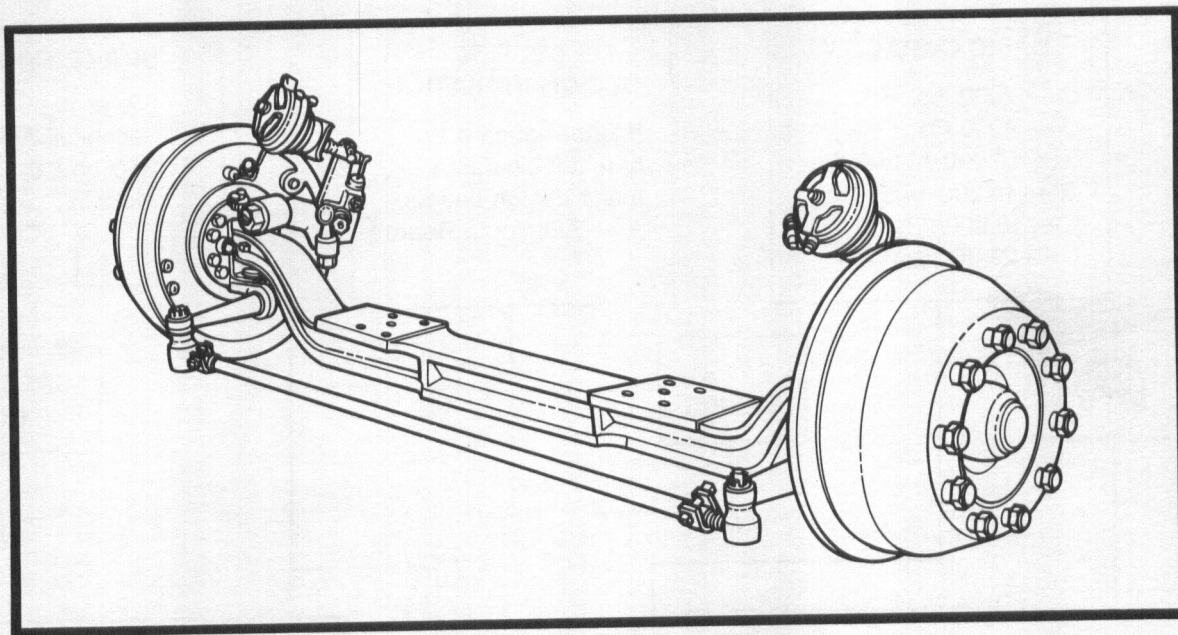


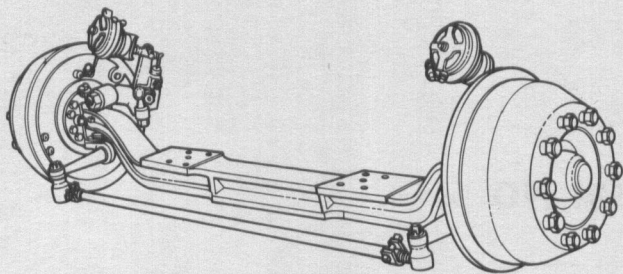


Field Maintenance Manual No. 2

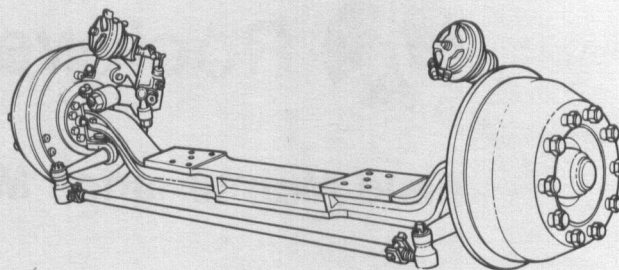
Non-Driving Front Axles

**All Models
Conventional and Sealed Knuckle Pins**

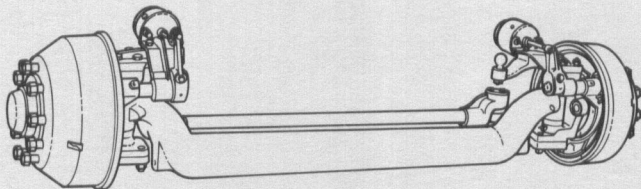




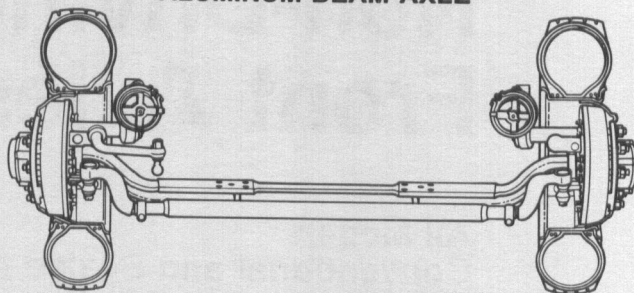
STANDARD I-BEAM AXLE



ALUMINUM BEAM AXLE



TUBULAR AXLE



CENTER-POINT™ STEERING AXLE

BASIC CAPACITY

- C — 7000 lbs.
- D — 9000 lbs.
- F — 12,000-13,200 lbs.
- G — 14,300-14,600 lbs.
- L — 16,000-20,000 lbs.
- U — 29,000 lbs.

**LETTER
DESIGN-VARIATION**

If letter appears
here it indicates a
major design change
A — Aluminum Beam

BRAKE TYPE

(Refer to
Technical Aid
Section #6
Aid #59)

**FRONT
AXLE**

**BASIC
SERIES**

**SPECIFICATION
NUMBER**

FF-931-P-X1

**MAJOR
VARIATION**

- 1 — Straight sealed knuckle pin
and new tie rod assembly
- 2 — Sealed knuckle pin construction
- 3 — Larger centers and knuckles
- 4 — Easy Steer™ design
- 5 — Tubular center
- 7 — Center-Point™ steer design

NUMBER DESIGN VARIATION

- 0 — Tapered knuckle pin
- 1 — Straight knuckle pin
- 2 — Special spindle and wheel ends
- 3 — 5" drop from spindle inter-
section to pad
- 4 — Special spindle and 5" drop
- 5 — Special spindle and wheel end

Technical Service Aid

SUBJECT: EASY STEER™ STEERING KINGPIN KITS

MODELS: FD-961, FF-931, 931A, 932, 933, 934, 941, 941A, 942, 943, 944, 952, 961; FG-931, 933, 941, 943, 952; FL-931, 941, 943, 951; 17100, 17101

THIS IS SUPPLEMENTAL INFORMATION FOR ROCKWELL FIELD MAINTENANCE MANUAL NO. 2.

Easy Steer steering kingpin kits are used to service Easy Steer axles. The kits can also be used to convert conventional axles to Easy Steer axles. Each kit contains four bushings. The bushings can be different colors. The different colors indicate only that the bushings were manufactured at different locations. The different color bushings included in a kit are interchangeable.

Use the kits as follows:

KIT NO.	USE TO	
	SERVICE	CONVERT
1307	FF-941	FF-931
	FF-942	FF-932
	FF-943	FF-933
	FF-944	FF-934
1308	FF-941A	FF-931A
1309	FG-941	FF-952
	FG-943	FG-931
	17100	FG-933
	17101	FG-952
1312	FL-941	FL-931
	FL-943	FL-951
1315	FD-961	
	FF-961	

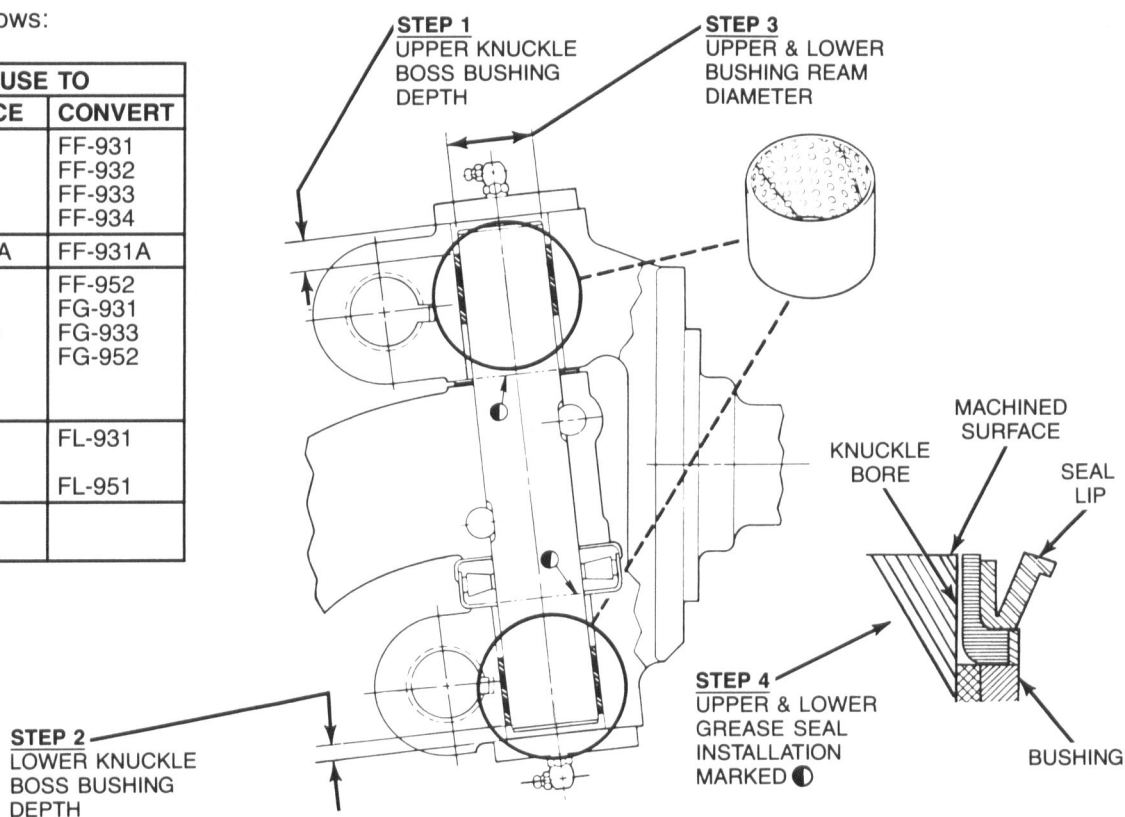


Figure 1

INSTALLATION AND SIZING OF BUSHINGS

NOTE

See Rockwell Field Maintenance Manual No. 2 for the correct procedures to remove and install the steering knuckle. Then see Figure 1.

Step 1 Press the upper bushing approximately 1/8 inch into the knuckle and then relieve the pressure. Now press the bushing to the correct depth as indicated in the following chart.

Step 2 Put the knuckle bottom side up. Repeat step 1 for the lower bushing making sure you press the lower bushing to the correct depth as indicated in the following chart.



CAUTION

FINISH THE BUSHINGS BEFORE YOU INSTALL THE SEALS. A REAMER WILL DAMAGE THE SEALS.

Step 3 Use a reamer to finish the bushings. Do not use a burnishing bar or burnishing balls. The bushings must be finished to the diameter indicated in the following chart and must be in line with each other within 0.001 inch.



CAUTION

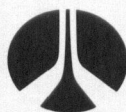
MAKE SURE YOU INSTALL THE SEALS SO THAT THE LIPS OF THE TWO SEALS ARE TOWARD EACH OTHER. IF YOU INSTALL THE SEALS BACKWARD, YOU WILL NOT BE ABLE TO PURGE GREASE WHEN YOU LUBRICATE THE KNUCKLE.

Step 4 Install the upper and lower grease seals so that the seals are even with the machined surfaces of the knuckle bosses.

KIT NO.	AXLE MODEL	DEPTH OF UPPER BUSHING	DEPTH OF LOWER BUSHING	FINISHED DIAMETER OF BUSHINGS (BOTH BUSHINGS IN LINE WITHIN 0.001 INCH)
1307	FF-931, FF-932 FF-933, FF-934 FF-941, FF-942 FF-943, FF-944	0.352-0.382 inch	0.352-0.382 inch	1.7950-1.7960 inches
1308	FF-931A, FF-941A	0.445-0.475 inch	0.290-0.320 inch	1.7950-1.7960 inches
1309	FF-952, FG-931 FG-933, FG-941 FG-943, FG-952	0.352-0.382 inch	0.352-0.382 inch	1.7950-1.7960 inches
	17100, 17101	0.477-0.507 inch	0.412-0.442 inch	1.7950-1.7960 inches
1312	FL-931, FL-941 FL-943, FL-951	0.955-0.985 inch	0.670-0.700 inch	2.0000-2.0010 inches
1315	FD-961, FF-961	0.352-0.382 inch	0.352-0.382 inch	1.7950-1.7960 inches

These Easy Steer steering kingpin kits are available from:

Rockwell International
Florence Distribution Center
7975 Dixie Highway
Florence, Kentucky 41042



Rockwell International

Automotive Operations
Rockwell International Corporation
2135 West Maple Road
Troy, Michigan 48064 U.S.A.

Technical Service Aid

SUBJECT: NEW RECOMMENDATIONS FOR TIE ROD ARMS AND WHEELBASES.

MODELS: ALL FRONT NON-DRIVE STEERING AXLES.

THIS INFORMATION UPDATES ROCKWELL FIELD MAINTENANCE MANUAL NO. 2.

The steering system used on steering axles is designed according to the Ackerman steering principle. Correct use of this principle can minimize, but cannot eliminate, steering error during turns.

Until now, the selection of tie rod arms for optimum steering geometry was based only on the vehicle wheelbase and the king pin intersection (KPI). But recently, more and more customers have specified steering axles with a larger maximum turn angle (MTA). This means that the procedure for

selecting tie rod arms must be modified to compensate for the extended steering range of these axles. The modified procedure is based on a new concept called "tie rod arm index" which takes into account the MTA to calculate the optimum Ackerman geometry.

Minimizing steering error during turns is important because steering error causes tire scrubbing which causes faster tire wear. However, remember that selection of the correct tie rod arms for optimum Ackerman geometry can only minimize, not completely eliminate, steering error.

Following are definitions of wheelbase, KPI and MTA. These definitions are shown in **Figure 1**.

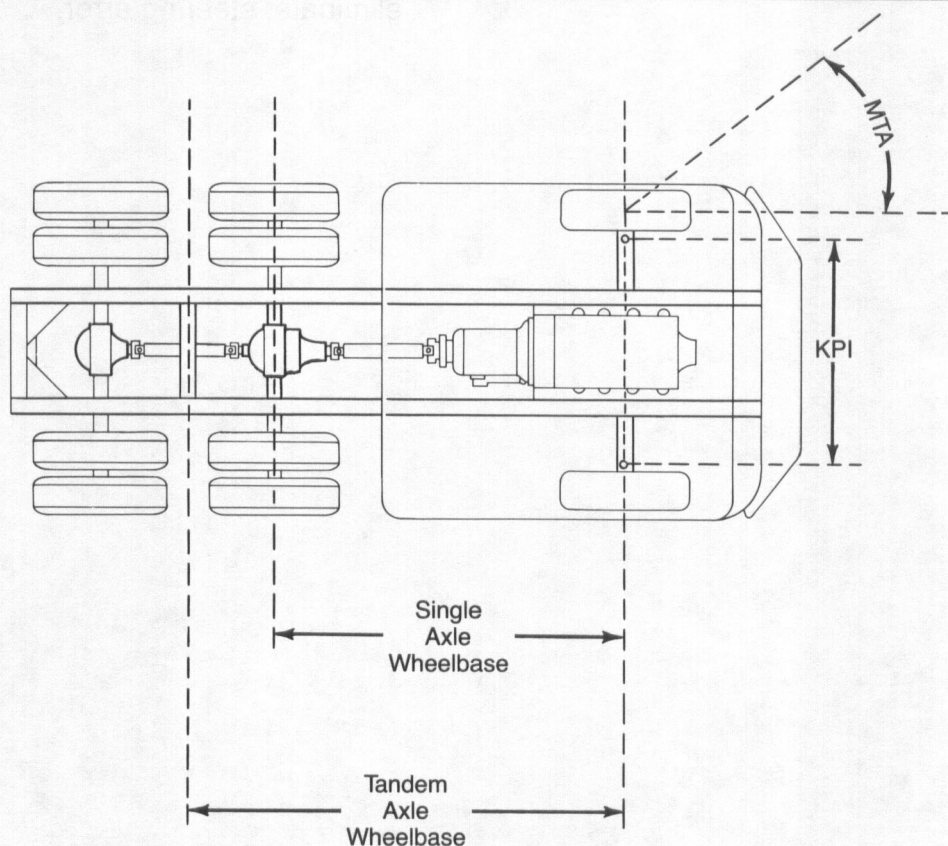
- **Wheelbase** is the distance from the centerline of the front axle to the centerline of a single rear axle. For a tandem axle, it is the distance from the front axle to the centerline between the two rear axles.
- **KPI** is the distance between the two king pins. This distance is measured at the points where the centerlines of the spindles meet the centerlines of the king pins.
- **MTA** is the maximum angle that a front wheel turns from the straight ahead position.

