COLUMBIA®

Columbia ParCar Corp.

SERVICE MANUAL

Models

IS12 Stockchaser

IR23 ROVR

IT34 TUGR

GENERAL

This service manual has been prepared with two purposes. First, it will introduce the trained maintenance professional to the latest field 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 profitable 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 specified. 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 efficient 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 identification number (VIN) when ordering parts or making inquiries about the vehicle. Use of the full and complete vehicle identification 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 fit 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 specific brand name product, tool or instrument, an equivalent product, tool or instrument may be used in place of the one mentioned.

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Table of Contents

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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 done 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.

⚠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 (indoor vehicle operation hazards are encountered.

⚠DANGER

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 and disconnect the batteries 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 9-Batteries* for details.

Batteries contain acid which can cause severe burns. Causes 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.**

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 made. Failure to make necessary repairs could result in fire, property damage, severe personal injury or death.

⚠WARNING

Only trained maintenance professionals should repair or service this vehicle. Persons doing 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.

Proper service and repair is important for safe, reliable operation of all Columbia Industrial/Commercial 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! Watch for international symbol icons in the margins. 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.

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.

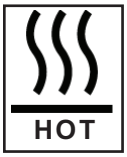
Working on Columbia ParCar vehicles without following proper procedures and using proper lifting equipment may result in vehicle damage or personal injury. See *Section 3 - Lifting Instructions* detailed instructions.

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.

Check the vehicle for proper location and condition of all vehicle safety and operation decals. Refer to pages 1-4 & 1-5 for locations.

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

Industrial vehicles are designed to transport one (1) operator unless adequate provisions have been factory installed to accommodate additional passengers.

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.

Before operating vehicle, always properly distribute and secure loads.

Cautions appear throughout this manual indicating possible hazards or unsafe practices that may result in minor personal injury, damage to vehicles or property.

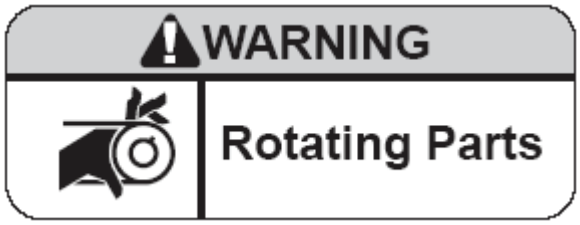
SAFETY PREPARATIONS

⚠ SAFETY FIRST ⚠

Always turn Power key to OFF, Directional key switch to Neutral, remove Power key, block tires and disconnect the battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.

ICONS IN PROCEDURES

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



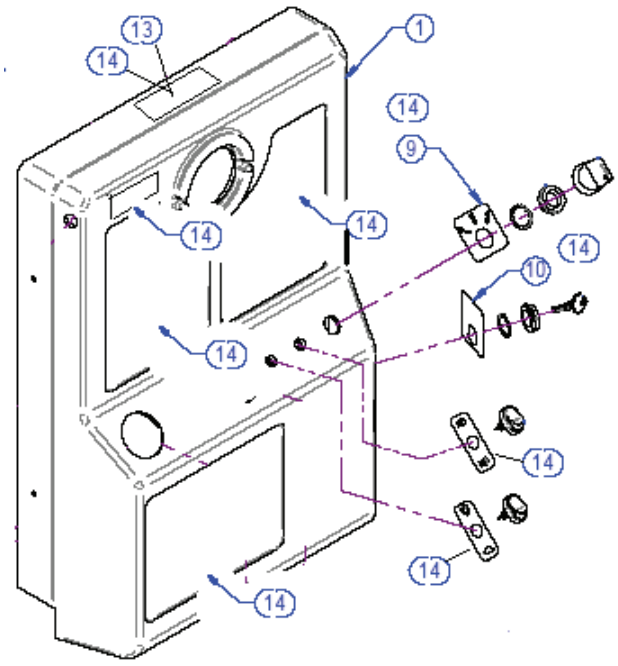
Example of safety related icon or symbol used throughout this manual.

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.

Refer to Figures 1-1, 1-2 and 1-3 for locations of these decals.

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.



1. **Console**
9. **F–N–R decal, Directional keyswitch**
10. **On, Off Power Switch**
13. **“Important” Decal**
14. **Decal Kit (includes all decals shown) Warning, Safety and Operation Instructions, F-N-R, ON OFF, Horn**

Figure 1-1. Decal Locations

Figure 1-2. Decals on Left Side of Control Console

Figure 1-3. Decals on Right Side of Control Console

MODEL INFORMATION

Vehicle Model Information

Model	Group Identifiers VIN Digits 1-3	Name	Use Type	Power System
IS-12	12S	Stockchaser™	Burden Carrier	Battery 24/48 Volt
IS-23	12R	ROVR™	Utililty	Battery 24/48 Volt
IT-34	12T	TUGR™	Utililty	Battery 24/48 Volt

Vehicle Identification Number (VIN) Charts

8 OR 9 DIGIT VIN–USED UP TO JANUARY 2006 (EXAMPLE 6TD-12345)	
Digit 1 = Power System	4 = XP + (Prior to 2003) 5 = XP + (After 2003) 6 = Ace +
Digit 2 = Model	T = Stockchaser, IS11 (12/01/04) T = Stockchaser, IS12 (2/28/05) W = ROVR 480, until 2005
Digits 3 & 4 = (when used) Factory Modifications/Options	D = 48V Power System 8 = 6V Batteries E = 48V Power System 6 = 8V Batteries
17 DIGIT VIN–USED FROM JANUARY 2006-FEBRUARY 2006 (EXAMPLE IS1206-C23Z11234)	
Digit 1 = Abbreviation (Model)	IS12 = IS Stockchaser IR23 = IR ROVR IT34 = IT TUGR
Digits 5-6 = Model Year	05 = 2005 06 = 2006
Digit 7 = Spacer	–
Digit 8 = Power System	C = Smart*drive* LP D = Smart*drive* HP E = Ace*Plus*
Digit 9 = Controller Voltage	2 = 24 volts DC 3 = 36 volts DC 4 = 48 volts DC
Digit 10 = Controller Amperage	3 = 300 Amps 4 = 400 Amps 5 = 500 Amps
Digit 11 = Brake System	Z = Rear Mechanical
Digit 12 = Warranty Length	1 = 1 Year
Digit 13-16 = Sequence	1234
Digit 17 = Special Character	(Blank) = not applicable S = Special Product

13 DIGIT VIN–USED AFTER FEBRUARY 2006 (EXAMPLE 12SC2-3ZF1234)	
Digit 1-3 = Abbreviation (Model)	12S = Stockchaser, IS12 12R = ROVR, IR23 12T = TUGR, IT34
Digit 4 = Power System	C = Smart*drive* LP D = Smart*drive* HP E = Ace*Plus* LP
Digit 5 = System Voltage	2 = 24 volts DC (4-6V) 3 = 36 volts DC (6-6V) 4 = 48 volts DC (8-6V)
Digit 6 = VIN Spacer	- = Normal # = Special Product
Digit 7 = Controller Amperage	3 = 300 Amps 4 = 400 Amps 5 = 500 Amps
Digit 8 = Axle/Brake System	Z = Rear Mechanical
Digit 9 = Build Year	E = 2006 F = 2007 G = 2008
Digits 10-13 = Sequence	1234

NOTICE

Always provide the complete VIN when contacting your dealer for technical assistance or maintenance and repair parts.

The VIN is printed on a white label, affixed to the fender, to the right of the accelerator pedal (Figure 2-1). It is also hand stamped into a frame member on the right hand side of the vehicle (Figure 2-2).

Figure 2-1. VIN Location on Fender

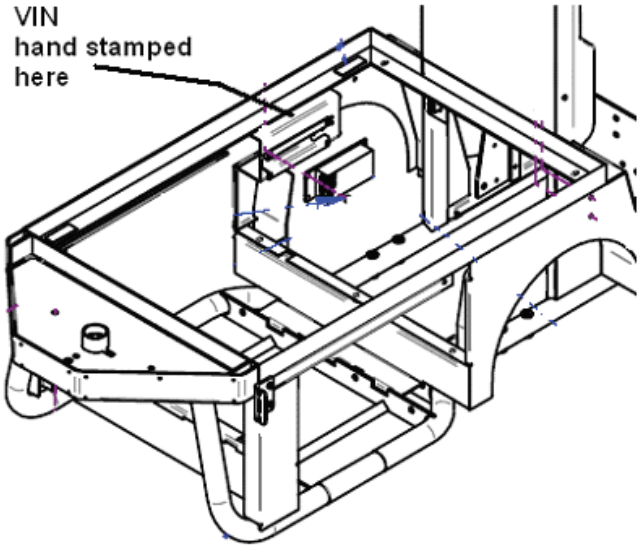


Figure 2-2. VIN Location on Frame

SAFETY COMMITTEE

If the Industrial & Commercial 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:

a. Define where the vehicles should and should not be driven and utilized.

b. Ensure all proper warnings as to driving hazards are properly displayed and visible.

c. Safety signage concerning hills, turns, blind crossings or intersections is highly recommended.

d. Enforcement of safe driving and operating rules.

e. Provide driver training for first time operators, and review safe operating recommendations regularly.

f. Maintain vehicles in a safe operating condition. Maintain a schedule for daily, weekly, and monthly vehicle inspections.

g. Determine who, when and how pre-operation inspections should be conducted.

h. Enforcement of safe driving and operating rules.

i. Define who should and who should not drive the vehicles.

j. Decide what to do should an unsafe condition or operating problem be discovered.

k. Enforce that vehicle should not be operated by persons under the age of 16.

NOTICE

Refer to OSHA regulations for additional requirements regarding operator training.

These basic rules of operation, combined with courtesy and common sense, will help make driving your Columbia ParCar Vehicles a safe and pleasant experience.

VEHICLE SPECIFICATIONS

Optional transaxles may be used for different applications.

Optional tire styles and sizes are available for different applications.

Columbia Industrial & Commercial 3-Wheeled Vehicles are designed to conform to ANSI B56.8 and OSHA standards.

Columbia ParCar Corporation reserves the right to change specifications, equipment or designs at any time without notice and without incurring obligations.

VEHICLE SPECIFICATION CHART

Item	Specifications	Vehicle		
	Power Source	IS 12	IR 23	IT 34
Motor	24 volt, 5.2 hp @ 875 rpm w/12.44 ratio	std		
	24 volt, 5.2 hp @ 875 rpm w/14.76 ratio		std	
	48 volt, 15.3 hp @ 1750 rpm w/12.44 ratio	opt		
	48 volt, 15.3 hp @ 1750 rpm w/14.76 ratio		opt	
	48 volt, 15.3 hp @ 1750 rpm w/16.99 ratio			std
Drive	Direct coupled to oil bath, helical geared, rear axle	√	√	√
Speed Control	Programmable, solid state, reduced speed reverse with diagnostic LED and calibrator interface	√	√	√
Rear axle	12.44:1 helical gear reduction with integral differential	std.		
	14.76:1 helical gear reduction with integral differential	opt.	std.	
	16.99:1 helical gear reduction with integral differential		opt.	std.
Batteries Deep Cycle	24 Volt: 4 - 6 volt, heavy duty, 220 Ah	std.	std.	
	24 Volt: 4 - 6 volt, heavy duty, 244 Ah	opt.	opt.	
	48 Volt: 8 - 6 volt, heavy duty, 220 Ah	opt.	opt.	
	48 Volt: 8 - 6 volt, heavy duty, 244 Ah	opt.	opt.	std.
Charger	Built in, micro-processor control, fully sealed, anti-drive away interlock, 110-240 V AC, 50/60 Hz	√	√	√
	24 VDC, 110-240 V AC	std.	std.	
	48 VDC, 110-240 V AC	opt.	opt.	std.
Directional Control	Console mounted Safety Directional Keyswitch with F (forward), R (reverse) and N (neutral)	√	√	√
Brakes	Spring applied, auto-adjusting mechanical drum on rear wheels, parking brake automatically applied upon dismount, anti-rollaway feature.	√	√	√
Steering	Direct steering, chain and rod linkage from steering wheel to front wheels	√	√	√
Tires	4.80” x 8” pneumatic, 6 ply rating, load range C	√	√	√
Body Chassis	Heavy duty welded tubular steel chassis with 14 gauge diamond plate steel body	√	√	√
Rated Capacity	Total number of occupants	1	1	1
	Cargo not to exceed __ lbs, including driver	1,000 w/48 volts, 1200 w/24 volts	800	800
Towing Capacity		2000 w/24 volts 4000 w/48 volts	2000 w/24 volts 4000 w/48 volts	6000
For a full list of dimensions and capacities, refer to the vehicle’s Owner’s Manual.				

CONTROLS AND OPERATION

Location of Controls

Figures 2-3, 2-4 & 2-5 show the location of the vehicle's controls.

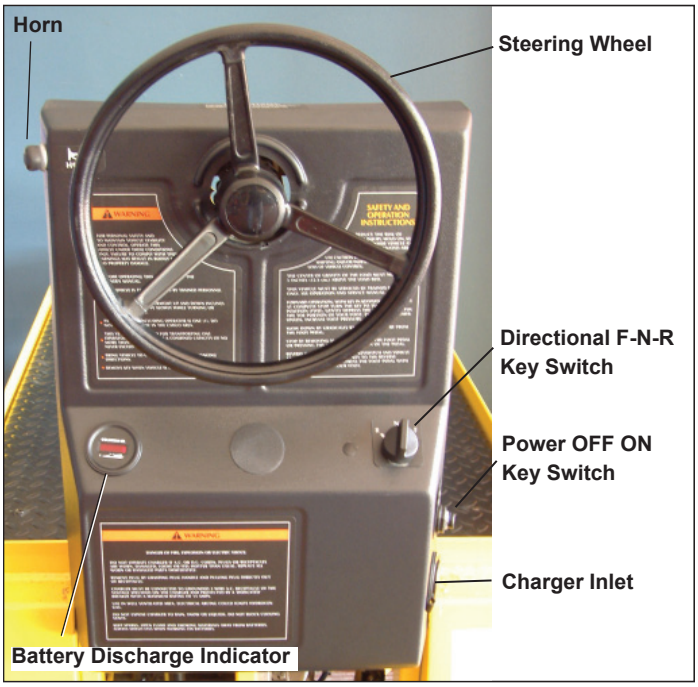


Figure 2-3. Location of Operator Controls-Later Style (without Hour Meter and Light Switch)

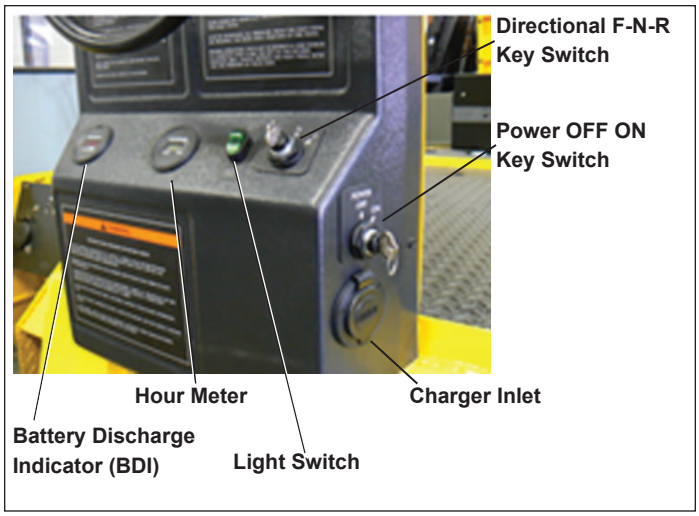


Figure 2-4. Console Controls;-Early Style (with Hour Meter and Light Switch)

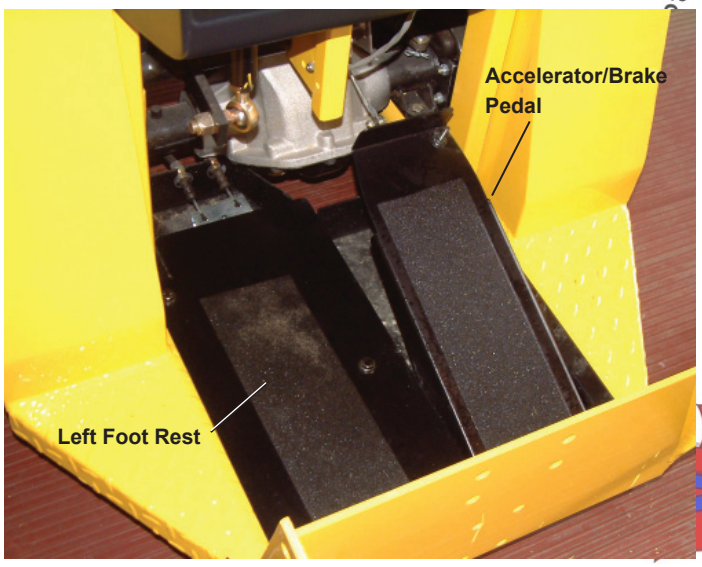


Figure 2-5. Accelerator / Brake Pedal

Operation

NOTICE

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

Simple controls make it easy to operate the vehicle. To operate the IS12 Stockchaser, IR23 ROVR or IT34 TUGR, follow these steps:

1. Place feet in proper stance and position on the pedals.
2. Set the power key switch to the ON position (Figure 2-4).
3. Set the directional key switch to the desired direction of travel (F=Forward, R=Reverse) (Figure 2-4).
4. Depress accelerator with the right foot (Figure 2-5)
5. To stop the vehicle, release the accelerator/brake pedal slowly and completely. Rapid release of the pedal will stop the vehicle abruptly.

⚠WARNING

Be sure safety directional key switch is in desired direction of travel before depressing accelerator.

⚠CAUTION

COMMERCIAL AND INDUSTRIAL VEHICLES

Industrial vehicles are designed to transport one (1) operator unless adequate provisions have been factory installed to accommodate additional passengers.

Never exceed the rated load capacity or vehicle stability or reliability and control will be reduced. See Vehicle Identification Plate (VIN) for capacities.

Before operating vehicle, always properly distribute and secure loads.

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 doing 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.

PRE-OPERATION CHECK LIST

Service Item	Service Method/Check	Reference
Vehicle Body	Visually, check for damaged or loose hardware.	See section 8.
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. Verify proper tire inflation.	Refer to Owner's Manual index for specifications.
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.	Refer to Owner's Manual index for specifications.
Head, Tail or Flasher, Lights	Check for proper operation	Verify lights and flashers work.
Batteries	Check "State of Charge" indicator for battery condition.	Refer to Owner's Manual index for specifications.

