COLUMBIA®

# SERVICE MANUAL

Summit (SMT)

Summit Utility (SUV)



Part No. 99530-10

## GENERAL

This service manual has been prepared with two purposes. First, it will introduce the trained maintenance professional to the latest f eld tested and factory approved major repair methods. Secondly it will acquaint the reader with the construction of the Columbia ParCar vehicles and assist him/her in performing basic maintenance and repair. We sincerely believe that this manual will make the association with Columbia ParCar vehicles a more pleasant and prof table experience.

In addition to the information given in this manual, Service Bulletins are issued to Columbia ParCar dealers, which cover interim engineering changes and supplementary information. Service Bulletins should be consulted for complete information on the models covered by this manual.

To ensure the safety of those servicing our vehicles and to protect the vehicles from possible damage resulting from improper service or maintenance, the procedures in this manual should always be followed exactly as specif ed. Execution of the procedures and troubleshooting tips as outlined will ensure the best possible service from the vehicle(s). To reduce the chance of personal injury and/or property damage, carefully observe the DANGER, WARNING, CAUTION & NOTICE recommendations throughout this manual. See *Section 1-Safety* for additional details.

## PREPARATION FOR SERVICE

Proper preparation is very important for ef f cient service work. A clean work area at the start of each job will allow you to perform the repair as easily and quickly as possible, and reduce the incidence of misplaced tools and parts. Columbia ParCar vehicles that are excessively dirty should be cleaned before work begins. Cleaning will occasionally uncover trouble sources. Tools, instruments and parts needed for the job should be gathered before work is started. Interrupting a job to locate tools or parts is a needless delay. Special tools required for a job are listed at the beginning of each section.

## MODEL IDENTIFICATION

Always give the vehicle identi f cation number (VIN) when ordering parts or making inquiries about the vehicle. Use of the full and complete vehicle identif cation number will ensure that the dealer or service provider is supplying you with the correct parts for the vehicle. See *Section 2-General Information* for VIN location and additional information.

## USE GENUINE REPLACEMENT PARTS

**⚠ WARNING**

**When replacement parts are required, use only genuine Columbia ParCar parts or parts with equivalent characteristics including type, strength and material. Failure to do so could result in product malfunction and possible injury to the operator and/or passenger.**

To ensure a satisfactory and lasting repair job, follow the service manual instructions carefully and use only genuine Columbia ParCar vehicle replacement parts. This is the insurance that the parts you are using will f t right, operate properly and last longer. When you use genuine Columbia ParCar vehicle parts, you use the best.

## PRODUCT REFERENCES

When reference is made in this manual to a specif c brand name product, tool or instrument, an equivalent product, tool or instrument may be used in place of the one mentioned.

**SECTION 8 - BATTERIES AND BATTERY CHARGER**



**SECTION 9 - TRACTION DRIVE SYSTEM**

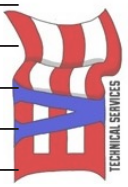




## NOTES





## OVERVIEW

Statements in this manual preceded by the words **DANGER, WARNING, CAUTION or NOTICE** and words printed in **bold face** are very important. We recommend you take special notice of these items.

It is important to note that some warnings against the use of specific service methods, which could damage the vehicle or render it unsafe, are stated in this service manual. However, please remember that these warnings are not all inclusive. Since Columbia ParCar Corporation could not possibly know, evaluate and advise servicing personnel of all possible ways in which service might be performed or of the possible hazardous consequences of each way, we have not undertaken any such broad evaluation.

Accordingly, anyone who uses a service procedure or tool which is not recommended by Columbia ParCar must first thoroughly satisfy him/herself that neither their nor the operator's safety will be jeopardized by the service methods selected.

## ICONS IN PROCEDURES

Watch out for icons and symbols in procedures. Watch for international symbol icons in the margins. They are there to help you avoid situations that might expose you to an unnecessary hazard or potential injury.

**⚠ DANGER**

**Danger indicates a hazardous situation which, if not avoided, WILL result in death or serious injury to the operator or bystanders.**

**⚠ WARNING**

**Warning indicates a hazardous situation which, if not avoided, COULD result in death or serious injury to the operator or bystanders.**

**⚠ CAUTION**

**Caution indicates a hazardous situation which, if not avoided, MAY result in moderate or minor injury to the operator or bystanders.**

***NOTICE***

***Notices are messages not related to personal injury. They will provide key information to prevent property damage and to ensure procedures are more easily understood or implemented.***

## SAFETY INFORMATION

It is Columbia ParCar's specific recommendation that the following safety information must be observed at all times. Not all are repeated throughout this manual, but the recommendations included must be observed whenever these subjects are encountered.

**⚠ WARNING**

**Any modifications or changes to the vehicle that affect the stability or increases vehicle speed beyond factory specifications could result in severe personal injury or death.**

**Always, remove keys before servicing or repairing your vehicle. See *Section 8-Batteries*, for specific details.**


**All batteries used in electric vehicles can explode! Always wear full face shield when working on or near batteries. Hydrogen fumes are a natural byproduct of charging and discharging and are extremely explosive.**

**Do not smoke around electric vehicle batteries. Keep sparks and flames away from batteries. Battery charging should only be done in a well-ventilated area. Refer to *Section 8-Batteries* for details.**


**Batteries contain acid which can cause severe burns. Avoid contact with skin, eyes, or clothing. Wear full face shield and rubber gloves when working on or near batteries.**

**ANTIDOTES:**

- **External: Flush with water. Call a physician immediately.**
- **Internal: Drink large quantities of milk or water. Follow with milk of magnesia or vegetable oil.**
- **Eyes: Flush with water for fifteen minutes. Call a physician immediately.**

**⚠ WARNING**

**When working around batteries, use approved insulated tools, remove jewelry such as rings, watches, chains, etc. and place an insulating material such as wood, plastic, rubber, etc. over batteries covering all connections.**

**If any problems are found during scheduled maintenance or inspections, do not operate vehicle until repairs are completed. Failure to make necessary repairs could result in fire, property damage, severe personal injury or death.**

**⚠ DANGER**

**Only trained maintenance professionals should repair or service this vehicle. Persons performing even simple repairs or service should have working knowledge and experience in general electrical and mechanical repair. Follow all procedures exactly and observe all warnings stated in this manual. Use caution and common sense.**

**⚠ DANGER**

**Proper service and repair is important for safe, reliable operation of all Columbia vehicles. The service procedures recommended and described in this service manual are effective methods for performing service operations. Some of these service operations require the use of tools specially designed for this purpose. These special tools should be used when and as recommended.**

**Use insulated tools when working near batteries or electrical connections. Use extreme caution to avoid shorting of components or wiring.**

**Moving parts hazard! When operating any vehicle in a stationary position, avoid chains, belts, and wheels which could snag clothing or cause severe injury to body parts. A running vehicle must be worked on with the greatest care. Use caution and common sense.**

**⚠ DANGER**

**Do not wear loose clothing or jewelry such as rings, watches, chains, etc. when servicing the vehicle. Failure to do so could result in personal injury or death.**

**⚠ WARNING**

**Working on Columbia ParCar vehicles without following proper procedures and using proper lifting equipment may result in vehicle damage or personal injury. See *Section 3 - Lifting Instructions* detailed instructions.**

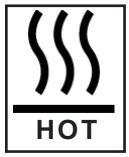
**Always wear safety glasses or approved eye protection while servicing vehicle. Wear a full face shield when working with batteries.**

**Failure to maintain vehicle properly could result in decreased vehicle performance, reliability or cause severe personal injury.**

**Exceeding rated vehicle load capacities could result in possible severe injury or property damage.**

***NOTICE***

***The modification of vehicles for use in other than its intended purpose is not recommended. Any unauthorized modification may void your vehicle warranty.***




**HOT! DO NOT attempt to service hot electric motor or resistors. Failure to observe this warning could result in severe burns.**

**⚠ CAUTION**

**Summit electric vehicles are designed to transport one (1) operator and one passenger (SM2 and SUV models) or one (1) operator and three passengers (SM4/SMT4 models).**

**Never exceed the rated load capacity or vehicle stability, reliability and control will be reduced. See vehicle identification plate for capacities and gross vehicle weights.**

## SAFETY PREPARATIONS

**⚠ DANGER**

**Always turn power key to OFF, position directional selector to NEUTRAL, remove power key and block tires and disconnect battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.**

## DECALS

Safety, Warning and Informational decals should be ordered and replaced as soon as they are discovered to be illegible or missing. Refer to Parts Manual or web site for part numbers and ordering info.

1. Use a heat gun or hair dryer to soften up and remove any damaged sticker.
2. Peel off backing and carefully position and press decal into place.


***Figure 1-1. Warning and Operating Instructions Decal on Console***



## NOTES



## VEHICLE IDENTIFICATION NUMBER (VIN)

**⚠ CAUTION**

**Do not remove any nameplate, warnings, or instructions affixed to the Columbia vehicle. Promptly replace any that become damaged or removed.**

Each vehicle is assigned a unique Vehicle Identif cation Number (VIN). The VIN describes facts and features of the vehicle and contains 17 digits (NEV). Refer to the chart on the right.

The VIN can be found in three locations: under the steering wheel cover, on the vehicle nameplate located in the driver side glove box, and on the driver's side windshield. The nameplate has important vehicle information such as vehicle weights and rated capacity (load, operator and passenger.

Record the VIN here and provide this number to the dealer when repairs or adjustments are required:

VIN_____

*Figure 2-1. VIN Located On The Driver Side Glove Box*

### VIN Matrix

**NEIGHBORHOOD ELECTRIC VEHICLE (NEV)**

| | |
|---|---|
| Digit 1 thru 3: Manufacturer Identif cation | 5FC = CPC |
| Digit 4: Line | L = Low Speed Vehicle |
| Digit 5: Series | E = Eagle<br>M = MEGA<br>S = Summit<br>U = Utility<br>N = Earlier NEV Series |
| Digit 6: Body Type | 2 = 2 Person<br>3 = Long Bed<br>4 = 4 Person<br>5 = Short Bed |
| Digit 7: Engine Type System | 4 = Series Wound 48V XP+<br>6 = Separately Excited 48V ACE*plus* System |
| Digit 8: Restraint | A = Type 1 Seat Belt Assembly |
| Digit 9: Check Digit | Calculated per 49CFR 565.4 |
| Digit 10: Model Year | Y = 2000 1 = 2001<br>2 = 2002 3 = 2003<br>4 = 2004 5 = 2005<br>6 = 2006 7 = 2007<br>8 = 2008 9 = 2009<br>A = 2010 B = 2011<br>C = 2012 D = 2013 |
| Digit 11: Plant Location | 1 = Reedsburg |
| Digit 12-17: Sequential Numbers | 00019 - 000999 |

## SPECIFICATIONS

| | SM-2 | SM4/SMT-4 | SUV-SN | SUV-LN |
|---|---|---|---|---|
| **Performance** | | | | |
| Speed - Forward Max. | 25 mph | | | |
| Range - Max | Up to 40 miles* | Up to 35 miles* | Up to 40 miles* | Up to 35 miles* |
| Turning - Curb to Curb | 248° | 315° | 265° | 315° |
| **Dimensions & Weight** | | | | |
| Overall L x W x H | 99” x 48” x 72” | 124” x 48” x 72” | 107” x 48” x 72” | 131” x 48” x 72” |
| Wheelbase | 66” | 92” | 76” | 91” |
| Ground Clearance | 5.5” | | | |
| Flat Bed | — | — | 36” x 44” | 36” x 44” |
| Curb Weight | 1500 lbs. | 1780 lbs. | 1600 lbs. | 1750 lbs. |
| Gross Vehicle Weight | 2090 lbs. | 2550 lbs. | 2338 lbs. | 2735 lbs. |
| **Power Train** | | | | |
| Motor | 48-Volt, separately excited, NEMA class H temperature rated | | | |
| Horsepower | 17.3 HP | | | |
| Batteries† | Eight, 6 volt, 225 amp hour, 115 minute, deep cycle | | | |
| Charger | Built-in, micro-processor controlled, fully sealed, global, 110-240 VAC, 50/60 HZ | | | |
| Motor/Speed Controller | Programmable, solid state, 400 amp, pedal proportional control and regenerative braking with reduced speed reverse, diagnostic LED and calibrator interface | | | |
| Directional Control | Console mounted safety directional keyswitch | | | |
| Drive Unit/Differential† | Automotive style, helical gears in oil bath, direct to motor, 10:35.1 f nal drive ratio | | | |
| **Body** | | | | |
| Passenger Capacity | 2 | 4 | 2 | 2 |
| Front Seating | Deluxe adjustable buckets with padded arm-rests and seats covered in marine grade vinyl | | Deluxe adjustable buckets with padded arm-rests and seats covered in marine grade vinyl | |
| Rear Seating† | — | Matching bucket or f xed bench seat | — | — |
| Lighting | Headlights, taillights, brake lights, backup lamps, turn signals, emergency, ref ectors | | | |
| Windshield/Mirrors | Safety glass windshield, rear and side mirrors | | | |
| Instrumentation & Accessories | Horn, battery discharge indicator, reverse warning alarm, cup holders, headliner, storage compartments, non-slip f oor board | | | |
| **Chassis** | | | | |
| Frame | High strength low alloy tubular steel frame, electro-statically powder coated | | | |
| Steering | Automotive rack and pinion | | | |
| Brakes† | Hydraulic rear drums, hand operated parking brake | | | |
| Suspension - Front | Transverse, 4 leaf spring with A-arm, dual shock absorbers, adjustable camber | | | |
| Suspension - Rear | Swing arm mounted “live” differential with dual coil springs and shock absorbers | | | |
| Front Bumper | Poly, painted to match body color | | Tubular steel, wraparound, painted black | |
| Rear Bumper | Steel, painted black | | | |
| Tires & Wheels | Varied DOT rated size tires mounted on steel wheels | | | |

** Range will vary depending on temperature, grade, payload and driving style.*

† *Subject to options ordered.*

*Note: Specifications are subject to change without notice.*



## OPERATION

### Power Keyswitch (Figure 2-1)

Two position switch; Off and On.

***NOTICE: Controls should operate smoothly and easily without sticking or requiring undue effort.***

**⚠ WARNING**

**Be sure directional knob is in desired direction of travel before depressing accelerator.**

### Directional Knob (Figure 2-1)

1. With the Power Switch in the ON position, move the directional knob to the desired direction of travel.
2. Move the knob to “F” to travel forward; move the knob to “R” to travel in reverse.

***NOTICE: If the directional knob was in either forward or reverse when keyswitch was placed in the ON position, move it to neutral (N), then back to the desired direction of travel.***

### High/Low Speed Switch (Figure 2-1)

1. The switch is a two position toggle switch. The up position (rabbit) is for high speed and allows the vehicle to reach full speed. This switch is not illuminated.
2. The down position (turtle) is a slower speed and is used for steep grades or off road in rough terrain. In this position the vehicle will produce more torque at the slower speed.

### Handbrake (Figure 2-2)

1. To apply the handbrake, pull the handle up without pressing the button on the end of the handbrake.
2. To disengage the handbrake, gently pull up on the handle, press the button on the end of the handbrake and fully lower the handle.

### Pre-Driving Checklist

**⚠ CAUTION**

**Should any item malfunction or need adjustment, do not operate vehicle until the problem has been corrected.**

- Check position of mirrors.
- Check and adjust seat.
- Check battery capacity . Make sure vehicle is adequately charged to provide power during duration of operation.
- Check tires for proper inf ation
- Check lights, horn and reverse buzzer for proper operation.
- Check that brake pedal has f rm pedal pressure with minimal travel.
- Check parking brake for proper engagement and release.
- Check that all warning and operation labels are in place.
- Check for smooth accelerator pedal operation.
- Make sure AC charger cord is disconnected.
- Put on and adjust seat belt.

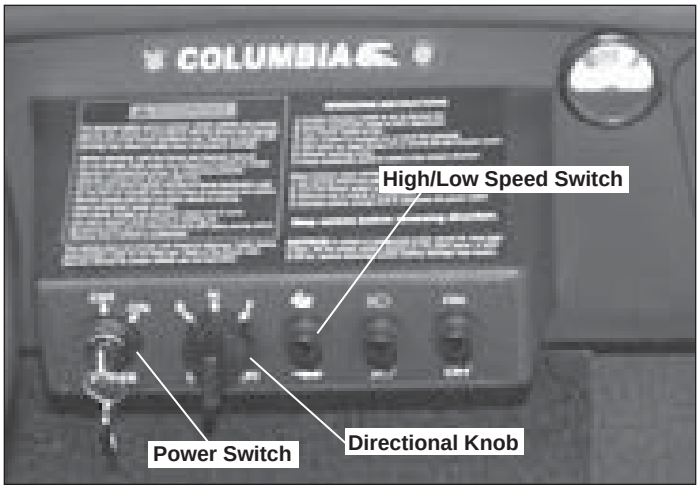



*Figure 2-1. Controls*

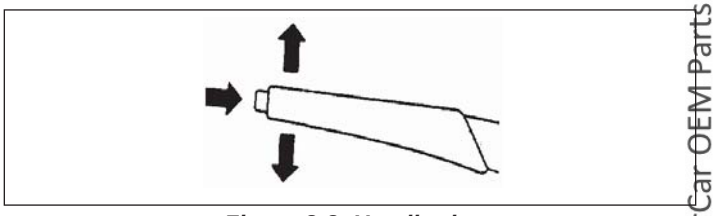


*Figure 2-2. Handbrake*

### Starting and Stopping

1. Release the handbrake.
2. Turn the key to the ON position and wait for the contact “click” and the sound of the ventilator motor fan running.
3. Select the direction of travel with the directional knob.
4. Select high or low speed.
5. Press down on the accelerator.

**⚠ CAUTION**

**Drive using only one foot to avoid using both pedals at the same time. Engaging both the brake and accelerator at the same time will prematurely damage the vehicle systems and will lead to a reduction in range.**

6. To stop, press the brake and come to a complete stop. Engage the handbrake.

***NOTICE: When going downhill, the regeneration of the current through the braking system will cause the vehicle to slow down. This does not take the place of using the brake to slow the vehicle.***

7. Place the keyswitch in the OFF position and remove the key.



## PRE-OPERATION INSPECTIONS

Each vehicle has been inspected and adjusted to factory specifications before delivery. Upon receipt of vehicle, perform a pre-delivery inspection of the vehicle. Also, before using the vehicle, there are checks that must be performed to ensure that it is in safe working order.

**⚠ WARNING**

**Only trained maintenance professionals should service or repair this vehicle. Persons performing even simple repairs or service should have a working knowledge and experience in general electrical and mechanical repair. Follow all procedures and observe all warnings stated in this manual. Use caution and common sense.**

| Service Item | Service Method/Check | Reference |
|---|---|---|
| Vehicle Body | Visually, check for damaged or loose hardware. | See Section 7. |
| Steering and Linkages | Test drive, check for free movement and proper operation. | See Section 6. |
| Accelerator/Brake Operation | Test drive, check free travel and braking action. | Refer to Owner's Manual index for specifications. |
| Warning Labels | Visually inspect all labels for readability or missing. | Verify labels are in place and readable. |
| Tires | Visually check for wear or damage. | See Section 6. Verify proper tire inflation. |
| Reverse Warning Buzzer or In- Motion Beeper | Test drive, check for proper operation. | Verify an audible sound heard. |
| Charger Plug and Receptacle | Check for damage and snug fit. | |
| Head, Tail or Flasher, Lights | Check for proper operation | Verify lights and flashers work. |
| Batteries | Check Battery Discharge Indicator (BDI) | See Section 8 for specifications |
| Horn | Check for proper operation. | |

## SAFETY COMMITTEE - LSV MODELS

If the vehicles are to be operated by renters or company employees, we recommend that a safety committee be appointed. The primary concern of this committee should be the safe operation of the vehicles.

Subjects which must be considered include, but are not limited to the following:

- Define where the vehicles should and should not be driven and utilized.
- Ensure all proper warnings as to driving hazards are properly displayed and visible.
- Safety signage concerning hills, turns, blind crossings or intersections is highly recommended.
- Enforcement of safe driving and operating rules.
- Provide driver training for first time operators, and review safe operating recommendations regularly.
- Maintain vehicles in a safe operating condition. Maintain a schedule for daily, weekly, and monthly vehicle inspections.
- Determine who, when and how pre-operation inspections should be conducted.
- Enforcement of safe driving and operating rules.
- Define who should and who should not drive the vehicles.
- Decide what to do should an unsafe condition or operating problem be discovered.
- Enforce that vehicle should not be operated by persons under the age of 16.
- These basic rules of operation, combined with courtesy and common sense, will help make driving your Columbia ParCar Vehicles a safe and pleasant experience.



## NOTES

## ELECTRIC VEHICLE SERVICE

When servicing the electric vehicle always observe the following:

**⚠ DANGER**

**Always turn power key to OFF, position directional selector to NEUTRAL, remove power key and block tires and disconnect battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.**

## PERIODIC MAINTENANCE

A comprehensive maintenance program is important for the safe, reliable operation of all Columbia ParCar vehicles. The recommended procedures described in this service manual are efective methods for performing periodic maintenance and repair.

The maintenance procedures outlined in this manual are recommended when servicing the vehicle. Refer to maintenance checklist for frequency of service. Perform only those maintenance instructions described in this manual. If major repairs are needed, contact the local Columbia Dealer for assistance. Columbia Dealers have the technical experience, training and original Columbia Vehicle parts for the vehicle.Always use original Columbia Vehicle parts when servicing the vehicle.

### Tools

Some procedures require the use of special tools. These special tools must be used when and where specif ed.

### Heavy Use Vehicles

The environment and duration which a vehicle operates in can very widely. Severe service operations will require the periodic mantenance recommendations to be adjusted to shorter time intervals to allow for more frequent service and inspections.

### Schedule

Daily maintenance is performed daily before operation of vehiclec by the owner or the operator . Weekly maintenance is performed on a weekly basis to include all daily maintenances and is performed by the owner, operator or trained maintenance personnel.

When performing Monthly , Quarterly, Semi-Annual or Annual maintenance, ensure that Daily and W eekly inspections are included.

***NOTICE: Schedule checklists indicate duration between maintenance based on standard hourly usage. (If vehicle is used approximately 100 hours on a monthly or quarterly basis, adjust and perform all Semi-Annual or Annual maintenance accordingly.***

**SAMPLE SERVICE SCHEDULE**

| PERIODIC SERVICE CALENDAR | | |
|---|---|---|
| **JANUARY** | **FEBRUARY** | **MARCH** |
| Monthly | Monthly | Quarterly |
| **APRIL** | **MAY** | **JUNE** |
| Monthly | Monthly | Semi-Annual |
| **JULY** | **AUGUST** | **SEPTEMBER** |
| Monthly | Monthly | Quarterly |
| **OCTOBER** | **NOVEMBER** | **DECEMBER** |
| Monthly | Monthly | Annual |

***NOTICE: Daily maintenance is performed daily before operation of vehicle by owner or operator. Weekly maintenance is performed on a weekly basis to include all daily maintenance and is performed by the owner, operator or trained maintenance personnel.***

With proper care and maintenance, your Columbia Electric V e hicle will provide years of dependable service and outstanding performance. Please contact your dealer for more information.

## MAINTENANCE SCHEDULE CHECKLIST - BODY / FRAME / CHASSIS

| Component | Procedure | Daily | Weekly | Monthly | Quarterly (25 Hours) | Semi-Annual (50 Hours) | Annual (100 Hours) |
|---|---|---|---|---|---|---|---|
| Body, Seat & Frame | Visually inspect for damage or tears | * | | | | | |
| Hardware | Tighten as needed | | | | † | | |
| Vehicle & Undercarriage | Wash as necessary | | * | | | | |
| Clean Body & Seat | Wash as necessary | | * | | | | |
| Lubricate Chassis | Lubricate hinges | | | | | † | |
| Lubricate Front Suspension & Steering | Lubricate per Sections in this Manual | | | | | † | |
| Warning & Operating Labels | Ensure labels are in place and legible | * | | | | | |
| Windshield | Verify visibility & mounted securely | * | | | | | |

* Service performed by owner/operator

† Service performed by trained maintenance personnel

## MAINTENANCE SCHEDULE CHECKLIST - FLUIDS

| Component | Procedure | Daily | Weekly | Monthly | Quarterly (25 Hours) | Semi-Annual (50 Hours) | Annual (100 Hours) |
|---|---|---|---|---|---|---|---|
| Brake System | Inspect level & condition. Verify no leaks. | | * | | | | |
| Differential Lubricant | Inspect level & condition. Verify no leaks. | | | | | | † |

* Service performed by owner/operator

† Service performed by trained maintenance personnel

## MAINTENANCE SCHEDULE CHECKLIST - ELECTRIC MOTOR

| Component | Procedure | Daily | Weekly | Monthly | Quarterly (25 Hours) | Semi-Annual (50 Hours) | Annual (100 Hours) |
|---|---|---|---|---|---|---|---|
| Brushes | Inspect length & wear, remove carbon dust | | | | | | † |
| Armature / Spline | Inspect commutator bars and spline for arcing or wear | | | | | | † |

* Service performed by owner/operator

† Service performed by trained maintenance personnel



## MAINTENANCE SCHEDULE CHECKLIST - OPERATING CONTROLS

| Component | Procedure | Daily | Weekly | Monthly | Quarterly (25 Hours) | Semi-Annual (50 Hours) | Annual (100 Hours) |
|---|---|---|---|---|---|---|---|
| Accelerator Linkage | Check for free movement and pedal return | * | | | | | |
| | Check micro switch adjustment | | | | | † | |
| | Check for 100% pedal push | | | | | † | |
| Brakes | Check brake operation | * | | | | | |
| | Check parking brake hold and release | | * | | | † | |
| | Check brake cables for damage | | | * | | † | |
| | Clean & adjust brakes | | | | | † | |
| | Check rear brake drum/axle nut torque (65 ft. lbs.) | | | | | † | |
| | Apply one shot of grease to pedal grease f tting | | | | | | † |
| Direction & Key Switches | Check for smooth operation | * | | | | | |
| Light Switch | Verigy all lights are operational | * | | | | | |
| Steering & Lingages | Check for free movement | * | | | | | |
| Turn Signal & Emergency Flashers | Verify all lights are operational | * | | | | | |

* Service performed by owner/operator

† Service performed by trained maintenance personnel

## MAINTENANCE SCHEDULE CHECKLIST - ELECTRICAL SYSTEMS

| Component | Procedure | Daily | Weekly | Monthly | Quarterly (25 Hours) | Semi-Annual (50 Hours) | Annual (100 Hours) |
|---|---|---|---|---|---|---|---|
| Batteries | Check battery pack charge (non-sealed batteries-ensure cells are f lled at least over plates prior to charging) | * | | | | | |
| | Check individual electrolyte levels (non-sealed batteries) | | * | | | | |
| | Clean terminals and wash battery casings | | * | | | | |
| | Test battery condition (individually and collectively) | | | | | † | |
| Electrical Wires | Check connection tightness | | | | † | | |
| | Inspect for damage caused by possible wear points | | | | † | | |
| Reverse Warning Buzzer | Verify operation | * | | | | | |

* Service performed by owner/operator

† Service performed by trained maintenance personnel

## MAINTENANCE SCHEDULE CHECKLIST - TIRES & WHEELS

| Component | Procedure | Daily | Weekly | Monthly | Quarterly (25 Hours) | Semi-Annual (50 Hours) | Annual (100 Hours) |
|---|---|---|---|---|---|---|---|
| Tires | Check for abnormal or uneven wear or damage | * | | | | | |
| | Check tire pressure | * | | | | | |
| | Check for dented or damaged rims | | | * | | | |
| Front Wheel Alignment | Check and adjust as necessary | | | | | † | |
| Lug Nuts | Check for tightness | | | * | | | |
| Front Wheel Hubs | Apply one shot of grease to f tting | | | | | | † |

* Service performed by owner/operator

† Service performed by trained maintenance personnel

## MAINTENANCE SCHEDULE CHECKLIST - FRONT SUSPENSION

| Component | Procedure | Daily | Weekly | Monthly | Quarterly (25 Hours) | Semi-Annual (50 Hours) | Annual (100 Hours) |
|---|---|---|---|---|---|---|---|
| Leaf Spring | Visually inspect bushing condition | | | | | † | |
| | Torque to 40 ft. lbs. | | | | | † | |
| Spring Lift Block and Plate | Inspect for bends | | | | | † | |
| | Torque to 45 ft. lbs. | | | | | † | |
| Kingpin | Inspect for wear or freeplay | | | | | † | |
| | Torque mounting bolts to 40 ft. lbs. | | | | | † | |
| | Torque kingpin nut to 45 ft. lbs. | | | | | † | |
| Camber Adjustment | Torque to 25 ft. lbs. after alignment | | | | | | † |
| A-Arms | Check bushings for wear | | | | | † | |

* Service performed by owner/operator

† Service performed by trained maintenance personnel

## BATTERIES

Batteries may be recharged if vehicle has been driven 15 minutes or more since the previous charge. Before charging, be sure master power keyswitch is Off and key is removed from the switch.

Refer to *Section 8* for all procedures relating to the batteries.

## CHASSIS LUBRICATION

### Wheel Hubs

The vehicle has two grease f ttings, one in each wheel hub. These f ttings should get one pump of grease annually.

### Brake Pedal

The brake pedal assembly has one f tting located under the vehicle. Apply one pump of grease annually.

## DIFFERENTIAL

- Check the differential oil only if signs of leakage are detected.
- Capacity 12-14 ounces (1 L). Light weight gear lubricant SAE 30 gear oil.

To check/change differential oil, see Figure 3-1:

1. Make sure vehicle is on a level surface.
2. Remove Level/Fill screw. No oil should drain out. The correct level of oil is level with this hole.
3. Fill if necessary as follows:

   Remove the traction motor and input and f ll through the top opening. *See Section 9, Traction Motor*.

   or

   Remove bottom pan. Fill pan with oil and carefully reinstall pan.

## CHASSIS CLEANING

Proper cleaning materials and techniques are vital to the care of the vehicle.

Wash underside of vehicle to remove all dirt and debris. W ash chassis and body with a mild detergent only Do not use abrasives on the paint.

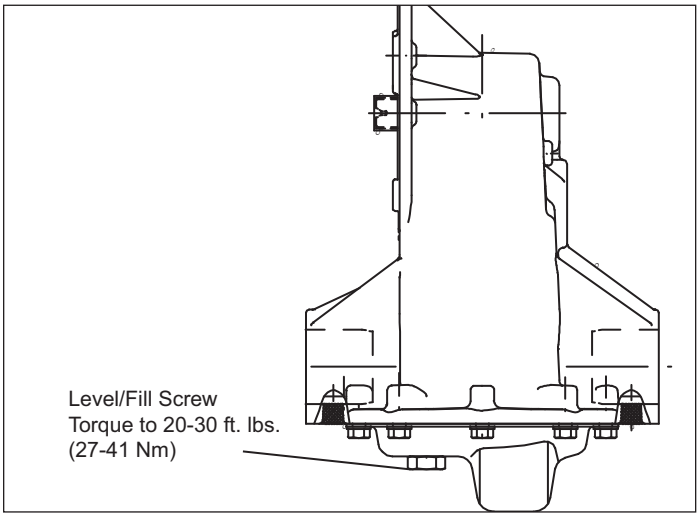



***Figure 3-1. Differential***

**⚠ CAUTION**

**Do not direct high pressure water at the controller, speed switch, or top of batteries. Dry the controller and top surfaces of the batteries immediately after washing.**

## SEAT CLEANING

Proper cleaning will extend the life of the vehicle seat. Use mild soap or detergent and a soft sponge to clean whenever necessary. For stubborn or imbedded dirt, a soft bristle brush may be used.

***NOTICE: Do not use harsh chemicals or abrasives to clean seat material. Cracking, splitting, or "melting" of seat materials may occur. If seat material becomes torn or split, it should be replaced.***



## LIFTING INSTRUCTIONS

**⚠ WARNING**

**Use extreme caution lifting or working around lifted vehicle. Vehicle should be lifted only when parked on a flat, hard and level surface.**

**Do not work under the vehicle unless it is firmly supported on jack stands.**

**When lifting the vehicle for service, use a sturdy lifting device such as a floor jack or hydraulic lift. Always wedge wheels and set parking brake of the vehicle to keep it from rolling. When using a floor jack, lift only on the frame. Place jack stands or support blocks under vehicle frame to support vehicle weight for added safety. Watch for cables, linkages or wire harness.**

**⚠ CAUTION**

**If any vehicle is raised while loaded, check that the load is secured before lifting vehicle. Failure to do so could cause damage to load, vehicle, or personal injury.**

**Before lifting, always chock tires. Use care to prevent tipping or rolling over.**

**Be careful not to damage the brake cables during lifting operation.**

### Tools Required

- hydraulic jack
- chocks or wooden blocks
- jack stands or support blocks

### Floor Jack Procedure

Check that the floor jack is rated at a capacity greater than the vehicle weight. Lift the vehicle sufficiently from the floor to allow the placement of jack stands or wooden blocks and hold the weight of the vehicle during service.

#### LIFTING THE REAR OF VEHICLE

1. To lift the rear, place wheel chocks in front of front wheels to prevent vehicle from rolling. Place floor jack under the rear cross frame. Do not use the cargo bed for lifting. Raise vehicle sufficiently to place jack stands underneath frame.

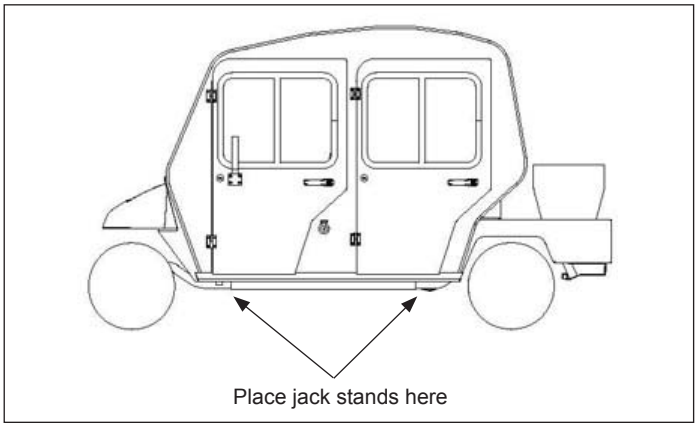



***Figure 3-2. Jack Stands Position***

2. Place jack stands under frame at right and left sides to allow access under the vehicle.
3. When work is completed, place floor jack under rear frame cross brace, lift the vehicle and remove the jack stands, then lower vehicle to the floor.

#### LIFTING THE FRONT OF VEHICLE

1. To lift the front, set parking brake and place wheel chocks behind rear wheels. Place floor jack under the frame. Do not use the bumper for lifting. Raise vehicle sufficiently to place jack stands underneath frame.
2. Place jack stands under frame at right and left sides to allow access under the vehicle.
3. When work is completed, place floor jack under frame, lift the vehicle and remove the jack stands, then lower vehicle to the floor.

### Jack Stands

Jack stands need to be of sufficient rated load capacity to hold the vehicle safely. See *Section 2 - Vehicle Specification Chart* for empty vehicle weight.

## VEHICLE STORAGE

Electric vehicles stored over 6 to 8 weeks must be protected to maintain battery life. Several guidelines should be observed when storing the electric vehicle.

1. Clean battery terminals as described in *Section 8*.
2. Store vehicle in a cool dry place to prevent battery discharge.
3. Maintain tire pressure at 32 psi during storage.
4. Continue quarterly lubrication during storage period. Refer to *Periodic Maintenanc*e chart in the beginning of this section.
5. Clean vehicle body, seat, battery compartment and vehicle underside.
6. Do not engage parking brake. Block wheels to prevent movement.
7. Quarterly check water levels as described in*Section 8, Single Point Watering System*.

The Delta-Q charger has the capability to test and recharge batteries during storage. Leave the batteries connected and the Delta-Q charger plugged into a reliable source.

## RETURNING VEHICLE TO SERVICE

1. Check tire pressure and readjust to 32 psi if necessary.
2. Perform initial maintenance per *Periodic Maintenance* in the beginning of this section.
3. If equipped with non-sealed batteries and the single point watering system, connect the system to its water supply for 3-5 seconds, then disconnect regardless of whether or not the batteries are completely full. Return the vehicle to its regular service. Place the vehicle back into its regular watering schedule (waiting at least 1 week until next watering).

## TRANSPORTING THE VEHICLE

***NOTICE: Never tow a vehicle behind an auto or truck unless on an approved trailer.***

When transporting the vehicle on a trailer over long distances or on the highway observe the following:

- Use trailers specif cally designed to carry the Columbia ParCar vehicle that meets all federal, state and local requirements.
- Secure vehicle to the trailer following trailer manufacturer's instruction.
- The power key should be removed from the vehicle, the parking brake f rmly locked, and the wheels blocked.
- On vehicles equipped with high or wide additions or accessories, be certain they are secured properly to prevent loss or damage while transporting.

**⚠ CAUTION**

**Increased transporting speed adds undo stress to wind shield or cab and will increases chance of loss, damage, accident or injury.**

**Use care when transporting on windy days. Example: A 60 MPH speed into a 40 MPH head wind is equal to traveling at 100 MPH. Industrial vehicles are not rated to withstand this level of stress and parts could be blown from top or cab, causing accident or injury.**



## TORQUES AND METRIC CONVERSION FACTORS

Individual component torques and metric equivalents are listed where the maintenance is to be performed throughout this manual. When a specific fastener torque is not specified, use the following Torque Table as a general guide in determining proper torque. When a metric equivalent is not listed, use the Conversion Factors Chart to convert to metric values.

