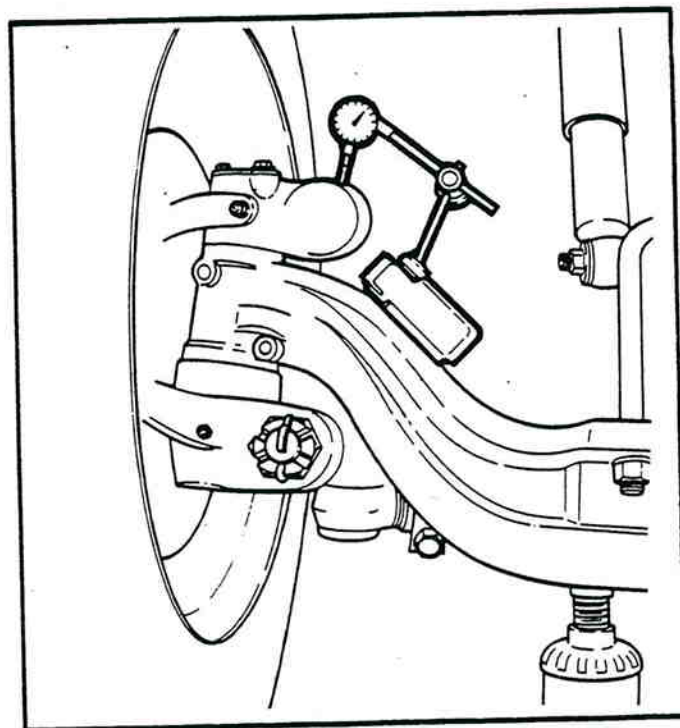


Figure 1-28. Dial Gauge Installed.

4. Place the dial indicator plunger on top of the king pin cap or knuckle forging so that its line of action is approximately parallel to the king pin center line.
5. Zero the dial indicator.
6. Measure the knuckle clearance (end play) by using a suitable lever to lift the knuckle while observing the dial indicator. Make a note of the measurement.

On axles in service, the end play may increase to a maximum of .065" (1.70 mm) at which time it will be necessary to re-shim end play back to .001"-.025" (.02-.64 mm).

**NOTE: Both knuckles should be checked.**

If a reading of over .065" is taken, remove the tire and king pin cap and remeasure as per rebuild procedure. If the reading is still over .065", then re-shim to specifications.

## TIE ROD ENDS

The tie-rod assembly is of three-piece construction comprised of a rod and two end assemblies. See figures 1-29 and 1-30. The tie-rod end automatically compensates for wear on bearing surfaces. The tie-rod end stud is held in contact with the bearing surface by tension of a spring which holds the seat firmly against the inner end of the stud. An end plug, retained by a locking ring, holds the internal tie-rod end parts in position. Excessive play indicates that the bearing surfaces are worn, and new tie-rod end assemblies should be installed.

On some coaches non-repairable ends are used. These assemblies must be replaced as a complete unit.

Socket wear is indicated by ball stud turning torque and socket end movement. End movement may be checked with the socket assembly attached to its mating arm. If a force sufficient to overcome the spring pressure is applied to the end of the forging, the amount of movement is an indicator of wear. New socket assemblies should have an end movement of not more than .020 inches (.508 mm). Maximum allowable end movement on worn sockets is .090 inches (2.28 mm).

To check the turning torque value between the tie rod end assembly stud and the ball cavity, the socket must be removed from the vehicle. Minimum allowable torque value is 5 in. lbs. (.565 Nm).