ELECTRIC VEHICLE SERVICE

When servicing the electric Columbia Industrial/Commercial vehicle always observe the following:

⚠ SAFETY FIRST ⚠

Always turn Power key to OFF, Directional key switch to Neutral, remove Power key, block tires and disconnect the 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 effective methods for performing periodic maintenance and repair.

The maintenance procedures outlined in this manual are recommended when servicing the Columbia Industrial & Commercial 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 Industrial & Commercial Dealer for assistance. Columbia Industrial & Commercial Dealers have the technical experience, training and original Columbia Industrial & Commercial Vehicle parts for the vehicle. Always use original Columbia Industrial & Commercial Vehicle parts when servicing the vehicle.

NOTICE

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

NOTICE

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

NOTICE

The environment that the vehicle operates in can vary widely. Severe service operations will require the periodic maintenance recommendations to be adjusted to shorter time intervals. Examples of severe service operations would include (but are not limited to) the following:

- **Dusty or sandy locations such as cement plant, lumber or flour mills, coal yards 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, etc.**

The following calendar is one example of how scheduling routine maintenance can be managed.

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 maintenances and is performed by the owner, operator or trained maintenance personnel.

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	x					
Hardware	Tighten as needed		x				
Wash vehicle and undercarriage		x					
Clean Body and Seat	Wash as needed		x				
Lubricate chassis	Lubricate pivot points						
Lubricate upper and lower steering hubs	Lubricate						
Warning and operating labels	Ensure labels in place and readable	x					

** Service done by Owner*

† Service done by trained maintenance personnel

MAINTENANCE SCHEDULE CHECKLIST - OPERATING CONTROLS							
Component	**Procedure**	**Daily***	**Weekly**	**Monthly†**	**Quarterly† (25 hours)**	**Semi-Annual† (50 hours)**	**Annual† (100 hours)**
Steering & Linkages	Check for free movement	x					
Accelerator Linkage	Check for free movement and return	x					
Brakes	Check brake operation	x					
	Check parking brake latching release	x					
	Check brake cables for damage				x		
	Clean and adjust brakes	x				x	
	Check rear brake drum/ axle nut torque (6.5 ft lbs)						x
Directional Keyswitch	Check for smooth Forward & Reverse operation	x					
Light Switch (optional)	Check for operation	x					

** Service done by Owner*

† Service done by trained maintenance personnel

MAINTENANCE SCHEDULE CHECKLIST - ELECTRICAL							
Component	**Procedure**	**Daily***	**Weekly**	**Monthly†**	**Quarterly† (25 hours)**	**Semi-Annual† (50 hours)**	**Annual† (100 hours)**
Batteries	Check charge (fill cells prior to charging	x					
	Check electrolyte level		x				
	Clean terminals and wash battery case		x				
	Test batteries						x
Electrical wires	Check for tightness or damage		x				
Reverse warning buzzer	Check for operation (use keyswitch)	x					

** Service done by Owner*

† Service done 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 wear and damage	x					
	Check tire pressure	x					
	Check for dented or damaged rims			x			
Front wheel alignment	Visually check, adjust necessary					x	
Lug nuts	Check for tightness	x					
Steering linkage	Check for excessive movement, tightness of hardware			x			

** Service done by Owner*

† Service done by trained maintenance personnel

MAINTENANCE SCHEDULE CHECKLIST - ELECTRIC MOTOR							
Component	**Procedure**	**Daily***	**Weekly**	**Monthly†**	**Quarterly† (25 hours)**	**Semi-Annual† (50 hours)**	**Annual† (100 hours)**
Operation	Test drive for proper operation	x					
Brushes	Inspect motor brush length and remove carbon dust						x
** Service done by Owner*							
† Service done by trained maintenance personnel							

MAINTENANCE SCHEDULE CHECKLIST - FLUIDS							
Component	**Procedure**	**Daily***	**Weekly**	**Monthly†**	**Quarterly† (25 hours)**	**Semi-Annual† (50 hours)**	**Annual† (100 hours)**
Differential lubricant	Check level					x	
** Service done by Owner*							
† Service done 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 power key switch is Off and key is removed from the switch.

Refer to *Chapter 9* for all procedures relating to the batteries.

CHASSIS LUBRICATION

The vehicle has 2 grease fittings in the upper and lower steering hubs. These fittings should get one pump of grease annually. See *Section 6 - Upper and Lower Steering Group.*

REAR AXLE

Check the rear axle oil only if signs of leakage are detected.

Change oil at 24 months or 1250 mile (2000 km) intervals, whichever occurs first. Refer to Section 7.

Capacity - 12 ounces (360 ml). Light weight gear lubricant SAE #30 oil.

CHASSIS CLEANING

The vehicle is constructed of 14 gauge E-Coated diamond plate steel.

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

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

⚠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 BACK CLEANING

Proper cleaning will extend the life of the vehicle seat back. 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 back. Cracking, splitting, or "melting" of seat materials may occur. If seat back 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.

Columbia ParCar Corp. does not endorse or recommend any procedure that lifts only the rear of any 3-wheeled vehicle.

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 lifting device, lift only on sturdy parts under the vehicle, an example being the frame. When using a floor jack, lift only on sturdy parts under the vehicle, an example being the frame or axle housing. 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. These vehicles are extremely unsteady when one side is raised. Use care to prevent tipping or rolling over.

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

Tools Required

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

If a floor jack is used to lift the vehicle, 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. Lower vehicle on to stands or wooden blocks and remove floor jack.

When work is completed, use floor jack, lift vehicle, and remove jack stands. Then, lower vehicle to the floor. See Figure 3-1.

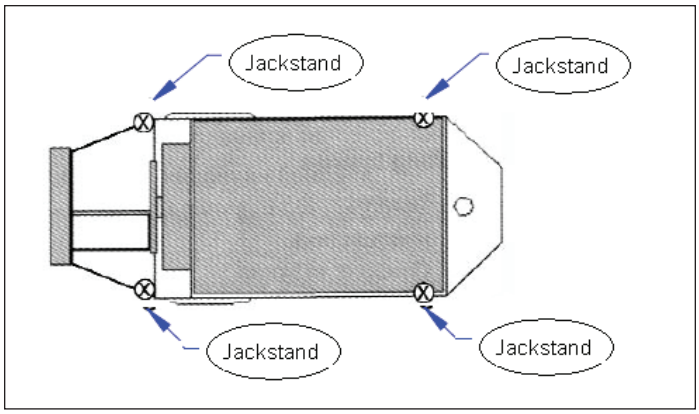


Figure 3-1. Lifting and Support Points

Floor Jack Procedure

1. Place jack under one side of vehicle on frame rail at point midway from front and back of vehicle.
2. Raise one side of vehicle with jack, and place a 6 – 8 inch block under both ends of vehicle being raised. Be careful not to angle too much or to tip over.
3. Slowly lower jack and move it to opposite side of vehicle.
4. Repeat lifting procedure previously described and position blocks corresponding to those on opposite side as described above.
5. Slowly lower jack and ensure that vehicle is supported by four blocks.
6. To lower vehicle, use above procedure in reverse order.

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.

⚠WARNING

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

VEHICLE STORAGE

⚠WARNING

Turn Power key switch OFF. Remove Power key during storage to prevent unintentional starting of vehicle.

⚠WARNING

Do not attempt to charge a battery that is frozen or if battery case is excessively bulged. Properly dispose of battery. Frozen batteries can explode.

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. Charge batteries fully. With electrolyte full in all cells, store batteries in as cool place as possible. If stored above 50°F (10°C), check state of charge every 4 to 6 weeks and charge as necessary to maintain 1.250 to 1.270 specific gravity. If vehicles are stored in temperatures below 40°F (4°C) check state of charge every 15 to 18 weeks. Use table below to determine freezing point of battery and maximum recommended storage temperature. Refer to *Section 9 - Batteries* in this manual for a charging procedure. Remove battery pack negative cable.
2. Wash off any corrosion around the terminals with a solution of baking soda and water. Do not allow this solution to enter batteries.
3. Store vehicle in a cool dry place to prevent battery discharge.
4. Maintain tire pressure at 60 psi during storage for 4.80 x 8 tires.
5. Grease upper and lower steering hubs and continue quarterly lubrication during storage period. Refer to periodic maintenance in the beginning of this section.
6. Clean vehicle body, seat, battery compartment and vehicle underside.
7. Block wheels to prevent movement.
8. Periodically charge battery during storage to prevent damage to battery. See step 1.

Specific Gravity and Freeze Point					
Specific Gravity	1.250	1.225	1.200	1.117	1.110
Freezing Point of Electrolyte	F C -65° -54	F C -39° -39	F C -18° -28°	F C -2° -19°	F C +17° -8°

RETURNING VEHICLE TO SERVICE

1. Reconnect battery negative (-) terminal.
2. Charge batteries fully.
3. Check tire pressure and readjust if necessary.
4. Perform initial maintenance per *Periodic Maintenance* in the beginning of this section.

TOWING THE VEHICLE

⚠CAUTION

Use only straps, chains or towing devices that are rated to handle the full weight capacity of the vehicle in tow.

⚠CAUTION

Use caution and common sense while towing disabled vehicles.

- **Use a tow chain, strap or towing device long enough to provide a safe distance between vehicles.**
- **Connect the selected towing device to the front tubular frame undercarriage.**
- **Connect the towing device to the towing vehicle frame.**
- **Turn Power key to the Off position. Remove key.**
- **Release the brake.**
- **Do not exceed 5 MPH (8 KPH) while towing.**
- **Allow only one person in the towed vehicle to steer and apply additional braking, as necessary.**
- **Tow only one vehicle at a time.**
- **Avoid sudden stops, sudden starts and sharp turns while towing.**

TRANSPORTING THE VEHICLE

⚠WARNING

Remove power key from vehicle.

⚠CAUTION

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

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

- Use trailers specifically designed to carry the Columbia ParCar or Industrial vehicle that meets all federal, state and local requirements.
- Secure vehicle to the trailer following trailer manufacturer's instruction.

⚠CAUTION

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

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ELECTRIC VEHICLE SERVICE

When servicing your electric vehicle always observe the following:

⚠ SAFETY FIRST ⚠

Always turn Power key to OFF, Directional key switch to Neutral, remove Power key, block tires and disconnect the battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.

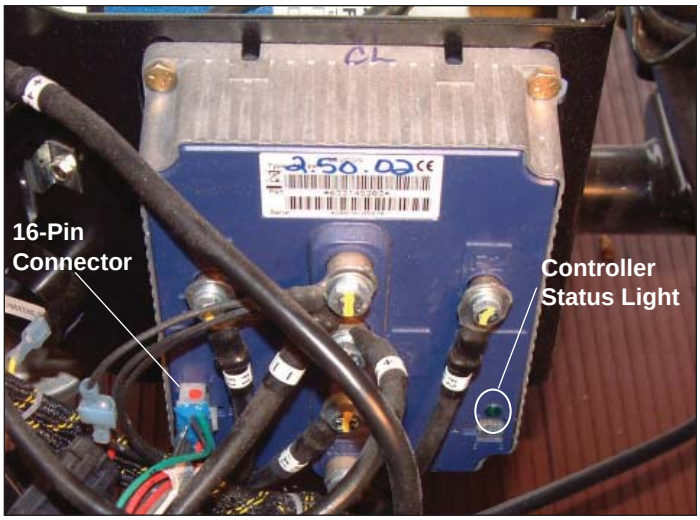

Figure 4-1. Motor Controller Status Light & Pin Connector

PRE-TROUBLESHOOTING STEPS

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

Inspect/Test	Correctiive 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. 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 sevicing 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/TestCondition		Correctiive 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). 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 asid 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, change the battery individually witht he auxiliary charger or the entire pack with the onboard charger (allow vehicle to charge until the green charger light is illuminated, indicating full charge). See Figure 1. If one or more batteries still test low, the battery should be tested individually and replaced as necessary. *NOTE: If 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.

TROUBLESHOOTING SPECIFIC COMPLAINTS

The first step in sevicing any electric vehicle that is not operating 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 that may arise in the service life of an electric vehicle.

The main key problems encountered with the vehicle(s) are:

- Vehicle will not move; forward or reverse
- 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 electri-

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.

NOTE: 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	Correctiive 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. 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. 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. 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 the charger positive (red) wire is connected to the main battery pack positive terminal, then check the table below.

VOM Black Lead	VOM Red Lead	Pass	Fail	Correction Action - Check
Main battery negative post	Green charger interlock wire	Full system voltage	Low or no voltage	Charger red lead to battery positive connection. Charger output wires for damage
Main battery ` negative post	Red wire #15 side of 1 amp fuse connector	Full system voltage	Low or no voltage	Red wire #15 connection to green charger interlock wire Red wire #15 for damage
Main battery negative post	Red wire #16 side of 1 amp fuse connector	Full system voltage	Low or no voltage	1 amp fuse or fuse connections
Main battery negative post	Red wire #28 at power key switch	Full system voltage	Low or no voltage	Red wire #18 for damage Red wire #28 to red wire #16 connection (at optional low/run connection)
Main battery negative post	Red wire #17 at solenoid positive tab	Full system voltage	Low or no voltage	Wiring from power key switch for damage/poor connections
Main battery negative post	Red wire #1 at 16 pin connector	Full system voltage	Low or no voltage	Wiring from power key switch for damage/poor connections

Vehicle Will Not Move; Forward or Reverse (continued)		
Fault Code	**Condition**	**Correctiive Action**
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 not roll when pushed on a level surface. 2. Check for other mechanical failures such as stripped hubs or anythng 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). Check the inputs of the electrical system by using the Computer Diagnostcs Utilities (Columbia Part No. 30001-04) or the handheld calibrator (Columbia Part No. 30003-04) . See the following procedures.

TROUBLESHOOTING WITH PCPAK

With the vehicle power system off, connect the PCPak (computer diagnostic utility) and then turn the vehicle power on.

1. Open the connection between the controller and the PCPaK utility. On the left side of the screen, select the “test” section under the “traction” pull down. This screen will display the inputs the controller is observing at that time (Figure 4-2).

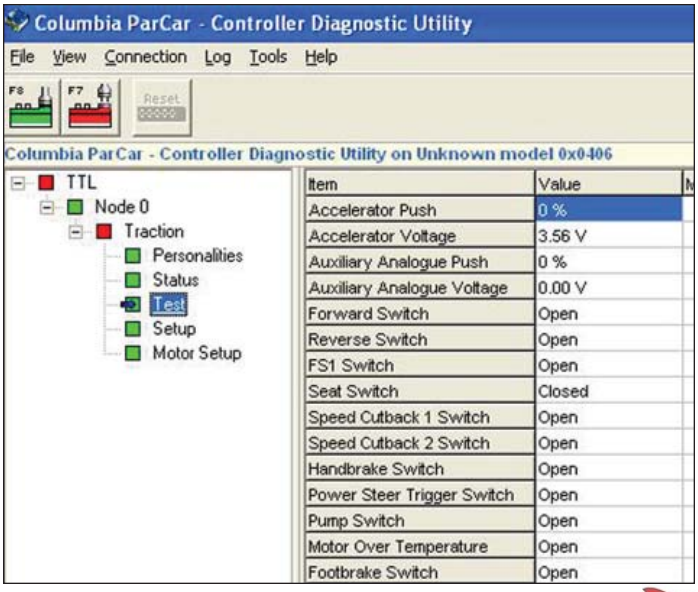

Figure 4-2. Basic Test Inputs

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 (Figure 4-3). 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 that attaches to the accelerator device.

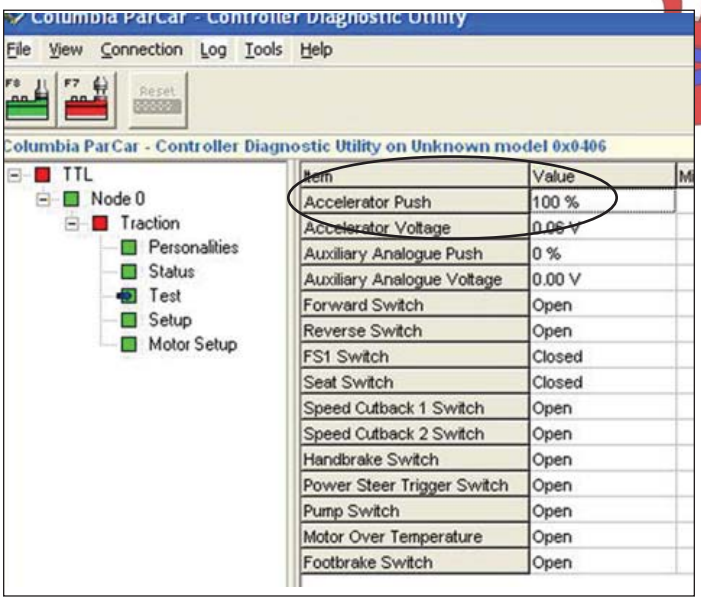

Figure 4-3. Accelerator Push Test

TROUBLESHOOTING WITH PCPAK (continued)

3. Check the FS1 Switch input on the same screen. With the accelerator at rest, the value for the FS1 Switch should read “open”. When the accelerator pedal is pressed, the value should change to “closed” (Figure 4-4). 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).

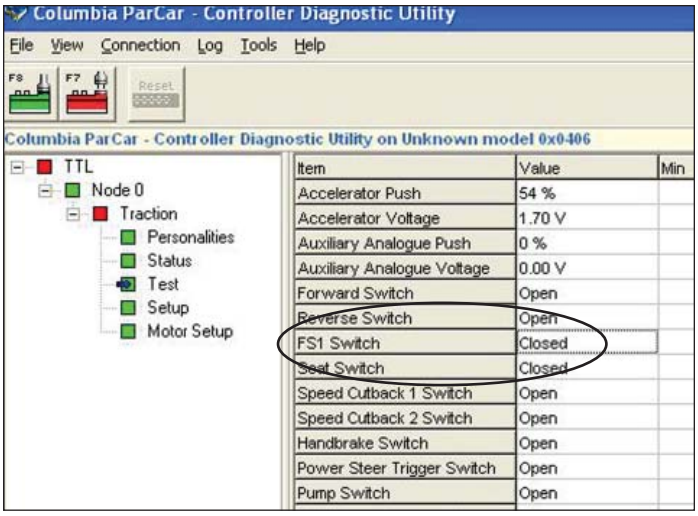

Figure 4-4. FS1 Switch Test

4. Check the direction input to the controller. Observe the value of the “Forward Switch” item while turning the direction selection switch to “Forward” and to “Neutral”. The switch should read “open” when the switch is in neutral and “closed” when in forward (Figure 4-5). Do the same in reverse by monitoring the “Reverse Switch” item 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).