As shown in **Table 1**, a greater MTA improves the maneuverability of a vehicle because it decreases the turn radius. But the improvement in turn radius decreases rapidly as the MTA increases above 40°. For example, there is a 9% improvement between 30° and 40° MTA, but only a 5% improvement between 40° and 50° MTA. Also, the increase in MTA increases the potential for tire wear caused by steering error.

Table 1

TURN RADIUS (170" Wheelbase and 69" KPI)			
Tie Rod Arm Reference Number	30°MTA	40°MTA	50°MTA
C2551	33.8'	30.8'	29.3'
J998	33.5'	30.4'	28.8'
J4776	32.8'	29.8'	28.0'

Figure 1



The fact that a larger MTA can increase tire wear can be seen by looking at the principle of Ackerman steering geometry.

The principle of Ackerman steering geometry is as follows: for any given wheelbase and KPI, there is only one turn angle at which the centerlines of both front wheels meet at a point on the centerline of the rear axle.

At that angle, the tires roll freely and tire wear is at a minimum. All other turn angles introduce an error in the geometry which causes tire scrub and therefore tire wear.

Figure 2 shows the principle of Ackerman steering geometry.

The amount of Ackerman error changes with the turn angle. The greater the MTA, the greater the potential tire scrub wear due to Ackerman error. For minimum tire wear, you must use the tie rod arm that keeps total Ackerman error to a minimum. Rockwell's tie rod arm index takes into account the MTA and therefore selects the tie rod arm that keeps total Ackerman error to a minimum.

The index is calculated according to the amount of Ackerman error at each turn angle and the number of miles driven at that angle. Calculations are made for each turn angle in the range of the MTA to get a weighted average index. After the duty cycle of an application is analyzed, indexes can be calculated for different combinations of wheelbase, KPI and tie rod arms.

The formula to calculate the tie rod arm index for each turn angle is:

$$\frac{AE \times DT}{TD} \times 100$$

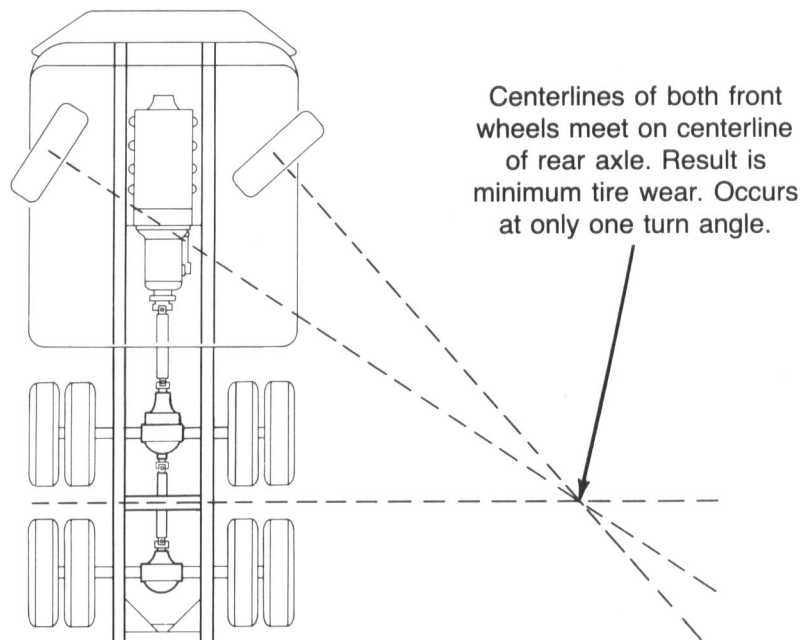
AE = Ackerman error at a given angle.

DT = distance traveled at the given angle.

TD = total distance traveled.

Multiplying by 100 allows the index to be expressed as a number from 0-50.

Figure 2



Tire wear caused by Ackerman error can be compared to tire wear caused by toe-in setting, a well known factor in tire wear. For example, operating a vehicle with a tie rod arm index of 17 is equivalent to operating a vehicle with a 1/8 inch toe-in setting. **Table 2** shows the equivalent tie rod arm indexes for several toe-in settings.

Table 2

TIE ROD ARM INDEX vs. TOE-IN	
Toe-In Inches	Tie Rod Arm Index
1/32	4
1/16	9
1/8	17
1/4	35

Rockwell did an analysis of linehaul and city applications and selected a city application with heavy tire wear to be the standard for the index. Getting good tire wear in this application should give good tire wear in most other applications.

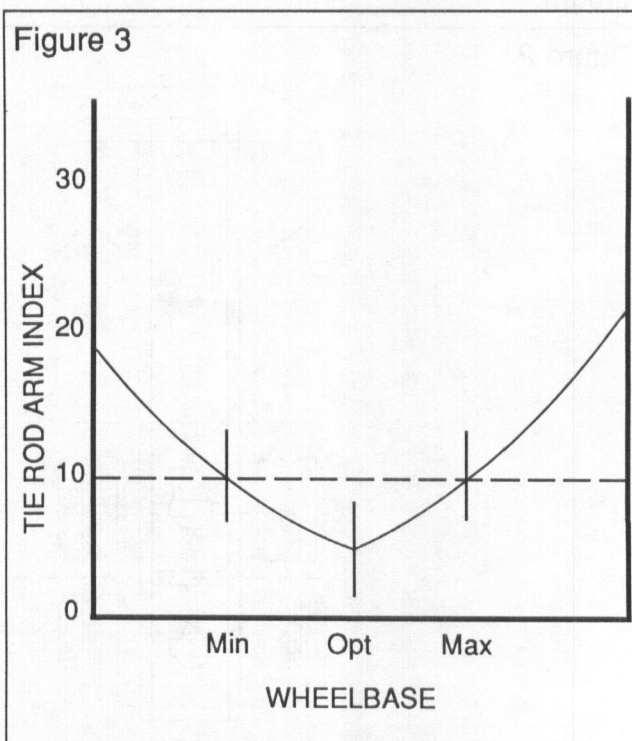
As a general guideline, Rockwell recommends using tie rod arms with an index of 10 or less. The lower the index, the better. This guideline is made for two reasons:

- An index of 10 or less is approximately equivalent to the industry toe-in standard of 1/16 inch or less. For example, the industry standard for radial tires is 1/32 inch $\pm$ 1/32 inch which gives a maximum of 1/16 inch.
- Customers find that installing tie rod arms with an index of 10 or less decreases tire wear to an acceptable level.

Arms with an index higher than 10 may be permitted in applications where Ackerman error makes only a small contribution to tire wear. For more information on these applications, contact Rockwell On-Highway Axle Engineering.

Figure 3 shows a typical index curve for a pair of tie rod arms. Rockwell has made graphs like this for every tie rod arm it makes. **Figure 3** shows several points:

- The low point on the curve indicates the "optimum" wheelbase for this pair of tie rod arms.
- The optimum wheelbase changes according to the MTA.
 - Increasing the MTA decreases the optimum wheelbase.
 - Decreasing the MTA increases the optimum wheelbase.
- The minimum and maximum marks show the range of recommended wheelbases for this pair of tie rod arms.
- The recommended wheelbases are those where the tie rod arm index is 10 or less.
- The range of recommended wheelbases also changes according to the MTA the same way the optimum wheelbase does.



Tables 3 and 4 show the wheelbase ranges now recommended for some of the most commonly used Rockwell tie rod arms.

Table 3 shows some tie rod arms most often used with FF series axles. Table 3 assumes a 69 inch KPI which is the most common KPI for FF series axles.

Table 4 shows some tie rod arms most often used with FL series axles. Table 4 assumes a 68.5 inch KPI, the most common KPI for that series. When you read the tables, remember the following points:

- The recommended wheelbases will change if the KPI changes. Normally, a four inch increase (or decrease) in KPI will increase (or decrease) the optimum wheelbase by approximately 10 inches.
- The "lock-up" angle is that angle of the inside wheel which makes a 165° included angle between the tie rod arm and the tie rod. This angle can cause the tie rod and the tie rod arm to "lock-up" because they are almost in a straight line. "Lock-up" makes it difficult to move the steering wheel out of this steering angle and puts high stress on the steering components. The MTA of the axle must not exceed the "lock-up" angle of the tie rod arms. Blanks in each chart indicate the tie rod arms that cannot be approved for use with that MTA because of possible "lock-up".
- The "Old Ideal Wheelbase" indicates the wheelbase that was considered "ideal" before adoption of the tie rod arm index. The wheelbase considered "ideal" was the one that had zero Ackerman error at a 20° turn. Note that the old ideal wheelbase is still near the optimum wheelbase now recommended for axles with a 30° MTA. This is because the old ideal wheelbases were calculated when a 30° MTA was standard. Adoption of the tie rod arm index had the largest effect on the wheelbase recommendations for axles with 40° and 50° MTAs.
- For each tie rod arm, the optimum wheelbase and the range decrease as the MTA increases. Rockwell recommends that you specify tie rod arms for new vehicles according to Tables 3 and 4. Specify the arm with the best index that is within the OEM specifications for tire and rim clearance.
- There are many causes of tire wear such as toe-in, axle misalignment, fifth wheel position, tire pressure, etc. Changing tie rod arms will only decrease the tire wear that is caused by steering error during turns.



CAUTION

If you change the tie rod arms, you change the steering geometry. Changing the tie rod arms can mean that you must also change the cross tube assembly. You must get approval from the OEM before you change the arms supplied by the OEM. If you change the steering geometry, you must adjust the steering stops and the poppet valves in the power steering gear.

Table 3

WHEELBASE RANGES, IN INCHES, FOR FF AXLE SERIES TIE ROD ARMS
Based on Maximum Tie Rod Arm Index of 10

Tie Rod Arm Reference Number	"Lock-Up" Angle	Old Ideal Wheelbase	Wheelbase Range 30" MTA 69" KPI			Wheelbase Range 40" MTA 69" KPI			Wheelbase Range 50" MTA 69" KPI		
			Min	Opt	Max	Min	Opt	Max	Min	Opt	Max
R1604	>60	440	230	>300	>300	250	>300	>300	230	280	>300
R4776	58	300	180	270	>300	180	240	>300	170	200	260
V1426	56	230	150	210	>300	150	190	255	135	150	190
J998	53	200	135	180	290	130	160	215	125	140	160
G2997	51	180	125	170	250	120	150	190	115	130	145
C2551	50	170	120	160	235	115	140	180	110	120	135
M1339	48	150	110	140	200	105	130	155	-	-	-
T5896	47	145	105	135	190	100	120	150	-	-	-
P4748	46	130	100	125	170	<100	110	135	-	-	-
U1399	44	125	<100	110	155	<100	100	125	-	-	-
S4413	42	110	<100	100	135	<100	<100	110	-	-	-
F5882	40	100	<100	100	120	<100	<100	<100	-	-	-

Table 4

WHEELBASE RANGES, IN INCHES, FOR FL AXLE SERIES TIE ROD ARMS Based on Maximum Tie Rod Arm Index of 10												
Tie Rod Arm Reference Number	"Lock-Up" Angle	Old Ideal Wheelbase	Wheelbase Range 30° MTA 68.5" KPI			Wheelbase Range 40° MTA 68.5" KPI			Wheelbase Range 50° MTA 68.5" KPI			
			Min	Opt	Max	Min	Opt	Max	Min	Opt	Max	
V5118	60	305	180	280	>300	190	240	>300	180	200	280	
H5182	59	290	180	260	>300	180	220	>300	170	190	260	
U5403	58	245	160	220	>300	160	200	280	150	170	210	
U5143	54	195	130	180	280	130	155	210	120	130	160	
L5186	52	190	130	180	270	130	155	210	115	130	150	
E5179	52	190	130	180	260	125	150	200	115	130	150	
A5149	50	175	120	160	240	115	140	180	110	120	135	
W5145	47	140	100	130	180	<100	110	140	-	-	-	
Y5147	46	135	100	130	175	<100	105	135	-	-	-	
C5125	43	115	<100	110	145	<100	100	115	-	-	-	
E5127	42	115	<100	110	145	<100	<100	110	-	-	-	
Q5113	42	110	<100	100	135	<100	<100	105	-	-	-	
M5135	40	95	<100	<100	115	<100	<100	<100	-	-	-	
X5120	39	95	<100	<100	115	<100	<100	<100	-	-	-	
G5129	37	90	<100	<100	105	-	-	-	-	-	-	
K5133	35	80	<100	<100	<100	-	-	-	-	-	-	



Rockwell International

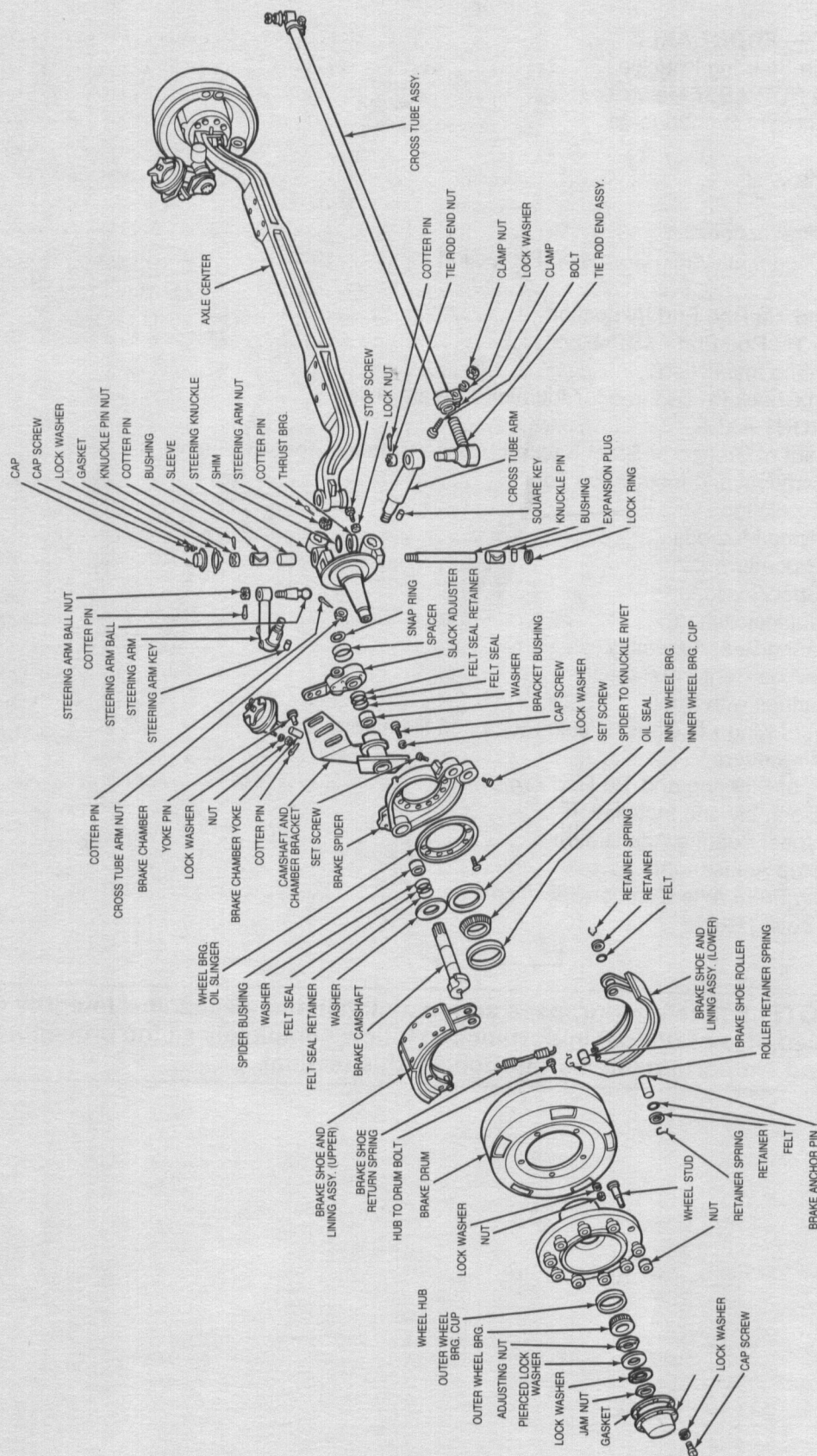
Automotive Operations
Rockwell International Corporation
2135 West Maple Road
Troy, Michigan 48064 U.S.A.