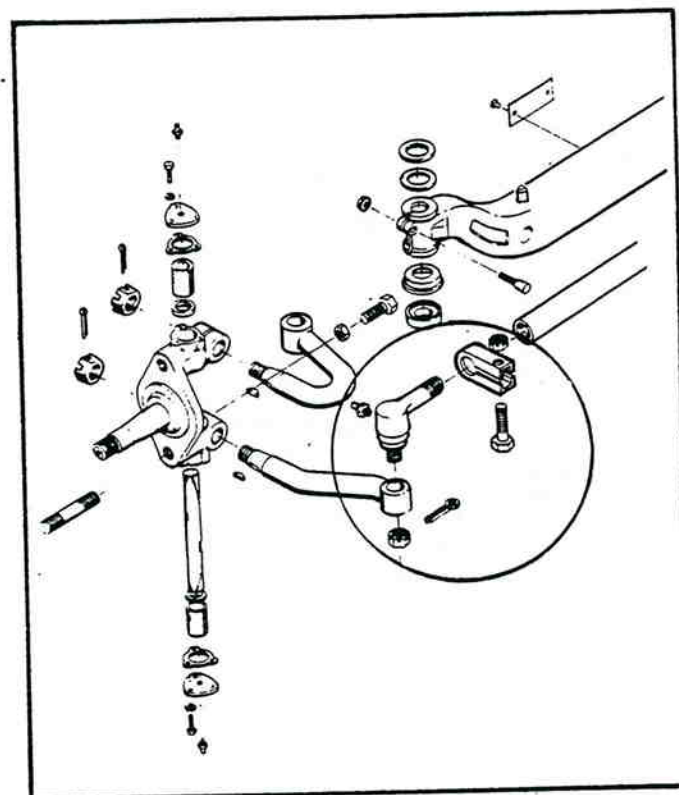


Figure 1-29. Tie Rod End (Later MC-9 Coaches).

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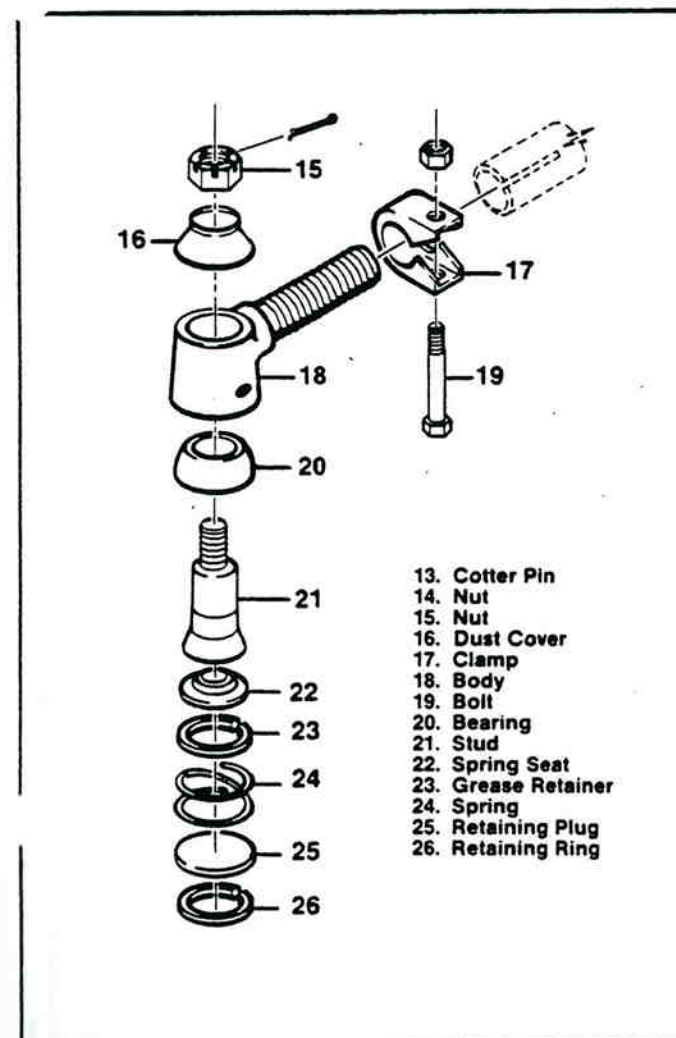


Figure 1-30. Tie Rod End (Earlier MC-9 Coaches).

13. Cotter Pin
14. Nut
15. Nut
16. Dust Cover
17. Clamp
18. Body
19. Bolt
20. Bearing
21. Stud
22. Spring Seat
23. Grease Retainer
24. Spring
25. Retaining Plug
26. Retaining Ring

All worn parts should be replaced. Tension of the retaining spring should be checked, and the spring replaced if it does not have sufficient tension to hold the tie-rod end stud firmly against the bearing. A new grease retainer should be used.

Lubricate parts with light grease before reassembly. Insert stud and bearing assembly into tie-rod end body, place grease retainer over end of end stud seat, and position seat in body. Place the retaining spring inside the seat, position end plug on spring, then compress spring and install end plug lock in groove.