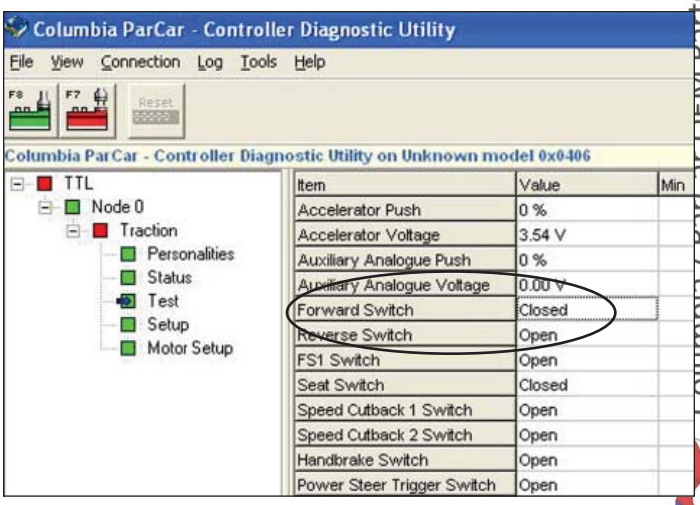

Figure 4-5. Forward Switch Test

5. Check the “Seat Switch” item and value (Figure 4-6). For vehicles equipped with a seat switch, the value should read “open” when the operator seat is not occupied, and “closed” when the operator seat is occupied. If the switch fails to close, check the wiring from the B- post of the controller to the seat switch, test the seat switch with a VOM, and check the wiring back to the controller (pin 5). For vehicles without a seat switch, the value should read “Closed”. If the switch does not register as closed, check the black 5 wiring from the B- post of the controller to controller plug (pin 5).

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

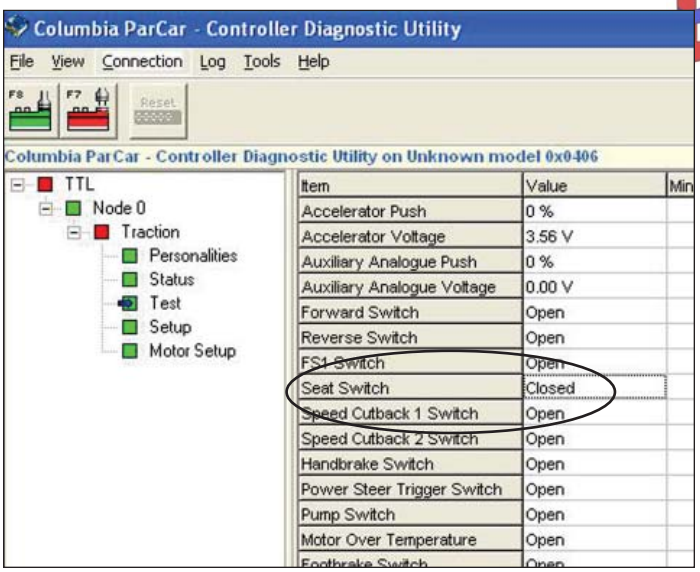

Figure 4-6. Seat Switch Test

TROUBLESHOOTING WITH THE HANDHELD CALIBRATOR

1. Connect the handheld calibrator to the vehicle 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).
5. Check the Seat Switch at location 19.09. For vehicles equipped with a seat switch, the value should read open (5.OP) when the operator seat is not occupied, and closed (5.CL) when the operator seat is occupied. If the switch fails to close, check the wiring from the B- post of the controller to the seat switch, test the seat switch with a VOM, and check the wiring back to the controller (pin 5). For vehicles without a seat switch, the value should read closed (5.CL). If the switch does not register as closed, check the black wire #5 wiring from the B- post of the controller to controller plug (pin 5).

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 - 5 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). Call Columbia Technical Support if problem persists.
4 Flash	Bench test 24 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 (pot box) switch. Perform steps 1, 3 and 4 under *Troubleshooting with Handheld Calibrator* above. Check the Pot box with an analog ohmmeter.
7 Flash	Low or high battery voltage. Check battery voltage with a voltmeter. If battery voltage drops below 15 volts (24 volt system) or 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 24 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 or Reverse Only

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

Vehicle Drives But Operation Is Jerky or Inconsistent

- Check Pot box carefully with analog ohmmeter for gradual, smooth resistance sweep.
- Check motor brushes. Replace if bad or worn (Figure 4-7).
- Call Columbia Technical Support if problem persists. Have the following information ready:
  - VIN
  - Vehicle Checksum (19.15)
  - Direction of trave 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.

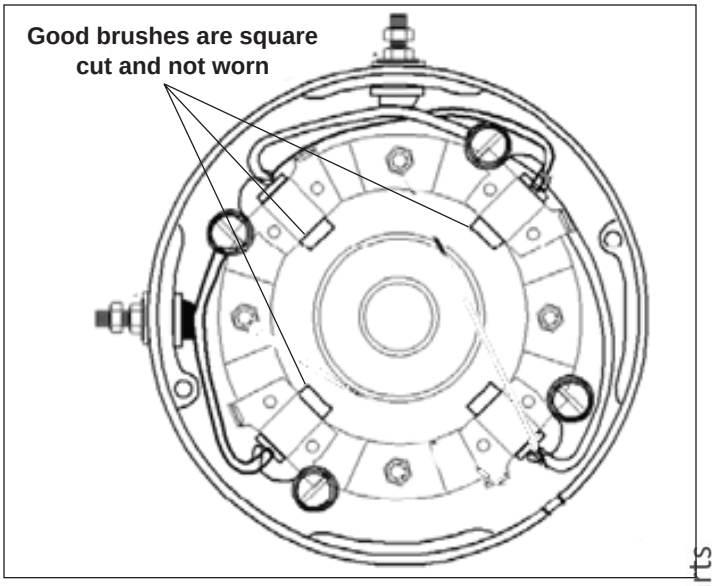

Figure 4-7. Motor Brushes

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 Tow or Power switch 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.		2005 (and later) vehicles may be equipped with a charger interlock. The green charger wire connects to red wire #15 in main harness and only provides power to system when charger is unplugged from AC power source. (See Rev 3 wiring diagram).

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 Newer (Beta) 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 Run/Tow or 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	Illegal 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.
		7	Seat switch not closed on accelerator depress (when equipped).
		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		External strobe (flasher) light caused fault. Wiring polarity reversed on flasher (Rovr/IS only).
		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	Speed (Pot Box) adjustment required.
		5	Pedal depressed at power up (see 2 Flash).

Sevcon Newer (Beta) 633T45303 6 Post 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: 24 Volt system: 15 V Low - 36.5 V High 36 Volt system: 22.5 Low - 50 V High 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

Smart*drive* SEVCON CONTROLLER POWER SYSTEM - 5 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 Tow or Power switch 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.		2005 (and later) vehicles may be equipped with a charger interlock. The green charger wire connects to red wire #15 in main harness and only provides power to system when charger is unplugged from AC power source. (See Rev 3 wiring diagram).

ELECTRIC VEHICLE SERVICE

When servicing the electric Columbia Industrial/Commercial vehicle always observe the following:

⚠ SAFETY FIRST ⚠

Always turn Power key to OFF, Directional key switch to Neutral, remove Power key, block tires and disconnect the 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 and adjustment. No lubrication is necessary.

Speed Switch for Smart*drive* and ACE*plus* Vehicles

The speed switch assembly used with Smart*drive* and ACE*plus* systems consists of two separate circuits.

ACCELERATOR MICRO SWITCH

This switch activates the vehicle electrical system as the accelerator is depressed. The switch arm is pulled down and away from the micro switch roller until the roller is released.

When the accelerator pedal is released, two heavy springs apply equal pressure on the brake cables. The switch lever contacts the micro switch roller and deactivates the vehicle electrical system.

VARIABLE RESISTOR

The variable resistor is commonly referred to as a “pot” or potentiometer. The speed switch lever is mounted to the pot. The potentiometer is a variable resistor used to signal the speed control module regarding acceleration position.

Establish Pedal Position

The accelerator pedal should stretch out the lanyard and release the micro switch when depressed about 65-75% of its travel to the floor. The pedal should also stop its travel before causing the lever on the speed switch to contact the speed switch post. The lever should never travel far enough to contact the post. When the accelerator is released, the lever on the speed switch should contact the micro switch and activate it before contacting its spring-loaded resting position against the upper stop of the switch.

In addition, as the accelerator pedal is depressed, the spring applied brakes are overcome.

1. Place yourself in the vehicle where you can see and observe the lanyard (wire cable) and hear the micro switch operate (Figure 5-1). The lanyard connects the accelerator pedal and speed switch lever.
2. Depress the accelerator pedal while watching the lanyard. When the lanyard is stretched taut, the lever it is attached to disengages the micro switch. The pedal travel should be about 65-75% to the floor.

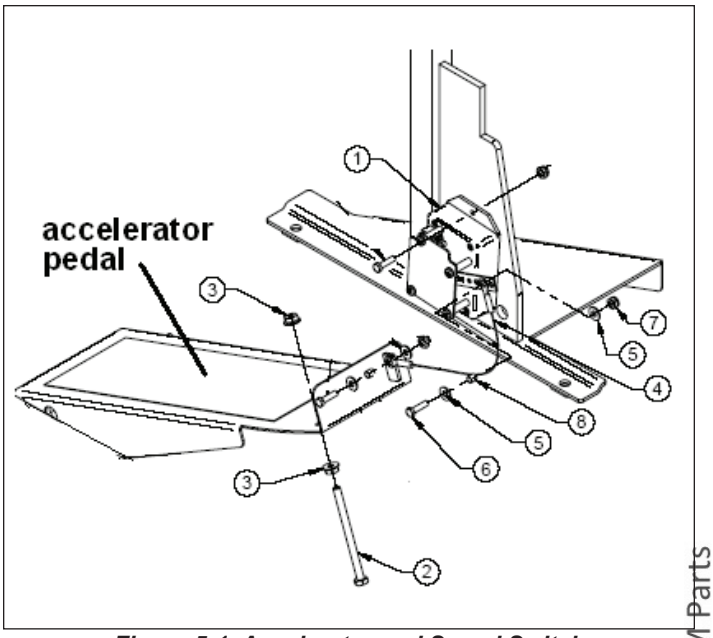

Figure 5-1. Accelerator and Speed Switch

If the pedal contacts the switch post before pulling on the lanyard, the pedal stop must be made longer.

If the lever on the speed switch contacts the switch post before the accelerator pedal contacts the stop, the pedal stop must be made longer.

3. If the pedal stop has been adjusted and retested, and the speed switch does not activate correctly, relocate the lanyard to a different hole in the lever arm. After relocating the lanyard, retest and adjust the pedal position as necessary.

Adjusting Accelerator Pedal Stop

1. Loosen both locknuts (3) on long bolt (Figure 5-1).
2. Turn long bolt (2) *clockwise* (viewed from bolt head) to shorten pedal travel or *counterclockwise* to shorten pedal travel.
3. Retest pedal travel and adjust as necessary.
4. When adjustment is correct, retighten the two locknuts 3).

Testing the Speed Switch

Testing can be performed on or off of the vehicle using a volt/ohm meter (VOM), the SevControl Calibrator available from Columbia ParCar, or a laptop and interface cable. To determine if speed switch is functioning correctly, follow the precise testing instructions in order.

The speed switch assembly uses two separate circuits. Test each circuit to ensure both components are in proper working order.

MICRO SWITCH TESTING USING A VOLT/OHM METER (VOM)

1. Set the digital volt/ohm meter (VOM) to test continuity and touch the probe to the first and third terminals on the micro switch (Figure 5-2).
2. With the micro switch arm depressed, accelerator pedal in full up position and brakes applied, no continuity should be observed.

3. With micro switch arm released, accelerator pedal depressed, continuity should be present.
4. If results of the test are erratic or inconsistent, the switch must be replaced.

MICRO SWITCH TESTING USING SEVCONTROL CALIBRATOR

1. With the vehicle power in the off position, connect the handheld sevcontrol and enter Read-only Mode. Advance to the 19.07 Menu location (Pot Box Switch, Digital Switch 3).
2. With the pedal in the up (at rest) position, the value should read “3.OP”. Depress the accelerator pedal. The value should change to “3.CL”. Release the pedal and it should return to “3.OP”.
3. If readings are erratic or inconsistent with this, test the microswitch with a VOM and check the microswitch circuit.

SPEED SWITCH TESTING USING VOLT/OHM METER (VOM) FOR SMART*DRIVE* AND ACE*PLUS* SYSTEM VEHICLES

1. Note the locations of wires and connections (Figure 5-2). Disconnect white wire (10) and black wire (11) coming from pot and going to wiring harness.
2. Switch the volt/ohm meter to ohms scale. Select a setting capable of reading 1 to 100 ohms.
3. Place probe to the terminals at ends of black and white lead wires. Notice the white wire has a female push-on type connector and the black wire has a male spade type connector.
4. Set the power switch to OFF. Do not depress the accelerator. With the speed switch lever released, 0-50 ohms should be present.
5. If reading is greater than 50 ohms, the pot is out of adjustment. Adjust or replace potentiometer.
6. Leave ohm meter leads connected to white and black electrical leads. Switch ohm meter to a scale capable of measuring up 6,000 ohms (K ohms).
7. Slowly depress accelerator and monitor change. As speed switch lever is depressed, resistance should rise smoothly from 0-50 ohms to a maximum of 4500-5500 ohms. Ohms of resistance should rise gradually to a maximum of 4500-5000 ohms, with speed switch lever depressed completely.
8. If rise in resistance is erratic or skips as pedal is depressed, replace the speed switch.
9. If maximum resistance is less than or greater than 4500-5500 ohms, potentiometer is out of adjustment. Adjust or replace potentiometer.

POTENTIOMETER SWITCH TESTING USING HANDHELD SERCONTROL CALIBRATOR FOR SMART*DRIVE* AND ACE*PLUS* SYSTEM VEHICLES

1. With the vehicle power switch in the off position, connect the handheld sevcontrol and enter Read-only Mode.
2. Advance to the 19.07 Menu location (Pot Box Switch, Digital Switch 3). With the pedal in the up (at rest) position, the value should read “3.OP”. Depress the accelerator pedal. The value should change to “3.CL”. Release the pedal and it should return to “3.OP”. If readings are erratic or inconsistent with this, test the micro switch with a VOM and check the micro switch circuit. Replacing speed switch

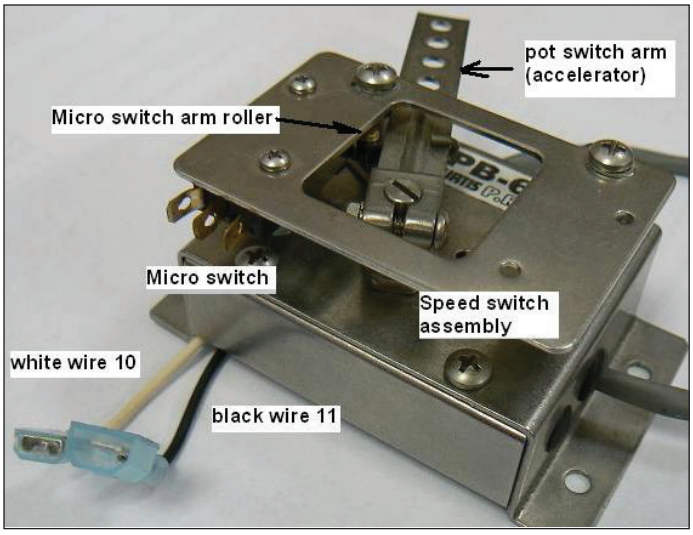

Figure 5-2. Speed Switch Assembly with Micro Switch

Replacing Speed Switch

Refer to Figure 5-2.

1. Note location of wires and connections. Disconnect white wire (10) and black wire (11) coming from speed switch and going to wiring harness.
2. Disconnect black wire (12) and black wires (4 & 14) from spade lugs on micro switch.
3. Remove one nut (7), two washers (5), spacer (8) and bolt (6). Remove cable from pedal (Figure 5-3).
4. If vehicle is equipped with early style Linemaster switch, remove two nuts (7), two bolts (6) and speed switch (1). I vehicle is equipped with later style CPC switch, remove four nuts (7), four bolts (6) and speed switch.
5. Set speed switch (1) into place on frame mount. If replacing an early style Linemaster switch with a later style CPC switch, additional mounting holes will need to be drilled.
6. Install the switch with bolts (6) and lock nuts (7). Do not tighten nuts at this time.
7. Connect lanyard (4) using bolt (6), washers (5), spacer (8) and lock nut (7).

⚠CAUTION

When connecting lanyard, check that lever arm and lanyard move freely without interference with frame or other components. Tension from interference could damage switch over time and cause potentiometer failure.

8. Adjust speed switch position, if necessary, to avoid interference. Tighten lock nuts (7).
9. Reconnect two black wires to micro switch. Do not use center terminal (Figure 5-2).

10. Reconnect black wire (11) and white wire (10) as per the wiring schematic for the vehicle. The white wire has a female push-on connector and the black wire has a male spade connector.
11. Perform the pedal adjustments on page 5-1.

MECHANICAL BRAKING SYSTEM

The mechanical braking system consists of two rear wheel drum brakes. This system is standard on vehicles covered in this manual.

Brake Operation

All three vehicles use the accelerator pedal, springs and brake cables to operate the brakes.

A brake equalizer pulls evenly on both brake cables. The brake equalizer floats to create equal tension to each brake cable leading to the rear brake assemblies.

These brakes are self-adjusting and should not require adjustment. However, manual adjustment may be required to maintain braking performance.

To check brake operation, operate the vehicle with no load, in a large, clear area. Release the accelerator/brake pedal completely. The vehicle should stop abruptly. If it doesn't, see *Brake Adjustments* in this section.

Periodic Brake Inspection

Intervals between brake service and inspection may vary depending 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. Inspect brake parts under vehicle for physical damage, corrosion, or cable fraying. Inspect dust boot at brake actuating lever. If cracked or split, replace dust boot.
2. 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 linkage or excessive wear to brake shoes.

Annual Brake Inspection

⚠WARNING

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

1. See Figure 5-4. Remove four lug nuts (20) and remove rear wheel/tire assembly. Repeat for other rear wheel.
2. See Figure 5-5. Remove cotter pin (12) at axle nut (11). Remove axle nut (11), spacer (10) and brake drum (9).
3. Inspect drum for excessive or uneven wear. Look for cracks radiating from stud holes.