**Torque Table**

**Torque to the value in this table unless specified otherwise.**

| Fine or coarse thread fastener | Grade Designation | Tensile Strength Minimum | Material | Screw, Stud or bolt shank size or diameter Torque figures are in ft. lbs. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1/4 | 5/16 | 3/8 | 7/16 | 1/2 | 9/16 | 5/8 | 3/4 | 7/8 | 1 |
| cap screw | S.A.E. 2 A.S.T.M. A-307 steel | 64,000 psi | low carbon steel | 6 | 11 | 19 | 30 | 45 | 66 | 90 | 150 | 202 | 300 |
| cap screw | S.A.E. 3 steel | 100,000 psi | medium carbon steel | 9 | 17 | 30 | 47 | 69 | 103 | 145 | 234 | 372 | 551 |
| cap screw | S.A.E. 5 A.S.T.M. A-499 steel | 105,000 psi | medium carbon steel or low alloy heat treated | 9 | 18 | 31 | 50 | 75 | 110 | 150 | 250 | 378 | 583 |
| cap screw | A.S.T.M A-354BB steel | | | 9 | 18 | 31 | 50 | 75 | 110 | 150 | 250 | 378 | 583 |
| cap screw | A.S.T.M A-325 | | | | | | | 100 | | 200 | 355 | 525 | 790 |
| cap screw | A.S.T.M A-354-BC Steel | 125,000 psi | low alloy or med. carbon steel quenched tempered | 11 | 20 | 34 | 54 | 81 | 119 | 167 | 269 | 427 | 611 |
| cap screw | S.A.E. 6 Steel | 133,000 psi | med. carbon steel quenched tempered | 12.5 | 24 | 43 | 69 | 106 | 150 | 209 | 350 | 550 | 825 |
| cap screw | S.A.E. 7 Steel | | med. carbon alloy quenched tempered roll threaded | | | | | | | | | | |
| cap screw | S.A.E. 8 Steel | 150,000 psi | med. carbon alloy quenched tempered | 13 | 28 | 46 | 75 | 115 | 165 | 225 | 370 | 591 | 893 |



| Conversion Factors Chart | | | | | |
|---|---|---|---|---|---|
| Into Metric | | | Out of Metric | | |
| to convert from | To | Multiply by | to convert from | To | Multiply by |
| **Work force measurements** | | | | | |
| inch-pound | N. m. | 0.1130 | Newton-meter | in. lb. | 8.8496 |
| foot-pound | N. m. | 0.3558 | Newton-meter | in. lb. | 0.7376 |
| **Length Measurements** | | | | | |
| inch | mm | 25.4 | micrometer | in. | 0.394 |
| foot | m | 0.3048 | meter | ft. | 3.2808 |
| miles | kilometers | 1.6 | kilometers | miles | 0.62 |
| **Liquid Volume Measurements** | | | | | |
| fluid ounces | milliliters | 30 | millimeters | fluid ounces | 0.03 |
| pints | liters | 0.47 | liters | pints | 2.1 |
| quarts | liters | 0.95 | liters | quarts | 1.06 |
| gallons | liters | 3.8 | liters | gallons | 0.26 |
| **Temperature** | | | | | |
| Fahrenheit | °C | °C = (°F-32/1.8) | Celsius | °F | °F = 1.8°C + 32 |

## NOTES

## ELECTRIC VEHICLE SERVICE

When servicing your electric vehicle always observe the following:

**⚠ DANGER**

**Always turn power key to OFF, position directional selector to NEUTRAL, remove power key and block tires and disconnect battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.**


*Figure 4-1. Controller Located Under Rear Seat or Utility Bed*



## PRE-TROUBLESHOOTING STEPS

Before troubleshooting a vehicle for any problem or symptoms, certain steps must be followed.

| Inspect/Test | Corrective Action |
|---|---|
| 1. Ensure the vehicle is safe for service. | Visually inspect for any obvious signs of hazards such as sharp edges in the body or other parts, open wire insulation or wire connections, or discolored parts of the vehicle indicating heat or chemical presence. |
| 2. Record the VIN (Vehicle Identification Number) or serial number. | This number is necessary to obtain technical help or support, submit warranty, and is essential in order to understand completely the vehicle that is being serviced.<br>The VIN, with the help of the correct VIN matrix, will denote specific information about each vehicle, such as operating power system and voltage, brake package options, speed operation settings, and other vehicle configuration options. |

## BATTERY TESTING

The first step in servicing any electric vehicle that is not operating properly is to completely test the batteries. The batteries are the source of power for the vehicle drive and auxiliary systems, therefore are the most integral part of the electric vehicle troubleshooting. Battery testing should be done as follows and in the order as follows

| Inspect/Test Condition | | Corrective Action |
|---|---|---|
| 1. Perform a visual examination of batteries and connections. | Examine for signs of corrosion and clean/or replace any affected terminals or cables. | The batteries can be cleaned by hose washing with a standard garden hose or with a soft bristle brush (ensure battery caps are present and tight before washing batteries). |
| | Examine the battery hold-down. If the material from the hold-down has been dissolved by the sulfuric acid in the batteries, the hold-down can act as a drain on the battery pack. | Replace the hold-down if it appears damaged. |
| 2. Test each battery with a VOM (volt-ohm meter). | With VOM set to a scale able to read DC volts at up to 100 volts (or greater), check each battery individually, and test the entire pack together. | Place the VOM probes on the battery positive post and battery negative post of each battery. Write down the reading from each battery. Each battery should contain at least 6.0 volts and no battery should be more than .5 volts lower than the highest reading. If any battery tests low on charge, charge the battery individually with the auxiliary charger or the entire pack with the onboard charger (allow vehicle to charge until the green charger light is illuminated, indicating full charge). If one or more batteries still test low, the battery should be tested individually and replaced as necessary.<br>*NOTICE: It is recommended that all batteries in a system be changed together to ensure the batteries are the same brand, vintage, and service life.* |
| 3. Test each battery cell with a battery hydrometer. | Any battery or battery cell that tests low should be fully charged and then rechecked. | If the cell continues to test low with a hydrometer, the battery should be replaced. See note above. |
| 4. A battery may test good with a voltage or hydrometer test when no load is being drawn from it. Test using a battery load tester. | A battery must be able to produce 45 minutes of capacity when tested at 55 amp draw after a complete recharge cycle. | A battery that is not able to produce this capacity should be replaced. See note above. |


**Non-Sealed Batteries** **Sealed Batteries**

**Note: Sealed batteries are unserviceable.**
**DO NOT attempt to remove caps or open vents.**

***Figure 4-2. Batteries***

## TROUBLESHOOTING SPECIFIC COMPLAINTS

Troubleshooting is a matter of investigation and deduction based on the symptoms and the possible causes. Recording every possible solution to every possible cause would be impossible, but this troubleshooting section is designed to assist in solving issues which may arise in the service life of an electric vehicle.

Problems that could be encountered with the vehicle(s) are:

- Vehicle operates slowly
- Vehicle drives in forward or reverse only
- Vehicle drives but operation is jerky or inconsistent
- Vehicle power cuts out

**IMPORTANT: Always follow troubleshooting guide in exact sequence as listed. Performing tests out of sequence will cause inaccurate results and lost time in diagnosing electrical system problems**.

### Vehicle Will Not Move; Forward or Reverse

Before attempting to service a vehicle, complete the pre-service inspection and fully test the batteries as described on the previous page. Set the vehicle power switch to “ON”. The green status light (Figure 4-1) on the controller will show one of three conditions; steady off, steady on, or flashing.

*NOTICE: In some lighting situations it is difficult to determine the condition of the fault light. Ensure an accurate reading of the light by shading it.*

| Fault Code | Condition | Corrective Action |
|---|---|---|
| Fault code light steady OFF | The controller is not getting the proper voltage or the controller has failed internally. | 1. Check to make sure the controller has a good battery negative connection at the B- terminal. Attach the black lead of the VOM to the B- terminal and attach the red lead to the battery pack positive post.<br>On DC volts scale, full battery pack voltage should be observed. If not, check or replace the connections and cable between the main battery pack negative post and the controller B- post. If correct voltage is present, disconnect the 16 pin wire connection from the controller. Set main power switch to ON. Insert the black lead to the B- terminal on the controller and the red lead to the red #1 wire of the 16 pin connector. Full voltage should be observed.<br>2. If voltage is present, reconnect the 16 pin plug connector to the controller and ensure the wires are fully seated in the back of the plug. If there is system voltage between B- post and the #1 pin, and the controller light does not illuminate, the controller has failed internally and must be replaced.<br>3. If there is no voltage present between the #1 pin and the B- terminal, and B- terminal has a good connection to battery pack negative, the red #1 wire circuit is not energizing properly. Make sure the charger positive (red) wire is connected to the main battery pack positive terminal, then check the table below. |
| Fault code light steady ON | Indicates the controller is powered up and ready to perform. If the vehicle fails to operate with the fault code light in the steady on condition, it is likely the controller is not receiving the correct input from the drive system, or a mechanical fault has occurred. | 1. Check to make sure the parking brake is releasing and the vehicle will roll when pushed on a level surface.<br>2. Check for other mechanical failures such as stripped hubs or anything that would prevent the vehicle from being able to operate. Make sure a direction of travel is selected (the vehicle will not attempt to drive while set to Neutral).<br>3. Check the inputs of the electrical system by using the Computer Diagnostics Utilities (Columbia Part No. 30001-04) or the handheld calibrator (Columbia Part No. 30003-04) . See the following procedures on page 4-5. |

**TROUBLESHOOTING WITH THE HANDHELD CALIBRATOR**

1. With power keyswitch in the OFF positiion, connect the handheld calibrator to the vehicle then turn keyswitch to the ON position and enter the “Read-Only” mode (RON). Scroll down by pressing “Select” button until you reach the “19” menu (location 19.01). The “Test” light on the left side of the calibrator will illuminate when the “19” menu is selected. This menu shows the inputs the controller is observing at that time. At 19.01, the calibrator displays the “Accelerator Push” in percentage.
2. With the Forward / Reverse switch set to Neutral, slowly press the accelerator pedal. The “Accelerator Push” value should rise in value from 0-100% smoothly as you press the pedal. If the value does not change, the controller is not receiving input from the accelerator control device (potentiometer or linear accelerator device).

   Check all cable and wire connections regarding the accelerator control device. If the value does rise, but not to 100%, adjust the accelerator cable attached to the accelerator device.
3. Next, check the FS1 Switch input by scrolling to the 19.07 location. At rest, the value for the FS1 Switch should read open, or (3.OP). When the accelerator pedal is pressed, the value should change to closed, or (3.CL). If the value fails to close, check the FS1 wiring circuit and test the switch with a VOM. Check the wiring back to the controller (Pin 4).
4. Check the direction input to the controller. Observe the value of the “Forward Switch” item at location 19.05 while turning the direction selection switch to “Forward” and to “Neutral”. The switch should read open (1.OP) when the switch is in neutral and closed (1.CL) when in forward. Do the same in reverse by monitoring the Reverse Switch at location 19.06 and value. If the switch fails to close in either direction, check the switch with a VOM and the wiring back to the controller (Pin 2 for Forward and Pin 3 for Reverse).

If the vehicle is receiving the correct inputs and fails to operate, contact Columbia tech support for further assistance.

| VEHICLE WILL NOT MOVE; FORWARD OR REVERSE - LED DIAGNOSTIC GUIDE | |
|---|---|
| **Green LED Flashes** | **Check/Test** |
| 1 Flash | Check all wire connections for good connection and free of corrosion. |
| | Call Columbia Technical Support if problem persists. |
| 2 Flash | Perform steps 1 - 4 under *Troubleshooting with Handheld Calibrator* above. |
| 3 Flash | Check all wire connections. Disconnect all electrical accessories (strobe lights, heaters, etc.) External or internal wiring faults will cause controller 3 Flash. Eliminate all “non-controller” sources first. Plug in calibrator and read location 13.10 fault code for more precise fault cause(s).<br>Call Columbia Technical Support if problem persists. |
| 4 Flash | Bench test 48 volt main solenoid. Check all wiring. Plug in Calibrator and read location 13.01 for more precise fault cause(s). |
| 5 Flash | Motor stall fault. Check motor for damage. Plug in Calibrator and read location 13.10 for more precise fault cause(s). |
| 6 Flash | Accelerator fault. Check all wiring pertaining to the accelerator switch.<br>Perform steps 1, 3 and 4 under *Troubleshooting with Handheld Calibrator* above.<br>Check the accelerator control device with an analog ohmmeter. It should read 0 - 5k ohms. |
| 7 Flash | Low or high battery voltage. Check battery voltage with a voltmeter. If battery voltage drops below 32 volts (48 volt system), the controller will shut down. Read pack voltage both stationary and under hard acceleration if possible. If voltage is good while static, but drops significantly while accelerating, weak or damaged batteries may be the cause. |
| 8 Flash | Over temperature cutout. Call Columbia Technical Support. |
| 9 Flash | Out of range. Call Columbia Technical Support. |
| 10 Flash | Bench test 48 volt main solenoid. Check all wiring. Plug in Calibrator and read location 13.01 for more precise fault cause(s). |



### Vehicle Drives Slowly

- Check for all physical/visual signs of damage, low tire pressure or jammed linkages.
- Check for brake drag by turning vehicle power off, releasing parking brake, and attempting to roll vehicle a short distance.
- Plug in the Handheld Calibrator and check 5.01, 6.01 and 7.01 for appropriate values (maximum speed settings).
- Perform step 2 in *Troubleshooting with Handheld Calibrator*.
- Check for weak, discharged or damaged batteries, or poor connections.

### Vehicle Drives in Forward Only or Reverse Only

- Perform step 4 in *Troubleshooting with Handheld Calibrator*.

### Vehicle Drives But Operation Is Jerky or Inconsistent

- Check speed switch carefully with analog ohmmeter for gradual, smooth resistance sweep.
- Check motor brushes. Replace if bad or worn (Figure 4-3).
- Call Columbia Technical Support if problem persists. Have the following information ready:
  - VIN
  - Vehicle Checksum (19.15)
  - Direction of travel the operation is “jerky”
  - Speeds at which vehicle jerks.

### Vehicle Power Cuts Out

- The fault for a vehicle that exhibits a cut out symptom can only be diagnosed while the vehicle is in a fault condition.

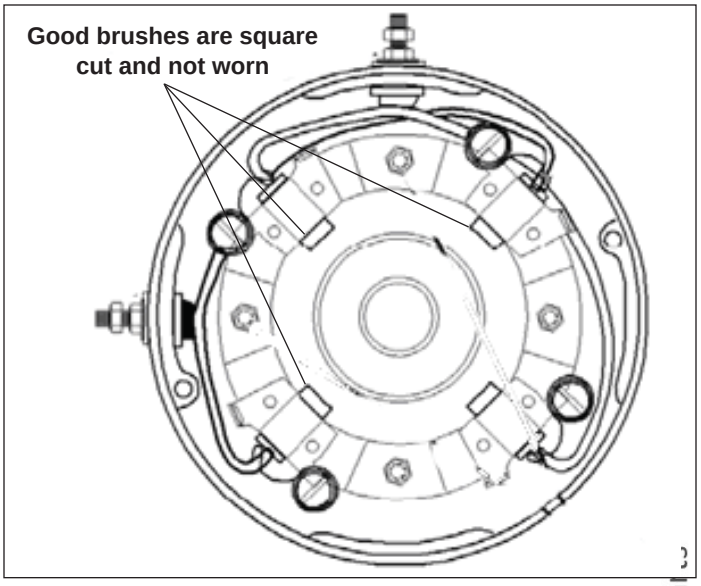



***Figure 4-32. Motor Brushes***

When a vehicle faults, immediately check the flash code, or for fault out location 13.01 to diagnose the cause. Follow the corrective steps. Before calling Technical Support, have the following information ready:

- VIN
- Fault code or fault location
- Battery voltage
- Full description of fault out symptoms (does the vehicle coast to a stop, or stop abruptly, was it travelling uphill, downhill, or on level ground).



## ACE*plus* SEVCON CONTROLLER POWER SYSTEM - 6 POST

**IMPORTANT: Always follow troubleshooting guide in exact sequence as listed. Performing tests out of sequence will cause inaccurate results and lost time in diagnosing electrical system problems**.

| Troubleshooting Guide | | |
|---|---|---|
| **Test** | **Passed** | **Failed** |
| Voltmeter positive red lead to battery B+ terminal, Voltmeter negative black lead to battery B- terminal. | Full battery voltage = Good | Less than full battery voltage, verify battery connections, check for corrosion, state of charge and/or replace batteries. |
| Turn Power keyswitch to OFF and then back ON. Observe green LED on controller for flashing pattern. If flashing, count number of flashes and refer to the LED Diagnostic Table on next page. | Contactor will close to start charging controller capacitors and open after approximately 30 seconds. | If contactor does not close, check fuse and wiring to coil. Replacement of a defective controller should always be confirmed by verification that other faults have been eliminated first. Controllers must be factory programmed to specific VIN, axle, tire size and vehicle voltage. |
| No power to controller. | | Vehicles are equipped with a charger interlock. The green charger wire connects to red wire in front harness and only provides power to system when charger is unplugged from AC power source. |

### LED Fault Code Diagnostic Guide

The Sevcon Controller Flash Code Diagnostic Guide can be used to get an initial indication of a problem. In some cases, there are multiple possible causes for a fault in that category. The causes and verification steps for some fault codes related to system input or circuitry for the drive system are listed. These obvious faults may not require use of the handset or computer interface. In order to perform complete specific fault diagnosis, a Sevcon Controller Customization Utility Handheld Calibrator PN 79001-04, or Computer Interface 79003-04, may be required. Training is required to use these tools.

| Sevcon 633T45303 Controller - 6 Post | | | |
|---|---|---|---|
| **Green LED Flashes** | **Possible Fault Condition** | **Handset ID#** | **Cause/Test/Failure** |
| 0 Flash (no green LED) | Internal MOSFET/Contactor | | No power to Pin 1 from Power Switch. Also see *No Power To Controller, Troubleshooting Guide page 4-4.* |
| | | | No power to contactor coil connections. |
| | | | No power from main contactor to controller B+. |
| | | | Controller connector wiring open circuit. |
| | | | Controller connector pin not in place. |
| | | | Dielectric break down at connector (wet/shorted). |
| | | 25/26 | Internal controller fault, MOSFET problem. Replacement of controller may be required. |
| 1 Flash | Personality (CRC) out of range | 17/18 | Incorrect range settings; requires Handset/Computer or replacement of controller. |
| 2 Flash | Improper start condition | various | The wire harness controller connector pins may develop an open or intermittent connection which can also result in these faults. Check pins and crimps. |
| | | 8 | Accelerator switch (pedal) needs to be recycled after a direction change. |
| | | 9 | Pedal depress when key turned on. |
| | | 10 | Wiring fault - two directions selected. |
| | | 11 | Forward/Reverse switch turned on at power up. |
| | | 11 | Speed switch out of adjustment. |
| | | 11 | Micro switch not open with pedal up. |
| 3 Flash | MOSFET short circuit | 23 | Armature circuit short detected or other intermittent electrical short such as brush dust, etc. |
| | | 27 | Internal controller fault. |
| 4 Flash | Contactor fault or motor open circuit | 19 | Contactor failed or stuck. Bench test contactor. |
| | | 20 | Main post to battery corroded. |
| | | 20 | Test switched side of contactor. |
| | | 20 | Test 24 Volt small terminal coil (verify correct coil voltage). |
| | | 22 | Motor open circuit or brushes. |
| 5 Flash | Motor stall fault | 15 | Motor stall condition detected. |
| 6 Flash | Accelerator fault | 4 | Input wire disconnected (white/black lead). |
| | | 5 | Accelerator cable adjustment required. |
| | | 5 | Pedal depressed at power up (see 2 Flash). |

| Sevcon 633T45303 Controller - 6 Post (continued) | | | |
|---|---|---|---|
| **Green LED Flashes** | **Possible Fault Condition** | **Handset ID#** | **Cause/Test/Failure** |
| 7 Flash | Low or high battery voltage | 13/16 | End of charge cycle with Power switch left on. Check for BDI scan sweep. |
| | | 12/13/16 | Battery voltage has fallen or risen:<br>24 Volt system: 15 V Low - 36.5 V High<br>36 Volt system: 22.5 Low - 50 V High<br>48 Volt system: 30 V Low - 65 V High |
| 8 Flash | Over temperature or timed cut out | | Defective controller; replacement may be required. |
| | | 1 | Excessive temperature heat sink. |
| | | 3 | Current cut-back. |
| 9 Flash | Monitor tripped | 2 | F1 or A1 out of range boundaries 125%. |
| 10 Flash | Auto zero fault | | Contactor coil disconnected. |
| | | 34 | May be controller internal fault. |
| | | 34 | Contactor did not operate properly. |
| NOTE: Fault indication will be cleared by Power-up sequence after fault cause has been corrected. | | | |



## Flash Codes and Corrective / Investigative Action (633T45303)

| Flash Code | Description | Action | Handset ID fault number (13.01) | Calibrator reference loc | Correction - If fault does not clear |
|---|---|---|---|---|---|
| 0 Flash (Light does not illuminate or light turns on and then back off.) | Internal Mosfet failure | Disconnect any electrical accessories and retry | 25 / 26 | - | Controller replacement required, contact Tech Support |
| | Pin 1 Circuit Fault | Trace current from battery positive to Pin 1 | - | - | Replace failed connection, component, or wiring. |
| | Contactor Circuit fault | Trace current to solenoid and contact connections | - | - | Replace failed connection, component, or wiring. |
| 1 Flash | Personality out of range | Check personality Checksum | 17 / 18 | 19.15 | Controller replacement required, contact Tech Support |
| 2 Flash | Seat Switch Fault | Check Seat switch and Seat switch circuit | 7 | 19.08 | Repair or replace failed connection or component |
| | Accelerator not at rest when direction selected | Ensure Accelerator Pedal returns to 0 (rest) position | 8 or 9 | 19.01 / 19.07 | Repair or replace failed connection or component |
| | Two directions selected | Ensure Direction Key switch is functioning properly | 10 | 19.05 / 19.06 | Repair or replace failed connection or component |
| | Forward or reverse selected at power up | Ensure Direction Key switch is functioning properly | 11 | 19.05 / 19.06 | Repair or replace failed connection or component |
| | Speed Switch out of range | Check speed switch range | 11 | 19.01 / 19.02 | Repair or replace failed connection or component |
| | FS1 not open with pedal up | Ensure Pedal returns to 0 and microswitch is functioning properly | 11 | 19.07 | Repair or replace failed connection or component |
| | Controller pins are cross - shorted | Check wire harness connector pins for good connections | Various | 19.01 - 19.09 | Repair any faulty connections |
| 3 Flash | Auxiliary wiring short | Disconnect auxiliary electrical components and retry | - | - | Controller replacement required, contact Tech Support |
| | Armature Short Detected | Clean and Check motor and wiring for faults | 23 | - | Motor replacement may be required, contact Tech Support |
| | Internal controller fault | Disconnect auxiliary electrical components and retry | 27 | - | Controller replacement required, contact Tech Support |
| 4 Flash | Contactor Failed or Stuck | Bench test contactor | 19 | - | Replace Solenoid, If good - Controller replacement required, contact Tech Support |
| | Contactor Failed or contactor wiring fault | Bench test contactor and test contactor wiring | 20 | - | Repair or replace failed connection or component |
| | Motor open circuit or brushes fault | Clean and Check motor and wiring for faults | 22 | - | Motor replacement may be required, contact Tech Support |
| 5 Flash | Motor stall detected | Clean and Check motor and wiring for faults review application | 15 | - | Motor replacement may be required, contact Tech Support |
| 6 Flash | Input wire disconnected | Check wiring to the speed switch and FS1 | 4 | 19.01 / 19.07 | Repair or replace failed connection or component |
| | Speed switch out of adjustment | Check speed switch range | 11 | 19.01 / 19.02 | Repair or replace failed connection or component |
| | Pedal depressed at start up | Ensure Accelerator Pedal returns to 0 (rest) position | 8 or 9 | 19.01 / 19.07 | Repair or replace failed connection or component |
| 7 Flash | Battery voltage low fault | Check Static battery voltage and voltage while operating | 12 / 13 or 16 | 15.01 | Check to see if voltage drops below 32 volts, charge / replace batteries |
| | Battery voltage high fault | Check Static battery voltage and voltage while operating | 12 / 13 or 16 | 15.01 | Check to see if voltage rises above 63 volts in while operating, see SB - 12-07 |
| | Capacitor voltage is too high | Check Static battery voltage and voltage while operating | 14 | 15.02 | Contact tech support with reading from 15.02 |
| 8 Flash | Over Temperature cut - out | Review application and allow vehicle to cool | 1 | 18.01 | Contact Tech Support |
| | Current Cut - Back | Review application and allow vehicle to cool | 3 | 18.01 | Contact Tech Support |
| 9 Flash | Internal monitor tripped | Disconnect any electrical accessories and retry | 2 | - | Controller replacement required, contact Tech Support |
| 10 Flash | Contactor Coil Disconnected | Bench test contactor and test contactor wiring | - | - | Contactor or Controller replacement may be required, contact Tech Support |
| | Value out of range | Check personality Checksum | 34 | 19.15 | Controller replacement may be required, contact Tech Support |
| | Internal controller fault | Disconnect any electrical accessories and retry | 34 | - | Controller replacement may be required, contact Tech Support |

## SPEED SWITCH (POT BOX) TESTING

| Speed Switch Testing | | |
|---|---|---|
| **Test** | **Passed** | **Failed** |
| Disconnect white and black lead wires from wire harness to speed switch under front body. Switch volt/ohm meter to ohms scale, capable of measuring 0-100 ohms. Connect volts/ohm meter leads to white and black wires from speed switch. **Do not depress accelerator. Leave key in OFF position.** | 0-50 ohms resistance = Good | Greater than 50 ohms, refer to Pot Switch adjustment. If adjustment does not correct, replace pot switch or speed switch assembly. |
| Leave ohm meter leads connected to white and black leads (speed switch). Switch ohm meter to a scale capable of measuring up to 6,000 ohms (K ohms). Slowly depress accelerator and monitor change. | Ohms of resistance should decrease gradually from a maximum of 4,500 - 5,000 ohms to almost 0 ohms. | If rise in resistance is erratic or skips as pedal is depressed, replace speed switch assembly.<br>If maximum resistance is less than or greater than 4,500-5,500 ohms, adjust pot switch to correct. |

## COMPONENT TROUBLESHOOTING

In addition to the problems/cause/solutions listed in this section, individual sections also contain some testing and problem solution for individual components. Check the appropriate section first, and if the information is not found, check the following when a component is causing a problem:

### Battery Discharge Indicator (BDI)

1. Fuse failed.
   *Check fuse and replace if failed.*
2. Open wiring or failed connection.
   *Check wiring and connections*
3. Inoperable BDI gauge.
   *Replace gauge.*
4. Weak or failed batteries.
   *Test batteries and charge as necessary.*

### Brake Lights

1. Fuse failed.
   *Check fuse and replace if failed.*
2. Open wiring or failed connection.
   *Check wiring and connections*
3. Bulb failed.
   *Replace lamp.*
4. Misadjusted or inoperable brake light switch.
   *Check switch adjustment, replace switch if necessary.*

### Reverse Beeper

1. Fuse or relay failed.
   *Replace fuse or relay.*
2. Open wiring or failed connection.
   *Check wiring and connections*
3. Inoperable reverse beeper.
   *Replace beeper.*
4. Weak or failed batteries.
   *Test batteries and charge as necessary.*
5. Controller set wrong.
   *Check controller setting using hand held. Reset if necessary.*
6. Inoperable directional switch.
   *Test switch and replace if necessary.*

### Headlight

1. Fuse failed.
   *Check fuse and replace if failed.*
2. Open wiring or failed connection.
   *Check wiring and connections*
3. Lamp burnt out.
   *Replace lamp.*
4. Failed power key switch.
   *Test and replace contactor as necessary.*
5. Inoperable switch.
   *Replace switch.*

### Power Outlet

1. Fuse failed.
   *Check fuse and replace if failed.*
2. Open wiring or failed connection.
   *Check wiring and connections*
3. Inoperable power outlet.
   *Replace power outlet.*

### Taillight

1. Fuse failed.
   *Check fuse and replace if failed.*
2. Open wiring or if failed connection.
   *Check wiring and connections*
3. Lamp burnt out.
   *Replace lamp.*
4. Failed power key switch.
   *Test and replace as necessary.*

### Backup Light

1. Fuse or relay failed.
   *Replace fuse or relay.*
2. Open wiring or if failed connection.
   *Check wiring and connections*
3. Light burnt out.
   *Replace light.*
4. Failed power key switch.
   *Test and replace as necessary.*

### Brakes

Slow or incomplete release of brakes.

1. Shoes and linings.
   *Shoes improperly adjusted. Shoes are self-adjusting; check parts for wear.*
   *Shoes distorted or incorrect. Replace with new parts*
2. Mechanical parts.
   *Damaged or weak return springs-replace.*
   *Cables and linkage sticking, dirty or corroded. Lubricate with a commercial solvent like WD40, PB Blaster, etc. Make sure not to contaminate brake pads with solvent.*
3. Wheel bearings.
   *Damaged or contaminated-replace.*
   *Grabbing or pulling-replace.*
4. Air in hydraulic lines (hydraulic brakes).
   *Bleed hydraulic lines.*

Severe reaction to pedal pressure and uneven stopping.

1. Shoes and linings.
   *Shoes improperly adjusted. Shoes are self-adjusting; check parts for wear.*
   *Shoes distorted or incorrect. Replace with new parts*
2. Mechanical parts.
   *Damaged or weak return springs-replace.*
   *Cables and linkage sticking, dirty or corroded. Lubricate with a commercial solvent like WD40, PB Blaster, etc.*
3. Drums.
   *Drums are thin (expanding when hot); oversize (beyond .030") of original specification – replace.*
   *Scored, out-of-round – replace*

Squealing, clicking or scraping noises upon application of brakes.

1. Shoes and linings.
   *Shoes twisted, distorted, incorrect or broken – replace.*
   *Linings worn out, glazed, loose or contaminated – replace.*
2. Mechanical parts.
   *Damaged or weak return springs-replace.*
   *Backing plate loose or failed – replace.*
3. Drums.
   *Drums are thin (expanding when hot); oversize (beyond .030") of original specification – replace.*
   *Scored, out-of-round – replace*

## NOTES



## ELECTRIC VEHICLE SERVICE

When servicing the electric vehicle always observe the following:

**⚠ DANGER**

**Always turn power key to OFF, position directional selector to NEUTRAL, remove power key and block tires and disconnect battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.**

## ACCELERATOR PEDAL

Accelerator pedal maintenance consists of periodic inspection. No lubrication or adjustment is necessary.

The accelerator pedal works in conjunction with the linear accelerator and the Sevcon controller to adjust and control vehicle direction and speed.

All adjustments are made using the handheld Calibrator. *See Section 4-Troubleshooting*.

## HYDRAULIC BRAKE SYSTEM

### General

The hydraulic brake system utilizes a combination of mechanical and hydraulic components and is equipped with rear drum brakes and optional front disc brakes.

A mechanical brake pedal/linkage assembly is utilized to actuate a master cylinder. The master cylinder creates hydraulic pressure which operates the brakes. Hydraulic brake systems require a separate mechanical parking brake. A hand operated parking brake, mechanical linkage and cables are utilized to mechanically lock the rear brakes for parking.

**⚠ CAUTION**

**Do not handle hydraulic system parts with greasy hands or permit parts to come in contact with oil or grease. Grease or oil will damage the rubber parts.**

### Periodic Brake Inspection

Intervals between brake service and inspection may vary depending on driving habits, type of driving, road and climate conditions, and vehicle load.

**⚠ CAUTION**

**Periodic brake inspection is required to prevent potential accident or injury and vehicle damage.**

Periodic inspection should always include the following:

1. With vehicle stationary, depress the brake pedal. Pedal should not travel in excess of 2-1/2" as measured from floor board. If pedal travels in excess of 2-1/2" before resistance is felt, or if pedal feels spongy and soft, repair or maintenance is required.
2. Inspect brake master cylinder and adjoining brake lines for signs of fluid leakage. Remove master cylinder cover (Figure 5-1), located under front cowl). Fluid must be clear and fluid level should be within 1/4" of cylinder top (with vehicle on level ground).


***Figure 5-1. Brake Fluid Reservoir***

3. Check parking brake operation. Parking brake hand lever should travel no more than 3-1/2" upward when engaged. Check that ratchet mechanism automatically holds parking brake handle in up position. Make sure release button on handle frees the parking brake lever and that lever returns to full down (released) position.
4. Operate vehicle on level ground, applying brakes to ensure that both rear brakes apply equally. Check that excessive force is not required to apply brakes. Excessive force required to apply brakes could indicate malfunctioning brake system or excessive wear to brake shoes.

### Annual Brake Inspection

**⚠ WARNING**

**To perform this service, raise vehicle using floor jack and safely support it with jack stands positioned under main frame tubes. See *Section 3 - Lifting Instructions*.**

1. Perform steps 1 & 2 under *Rear Drum Brake Disassembly*.
2. Inspect drum for excessive or uneven wear. Refer to *Brake Drum Service*. Look for cracks radiating from stud holes.
3. Inspect brake shoes for thickness, uneven wear or physical damage. If brake shoe lining at any point is measured to be less than 1/16" (1.6 mm), brake shoes must be replaced. See *Rear Drum Brake Disassembly.*
4. Inspect for oil or grease contamination. Replace brake shoes that are contaminated. See *Rear Drum Brake Disassembly*.
5. Inspect wheel cylinder area for fluid leakage. Inspect axle and axle tube area for leakage from axle bearing.
6. Wash mud, brake shoe debris, and dirt from brake assemblies and drum. Apply white lithium grease to contact points between brake shoe and brake back plate. Remove excess grease to prevent brake shoe contamination.

**⚠ WARNING**

**Do not use compressed air to blow dust from brake assembly. Brake dust contains potentially harmful contaminants.**

7. Perform steps 5-8 under *Rear Drum Brake Reassembly*.



## REAR DRUM BRAKE

### General

**⚠ CAUTION**

**Do not depress brake pedal while shoes and drum are removed from the vehicle. Pistons will be forced from the wheel cylinders causing fluid leakage and damage.**

***NOTICE: It is not recommended to remove the hydraulic brake assembly from the axle for repair or service.***

- Before removal of existing parts, note location of colored springs and other parts for correct reassembly.
- Always use a brake spring tool to remove and install springs.
- Always lay out brake shoes and other parts in order removed. Reinstall in same order.
- Always replace brake shoes that have been contaminated with oils or lubricants.
- Always replace any springs that appear stretched or deformed.
- Never use petroleum based cleaners or lubricants on hydraulic brake parts as they will contaminate the brake fluid.

***NOTICE: Do not mix parts from left and right brake assemblies as they may differ.***

### Rear Drum Brake Disassembly - Dana Spicer Models

1. Engage the parking brake. Remove four nuts and remove rear wheel/tire assembly.
2. Release parking brake and remove the brake drum.
3. Remove axle nut and wheel hub (Figure 5-2)

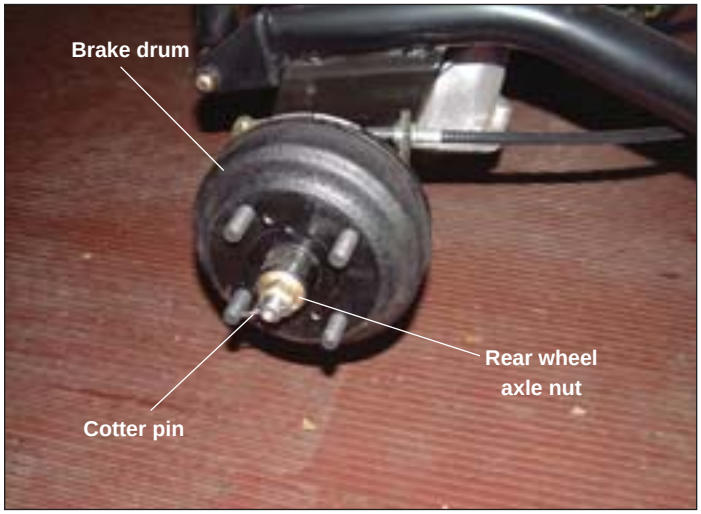



*Figure 5-2. Rear Axle Nut*

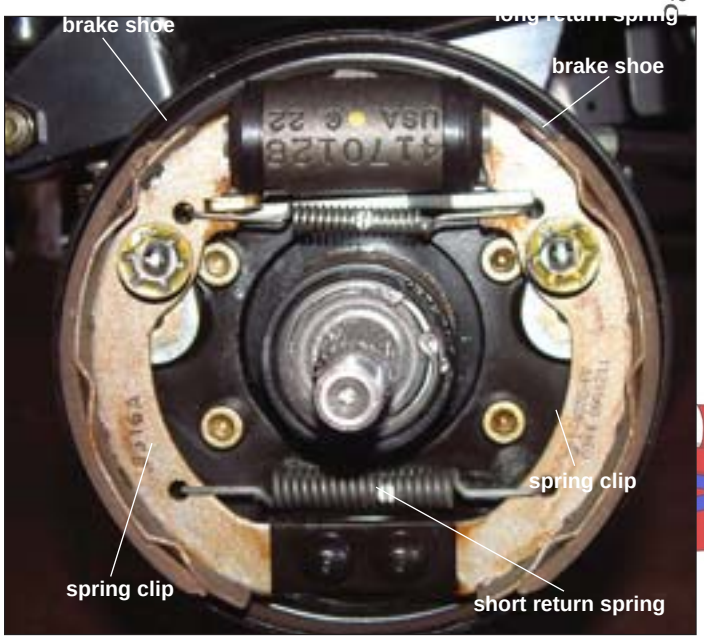



*Figure 5-3. Rear Drum Brake - Dana Spicer Models*



4. Use a brake spring tool and remove the shoe retaining spring and return spring (short and long). Unhook each spring from the brake shoes and set it aside (Figure 5-3).
5. Remove the spring clips and remove the brake shoes.
6. Clean the brake assembly to remove brake debris, dust, dirt and mud.
7. See *Brake Drum Service* and rebore/replace drum as necessary.
8. See *Wheel Cylinder* below and replace as necessary.

**⚠ CAUTION**

**Do not use solvents or other chemical cleaners unless formulated for cleaning brake parts.**

### Rear Drum Brake Reassembly - Dana Spicer Models

1. Place brake shoes into position on retaining pins. Install spring clips. Make sure shoes are positioned properly on cylinder. Check that brake shoes are correctly positioned into the slots provided in each master cylinder piston (Figure 5-3).
2. Install long retaining spring (top) and short return spring (bottom).
3. Install axle nut and torque to 95-115 ft.lbs. (128.8-155.9 Nm).
4. Install the brake drum fully onto brake assembly.
5. Reinstall rear wheel/tire assembly and four lug nuts. Engage brake and tighten lug nuts in a criss-cross pattern to a maximum 65 ft. lbs. (88.1 Nm) (Figure 5-5). Repeat for other rear wheel/tire assembly. Recheck lug nut torque with vehicle on the ground.