Before replacement of tie-rod on steering arm, clean tapered portion of tie-rod end stud.

## REASSEMBLY

Assemble the tie rod end on the tie rod tube, but do not tighten the clamp bolt. Insert the tie rod end stud into the steering arm and tighten to 165-180 lb. ft. torque (224-244 Nm). Tighten clamp bolts to 55-60 lb. ft. torque (75-88 Nm). When replacement of the tie rod assembly is required, the toe-in should be checked as described later in this section.

## FRONT END ALIGNMENT

Correct front end alignment must be maintained for ease of steering and satisfactory tire life. Road shock, vibrations, normal stresses and strains set up in the front end system under average operation can result in loss of front end alignment.

If incorrect front end alignment is suspected, front wheel balance should first be checked to make sure that the difficulties are not originating from out-of-balance front wheels. A check of the inflation, wheel installation and runout, wheel bearing adjustment, tie rod and draglink end wear should also be made.

Correct front end alignment can only be maintained when parts in the steering knuckle are in satisfactory condition.

Factors in front end alignment are as follows:

A. Front wheel toe-in: The distance the wheels are closer together at the front than at the rear.

B. Front wheel camber: The amount the wheel inclines from the vertical plane. "Positive" camber means the wheels lean outward at the top. "Negative" camber means the wheels lean inward at the top, and "Zero" camber means that the wheels are in a vertical plane.

## REMOVAL

To remove tie-rod ends from the tie-rod assembly, remove cotter pins and nuts from the tie-rod ends, and support the steering arm to prevent bending. Using a small drift, rap the side of the tie-rod end to loosen it. Loosen clamp bolts and remove tie-rod ends from the tie-rod tube.

## REPAIR (REPAIRABLE ENDS ONLY)

Pry end plug lock out of groove in body. Remove plug, seat, and spring. Remove grease retainer. Stud and bearing assembly can then be removed from the tie-rod end body.



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C. Axle caster: The fore and aft inclination from vertical of the steering knuckle. "Positive caster" is inclination of the top of the steering knuckle towards the rear of the vehicle. "Negative caster" is the inclination of the top of the steering knuckle towards the front of the vehicle. "Zero" caster means no inclination of the steering knuckle.

D. King pin inclination: The amount king pins are inclined inward at the top.

E. Steering geometry: The science of keeping the front wheels in proper alignment during left or right turns.

## CAMBER

Wheel camber is the tilting of the front wheels from the vertical center line. Outward inclination at top provides positive camber and inward inclination provides negative camber.

Camber variations may be caused by wear at wheel bearings and steering knuckle bushings or by bent knuckle or sagging axle center.

Excessive positive camber results in irregular wear of tires at outer shoulders. Negative or reverse camber causes wear at inner shoulders. Ease of steering is also affected by any deviation from specified camber.

Position front wheels on turning plates in a straight ahead position. Attach alignment gauges to each wheel spindle. Record the camber readings for each wheel and compare with specifications. Refer to figure 1-32 and Front Axle Specifications Chart at the end of this section.

## TOE-IN ADJUSTMENT

Wheel toe-in is the distance the front wheels are closer together at the front than at the rear of axle.

Incorrect toe-in results in excessive tire wear caused by side slippage. Unstable steering with a tendency to wander may also result. The following steps are to check and adjust toe-in:

**NOTE: Make sure vehicle is on a level floor.**

Do not measure toe-in with the front axle jacked up. The toe-in should be measured with the weight of the vehicle on the axle.

1. Jack up the front axle.
2. Use paint or chalk and whiten the center area of both front tires around the entire circumference.
3. Position a scribe or pointed instrument against the whitened part of each tire and rotate the tires. The scribe must be held firmly in place so that a single straight line is scribed all the way around the tire.
4. Place a full-floating turning radius gauge plate under each wheel. Lower the vehicle and remove the lock pins from the gauge plates. If full-floating turning radius gauge plates are not available, lower the vehicle and move it backward and then forward approximately 6 feet (1.8 m).
5. Position trammel bar at rear of tires and adjust pointers to line up with scribe lines and lock in place (scale should be set on zero). Pointers must be raised to spindle height on the tire as shown (figure 1-31).
6. Position the trammel bar at the front of the tires. Adjust scale end so that pointers line up with scribe marks.
7. Read toe-in or toe-out from the scale. Scale should read toe-in  $1/16" \pm 1/16"$  (1.58 mm  $\pm$  1.58 mm) (see figure 1-31).
8. If adjustment is necessary, loosen the tie-rod clamps and turn tie rod as required, then tighten the clamps. If the vehicle is not on gauge plates, move it backward, then forward about 6 feet (1.8 m).
9. Recheck the toe-in to ensure that it is correct.