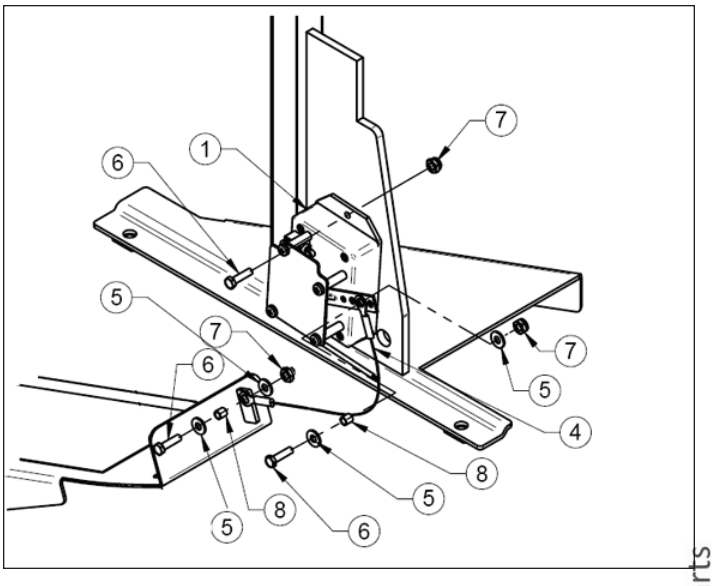

Figure 5-3. Accelerator and Speed Switch

Maximum drum inside diameter is 6.635" (168.4 mm). If drum is worn beyond service limit, or uneven wear is shown, drum must be replaced. See *Brake Disassembly*.

4. 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 *Brake Disassembly*.
5. Inspect for oil or grease contamination. Replace brake shoes that are contaminated. See *Brake Disassembly*.
6. Inspect dust boot at brake actuating lever. If cracked or split, replace dust boot.
7. 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.
8. See Figure 5-5. Install brake drum (9), spacer (10) and axle nut (11). Tighten axle nut to a minimum 65 ft. lbs. (23 Nm) Install new cotter pin (12).
9. See Figure 5-4. Reinstall rear wheel/tire assembly and four lug nuts (20). Tighten lug nuts in a criss-cross pattern to a maximum 65-70 ft. lbs. (23-25 Nm) Repeat for other rear wheel. Recheck lug nut torque with vehicle on the ground.

Brake Disassembly

- 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.

NOTICE

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

Refer to Figures 5-7 & 5-8.

1. Using good, quality brake pliers, remove auto adjuster spring.
2. To remove brake shoes, locate shoe retainer springs and 1/4 turn fasteners. Holding 1/4 turn fastener with a brake spring tool, rotate 1/4 turn and remove fastener and spring. Repeat for other 1/4 turn fasteners.
3. Grasp two brake shoes at centers. Pull them outward and fold away from backing plate. Lift one shoe at a time from brake anchor. Remove springs and shoes from brake backing plate.
4. Slide the automatic adjuster screw and automatic adjuster nut from brake assembly. Clean these parts thoroughly.
5. Wash any mud, brake debris, and dirt from brake plate.

⚠CAUTION

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

Brake Reassembly

1. Apply a small amount of white lithium grease to the threads of automatic adjuster screw and to contact points where brake shoes rest against back plate.
2. Install automatic adjuster screw and nut into automatic adjuster assembly. Reconnect top and bottom shoe return springs to brake shoes in same order as removed.

   Brake shoes may not be equal in length. The shoe with the shorter lining should be installed on the brake assembly side closest to the front of the vehicle. Shoe with longer lining installs to the rear.
3. With the springs attached to the brake shoes, hook bottom of each brake shoe, one at a time, into slots on automatic adjuster screw and opposing retainer. Next, hook top end of each brake shoe behind anchor at the top of brake plate. Fold ends of shoes inward towards brake plate. Secure them in place with brake shoe pins, retainer springs and 1/4 turn fasteners.
4. Install auto adjuster spring.
5. Locate adjuster nut (Figure 5-7).
6. Using a flat blade screwdriver, turn the adjuster nut (at the top) away from the backing plate. Check to make sure the shoes are spreading further apart. Make sure the brake drum still slides on easily.

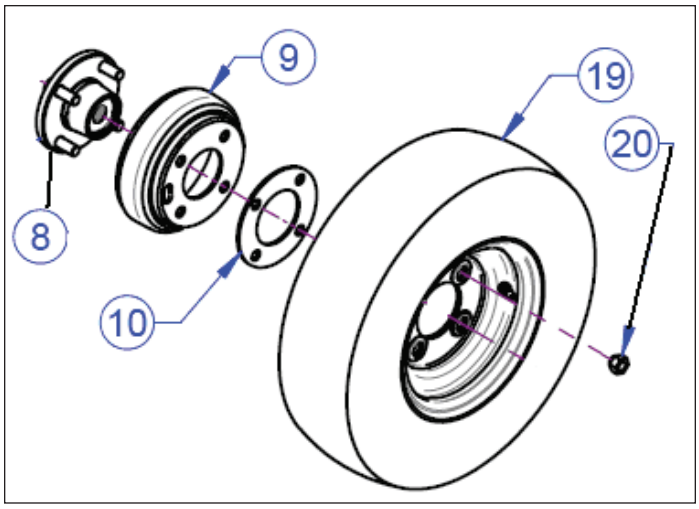

Figure 5-4. Rear Wheel/Tire Assembly

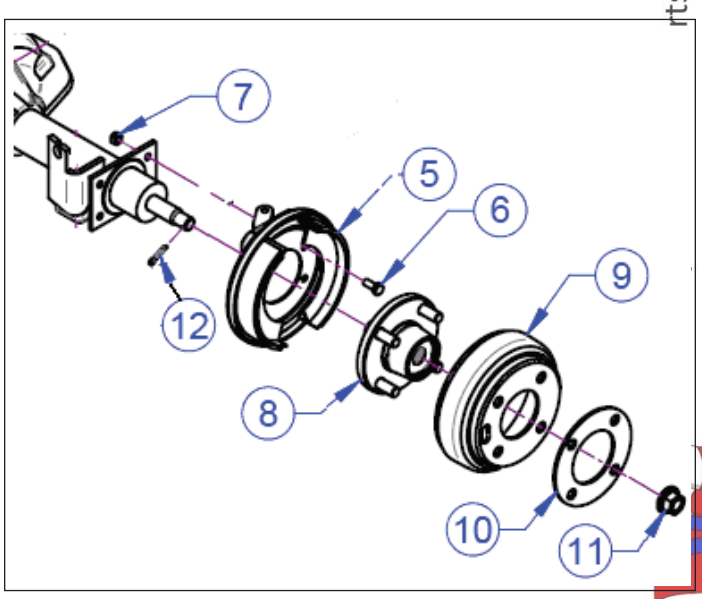

Figure 5-5. Rear Brake Assembly

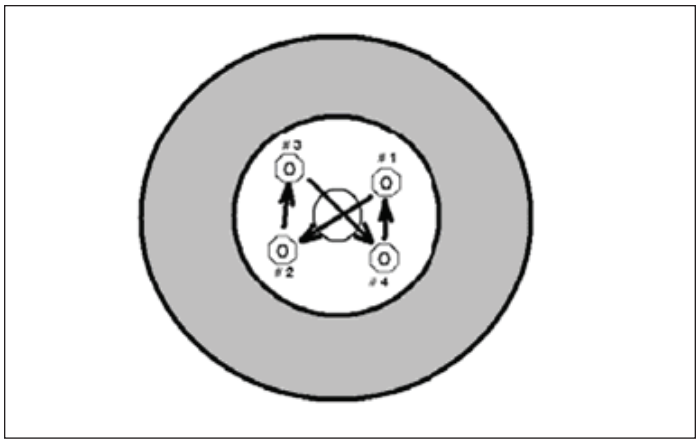

Figure 5-6. Lug Nut Tightening Pattern

7. Install brake drum. Torque axle nut to minimum 65 ft. lbs. (23 Nm). Install new cotter pin.
8. See Figure 5-4. Reinstall rear wheel/tire assembly and four lug nuts (20). Tighten lug nuts in a criss-cross pattern to a maximum 65-70 ft. lbs. (23-25 Nm) Repeat for other rear wheel.

Brake Cables

BRAKE CABLE REPLACEMENT

⚠ WARNING

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

1. At rear brake assembly (Figure 5-9), remove cotter pin (25), clevis pin (24) and e-ring (23) from brake cable (21).
2. Remove cable yoke from rear wheel brake actuator arm.
3. Locate brake cable ball end at brake equalizer (17) and remove it from equalizer (Figure 5-10).
4. Remove e-ring (30) and brake cable (29) from vehicle (Figure 5-11).
5. Repeat for other cable.
6. In order to install new cables, it may be necessary to lengthen rod (16, Figure 5-10).
7. Locate brake cable ball ends at brake equalizer (17). Thread rod (16) through equalizer.
8. Depress accelerator/brake pedal. Thread nut (18) onto rod (16).
9. Secure brake cables (29) to mounting base with e-ring (30) on inside of the base (Figure 5-9).
10. Route brake cable (21) clevis end to rear axle brake actuator arm (Figure 5-9).
11. Secure cable clevis end to arm with clevis pin (24) and cotter pin (25) (Figure 5-9).
12. Secure cable sheath with e-ring (23).

ANTI-ROLL AWAY FEATURE

There is no separate parking brake pedal. However, every time the accelerator/brake pedal is released, two heavy springs apply and hold the brakes in the applied position so the vehicle will not roll away. This anti-roll away feature will work on a loaded vehicle as well. And if adjusted correctly, will hold a vehicle parked on a slope.

The service brakes are on all the time until the accelerator pedal is depressed. Check the anti-roll away feature as follows:

1. With the power key in the OFF position, the directional key in Neutral (N) and the brakes applied, the vehicle should not roll.
2. If the vehicle is able to roll at all, the brake spring pressure must be adjusted.

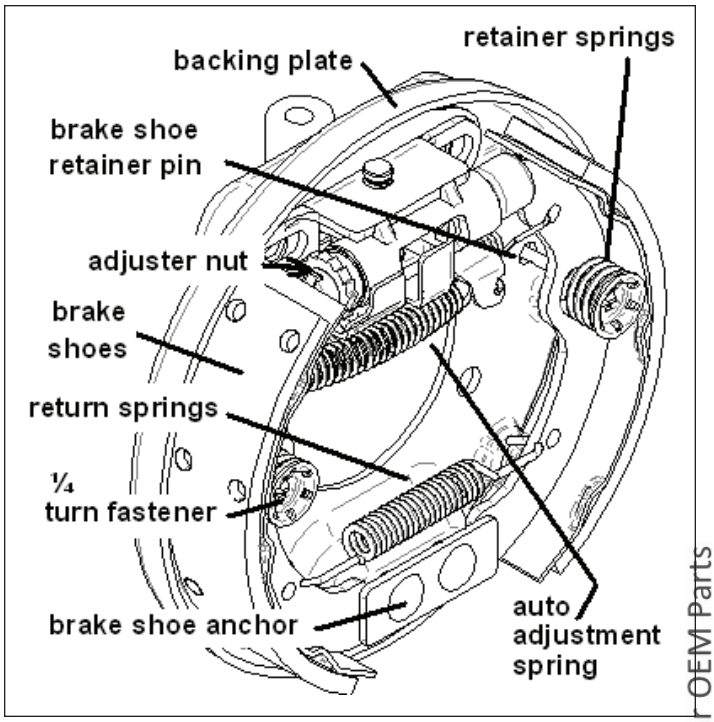

Figure 5-7. Mechanical Drum Brake Assembly

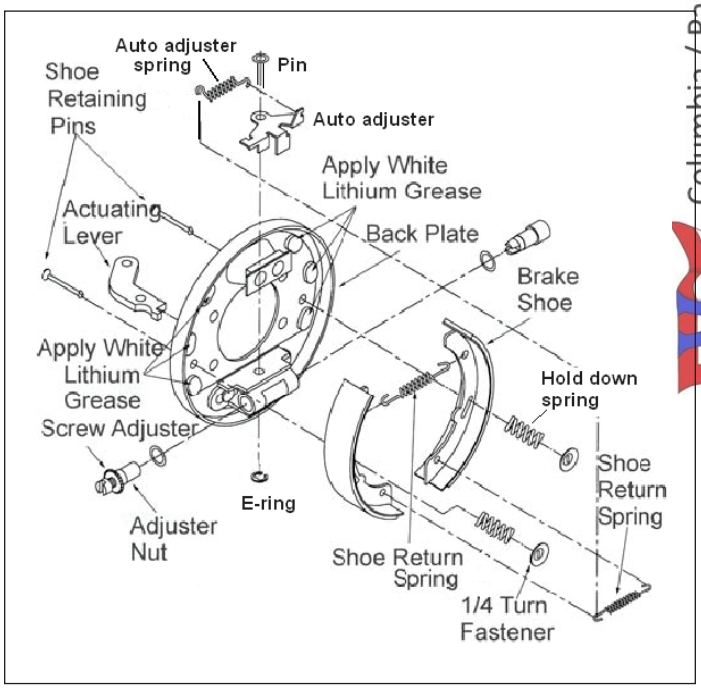

Figure 5-8. Mechanical Drum Brake Assembly

3. Tighten the nut (18, Figure 5-10) on the equalizer block stud (16).
4. Repeat step 1 and adjust nut until vehicle does not roll with brakes applied.

Brake Shoe Adjustment

⚠DANGER

Varying surfaces, surface conditions (wet, oily or dry) and vehicle loads will affect stopping distances. Should the stopping action of the brakes be in question, STOP and DO NOT use the vehicle.

1. See Figure 5-4. Remove four lug nuts (20) and remove rear wheel/tire assembly. Repeat for other rear wheel.
2. See Figure 5-5. Remove cotter pin (12) at axle nut (11). Remove axle nut (11), spacer (10) and brake drum (9).
3. See Figure 5-7. Using a flat blade screwdriver, turn the adjuster nut (at the top) away from the backing plate. Check to make sure the shoes are spreading further apart. Make sure the brake drum still slides on easily.
4. Install brake drum. Torque axle nut to minimum 65 ft. lbs. (23 Nm). Install new cotter pin.
5. See Figure 5-4. Reinstall rear wheel/tire assembly and four lug nuts (20). Tighten lug nuts in a criss-cross pattern to a maximum 65-70 ft. lbs. (23-25 Nm) Repeat for other rear wheel.

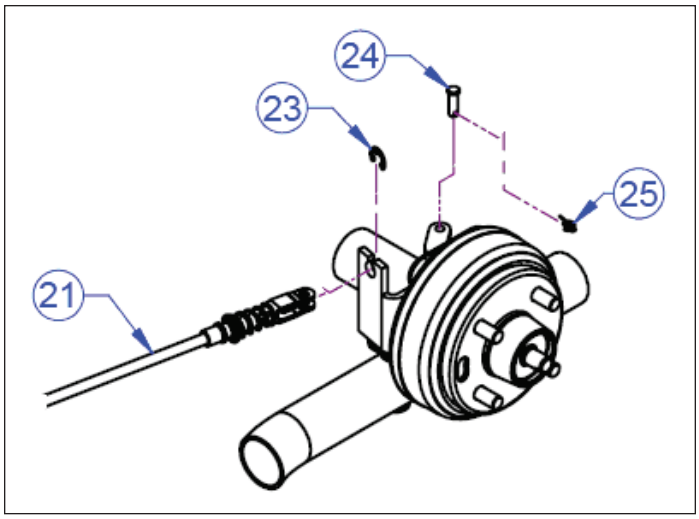

Figure 5-9. Brake Cable at Rear Axle

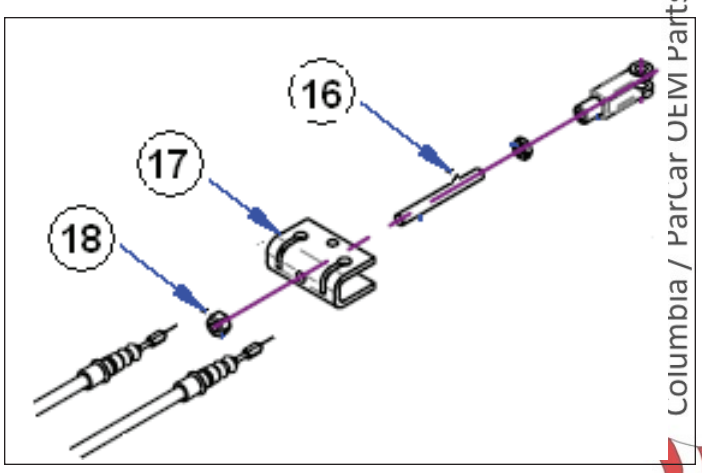

Figure 5-10. Anti-Roll Away Adjustment

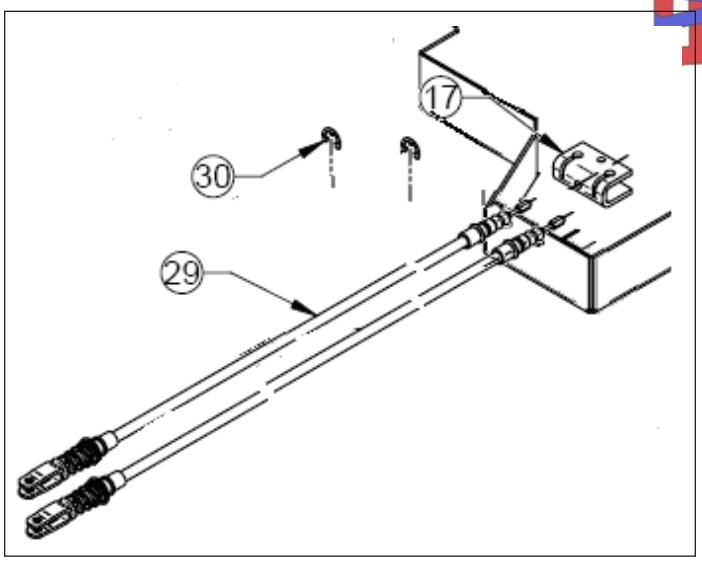

Figure 5-11. Brake Cable Removal/Installation

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ELECTRIC VEHICLE SERVICE

When servicing the electric Columbia Industrial/Commercial vehicle always observe the following:

⚠ SAFETY FIRST ⚠

Always turn Power key to OFF, Directional key switch to Neutral, remove Power key, block tires and disconnect the battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.

DESCRIPTION

These vehicles utilize a chain and rod linkage assembly from the steering wheel to front tires. Turn the top of the steering wheel to the left, the vehicle will turn left; turn the top of the steering wheel to the right, the vehicle will turn right, when operating in the forward direction.

There are no traditional front suspension components on these vehicles. They are designed to be used on smooth, indoor surfaces. However, the ROVR model is designed to be used on smooth, outdoor surfaces.

NOTICE

Always inspect the condition of vehicles steering components before making adjustments. All worn, broken or damaged parts must be replaced before proper adjustment can be performed.

FRONT WHEELS AND HUBS

⚠ 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*.