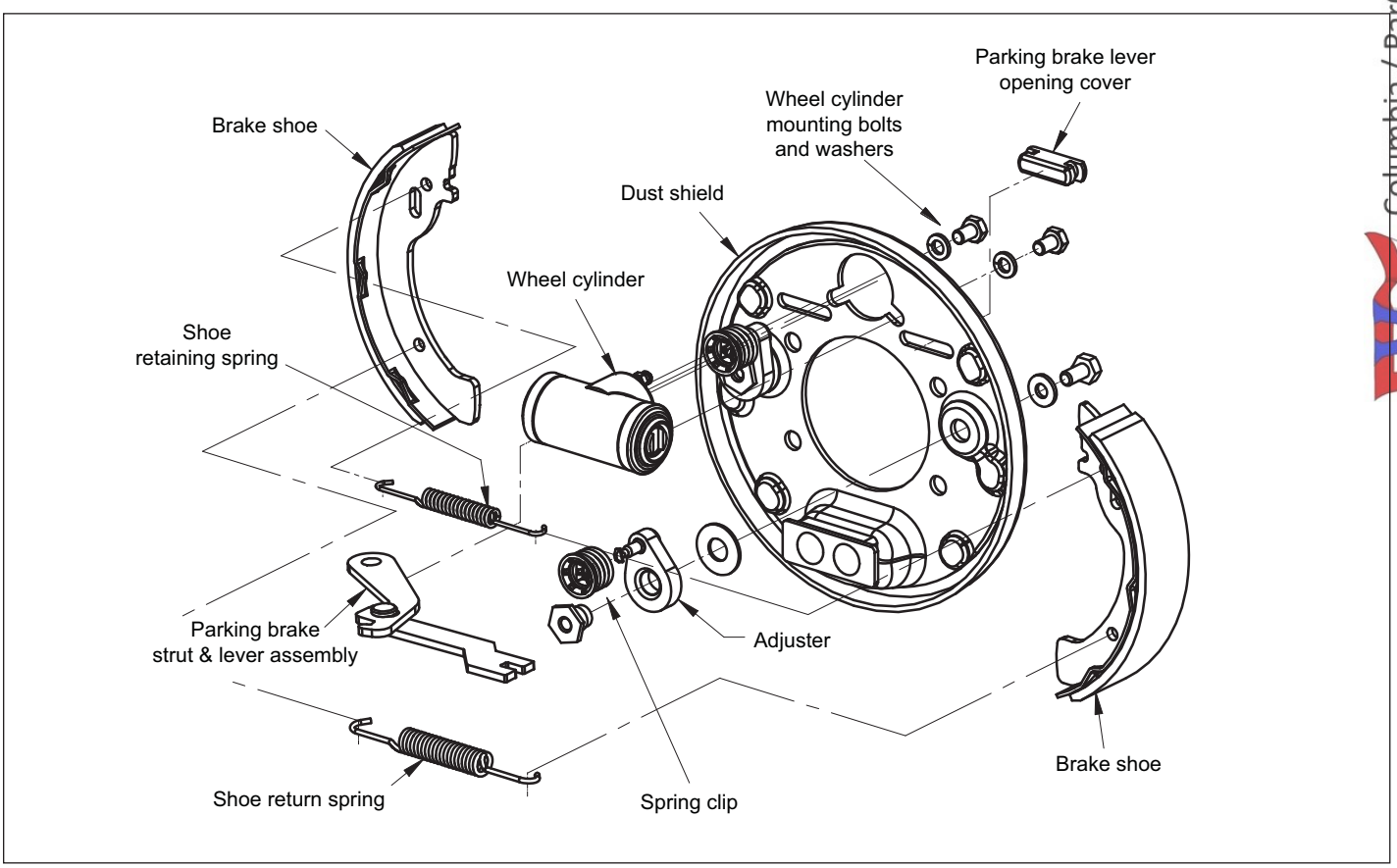



*Figure 5-4. Rear Drum Brake Assembly - Dana Spicer Models*



### Wheel Cylinder Service - Dana Spicer Models

The wheel cylinder is a one piece cast assembly. Removal of the wheel cylinder is recommended only when replacement is required.

1. Perform steps 1 - 5 under “Rear Drum Brake Disassembly - Dana Spicer Models” on page 5-3.
2. Remove the two mounting bolts and washers (Figure 5-4) and remove cylinder.
3. Install new wheel cylinder using bolts and washers removed in step 2.
4. Proceed to *“Rear Drum Brake Reassembly - Dana Spicer Models” on page 5-4*.

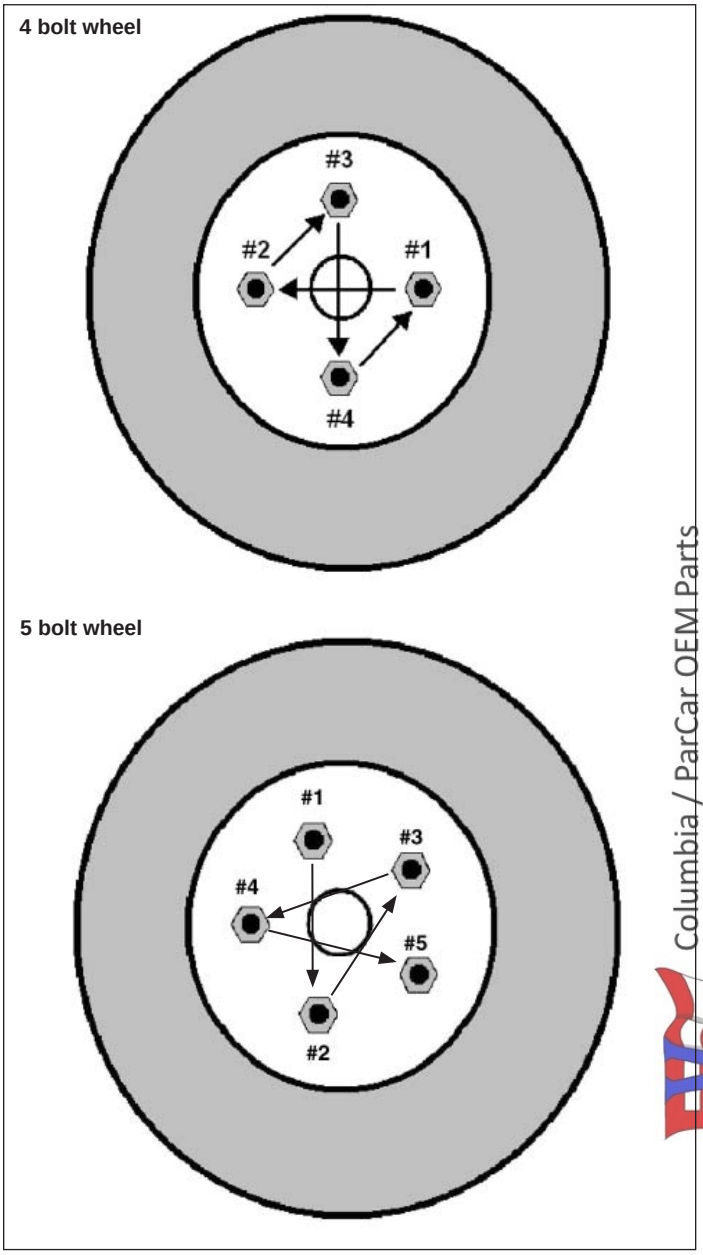



***Figure 5-5.*** **Lug Nut Tightening Pattern**

### Rear Drum Brake Disassembly - TEAM Axle Models

1. Engage the parking brake. Remove four nuts and remove rear wheel/tire assembly.
2. Release parking brake.
3. Remove cotter pin, nut cap and wheel nut (Figure 5-6). Remove brake drum by pulling straight out. Tap drum from back side if necessary.

***Note:*** *Brake drum is an integrated hub with a splined center shaft. Be careful not to damage the splines when removing.*

4. Remove the adjuster retaining spring (Figure 5-7).
5. Separate the shoes and remove adjuster.
6. Remove small retaining clips at bottom of shoes.
7. Using a brake spring tool, release tension from shoe spring at top of spring (Figure 5-8).
8. Rotate shoe and lift it out.

### Rear Drum Brake Assembly - TEAM Axle Models

1. Install shoes. Secure with springs using brake spring tool.
2. Install small retaining clips at bottom of shoes.
3. Separate shoes and install adjuster.
4. Install wheel nut, nut cap, cotter pin and brake drum.
5. Reinstall rear wheel/tire assembly and four lug nuts. Engage brake and tighten lug nuts in a criss-cross pattern to a maximum 65 ft. lbs. (88.1 Nm) (Figure 5-5). Repeat for other rear wheel/tire assembly. Recheck lug nut torque with vehicle on the ground.

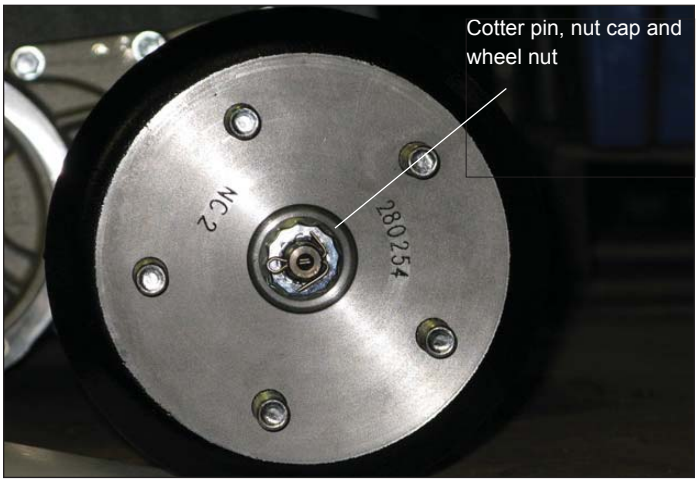



*Figure 5-6. Removing Brake Drum*

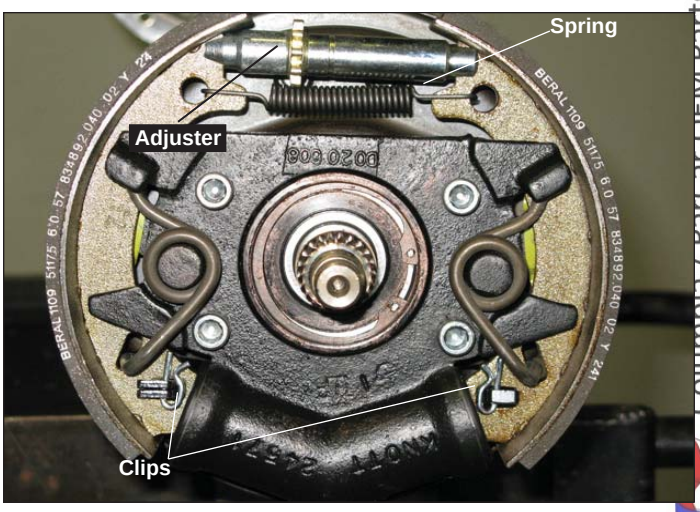



*Figure 5-7. Rear Drum Brake - TEAM Axle Models*

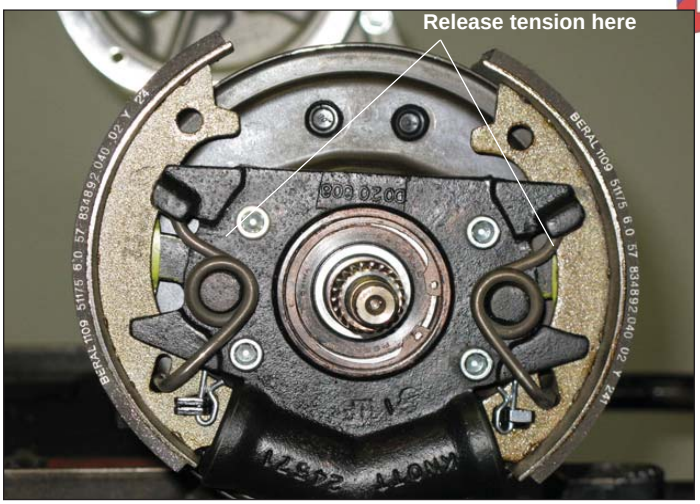



*Figure 5-8. Rear Drum Brake - TEAM Axle Models*

## Brake Drum Service

1. Re-bore or replace drum:

   if rubbing surface is rough or ragged, or if depth of scoring exceeds .010".

   if inside diameter of drum at open end exceeds inside diameter at closed end by more than .010".

   if surface variance exceeds .005" on the side.

   if hard spots cause noticeable effects such as pedal pulsations or brake roughness. If spots are severe, replace drum.

   if heat checking is plainly visible or can be felt with a fingernail. If checks are severe, replace drum.

   if out-of-round condition exceeds .006" total indicator reading or if pedal pulsations or brake roughness is noticeable.

2. To measure a drum diameter, place gauge in drum so contact points are at greatest diameter. Be careful to hold both contact points at same depth (distance from outside edge of drum).

3. Re-bore limit is .060" over original drum diameter.

4. Difference in diameter of drums on opposite ends of the same axle must not exceed .010", or when turning drums turn them in pairs to same oversize (within .010") to ensure equal braking effort on all wheels.

**⚠ CAUTION**

**Never re-bore a drum to maximum wear or discard diameter.**

5. When re-boring a drum, remove only enough metal to obtain a smooth braking surface. If drum does not clean up when turned to maximum re-bore diameter, replace it. Removal of more metal will affect ability of drum to dissipate heat and may cause drum distortion.

## Hydraulic Master Cylinder

### BRAKE FLUID MAINTENANCE

1. Maintain fluid level within 1/4" of master cylinder filler opening (Figure 5-1).

2. Changing brake fluid:

   As a result of use, brake fluid loses some of its original qualities and may become contaminated. When performing major brake work to the hydraulic system, remove old fluid and replace it with clean brake fluid.

   Brake fluid must be changed following extended usage or contamination. Anytime fluid looks milky or dark, there are contaminants in the fluid.

   If any of the hydraulic system parts are corroded, or the fluid is discolored, flush the hydraulic system to remove old fluid, then fill with clean brake fluid.

3. Soft or swollen rubber parts, or milky or discolored fluid indicate the brake fluid is contaminated.

   Drain old fluid from the system. See *Bleeding the Hydraulic Brake System* on the next page.

   Replace cups and seals.

   Flush hydraulic system with clean brake fluid.

   Refill system with clean brake fluid.

4. Handling and storing brake fluid:

   Keep brake fluid clean. Do not allow any foreign material in the fluid.

   Prevent any petroleum product (gasoline, kerosene, oil, grease, etc.) from contaminating the brake fluid.

   Use only clean containers for dispensing brake fluid. Do not use containers contaminated with dirt, grease, etc.

   Always cover or cap brake fluid containers when not actually dispensing the fluid. If containers are left open or uncovered, the fluid absorbs moisture from the air.

   Never reuse old brake fluid drained from the system. Used brake fluid is contaminated to some extent.

   Store brake fluid containers in a clean, dry place.



**BLEEDING THE HYDRAULIC BRAKE SYSTEM**

**⚠ WARNING**

**Brake fluid can cause irritation of eyes and skin, and may be harmful if swallowed. If fluid is swallowed, induce vomiting by administering two tablespoons of salt in a glass of warm water. Call a doctor. In case of contact with skin or eyes, flush with plenty of water. Get medical attention for eyes. KEEP BRAKE FLUID OUT OF THE REACH OF CHILDREN!**

If any line or cylinder has been opened when servicing the brake system, or when satisfactory brake adjustment is unobtainable, or pedal is spongy, bleed air from the hydraulic system as follows:

1. Install a length of appropriate size plastic tubing over the wheel cylinder bleeder valve located on the back side of the hub assembly (Figure 5-9).

***NOTICE: Bleed both right side wheels first, then both left side wheels.***

2. Place the other end of tubing in any clear glass jar containing about 1/2" of brake fluid.
3. Open bleeder valve by rotating it counterclockwise about 1/2 turn. With master cylinder full of fluid at all times, slowly depress the brake pedal repeatedly until fluid flows from bleeder valve free of air bubbles.
4. Add fluid to master cylinder to bring 1/4" from cover. Close bleeder valve. Repeat procedure on left wheel.
5. Do not reuse fluid unless it is clear and free of sediment. If it is impossible to bleed all air from system, master cylinder is faulty and a master cylinder repair kit should be installed.

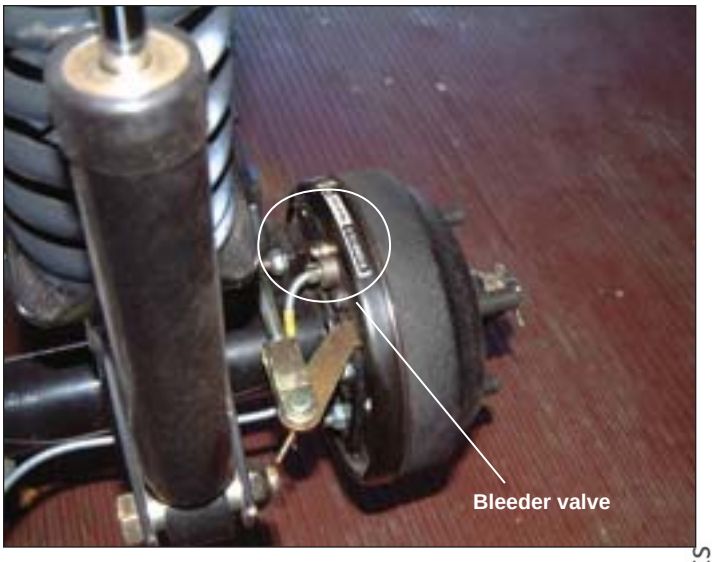



*Figure 5-9. Hydraulic Brake Caliper Bleeder Valve*

## Front Disc Brake

Disc brakes are not adjustable and rarely cause problems. If problems are encountered, refer to the following service and inspections procedures for possible causes and solutions.

### REPLACING BRAKE PADS

**⚠ CAUTION**

**Do not depress brake pedal while brake pads are removed from the vehicle. Pistons will be forced from the wheel cylinders causing fluid leakage and damage.**

1. With vehicle on the ground, depress the brake pedal to engage the brakes. Loosen front wheel/tire assembly mounting nuts.
2. Raise and secure vehicle as described in *Section 3, Lifting Instructions.*
3. Remove four nuts and front wheel/tire assembly.
4. Disengage the brakes and remove brake caliper mounting hardware (Figure 5-10).
5. Remove retaining rings and pins securing old pads and replace with new pads. Reinstall pins and retaining rings.

***NOTICE: The inner brake pad has a sensor wire attached. Unwrap the protective wire covering on the brake line enough to expose the wire connector. Disconnect brake pad wire from main harness. Plug in wire from new pad and rewrap protective covering.***

6. Reinstall brake caliper and mounting hardware and tighten.
7. Repeat steps 1 - 6 for other front wheel.
8. Reinstall wheel/tire assembly as described in *Section 6, Wheels*.

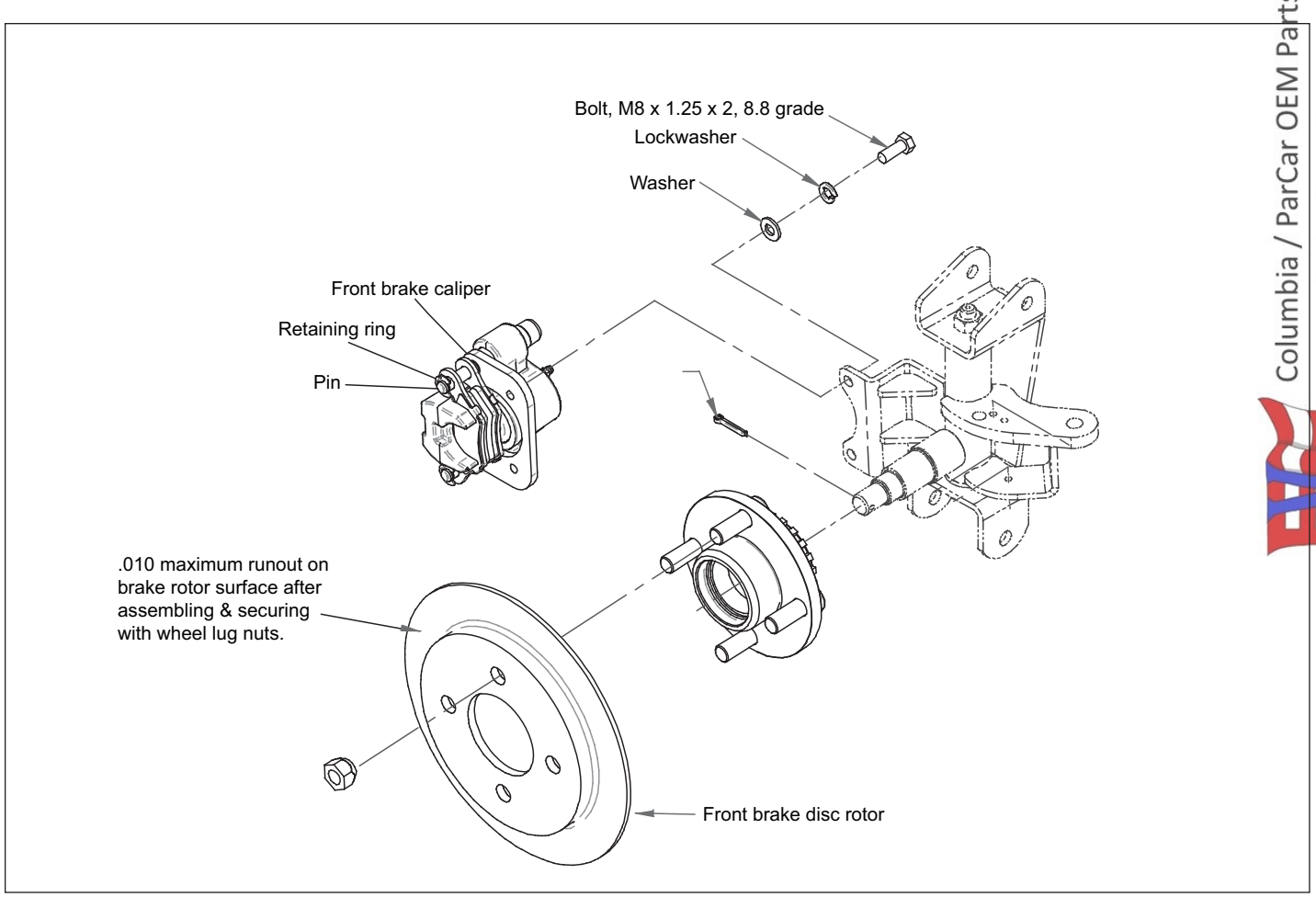



*Figure 5-10. Front Disc Brake Assembly*

**BRAKE CALIPER SERVICE**

The pistons must be removed from the bores. Using the vehicle's hydraulic pressure to force them out is the easiest method.

1. Remove brake pads as described above.
2. Remove bottom mounting bolt and rotate the caliper off the rotor (Figure 5-10). With caliper still bolted to the vehicle and hydraulic lines connected, press brake pedal until both pistons slide out of the bores. Push one side out, then remove piston from the other side.

   To prevent brake fluid from squirting out, cover the calipers with a cloth.
3. Remove the seals and boots. Rubber dust boots and seals should be replaced whenever the caliper is disassembled.
4. Clean pistons in alcohol, then wipe dry with a clean lint-free cloth.
5. Blow out all drilled passages with compressed air.
6. Inspect cylinder bores in both sides of the caliper housing for scoring and pitting. Bores that show light corrosion can be cleaned with fine grit crocus cloth. Caliper bores with deep scratches or scoring should be honed with a 1/4" electric drill. The same attachment is used for honing wheel cylinders on drum brakes.

   The caliper cylinder must not be honed out larger than the manufacturer's specifications-not more than .002" oversize.
7. Black stains on the bore caused by piston seals are not harmful and need not be removed.
8. After honing, take care in cleaning the caliper parts. Flush them with alcohol, wipe dry with a clean lint-free cloth, then flush and dry them again. Clean mating surfaces with No. 400 wet or dry sandpaper, ***never*** use a file.
9. Lubricate internal areas, pistons and piston O-rings with new brake fluid. Install parts into caliper.
10. Install brake pads and secure with mounting bolts.
11. Rotate caliper with rotor centered in brake pads and install caliper upper mounting hardware (Figure 5-6).
12. Reinstall rear wheel/tire assembly and four lug nuts. Engage brake and tighten lug nuts in a criss-cross pattern to a maximum 65 ft. lbs. (88.1 Nm) (Figure 5-5).
13. Perform all steps in *Bleeding the Hydraulic System*.
14. Recheck lug nut torque with vehicle on the ground.

**BRAKE ROTOR SERVICE**

Rotor must be flat with no warping or hot spots. Runout in a disc brake rotor is like out-of-roundness in a drum brake. It causes a loss of brake pedal height because of extra lining clearances. Runout wears the caliper pistons and seats rapidly due to the high speed pulsations created whenever the brakes are applied.

Runout tolerances are critical, usually only about .002".

***NOTICE: As much as .015" of metal can be removed from each side of the rotor without exceeding specifications. If removing the maximum specified amount will not clean up a rotor's problems, install new rotors.***

1. With vehicle on the ground, depress the brake pedal to engage the brakes. Loosen wheel assembly mounting nuts on both wheels if both rotors are to be serviced.
2. Raise and secure vehicle as described in *Section 3, Lifting Instructions.*
3. Remove four nuts and front wheel/tire assembly.
4. Remove brake caliper mounting hardware and brake caliper (Figure 5-10).

**Do not depress brake pedal while brake caliper is removed from the vehicle. Pistons will be forced from the wheel cylinders causing fluid leakage and damage.**

5. Remove rotor and perform rotor service or replace rotor.
6. Install rotor.
7. Reinstall brake caliper with mounting hardware (Figure 5-10).
8. Reinstall front wheel/tire assembly and four lug nuts. Engage brake and tighten lug nuts in a criss-cross pattern to a maximum 65 ft. lbs. (88.1 Nm) (Figure 5-5).
9. Lower vehicle to the ground as described in *Section 3, Lifting Instructions.*
10. Recheck lug nut torque and axle nut torque with vehicle on the ground.



## Hydraulic Brake Adjustments

### HYDRAULIC BRAKE LINKAGE ADJUSTMENT

Gently depress brake pedal and check for free movement before master cylinder piston is depressed. If there is no free travel in the pedal before the master cylinder plunger begins to move, or if the free travel of the pedal exceeds 3/8", adjustment of the brake rod will be required.

1. Remove four screws and washers securing the pedal surround module and remove the module to expose the brake linkage.
2. Remove cotter pin and clevis pin from brake rod at the brake pedal (Figure 5-11).
3. Loosen jamnut (from front of vehicle) and rotate brake rod clevis accordingly to decrease or increase free play as required. Tighten jamnut
4. Reconnect brake rod clevis with clevis pin and new cotter pin.
5. Recheck brake pedal for correct free movement.
6. Reinstall pedal surround module with four screws and washers.

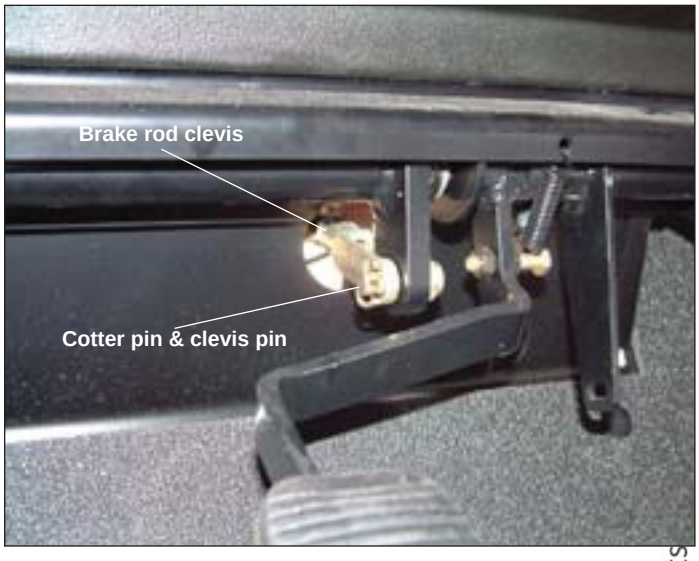



*Figure 5-11. Hydraulic Brake Linkage Adjustment*

## Mechanical Parking Brake Lever Adjustment

***NOTICE: Correct parking brake operation should be confirmed before adjustments are made to cables and mechanical linkage. Check that corrosion has not caused excessive resistance in the operation of the brake cables. If corrosion is present, replace cables before performing adjustments.***

Lift up the parking brake handle to monitor the amount of travel. The handle should click or ratchet two or more times before resistance is felt and the parking brake is set. If the brake handle rises in excess of 3-1/2" from its original down position, brake cable and linkage adjustment is required as follows:

1. Parking brake rod linkage is connected to the brake equalizer, located under the front seats. Lift seat to access the equalizer (Figure 5-12).
2. Loosen jamnut securing the brake clevis to the rod. Turn adjusting nut to shorten or lengthen rod as required, then retighten jamnut.
3. Recheck parking brake operation to confirm adjustment.

*Figure 5-12. Parking Brake Adjustment*

## Replacing Linear Accelerator

1. Remove upper front cowl as described in Section 7- *Body and Chassis*.
2. Disconnect the cable at the clevis (Figure 5-13).
3. Remove the two mounting bolts securing the linear accelerator.
4. Install new linear accelerator with mounting bolts.
5. Reconnect cable to to clevis.
6. Re-install front cowl as described in *Section 7 - Body and Chassis*.

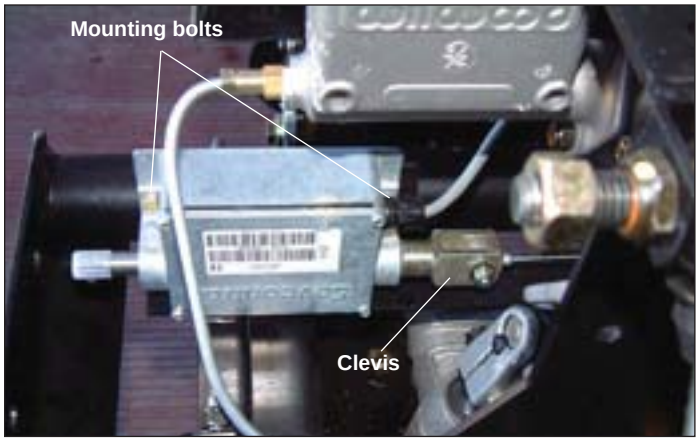



*Figure 5-13. Linear Accelerator*

### Adjusting Linear Accelerator

To adjust the linear accelerator:

1. Loosen the adjuster nuts on the accelerator cable (Figure 5-14).
2. Using a calibrator, adust the accelerator cable so the calibrator reads 100% with full pedal travel and 0% when pedal is at full rest.
3. Tighten adjuster nuts.

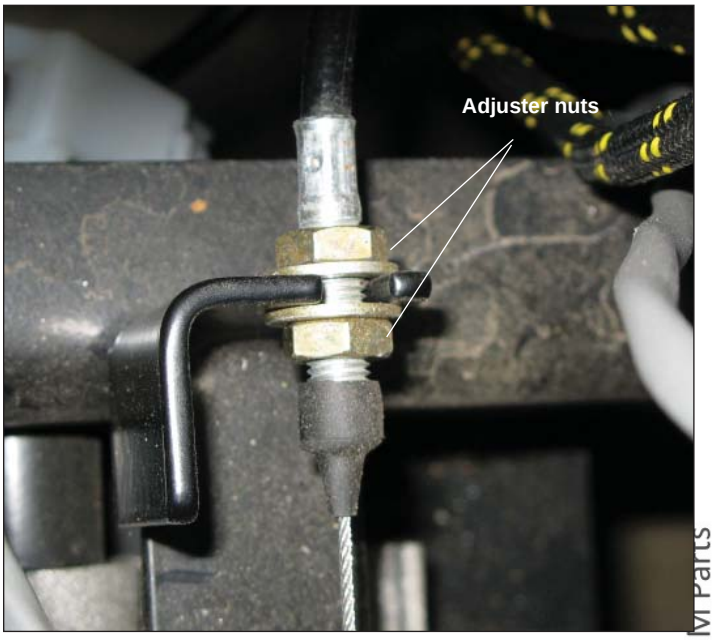



*Figure 5-14. Linear Accelerator Adjustment*

## ELECTRIC VEHICLE SERVICE

When servicing the electric vehicle always observe the following:

**⚠ DANGER**

**Always turn power key to OFF, position directional selector to NEUTRAL, remove power key and block tires and disconnect battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.**

## GENERAL

The steering system is operated by rotating the steering wheel. The steering wheel rotates the steering shaft connected to the rack and pinion steering assembly. The rack and pinion assembly pushes and pulls on tie rod ends to control front wheel steering.

The front suspension consists of two shock absorbers and a leaf spring assembly.

***NOTICE: Always inspect the condition of vehicle steering components before making adjustments. Worn, broken or damaged parts must be replaced before proper adjustment can be performed.***

## WHEELS

### Removing Wheels

1. Before raising vehicle, with wheels on the ground, remove wheel cover (if equipped) and break loose the lug nuts.

**⚠ WARNING**

**To perform this service, raise vehicle using floor jack and safely support it with jack stands positioned under main frame. *See Section 3, Lifting Instructions*.**

2. Remove lug nuts and wheel assembly from the hub.

### Installing Wheels

1. Place wheel assembly (with chrome cap if equipped) on the hub studs.
2. Tighten lug nuts by hand and wrench until snug using a criss-cross pattern (Figure 6-1).
3. Lower the vehicle as instructed in *Section 3-Lifting Instructions*.
4. Torque the lug nuts to 65 ft. lbs. (89 Nm) using the same crisscrossing pattern.
5. Reinstall wheel cover (if equipped).

## TIRES

In the event of a flat tire, remove wheel assembly from vehicle. Inflate tire to 20 psi (1.33 Atm). Immerse wheel assembly in water to determine point of leak. Mark leak location. If tire can be repaired, use the following procedure to remove and install tire.

***NOTICE: Tire must be removed and installed using professional tire removal/installation tools.***

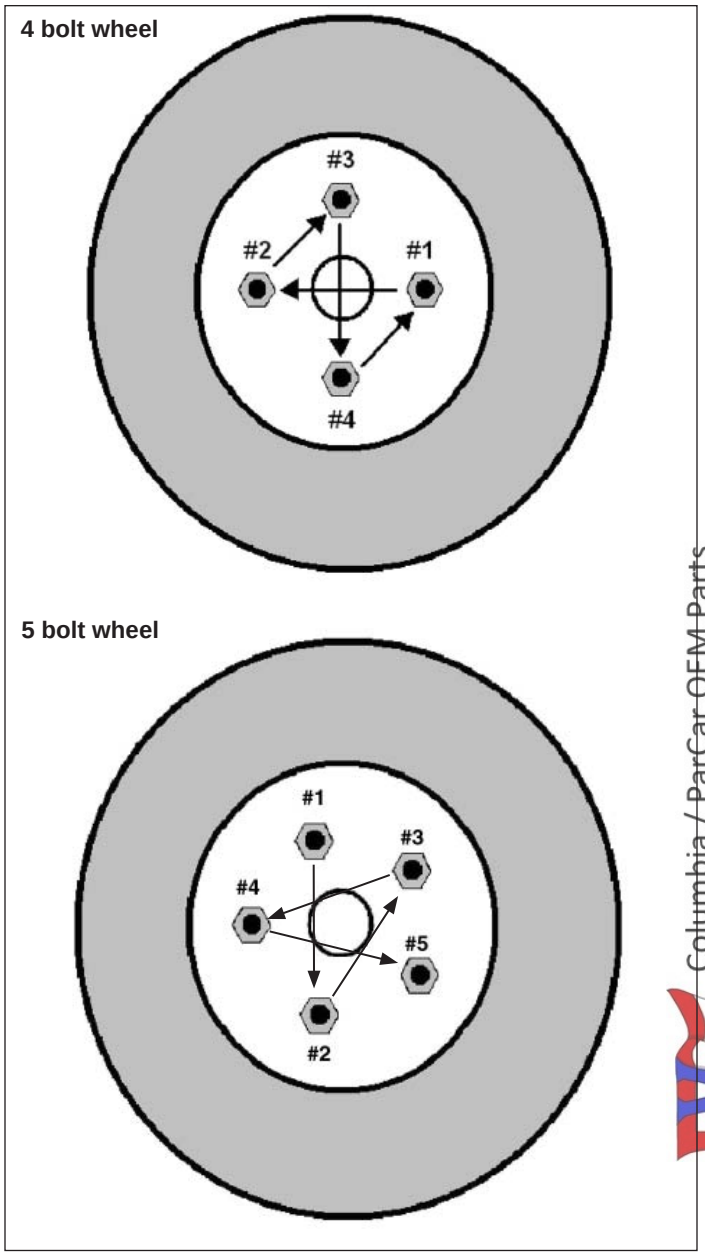



***Figure 6-1. Lug Nut Tightening Pattern***

**Keep hands, fingers, etc. from exposed areas between tire bead and wheel while mounting or inflating tire.**

**⚠ WARNING**

**Use care when inflating a tire with a high pressure air supply. Due to low pressure requirements of a small tire, over inflation may be reached in a matter of seconds. Over inflation could cause the tire to explode resulting in possible personal injury. Do not exceed maximum tire pressure of 51 psi.**



## REPLACING FRONT SHOCK ABSORBER

1. Remove front bumper, upper front cowl and lower front cowl as described in *Section 7, Body and Chassis*.
2. Remove upper and lower nuts and bolts securing shock absorber to upper frame (Figure 6-2).
3. Install new shock assembly, securing with bolts and nuts.
4. Reinstall upper and lower cowls, then reinstall front bumper.