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SERVICE NOTE: For safety purposes and to maintain the mechanical integrity of components being serviced, it is of utmost importance to follow completely all the procedures including all "caution" and "important" items throughout this manual.

TAPERED KNUCKLE PIN DESIGN



[illegible]

NON-DRIVING FRONT AXLES

- CONVENTIONAL MODELS: 900, 901 AND 970
- SEALED KNUCKLE PINS AND PERMANENTLY LUBRICATED CROSS TUBE MODELS: 921, 931, 932, 933, 934 AND 971
- "EASY STEER"™ MODELS: 941 SERIES INCLUDES 941, 942, 943, 944
- ALUMINUM BEAM MODELS: 931A SERIES INCLUDES 931-A AND 941-A
- TUBULAR BEAM MODELS: 951, ALL FU SERIES AND FAE

DISASSEMBLY — FRONT AXLE

CAUTION: Heating of components to aid in disassembly is not allowed because it has a detrimental effect on axle components.

NOTE: It is recommended that safety glasses be worn during disassembly and assembly.

REMOVE THE STEERING KNUCKLE

- A. Jack up the front end of vehicle so that tires clear floor. Block up securely at this position and remove jacks.

CAUTION: To prevent the vehicle from falling, do not disassemble or perform knuckle repair with vehicle supported by jacks only.

NOTE: The aluminum beam axle (FF-931-A) is designed to allow jacking on the bottom surface of the beam. **UNDER NO CIRCUMSTANCES SHOULD IT BE JACKED UNDER THE SPRING.** Be sure to jack up the aluminum beam with care to prevent grooving or notching the lower surface of the beam. Rockwell recommends the following procedures:

1. Use a jack with a minimum of 10 tons (20,000 lbs.) capacity.
2. A jack with a low pick-up height of 8" should be used with a minimum power raise of approximately 5".
3. The Walker 93660 or 93662 jacks, or equivalent, are acceptable for use on the aluminum axle beam.

- B. Remove the hub cap from hub. Then, remove jam nut, wheel bearing adjusting nut and lock washers from knuckle spindle.
- C. Remove the outer wheel bearing cone.
- D. Remove wheel and hub assembly.
- E. Disconnect brake air chamber lines on units equipped with air brakes, or hydraulic lines on units equipped with hydraulic brakes.
- F. Remove brake assembly from steering knuckle if knuckles are to be rebuilt.
- G. If knuckles are to be rebuilt or tie rod to be serviced, remove cross tube end nut and disassemble cross tube assembly from cross tube arm (Figure 1).

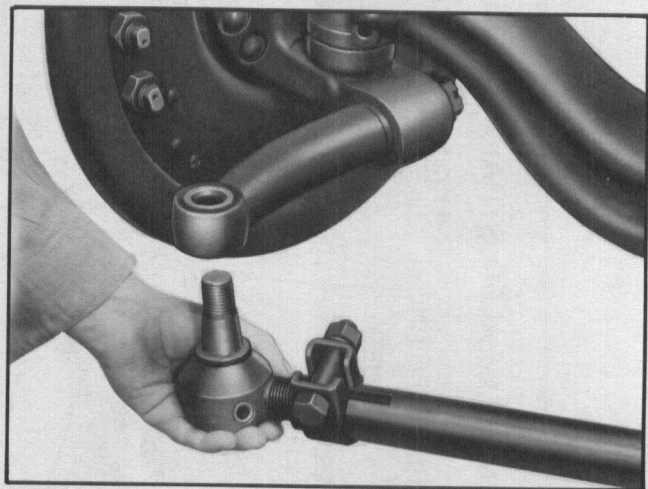


Figure 1

- H. Remove steering knuckle cap capscrews, caps and gaskets from top and bottom of knuckle. Some models may have a welsh plug in place of the lower king pin cap assembly. Remove snap ring and plug.

I. Depending upon type of axle being serviced, proceed as follows:

- a. Straight knuckle pin models (901, 921, 931, 941 and 951) continue from here.
- b. Tapered knuckle pin models (900, 910, 930 and 970) start on page 7.

STRAIGHT KNUCKLE PINS (901, 921, 931, 941, 951, 970 & 971 Series Models)

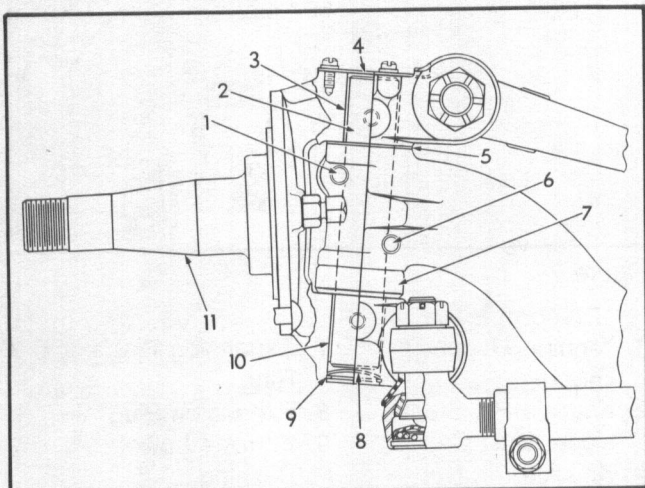


Figure 2

- | | |
|----------------------------|-----------------------------|
| 1. Draw Key — Upper | 7. Thrust Bearing |
| 2. Knuckle Pin | 8. Expansion Plug |
| 3. Knuckle Bushing — Upper | 9. Expansion Plug Lock Ring |
| 4. King Pin Cap | 10. Knuckle Bushing Lower |
| 5. Shims | 11. Knuckle/Spindle |
| 6. Draw Key — Lower | |

A. Straight Knuckle Pin Removal (Figure 3)

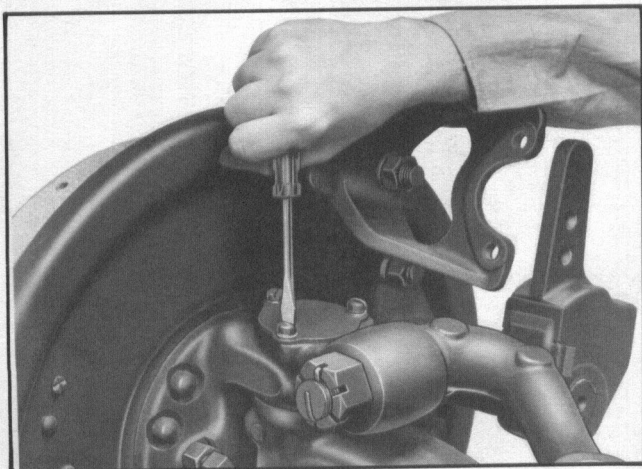


Figure 3

Straight knuckle pins may be removed from the bottom of the knuckle where adequate clearance is provided; however, on some models such as those with riveted backing plates, less work is involved by tapping the knuckle pin out the top of knuckle. In either case the adjacent parts, such as air chambers, hydraulic lines or fittings, etc. that might cause an obstruction to the knuckle pin, must be removed first. Refer to brake manual for brake disassembly.

B. Draw Key Removal (Two per King Pin)

1. Plain draw keys should be driven out from the small end ("D" shaped) using a steel drift and a brass hammer (Figure 4).

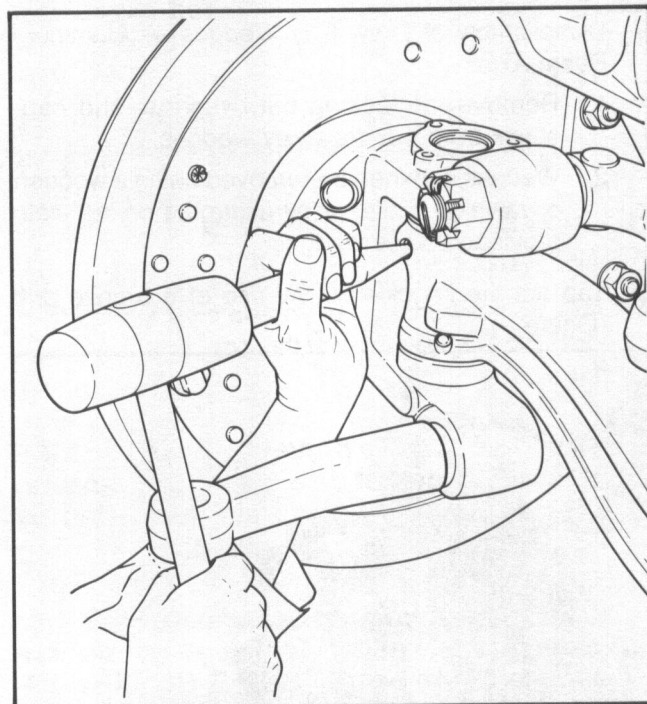


Figure 4

2. Threaded draw keys (current model axles) should be removed as follows:

- a. Loosen locknut 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 square may result in a damaged key causing removal difficulties.

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

NOTE: Aluminum beam axles do not have machined draw key flat on the king pin (Figure 5).

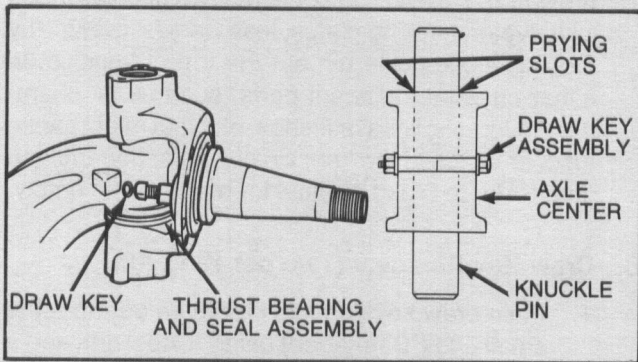


Figure 5

C. Disassembly of Draw Key Wedges — Aluminum Beam Axles

1. Remove the locking nut, washers and cap-screw from the draw key wedges.
2. Wedges can then be removed using a wooden or rawhide mallet or by using the prying slots provided on the wedges.

D. Tap out the knuckle pin by use of a bronze drift (Figure 6).

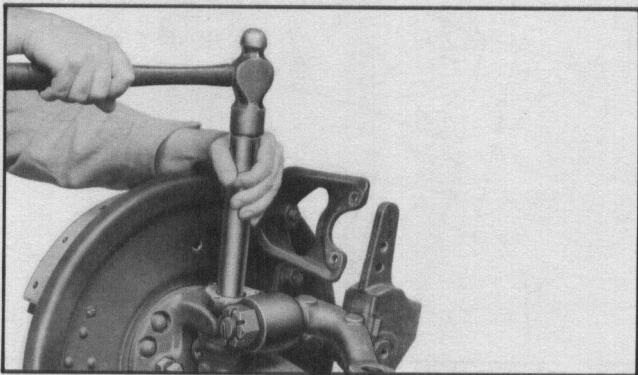


Figure 6

NOTE: If bushings are not to be replaced precautions must be taken not to damage the bushings while removing the king pin. 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 step is especially important for Delrin and easy steer bushings.

CAUTION: Do not strike these hardened steel pieces directly with a steel hammer. Personal injury from chips or splinters may result.

- E. Lift off the knuckle assembly, thrust bearing and shims. Retain shims, thrust bearing and seal for assembly.**

NOTE: Aluminum beam axles employ an integral thrust bearing and lower seal assembly. **DO NOT SEPARATE THE SEAL FROM THE THRUST BEARING.**

**TAPERED KNUCKLE PINS
(900, 910, 930 and 970 Models)**

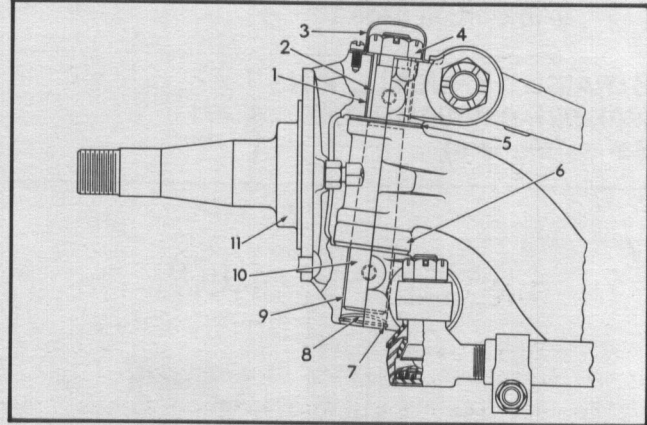


Figure 7

- | | |
|--------------------------|-----------------------------|
| 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 | |

A. Tapered knuckle pins must be removed from the bottom side of the knuckle.

1. On some models it will be necessary to remove the brake components to provide clearance for knuckle pin removal. Refer to brake manual for brake disassembly (Figure 8).

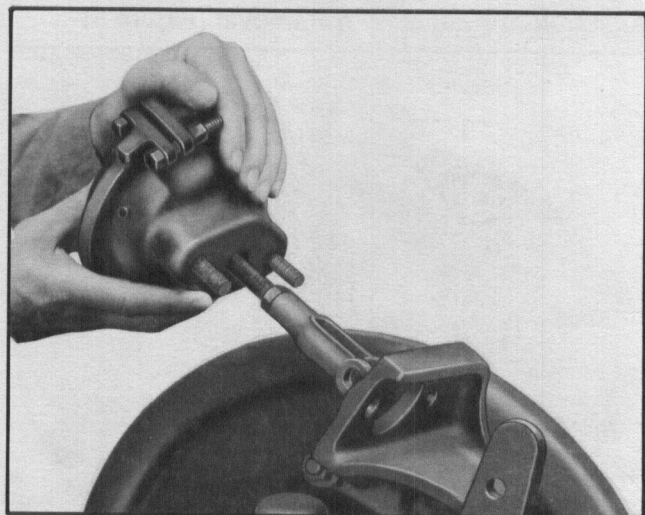


Figure 8

- B. Remove the knuckle pin cover capscrews, cover and cover gasket.
- C. Knuckles employing lower expansion plugs and lock rings:
 1. Remove the lock ring with a pair of snap ring pliers.
 2. Dislodge and remove expansion plug with a small drift.
- D. Remove knuckle pin cotter key and nut (Figure 9).



Figure 9

- E. Drive knuckle pin out by use of drift on upper end. Bronze drift should be used to avoid any damage to threads (Figure 10).