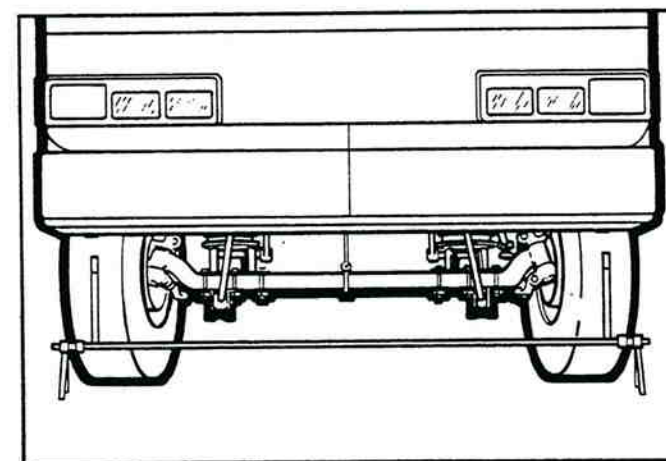
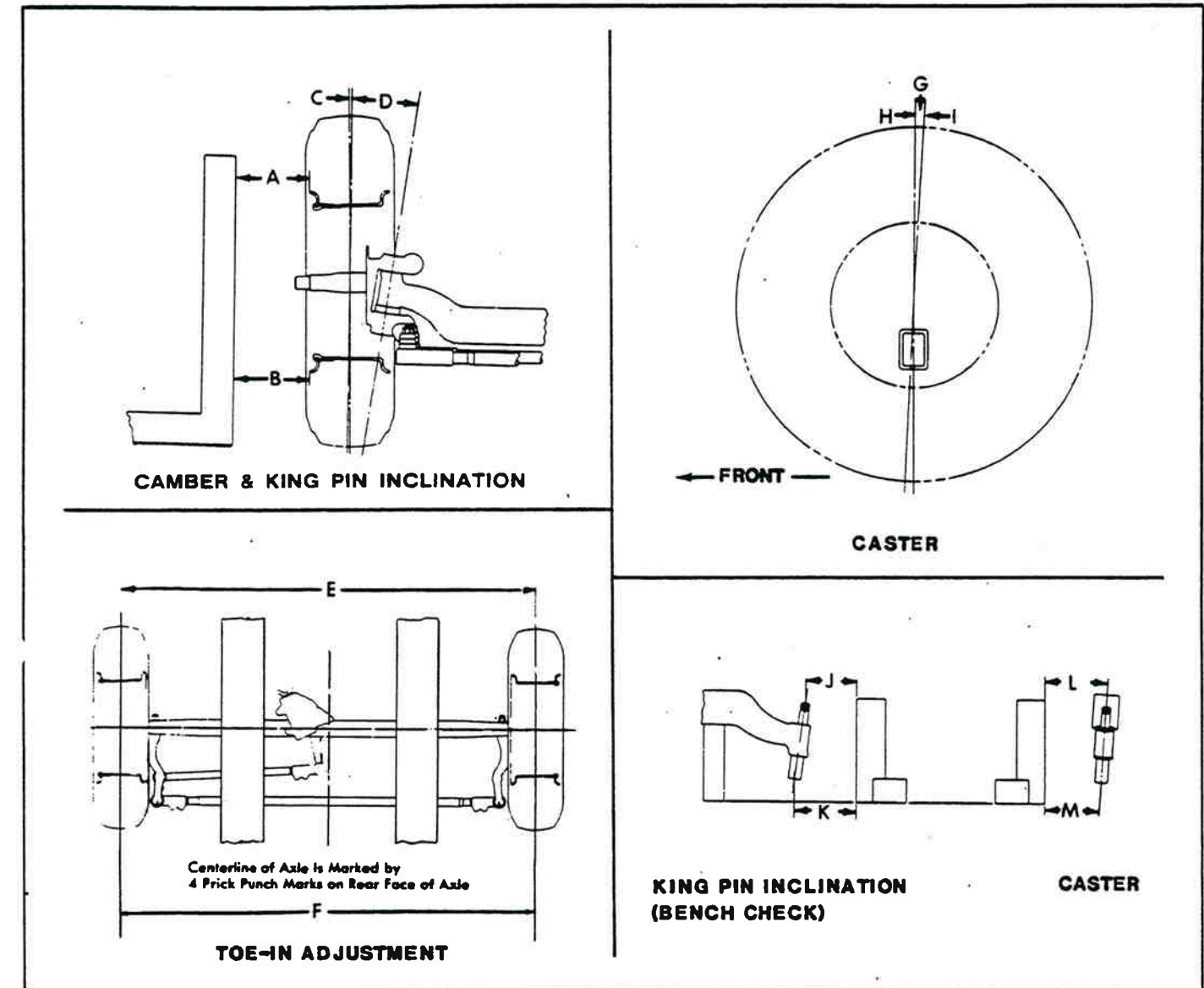