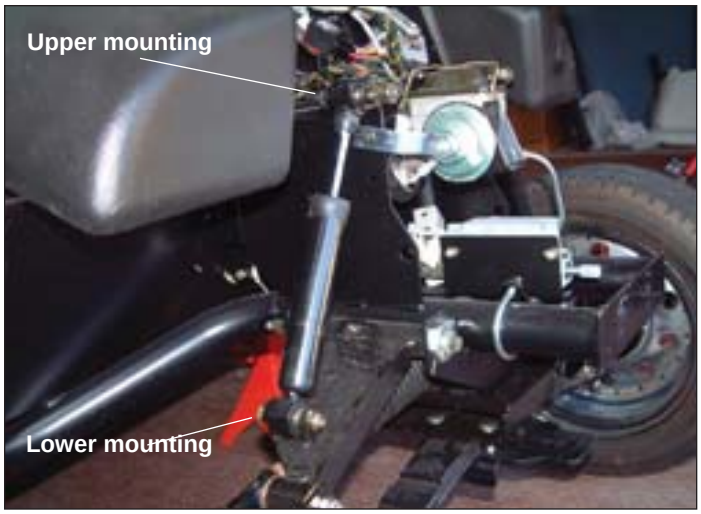



*Figure 6-2. Front Shock Mounting*

## FRONT HUB ASSEMBLY & WHEEL BEARINGS

### Removing Front Hub Assembly

1. Remove wheel assembly. See “Removing Wheels” 6– 2.
2. Carefully remove bearing cap by prying off
3. Remove axle nut and washer (Figure 6-3).
4. Remove hub assembly from drive shaft.

*Note: if equipped with front brakes, remove brake caliper from spindle assembly as described in Section 5, Accelerator and Brakes.*

### Replacing Front Hub Bearings

Bearings should be replaced whenever wheel hub is removed. Never reuse a sealed bearing once it has been removed from the wheel hub. Replace with a new bearing.

1. Remove washer and roller bearing from hub (Figure 6-3).
2. Pry out oil seal from front hub assembly.
3. Clean the hub. Inspect the bearing race for galling, rust, or metal residue. Replace race if it is damaged.
4. Support hub in a press. Carefully press in new oil seal until it is flush with outside edge of hub.

***NOTICE: Press on the outside of the oil seal rim and not on the inside parts, or the seal will be destroyed.***

5. Apply a quality lithium wheel bearing grease to inside of wheel hub and around bearings.
6. Install new roller bearing.

### Installing Front Hub Assembly

1. Place hub assembly onto drive shaft.
2. Install washer and axle nut. Torque axle nut to 65 ft. lbs. (89 Nm).
3. Install bearing cap by tapping into place with a soft mallet.
4. Re-install wheel assembly. See “Removing Wheels” 6– 2.

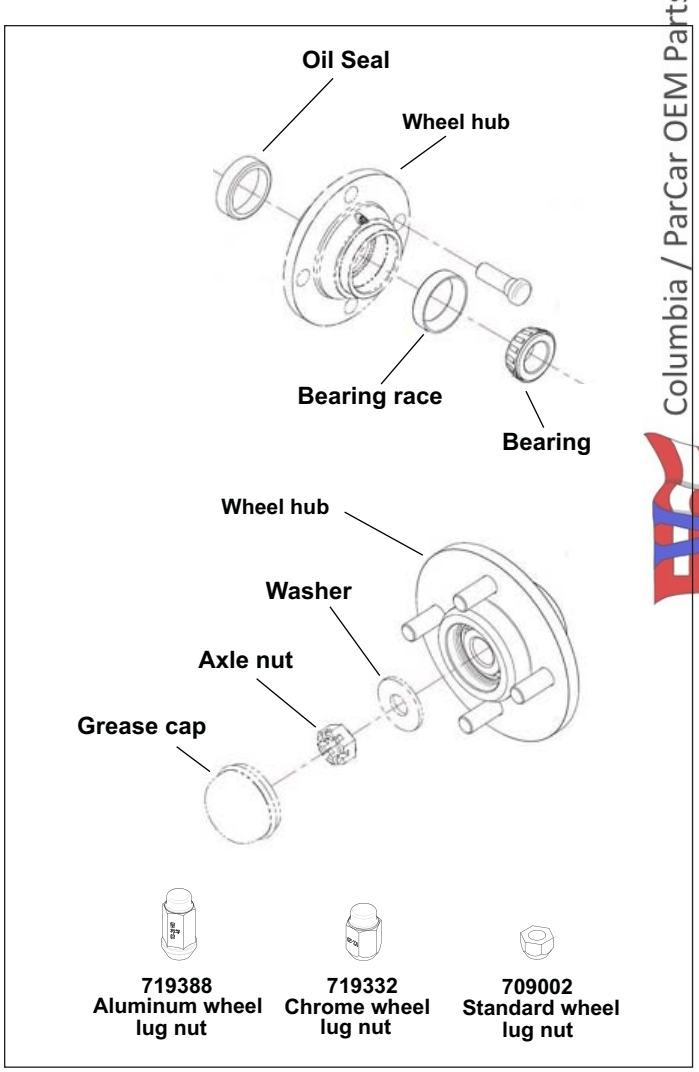



*Figure 6-3. Front Wheel Hub (4 bolt Hub Shown)*



## FRONT SUSPENSION

### Replacing Tie Rod End

1. Remove front wheel. See “Removing Wheels” on page 6– 2.
2. Remove the tie rod mounting nut and disconnect tie rod end from spindle (Figure 6-4).
3. Loosen jamnut and unscrew tie rod end from tie rod (Figure 6-4).

*NOTE: After loosening jamnut, mark threads where tie rod is located, then remove tie rod end from tie rod.*

4. Install new tie rod end to tie rod and thread onto tie rod where threads were marked previously.
5. Tighten jamnut against tie rod end.
6. Re-install tie rod end to spindle (Figure 6-4) with locknut.
7. Re-install wheel assembly. See “Removing Wheels” on page 6– 2.
8. Lower vehicle to the ground.

### Steering Rack & Pinion Assembly

#### REMOVING

1. Remove front wheel. See “Removing Wheels” on page 6– 2.
2. Remove the upper and lower front cowls as described in *Section 7, Body and Chassis*.
4. Disconnect tie rod ends from left and right spindles (Figure 6-4).
5. Disconnect steering rack from steering shaft (Figure 6-5).
6. Remove steering rack-to-frame mounting hardware (Figure 6-6).

#### INSTALLING

1. Install steering rack to frame with spacer and three capscrews (Figure 6-7). Tighten capscrews to 30 ft. lbs. (41 Nm).
2. Connect steering rack to inner steering shaft (Figure 6-5).
3. Connect tie rod ends to spindles (Figure 6-4).
4. Re-install front wheels and lower vehicle to the ground.
5. Check camber and toe-in.
6. Perform adjustments if required. See “Adjustments” 6– 7.

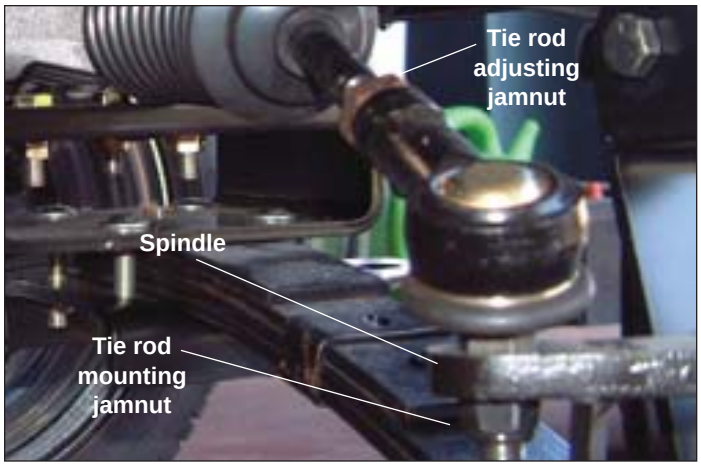



*Figure 6-4. Tie Rod*

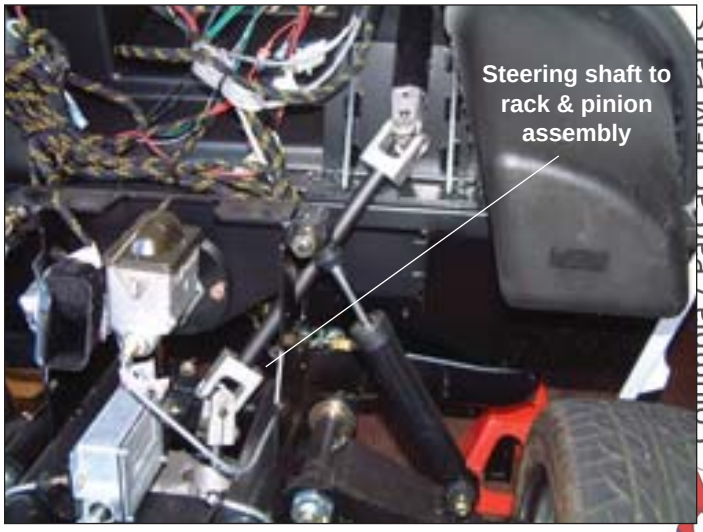



*Figure 6-5. Rack & Pinion to Steering Shaft*

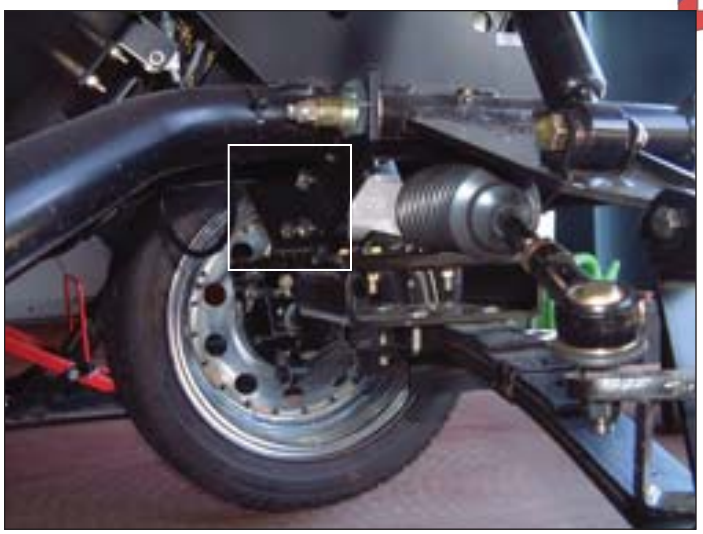


*Figure 6-6. Rack & Pinion to Frame Mounting*

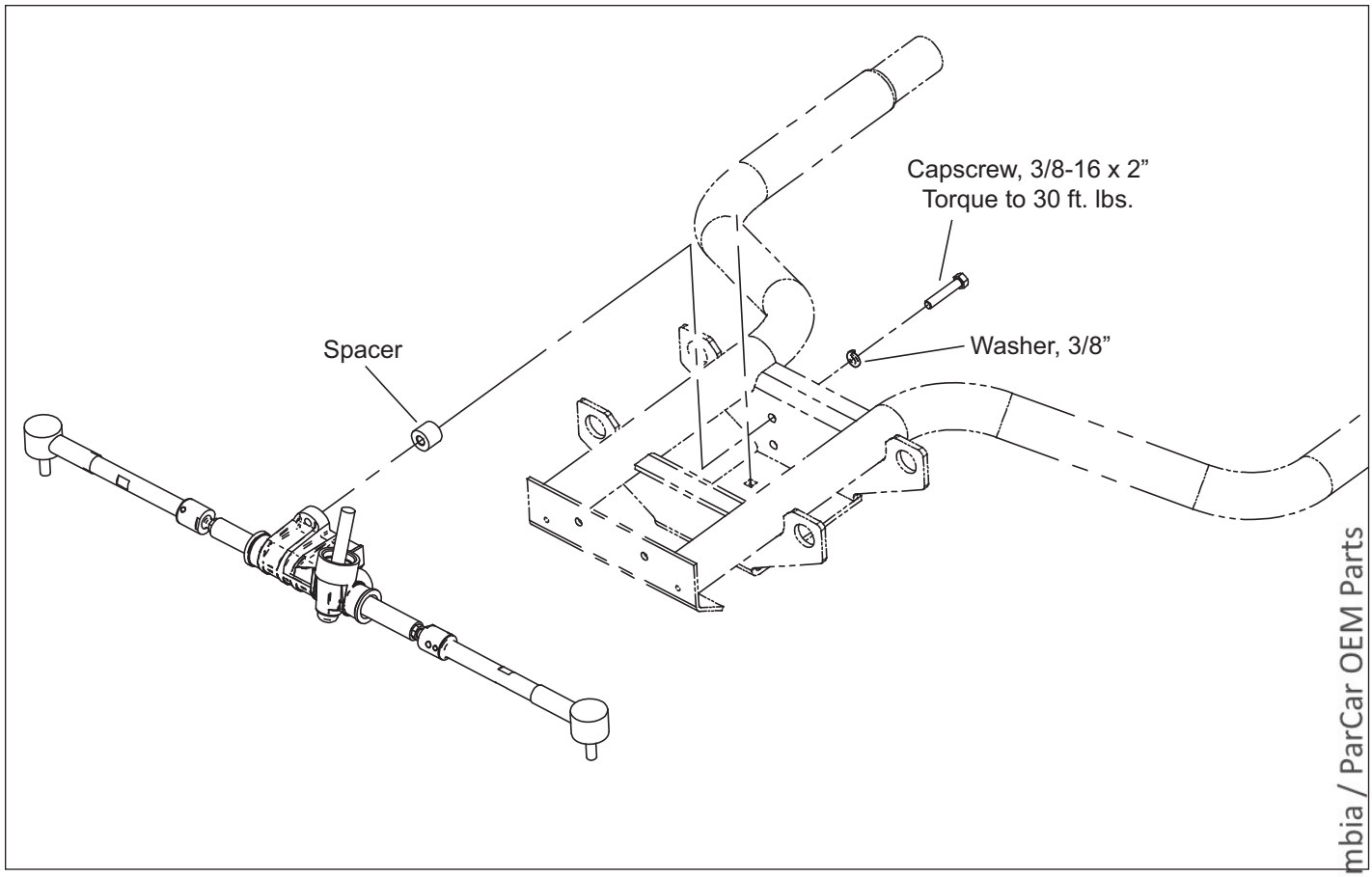



*Figure 6-7. Rack and Pinion Assembly*

### Replacing Leaf Spring Bushing

1. Remove front wheel. See “Removing Wheels” on page 6– 2.
2. Remove and discard nut and bolt securing kingpin to leaf spring (Figure 6-8).
3. Inspect bushing for excessive wear and/or damage. Install new bushing if required.
4. Re-install kingpin to leaf spring using nylon washers and new nut and capscrew. Torque to 40 ft. lbs. (54 Nm).
5. Repeat for other side of leaf spring.
6. Re-install front wheel assembly. See “Removing Wheels” on page 6– 2.

### Replacing Leaf Spring

1. Remove front wheels as described on page 6-2.
2. Remove and discard nut and bolt securing kingpins to leaf spring (Figure 6-8).
3. Remove carriage bolts and nuts securing leaf spring to front lift weldment (Figure 6-9).
4. Install new leaf spring to front lift weldment using carriage bolts and nuts. Tighten nuts to 45 ft. lbs. (61 Nm).
5. Re-install kingpins to leaf spring using nylon washers and new nuts and capscrews (Figure 6-8). Torque to 40 ft. lbs. (54 Nm).
6. Re-install front wheel assembly. See “Removing Wheels” on page 6– 2.

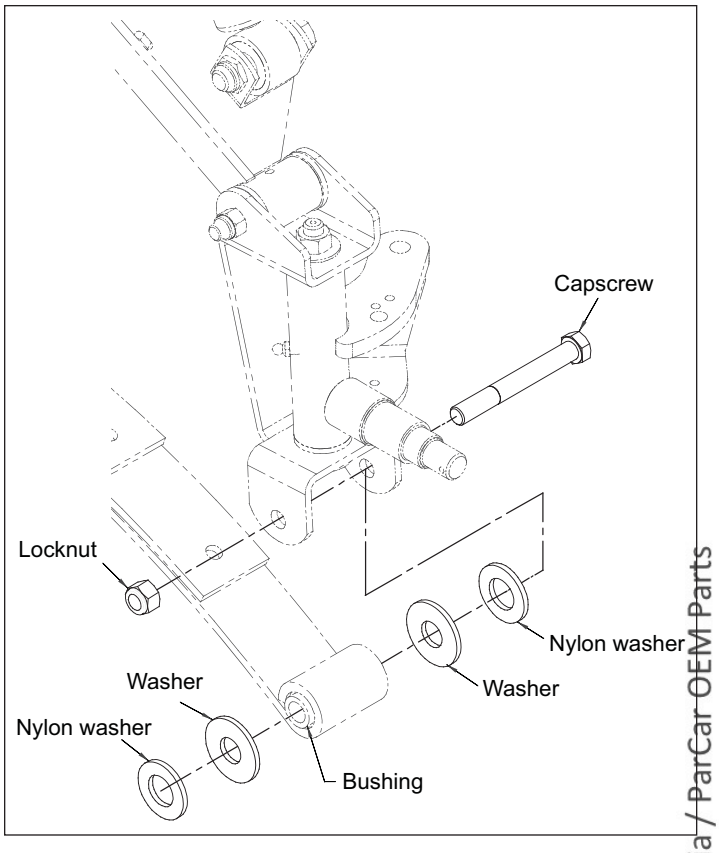



*Figure 6-8. Replacing Leaf Spring Bushing*

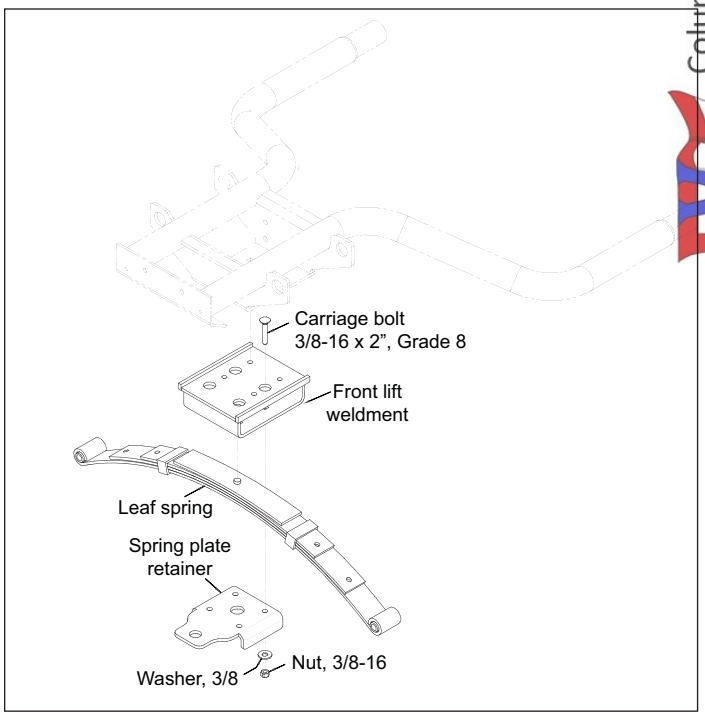



*Figure 6-9. Replacing Leaf Spring*

## Adjustments

### CAMBER ADJUSTMENT

1. Place vehicle on a flat, level surface with the front tires pointed directly forward.
2. Place a carpenters square against left front tire and check that the tire is straight up and down. If it is not vertical, loosen A-arm mounting bolt.
3. Rotate both camber adjusters equally until tire is straight up and down (Figure 6-11).

   The camber adjusters on each end of the upper A-arm have a dimple in the same position (Figure 6-11). Check that both camber adjuster dimples are set in the same position.
4. When correct adjustment is achieved, torque A-arm mounting bolt to 25 ft. lbs. (34 Nm).
5. Repeat steps 1 - 4 for right front wheel.

### TOE-IN ADJUSTMENT

***NOTICE: Always check that camber is correct before performing toe-in adjustment. See above.***

1. With wheels pointed directly forward, loosen jamnuts on tie rod ends (Figure 6-12).
2. Using a rod or stick approximately 46”- 46½” long, check distance between front edge of both tires. Then check the distance between back edge of both tires.
3. The distance between tires at front edge should be 1/4”-1/8” less than the distance between the back edge of the tires.
4. If distance between tires (toe in - toe out) is incorrect, rotate tie rods to adjust as necessary.
5. When correct distance is achieved, tighten tie rod jamnuts against tie rods ends.
6. Recheck measurements.

### STEERING WHEEL ALIGNMENT

1. If the steering wheel requires repositioning, verify tires are pointed straight ahead, then remove the steering wheel cover by carefully prying it out from the steering wheel.
2. If equipped, remove the two Phillips head screws securing steering wheel to collar, located on backside of steering wheel.

   Some models are equipped with a collar that is secured to the steering wheel with two plastic tabs. Squeeze the tabs inward to disengage the collar from the steering wheel.
3. Remove the steering wheel nut from the center of the steering wheel and pull the steering wheel from the shaft.

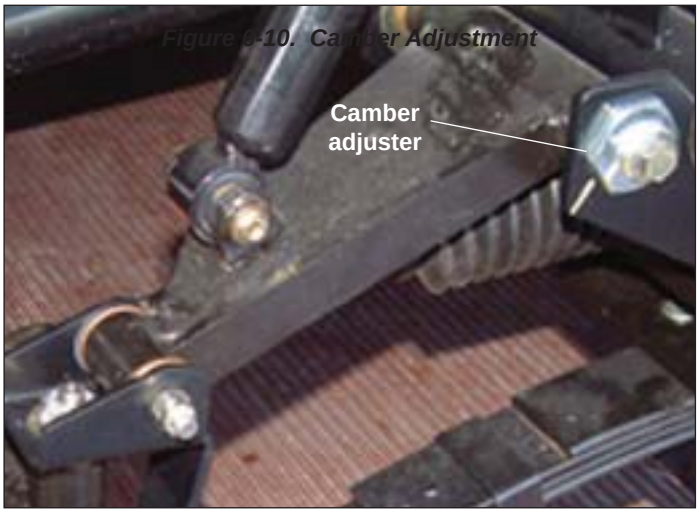



*Figure 6-11. Camber Adjustment*

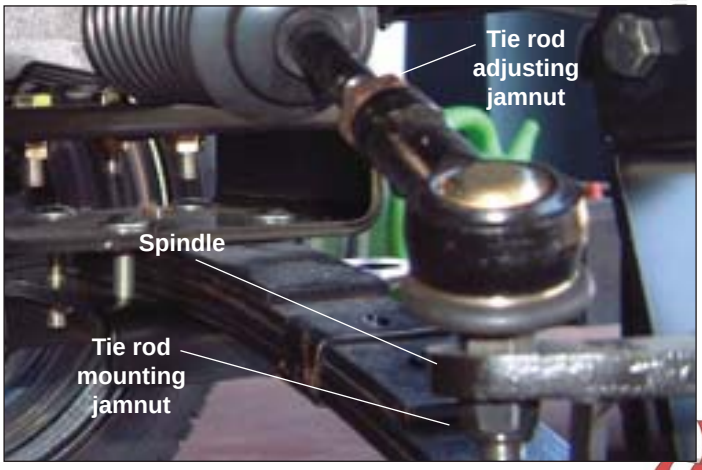



*Figure 6-12. Tie Rod*

4. Apply Anti-Seize to steering shaft and install the steering wheel so it is centered on the shaft.
5. Install the steering wheel nut and torque to 22-25 ft. lbs. (29-33 Nm).
6. Reconnect the collar to the steering wheel and install the cover.
7. Test drive vehicle to verify ease and trueness of steering.



## REPLACING REAR SHOCK ABSORBERS

1. Remove rear wheel. See “Removing Wheels” on page 6– 2.

   *Note: On SUV models, removing the rear deck cover will provide easier access to the top shock mounting hardware.*

2. Remove top and bottom mounting hardware securing shock absorber (Figure 6-13).
3. Install new shock absorber and attach with upper and lower mounting hardware.
4. Repeat for other side.
5. Re-install wheel assembly. See “Installing Wheels” on page 6-2.

## REPLACING REAR SPRINGS

1. Remove rear wheel. See “Removing Wheels” on page 6– 2.

*Note: On SUV models, removing the rear deck cover will provide easier access to the top mounting hardware.*

2. Place a hydraulic jack underneath the center of the transaxle.
3. Remove top and bottom mounting hardware securing shock absorbers (Figure 6-13).
4. Using the hydraulic jack, lower the transaxle enough to remove springs.
5. Install new springs and raise the transaxle to secure springs.
6. Install shock absorbers and attach with upper and lower mounting hardware.
7. Re-install wheel assembly. See “Installing Wheels” on page 6-2.

## REPLACING REAR FORK BUSHINGS

1. Place vehicle on jack stands as described in *Section 3, Lifting Instructions.*
2. Place a hydraulic jack underneath the center of the rear fork.
3. Remove capscrews and nuts securing rear fork to frame (Figure 6-14).
4. Using the hydraulic jack, lower the rear fork to expose the rear bushings.
5. Remove old bushings and install new bushings.
6. Using the hydraulic jack, raise rear fork and align mounting tabs with bushings.
7. Install capscrews and nuts.
8. Lower vehicle from jack stands as described in *Section 3, Lifting Instructions.*

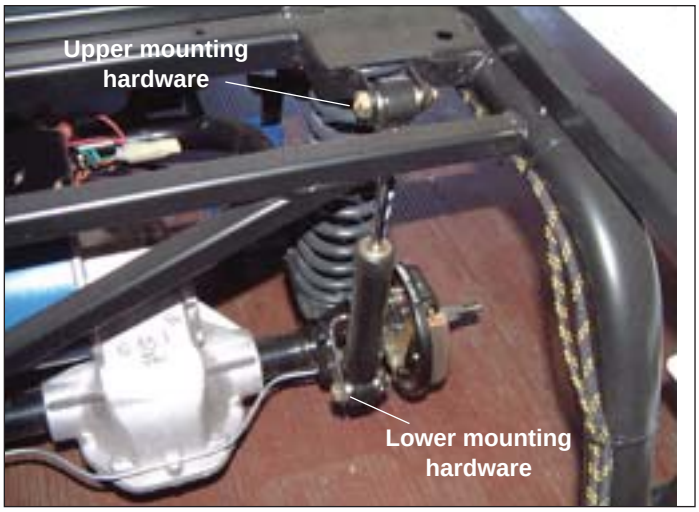



***Figure 6-13. Rear Shock Absorber***

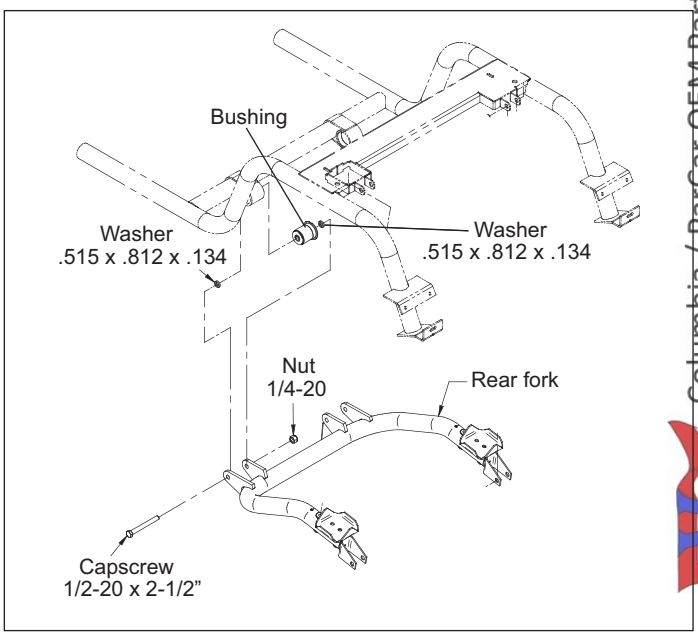



***Figure 6-14. Rear Fork Bushings***

## REAR DIFFERENTIAL/AXLE ASSEMBLY DANA SPICER MODELS

**⚠ WARNING**

**To perform this service, raise vehicle using floor jack and safely support it with jack stands positioned under main frame tubes. See Section 3, Lifting Instructions.**

### General

The rear differential/axle assembly is a precision assembly and any repair or replacement of parts must be done with great care in a clean environment. Before attempting to perform any axle service, read and understand all the procedures in this section.

- Handle all gears with extreme care.
- The axle assembly should be degreased prior to disassembly.
- Dirt is an abrasive and will cause premature wear of bearings and other parts. A small wash tank for cleaning parts should be close by when disassembling the axle assembly.
- Use soft, clean, lint-free towels to dry components before cleaning.
- Parts should be cleaned with emulsion cleaners or petroleum based cleaners.

**⚠ CAUTION**

**Do not use gasoline as a cleaner.**

***NOTICE: Bearings should not be dried by spinning with compressed air. This can damage mating surfaces due to lack of lubrication.***

- After drying, parts should be lightly coated with SAE 30 weight oil to prevent corrosion damage. If parts are to be stored for a prolonged period of time, they should be wrapped in newspaper and plastic.
- Bearings, seals and O-rings should be replaced with new parts whenever they are removed. Always wipe seals and O-rings with SAE 30 oil before installing.
- Snap rings must be removed/installed with care to prevent damage to bearings, seals and bearing bores.
- Remove all residual gasket material from sealing surfaces.
- Use soft, clean, lint-free towels to dry components before cleaning.
- Parts should be cleaned with emulsion cleaners or petroleum based cleaners. Inspect all parts for signs of wear or damage and replace if necessary.

### Torques

| | |
|---|---|
| Differential bearing cap | 35-45 ft.lbs. (12-16 Nm) |
| Ring gear bolts | 35-45 ft.lbs. (12-16 Nm) |
| Cover plate screws | 16-24 ft.lbs. (6-9 Nm) |
| Fill plug | 25-40 ft.lbs. (9-14 Nm) |
| Brake bolts<br>- 160 mm brakes | 15-19 ft.lbs. (5-7 Nm) |
| Spindle nut | 95-115 ft. lbs. (34-41 Nm) |

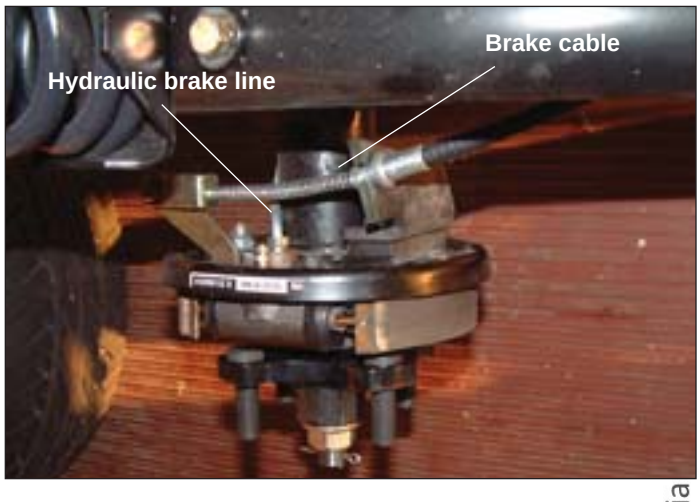
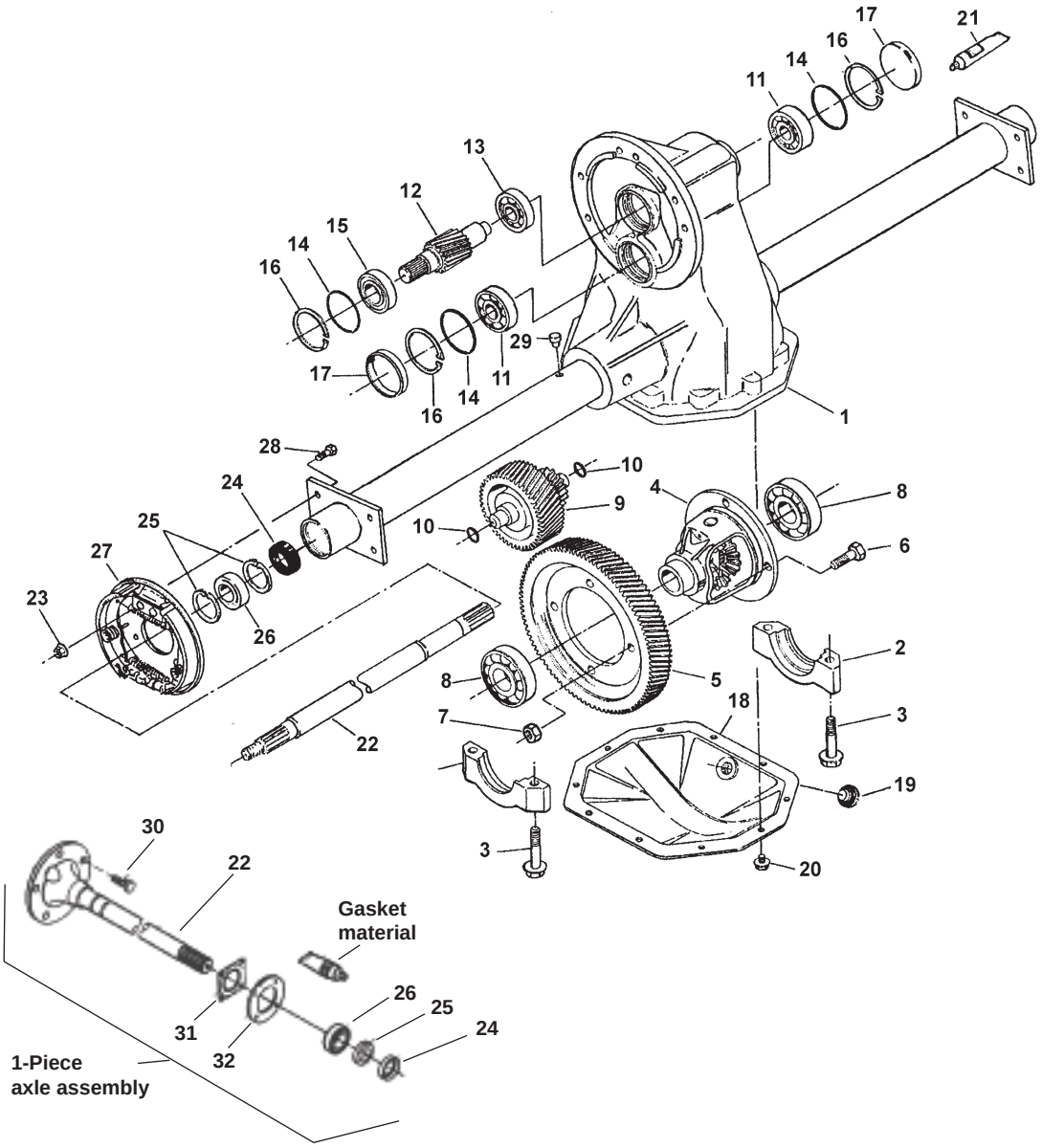



*Figure 6-15. Rear Brake Drum and Hub*






| Item | Qty. | Description |
|---|---|---|
| 1 | 1 | Carrier Sub-Assy. |
| 2 | 2 | Bearing cap |
| 3 | 4 | Bolt, bearing cap |
| 4 | 1 | Diff. Case Assy. |
| 5 | 1 | Gear, output |
| 6 | 4 | Cap screw |
| 7 | 4 | Nut |
| 8 | 2 | Bearing, ball |
| 9 | 1 | Intermediate Shaft & Gear |
| 10 | 2 | O-ring |

| Item | Qty. | Description |
|---|---|---|
| 11 | 2 | Bearing, ball |
| 12 | 1 | Input shaft |
| 13 | 1 | Bearing, ball |
| 14 | 3 | O-ring |
| 15 | 1 | Bearing, ball |
| 16 | 3 | Snap ring |
| 17 | 2 | Plug, cup |
| 18 | 1 | Cover, carrier |
| 19 | 1 | Plug, fill |
| 20 | 10 | Screw, cover plate |
| 21 | 1 | Sealant, anaerobic |

| Item | Qty. | Description |
|---|---|---|
| 22 | 1 | Axle shaft |
| 23 | 8 | Nut, brake, 160mm |
| 24 | 2 | Oil seal |
| 25 | 4 | Snap ring |
| 26 | 2 | Bearing |
| 27 | 1 | Brake Assy. |
| 28 | 8 | Bolt, brake, 160mm |
| 29 | 1 | Vent |
| 30 | 4/5 | Wheel bolt |
| 31 | 2 | Wiper seal |
| 32 | 2 | Retainer, bearing |

*Figure 6-16. Rear Differential/Axle Assembly - Dana Spicer Models*



## Rear Axle - Dana Spicer Standard Duty

### DISASSEMBLY - DANA SPICER STANDARD DUTY

**⚠ DANGER**

**Safety glasses should be worn at all times when disassembling and assembling the axle.**

Reference numbers in parenthesis refer to Figure 6-16.

1. Remove rear wheel. See “Removing Wheels” on page 6– 2.
2. Remove outer snap ring.
3. Remove axle shaft and bearing assembly (Figure 6-18).
4. Remove inner snap ring (Figure 6-17). Use care to not damage bearing surfaces.
5. Remove the bearing from the axle shaft by supporting the inner race of the bearing in an arbor press. Apply pressure to the threaded end of the axle shaft (Figure 6-19).
6. Repeat steps 1-5 for the other shaft.

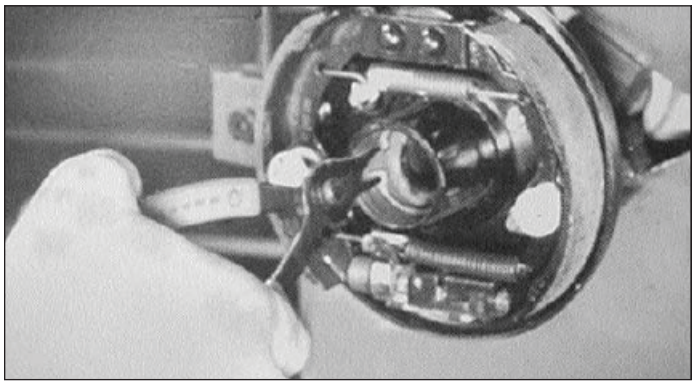


*Figure 6-17. Removing Inner Snap Ring*

*Figure 6-18. Removing Rear Axle and Bearing*

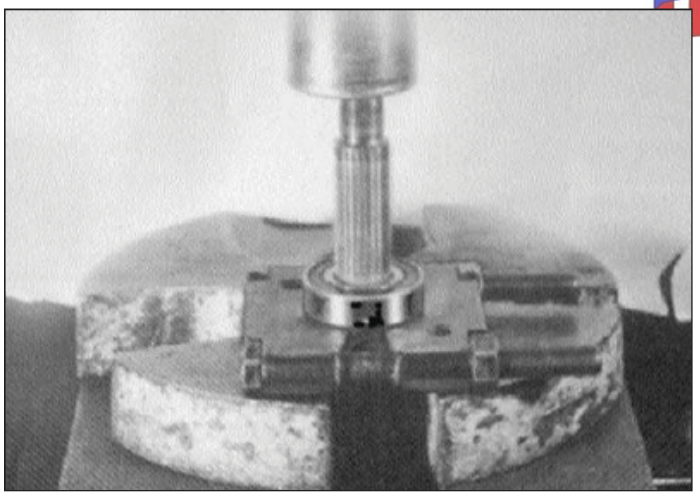


*Figure 6-19. Removing Axle Bearing*



**ASSEMBLY - DANA SPICER STANDARD DUTY**

All callout numbers in steps refer to Figure 6-16.