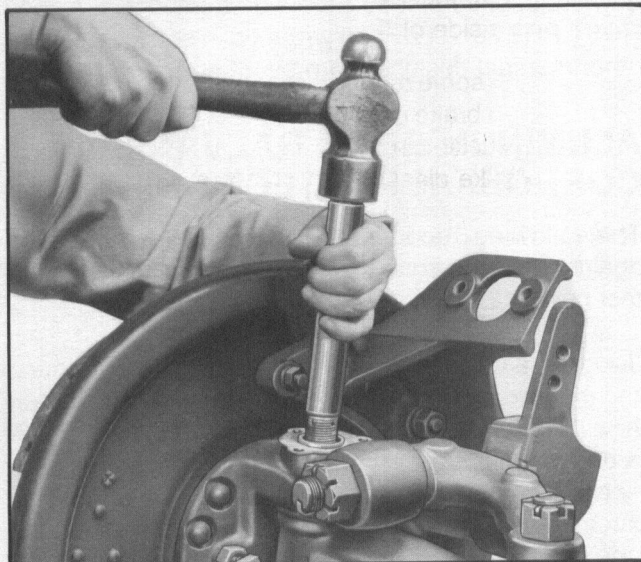


Figure 10

CAUTION: Do not strike these hardened steel pieces directly with a steel hammer. Personal injury from chips or splinters may result.

- F. Remove the knuckle pin sleeve and lift off steering knuckle, thrust bearing, spacing washers, and backplate assembly (Figure 11).

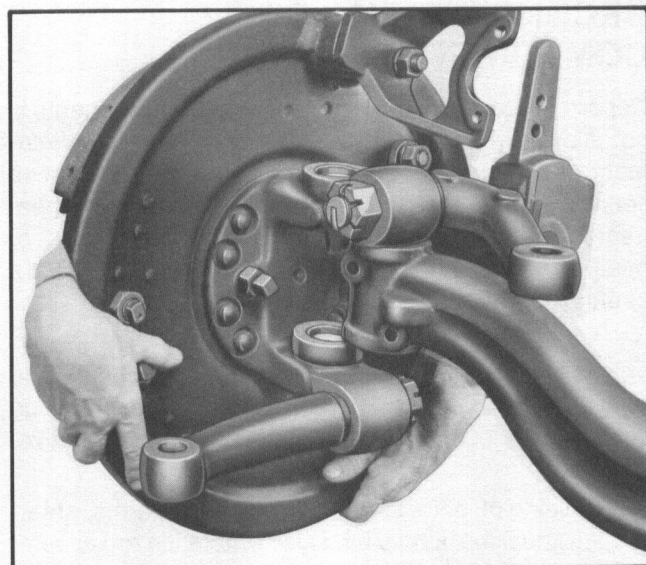


Figure 11

- G. 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 a seal must be removed, pry it out with a screwdriver (Figure 12).

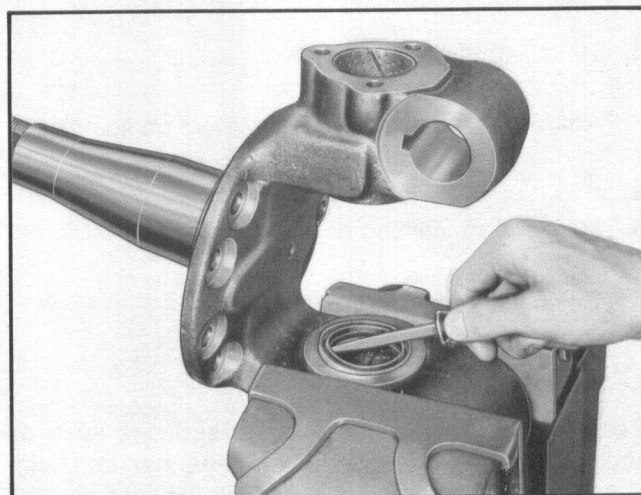


Figure 12

- H. Bushing Removal

1. Delrin bushings require no tools for removal. Bronze and Easy Steer bushings require a 5-ton press and a simple tool. See assembly section for details. Fixture the knuckle rigidly with the king pin hole vertical. Press the bushings out slowly with frequent stops to check alignment of the tool with the bushing bore and with the press ram face.

PREPARATION FOR ASSEMBLY

RECONDITIONING OF COMPONENTS

Repair or reconditioning of any front axle components is not allowed. Rockwell strongly recommends replacement of any component which is damaged or out of specification. All of the major components are heat treated and tempered and cannot be bent, welded, heated or repaired in any fashion without experiencing a strength or fatigue life reduction.

This is a partial list of operations strictly prohibited on front axle components. For further items or explanation contact your local Rockwell Technical Representative.

1. Welding of, or to, steering arms, tie rod arms, steering knuckles, king pins, axle centers, tie rod assemblies, hubs, drums or brakes.
2. Hot or cold bending of spindles, steering arms, tie rod arms, bull studs, axle centers or tie rod assemblies for any reason.
3. Redrilling and bushing of axle center king pin holes.
4. Redrilling of draw key holes.
5. Spray welding of bearing diameters on spindles or in machined bores.
6. Milling or machining of any component.
7. Relocation of tie rod clamps.

CLEANING

Parts having ground and polished surfaces such as knuckle pins, knuckle pin sleeves, bearings and spindles, should be cleaned in a suitable solvent such as kerosene or diesel fuel.

 **CAUTION: Exercise care to avoid skin rashes, fire hazards and inhalation of vapors when using solvent type cleaners. GASOLINE SHOULD NOT BE USED AS A SOLVENT.**

DO NOT clean these parts in a hot solution tank or with water and alkaline solutions such as sodium hydroxide, orthosilicates or phosphates.

ROUGH PARTS

Rough parts such as cast brackets and some brake parts, may be cleaned in hot solution tanks with mild alkali solutions, providing these parts are not ground or polished. The parts should remain in the tank long enough to be thoroughly cleaned and heated. This will aid the evaporation of the rinse water. The parts should be thoroughly rinsed after cleaning to remove all traces of alkali.

 **CAUTION: Exercise care to avoid skin rashes and inhalation of vapors when using alkali cleaners.**

DRYING

Parts should be thoroughly dried immediately after cleaning. Use soft, clean, lintless, absorbent paper towels or wiping rags free of abrasive material, such as lapping compound, metal filings or contaminated oil. Bearings should never be dried by spinning with compressed air.

CORROSION PREVENTION

Parts that have been cleaned, dried, inspected and are to be immediately assembled, can be coated with light oil to prevent corrosion. If these parts are to be stored for any length of time, they should be treated with a good RUST PREVENTIVE and wrapped in special paper or other material designed to prevent corrosion.

ALUMINUM BEAM GALVANIC CORROSION PROTECTION

The following recommendations are for protection against galvanic corrosion of the steel-aluminum contact points on aluminum beam axles:

Using an aluminum spacer between the steel spring and the axle beam will eliminate galvanic corrosion on the axle beam. If it is necessary for the steel spring to be in direct contact with the aluminum axle, it is recommended that the spring pad area be treated with a zinc chromate paint. The entire spring pad, as well as the inner surface of the dowel and U-bolt should be covered.

The U-bolt should be used with flat washers that are cadmium plated and dichromate converted per Federal Specification QQ-P-416, Type II. The clearance space

between the U-bolt and the holes in the axle spring pad should be filled with a rust preventive compound, such as Texaco Compound L, to prevent water from standing in this space.

INSPECTION

It is impossible to overstress the importance of careful and thorough inspection of steering knuckle components prior to assembly. Thorough visual inspection for indications of wear or stress, and the replacement of such parts as are necessary, will eliminate costly and avoidable front end difficulties.

- A. Inspect the steering knuckles, king pins, steering arms and tie rod arms and replace if indications of weakness, cracks or excessive wear is found. Cracks can be located by die check, magnetic particle or fluorescent particle inspection performed by a qualified technician.
- B. Check spindle bearing diameters for size and condition. Replace spindle if bearing diameters are under specification, discolored from heat or severely scored.
- C. If tie rod arm or steering arm has been removed, inspect tapers for fretting pits. If the tapered hole in the knuckle is fretted and pitted replace both the knuckle and the arm. If only the arm taper is fretted, replace only the arm.
- D. If the king pin has worn through the bushing and into the knuckle, replace the knuckle.
- E. Check the tightness of the steering connections such as cross tube arms, steering arm, etc.
- F. For units with sealed knuckle pins, check knuckle pin seal for rips, tears and excessive wear. Do not remove the seals from the steering knuckle unless replacement is necessary or the knuckle is to be rebushed.
- G. Remove the thrust bearing seal from the thrust bearing case and inspect the seal for wear, rips and tears. On aluminum axles with integral seals, do not remove seal.
- H. Check thrust bearing.
- I. Check knuckle pin bushings for wear, flaking or scoring. Compare diameter with correct specification, if the bushing diameter is .010" greater than the new bushing dimension, replace the bushings.
- J. Check axle center bore for condition and size. Replace center if bore is .001" greater than specification.

IMPORTANT: Any indication of looseness in the total steering linkage arrangement 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.

TIE ROD AND TIE ROD END INSPECTION

- A. Check seals visually for any indication of damage, also check to make sure that the seal is securely seated on the socket. If the cross tube end has a grease fitting, replace damaged seals. Ends not having greasing provisions, the entire tie rod end should be replaced if seals are damaged or loose.

IMPORTANT: Rockwell does not recommend attempts to salvage damaged ends by repacking and replacing the boot seal on non-greasable ends.

- B.
 1. Check the turning torque value between the ball stud and the ball cavity. If torque value is less than five (5) inch pounds, the cross tube end assembly should be serviced.
 2. No lateral or vertical movement should be found in any tie rod assembly when checked by hand. Leverage or prying with a tool can produce vertical movement in most tie rod ends which is inherent in their design. Use of tools for checking free play is not recommended.
 3. Permanently lubricated and extended lube end assemblies should be replaced if found below specifications. Serviceable models should be rebuilt.
- C. Any tie rod tubes found to be cracked, bent, dented or severely gouged should be replaced.

REBUILDING TIE ROD END ASSEMBLIES

Some older models contain tie rod assemblies which are rebuildable. These are however limited in the number of rebuilds. A determination must first be made of the condition of the socket forging. Those excessively worn must not be used again, but replaced. These can be replaced with new rebuildable or non-rebuildable end assemblies.

WHEEL BEARING INSPECTION

Wheel bearings should be very closely inspected at the time of knuckle inspection or when knuckle repair is being made.

Inspect wheel bearing cones and cups. Replace if rollers or cups are worn, pitted or damaged in any way. If wheel bearing cups are to be replaced, remove from hubs with a suitable puller. To avoid hub damage don't use drifts and hammers.

Remove all the old grease from the wheel bearings, spindle, hub cavity, and hub cap.

(The old grease may contain moisture which would lead to an early bearing failure if not removed.) Use kerosene or diesel fuel and a stiff brush. Gasoline and heated solvents should be avoided.

Allow the cleaned parts to dry, or dry them with a clean absorbent cloth or paper. Clean and dry hands and all tools used in the service operation. Grease will not adhere to a surface which is wet with solvent, and solvent may dilute the lubricant.

Bearings must be replaced if any of the following conditions exist:

1. Large ends of rollers worn flush to recess or radii at large ends of rollers worn sharp (Figure 13).

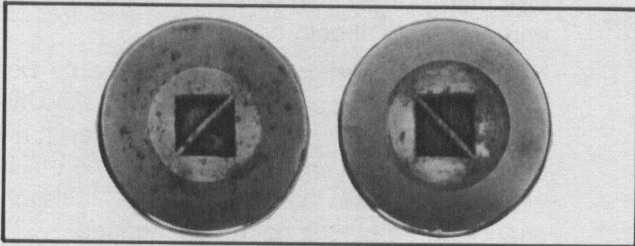


Figure 13

2. (a) Visible step wear, particularly at the small end of the roller track.
(b) Deep indentations, cracks or breaks in bearing cup and/or cone surfaces (Figure 14).

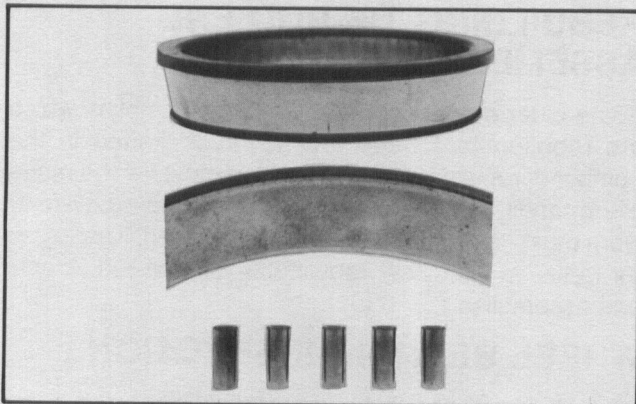


Figure 14

3. Bright rubbing marks on the dark phosphate surfaces of the bearing cage (Figure 15).

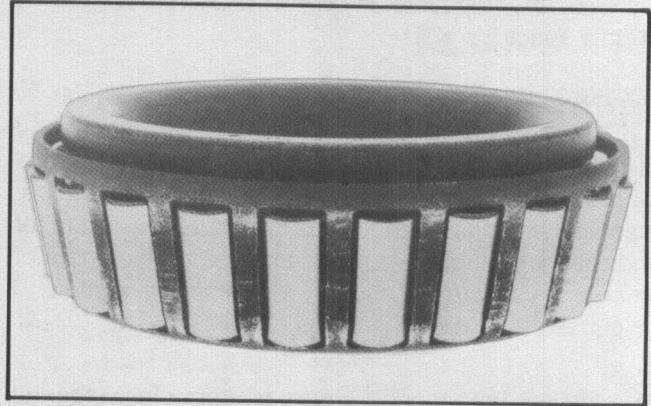


Figure 15

4. Etching or pitting on functioning surfaces (Figure 16).

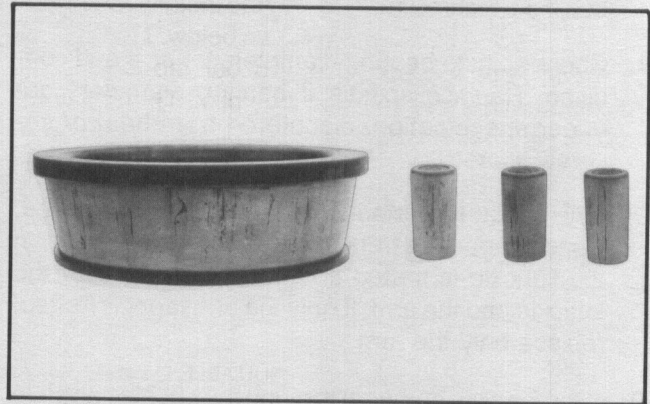


Figure 16

NOTE: Repeat bearing failures are a result of out of round hubs or spindles or indicate a poor assembly or adjusting practice.

5. Spalling or flaking on bearing cup and/or cone surfaces (Figure 17).

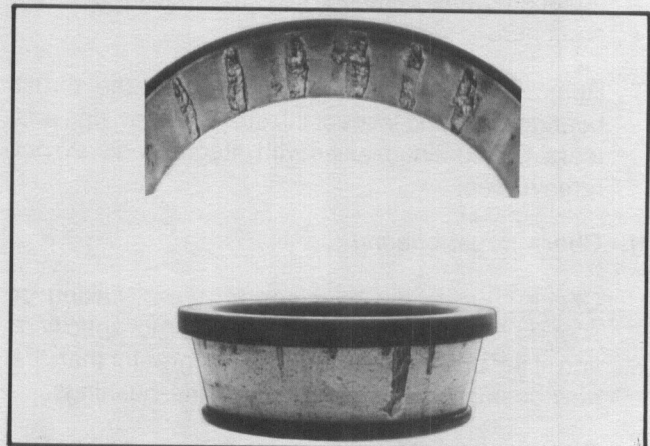


Figure 17

REPAIR AND CHECK PROCEDURES FOR ALUMINUM BEAM AXLES

Rockwell disapproves of heating, welding, bending, altering or drilling the aluminum axle center.