Figure 1-31. Trammel Bar With Pointers Set At Spindle Height.

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- B Minus A ..... Camber (Inches)
- C ..... Camber (Degrees)
- D ..... King Pin Inclination (Degrees)
- F Minus E ..... Front End Toe-In (Inches)
- G ..... Caster (Degrees)
- H ..... Vertical
- I ..... Centerline of King Pin
- K Minus J ..... King Pin Inclination (Inches)
- L Minus M ..... Caster (Inches)
- (Measure at Front of Axle)

Refer to "Front Axle Specifications" for numerical values.

Figure 1-32. Alignment Chart.

# MC-9 MAINTENANCE MANUAL

## TROUBLESHOOTING

- |  |   |
|--|---|
| <p>1a. Rapid or Uneven Tire Wear</p> <ul style="list-style-type: none"> <li>● Incorrect toe-in setting</li> <li>● Improper tire inflation</li> <li>● Unbalanced tires</li> </ul> <p>b. Toe-in Control</p> <ul style="list-style-type: none"> <li>● When setting toe-in, it is important to neutralize the component and tire deflections by backing up and then going forward and rechecking the toe-in. This is especially important with radial tires. The check and possible re-set should be followed even if bearing plates are used.</li> </ul> <p>2. Hard Steering</p> <ul style="list-style-type: none"> <li>● Low power steering system pressure</li> <li>● Improper assembly or adjustment of steering gear box</li> <li>● Inadequate or improper lubrication of knuckle pins</li> <li>● Improper caster</li> <li>● Tight draglink or tie rod ends</li> <li>● Worn thrust bearing</li> </ul> <p>3. Rapid Wear of Cross Tube Ends</p> <ul style="list-style-type: none"> <li>● Inadequate or improper lubrication</li> <li>● Severely contaminative environment</li> <li>● Failure of protective dust cover.</li> </ul> | <p>4. Bent or Broken Cross Tube, Broken Ball Stud, Bent or Broken Steering Arm or Cross Tube Arm</p> <ul style="list-style-type: none"> <li>● Excessive power steering system pressure</li> <li>● Misadjusted power steering cut-off</li> <li>● Operational (curbing)</li> </ul> <p>5. Heavily Worn or Broken Steering Arm Ballstud</p> <ul style="list-style-type: none"> <li>● Overtightened draglink</li> <li>● Inadequate or improper lubrication</li> </ul> <p>6. Excessive Wear of Knuckle Pins and Bushings</p> <ul style="list-style-type: none"> <li>● Worn or missing seals and gaskets</li> <li>● Improper type of grease</li> <li>● Inadequate lubrication frequency</li> <li>● Improper lubrication technique</li> <li>● Inadequate lubrication frequency due to extreme operating conditions such as abrasive dust and sandy environments</li> </ul> <p>7. Front Axle Shimmy or Vibration</p> <ul style="list-style-type: none"> <li>● Incorrect master setting</li> <li>● Wheels and/or tires not properly balanced</li> <li>● Worn shock absorbers</li> </ul> |
|--|---|