1. Press bearings (26) onto axle shafts (22). Bearing should seat on shoulder. Use appropriate driver to install bearings (Figure 6-20).
2. Coat lip of seal (24) with SAE 30 oil before inserting axle shaft (22). Insert axle shaft assemblies into tubes. Using a properly sized bearing driver, tap axle shaft assembly until it is seated firmly against inner snap ring (25).

   Shaft may have to be rotated to engage differential splines during installation.
3. Install outer snap ring (25) in each tube (Figure 6-21).
4. Remove fill plug (19) in cover plate (18). Fill axle assembly with 12 ounces (360 ml) of Light Weight Gear Lubricant, SAE 30.

   Install fill plug. If it is a threaded plug, torque to 25-40 ft. lbs. (6-14 Nm).
5. Apply Anti-Seize compound to the splines before installing the drum/hub.
6. Re-install wheel assembly. See “Installing Wheels” on page 6– 2.

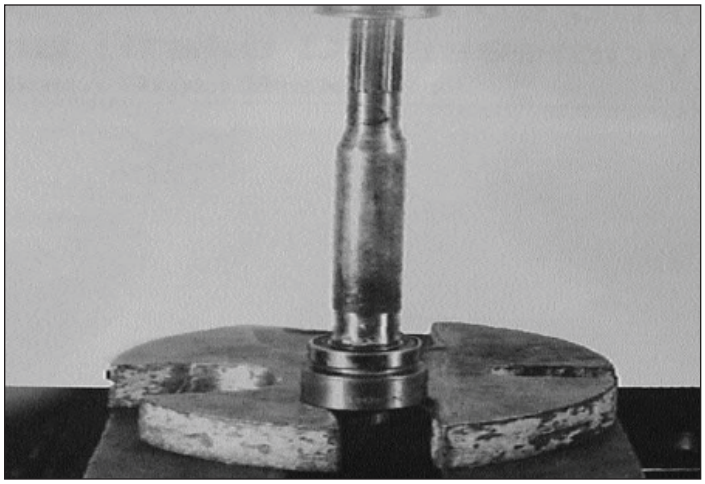


***Figure 6-20. Installing Bearings on Axle Shaft***

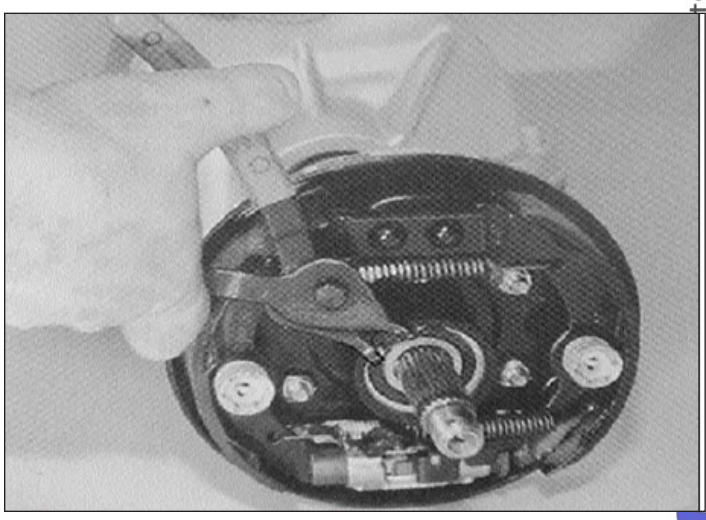


***Figure 6-21.*** **Installing Outer Snap Ring.**

## Rear Axle - Dana Spicer Heavy Duty

### DISASSEMBLY - DANA SPICER HEAVY DUTY

**⚠ DANGER**

**Safety glasses should be worn at all times when disassembling and assembling the axle.**

Reference numbers in parenthesis refer to Figure 6-16.

1. Remove the rear wheel. See “Removing Wheels” on page 6– 2.
2. Remove the brake drum (Figure 6-22).
2. Using a 1/2” socket, line up the hole in the axle shaft to remove backing plate nuts holding the axle shaft assembly to the axle (Figure 6-23).
3. Remove the axle shaft assembly. Grasp the axle shaft assembly with both hands (the assembly includes axle shaft, oil seal, brake assembly, bearing and retainer) and pull axle shaft free (Figure 6-24).

***NOTICE: The unit bearing assembly cup and retainer ring are cemented together with epoxy adhesive and, in most cases, the bearing assembly will remain intact. If not, the bearing cup must be removed from the housing with an internal puller.***

4. Remove inner axle shaft seal using puller (Figure 6-25).

***NOTICE: Avoid contacting seals with cleaning solvent in the cleaning operation.***

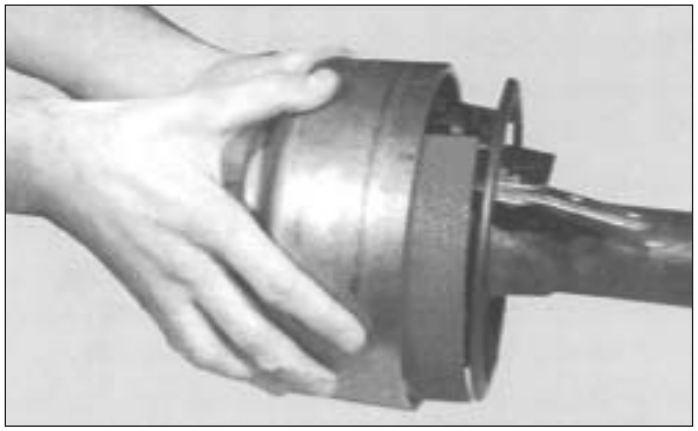


*Figure 6-22.* **Removing Brake Drum**

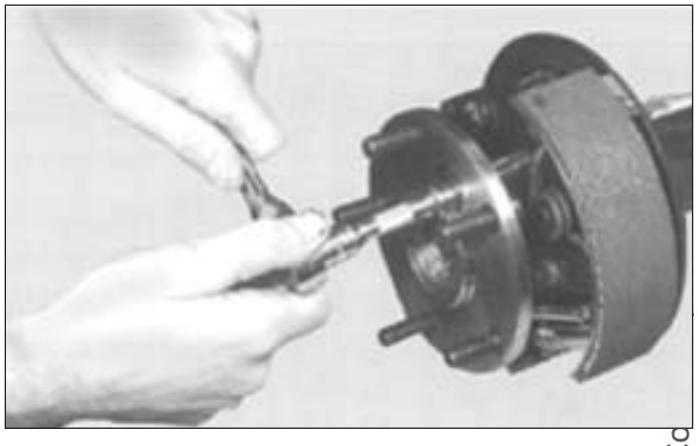


*Figure 6-23. Removing Backing Plate Nuts*

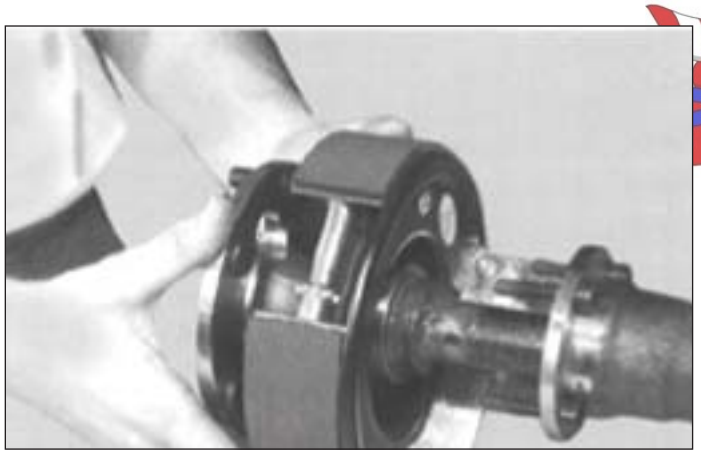


*Figure 6-24. Removing Axle Shaft*

5. Place axle shaft assembly in a vise. Center punch the outside of the retaining ring (Figure 6-26).
6. Drill a 1/4" hole in the outside retaining ring to a depth approximately 3/4 of the thickness of the ring (Figure 6-27).

**⚠ CAUTION**

**Drilling completely through the retaining ring will damage the shaft.**

7. After drilling, position a chisel across the hole and strike sharply to break the ring. Replace with a new retaining ring when reassembling (Figure 6-28).
8. Support the axle shaft assembly in a suitable press. Press on the end of the shaft until the wheel bearing and the brake assembly are removed (Figure 6-29).

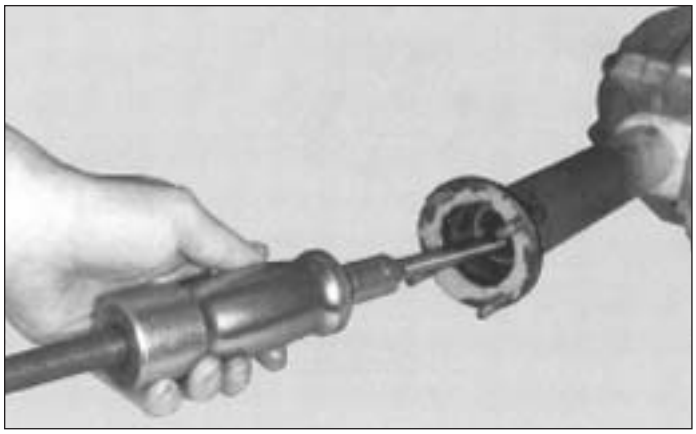


*Figure 6-25. Removing Axle Shaft Inner Seal*

*Figure 6-26. Removing Center Punch Retaining Ring*

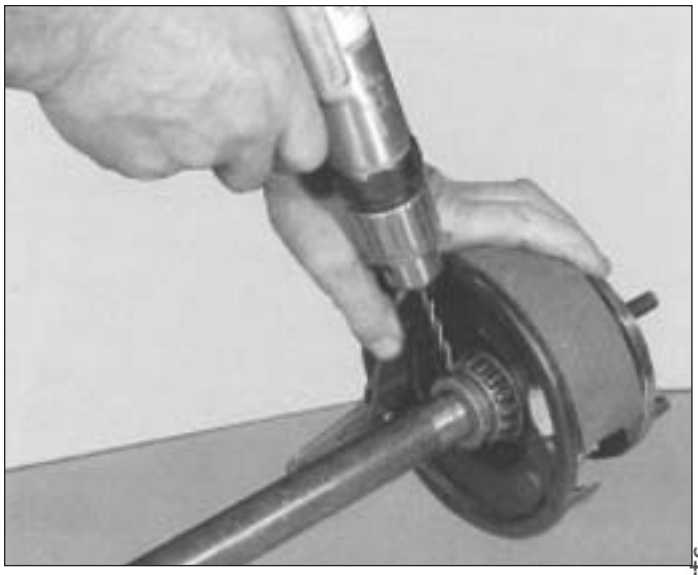


*Figure 6-27. Drill 1/4" Hole*

*Figure 6-28. Removing Retaining Ring*

*Figure 6-29. Removing Wheel Bearing and Brake Assy*



**ASSEMBLY - DANA SPICER HEAVY DUTY**

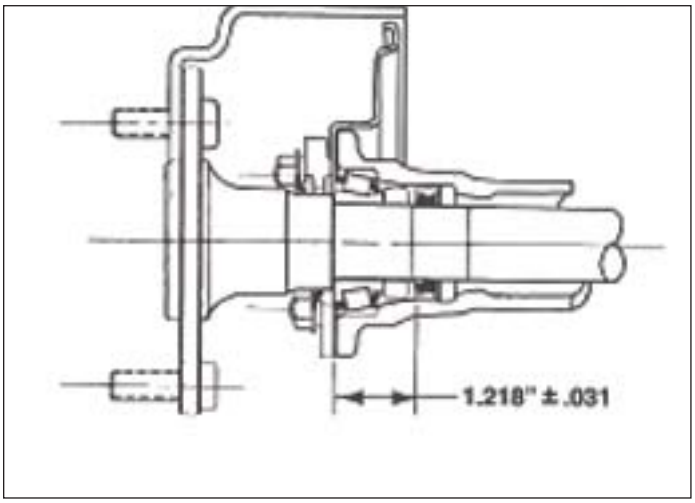



*Figure 6-30.* **Rear Axle Tolerance - Dana Heavy Duty**

All callout numbers in steps refer to Figure 6-16.

***NOTICE: Take note of the order of components for axle shaft assembly, especially the correct orientation for the bearing assembly.***

***NOTE: The retaining ring is placed onto the shaft later in the assembly process.***

1. Support the bearing in a suitable press (Figure 6-31).
2. Press assembly until bearing is firmly seated against axle shaft shoulder (Figure 6-32).
3. Slide new retaining ring on the axle shaft and support the shaft in a suitable press (Figure 6-33).
4. Press the retaining ring firmly against bearing (Figure 6-34).
5. Assemble the new grease seal into the housing to original depth (1.218 ± .031) (Figure 6-35). After the seal has been assembled, grease the seal lip.
6. Assemble the bearing retainer bolts and apply gasket material on the axle housing. Install the axle shaft assembly to the differential housing (Figure 6-36).
7. Take care not to damage the oil seal and bearing. Line up the holes of the brake assembly and oil seal. Push the axle shaft as far as possible into the differential housing.
8. Install flat washers and start nuts on by hand. Tighten bolts in a manner that ensures the seal and bearing assembly are drawn evenly into the differential housing.

   When assembling, the flat on the head of the screw should be held away from the tube with a putty knife or thin bladed screwdriver to avoid the head turning into the tube radius. Torque the nut to 16-20 ft-lbs (22-27 Nm).

*Figure 6-31. Bearing Supported In Press*

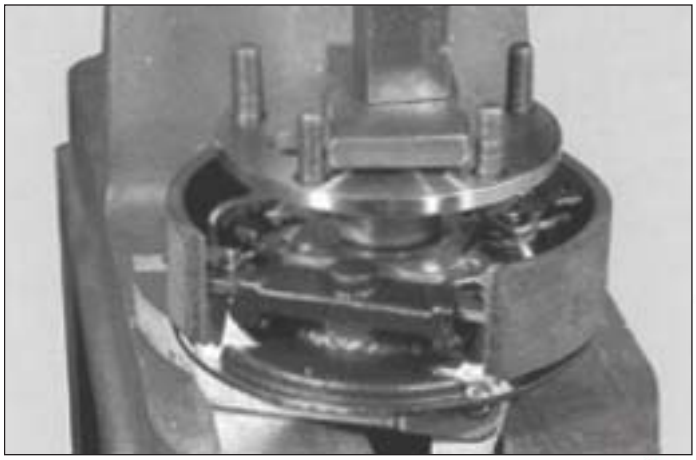


*Figure 6-32. Bearing Firmly Seated*

*Figure 6-33. Retaining Ring on Axle Shaft*



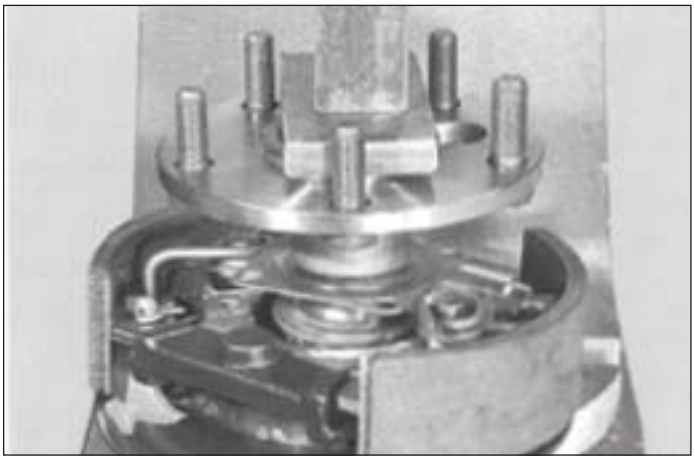


*Figure 6-34. Pressing Retaining Ring Against Bearing*

*Figure 6-35. Assembling Grease Seal*

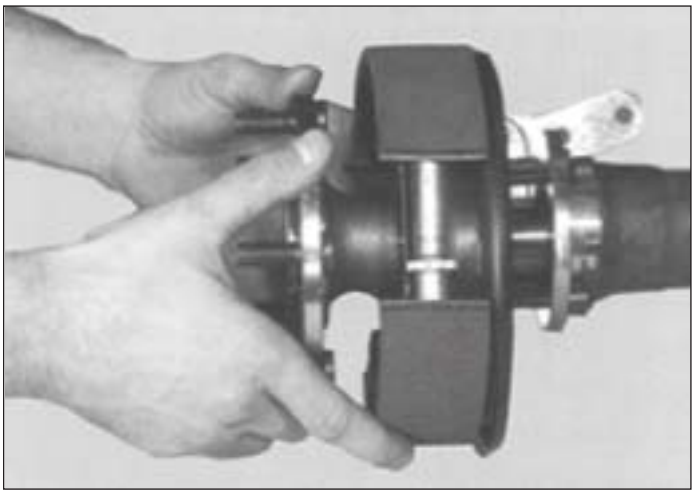


*Figure 6-36. Installing Axle Assembly*

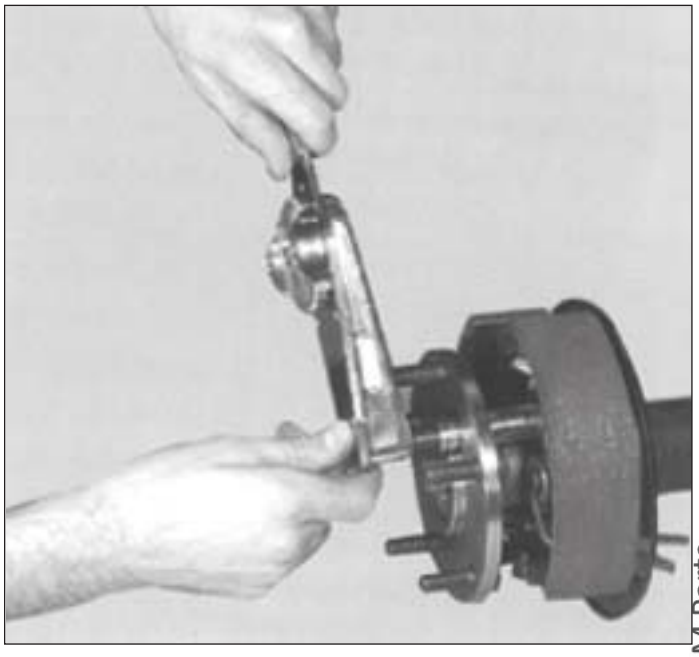


*Figure 6-37. Installing Washers and Nuts*

## Differential - Dana Spicer

### REMOVING DIFFERENTIAL ASSEMBLY

1. Before raising vehicle, with wheels on the ground, break loose the lug nuts.
2. Raise the vehicle as described in *Section 3, Lifting Instructions* and engage the brake.
3. Remove lug nuts and remove rear wheel/tire assemblies. Remove and discard cotter pin and axle nut. Release brake and remove spacer and rear brake drum. Repeat for other side.
4. Remove rear shock absorbers and springs. See “Replacing Rear Shock Absorbers” 6– 8.
5. Remove the traction motor as described in *Section 9, Traction Drive System*. Remove U-bolt securing rear axle to traction drive motor mounting plate.
6. Remove cotter pins, clevis pins and e-rings. Disconnect brake cables from brake assemblies on the rear axle (Figure 6-15).
7. Disconnect hydraulic brake lines from brake assemblies on the rear axle.
8. Remove four nuts, bolts and washers securing rear axle to rear frame.

**⚠ DANGER**

**Differential/axle assembly is heavy and awkward to move. Get help lifting and removing to prevent possible personal injury.**

### DISASSEMBLING DIFFERENTIAL - DANA SPICER

Reference numbers in parenthesis refer to Figure 6-16.

1. Remove the rear axles. For disassembly procedures see one of the following depending on the applicable axle:

   “Rear Axle - Dana Spicer Standard Duty” 6– 11

   “Rear Axle - Dana Spicer Heavy Duty” on page 6– 13
2. Remove ten cover screws (20).
3. Position the axle housing (1) over a drain pan. Using a putty knife, separate the cover plate from the housing (Figure 6-38). Use care to not damage the housing sealing surfaces or to deform the cover plate.
4. Remove four bearing cap bolts (3) and both bearing caps (2).

***NOTICE: Bearing caps (Figure 6-39) are marked for identification. Letters or numbers are stamped in horizontal and vertical position. When reassembling, install caps back in their original positions, using these stamps as a guide.***

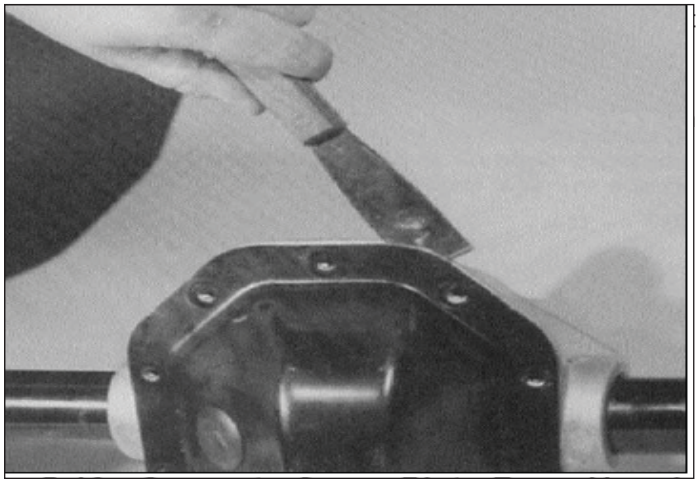


*Figure 6-38. Removing Cover Plate*

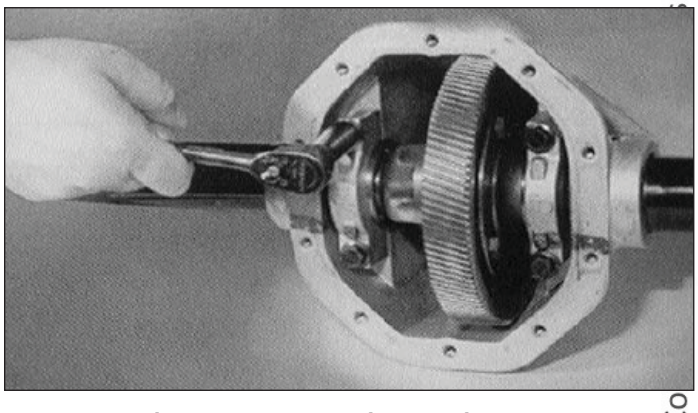


*Figure 6-39. Removing Bearing Caps*

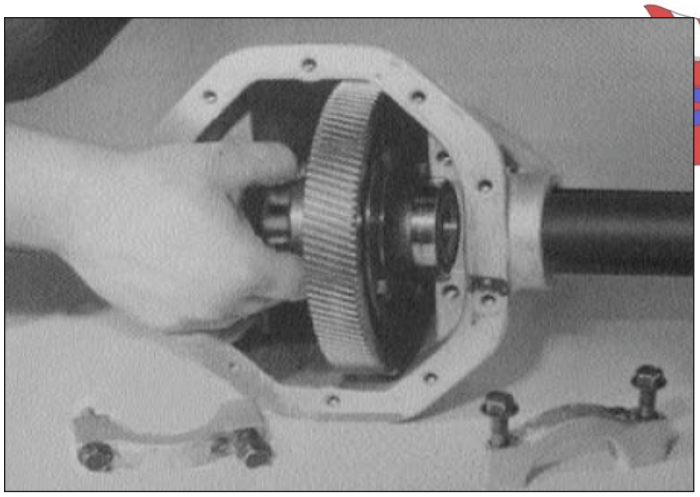


*Figure 6-40. Removing Differential Assembly*

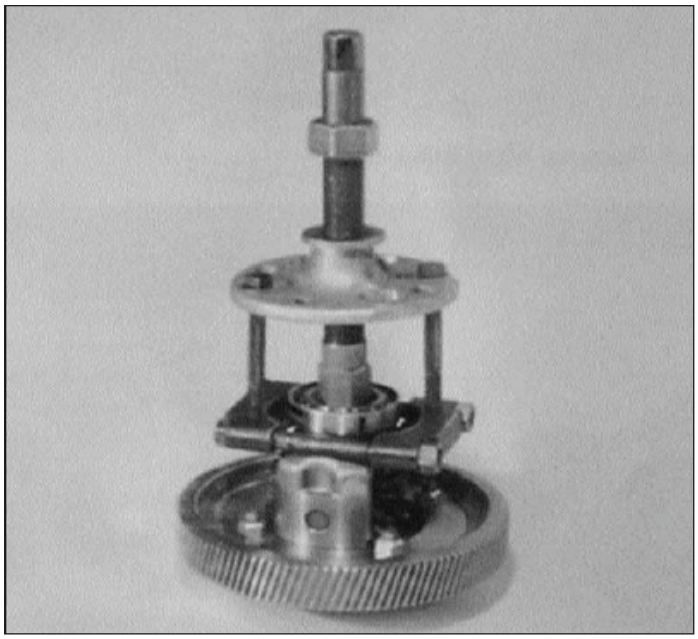


*Figure 6-41. Removing Differential Bearings*

5. Remove four bolts (6) and nuts (7) from the final drive output gear (5). Remove gear from differential case (Figure 6-40). Use care not to damage gear teeth.
6. Using a bearing puller, remove differential bearings (8) from each side of the differential case (Figure 6-41).
7. Remove output gear from differential (Figure 6-42).
7. Punch or drill a 1/8" diameter hole near the center of each intermediate cup plug. Insert a suitably sized sheet metal screw until the metal bore plug is forced out of the bearing bore (Figure 6-43).
8. Remove snap rings from each intermediate bore (Figure 6-44).

***NOTICE: Shaft and gear assembly must be supported by hand as not to damage gear teeth.***

***NOTICE: Small end of intermediate shaft and gear assembly must be tilted toward opening in bottom of housing for removal.***

9. Using a brass drift pin, drive the intermediate shaft from the flange side of housing. Shaft should travel far enough to allow engagement of I.D. bearing puller.
10. Using an I.D. bearing puller attached to a slide hammer, remove intermediate bearing (11) from flange side of housing (Figure 6-45).

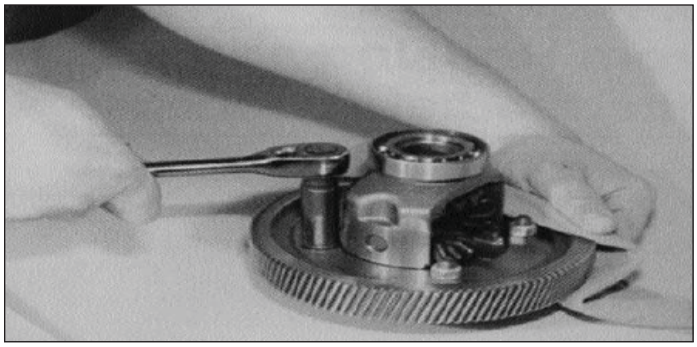


*Figure 6-42. Removing Output Gear from Differential*

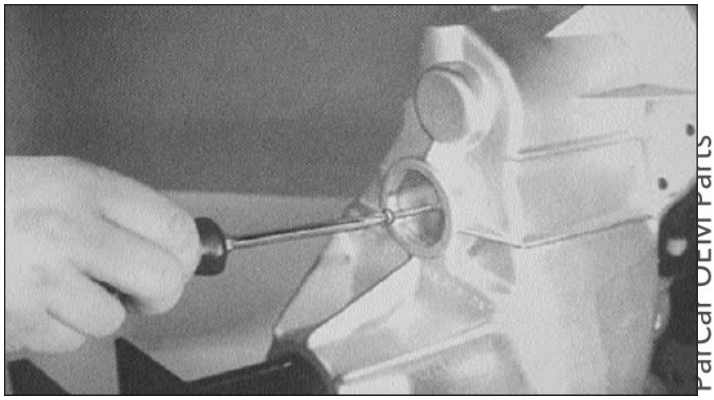


*Figure 6-43. Removing Cup Plugs*

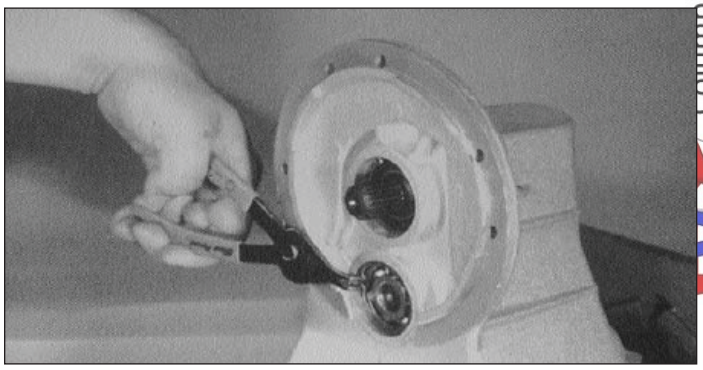
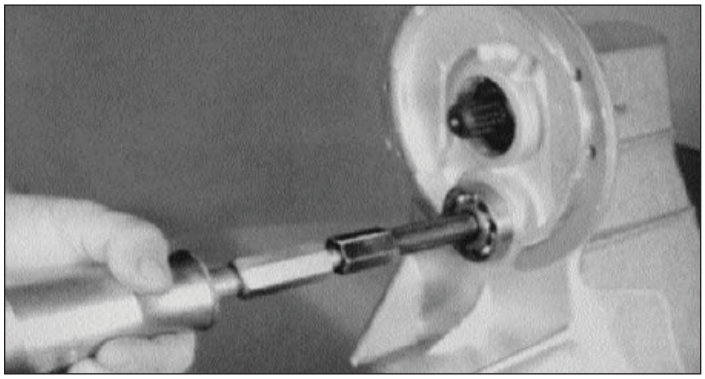


*Figure 6-44. Removing Snap Rings*



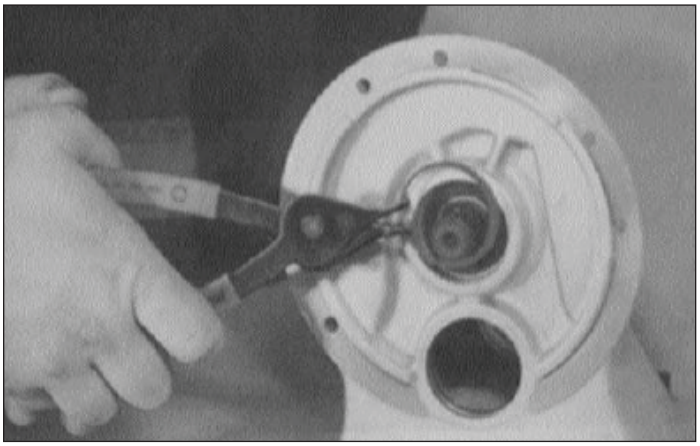


*Figure 6-46. Input Shaft Bore Snap Ring*

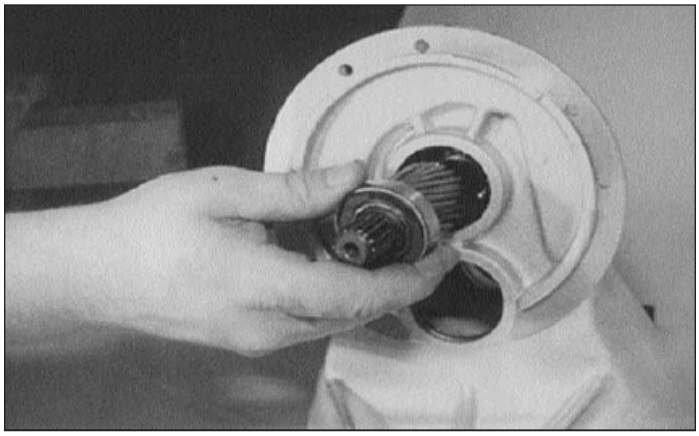


*Figure 6-47. Intermediate Shaft and Bearing*

11 Repeat steps 1-14 for intermediate bearing on opposite side.

12. Remove snap ring (16) from input shaft bore (12) (Figure 6-46).

***NOTICE: Input shaft assembly must be supported by hand as not to damage gear teeth.***

13. Pull input shaft assembly (12) from housing (Figure 6-47). The input shaft assembly should slide out easily. If resistance is encountered, a slide hammer may be required.
14. Remove O-rings from outer input bearing bore and both intermediate bores (Figure 6-48).
15. Remove O-rings (10) at each end of intermediate shaft on bearing shoulders (Figure 6-49).
16. Clean the axle housing and carrier cover (18) with lint-free rags. Remove all traces of old silicone sealant from sealing surface of cover and housing.

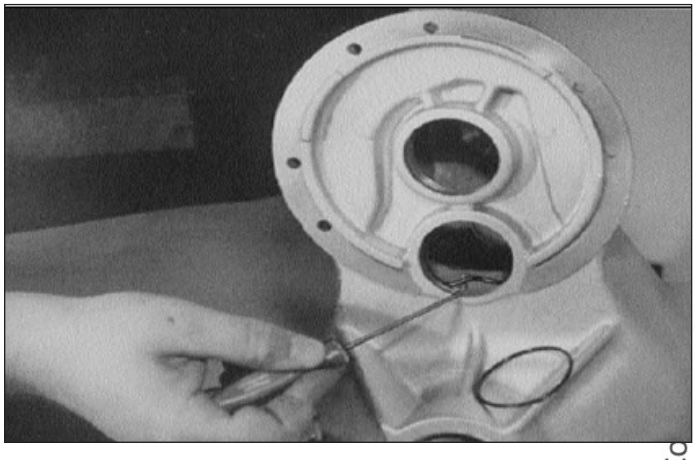


*Figure 6-48. O-rings*

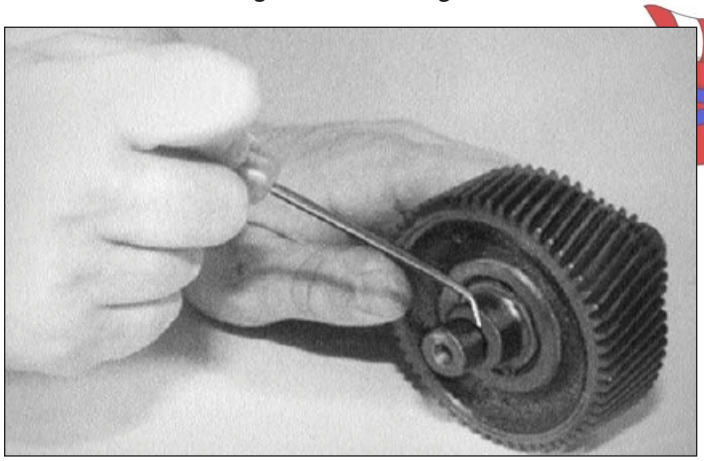


*Figure 6-49. Removing O-rings from Intermediate Shaft & Gear*

**ASSEMBLING DIFFERENTIAL - DANA SPICER**

All callout numbers in steps refer to Figure 6-16

1. Prior to installing, wipe new O-rings with SAE 30 weight oil. Install one O-ring (14) into outer input shaft (12) bearing bore. Install two O-rings (14) into intermediate shaft (9) bearing bores and two O-rings (10) onto intermediate shaft and gear assembly.
2. Press inner and outer bearings (13, 15) on input shaft (12) until seated against bearing shoulders (Figure 6-50).
3. Install new O-ring (14) into bearing bore of input shaft (12).

***NOTICE: Input shaft assembly must be supported by hand as not to damage gear teeth. Use care if using a hammer to coax shaft and gear into correct position. Use care if using a hammer to coax shaft and gear into correct position.***

4. Install input shaft (12). Bearings (13, 15) and shaft should slide easily into housing (Figure 6-47). If resistance is encountered, use a plastic or leather mallet to tap shaft into position.
5. Install outer snap ring (16) at input shaft bore (Figure 6-48).
6. After O-rings (10) are installed on shaft (9) and housing (1), install intermediate shaft and gear assembly (9) through bottom opening in housing.

***NOTICE: Small end of intermediate shaft and gear assembly must be tilted toward bottom opening until bearing trunnion visually engages intermediate bores.***

7. Align both bearing trunnions with intermediate bore. Continue supporting intermediate shaft and gear assembly with one hand and insert the flanged side bearing (11) into opening. To seat the bearing past the O-ring, a leather or plastic mallet may be required.

***NOTICE: Intermediate shaft assembly must be supported by hand as not to damage gear teeth. Use care if using a hammer to coax shaft and gear into correct position.***

8. After flanged side bearing is seated past snap ring groove, install snap ring (16). Repeat procedure for opposite side bearing and snap ring.