Repair of the spring seat dowel hole is permitted, if necessary. Our recommendation is to drill out the dowel hole so that the new diameter is no more than .5" larger than the original diameter. Install an aluminum bushing

(aluminum alloy 7075-T73 or 7075-T76) with an interference fit of .000" to .003". The bushing should be shrunk by freezing prior to installation in the enlarged hole. Pressing the bushing into place at ambient temperature is not recommended. Under no circumstances should the axle center dowel hole be expanded by heating during installation of the bushing.

NOTE: If brakes require service, refer to Rockwell Field Maintenance Manual No. 4 for Cam-Master® Brakes. (Also Disc.)

ASSEMBLE FRONT AXLE

REPLACEMENT OF BRONZE OR STEEL BACKED BRONZE STEERING KNUCKLE BUSHINGS

A tool used for removal of old and the installation of new steering knuckle bushings is shown below. The tool can be made from a piece of round bar stock which is machined with a step to serve as a pilot. This tool is not required for Delrin bushings.

BUSHING REMOVAL AND INSTALLATION TOOL (Figure 18)

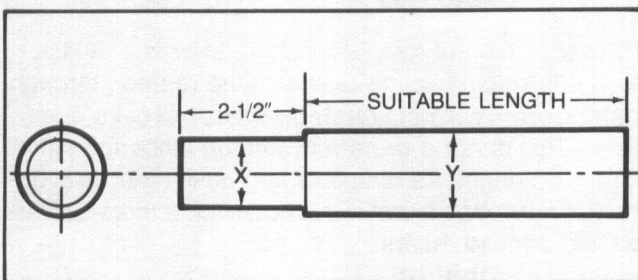


Figure 18

Dimension "X" is 0.010" less than the bushing bore.

Dimension "Y" is 0.010" less than the steering knuckle bore.

See page 15 for dimensions.

A minimum press capacity of 5 tons is required to remove bronze and easy steer bushings.

IMPORTANT: Fixture the knuckle firmly on the bed of the press to avoid knuckle slippage during bushing removal or installation.

A. The worn bushings are pressed out of the knuckle, employing tool shown.

B. The new bushings will be installed with the same tool. The pilot of this tool prevents collapse or distortion of bushing during installation.

BUSHING INSTALLATION STANDARD BRONZE BUSHINGS

Before installation, the bushings on some models must be properly oriented.

The grease hole in the bushing must line up with the grease hole in the knuckle. The circumferential grease groove should be positioned toward the end of the king pin.

First press bushing into knuckle approximately 1/8", relieve press pressure and check alignment of tool and bushing. The bushing can now be pressed in until it is flush with the top machined surface of the knuckle. For those designs that have king pin seals, the bushing can 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 completed (Figure 19).

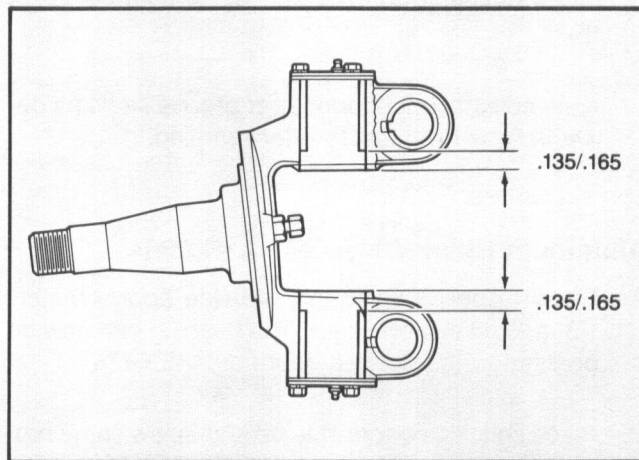


Figure 19

EASY STEER™ BUSHING INSTALLATION

Steel Beam Axle FF-941, FG-943, FG-941, FF-942, FF-943, FF-944 Models (Figure 20)

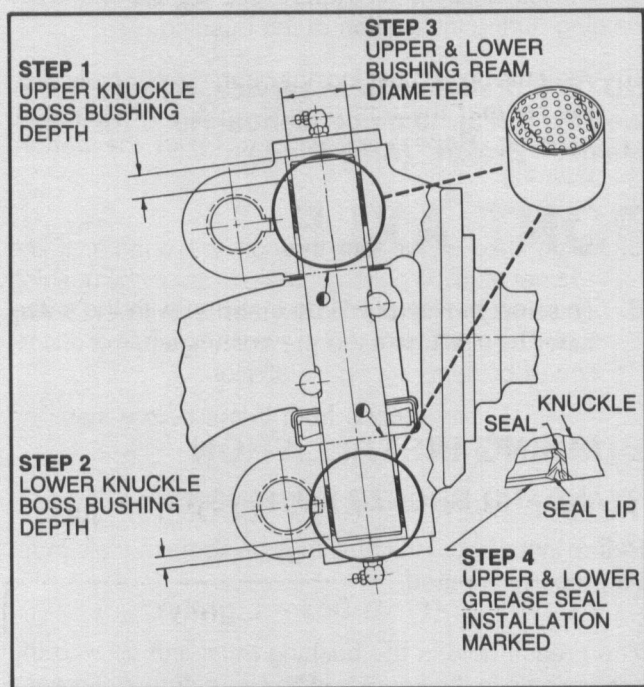


Figure 20

- Press upper bushing into knuckle approximately 1/8" and relieve pressure. Bushing can now be pressed to the desired depth of .352"/.382" from the top of the machined surface.
- Place knuckle bottom side up and follow same procedure as step #1 to a depth of .352"/.382" from the bottom machined surface.
- Ream bushings to specified diameter (see page 15).
- Assemble the upper and lower grease seals as per instructions on page 16 after reaming.

Aluminum Beam Axles 941-A Models

- Press **upper** bushing into knuckle approximately 1/8" and relieve pressure. The bushing can now be pressed to the desired depth of .445"/.475".
- Place knuckle bottom side up and follow same procedure as step #1 to a depth of .290"/.320".
- Ream bushings per specifications on page 15.

All other Models

For all other models follow the bronze bushing sealed king pin design installation procedure for installation and use chart page 15 for new bushing diameter.

NOTE: Easy Steer retrofit kit may contain king pin seals which are not part of the original design of the axle assembly. The Easy Steer bushings are to be installed .135" to .165" from the inner knuckle yoke faces. The grease hole in the bushing must line up with the grease hole in the knuckle.

BUSHING SIZING METHODS

DELTRIN BUSHINGS (No Sizing Required)

BRONZE BUSHINGS (Recommended Method)

Reaming — this is the only method of sizing bushings which gives accurate size and alignment of bores as good as a new factory finished part. Single purpose piloting reamers per the illustration and charted dimensions are the best.

An acceptable but less accurate reamer is a multipurpose adjustable piloting reamer. One reamer, through trial and error, can accurately be sized to fit several axle sizes. This is not a preferred method since the cutter cannot be gaged for diameter and bushing bore alignment is not very accurate. It is however, a more universal and affordable tool.

Methods Not Recommended

Burnishing — burnishing bars and balls are seldom the correct size and do not provide alignment of the upper and lower bushing bores.

Honing — although this is the most universal method of sizing bushings, it is not recommended because it does not provide good bushing bore alignment. Bushing bore size is good with this method.

EASY STEER BUSHINGS

Reaming — as with bronze bushing, a new axle finish can only be accomplished with a reamer. See details under "Bronze Bushings."

Methods Not Recommended

Burnishing — the Easy Steer bushing material is too resilient to be sized with burnishing bars or balls.

Honing — this method does not work well with the Easy Steer bushing material and does not provide proper alignment of the bores. This can be used as a last resort but must be done dry (no lubricant) and with new stones.

REAMING PROCEDURE

REAM UPPER BUSHING FIRST (Figure 21)

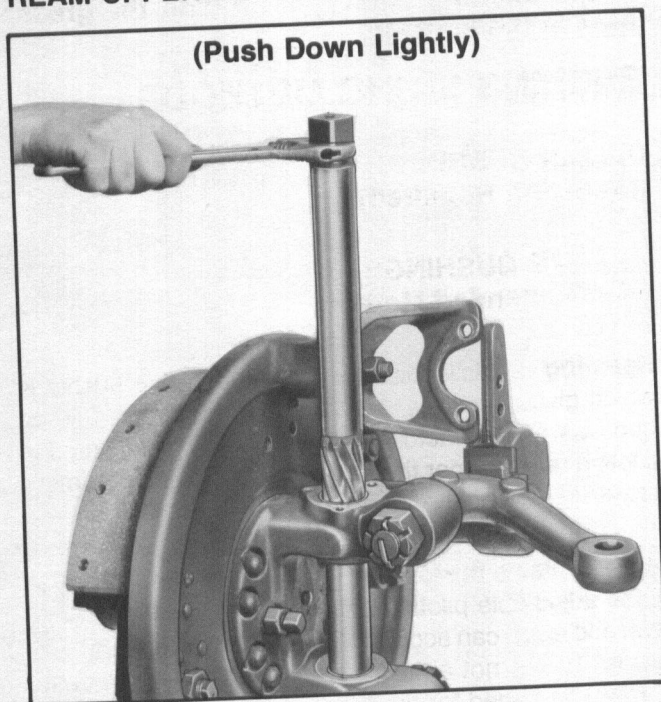


Figure 21

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.
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. Repeat steps 3 and 4 for the bottom 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.

REAM LOWER BUSHING SECOND (Figure 22)

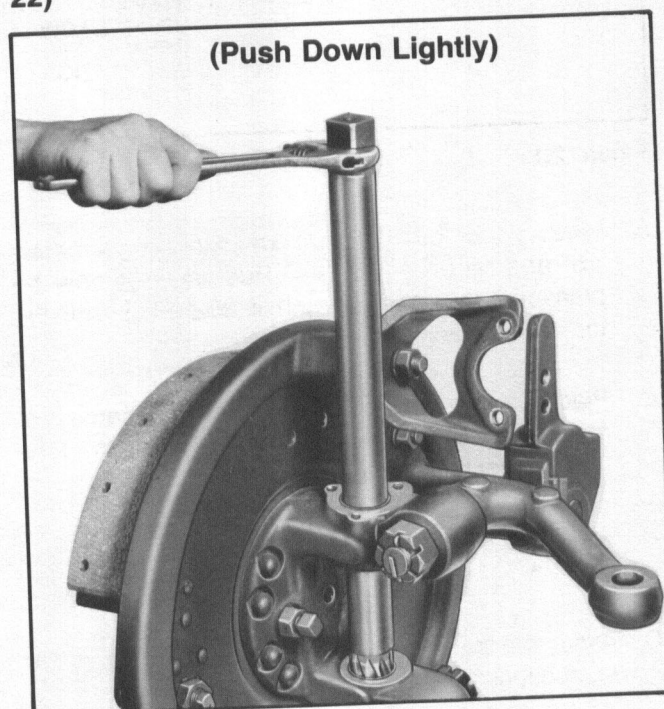
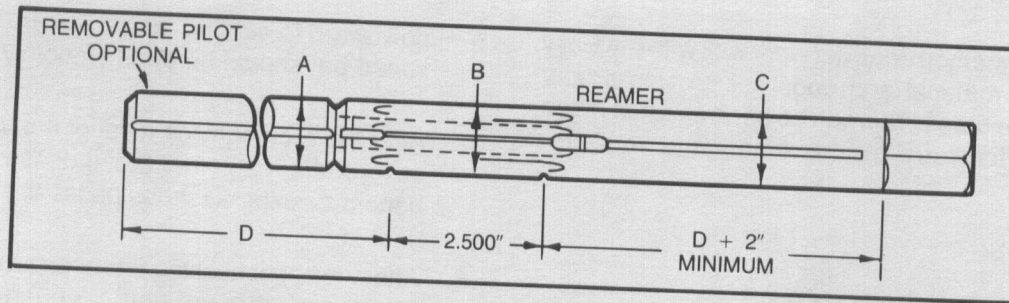


Figure 22



BUSHING INSTALLATION AND REMOVAL TOOL

REAMING SPECIFICATIONS

Axle Model	Reamer Tool Dimensions (All Dimensions in Inches)				Bushing Removal and Installation Tool Dimensions (All Dimensions in Inches)	
	'A' (± 0.001)	'B' (± 0.0005)	'C' (± 0.001)	'D'	'X' (± 0.001)	'Y' (± 0.001)
FC-901, 900 and FC-901 'Easy Steer' Retrofit	1.2205	1.2355	1.2305	6.75	1.218	1.315
FD-900/901/903	1.422	1.4370	1.4315	8.50	1.417	1.552
FD-901/903 'Easy Steer' Retrofit	1.420	1.435	1.430	8.50	1.417	1.552
FD-931	1.596	1.6100	1.6045	8.50	1.595	1.725
FD-941	1.5940	1.6085	1.6035	8.50	1.595	1.725
FE-900	1.596	1.6100	1.6045	8.30	1.595	1.725
FE-970 Delrin Bushing ^①	—	—	—	—	—	—
FE-970	1.596	1.6100	1.6045	8.30	1.595	1.725
FF-901/903	Same as FF-931					
FF-901/903 'Easy Steer' Retrofit	Same as FF-941					
FF-921	Same as FF-931					
FF-930	Same as FF-931					
FF-931/933/932/934	1.774	1.7970	1.7915	9.30	1.780	1.912
FF-931-A	1.774	1.7970	1.7915	10.25	1.780	1.912
FF-941/943/942/944	1.780	1.7955	1.7905	10.25	1.780	1.912
FF-941-A	1.780	1.7955	1.7905	10.25	1.780	1.912
FF-971	1.596	1.6100	1.6045	8.90	1.595	1.725
FG-931/933	Same as FF-931					
FG-941/943	Same as FF-941					
FH-901 Delrin Bushing ^①	—	—	—	—	—	—
FH-901/903	1.987	2.0025	1.9965	10.1	1.987	2.116
FL-901 Delrin Bushing ^①	—	—	—	—	—	—
FL-901/903	Same as FH-901					
FL-901/903 'Easy Steer' Retrofit	Same as FL-941					
FL-931/933	1.987	2.0025	1.9965	10.1	1.987	2.116
FL-941/943	1.985	2.0005	1.9955	10.1	1.987	2.116
FL-951	Same as FL-931					
FL-951 'Easy Steer'	Same as FL-941					
FQ-901/921	2.0495	2.0645	2.0590	11.315	2.047	2.179
FU-901/910/915/ 900/930/935	Same as FQ-901					
FAE-951	1.0145	1.110	1.115	5.8	1.104	1.223
16931	Same as FF-931					
17100	Same as FF-931					

NOTES: ^① On models equipped with Delrin bushings, the reamer and the removal/installation tool are not required.

NOTE: Models with tapered knuckle pins employ a sleeve in the upper bushing location allowing the upper and lower bushings to be reamed to the same size.

GREASE SEAL INSTALLATION

IMPORTANT: Do not install seals until bushings have been reamed; seals will be damaged during reaming.

BRONZE BUSHING KNUCKLES

- A. 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.

- B. With the top end of the knuckle held firmly in this position, place the seal over the knuckle counter-bore, with the rubber lip facing up.
- C. Using a suitable sleeve and a bronze drift, tap the seal into the knuckle until it bottoms against the bushing or counter bore.
- D. 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.

EASY STEER BUSHING KNUCKLES

- A. Follow instructions for bronze bushed knuckles A, B and C.
- B. 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 23.