Removing Front Wheels and Hubs

1. Before raising vehicle, with wheels on the ground, break loose the lug nuts (11, Figure 6-1).
2. Remove lug nuts and wheel assembly from the hub.
3. Remove grease cap (18, Figure 6-2)
4. Remove cotter pin (14), axle nut (13) and flat washer (12) (Figure 6-2).
5. Carefully pull hub (9) off the axle.
6. Repeat steps 1 - 5 for the other front wheel.

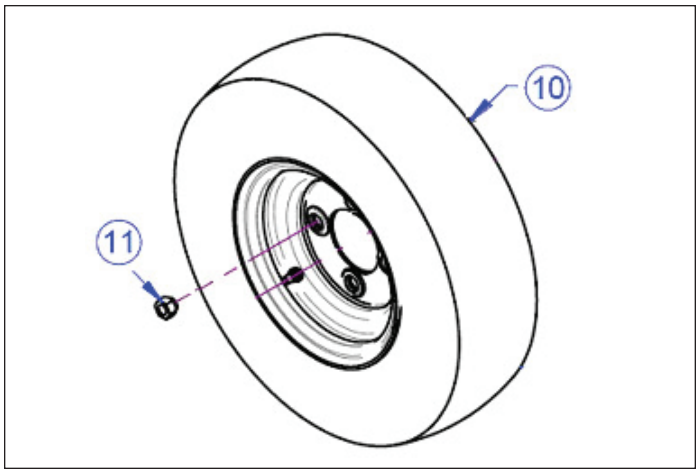

Figure 6-1. Front Wheel Assembly

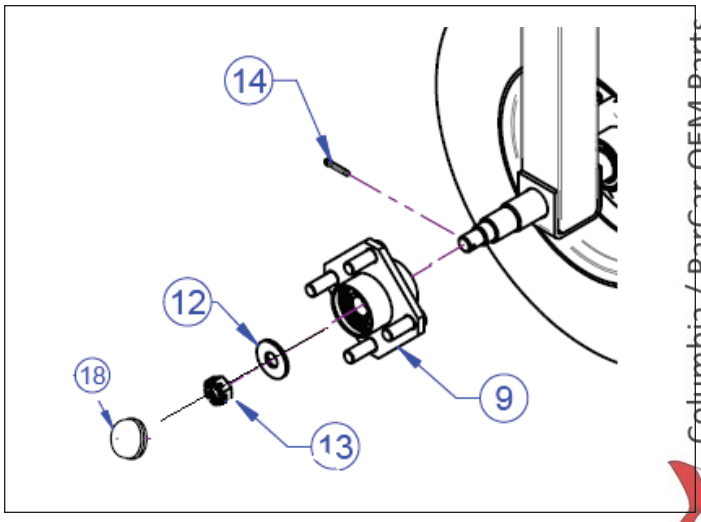

Figure 6-2. Front Hub Assembly

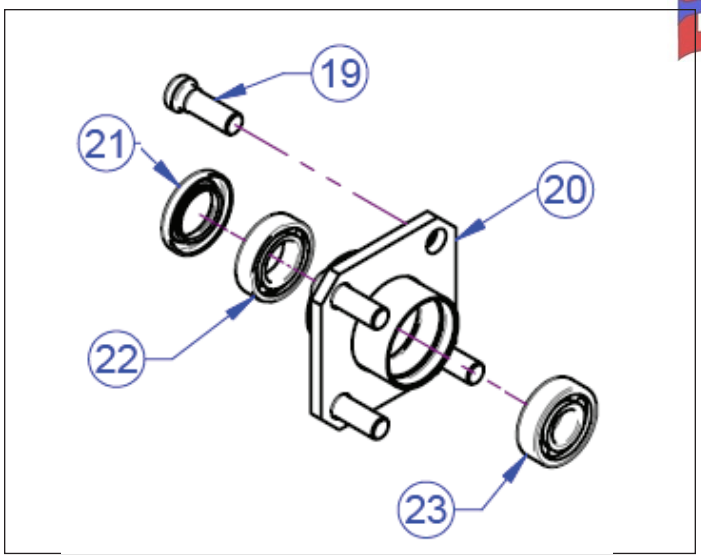

Figure 6-3. Front Hub and Bearings

Removing Wheel Hub Bearings for Inspection/Replacement

Front wheel bearings are sealed. They cannot be repacked and must be replaced if damaged.

1. Use a good quality commercial puller to remove bearing (23, Figure 6-3).

NOTICE

Make sure to only pull on the outside of the bearing rim and not on the inside parts, or the bearing will be destroyed.

2. Set hub (20) on blocks, in a press, with grease seal (21) on the bottom.
3. Match up a socket to the outside diameter of the bearing (22). Bearing outside diameter is 0.98" (25.89 mm).

NOTICE

Make sure to only press on the outside of the bearing rim and not on the inside parts, or the bearing will be destroyed.

4. Carefully press out the bearing (22). Grease seal (21) will be removed also.
5. Wipe off and inspect the bearings (22, 23). Replace bearings if there is any sign of wear or damage.
6. Inspect grease seal (21). Replace if there is any sign of wear or damage.
7. Clean the hub (20). Inspect the hub for galling, rust, or metal residue. Replace hub if it is damaged.

Installing Hub Bearings

1. Support hub (20) in a press, with the large opening facing up.
2. Carefully press in bearing (22) until it bottoms.

NOTICE

Make sure to only press on the outside of the bearing rim and not on the inside parts, or the bearing will be destroyed.

3. Carefully install grease seal (23).
4. Turn over hub (20) and support it in the press, with the smaller opening facing up.
5. Carefully press in bearing (23) until it bottoms.
6. Repeat steps 1 - 5 for the bearings in the other hub.

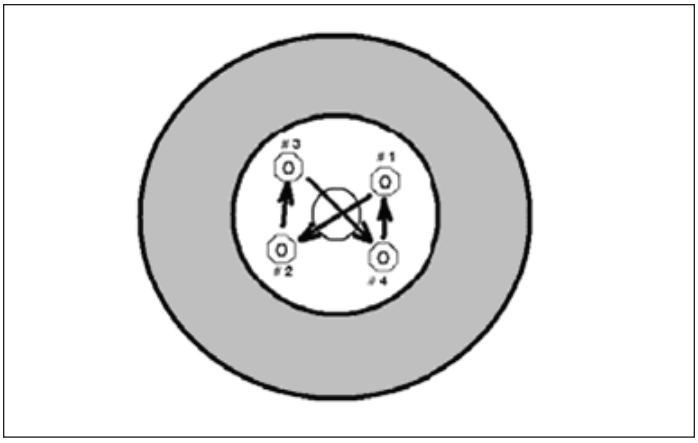

Figure 6-4. Lug Nut Tightening Pattern

Installing Wheel Hubs and Front Wheels

1. Clean axle. Apply a thin coating of grease. Install hub onto the axle (Figure 6-2).
2. Install flat washer (12) and nut (13).
3. Tighten axle nut (13) until the hub (9) won't rotate. Then, back off axle nut until hub turns freely.
4. Install a new cotter pin (14). Install grease cup (18).
5. Repeat steps 1 - 4 for other hub.
6. Place wheel assembly on the hub studs.
7. Tighten four lug nuts (11, Figure 6-1) by hand and wrench until snug using a criss-cross pattern (Figure 6-4).
8. Lower the vehicle to the ground and torque the lug nuts to 35 ft. lbs. (23 Nm) using the same criss-crossing pattern.

TIRES

NOTICE

Tire repair is not covered in this manual. See the dealer for tire repair/replacement, or take the damaged wheel/tire assembly to a commercial tire repair facility.

Tire sizes are:

Standard: 4.80" x 8" pneumatic, 6-ply rating, range C

Optional: 4.80" x 8" foam filled, 6-ply rating, range C

DUAL FORK ASSEMBLY

⚠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*.

Removing Dual Fork Assembly

1. Remove the front wheel assemblies. See *Removing Front Wheel and Hub* previously in this section.
2. Remove locknut (5) from tie rod end (4) at dual fork weldment (8). Lift tie rod (7) out of way.
3. Remove grease cup (18).
4. Remove cotter pin (17), slotted nut (16), flat washer (15) and upper bearing (2).
5. Pull down on the dual fork weldment (8). It should come out the bottom of the neck.
6. Remove the lower bearing (2) and the grease seal (3).
7. Clean and inspect both bearings (2). Repack the old bearings (20) or replace with new bearings and races (1).
8. Clean and inspect the old grease seal (3). Replace it if it appears worn or damaged.
9. Clean and inspect shaft of dual fork weldment (8). Look for grooves, cuts, rusty areas and damaged threads. Ensure shaft is straight.

Installing Dual Fork Assembly

1. Clean the inside of body steering neck. Coat it with wheel bearing grease before installing new races (1) and new bearings (2), or reinstalling the old bearings.
2. Install grease seal (3) and lower bearing (2) on neck of the dual fork weldment (8).
3. Insert the neck of the fork weldment (8) through the steering neck of the vehicle.
4. Grease neck of vehicle with wheel bearing grease. Install the upper bearing (2), flat washer (15) and slotted nut (16).
5. Tighten down nut (16) to seat the bearings. Then back off nut (16) until there is no wobble in the bearings and neck, but so the fork still turns freely.
6. Install cotter pin (17) and grease cup (18).
7. Install long steering rod (7) onto dual fork weldment (8) with locknut (5).
8. Reinstall the wheel assemblies. See *Installing Hubs and Front Wheels*.
9. Perform a functional operational check on steering.

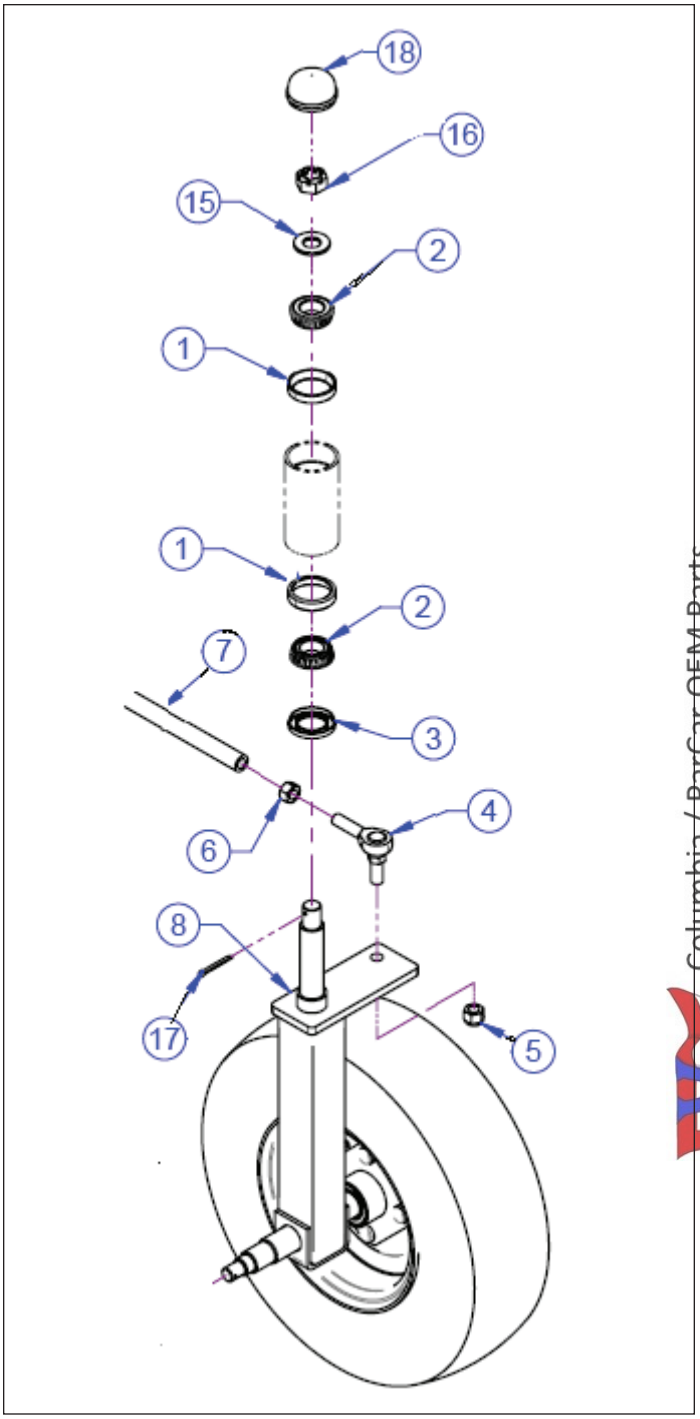

Figure 6-5. Dual Front Fork Assembly

STEERING WHEEL & CONSOLE

Removal

1. Remove pin (26) using a soft drift of the same size (Figure 6-6). Pull steering wheel from sprocket.
2. Remove four screws (14) on sides of console and pull console away from frame, exposing the upper and lower steering groups.

Installation

1. Set console into place on frame and attach using four screws.
2. Set steering wheel onto sprocket shaft and align with mounting hole.
3. Drive in roll pin to secure steering wheel.

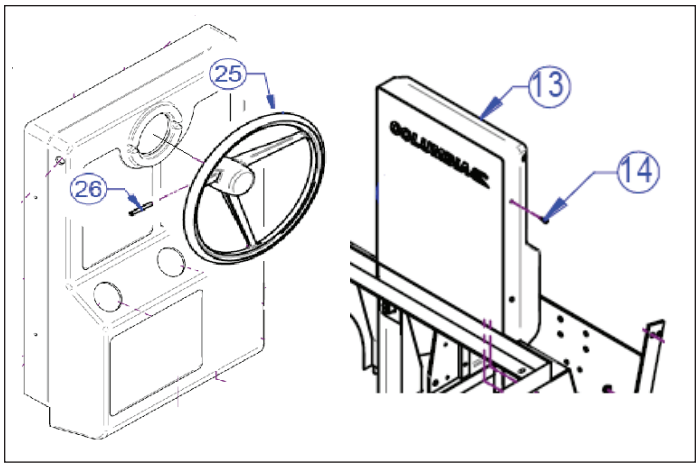

Figure 6-6. Steering Wheel and Console

UPPER AND LOWER STEERING GROUP

Upper and Lower Hubs

LUBRICATION (FIGURE 6-7)

There are two grease fittings, one on each hub. To access the grease fittings, remove the steering wheel and console as described above. Each grease fitting should receive one shot of grease at the stated intervals. See *Section 3 - Maintenance Scheduled Checklist.*

DISASSEMBLY (FIGURE 6-7)

1. Remove steering wheel and console as described above.
2. Remove master link from chain (13) and remove chain.
3. Remove nut (4) and bolt (3) from upper steering hub (1). Remove upper hub and steering sprocket (6) assembly.
4. Pull steering sprocket (6) out of upper hub (1) and remove nylon bushing (2), washer (8) and four washers (5).
5. Remove nut (19) and tie rod end assembly (18) from lower sprocket (11). Rotate tie rod out of the way.
6. Remove locknut (15) and three washers (14) and adjustment screw.
7. Remove nut (4) and bolt (3) from lower steering hub (9). Remove lower hub and steering sprocket (11) assembly.
8. Remove cotter pin (12) and pull lower sprocket (11) out of lower hub (9) along with two nylon washers (5), two nylon bushings (10), five washers (8) and one nylon washer (5).

ASSEMBLY (FIGURE 6-8)

1. Inspect nylon bushings (10) and replace them if they are worn or damaged. Replace any washers (5, 8) that are worn thin or uneven.
2. Install two nylon washers (5) and two bushings (10) onto lower sprocket (11).
3. Insert lower sprocket (11) into lower hub (9). Install five washers (8) and nylon washer (5), and secure in place with a new cotter pin (12).
4. Install lower hub and sprocket assembly with two nuts (4) and bolts (3). Snug up nuts. Make sure lower hub assembly can move to allow installation and adjustment of the chain.
5. Install adjustment screw with three washers (14) and locknut (15).
6. Rotate lower sprocket assembly (11) until hole is positioned at the bottom. With front wheels pointed straight ahead, install short tie rod end assembly to lower sprocket (11) with nut (19).
7. Inspect nylon bushings (2) and replace them if they are worn or damaged. Replace any washers (5, 8) that are worn thin or uneven.
8. Assemble bushing (2) on upper sprocket (6). Install upper sprocket assembly into upper hub along with washer (8) and four nylon washers (5).
9. Install upper hub assembly with bolt (3) and nut (4). The hole in the upper hub, for the roll pin, should be horizontal.
10. Lift the lower hub/sprocket assembly to install chain and master link to sprockets (6 and 11).
11. Tighten nut (15) to adjust chain. Chain should be neither too loose nor too tight and should turn freely.
12. Install console and steering wheel.