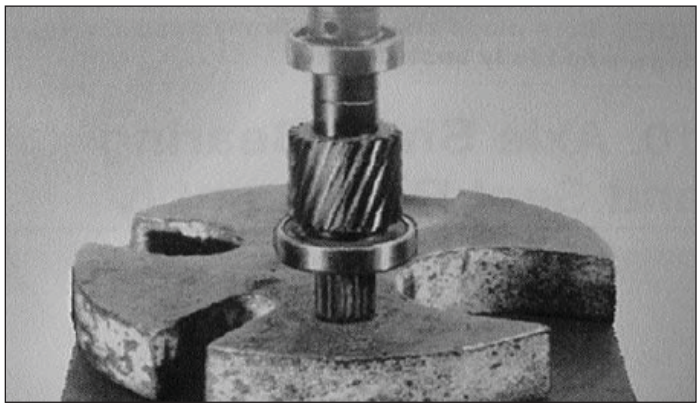


*Figure 6-50.* **Installing Bearings on Input Shaft**

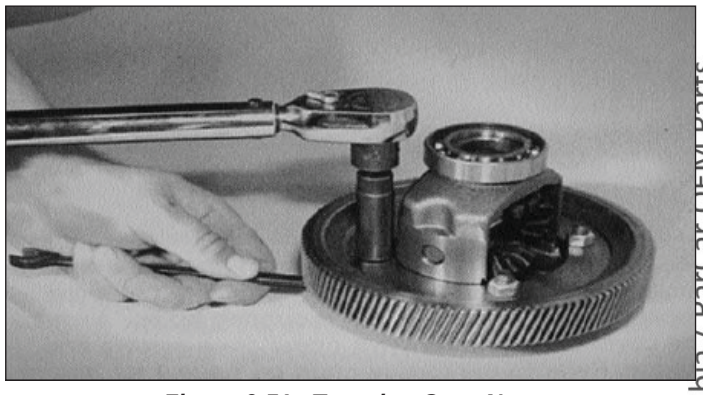


*Figure 6-51. Torquing Case Nuts*

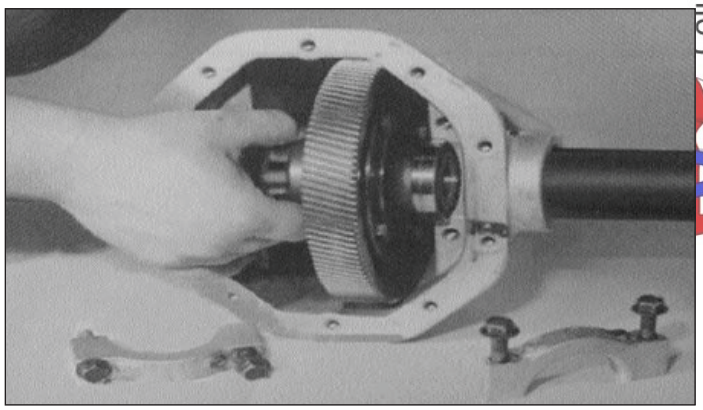


*Figure 6-52.* **Installing Differential Assembly**

9. Position differential case assembly (4) with flanged side trunnion face down on work surface. Align output gear (5) mounting holes with differential case. Install four bolts (6) and nuts (7). Bolts should be installed from differential flange side. Torque nuts to 35-45 ft. lbs. (47-61 Nm).
10. Differential bearings (8) can be installed on differential case (4) before or after installing ring gear. Use care not to damage differential bearings or final gear (5) when installing the opposite component.
11. Position housing (1) with opening facing up. Insert differential case, output gear (5) and bearing (8) assembly into housing. Make sure teeth of gear (5) mesh with teeth of small gear on intermediate shaft (9) and that both turn freely (Figure 6-52).

***NOTICE: Bearing caps are marked for identification. Letters or numbers are stamped in horizontal and vertical position. When reassembling, install caps back in their original positions, using these stamps as a guide.***

12. Install differential bearing caps (2) with bolts (3). Torque bolts to 35-45 ft. lbs. (47-61 Nm).
13. Place a small bead of RTV (non-acidic) silicone sealant to flange of cover plate (18). Sealant should be applied to inside of cover plate mounting holes (Figure 6-53).
14. Install cover plate (18) with ten bolts (20). Torque bolts to 16-24 ft. lbs. (21.5-32.5 Nm).
15. Install new intermediate cup plug (17) to both sides of housing (1). Use Loctite Safety Solvent #75559 to clean bores, then apply Loctite RC 609 to housing bores. Cup plugs can be installed by using a properly sized driver and hammer. Cup plugs should be firmly seated against snap rings (16) (Figure 6-36).
16. With properly sized seal driver, install shaft oil seals (24). Press seals to depth of 1.125" (28.5 m) (Figure 6-56).
17. Install inner snap ring (25) to both right and left tubes (Figure 6-55).
18. Assemble the rear axles to the differential. For assembly procedures see one of the following depending on the applicable axle:

    "Rear Axle - Dana Spicer Standard Duty" 6– 11

    "Rear Axle - Dana Spicer Heavy Duty" on page 6– 13

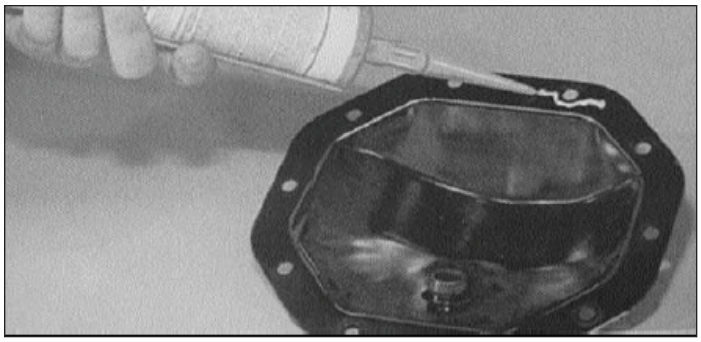


*Figure 6-53. Installing Differential Cover*

*Figure 6-54. Installing Cup Plugs*

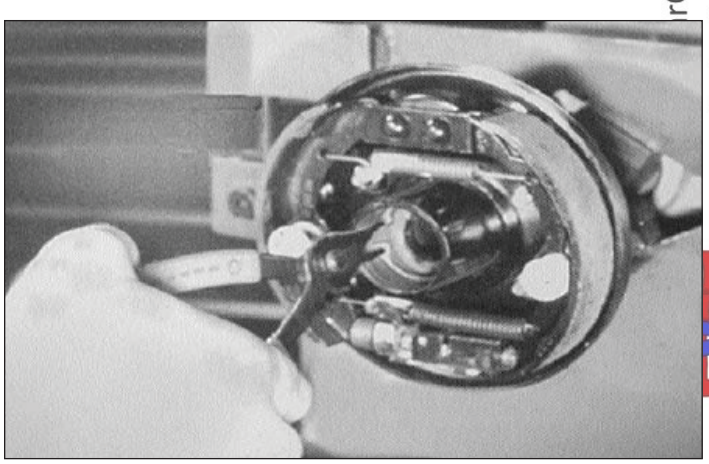


*Figure 6-55. Installing Snap Ring*

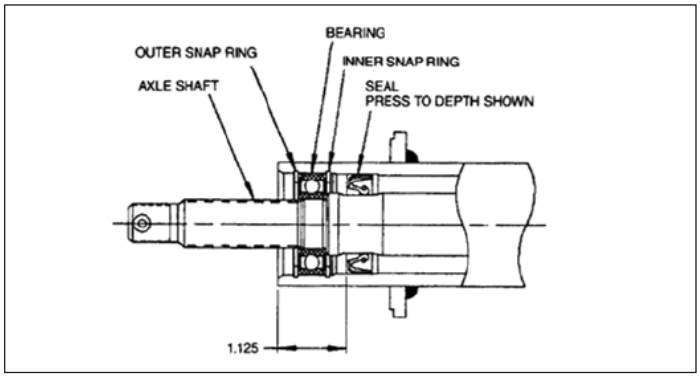



*Figure 6-56. Axle Components*



**INSTALLING DIFFERENTIAL ASSEMBLY - DANA SPICER**

***NOTICE: Make sure rear axle has oil in the differential before installing. See Checking Differential Oil in this section before installing.***

**⚠ DANGER**

**Differential/axle assembly is heavy and awkward to move. Get help lifting and installing to prevent possible personal injury.**

1. Carefully position assembly into place.
2. Secure to frame with four bolts, washers and nuts. Torque nuts to 45 ft. lbs. (16 Nm).
3. Connect brake cables to brake assemblies using new cotter pins, clevis pins and e-rings.
4. Connect hydraulic brake lines to brake assemblies on the rear axle (Figure 6-57)

*NOTE: After installation is complete, bleed the hydraulic brake system. See Section 5, Accelerator & Brake System.*

5. Install U-bolt securing rear differential/axle assembly to traction drive motor mounting plate.
6. Install the traction motor as described in *Section 9-Traction Drive System*.
7. Install rear shock absorbers. See “Replacing Rear Shock Absorbers” 6– 8.
8. Install brake drum and spacer.
9. Install new axle nut. Engage brake and tighten axle nut to a minimum 65 ft. lbs. (62 Nm). Install new cotter pin. Install spacer and rear brake drum. Repeat for other side.
10. Install rear wheel. See “Removing Wheels” on page 6– 2.
11. Drive the vehicle and test axle operation.

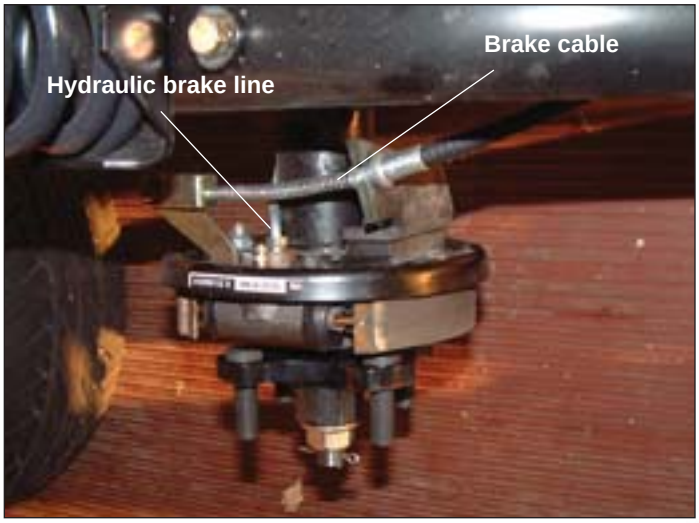



***Figure 6-57. Rear Brake Drum and Hub***

## REAR DIFFERENTIAL/AXLE ASSEMBLY TEAM AXLE MODELS

**⚠ WARNING**

**To perform this service, raise vehicle using floor jack and safely support it with jack stands positioned under main frame tubes. See Section 3, Lifting Instructions.**

### General

The rear differential/axle assembly is a precision assembly and any repair or replacement of parts must be done with great care in a clean environment. Before attempting to perform any axle service, read and understand all the procedures in this section.

- Handle all gears with extreme care.
- The axle assembly should be degreased prior to disassembly.
- Dirt is an abrasive and will cause premature wear of bearings and other parts. A small wash tank for cleaning parts should be close by when disassembling the axle assembly.
- Use soft, clean, lint-free towels to dry components before cleaning.
- Parts should be cleaned with emulsion cleaners or petroleum based cleaners.

**⚠ CAUTION**

**Do not use gasoline as a cleaner.**

***NOTICE: Bearings should not be dried by spinning with compressed air. This can damage mating surfaces due to lack of lubrication.***

- After drying, parts should be lightly coated with SAE 30 weight oil to prevent corrosion damage. If parts are to be stored for a prolonged period of time, they should be wrapped in newspaper and plastic.
- Bearings, seals and O-rings should be replaced with new parts whenever they are removed. Always wipe seals and O-rings with SAE 30 oil before installing.
- Snap rings must be removed/installed with care to prevent damage to bearings, seals and bearing bores.
- Remove all residual gasket material from sealing surfaces.
- Use soft, clean, lint-free towels to dry components before cleaning.
- Parts should be cleaned with emulsion cleaners or petroleum based cleaners. Inspect all parts for signs of wear or damage and replace if necessary.

### Torques

| | |
|---|---|
| Wheel nuts | 90-110 ft.lbs. (12-16 Nm) |
| Axle tube retaining bolts | 26-30 ft.lbs. (35-40 Nm) |
| Differential case retaining bolts | 22-27 ft. lbs. (29-36 Nm) |

## Rear Axle - TEAM Axle

### REMOVING AXLE SHAFT

1. Remove rear wheel. See “Removing Wheels” on page 6– 2.
2. Remove cotter pin, nut cap and wheel nut (Figure 6-58). Remove brake drum by pulling straight out. Tap drum from back side if necessary.

***Note:*** *Brake drum is an integrated hub with a splined center shaft. Be careful not to damage the splines when removing.*

3. Remove snap ring from inside axle tube (Figure 6-59).
4. Slide axle shaft assembly out with both bearings attached (Figure 6-60).

*Note: If replacing axle shaft, replace bearings also.*

### INSTALLING AXLE SHAFT

1. Apply Anti-Seize to inside tube at bearings and drum spline.
2. Slide axle shaft and bearings assembly into tube.
3. Install snap ring to inside of axle tube.
4. Install wheel nut, nut cap and cotter pin. Tighten wheel nut to 90-110 ft.lbs. (122-149 Nm).
5. Install rear wheel. See “Installing Wheels6-2” on page 6–2.

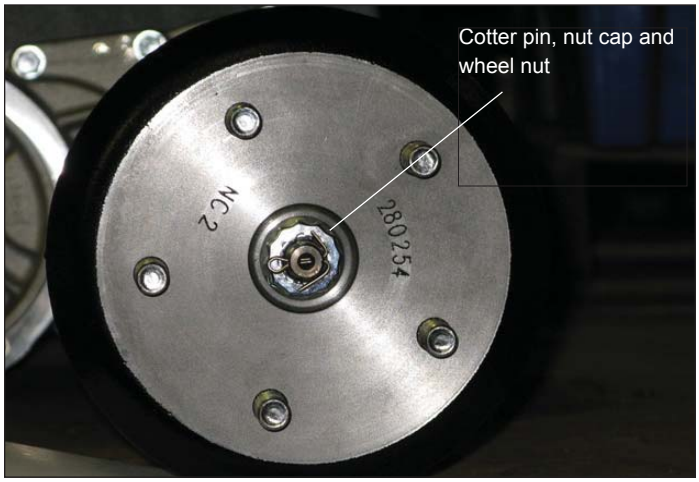



***Figure 6-58. Removing Brake Drum***

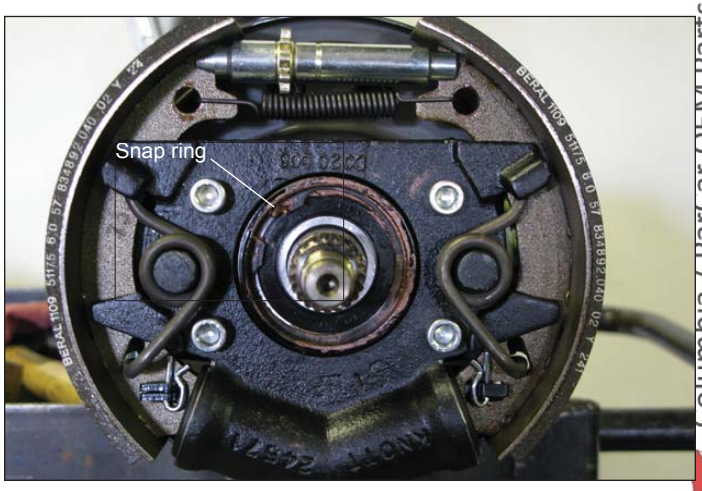



***Figure 6-59. Removing Snap Ring***

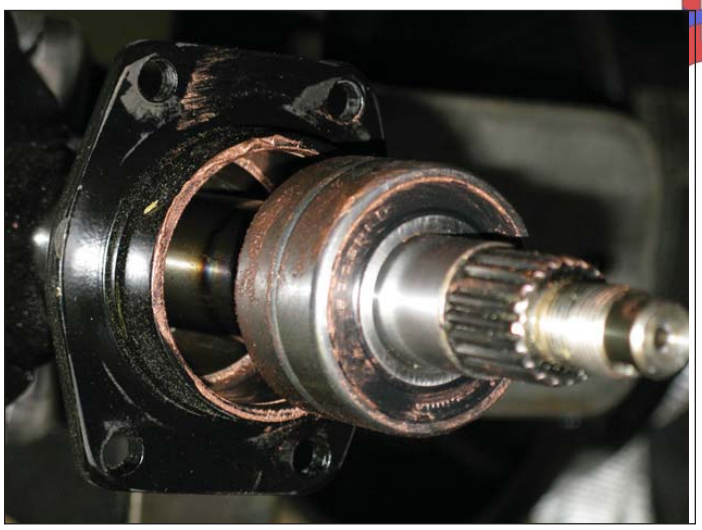


***Figure 6-60. Removing Axle with Bearings***

*Figure 6-61. Removing Axle Tube Six Bolts*

## Axle Tube - TEAM Axle

### REMOVING AXLE TUBE

1. Remove axle shaft. See “Removing Axle Shaft” 6– 24.
2. Remove six retaining bolts at tube and casing (Figure 6-61).
3. Slide complete tube assembly away from casing.

### INSTALLING AXLE TUBE

1. Clean all mating surfaces of tube and casing. Apply RTV silicone sealant to all mating surfaces before reassembly.
2. Slide complete tube assembly into casing.
3. Apply thread lock to six retaining bolts and install bolts. Tighten bolts to 26-30 ft. lbs. (35-40 Nm).
4. Install axle. See “Installing Axle Shaft” 6– 24.

## Differential - TEAM Axle

### DISASSEMBLING CASE

1. Drain gear oil from case.
2. Remove drive motor. See *Section 9-Traction Drive System*.
3. Remove left side axle shaft. See “Removing Axle Shaft” 6– 24.
4. Remove left side axle tube. See “Removing Axle Tube” 6– 25.
5. Remove twelve retaining bolts from differential case (Figure 6-62).
6. Gently pry casing apart at bottom pry point as shown (Figure 6-63).
7. Tap casing apart at the top point as shown (Figure 6-64).

*Figure 6-62. Case Bolts*

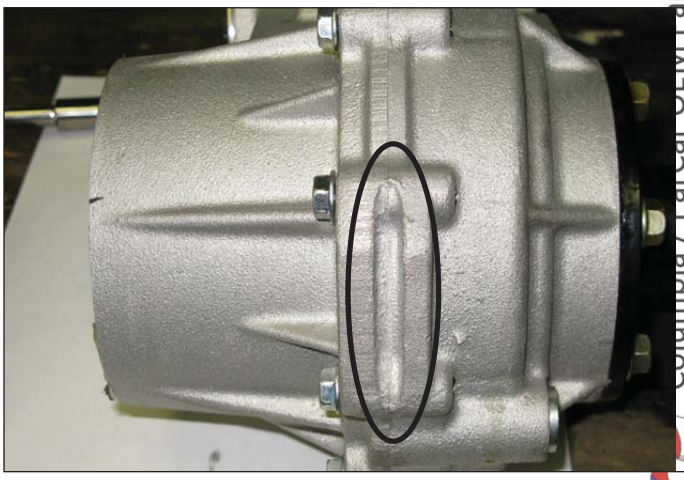


*Figure 6-63. Pry Points at Bottom*

*Figure 6-64. Pry Points at Top*



*Figure 6-65. Oil Fill Screw*

**ASSEMBLING CASE**

1. Clean all mating surfaces and apply RTV silicone sealant to mating surfaces before reassembly.
2. Apply thread lock compound to thread surfaces and assemble case halves with original bolts (Figure 6-62). Torque bolts to 22-27 ft. Lbs. (29-36 Nm).
3. Reinstall left side axle tube and axle. See “Installing Axle Tube” 6– 25.
4. Refill case with 410 ml of 80/90 wieght gear oil (Figure 6-65).
5. Reinstall rear wheel. See “Installing Wheels” 6– 2.

## Replacing Inner Gear Assembly, Seal or Ring Gear

1. Disassemble the differential case. See “Disassembling Case” 6– 25.
2. Gently lift out input gear assembly (Figure 6-65). New input gear assembly comes with bearings attached.
3. If replacing seal, knock out seal with a punch and insert new seal.
4. If replacing ring gear, remove intermediate gear and spider differential. Remove eight bolts securing ring gear and remove ring gear. Install new ring gear with eight bolts. Install spider differential and intermiediate gear.
4. Reassemble case as described above.

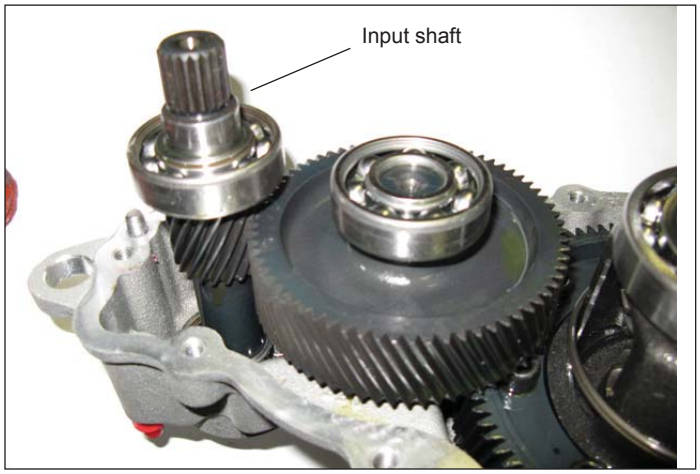



*Figure 6-66. Removing Input Shaft*

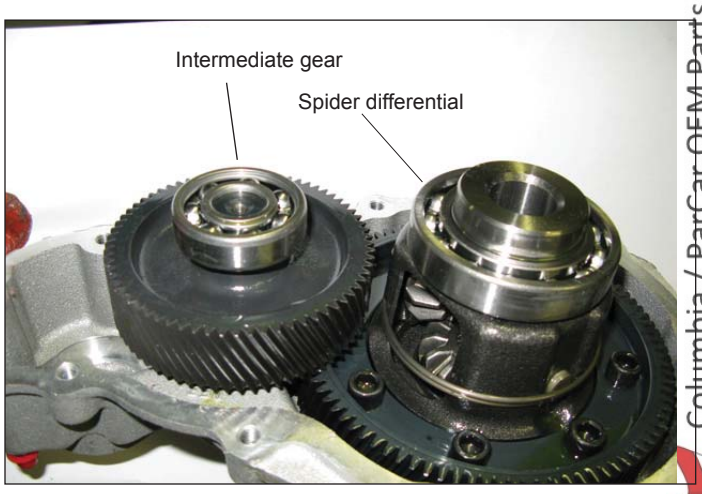



*Figure 6-67. Replacing Ring Gear*

## ELECTRIC VEHICLE SERVICE

When servicing the electric vehicle always observe the following:

**⚠ DANGER**

**Always turn power key to OFF, position directional selector to NEUTRAL, remove power key and block tires and disconnect battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.**

## REPLACING FRONT HEADLIGHT ASSEMBLY

1. Remove side mounting screws and adjusting screw from the headlight assembly (Figure 7-1).
2. Unplug wires from the headlight and remove headlight.
3. Plug in wires to new headlight.
4. Install headlight assembly using screws removed in step 1.

## ADJUSTING FRONT HEADLIGHT

Use the adjusting screw to level the headlight (Figure 7-1)

## REPLACING FRONT TURN SIGNAL LAMP

1. Disconnect wire plug from back of turn signal lamp (Figure 7-1).
2. Push turn signal lamp out through front of rubber housing.
3. Install new turn signal lamp into rubber housing and connect wire plug to new lamp.
4. Reinstall headlight as described above.

## REPLACING TAILLIGHT/TURN SIGNAL ASSEMBLY & BACKUP LIGHT

1. Unplug wiring connector (Figure 7-2). Push backup light through body to remove.
2. Lightly coat the new light rubber gasket with soap. Carefully install light through the body so gasket seals on both sides of body.
3. Plug the wiring connector to the light.

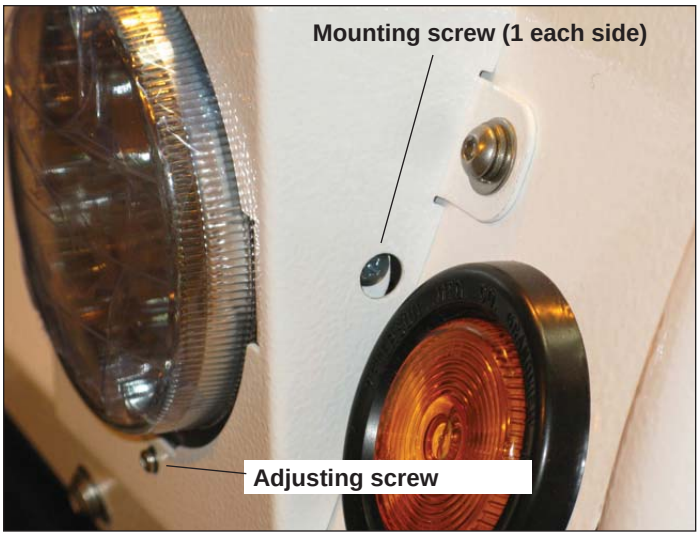



*Figure 7-1. Front Headlight and Turn Signal Lamp*

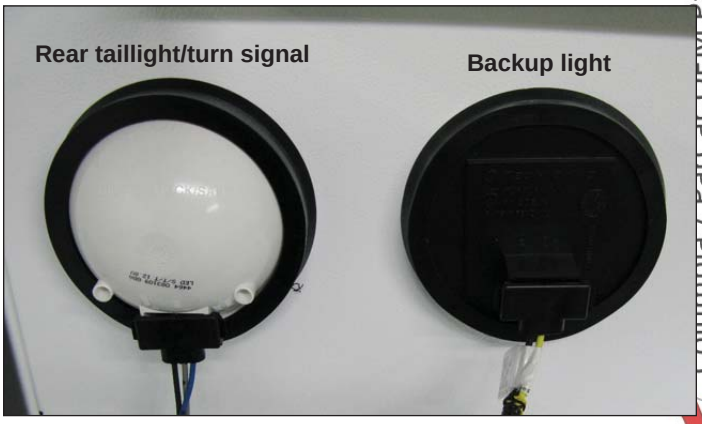



*Figure 7-2. Rear Turn Signal Assembly and Backup Light*



## FRONT UPPER COWL

### Removing Upper Cowl

1. Remove “Columbia” nameplate from cowl.
2. Remove screw and nut securing upepr cowl to lower cowl.
3. Cowl is a “press fit” into body. Pull out on edges of cowl to remove.

### Installing Upper Cowl

1. Place upper cowl on body and push edges in until fully seated.
2. Install screw and nut to secure upper cowl to lower cowl.
3. install “Columbia” nameplate, centered on cowl over screw.

## FRONT LOWER COWL

### Removing Lower Cowl

1. Remove upper cowl as described above.
2. Bumper is secured on right and left side to underside off oorboard with bolt, washer and nut. Remove hardware.
3. Remove bolts, washers, and nuts securing bumper to lower cowl.
4. Remove nuts securing lower cowl to upper front shock mounting bolts (Figure 7-3).
5. Remove two self-tapping screws from underneath lower cowl.
5. Remove lower cowl.

### Installing Lower Cowl

1. Place lower cowl over front shocks upper mounting bolts and secure with nuts.
2. Install two self-tapping screws to underside of lower cowl.
3. Install front bumper to lower cowl and secure with bolts, washers and nuts.
4. Secure bumper to right and left foorboards with bolts, washers and nut.


*Figure 7-3. Front Lower Cowl*



## INSTRUMENTS & SWITCHES

***NOTICE: The front cowl must be removed to service any dash mounted instruments or switches. After servicing switch, re-install front upper cowl as described on page 7-3.***

### Battery Discharge Indicator (BDI)

1. Disconnect wires from BDI (Figure 7-5). Note position of wires.
2. Remove screws and mounting bracket from BDI.
3. Install new BDI and reconnect wires to terminals.
4. Reinstall bracket and screws.

### Turn Signal Indicators/System LED

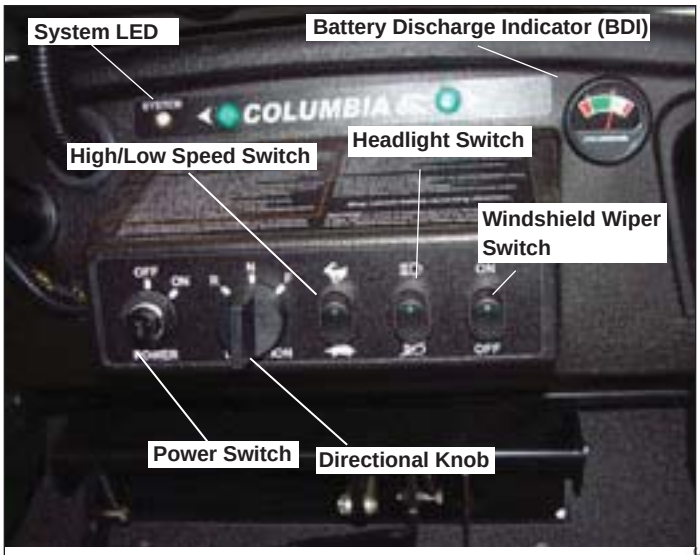
1. Disconnect wires from back of lamp/LED (Figure 7-5).
2. Push indicator lamp/LED out through front of dash.
3. Install new indicator lamp/LED and reconnect wires.

### High/Low Speed Switch (Standard)
### Headlight Switch (Standard)
### Windshield Wiper Switch (Standard)

1. Disconnect wires from switch (Figure 7-5). Note position of wires.
2. Remove retaining nut from back of switch and remove switch.
3. Install new switch and secure in place with retaining nut.
4. Reconnect wires to switch.

### High/Low Speed Switch (Optional)
### Headlight Switch (Optional)
### Windshield Wiper Switch (Optional)

1. Disconnect wires from switch (Figure 7-5). Note position of wires.
2. Remove retaining nut from front of switch and remove switch (Figure 7-4).
3. Install new switch and secure in place with retaining nut.
4. Reconnect wires to switch.




*Console with Standard Switches*

**Optional column mounted keyswitch**


*Console - With Optional Switches*

***Figure 7-4 Console Controls***

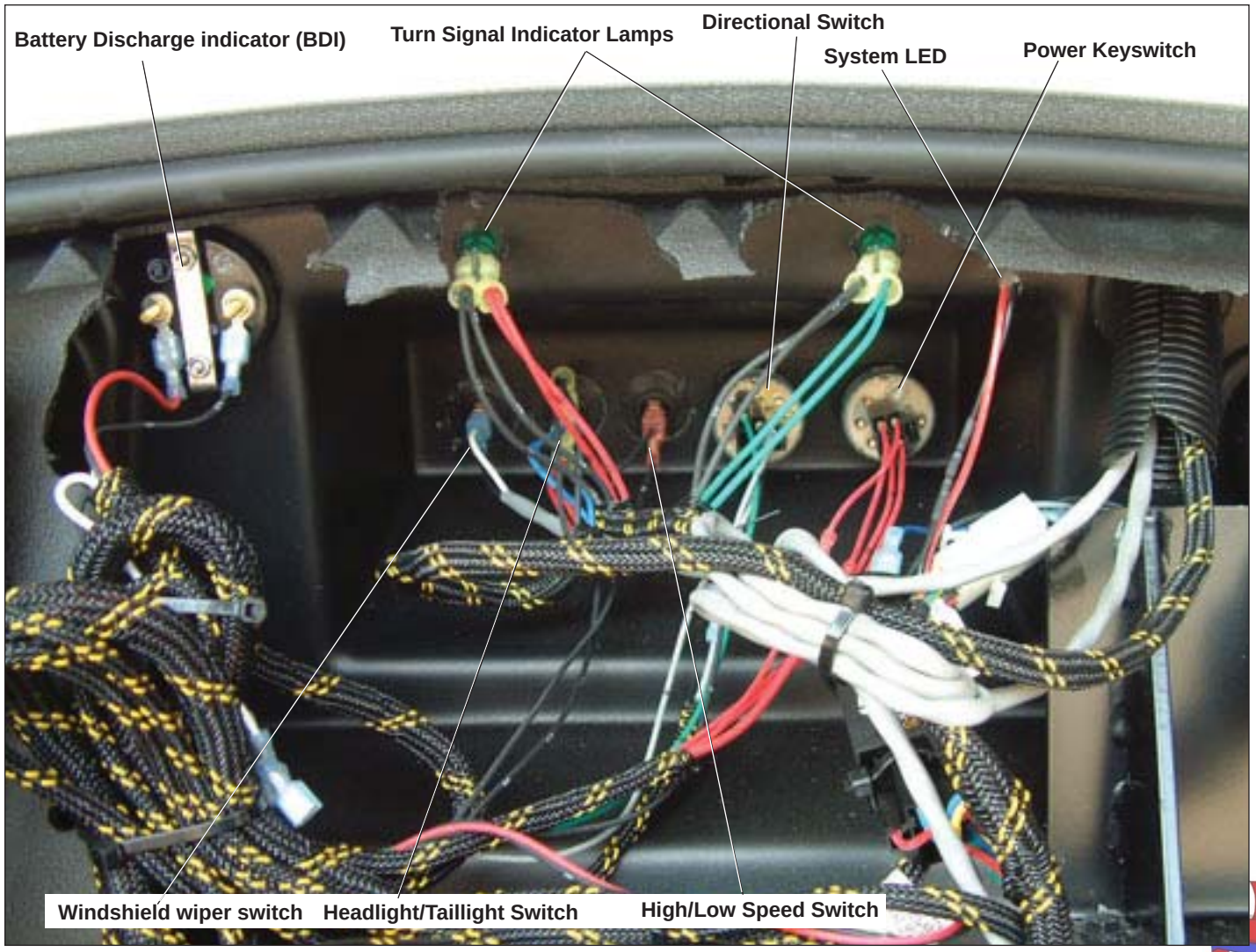



*Figure 7-5. Controls Switches and BDI Mounting*

### Power Keyswitch Switch (Console mounted)

1. Disconnect wries from back of switch (Figure 7-5).
2. Remove nut from front of switch and remove switch Figure 7-6)
3. Install new switch and secure in place with nut.
4. Reconnect wires to switch.

### Directional Switch

1. Disconnect wries from back of switch (Figure 7-5).
2. On models with plastic directional knob, break of f directional knob from switch. Remove nut from front of switch and remove switch (Figure 7-6)
3. Install new switch and secure in place with nut. Install new directional knob (if not a keyed switch).
4. Reconnect wires to switch.

### Turn Signal Switch/Emergency Flasher Switch

1. Remove two screws securing turn signal/emergency f asher assembly to the bracket on steering column (f gure 7-7).
2. Pull wiring harness cover from steering column (Figure 7-7).
3. Disconnect wires from turn signal indicator lamps (Figure 7-6).
4. Install new turn signal/emergency f asher assembly to steering column bracket with two screws.
5. Routed wires through f oorboard and connect to turn signal indicator lamps and connect wires to lamps.
6. Reinstall wiring harness cover to steering column.

### Horn Switch

1. Pull wiring harness cover from steering column (Figure 7-8).
2. Disconnect wires from horn switch and remove switch from harness cover.
3. Install new switch and reconnect wires to switch.
4. Reinstall wiring harness cover to steering column.

### Horn

1. The horn is mounted under the front upper cowl.
2. Remove upper cowl as described on page 7-3.
3. Disconnect wires from horn and remove horn from mounting bracket.
4. Install new horn to mounting bracket and reconnect wires to horn. Reinstall upper cowl as described on page 7-3.


*Figure 7-6. Power Keyswitch Mounting Nut (Console)*


*Figure 7-7. Turn Signal Assembly Mounting*

*Figure 7-8. Horn Switch*



## IMPORTANT INFORMATION

The type of battery used in a Columbia vehicle has a service requirement which is quite different from that of an automotive battery.

The electric vehicle battery supplies all of the power to drive the vehicle. During operation the power stored in the batteries is expended. While the amperage drain rate can vary greatly depending on the type of service, the duration of use and the number of "starts" and "stops" made during a day, the batteries nevertheless progress through each duty cycle from "fully charged" to an almost depleted state. This type of service is known as "deep cycle" service and electric vehicle batteries are specifically designed to handle this type of service.

Proper performance of your Columbia Vehicle can only be obtained from specified deep cycle, electric vehicle batteries.

Columbia recommends: U. S. Battery, model 2200, XB or XC, 225 amp hour, or U. S. Battery, model 145, XC, 244 amp hour., optional AGM Sealed battery Deka 8AGC2, 220 amp hour.

**PLEASE REVIEW IMPORTANT DANGER STATEMENTS WHEN WORKING AROUND BATTERIES AND CHARGING SYSTEMS!**

**⚠ DANGER**

**Before servicing or repairing the vehicle, always turn power keyswitch to OFF and remove, turn directional selector to NEUTRAL and block tires.**

**All batteries used in electric vehicles can explode! Batteries produce explosive hydrogen gas at all times, especially, during charging or discharging. Ventilate area when charging batteries.**

**Do not attempt to charge a battery if it is frozen, or if the case is bulged excessively. Frozen batteries can explode!**

**Properly dispose of the battery.**

**Do not smoke around batteries. Keep sparks and flames away from batteries and the charging area.**

**When working around or servicing batteries use care to prevent an accidental arc which could cause an explosion.**

**Use only approved insulated tools, remove jewelry such as rings, watches, chains etc. and place an insulating material (wood, plastic, rubber etc.) over all battery connections.**

**If any problems are found during scheduled maintenance or inspections, do not operate vehicle until repairs are made. Failure to make necessary repairs could result in fire, property damage, severe personal injury, or death.**

**Battery acid is poisonous and can cause severe burns. Avoid contact with skin, eyes, or clothing.**

**ANTIDOTES**

**EXTERNAL: Flush with water. Call a physician immediately.**

**⚠ DANGER**

**INTERNAL: Drink large quantities of milk or water. Follow with milk of magnesia or vegetable oil. Call a physician immediately**

**EYES: Flush with water for fifteen minutes. Call physician immediately.**

***NOTICE: Automotive batteries should never be used for "deep cycle" application, as their useful life will be very short.***

***Install surge arrestors on incoming AC power lines. Surge arrestors will help protect electrical/electronic components in the charger and vehicle from all but direct or "close proximity" lightning strikes.***

***Damaged or corroded battery terminals should be replaced or cleaned as necessary. Failure to do so may cause overheating during operation.***

## BATTERY INSPECTION & MAINTENANCE

Batteries and connections must be clean and dry. See *BATTERY CLEANING*.

Be sure battery hold downs are properly tightened. A loose hold down may allow the battery to become damaged from vibration or jarring. A hold down that is too tight may buckle or crack the battery case.

Weekly inspect battery posts, clamps and cables for breakage, loose connections and corrosion. Replace any that are damaged. Check to see that battery cap vent holes are clear. Plugged vent holes will not permit gas to escape from the cell and could result in battery damage.

## SINGLE POINT WATERING SYSTEM

***NOTICE: The following information does not apply to sealed batteries.***

Use only distilled water in your batteries. Vehicle batteries may use up to 16 quarts of water during their useful life and non-distilled water may contain harmful minerals which will have a cumulative adverse effect on battery performance and life.

The vehicle has a Single Point Watering System (Figure 8-1) used for adding water to the battery pack. It consists of a fill tube, one end having a filter screen, the other having a female coupler and a rubber squeeze bulb.

***NOTICE: To avoid overfilling of the Single Point Watering System do not operate this system on brand new batteries. New batteries should be in service 1 to 2 weeks with heavy use or 3 to 4 weeks with light use. System is to be used only after fully charging the batteries and batteries are warm.***

Watering intervals are dependent on the local climate, charging methods, application, and age of batteries. After the initial watering of new batteries, it is recommended that batteries be checked once a month until you get a feel for your water consumption rate.