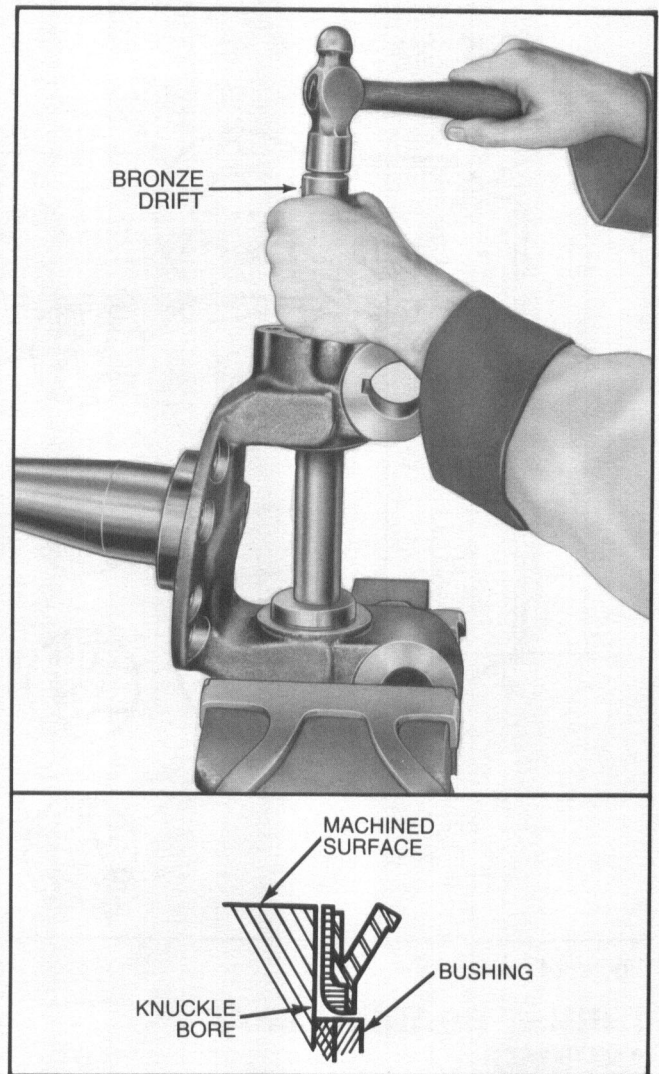


Figure 23

EASY STEER RETROFIT INTO NON-SEALED AXLE DESIGNS ONLY

- A. A driver is required to position the seals in the knuckle bore.
- B. Position the seals against the bushings as shown.

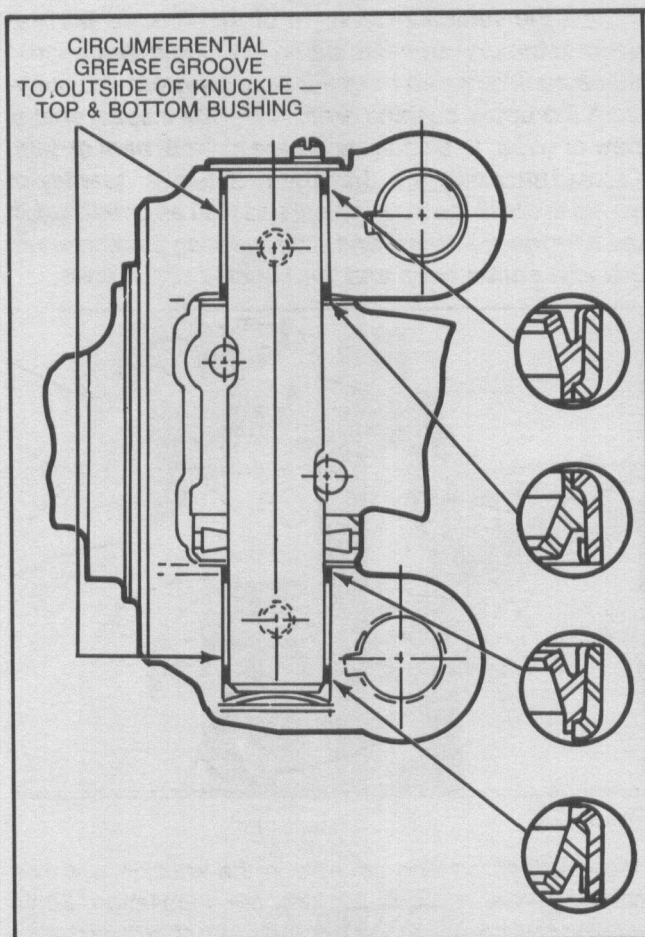


Figure 24

THRUST BEARING SEAL ASSEMBLY

NOTE: Aluminum beam axles employ an integral thrust bearing and seal assembly (Figure 25).

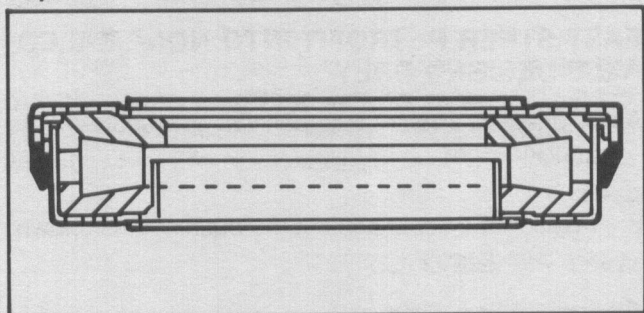


Figure 25

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.

FRONT AXLES WITH THRUST BEARING SEALS

- Before installing the thrust bearing and seal assembly on the steering knuckle, make certain the seal is assembled to the thrust bearing correctly.
- Hold thrust bearing with the opening between the bearing cage and the retainer up. Then snap the seal securely over the opening (Figure 26).

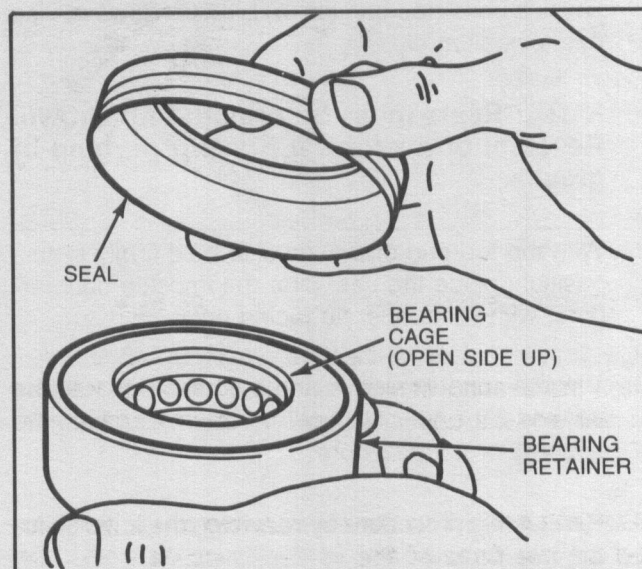


Figure 26

FRONT AXLES WITHOUT THRUST BEARING SEALS

No sub-assembly is required.

KNUCKLE TO AXLE CENTER ASSEMBLY

- Clean knuckle and axle center bores of any dirt and debris, and dry components.
- Place the knuckle in position on the axle center.

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 lower knuckle yoke (Figure 27).

IMPORTANT: The thrust bearing must be seated on the upper face of the lower knuckle yoke. On axles WITH thrust bearing seals the seal must always cover the opening between the bearing cage and retainer. Always install the bearing and seal assembly in the axle with the seal on top (Figure 27).

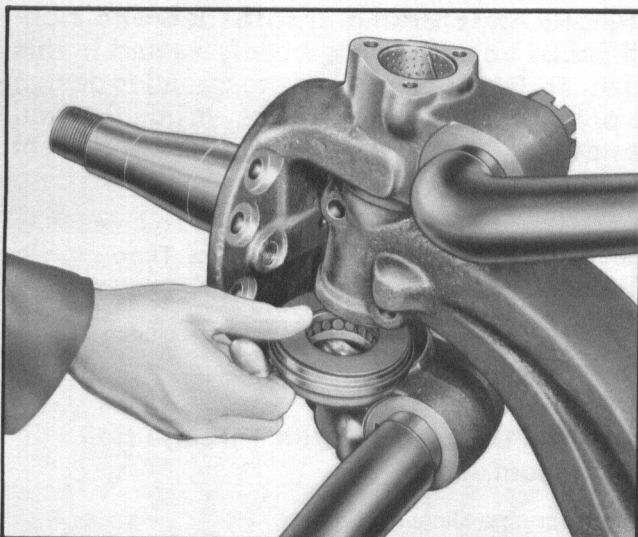


Figure 27

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 (Figure 28).

IMPORTANT: The thrust bearing must be seated on the face of the lower knuckle yoke. On axles **WITHOUT** thrust bearing seals the bearing should always be installed in the axle with the closed retainer face up and the cage face (with the opening) down (Figure 28).

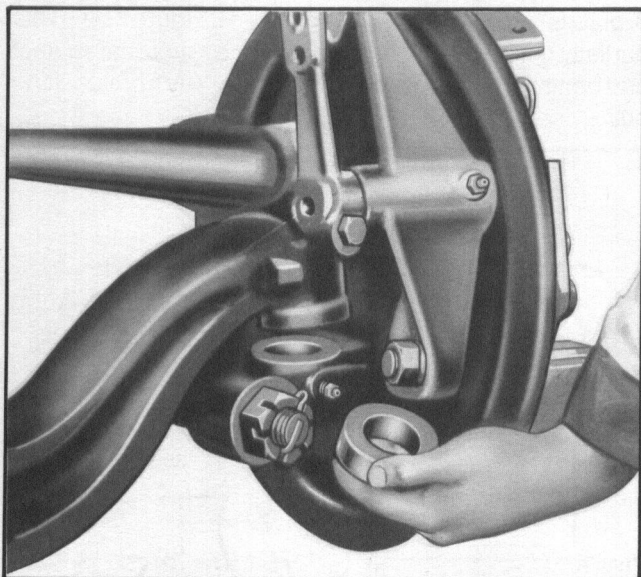


Figure 28

SHIM ASSEMBLY (Figure 29)

Shims must now be positioned between the upper axle center face and the upper knuckle yoke. 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.

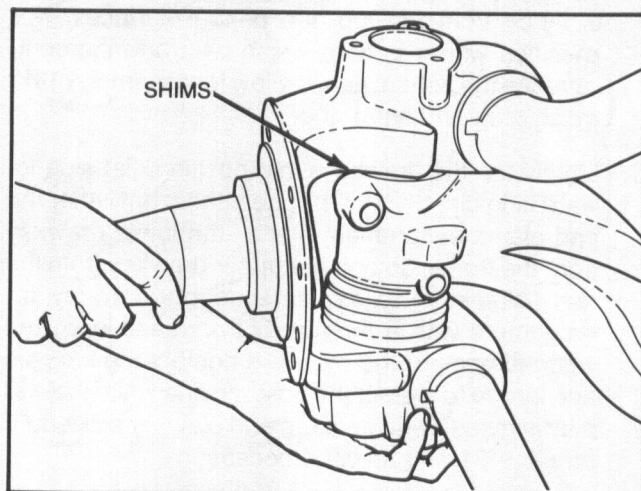


Figure 29

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.

KING PIN INSTALLATION

Straight King Pins

- 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 drawkey slots with the drawkey 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 drawkeys into position, flat side toward king pin; do not firmly seat them until after the end play measurement. Install the lower drawkey from the front side and the upper drawkey from the rear. Aluminum axles use a double drawkey arrangement with a through bolt. 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. Measure end play per procedure on page 21 and adjust if necessary.

NOTE: Never install both drawkeys from the same side.

Seating Keys

After the specified end play is obtained, seat the drawkeys firmly with a hammer and drift — all except aluminum axle which does not require seating (Figure 30).

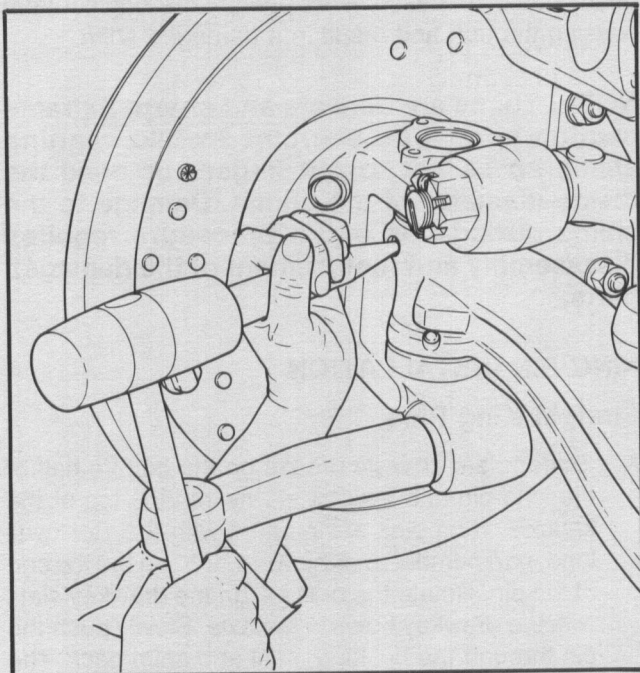


Figure 30

IMPORTANT: Both the threaded and non-threaded 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 (except aluminum axle).

Securing Threaded Drawkeys (Steel Axles)

Install flanged locknut and torque to specification. (Refer to torque chart.)

Securing Double Key With Through Bolt (Aluminum Axles)

Torque to specification.

Securing Plain Drawkeys

Plain drawkeys are secured by staking with a pointed punch and must therefore be only slightly below the forged surface of the axle center. King pin kits are supplied with three different length upper (shorter) and lower (longer) drawkeys.

The seated drawkeys should be 1/32" minimum to 1/8" maximum below the forged surface of the axle center boss. If the key falls out of this range, drive it out and replace it with the appropriate size.

Use a sharp pointed steel punch to indent the forging in 3 places around the drawkey hole (Figure 31). This partially collapses the hole and wedges material against and behind the drawkey to prevent the key from backing out.

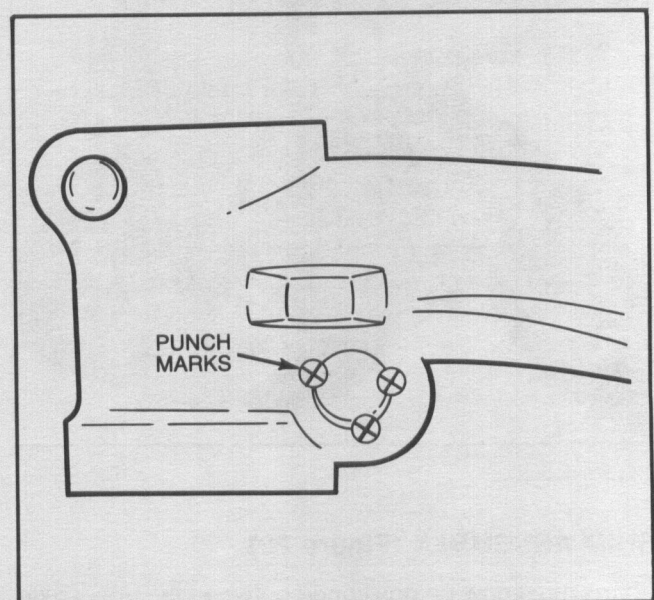


Figure 31

Tapered 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 per procedure on page 21 and adjust if necessary.
- E. Torque nut to specification and install cotter key. If the cotter hole does not align with the nut castellation, advance the nut. Do not back the nut off.

Rockwell does not recommend measurement of clearance tolerances on steering knuckles with shim gauges (feeler gauge). These will not give an accurate reading of end play. Use only a dial indicator.

Procedure for Measurement of Knuckle End Play

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.

- 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 32).

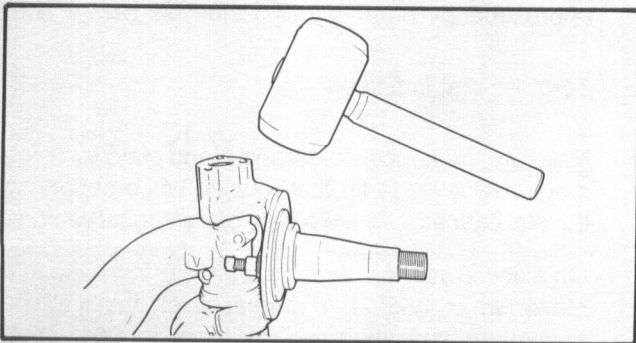


Figure 32

- 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 33).
- 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 33).