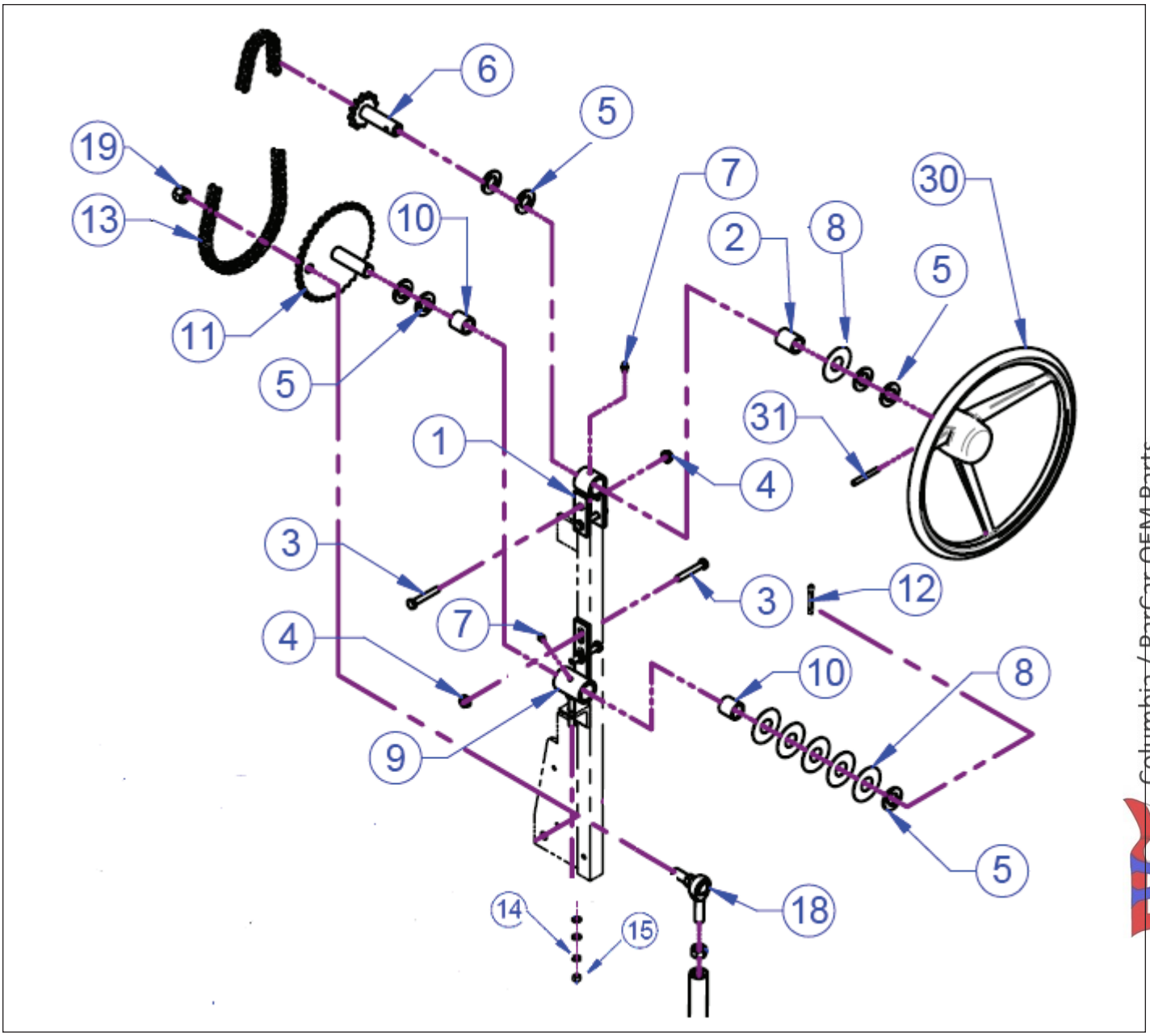

Figure 6-7. Upper and Lower Steering Components

Steering Rods and Bell Crank

REMOVAL

1. Remove wooden deck plate exposing long steering rod and the front of steering bell crank.
2. Remove steering wheel, console and steering chain. See *Upper and Lower Steering Group* previously in this section.
3. Remove nut (5), tie rod end (4) and long steering rod (7) from dual hub (8). See Figure 6-8.
4. Remove nut (19) and long steering rod tie rod end (18) from steering bell crank (35). See Figure 6-9.
5. Remove nut (19) and short steering rod (16) tie rod end (18) from steering bell crank (35).
6. Remove two cotter pins (24) and washers (23). Slide pivot shaft (21) to the left to remove steering bell crank (35) and bushings (22). See Figure 6-9.

TIE ROD/TIE ROD END REPLACEMENT

1. If tie rods or tie rod ends are to be replaced, take note of the tie rod end studs orientation. Use a felt tip marker to mark these directions on the ends of the steering shaft and tie rods as an aid for reassembly. Measure the length of the tie rod threads or count the number of threads as you remove tie rod ends (Figure 6-10).

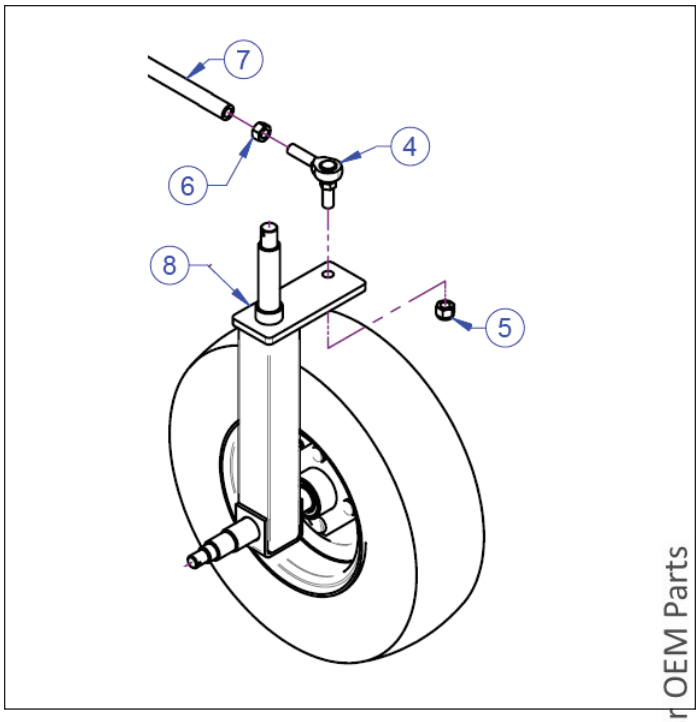

Figure 6-8. Long Steering Rod and Dual Hub

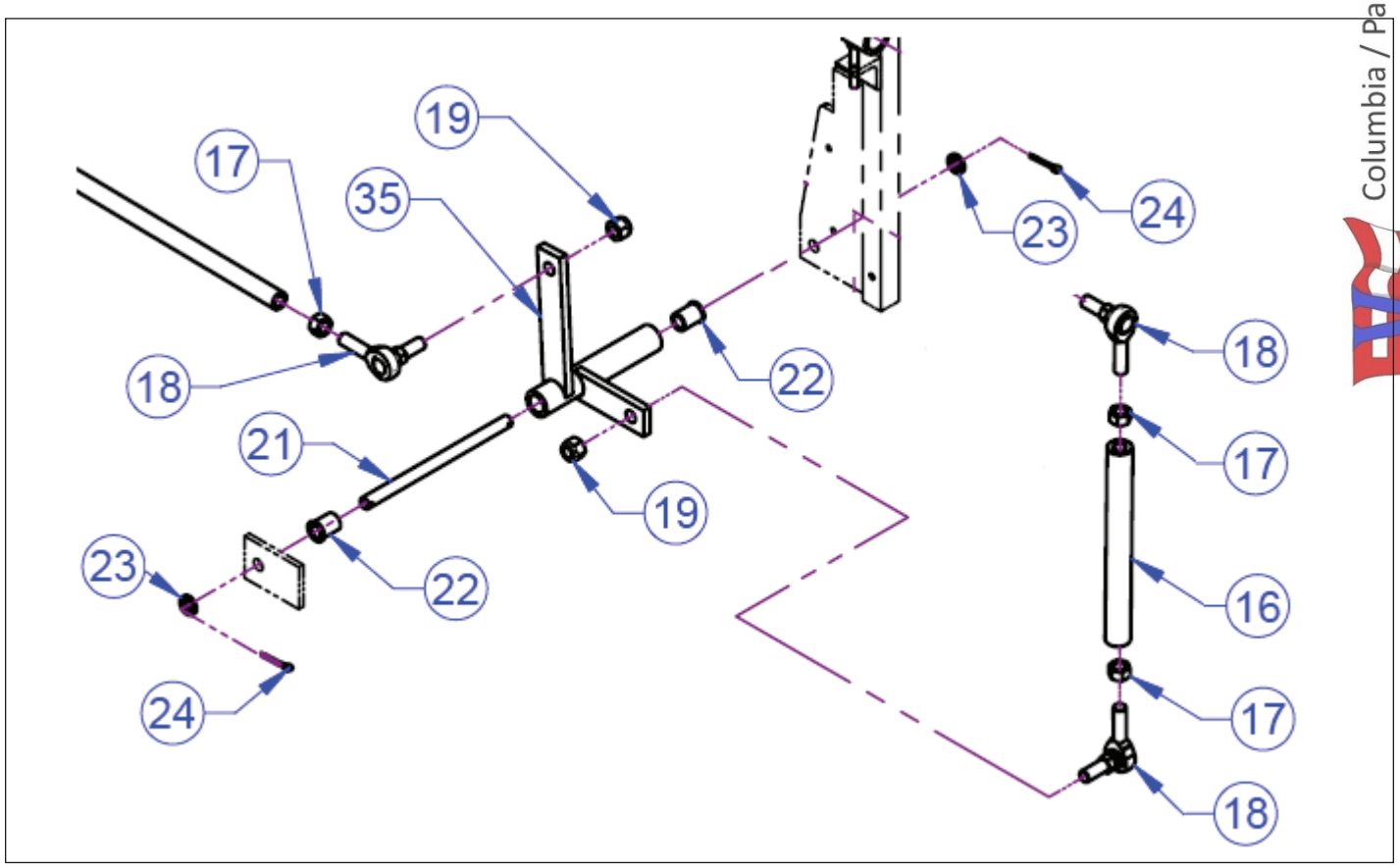

Figure 6-9. Steering Rods and Bell Crank

2. Loosen jam nut and remove rod end.
3. Apply a thin coat of grease or Anti-Seize to the threads of the new tie rod end.
4. Thread tie rod end into jam nut and steering rod. Make sure to thread in the same number turns, or the same length measured in step 1.
5. Tighten down jam nut to hold the adjustment and proper orientation of rod end.

ASSEMBLY

See Figure 6-9.

1. Inspect nylon bushings (22). Replace them if they are worn or damaged.
2. Assemble bushings (22) into bell crank (35). Set bell crank between tab on the left and the console support on the right.
3. Install the short shaft (21) through the holes in the tab and the console support on the right. Secure shaft with two washers (23) and new cotter pins (24). Make sure bell crank moves freely and is oriented correctly with the long arm straight up and the short arm towards the vehicle.
4. Attach one tie rod end (4) of the long steering rod (7) to the dual hub (8) with nut (5). See Figure 6-8.
5. Attach other tie rod end (18) of long steering rod (7) to bell crank (35) with nut (5). Bell crank long arm must be straight up when attaching tie rod end. .
6. Install bushings (22) into the steering bell crank (35). Slide pivot shaft (21) through bushings and steering bell crank (35) and secure with two washers (23) and new cotter pins (24).
7. Install short steering rod (16) tie rod end (18) to steering bell crank (35) and secure with nut (19). Bell crank short arm must be horizontally straight towards the vehicle when attaching tie rod end.
8. Install steering chain, steering wheel and console. See *Upper and Lower Steering Group* previously in this section.
9. Install wooden deck plate.

Count threads or measure before removing both tie rod ends.

Take note of tie rod ends orientation when disassembling. Reassemble to same orientation

Figure 6-10. Replacing Tie Rod Ends

ELECTRIC VEHICLE SERVICE

When servicing the electric Columbia Industrial/Commercial vehicle always observe the following:

⚠ SAFETY FIRST ⚠

Always turn Power key to OFF, Directional key switch to Neutral, remove Power key, block tires and disconnect the battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.

SPECIFICATIONS

IS12

Standard axle ratio: 12.44.1

Optional axle ratio: 14.76.1

Optional axle ratio: 16.99.1

IR23

Standard axle ratio: 14.76.1

Optional axle ratio: 14.76.1

IT34

Standard axle ratio: 16.99.1

REAR WHEELS

⚠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*.

Removing Rear Wheels

1. Before raising vehicle, with wheels on the ground, break loose the lug nuts (11, Figure 7-1).
2. Remove lug nuts and wheel assembly from the axle.
3. Repeat steps 1 - 5 for the other rear wheel.

Rear Axle Wheel Bearings

Rear axle wheel bearings are sealed type bearings and cannot be repacked. Bearings must be replaced if worn or damaged. Refer to *Appendix A - Axle Overhaul* for bearing replacement procedures.

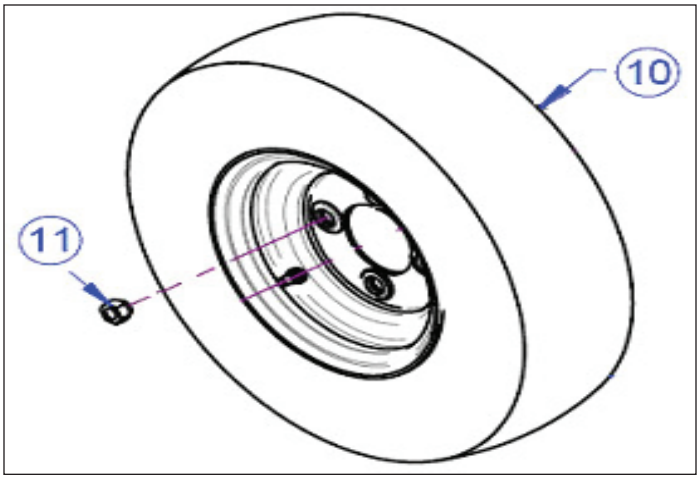

Figure 7-1. Rear Wheel Assembly

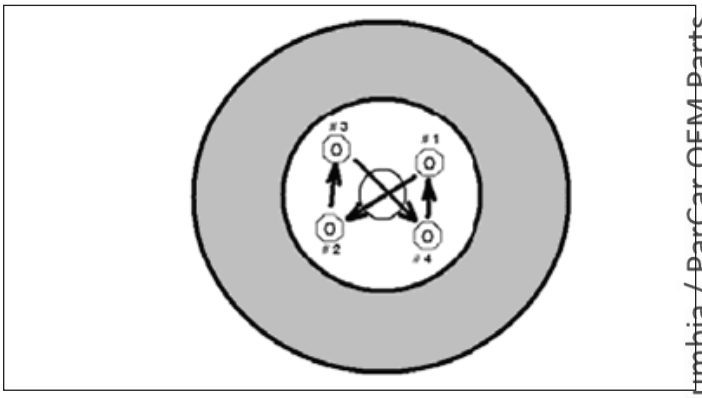

Figure 7-2. Criss-Cross Tightening Pattern

Installing Rear Wheels

1. Place wheel assembly on the hub studs.
7. Tighten four lug nuts (11, Figure 7-1) by hand and wrench until snug using a criss-cross pattern (Figure 7-2).
8. Lower the vehicle to the ground and torque the lug nuts to 65 ft. lbs. (23 Nm) using the same criss-crossing pattern.

TIRES

NOTICE

Tire repair is not covered in this manual. See the dealer for tire repair/replacement, or take the damaged wheel/tire assembly to a commercial tire repair facility.

Tire sizes are:

Standard: 4.80” x 8” pneumatic, 6-ply rating, range C

Optional: 4.80” x 8” foam filled, 6-ply rating, range C

REAR AXLE

Removing Rear Axle

NOTICE

Axle removal is made easier if the batteries are removed. Batteries weigh 560 lbs. (252 kgs).

⚠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. Before raising vehicle, with wheels on the ground, break loose the lug nuts (11, Figure 7-1).
2. Remove lug nuts and wheel assembly from both sides of the vehicle.
3. Label the motor terminals (Figure 7-3).

NOTICE

Studs and jam nuts on the electric motor can be damaged when removing or attaching electrical leads. Hold the terminal jam nut with a thin open end wrench when loosening or tightening the attaching nuts.

3. See Figure 7-5. Remove nuts (1), lock washers (2) and flat washers (3) and remove electrical cables from the terminals.
4. See Figure 7-4. Carefully support motor to prevent it from falling, and loosen and remove three bolts (16), lock washers (17) and flat washers (18) securing motor (14) to rear axle/differential housing (1). Pull motor away from rear axle housing and lift it clear of the vehicle.

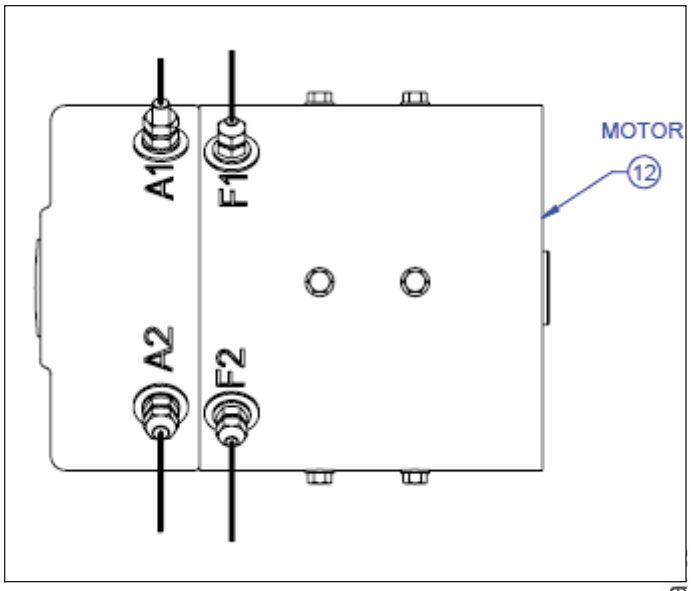

Figure 7-3. Labeling Motor Terminals

⚠CAUTION

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

5. See Figure 7-6. Remove cotter pins (25), clevis pins (24) and e-rings (23).
6. Disconnect brake cables (21, Figure 7-6) from brake assemblies on the rear axle.
7. Remove four nuts (4), bolts (2) and washers (3) securing rear axle (Figure 7-7).

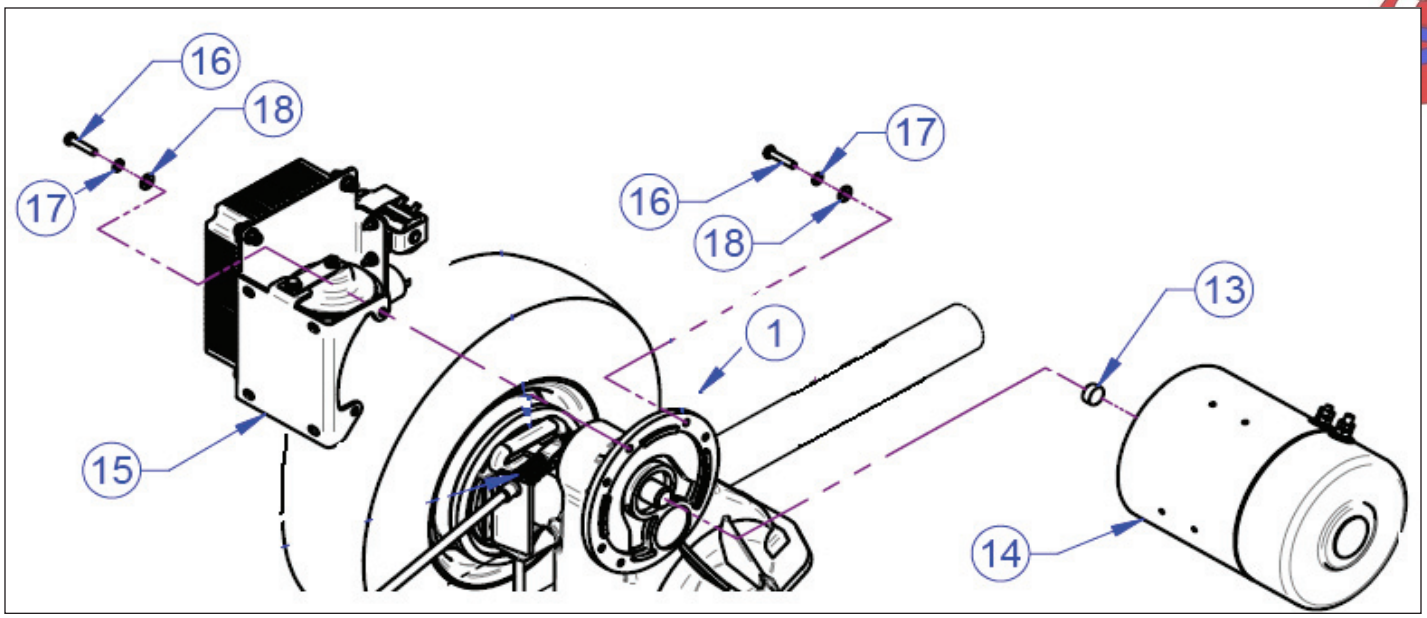

Figure 7-4. Motor Mounting Hardware

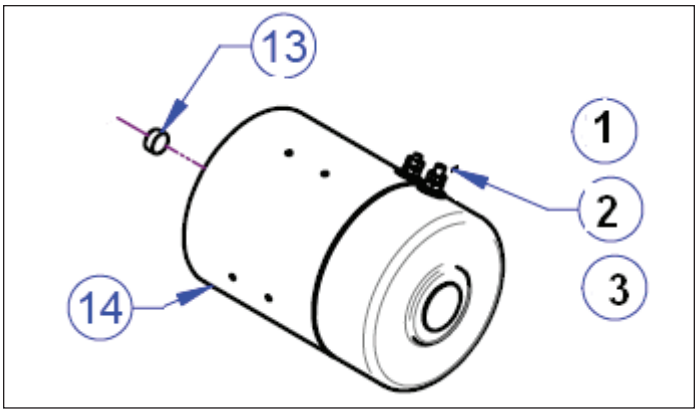

Figure 7-5. Motor Terminal Hardware

⚠CAUTION

Rear axle is heavy and awkward to move. Get help lifting and removing axle to prevent possible personal injury.