Typically for a heavy use application, recommend watering is maximum of once per week, and for light use applications once per month.



Check the battery pack water level weekly by:

- Inserting the f ll tube f lter end in a distilled water supply.
- Attaching the female coupler to the battery pack male coupler.
- Squeeze the rubber ball until f rm which indicates that f lling is complete. Immediately disconnect the couplers by depressing the push button on the female coupler. If the water supply is left connected after the f lling process is f nished it could lead to an overf ll.

## BATTERY CLEANING

Acid-soaked dirt on the battery terminal connections causes current leakage, reduces battery eff ciency, and battery life.

Check that all vent caps are tightly in place before washing.

Hose wash battery terminal connections periodically with clean low-pressure water to keep them free of acid spillage, dirt, and other debris. Do not hose wash switches, solenoids and other electrical control devices. Cover as necessary to prevent splashing.

Clean battery terminal connections with baking soda (sodium bicarbonate) and water solution (5 teaspoons baking soda per quart water) and stiff bristle brush. Rinse with clean water and dry with a clean cloth. Do not allow solution to enter cap vent holes.

***NOTICE: Follow local ordinances and codes for proper disposal of battery cleaning waste.***

## CONDITIONS WHICH AFFECT CHARGING

Always schedule enough charging time to allow the batteries to become fully charged. Charging time is af fected by age and battery condition, state of discharge, electrolyte temperature, AC line voltage, and other variables. Correct charging methods extend battery life and vehicle range between charges.

New batteries need up to four hours more charging than “mature” batteries. Charging time will vary based on conditions noted above but will probably be 6 to 10 hours.

Battery eff ciency is affected by temperature. If the temperature of the outside air and/or batteries is below 60º F, battery capacity is reduced. Batteries will require more frequent and longer charge periods in early spring, fall and winter.

As batteries age, they f nish charge at progressively higher charge rates and tend to use more distilled water . At this point in battery age, charger will automatically begin reducing charge time.

Batteries found defective must be replaced. All batteries in a vehicle should be matched according to age, capacity and brand.

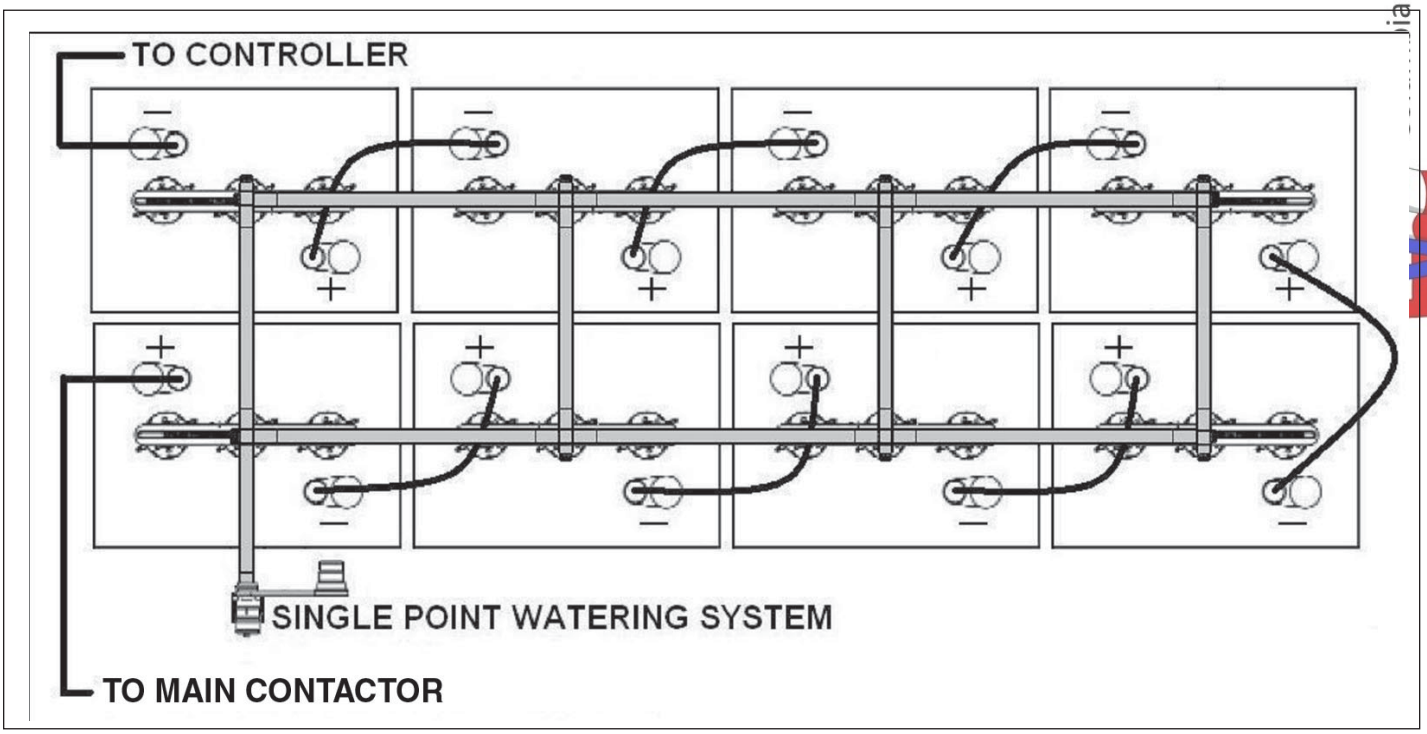



*Figure 8-1. Special Order Single Point Watering System - Non-Sealed Batteries*

## BATTERY CHARGING

### General

**⚠ DANGER**

**Observe all safety information in this section, safety information listed at the beginning of this section, and safety information in Section 1 of this manual.**

Columbia electric vehicles are equipped with a solid state, on-board, fully automatic, Delta-Q Battery Charger as standard equipment. See Figure 8-2.

It is important to be aware of the dif ferences and improvements over prior chargers, which are explained in the Delta-Q Charger Operating Instructions in this manual.

Correct charging methods extend battery life and vehicle range between charges. Before the f rst new vehicle use, completely charge new batteries. Charging time is affected by age of battery, condition of battery, state of discharge, temperature of electrolyte, AC line voltage level, and other variables. Charging time usually takes 12 hours. New batteries need up to four hours more charging time than “mature” batteries.

Always schedule enough charging time so that the charger completes a full charge cycle. Opportunity charging is an acceptable practice for use during a shift to extend the range, but always allow for a full charge cycle at end of shift.

Limit the use of new batteries between charges for the f rst 15 – 20 cycles. New batteries have less capacity than batteries which have been cycled.

Recharge batteries immediately after use. Leaving batteries in a state of discharge will reduce there capacity and useful life.

Battery chargers are voltage specif c; 24, 36 or 48 volts. However, chargers can be programmed at the factory for dif ferent types of batteries, as well as dif ferent brands and capacities of batteries. Refer to Battery Brand Algorithms for Charger Programming, See Figure 8-3.

The lead-acid storage battery supplies electrical power through the chemical action. This action is reversible, which means the battery must be connected to a charger and have an electrical current passed through it in the direction opposite to the direction of discharge in order to restore the battery’s active chemicals.

The Delta-Q Charger will not over charge batteries if left plugged in.

### Charger Safety Information

**⚠ WARNING**

**Do not attempt to charge a battery if it is frozen or if the case is bulged excessively. Frozen batteries can explode. Dispose of battery.**

- **Charge batteries in well ventilated area.**
- **Ventilation fans should be located at the highest point in charging area. These fans should be able to exchange the air 5x per hour. Consult a local HVAC engineer.**
- **Remove rings and watches prior to service. Only trained technicians should repair or service the charger. Contact Columbia for assistance.**
- **Replace worn, cut or damaged power cords or wires.**
- **Do not connect the power cord near fuels, grain dust, solvents, thinners, or other flammables.**
- **Install surge arrestors on incoming AC power lines. This protects from all but direct or close proximity lightening strikes.**
- **Do not cover charger cabinet cooling fins. This protects the charger from overheating.**
- **Make sure all battery and charger connections are clean and tight. This prevents overheating and arcing at the terminal. Replace as necessary.**
- **Disconnect negative (-) cable first to avoid crossing terminals that would create a spark.**

***NOTICE: When using ordinary automotive chargers, there is the possibility of overcharging and damaging the cells.***



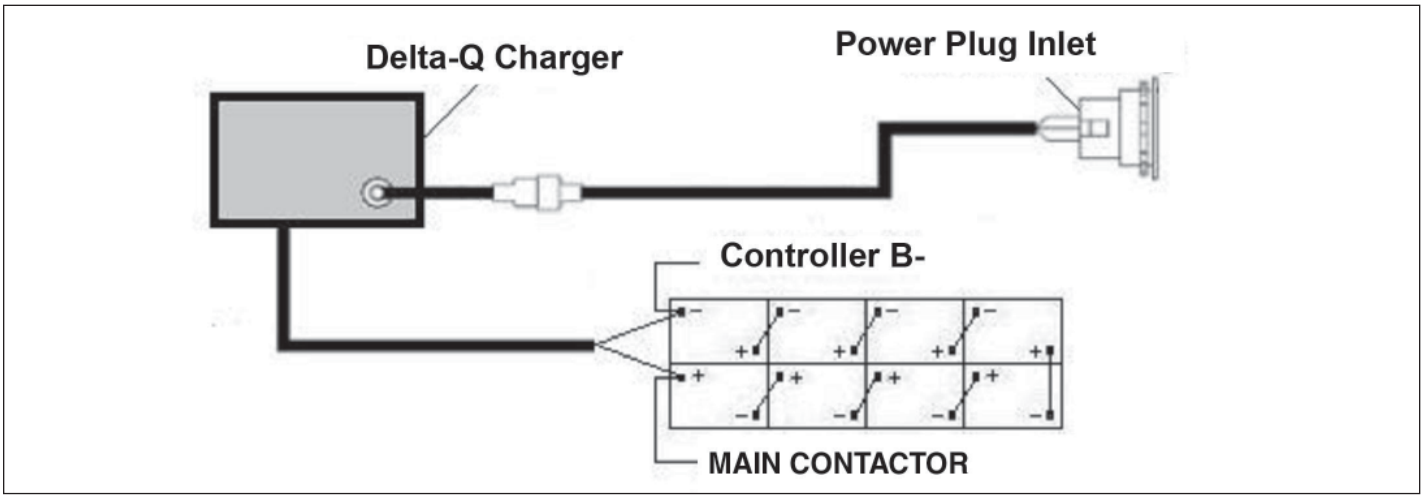



*Figure 8-2. Charging System*

| Algorithm ID | Algorithm Description | Amp Hour | Type | Designed For | Compatible With |
|---|---|---|---|---|---|
| 1* | Trojan f ooded | 225 | f ooded | Trojan T105 | Trojan 150 Ah - 260 Ah f ooded |
| 2 | Trojan T105 tapped | 225 | f ooded | Trojan T105 | Trojan 150 Ah - 260 Ah f ooded |
| 3 | Trojan T105 constant power dv/dt | 225 | f ooded | Trojan T105 | Trojan 150 Ah - 260 Ah f ooded |
| 4* | US Battery f ooded | 225 | f ooded | US 2200 | US Battery 165 Ah - 245 Ah f ooded |
| 5* | Trojan 30 XHS | 130 | f ooded | Trojan 30 XHS | Trojan 85 Ah - 150 Ah 12 V f ooded, Exide Orbital AGMs |
| 6* | Deka 8G31 | 100 | gel | Deka 8G31 | Deka 75 Ah - 100 Ah gel |
| 7* | Trojan J305 constant power dv/dt | 305 | f ooded | Trojan J305 series | Trojan 250 Ah - 400 Ah f ooded<br>US Battery 250 Ah - 400 Ah f ooded |
| 8 | Concorde 10 x Ah AGM | 100 | AGM | Concorde 100 Ah Range AGMs | - |
| 11* | Generic f ooded constant power dv/dt (parallel enabled) | 230 | f ooded | US Battery<br>US 125 | All 200 - 255 Ah f ooded |
| 12 | Exide gel | 240 | gel | Exide DF06240 | Exide/Sonnenschein<br>200 Ah - 300 Ah gel |
| 21 | Exide f ooded | 210 | f ooded | Exide 3ET200, FF06255, 185PZB210 | Exide 200 Ah - 300 Ah f ooded |
| 23 | Douglas constant power dv/dt | 200 | f ooded | - | T105, T125, T145, T875, T890<br>US 220, US 125, US 145 |
| 26 | Deka 8GGC2 gel | 180 | gel | Deka 8GGC2 | Deka 180 Ah - 200 Ah gel |
| 27 | Crown CR-325 dv/dt | 325 | f ooded | Crown CR-325 | Crown 225 Ah - 350 Ah f ooded |
| 32 | Deka EV31 dv/dt | 110 | f ooded | Deka EV31 | Deka 75 Ah - 150 Ah gel |
| 35 | Concorde 2xxAh AGM | 200 | AGM | Concorde 200 Ah range AGMs | - |
| 37 | Trojan T105 constant power dv/dt 42V pack w/48V charger | 225 | f ooded | Trojan T105 | Trojan 150 Ah - 260 Ah f ooded |
| 38 | Trojan 1275 113% | 150 | f ooded | Trojan T1275 | Trojan 130 Ah - 180 Ah f ooded |
| 41 | Crown CR395 | 395 | f ooded | Crown CR-395 | Crown 350 Ah - 400 Ah f ooded |
| 42* | Discover / Deka AGM | 200 | AGM | Deka 8AGC2 | - |
| 43* | Discover AGM | 300 | AGM | Discover EVL16A, EVGC6A | Discover 200 Ah - 400 Ah AGM |
| 47 | Generic 20 Ah VRLA pulse | 20 | AGM | - | - |
| 51 | Exide 180 Ah gel | 180 | gel | Sonnenschein 180 Ah gel | - |
| 52 | Exide 105 Ah gel | 105 | gel | Sonnenschein 105 Ah gel | - |
| 57 | Sacred Sun AGMs | 170 | AGM | Sacred Sun 140-200 Ah AGMs | - |
| 125* | Full River | 224 | AGM | DC224-6 | - |
| 126* | Full River | 145 | AGM | DC145-12 | - |

** The standard Delta-Q Charger is preloaded with these available algorithms.*

***Figure 8-3. Algorithm Table***



## DELTA-Q CHARGER OPERATION

1. Connect power cord at charger receptacle to properly grounded wall outlet.

***NOTICE: Connect the charger AC cord to a source capable of supplying 15 amperes minimum per charge (20 amperes recommended). The charger is equipped with an equipment-grounding AC electric cord, and a grounding type plug.***

2. Connect the cord to an appropriately installed receptacle grounded in accordance with the National Electric Code ANSI/NFPA 70, and all local codes and ordinances.
3. The yellow AC power LED (1, Figure 8-4) should remain illuminated while the charger is plugged into an AC source. If yellow LED (1) is not lit, before replacing charger, confirm the two AC connections supplying the charger on the vehicle are intact. First, check the extension cord receptacle, found on left side of the vehicle's body. Then check the three pronged connection on the short 6 inch AC cord extending from the LED panel. Also confirm the AC source fuse or breaker operation, then contact the Columbia Dealer for assistance.
4. Charger will automatically turn on and conduct a short self-test and battery pack test. All LEDs will flash in sequence, then a trickle current will be applied to batteries until a minimum voltage is reached. Three (3) amperes is displayed as the lowest LED on the Bar Graph. See (2, Figure 8-4).
5. If the batteries meet the minimum voltage requirements of the charger, signifying they are serviceable (chargeable), the charger enters the bulk charging (higher amperage-constant current) stage. The current (A) Bar Graph LEDs (3, Figure 8-4) indicate the electrical current delivered to the batteries as the charger moves through its automatic charge profile. The length of charge time at each level will vary due to battery size and battery charge depletion.

   If the charger only reaches the trickle stage (No. 2 above), and does not enter the higher rate Current (A) Bar Graph region with a steady LED lit, the batteries may be excessively discharged, and not capable of automatic charge with the Delta-Q. The charger may time-out with a RED Fault LED (6, Figure 8-4). (*Flash Code Faults - See Red Light Charger Error Codes*). It will then be necessary to follow the *Special Charging Procedure* Section. Also review the Battery Maintenance Procedures.
6. When the yellow 80% LED is lit, the Charger has completed the bulk stage and the batteries are at approximately 80% state of charge. The 80% LED remains on as the last 20% of charge is returned to the batteries in the second phase (constant voltage phase) (4, Figure 8-5).
7. Operator can terminate charging at this point if necessary. The vehicle can be used, but completing the charge cycle is highly recommended, until the 100% Green LED is lit (5, Figure 8-4). Repeated "short charging", leaving the charge short of 100%, will shorten operating cycle distance and reduce battery life.


***Figure 8-4. Delta-Q Charger and Lights***

8. A low current "finish-charge" phase returns and maintains batteries to maximum capacity. The Green LED will blink until "finish charge" phase is complete. On vehicles equipped with a battery discharge indicator (BDI), the Red LED display on the dash mounted meter scrolls across from right to left during the finish charge and is normal operation.
9. A Green LED continuously lit, indicates the batteries are completely charged (5, Figure 8-4). The charger may now be unplugged from the AC source. If the vehicle is not operated for a length of time, see *Section 3 - Vehicle Storage*.
10. A fault occurring while charging causes the RED FAULT LED (6, Figure 8-4) to flash with a code relaying the error. Some errors may require repair by a qualified technician and others may be simply transient and will automatically recover when the fault condition is eliminated and the Delta-Q cycled by disconnecting the AC source a minimum of 11 seconds. See *Red Light Charger Error Codes*.

***NOTICE: A yellow (amber) Blinking LED in the upper Bar Graph usually indicates the thermostatic control has limited the charger output due to ambient temperature conditions - it is still charging, but at a reduced rate.***

***The Yellow AC power LED should remain illuminated while the charger is plugged into an AC source. If charger does not power up, after following the instructions described, then contact the Columbia Dealer for assistance.***

***NOTICE: Do not disassemble the charger. There are no serviceable parts.***

## RED LIGHT CHARGER ERROR CODES

### 1 Flash

Battery Voltage High: Auto-recover. May be temporary condition, or wrong charger installed, i.e. 36 volt charger on 48 volt battery pack.

### 2 Flash

Battery Voltage Low: Auto-recover. Confirm each individual batteries minimum voltage with a volt meter Two or more 6 volt batteries register less than 5.85 volts, or accumulative total pack voltage



has been discharged to less than 20% remaining. Vehicle operation will cease until batteries are recharged. See Special Procedure for Excessively Discharged Batteries in this section.

### 3 Flash

Charge Timeout: The charging did not complete in allowed time, 12-14 hours. This may indicate a battery problem, or that the charger output was reduced due to high ambient temperatures. Disconnect AC supply, confirm sufficient ventilation, allow cool down time, and restart charger.

### 4 Flash

Check Battery: The batteries could not be trickle charged up to a minimum level to start charger. This may be the result of badly discharged batteries, or one (or more) damaged cells. See Special Procedure in this section.

### 5 Flash

Over-Temperature: The charger shut down due to high internal temperature. May require reset (AC unplugged) and a cool down to restart charging cycle. This fault may indicate inadequate cooling airflow or high ambient air temperatures. Check for debris or blockage at cooling fins. Move the vehicle to a cooler better ventilated area, or adjust time of day when charging.

### 6 Flash

Delta-Q Charger Fault: An internal fault was detected and charger may need to be checked/replaced by a qualified dealer technician. It may also be the result of badly discharged batteries, or one (or more) damaged cells. A RED 6 FAULT flash must be validated first by testing individual batteries with a voltmeter, and see Special Procedures, before deciding charger has failed.

### A Steady Red Fault LED

Confirms an internal electrical fault of the Delta-Q and also requires charger replacement and return.

### Yellow (amber) Blinking LED in the Bar Graph Area

Usually indicates a thermostatic control has limited the charger output due to ambient temperature conditions. It is still charging, but at a reduced rate.

## TESTING BATTERIES

### Specific Gravity Test

***NOTICE: Specific Gravity Test information does not apply to sealed batteries.***

It is possible to determine a battery's ability to perform by measuring the specific gravity of each cell with a hydrometer. The hydrometer readings indicate two things:

- State of Charge - The amount of electrical power stored in the battery.
- Condition - The ability of battery to store and deliver power.

***NOTICE: Batteries should be fully charged before performing specific gravity tests to determine battery condition. Hydrometer tests of batteries not fully charged are misleading and inconclusive.***

### Hydrometer Test

1. Squeeze rubber bulb and insert nozzle in cell, release bulb, slowly drawing electrolyte up into barrel.
2. Adjust electrolyte level in barrel so float rides free of bottom but is not striking top of barrel.
3. Hold hydrometer vertically, making sure float moves freely and is not contacting sides of barrel. Read scale at the level of electrolyte in the barrel. Record the reading.
4. Return electrolyte to cell from which it was removed.
5. Repeat these steps on all battery cells.

Hydrometer readings are affected by the temperature of the electrolyte being tested. Measure the temperature of the electrolyte, and correct the readings as follows:

**Above 80ºF**: Add .004 to the specific gravity readings for each 10º above 80ºF (26ºC).

**Below 80ºF**: Subtract .004 from the specific gravity readings for each 10º below 80ºF (26ºC).

#### INTERPRETATION OF HYDROMETER READINGS

If the difference between the highest and lowest cell is 0.050 (50 points) or more, the battery is nearing the end of its useful life and should be replaced.

| Specific Gravity vs. State of Charge | |
|---|---|
| Specific gravity reading @ 80º F (26º C) | State of charge in percentage |
| 1.250 - 1.270 | 100% |
| 1.220 – 1.240 | 75% |
| 1.190 – 1.210 | 50% |
| 1.160 – 1.180 | 25% |

If the highest cell reads less than 1.2, the test for condition is questionable. Recharge the battery and perform test again.

| Specific Gravity vs. Action Required | | | | |
|---|---|---|---|---|
| | Specific gravity reading for each cell | | | Required action |
| battery | Cell 1 | Cell 2 | Cell 3 | |
| 1 | 1.100 | 1.100 | 1.100 | Charge and recheck |
| 2 | 1.260 | 1.180 | 1.250 | Bad cell 2. Replace battery |
| 3 | 1.250 | 1.260 | 1.250 | Good |
| 4 | 1.190 | 1.170 | 1.120 | Charge and recheck. Suspect cell 3 |

### Discharge (Load) Test

The discharge, or load test, is the recommended method of determining battery condition because it simulates electric vehicle operation under controlled conditions. A 75 amp draw is applied to the battery bank with a Load Tester. The time it takes the battery bank to drop to 31.5 volts, along with individual battery voltages, is used to determine battery condition.

***NOTICE: Use of automotive type of load tester is not recommended and will offer inaccurate results.***

#### PREPARATION FOR DISCHARGE TEST

The following preparations must be verified before discharged load testing. Should any of the following recommendations not be performed, results of testing will be inaccurate and misleading.

- Batteries must receive a full charge before conducting Discharge (Load) Test.



- Discharge (Load) Test must be performed within 18 hours of charging.
- Vehicle must not be used, even for short runs, prior to Discharge (Load) Test.
- Electrolyte level must be correct in all cells.

**DISCHARGE (LOAD) TEST PROCEDURE**

**⚠ WARNING**

**Discharge Load Test must be performed in well ventilated area.**

1. Connect tester leads to battery bank.
2. Check and record electrolyte temperature of center cell of each battery.
3. Turn tester on.
4. After 20-30 minutes, with tester on, check and record individual battery voltages to the nearest 0.1 (1/10) volt.

   All four individual battery voltage readings for a 24 volt system must be made as rapidly as possible to be accurate.
5. Allow tester to shut off automatically, and record time elapsed from start of discharge.

   Tester shutoff should occur at a battery voltage of 42v +/- 0.2v (48 volt system) or 21v +/- 0.2v (24 volt system). Check tester shutoff voltage periodically. This setting must be accurate for a valid test.

**INTERPRETING DISCHARGE (LOAD) TEST RESULTS**

1. Compare individual battery voltages recorded in step 4 of*Discharge (Load) Test Procedure* and discard any battery that is 0.2 (2/10) volt lower than the highest battery in bank. If defective battery is found, recharge the entire bank for 12 hours. Then, replace the defective battery with a good fully charged battery of the same brand and date code, if possible. Equalize the bank by placing it on charge for an additional three hours, then retest.
2. If all battery voltages are within 0.2 volts of each other , compare discharge time from step 4 of*Discharge (Load) Test Procedure* with minimum times in Temperature and Time table on next page.

   Even if individual battery voltages are satisfactory, but the discharge time fails to meet minimums in Temperature and Time table, the entire battery bank should be replaced.

## STORING BATTERIES

- Batteries can remain in vehicle.
- Batteries should be fully charged.
- Clean battery tops and connections.
- Fully charged batteries should be stored in as cold of an environment as possible. Batteries “self discharge” when not in use. The colder the temperature, the slower batteries self discharge.

*Figure 8-5. Typical Commercial Discharge Tester*

**Discharge Load Test: temperature and time**

| Electrolyte temperature from step 2 | | Minimum Discharge Time to 3.1 volt from step 5 |
|---|---|---|
| 40 – 49 ° F | 4 – 9 ° C | 40 minutes |
| 50 – 59 ° F | 10 – 15 ° C | 45 |
| 60 – 64 ° F | 16 – 17 ° C | 50 |
| 65 – 69 ° F | 18 – 20 ° C | 54 |
| 70 – 74 ° F | 21 – 23 ° C | 57 |
| 75 – 79 ° F | 24 – 25 ° C | 60 |
| 80 – 84 ° F | 26 – 29 ° C | 62 |
| 85 – 89 ° F | 30 – 32 ° C | 64 |
| 90 – 99 ° F | 33 – 37 ° C | 66 |
| 100 – 109 ° F | 38 – 43 ° C | 68 |
| 110 – 119 ° F | 44 – 48 ° C | 70 |
| 120 – 129 ° F | 49 – 54 ° C | 72 |
| 130 – 150 ° F | 55 – 66 ° C | 74 |

**⚠ CAUTION**

**Batteries in low state of charge (low specific gravity readings) will freeze at higher temperatures than those fully charged.**

Check specif c gravity periodically, and recharge batteries as necessary. Batteries stored in temperatures above 80ºF (26ºC), will discharge faster and require recharge every few weeks. Batteries stored at or below 0ºF (-12ºC) may not require recharge for periods up to 4 months. When recharging, bring batteries to 1.250-1.270 specif c gravity to prevent freezing. See Table 8-8.

As ice forms in a freezing battery, the electrolyte expands and can crack the case, ruining the battery. If a battery is allowed to stand or is operated in a discharged condition for a long period of time, lead sulfate may develop on the plates, which is dense, hard and crystalline, and which cannot be electrochemically converted to normal active material again.

Lead sulfate formed on the plates during discharge is relatively insoluble as long as the specf c gravity of electrolyte is kept above 1.125 specif c gravity, but if allowed to drop below this value, the



lead sulfate becomes increasingly soluble and may migrate into the pores of the separators and deposit as a white crystalline mass.

Subsequent charging may convert these deposits into stringy metallic lead which may short the positive and negative plates through the areas affected. These small shorts may cause a condition of low cell voltage when battery is allowed to stand idle in less than 25% charged condition.

| State of Charge and Specific Gravity vs. Risk of Sulfation | | | | |
|---|---|---|---|---|
| State of charge | Specific gravity | F° freezing point | C° | Risk of sulfation |
| 100% | 1.260 | -70 ° | -57 ° | low |
| 75% | 1.230 | -39 ° | -38 ° | low |
| 50% | 1.200 | -16 ° | -26 ° | low |
| 25% | 1.170 | -2 ° | -19 ° | moderate |
| discharged | 1.110 | +17 ° | -8 ° | high |

## REPLACING BATTERIES

The batteries are located under the front seats.

1. Disconnect the main power cables and charger wires from the batteries.
2. Remove the battery hold down bar , the watering system (if equipped) and the positive & negative leads.
6. Reverse to reinstall batteries.

*Figure 8-6. Batteries*



## BATTERY CHARGER

### REMOVAL

***NOTICE: The black and white wires are terminated in a thermistor. Take extra care when handling the thermistor.***

1. The charger can be accessed from under the rear seat(s) or the deck cover.
2. Disconnect wires (Red, and Black & White together) in charger output lead from battery B- and battery B+ (Figure 8-8). Disconnect green safety interlock wire.
3. Unplug power inlet cable from charger pigtail.
4 Remove nuts, washers, bolts and charger. See Figure 8-7.

### INSTALLATION

1. Position new charger to mounting bracket. See Figure 8-7.
2. Secure new charger with four nuts, washers and bolts. Tighten charger attaching hardware.
3. Install charger output electrical leads as follows; black and white to battery B-, red wire to battery B+. See Figure 8-8. Reconnect green safety interlock wire. V ehicle will not operate if wire is not attached.
4. Plug in cord from power inlet to charger pigtail. Tape the two plugs together so they cannot accidentally separate.
5. Bundle up the excess charger output cable and secure it neatly with wire ties.
6. Reconnect battery negative cable. Install Power key.
7. Reinstall deck panel (if equipped).
8. Power key ON. Check BDI display.

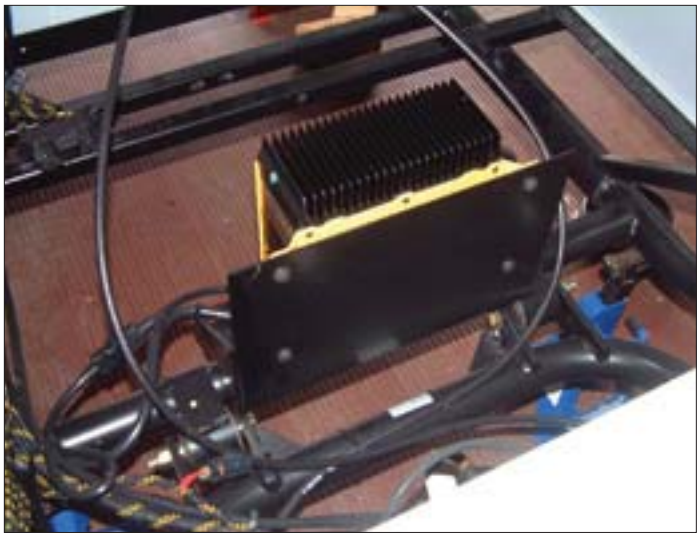


*Figure 8-7. Battery Charger Mounting Hardware*

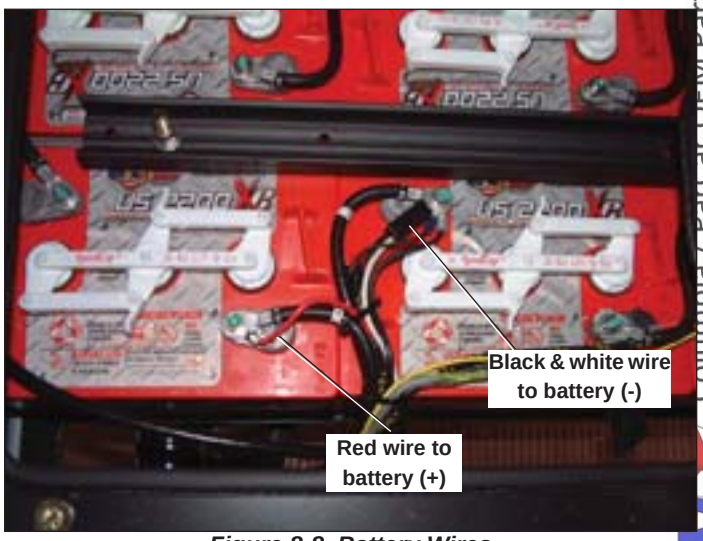



*Figure 8-8. Battery Wires*

## ELECTRIC VEHICLE SERVICE

When servicing the electric vehicle always observe the following:

**DANGER**

**Always turn power key to OFF, position directional selector to NEUTRAL, remove power key and block tires and disconnect battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.**

## TRACTION MOTOR

### Maintenance

A good planned maintenance program will save many hours of future down time and prevent catastrophic failure of major motor components. Maintenance schedules consist of periodic routine inspections of motors, battery and wiring circuitry.

Since operation of golf equipment varies widely, the following recommendations are suggested for periodic maintenance inspection:

Normal service – 8 hours per day operation

- Routine inspection every 1,000 hours

Severe service – 12-24 hours of daily operation

- Routine inspection every 500 hours

***NOTICE: Severe service would include; Dusty or sandy locations such as cement plant, lumber or flour mills, coal dust or stone-crushing areas. High temperature areas such as steel mills, foundries, etc. Sudden temperature changes such as continuous in-door-outdoor movement, as in refrigeration plants.***

### External Motor Inspection

1. Check for clean, tight, terminal studs and mounting bolts.
2. Internal and external spline drives, between motor and final drive axle, must be periodically lubricated with a thin layer of quality, anti-seize compound.
3. Check for any signs of oil leaks from final drive axle, which might cause oil to enter traction motor.

### Internal Motor Inspection

The brush and commutator inspection is the most important part of motor maintenance. By recognizing undesirable commutator and/or brush conditions, internal repairs can be performed before major component damage or failure occurs.

Brush and commutator inspection can be accomplished by removing the motor head. The brushes and commutator should be inspected for even wear and good commutation.

Good commutation will be indicated by a dark brownish, polished commutator and an evenly polished brush wearing surface. If the commutator appears rough, pitted, scored or has signs of burning or heavy arcing between the commutator bars, the motor should be removed for servicing.

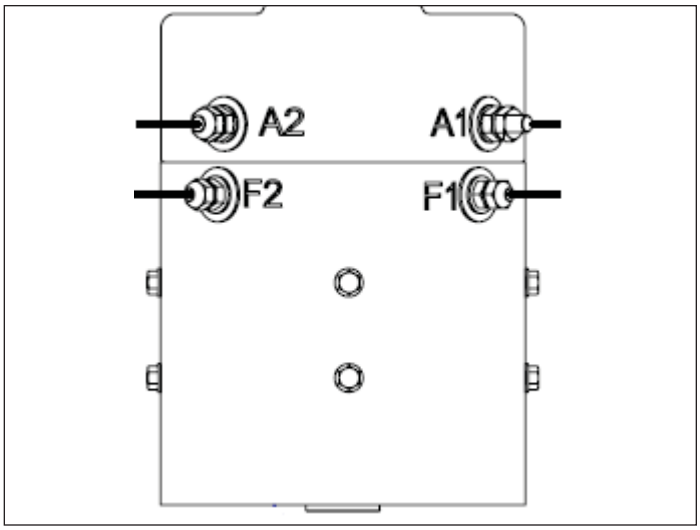



*Figure 9-1. Traction Motor Cables Labels*

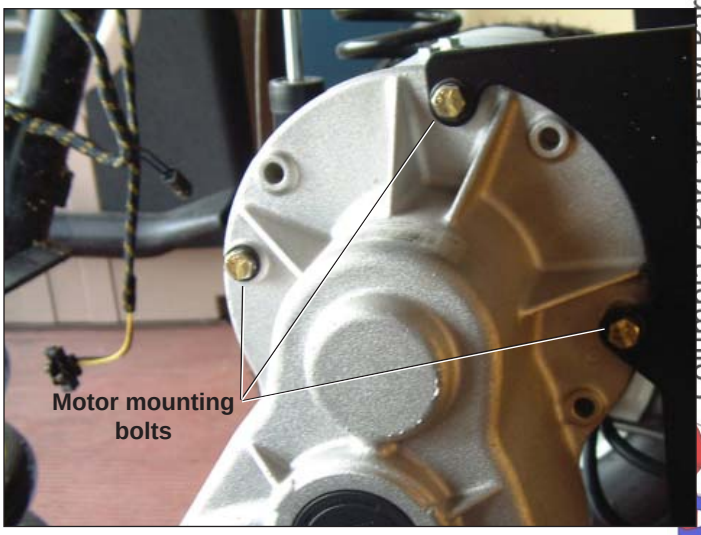



*Figure 9-2. Traction Motor Mounting*



### Traction Motor Removal

***NOTICE: Studs and jam nuts on the electric motor can be damaged when attaching or removing electrical leads. Hold a thin open end wrench on the electrical stud connector jam nut while loosening or tightening attaching nuts.***

1. Mark traction motor cables (if not already marked), with motor terminal identification. Figure 9-1.
2. F1 and F2 terminals are 1/4-20 UNC. A1 and A2 terminals are 5/16-18 UNC. Hold terminal jam nut with a thin open end wrench when loosening and removing hex nuts, lock washers and flat washers securing electrical cables to traction motor.
3. If equipped with a speed encoder, disconnect wiring harness 3-pin connector.

4. See Figure 9-2. Carefully support motor to prevent it from falling, and loosen and remove three bolts, lock washers and flat washers securing motor to rear axle/differential housing. Pull motor away from rear axle housing and lift it clear of the vehicle.

**⚠ CAUTION**

**Traction motor is heavy and awkward to move. Get help stabilizing and lifting motor to prevent possible personal injury.**

### Traction Motor Disassembly

1. Remove long bolts. Remove motor head hole plug. See Figure 9-3.
2. If equipped with a speed encoder, remove 2 small screws and lift encoder out of the way. Remove round magnet from motor by removing hex socket head bolt.
3. Pull on motor head to remove armature from frame. A light tap may be required to loosen motor head from frame. Motor head and armature come out together.
4. Place puller around the motor head. Use the center of the shaft to locate puller. See Figure 9-4.
5. Pull motor head assembly off of armature assembly maintaining equal pressure on all sides of head.
6. Move brush springs behind spring hooks shown in Figure 9-5.
7. Remove 1 hex nut, 1 lock washer, 1 hex nut, 1 flat washer and 1 insulator at each brush terminal, A1 and A2. Figure 9-6.
8. Remove 4 brush plate screws (Figure 9-7). Push brush terminal studs through, into the center of the head as the brush box, brushes and terminal assemblies are removed. (See exploded view Figure 9-9).
9. Remove bearing retainer (snap ring) shown in Figure 9-5. Carefully press out the bearing from motor head. Replace the bearing.
10. Remove all the brush dust from motor frame, brush box, and motor head.