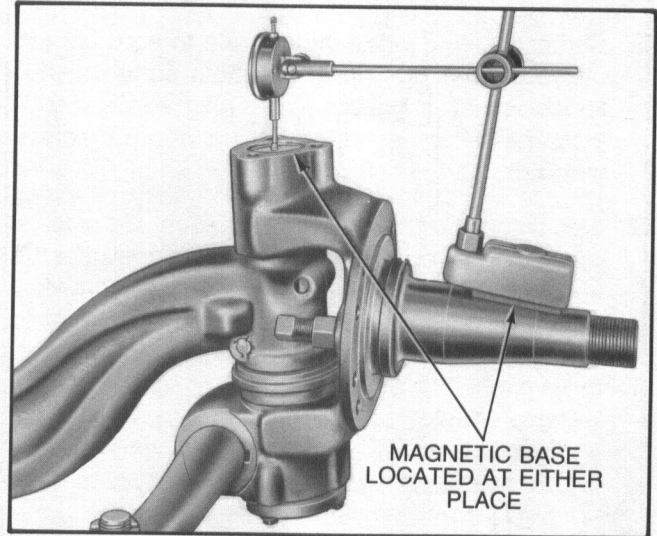


Figure 33

- D. Zero the dial indicator.
- 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 34).

NOTE: A protective pad, such as a piece of cardboard or heavy tape, should be placed between pry bar and aluminum axle center to prevent grooves.

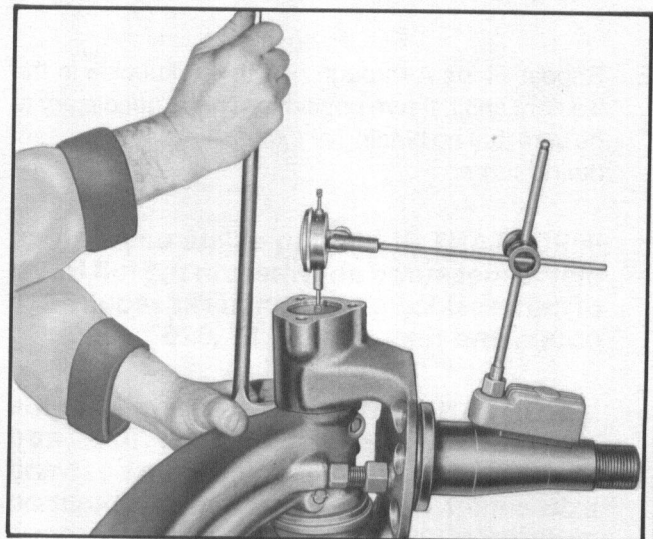


Figure 34

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 35).

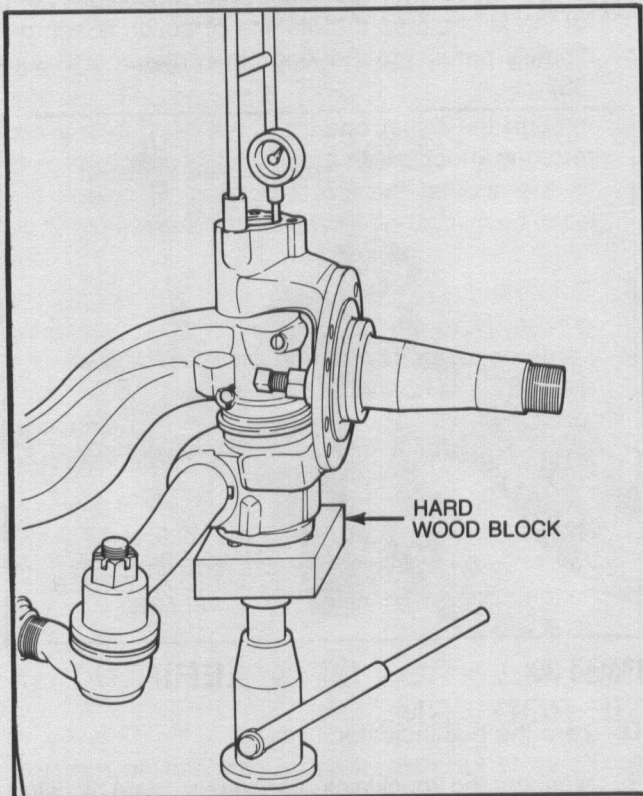


Figure 35

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.

- F. Repeat Steps A through E 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.

PROCEDURE FOR MEASUREMENT OF KNUCKLE AND END PLAY WITH TIRE AND WHEEL ASSEMBLY MOUNTED:

- A. Securely block vehicle to prevent rolling.
- B. 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.
- C. Attach a dial indicator to the axle beam with a "C" clamp or magnetic base (Figure 36).

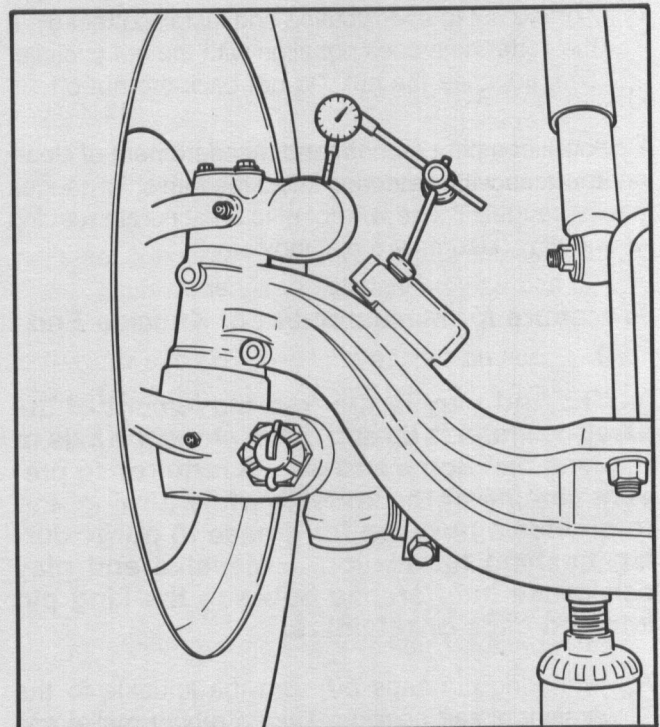


Figure 36

- D. 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.
- E. Zero the dial indicator.
- F. 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.

INSTALLATION OF KING PIN CAPS, WELSH PLUGS AND RETAINERS

IMPORTANT: Before king pin caps and/or welsh plugs are installed recheck drawkeys 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.

KING PIN CAPS AND COVERS

- A. Align king pin caps and gaskets and assemble to knuckles with capscrews and washers.
 - 1. Gaskets do not have a top or bottom orientation and may be installed in either position.
 - 2. Caps do require orienting the flat side toward the gasket and knuckle. The flat, sealing side contains no numbering or lettering.
- B. Torque fasteners to specification.

WELSH PLUGS

- A. Place welsh plug into the lower knuckle bore with the rounded (convex) side toward the king pin.
- B. Install lock ring.
- C. On models not grooved for lock rings, secure the plugs in place by staking in four equally spaced places.

KING PIN RETAINERS

- A. On units employing grooved knuckle pins that protrude below the knuckle lower yoke, install lock ring in groove.

The upper ends of steering knuckle are protected with covers, caps, or retainers and felts.

- B. Install the cover or cap and gasket with capscrews where used.

- C. Install the felt, retainer and lock ring on the protruding straight pins that are not provided with covers or caps.

GREASING PROCEDURE

- A. Grease upper bushing first then lower. (Grease specification 617 A or B). 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 1.
- D. On models using drawkeys fill the voids in the drawkey holes with grease to prevent corrosion and ease future disassembly.

INSTALLATION OF STEERING AND TIE ROD ARMS

- A. Press fit key into steering arm and tie rod arm keyway near the small end of the taper.
- B. Insert arms into knuckle.

NOTE: It is possible to mistakenly reverse the left hand and right hand tie rod arms. Distinction between left and right arm can be made by visualizing the tie rod assembly position.

On center point models FE970 and FF971 the tie rod ball stud is assembled into the arm from the top side; i.e., the ball stud is above the arm.

This is also true for FU series axles with tie rod ends that are rebuildable.

All other models have tie rod assemblies that install from the bottom side; i.e., the ball stud is below the arm.

- C. Assemble nuts and torque to specification.

IMPORTANT: The correct torque range must be reached on steering arms and tie

rod arms. Torques below minimum will not seat the tapers properly and reduce service life.

- D. Install cotter keys. If the cotter hole does not align with the nut castellation, advance the nut to the next castellation. Do not exceed the maximum specified torque value. Do not back nut off for cotter key hole alignment.

TIE ROD ASSEMBLY AND INSTALLATION

Tie rod assemblies with straight tubes contain left hand threads on one end and right hand threads on the other. These mate with similarly threaded tie rod ends. The ends therefore are not interchangeable. This type of assembly does not require removal from the arm for toe-in adjustment and provides very fine adjustment.

Tie rod assemblies with drop center tube contain coarse pitch threads on one side and fine pitch on the other. Ends for these are also not interchangeable. This type of assembly requires removal from the tie rod arm for adjustment since the drop center tube cannot be rotated. The differences in thread pitch provide a finer adjustment range for setting toe-in.

- A. Thread end assemblies into tube equally on both sides to the approximate overall length required.
- B. Torque clamp lock nuts to specification.
- C. Assemble tie rod assembly into the tie rod arms on the axle assembly.
- D. Torque the end assembly nuts to specification and install cotter key.
- E. If cotter pin hole does not align with the nut castellation, advance to the next castellation and install pin. Do not exceed the maximum specified torque while doing this. Do not back nut off to align the cotter hole.

NOTE: If tie rod end assemblies, tie rod tubes or tie rod arms have been removed or replaced, toe in must be checked and readjusted.

GENERAL WHEEL BEARING ADJUSTMENT

ASSEMBLY

- A. Assemble bearings and hub on the axle spindle.
- B. Install thrust washer, if used.
- C. Install the wheel bearing adjusting nut. Thread the nut against the bearing or thrust washer. Be sure there is sufficient clearance between the brake shoe and drum so brake shoe drag will not interfere with the bearing adjustment.

SEATING BEARINGS

NOTE: It is recommended that a torque wrench be employed for assembly of the adjusting nut and jam nut.

Tighten the adjusting nut to 100 lb. ft. torque while rotating the wheel in both directions to be sure all bearing surfaces are in contact. Loosen the nut completely and then re-torque to 50 lb. ft. while rotating the wheel.

FINAL BEARING ADJUSTMENT

The final bearing adjustment is designed to result in .001" to .010" end play. Always be sure that this end play has been obtained after the jam nut has been torqued or when the cotter pin has been installed.

IMPORTANT: Failure to obtain end play as specified will cause bearing overload and premature failure.

- A. For axles that have single nut construction, back off adjusting nut 1/6 to 1/8 turn. Install cotter pin and measure end play, adjusting if necessary.
- B. For axles that have double nut and lock construction, back off adjusting nut 1/4 to 1/3 turn. Assemble wheel bearing lock ring if used, jam nut lock and jam nut. Tighten jam nut to torque specified below. Measure end play and adjust if necessary.

NUT SIZE	LB. FT. TORQUE	
	MIN.	MAX.
1-1/8" to 2-5/8"	100	150
2-5/8" and over	100	200

- C. Bend the jam nut lock over the jam nut and over the adjusting nut if no lock ring is used.
- D. For assemblies using a dowelled adjusting nut, pierced lock washer, and no jam nut lock washer torque jam nut as follows, measure end play and adjust if necessary.

NUT SIZE	LB. FT. TORQUE	
	MIN.	MAX.
1-1/8" to 2-5/8"	200	300
2-5/8" and over	250	400

STEERING STOP ADJUSTMENT

All Rockwell axles are delivered with steering stop screws preset. Adjustments are often made by the vehicle manufacturer to accommodate various chassis designs and tire sizes. Steering stop adjustments on new vehicles are therefore not required.

These adjustments of both axle steering stops and power steering unit should be periodically checked and corrected if necessary.

The stop adjustment should be checked and corrected any time any part of the steering system is disassembled, replaced, added or adjusted.

Adjust the left and right knuckle steering stops to contact when the maximum turning angle of the specific axle is reached, and lock with jam nut (Figure 37). Refer to torque chart on page 24.

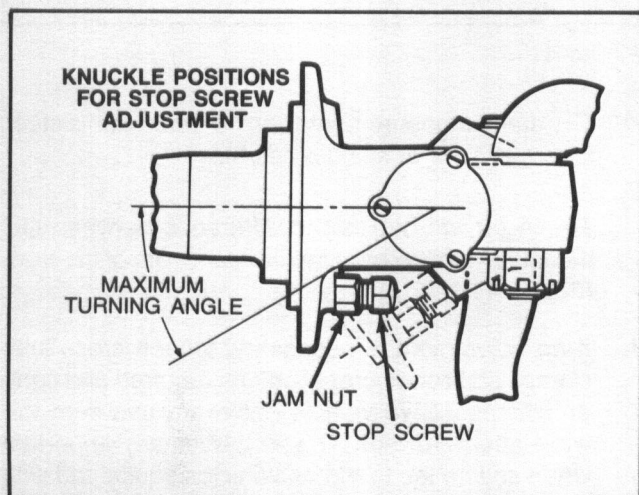


Figure 37

NOTE: Do not adjust the turn angle beyond that specified by the vehicle manufacturer.

POWER STEERING GEAR (OR CYLINDER) ADJUSTMENT

NOTE: Rockwell does not approve any power steering system without provision for pressure relief or positive mechanical stop to be set BEFORE maximum turn angle is reached. The power must be cut off or reduced substantially ahead of the axle stop to prevent unnecessary stressing of the axle components.

MECHANICAL RELIEF

Vehicles with mechanical Pitman arm stops or assist cylinder stops should be adjusted to end the travel of the Pitman arm or cylinder 1/8" before the steering stop screw would contact the axle boss (Figure 38).

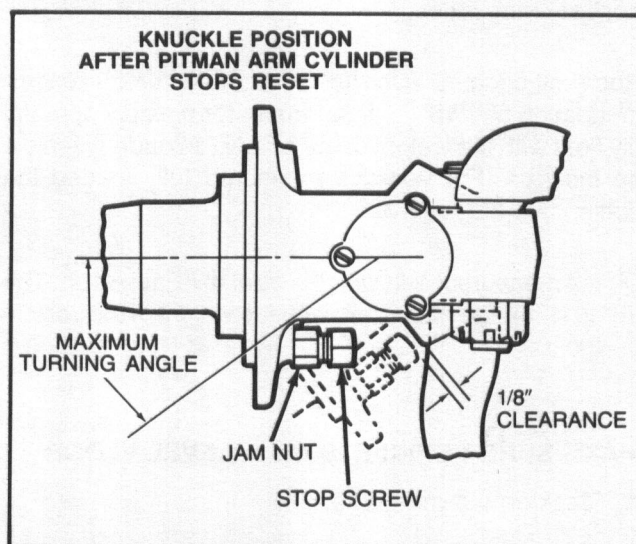


Figure 38

Maximum turn angle will then be determined by the arm or cylinder stop and not the axle stop. This must be done for full left and full right turns.

HYDRAULIC RELIEF

Hydraulic steering gears equipped with poppet valves should be adjusted while a 1/4" to 3/16" spacer is held between the axle stop pad and stop screws. The poppet valves should be adjusted to allow pressure bypass at this position with spacer in place in full left and right turn positions. During this setting the steering gear pressure should be at a minimum, 600 psi or less (Figure 39).