Disassembling Rear Axle

GENERAL INFORMATION

The rear axle 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 dray components before cleaning.
- Parts should be cleaned with emulsion cleaners or petroleum based cleaners.

⚠DANGER

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.

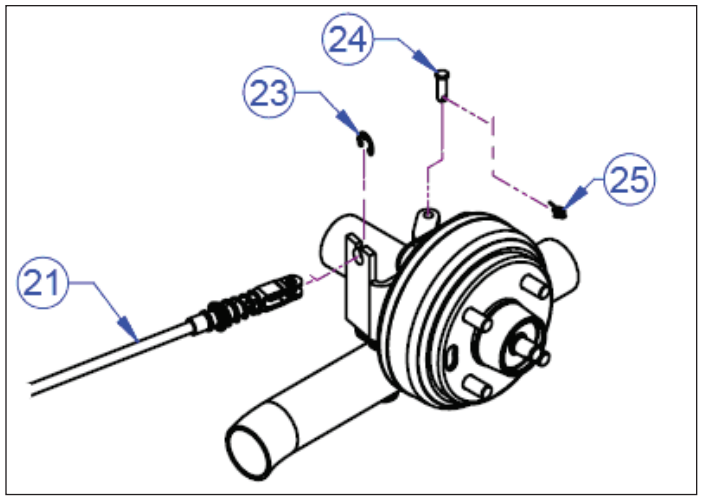

Figure 7-6. Brake Cable Attaching Hardware

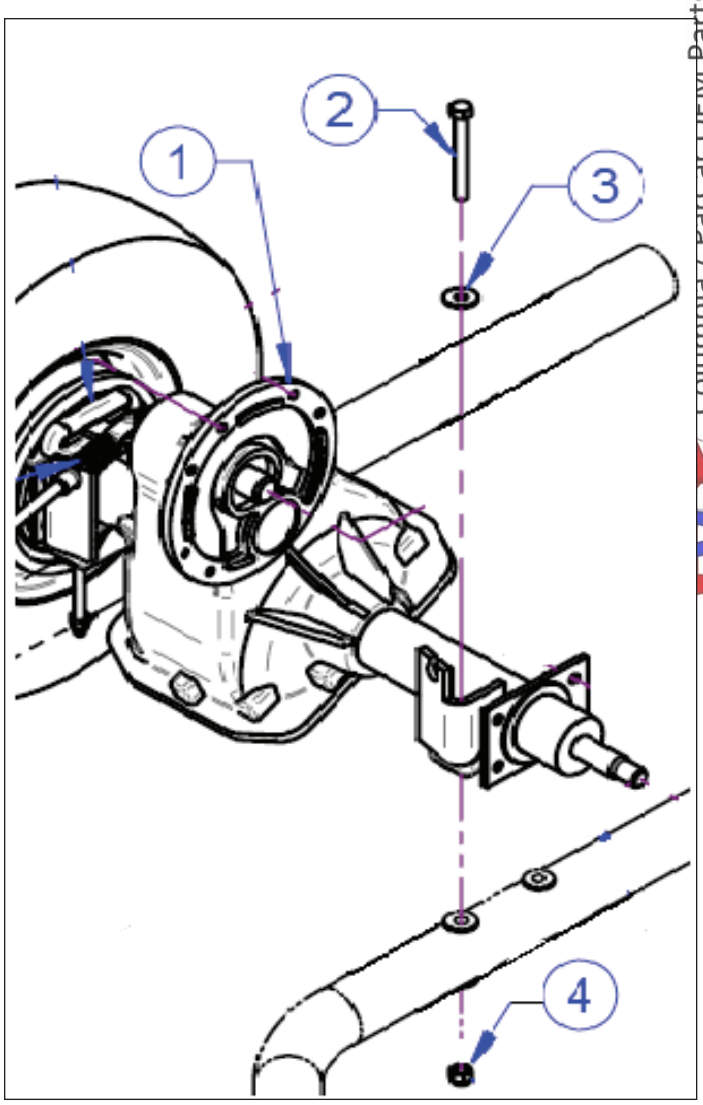

Figure 7-7. Rear Axle Attaching Hardware

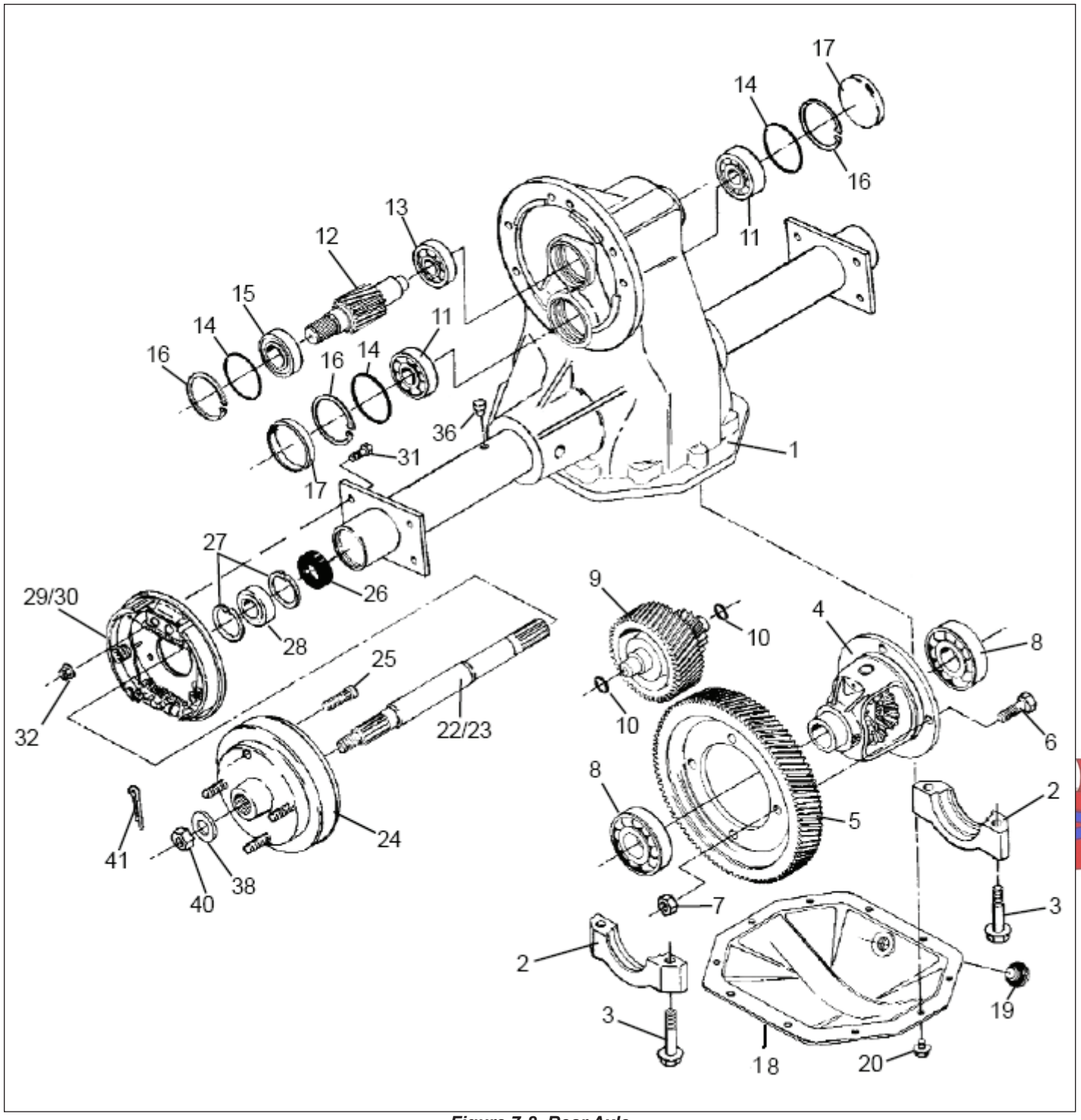

Figure 7-8. Rear Axle

- Remove all residual gasket material from sealing surfaces.
- Use soft, clean, lint-free towels to dray 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	
- 160 mm brakes	15-19 ft.lbs. (5-7 Nm)
- 7" x 1-3/4" brakes	16-20 ft. lbs. (6-7 Nm)
Spindle nut	95-115 ft. lbs. (34-41 Nm)

⚠DANGER

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

DISASSEMBLY

All callout numbers in steps refer to Figure 7-8.

1. Remove cotter pin (41), axle nut (40) and flat washer (38) from end of axle shaft (22, 23).
2. Remove outer snap ring (27). See Figure 7-9.
3. Using a slide hammer attached to the threaded end of the axle shaft (22, 23), remove axle shaft and bearing (28) assembly. See Figure 7-10).
4. Remove inner snap ring (27). Use care to not damage bearing surfaces. See Figure 7-11.

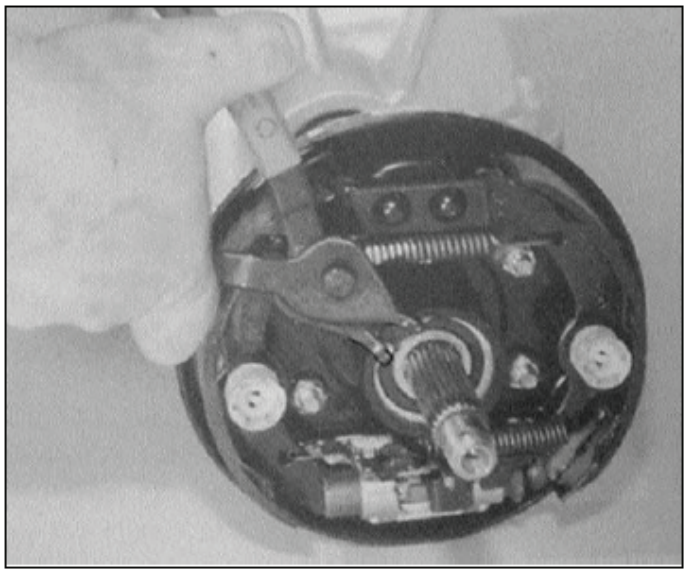

Figure 7-9. Removing Outer Snap Ring

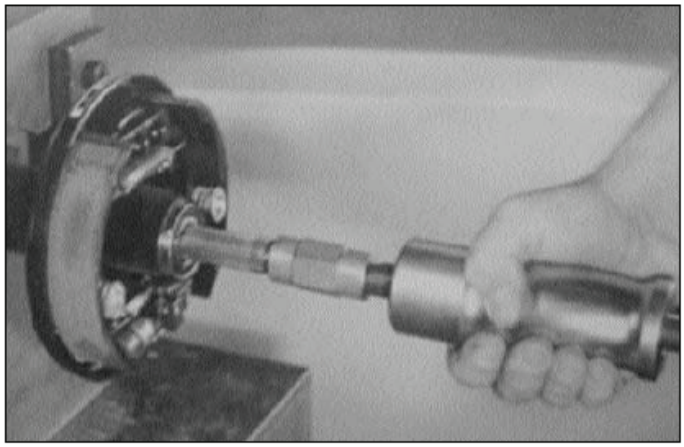

Figure 7-10. Removing Axle Shaft/Bearing Assembly

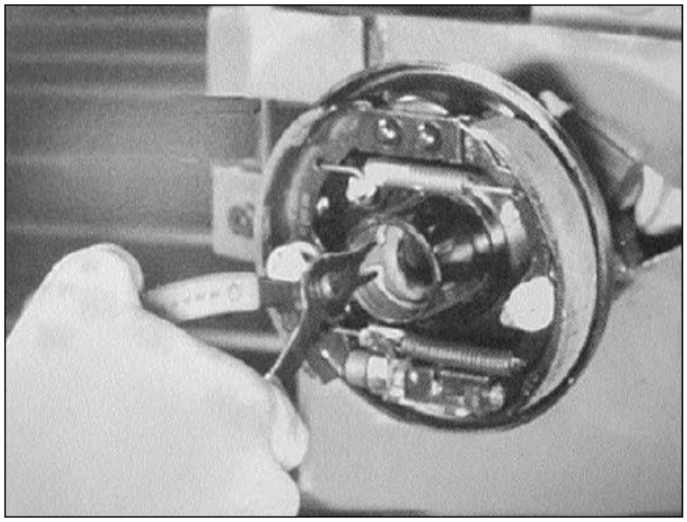

Figure 7-11. Removing Inner Snap Ring

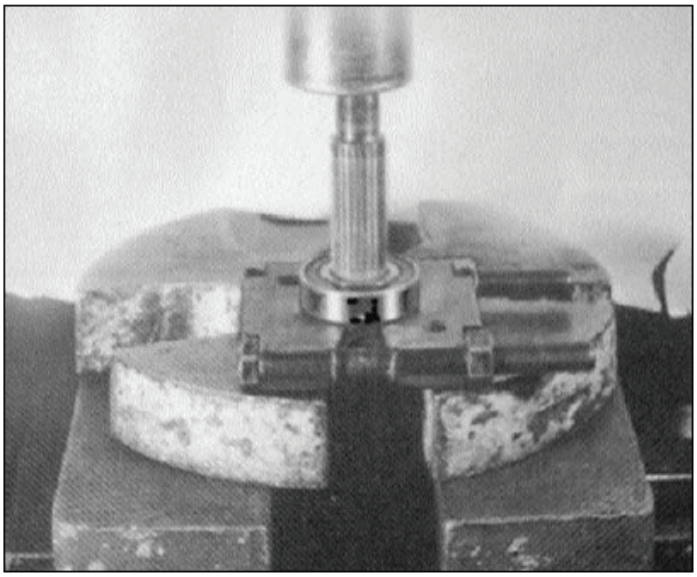

Figure 7-12. Removing Axle Bearing

5. Remove the bearing (28) 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. See Figure 7-12.
6. Repeat steps 1-5 to remove and disassemble the other shaft.
7. Remove ten cover screws (20).
8. Position the axle housing (1) over a drain pan. Using a putty knife, separate the cover plate from the housing (Figure 7-13). Use care to not damage the housing sealing surfaces or to deform the cover plate.
9. Remove four bearing cap bolts (3) and both bearing caps (2). See Figure 7-14.

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.

10. Using a bearing puller, remove differential bearings (8) from each side of the differential case. See Figure 7-16.
11. Remove four bolts (6) and nuts (7) from the final drive gear (5). Remove gear from differential case. Use care not to damage gear teeth. See Figure 7-17.