### Armature Inspection

1. Measure the diameter of the armature (Figure 10-8).

| | |
|---|---|
| Max dia. when new | 2.92-2.93” (74 mm) |
| Min dia. for re-slotting | 2.81” (71 mm) |
| Replacement dia. | 2.76” (70 mm) |

2. Support the armature at both bearing journals. Check runout of commutator with a dial indicator . Total indicated runout should not exceed 0.005” (0.12 mm). If the readings fall outside this limit, commutator must be turned and undercut. Figure 9-10.
3. After the commutator has been undercut, if required, the armature should be placed in lathe and the commutator lightly sanded with no. 00 sandpaper. This will remove any burrs left from the undercutting operation.
4. Clean commutator with dry , compressed air. Recheck commutator runout.

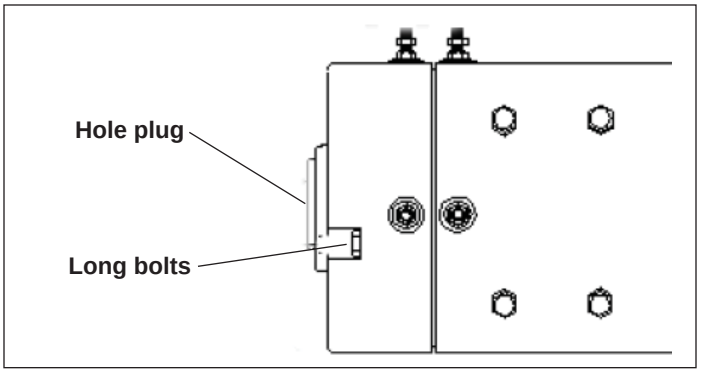



*Figure 9-3. Traction Motor Hardware*

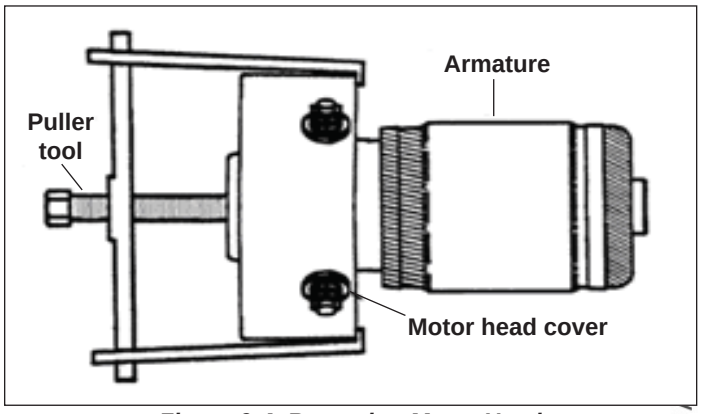



*Figure 9-4. Removing Motor Head*

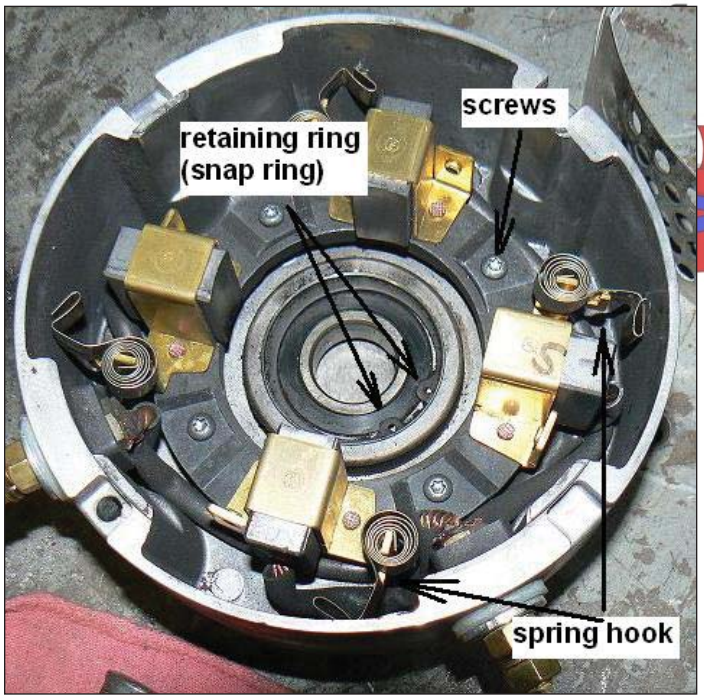



*Figure 9-5. Spring Hooks for Brush Springs*



### Armature Testing

Before the armature is reassembled into the motor , the following test should be performed.

1. Check armature for grounded circuits by placing one test lead of a Dielectric Breakdown Tester, also referred to as a “growler”, on the commutator and other lead at armature shaft. The ground test light should not f ash. A f ash indicates failed insulation between core and armature wiring. See Figure 9-11.
2. For short circuit connection, use a hacksaw blade to locate any shorted windings. Rotate armature slowly in growler jaws and hold a hacksaw blade in parallel against top of armature. The steel blade will be attached to the core and will vibrate when two shorted armature coils are located. See Figure 9-12.

### Brushes

Brushes should be inspected for uneven wear and signs of overheating, such as discolored brush leads and brush springs. Check brush box for physical damage. Make sure brush holders are not loose on the brush box assembly. See Figure 9-9.

Check brush for correct clearance and freedom of movement in the holder.

| | |
|---|---|
| New brush length: | 1.20” (30.5 mm) |
| Minimum brush length: | 0.60” (15.2 mm) |
| Replacement brush length: | less than 0.60” (15.2 mm) |

If any brushes are worn to the point that replacement is necessary, the complete brush set should be replaced. Never replace just one pair of brushes.

Do not substitute brushes. The brushes are matched to the motor type and application to provide the best service. Substituting brushes of the wrong grade can cause commutator damage or excessive brush wear.

### Brush Springs

Check the brush springs for correct alignment on the brush. A brush spring that does not apply equal pressure on the center of the brush will cause the brush to wear unevenly.

Use the following procedure for checking brushes for proper tension. See Figure 9-13.

1. Place paper strip between brush face and commutator.
2. Hook a commercial spring scale as shown.
3. Pull spring scale on a line directly opposite the spring force. When paper strip can be moved freely read spring tension on scale.

| | | |
|---|---|---|
| Brush spring tension | new | 64 ounces (1792 grams) |
| | worn | 40 ounces (1120 grams) |

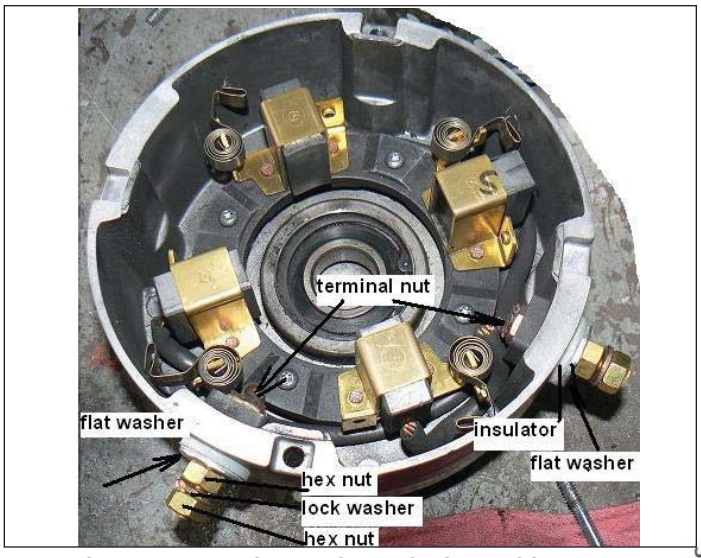



*Figure 9-6. Brushes and Terminal Attaching Parts*

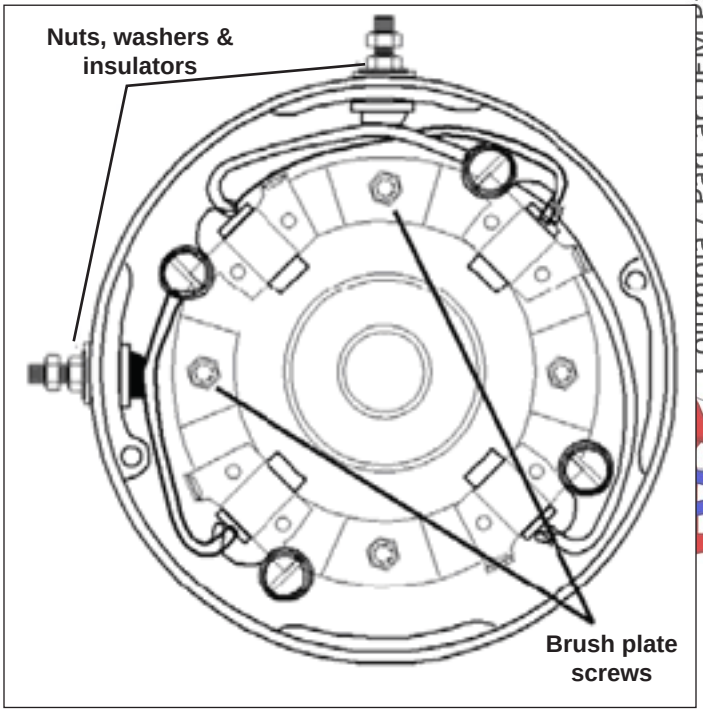



*Figure 9-7. Brush Box and Brushes*

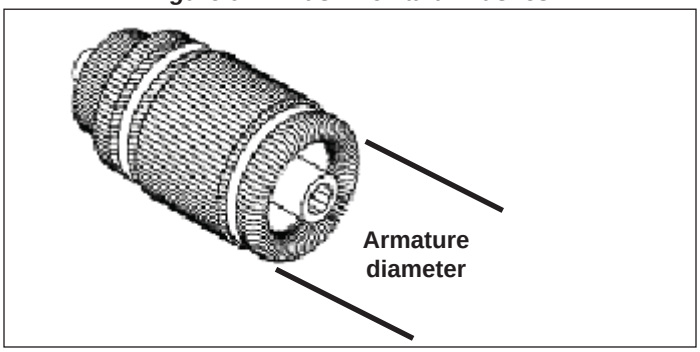



*Figure 9-8. Armature Inspection*



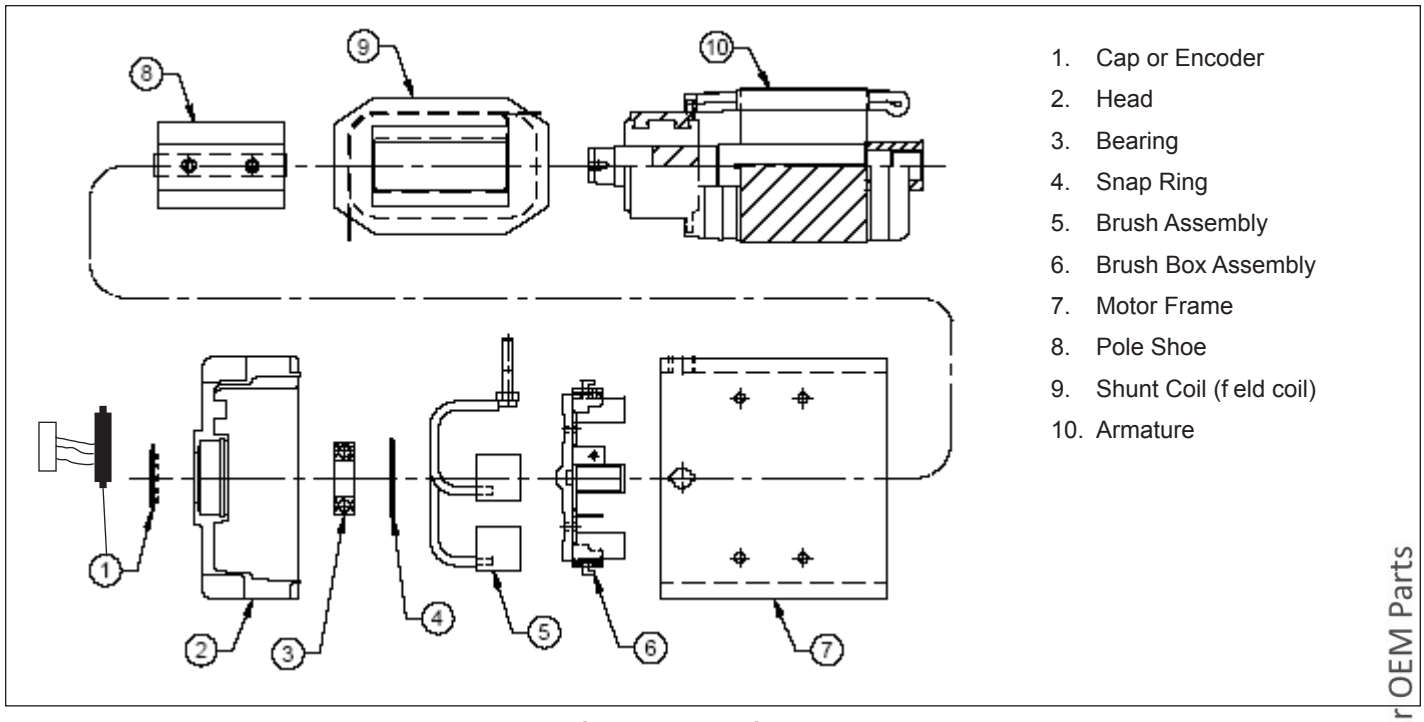



*Figure 9-9. Traction Motor*

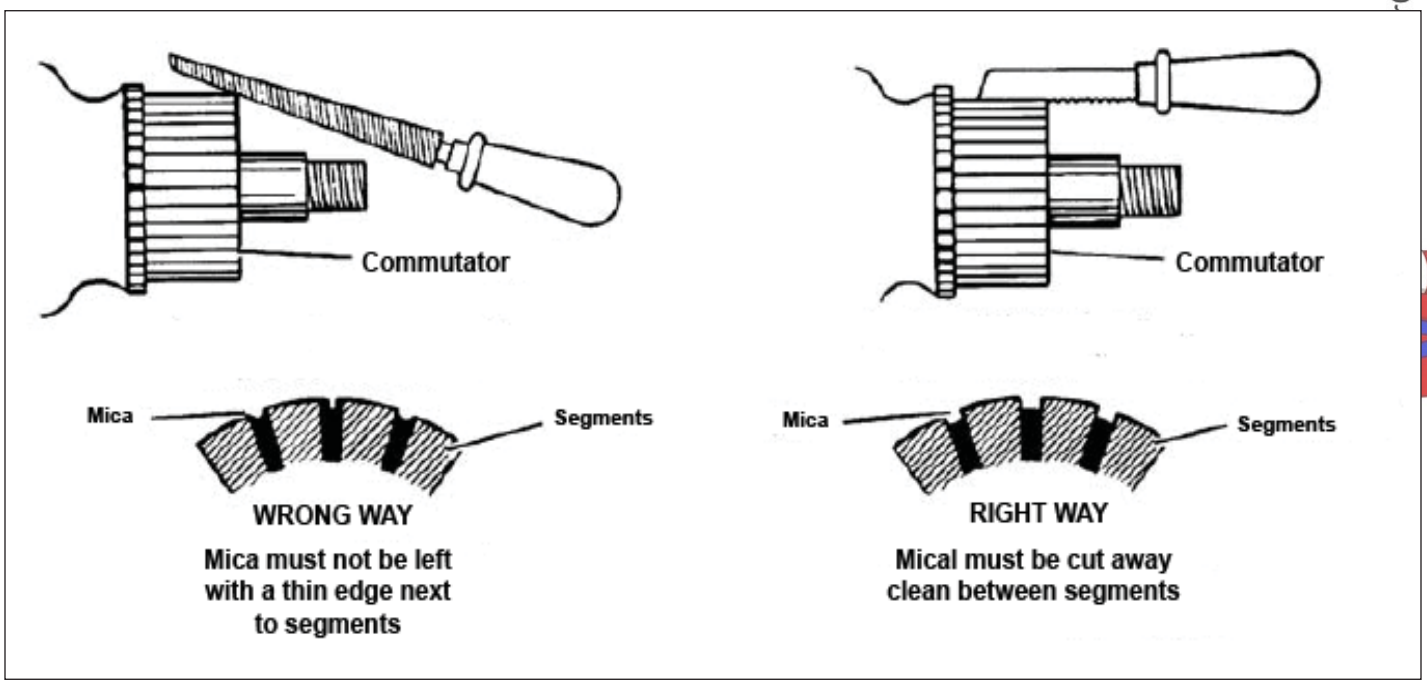



*Figure 9-10. Undercutting the Armature*



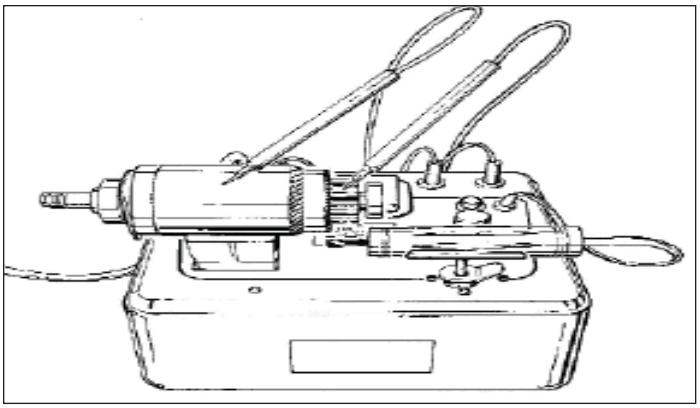


*Figure 9-11. Checking Armature for Grounded Circuits*

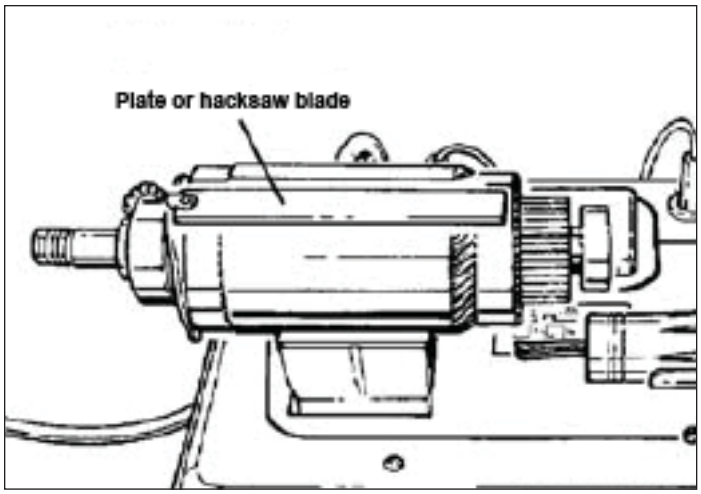



*Figure 9-12. Checking Armature for Shorted Windings*

### Bearing

After the motor has been disassembled, it is recommended that a new bearing be installed. Bearing may appear and feel ok, however, bearing may have been damaged during removal.

### Frame and Field Coils

***NOTICE: Do not remove the field coils (9, Figure 10-9), from the motor frame unless it is absolutely necessary for repair. Removal and re-installation could shorten field coil life.***

There should be no continuity between the frame of the motor and f eld coil (Figure 9-9). Set the volt ohm meter (VOM) to measure Ohms. See Figure 9-14.

### Field Coil Maintenance

NOT recommended by Columbia.

### Inspection

Motors that have been disassembled for servicing should also include a complete inspection of the frame and f eld assembly. It is not uncommon for the frame and f eld assembly of a motor to become exceptionally dirty after many hours of operation. This may result in a grounding condition due to dirt, grease and other foreign materials

### Traction Motor Reassembly

1. Always use a new bearing when reassembling a motor. Press bearing into motor head. Press only against the outer race. See Figure 9-15. Install snap ring to retain bearing. Figure 10-16.
2. Assemble brush assemblies into brush box assembly.
3. Position brush holder into motor head as shown in Figure 9-16. Make sure that the terminals for the brushes are loose and free.
4. Install insulators and brush leads into motor head. See Figure 10-17. Brush motor terminals, A1 and A2, should be torqued to 140 in. lbs. (15.8 Nm).

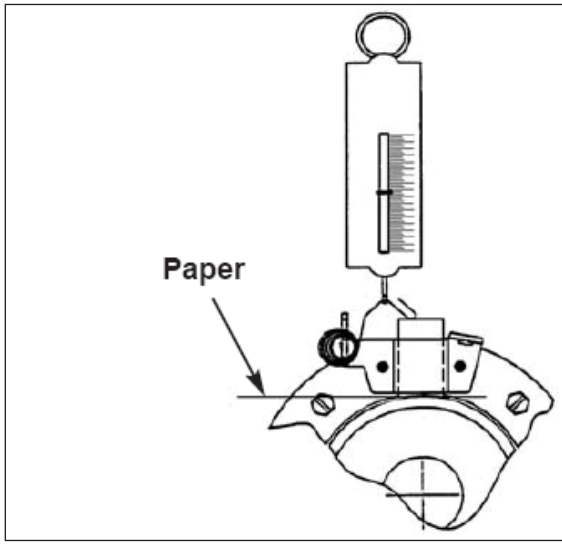



*Figure 9-13. Brush Spring Pull Test*

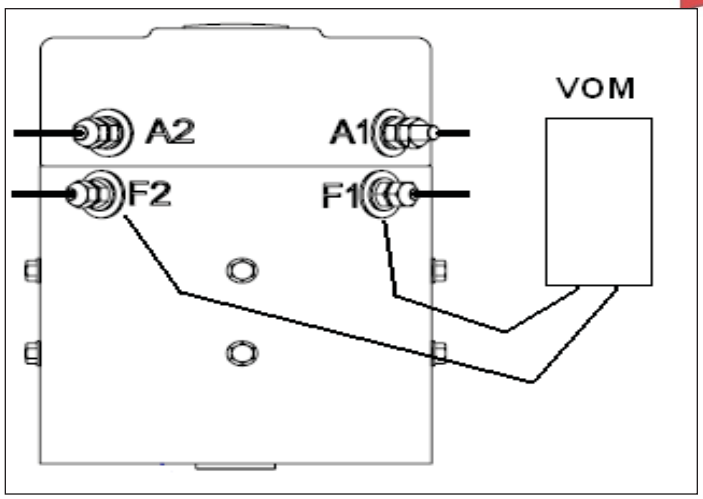



*Figure 9-14. Testing for Continuity Between Motor Frame and Field Coil*



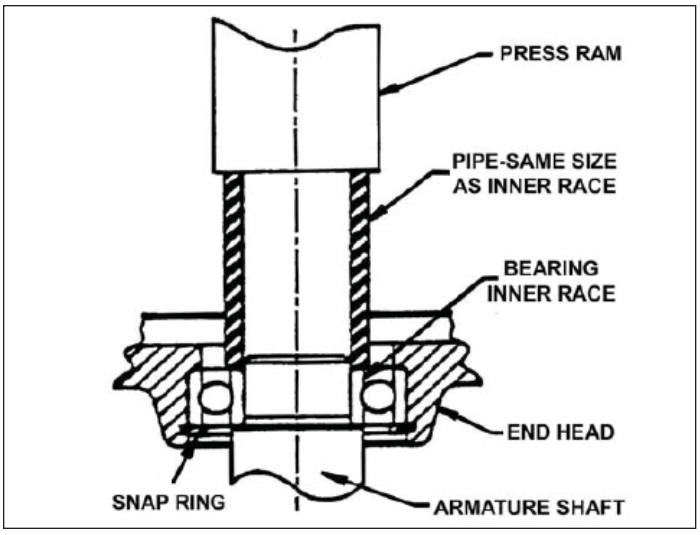



*Figure 9-15. Press Bearing and End Cover onto Assembly*

5. Pull back each brush in it's holder, allowing the spring to rest against the side of each brush. This will hold each brush in place, preventing interference and damage to commutator and brushes during armature installation.
6. Press motor head and bearing onto armature, pressing only against inner race of the bearing. See Figure 9-15.
7. Check that head and bearing rotates freely , without noise or irregular interference. Press brushes inward against armature commutator. Relocate the springs to push on the brushes. Check that brushes ride smoothly on the commutator.
8. Install motor head and armature assembly into f eld coil and frame assembly, aligning armature terminals to f eld coil terminals.
9. Install two bolts securing motor head to frame. Make certain motor head is completely seated to the frame before tightening. Torque bolts to 156 in. lb. (17.6 Nm).

### Traction Motor Installation

1. Coat open end of the armature and rear axle input shaft with Anti-Seize compound. Insert a new rubber bumper into open end of armature. Place motor into vehicle and onto input shaft.
2. Rotate motor to align mounting bolt holes to axle/dif ferential housing. Install 3 bolts securing motor to rear axle/differential housing, while carefully supporting motor to prevent it from falling. Loosely tighten screws A and B, then loosely tighten screw C to draw face of motor up to f ange on axle evenly (Figure 10-18). Torque screws A and B to 100 in. lbs. (1 1.3 Nm) Then tighten screw C to 100 in. lbs. (11.3 Nm).
3. Inspect electrical system cables for terminal identi f cation (A-1, A-2, etc.). Position cables to traction motor , double checking wiring diagram to motor cable installation to ensure connections are correct.

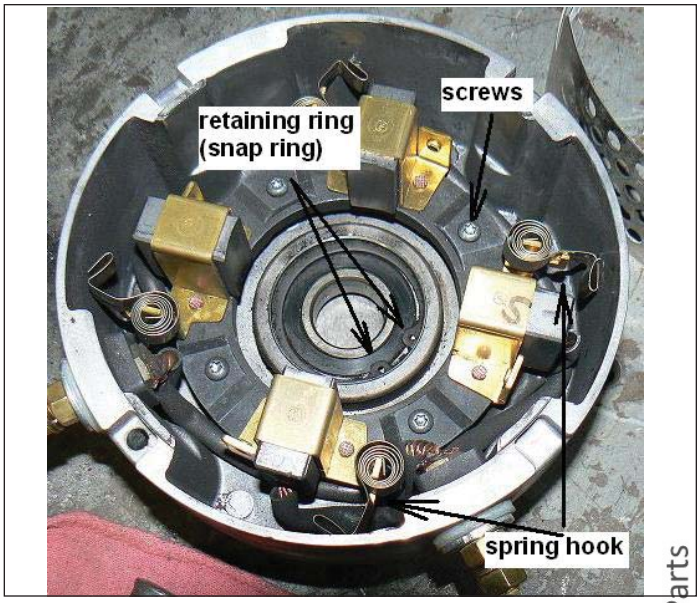



*Figure 9-16. Spring Hooks for Brush Springs*

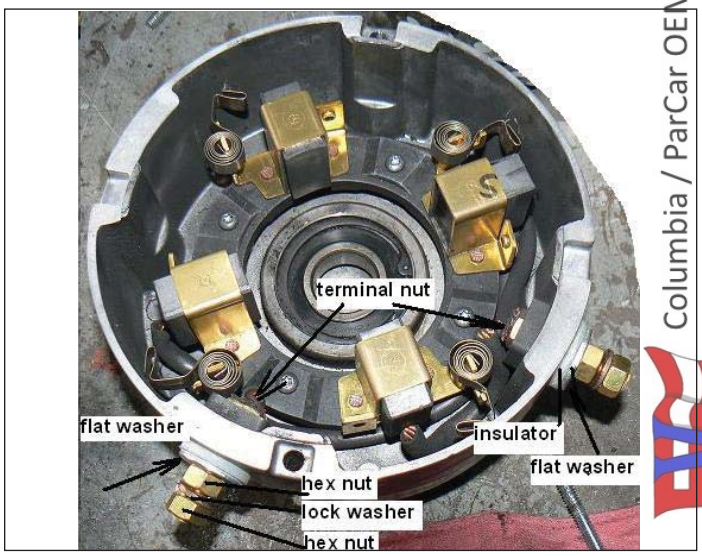



*Figure 9-17. Brushes and Terminal Attaching Parts*

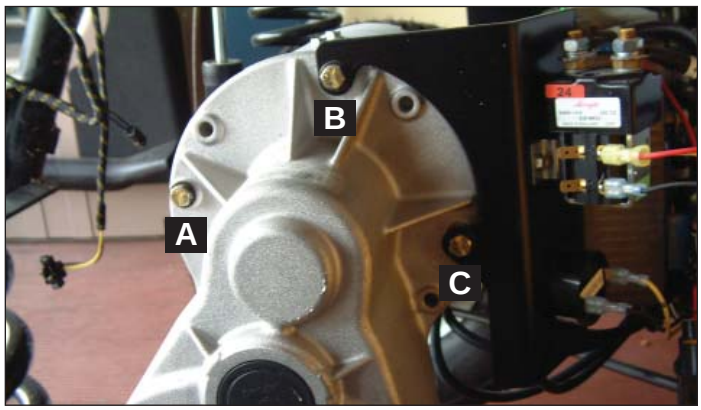



*Figure 9-18. Motor Attaching Bolts*



4. F1 and F2 terminals are 1/4-20 UNC while A1 and A2 terminals are 5/16-18 UNC. Attach cables with flat washers, lock washers and hex nuts.

   Torque A1 & A2 cable attaching nuts to 110 in. lbs. (12.4 N m), while holding the bottom nut, with a thin open-end wrench. Torque F1 & F2 cable attaching nuts to 50 in. lbs. (5.7 Nm), while holding the bottom nut, with a thin open end wrench.

5. If equipped with a speed encoder, reconnect it at this time. If not connected, vehicle will not operate at correct speeds.
6. Place vehicle on the ground or onto dynomometer to test motor operation.

**⚠ CAUTION**

**Do not run motor at full voltage without a load.**

## CONTROLLER

### ACE*plus* Traction Motor System

The ACE*plus* System is an advanced traction drive system that uses a fully integrated, solid state Sevcon Controller for speed regulation and forward/reverse control. Combined with a separately excited DC motor, the system provides optimized power efficiency through pedal proportional speed control and regenerative braking. This control system is ideal for hilly terrain or areas with multiple ramps. It is also used for towed loads and high braking demands. The ACE*plus* system is distinguished by a 6 post controller. See Figure 9-20.

### Controller Testing

Do not remove the controller. It can be tested while still in the vehicle.

1. Look for the steady green light on the controller. If it is on, the system is OK and ready (Figure 9-20). This light is also located on the vehicle dash panel and labelled “System” (Figure 9-21)
2. If it is flashing, count the number the flashes in each sequence. Refer to *Section 4 - Troubleshooting* for controller flash troubleshooting info, and for info on testing controller with Sevcon Calibrator or PC Pak computer interface.
3. If the tests indicate that the controller has failed, replace it.

### Removing the Controller

1. Label/mark controller cables with controller terminal identification, if not already labeled. See Figure 9-20.

***NOTICE: The controller terminal bolts and washers are Metric. Metric wrenches are required to remove the controller cable fasteners. The fasteners that attach the controller to the vehicle frame are SAE U.S.***

2. Remove six metric bolts, lock washers, flat washers and all the cables and wires connected to the controller.
3. Remove 16 pin controller connector at port B in the lower left hand corner of the controller (Figure 9-22). See *Columbia Service Bulletin 06-010* if the wiring harness or connector are damaged.
4. Remove four nuts, washers and bolts securing controller to mounting plate. See Figure 9-22.

***NOTICE: Do not attempt to disassemble the controller. There are no repairable parts inside.***

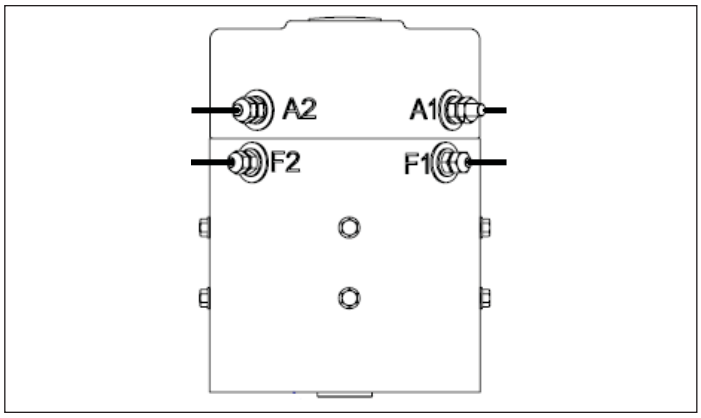



*Figure 9-19. Traction Motor Cables Labels*

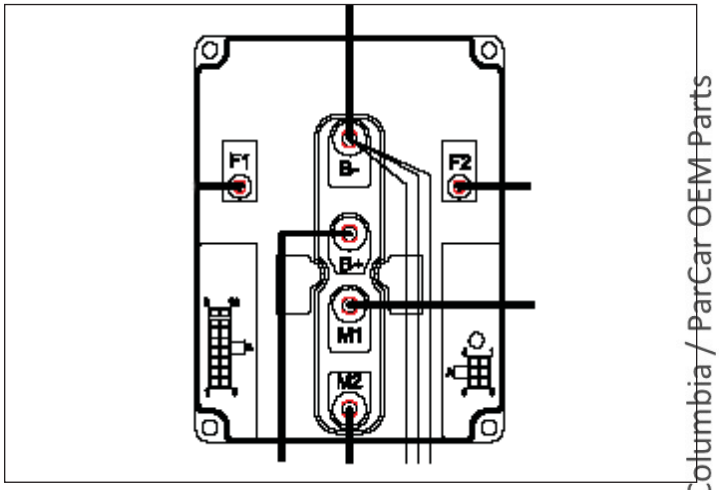



*Figure 9-20. 6 Post ACEplus Controller*


*Figure 9-21. System LED on Dash*

### Installing the Controller

1. Position new controller to mounting bracket. Secure controller with four bolts, washers and nuts. Figure 9-22.
2. Install cables to controller terminals according to schematic, and to cable identification labels. Make sure there is a flat washer under the terminal ends of the cables.This will spread the load and help prevent the terminal ends from folding over See Figure 9-22.

   Sometimes a cable terminal end has been replaced and the bolt hole may be too big for thef at washer. Install a bigger flat washer to help prevent the oversize terminal end from folding over.
3. Torque controller cable attaching bolts to 50 – 60 in. lbs. (5.7 – 6.8 Nm).
4. Reconnect battery negative cable. Insert Power key in switch.
5. Check for steady green light on new controller and system LED on dash (Figure 9-21).
6. Perform an operational check of the vehicle's driving abilities.

## MAIN CONTACTOR/SOLENOID

This solenoid is an electro-magnetic switch that energizes when current is applied to the small control circuit terminals. When energized, the solenoid core moves up from magnetism created by the coil and internal contacts, creating a connection between two large terminals, allowing current to pass through the solenoid.

When control circuit voltage is removed from the small terminals, the magnetic field collapses and a spring returns the core to its rest position. A single contact solenoid in the normal position has an open circuit between the large terminals, preventing current from passing through it.

Solenoids are mounted in vertical position. Gravitational pull aids internal spring in returning to normal position.

### Removing the Main Contactor

1. Label contactor cables with terminal identification. Refer to schematic for correct wire numbers.
2. Remove two nuts, washers and cables from stud terminals (Figure 9-23).
3. Remove control circuit wires from spade terminals.
4. Remove two nuts, washers, bolts and contactor (Figure 9-23).

### Installing the Main Contactor

1. Position new contactor to mounting bracket (Figure 9-23).
2. Secure contactor to mounting plate with two bolts, nuts and washers.

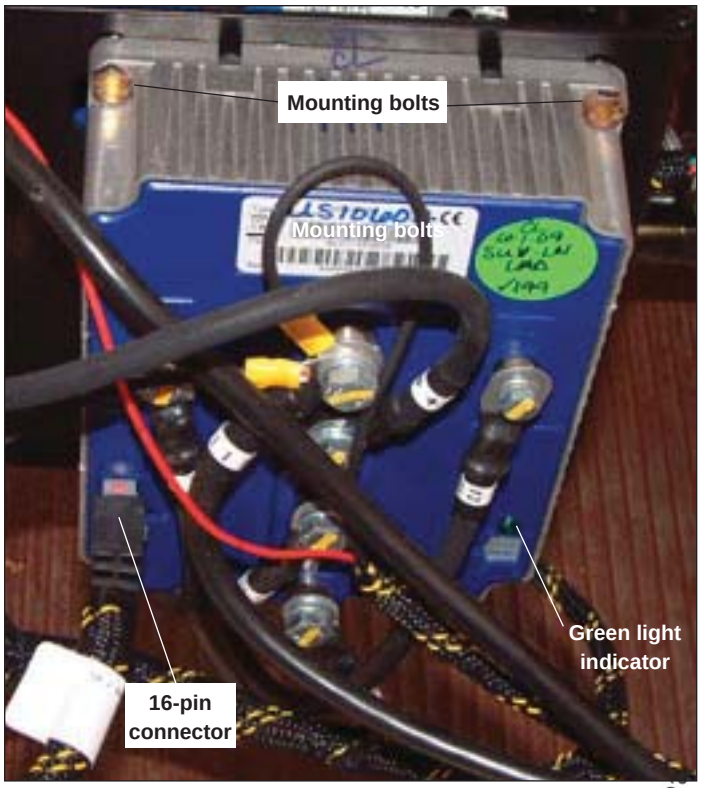



*Figure 9-22. Controller Mounting*

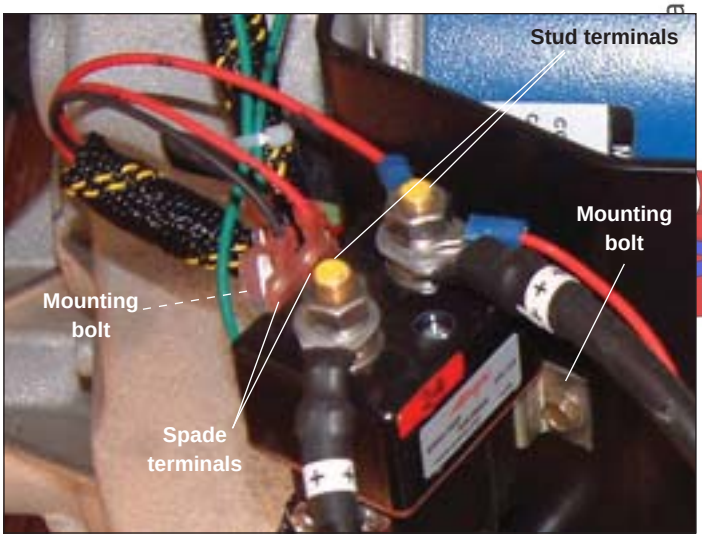



*Figure 9-23. Contactor Connections*

3. Install heavy cables to stud terminals. Install control circuit wires to spade terminals (Figure 9-23). Double check wiring diagram to ensure connections are correct.
4. Operational Check: Contactor should emit an audible click when the power key switch is set to ON position.

## NOTES



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