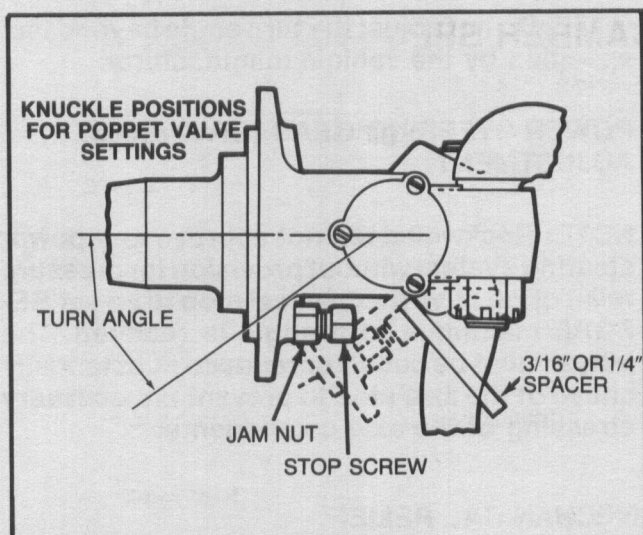


Figure 39

TOE-IN RECOMMENDATIONS

The following recommendations are for all Rockwell front steering axles.

Rockwell concurs with the tire manufacturer's recommendation of $1/16'' \pm 1/32''$ toe-in for bias ply or radial ply tires with the weight of the empty (unloaded) vehicle on the axle. For vehicles measured fully loaded the setting is $1/32'' \pm 1/32''$.

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.

MAKE SURE VEHICLE IS ON A LEVEL FLOOR

- A. Jack up the front axle.
- B. Use paint or chalk and whiten the center area of both front tires around the entire circumference.
- C. 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.
- D. Lower vehicle on floor and then move the vehicle backward and then forward approximately ten feet.
- E. 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 40).

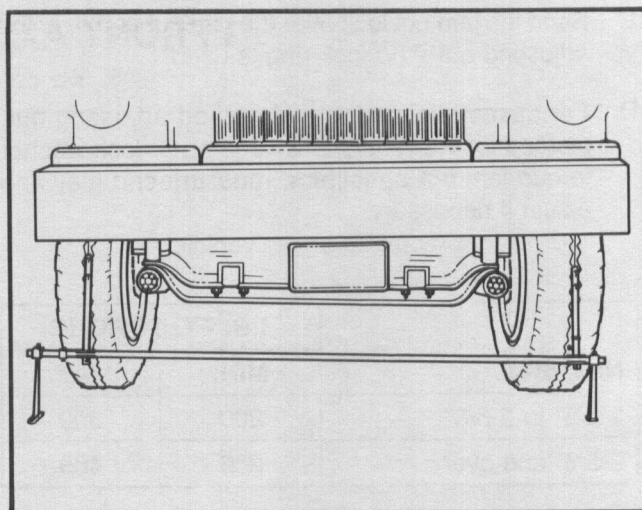


Figure 40

F. Position the trammel bar at the front of the tires. Adjust scale end so that pointers line up with scribe marks.

G. Read toe-in (or toe-out) from scale (Figure 41).

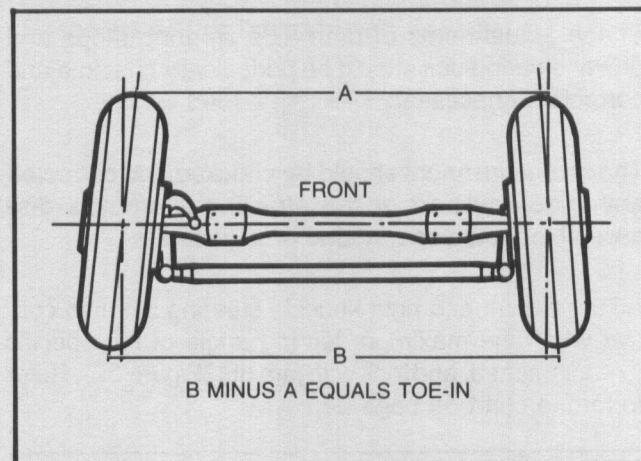


Figure 41

H. The same measurements can be made with a steel tape measure at spindle height.

Toe-in (or toe-out) is the difference between the measurement taken at the front and rear of the tires (Figure 41).

- I. If an adjustment is necessary, loosen cross tube clamps and rotate cross tube as required and tighten clamps. Move vehicle backward and then forward about 10 feet. This is particularly important when setting the toe-in on vehicles equipped with radial tires.
- J. Recheck toe-in setting to make SURE it is correct.

NON-DRIVING FRONT AXLE CAMBER SPECIFICATIONS

FF FG FL Series

CONDITIONS	LEFT (DRIVER'S) SIDE	RIGHT SIDE
1. Camber angles machined into axles. • less hubs. • axle not mounted under vehicle. • no load.	+3/4° nominal	+1/4° nominal
2. Camber angles of axle equipped with hubs. • axle not mounted under vehicle. • no load.	+3/4° ($\pm 7/16^\circ$) or +1-3/16° to +5/16° (final reading)	+1/4° ($\pm 7/16^\circ$) or +11/16° to -3/16° (final reading)
3. Camber angles of FF-931, FF-941, FL-931 and FL-951 axles under rated load. • axle mounted under vehicle.	+11/16° to -3/16° (final reading)	+3/16° to -11/16° (final reading)
4. Camber angles of FF-931A and FF-941A aluminum beam axles under rated load. • axle mounted under vehicle.	+13/16° to -1/16° (final reading)	+5/16° to -9/16° (final reading)

IMPORTANT: Camber is not adjustable. ROCKWELL DOES NOT APPROVE OF CHANGING THE CAMBER ANGLE OR BENDING OF STEEL OR ALUMINUM BEAMS. Bending the axle beam to alter camber angles is detrimental to the integrity of the axle beam.

If camber angles, of models mentioned, do not meet specifications shown in the chart, contact your area Rockwell Technical Service Representative for assistance.

Most other models have a +1° nominal camber on the left and right sides, for condition #1. Conditions #2 and #3 are proportionally higher.

CASTER

Caster settings are determined by the vehicle manufacturer; generally, manually steered vehicles operate best at 1° to 2-1/2° positive caster. Power steered vehicles are generally set between 2° and 4-1/2° positive caster.

Center point models FE970 and FF971 are the only exceptions. These operate best at -1/2° to -2° caster.

16900 and 17100 series axles have +3° caster machined into the axle center. All other models must be adjusted for the caster at assembly.

For maximum steering effort reduction, easy steer axles should be set at 1° positive caster.

TROUBLESHOOTING GUIDE

1a. Rapid or Uneven Tire Wear

- Incorrect toe-in setting
- Improper tire inflation
- Unbalanced tires
- Improper Ackerman steering geometry
- Tandem alignment

b. Toe-in Control

- When setting toe-in, it is important to neutralize the component and tire deflections by backing up and then going forward and re-checking 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.

2. Hard Steering

- Low power steering system pressure
- Improper assembly of steering gear box
- Inadequate or improper lubrication of knuckle pins
- Inadequate mechanical advantage of steering system in steering box ratio, lengths of pitman arm and steering arm
- Improper caster
- Tight draglink or tie rod ends
- Worn thrust bearing

3. Rapid Wear of Cross Tube Ends

- Inadequate or improper lubrication
- Improper installation of add-on type power steering cylinders

- Severely contaminative environment
- Failure of protective rubber boot

4. Bent or Broken Cross Tube, Broken Ball Stud, Bent or Broken Steering Arm or Cross Tube Arm

- Excessive power steering system pressure
- Misadjusted power steering cut-off
- Operational (curbing)
- Improper installation of add-on power steering

5. Heavily Worn or Broken Steering Arm Ballstud

- Over tightened draglink
- Inadequate or improper lubrication
- Misadjusted power steering stops

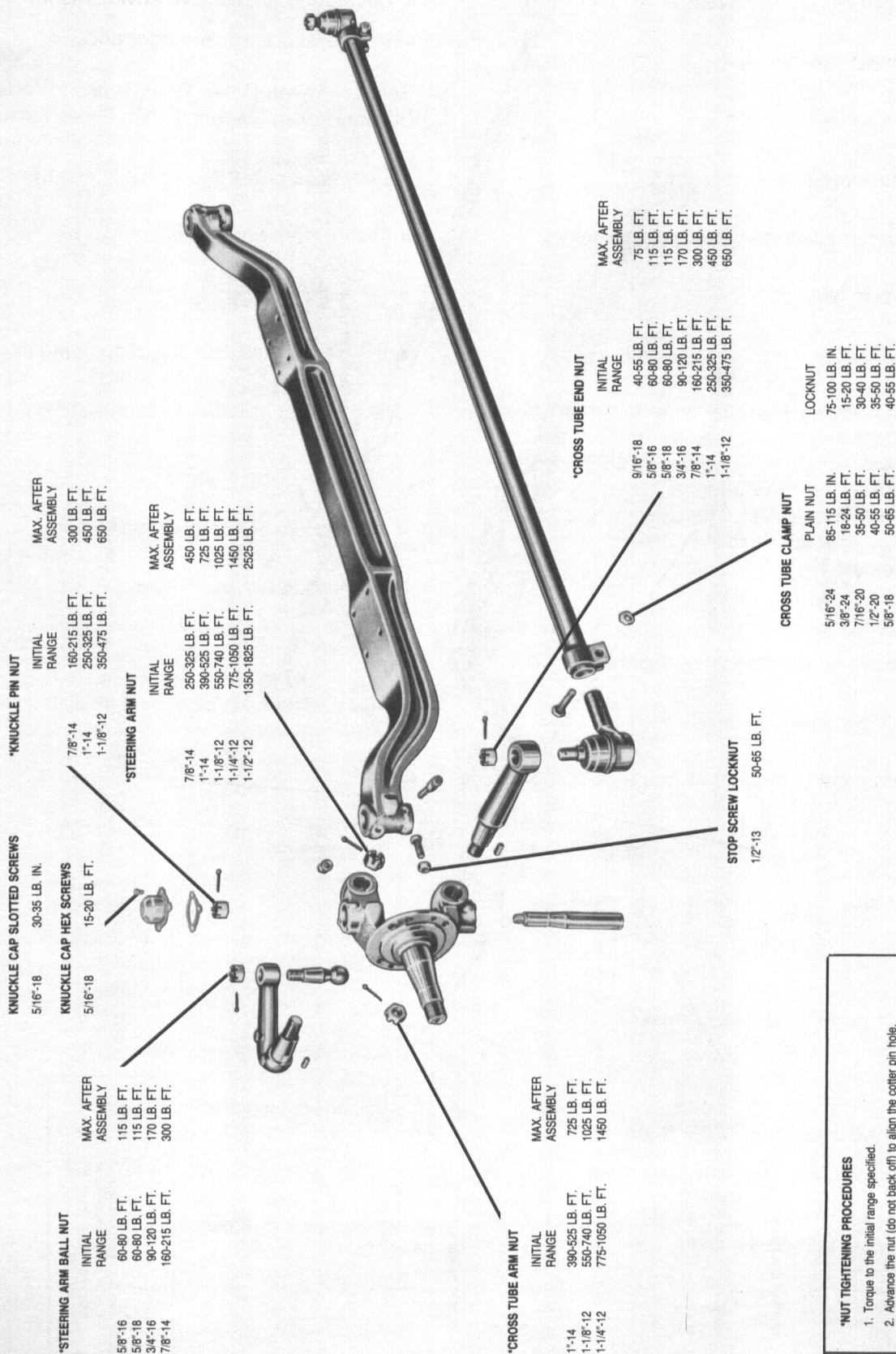
6. Excessive Wear of Knuckle Pins and Bushings

- Worn or missing seals and gaskets
- Improper type of grease
- Inadequate lubrication frequency
- Improper lubrication technique
- Inadequate lubrication frequency due to extreme operating conditions such as abrasive dust and sandy environments

7. Front Axle Shimmy or Vibration

- Incorrect caster setting
- Wheels and/or tires not properly balanced
- Worn shock absorbers

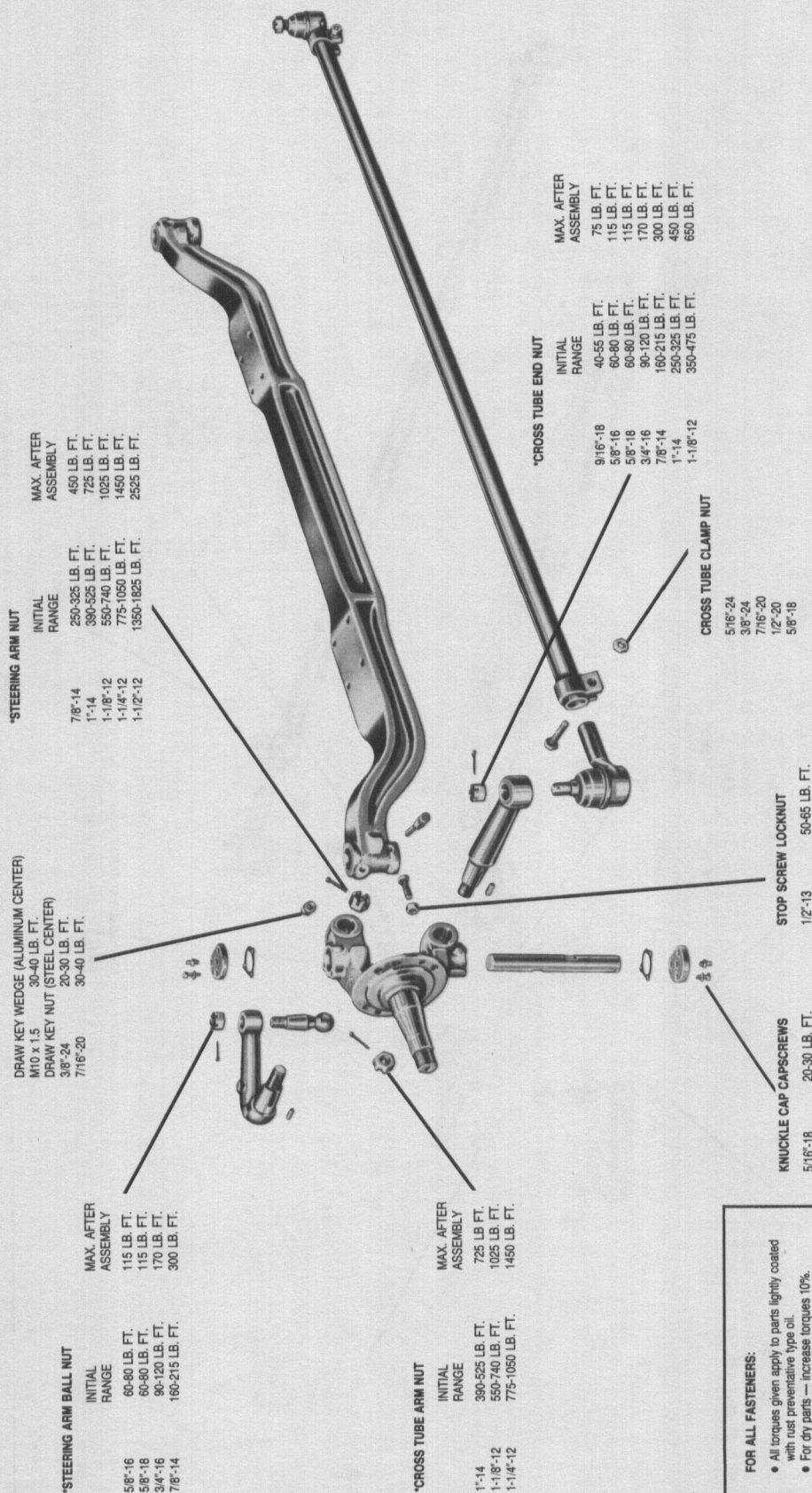
TAPERED KING PIN MODELS



*NUT TIGHTENING PROCEDURES

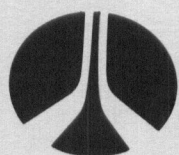
1. Torque to the initial range specified.
2. Advance the nut (do not back off) to align the cotter pin hole.
3. The final installed torque must not exceed the "Maximum After Assembly" torque specified.
4. If the final torque exceeds the maximum specified, remove the nut and reinstall to the correct specification.

STRAIGHT KING PIN MODELS



FOR ALL FASTENERS:

- All torques given apply to parts lightly coated with rust preventative type oil.
- For dry parts — increase torques 10%.
- For parts heavily coated with oil — decrease torques 10%.



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