# MC-9 MAINTENANCE MANUAL

## SPECIFICATIONS

### FRONT AXLE SPECIFICATIONS

#### AXLE CENTER - EARLIER MC-9

Type ..... I Beam  
 Allowable Twist (Variation Between Ends) ..... 1/2°

#### AXLE CENTER - LATER MC-9

Type ..... Tubular  
 Allowable Twist (Variation Between Ends) ..... 1/2°

#### STEERING KNUCKLES - EARLIER MC-9

Spindle Diameter: Inner Bearing ..... 2.562-2.561 in. (65.082-65.057 mm)  
 Outer Bearing ..... 2.125-2.124 in. (53.970-53.957 mm)  
 Up-And-Down Movement ..... .005-.065 in. (.127-1.65 mm)  
 Bushing Bore Diameter ..... 1.919-1.921 in. (48.743-48.793 mm)

#### STEERING KNUCKLES - LATER MC-9

Spindle Diameter: Inner Bearing ..... 2.625-2.624 in. (66.662-66.637 mm)  
 Outer Bearing ..... 2.125-2.124 in. (53.962-53.936 mm)  
 Up-And-Down Movement ..... .005-.065 in. (.127-1.65 mm)  
 Bushing Bore Diameter ..... 1.919-1.921 in. (48.743-48.793 mm)

#### STEERING KNUCKLE BUSHINGS - EARLIER MC-9

Material ..... Bronze  
 Inside-Line Ream ..... 1.794-1.795 in. (45.555-45.580 mm)  
 Line Burnish ..... 1.797-1.798 in. (45.631-45.657 mm)

#### STEERING KNUCKLE BUSHINGS - LATER MC-9

Material ..... "Easy Steer"  
 Ream Diameter ..... 1.796-1.795 in. (45.618-45.593 mm)

#### KING PIN - EARLIER MC-9

Type ..... Tapered  
 Diameter - Large End ..... 1.794-1.793 in. (45.568-45.542 mm)  
 Small End ..... 1.310-1.309 in. (33.261-33.236 mm)

#### KING PIN - LATER MC-9

Type ..... Straight  
 Diameter ..... 1.794-1.793 in. (45.568-45.542 mm)

#### FRONT WHEEL ALIGNMENT - LATER MC-9

Camber (B minus A) ..... 1/4° ± 3/8° (Curbside)  
 ..... 3/4° ± 3/8° (Roadside)  
 Caster Angle (G) ..... 4.5°-5.0° Pos  
 Toe-In (E minus F) ..... 0-1/16 in. (0-1.588 mm)  
 King Pin Inclination (D) ..... 6°15' (Curbside)  
 ..... 5°45' (Roadside)  
 Track: 102" Wide Models ..... 85.7 in. (2,177 mm)  
 96" Wide Models ..... 79.7 in. (2,024 mm)

# MC-9 MAINTENANCE MANUAL

## SPECIFICATIONS

### FRONT AXLE SPECIFICATIONS

#### FRONT WHEEL ALIGNMENT - EARLIER MC-9

Camber (B minus A) .....	$\frac{1}{4}^{\circ} \pm \frac{3}{8}^{\circ}$ Neg (Curbside)
.....	$\frac{3}{4}^{\circ} \pm \frac{3}{8}^{\circ}$ Pos (Roadside)
Caster Angle (G) .....	$2.5^{\circ} \pm 1^{\circ}$ Pos
Toe-In (E minus F) .....	0- $\frac{1}{16}$ in. (0-1.588 mm)
King Pin Inclination (D), Right .....	6.25°
Left .....	5.75°
Track .....	79.7 in. (2,024 mm)

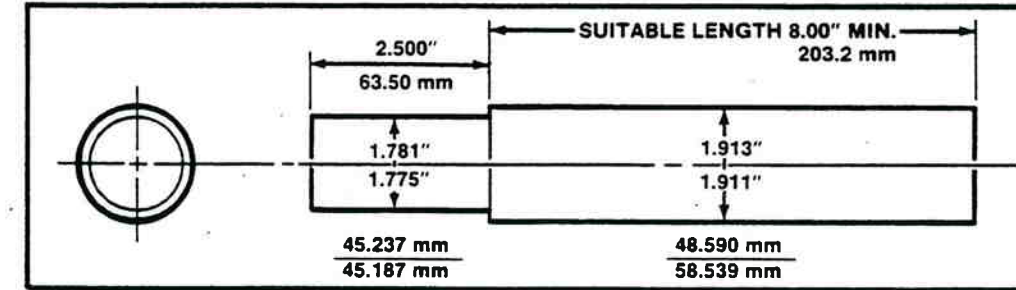
#### TORQUE SPECIFICATIONS

King Pin Nuts .....	350-390 ft. lbs. (475-529 Nm)
Tie Rod End Clamp Bolt Nuts .....	55-65 ft. lbs. (75-88 Nm)
Tie Rod End Steel Nuts .....	165-180 ft. lbs. (224-244 Nm)
Steering Arm Nuts .....	350-390 ft. lbs. (475-529 Nm)
Radius Rod Retainer Bolt Nuts .....	300-330 ft. lbs. (408-449 Nm)

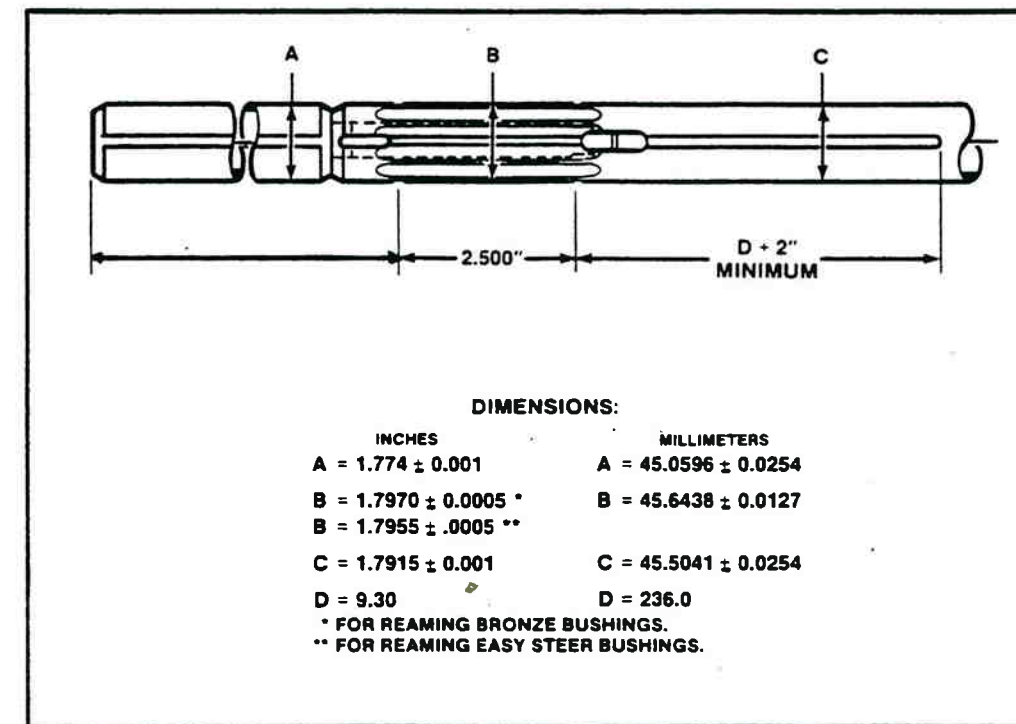
# MC-9 MAINTENANCE MANUAL

## SERVICE TOOLS

SOME OF THE TOOLS USED FOR THE MAINTENANCE PROCEDURES OUTLINED IN THIS SECTION ARE NONSTANDARD. THEY ARE, HOWEVER, AVAILABLE FOR PURCHASE FROM MOTOR COACH INDUSTRIES, TRANSPORTATION MANUFACTURING CORPORATION AND UNIVERSAL COACH PARTS. WHERE PRACTICAL, THEY MAY BE FABRICATED AT THE SERVICE FACILITY.



20-5 Tool - King Pin Bushing Removal & Installation



20-6 King Pin Bronze Bushing Reamer

20-312 King Pin "Easy Street" Bushing Reamer.