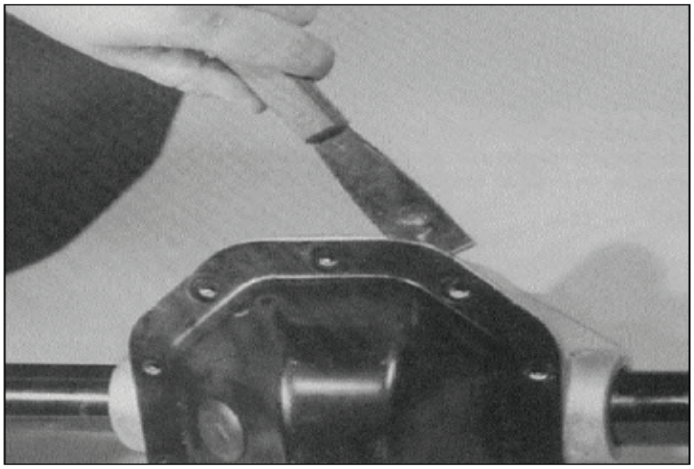

Figure 7-13. Removing Cover Plate

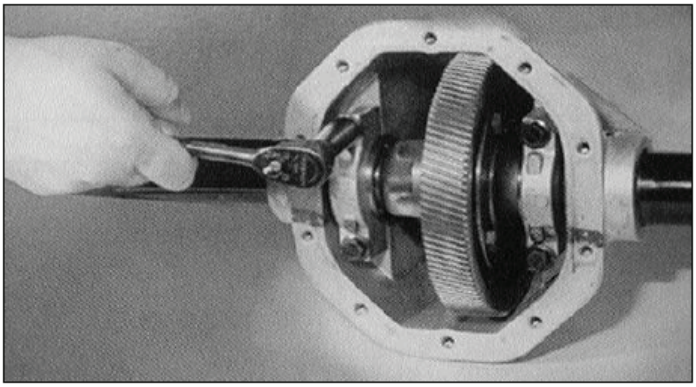

Figure 7-14. Removing Bearing Caps

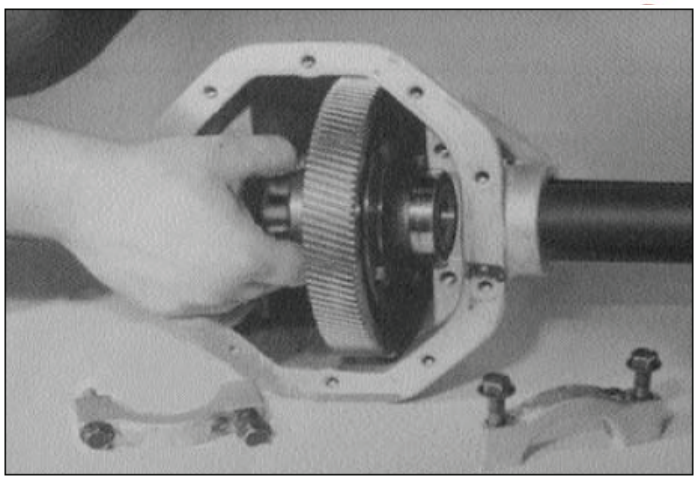

Figure 7-15. Removing Differential Assembly

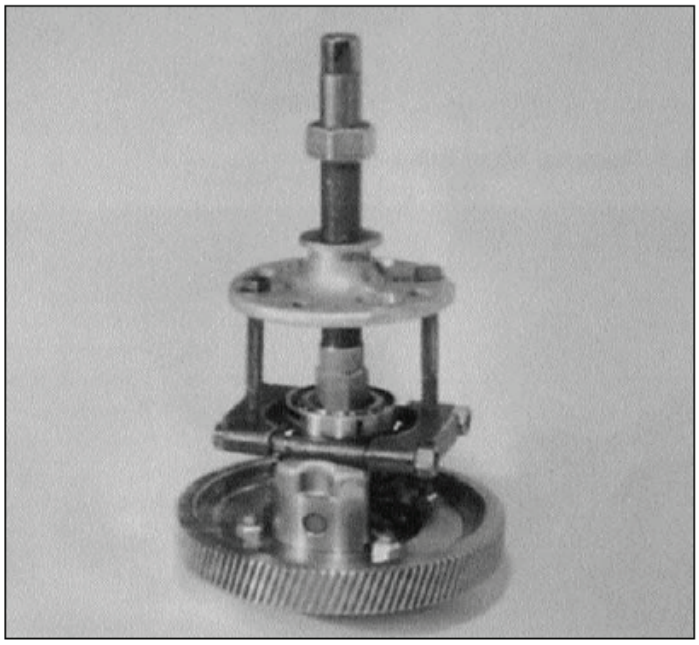

Figure 7-16. Removing Differential Bearings

12. Punch or drill a 1/8” diameter hole near the center of each intermediate cup plug (17). Insert a suitably sized sheet metal screw until the metal bore plug is forced out of the bearing bore. See Figure 7-18.
13. Remove snap rings (16) from each intermediate bore. See Figure 7-19.

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.

14. Using a brass drift pin, drive the intermediate shaft (4) from the flange side of housing. Shaft should travel far enough to allow engagement of I.D. bearing puller.
15. Using an I.D. bearing puller attached to a slide hammer, remove intermediate bearing (11) from flange side of housing. See Figure 7-20.
16. Repeat steps 1 - 15 for intermediate bearing on opposite side.
17. Remove snap ring (16) from input shaft bore (12). See Figure 7-21.

NOTICE

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

18. Pull input shaft assembly (12) from housing. The input shaft assembly should slide out easily. If resistance is encountered,

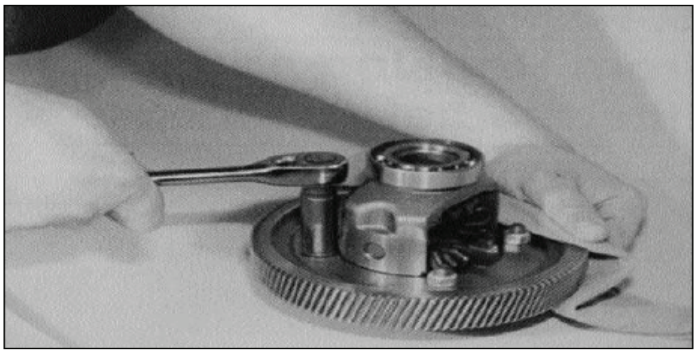

Figure 7-17. Removing Output Gear from Differential

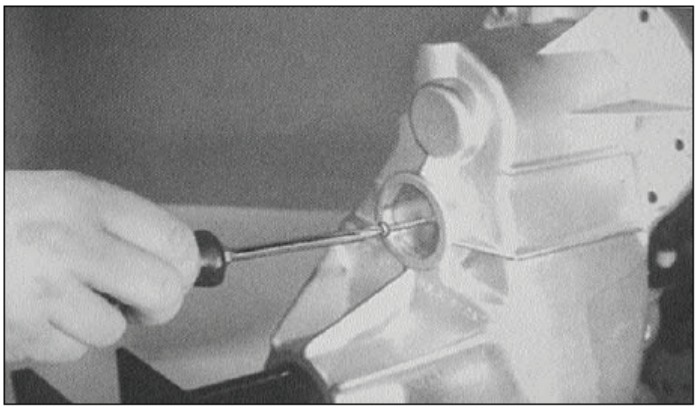

Figure 7-18. Removing Cup Plugs

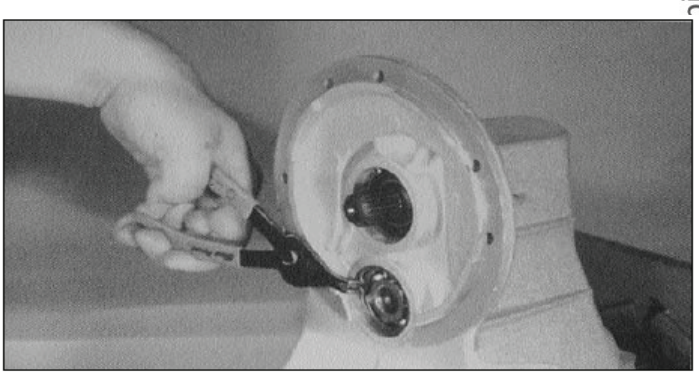

Figure 7-19. Removing Snap Rings

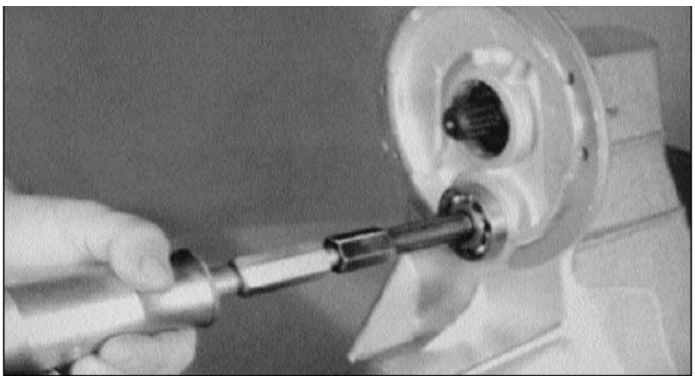

Figure 7-20. Removing Intermediate Shaft

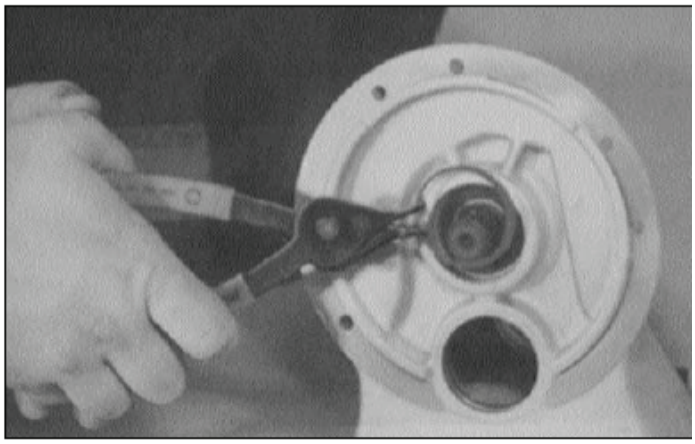

Figure 7-21. Input Shaft Bore Snap Ring

a slide hammer may be required. See Figure 7-22.

19. Remove O-rings from outer input bearing bore and both intermediate bores (Figure 7-23).
20. Remove O-rings (10) at each end of intermediate shaft on bearing shoulders (Figure 7-24).
21. 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.

Assembling Rear Axle

All callout numbers in steps refer to Figure 7-8.

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 7-25).
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. If resistance is encountered, use a plastic or leather mallet to tap shaft into position. See Figure 7-22.
5. Install outer snap ring (16) at input shaft bore. See Figure 7-23.

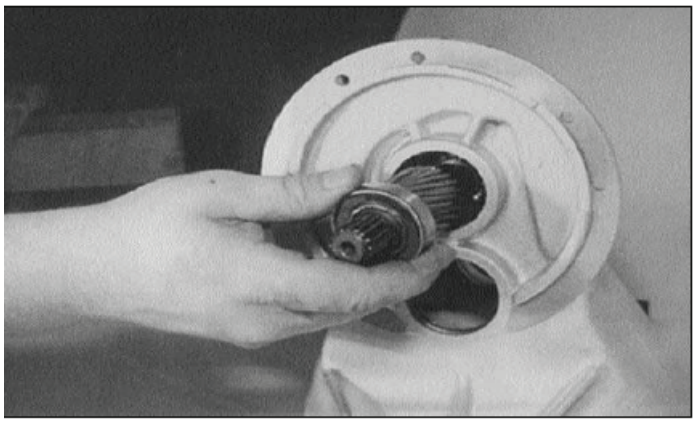

Figure 7-22. Intermediate Shaft & Bearing

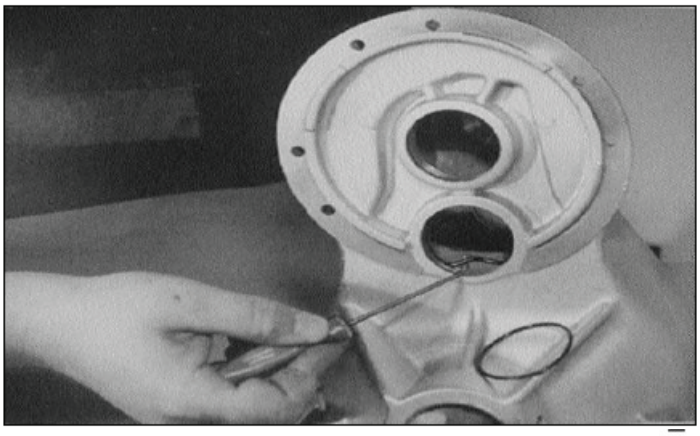

Figure 7-23. Removing O-rings

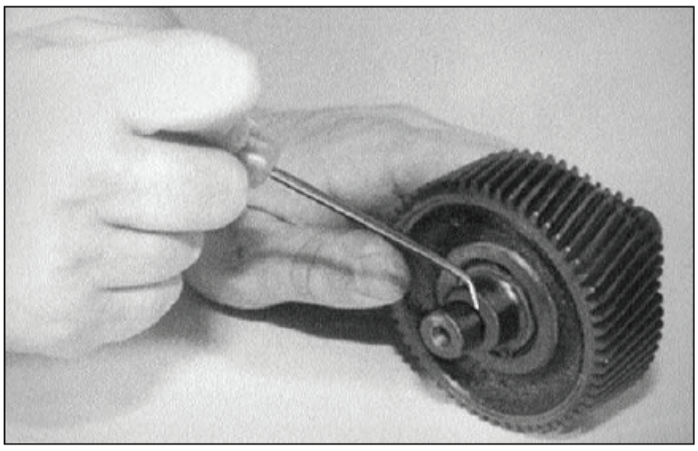

Figure 7-24. Removing O-rings from Intermediate Shaft & Gear

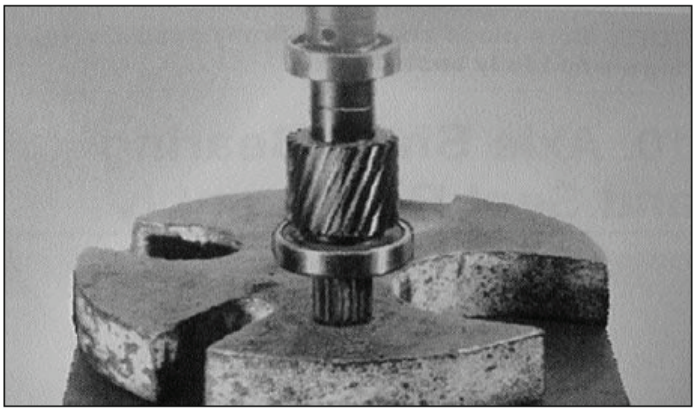

Figure 7-25. Installing Bearings on Input Shaft

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.
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). See Figure 7-26.
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. See Figure 7-27.

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.

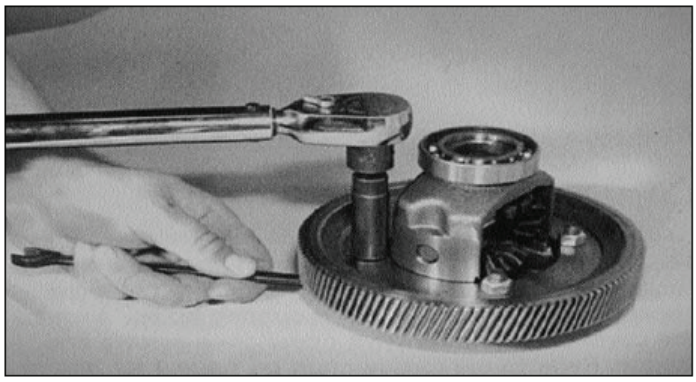

Figure 7-26. Torquing Differential Case Nuts

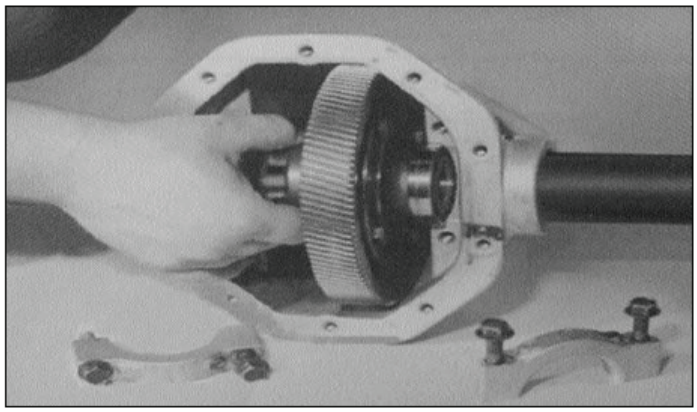

Figure 7-27. Installing Differential Case Assembly

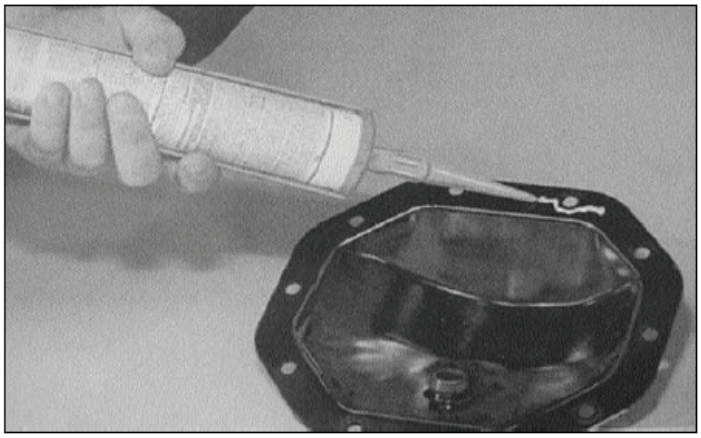

Figure 7-28. Installing Differential Case Assembly

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 7-28).
14. Install cover plate (18) with ten bolts (20). Torque bolts to 16-24 ft. lbs. (21.5-32.5 Nm).

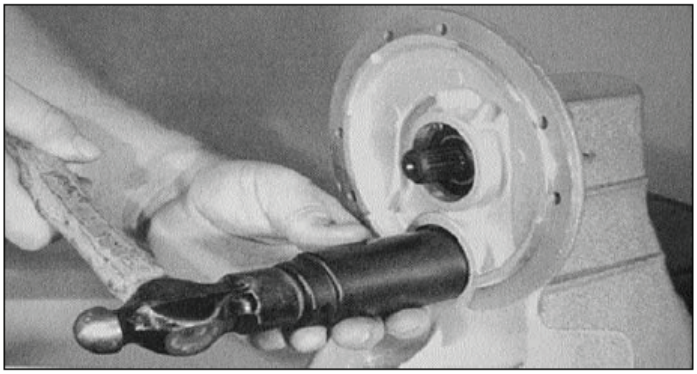

Figure 7-29. Installing Cup Plugs

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). See Figure 7-29.
16. With properly sized seal driver, install shaft seals (26). Press seals to depth of 1.125" (28.5 m). See Figure 7-30.
17. Install inner snap ring 927) to both right and left tubes (Figure 7-31).
18. Press bearings (28) onto axle shafts (22, 23). Bearing should seat on shoulder. Use appropriate driver to install bearings. See Figure 7-32.
19. Coat lip of seal (26) with SAE 30 oil before inserting axle shaft (22, 23). 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 (27).

    Shaft may have to be rotated to engage differential splines during installation.
20. Install outer snap ring (27) in each tube (Figure 7-33).
21. 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 threaded plug, torque to 25-40 ft. lbs. (6-14 Nm).
22. Apply Anti-Seize compound to the splines before installing the drum/hub. Install the hub on the spline shaft and install spindle nut on the threaded end of the shaft. Torque spindle nut to 95-115 ft. lbs. (34-41 Nm).]

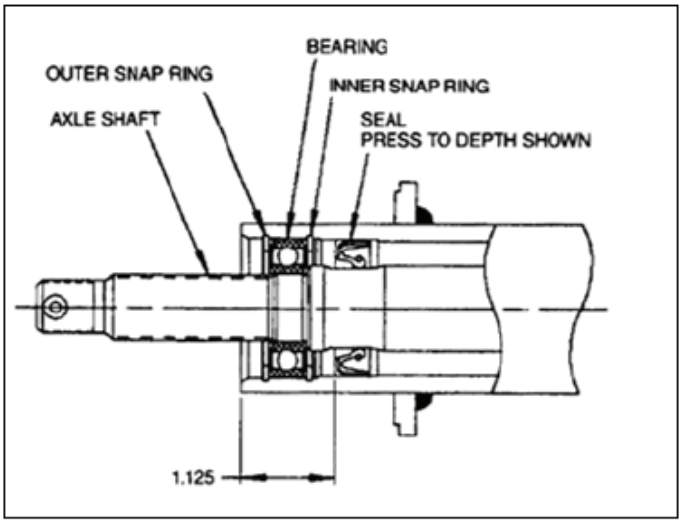

Figure 7-30. Axle Components

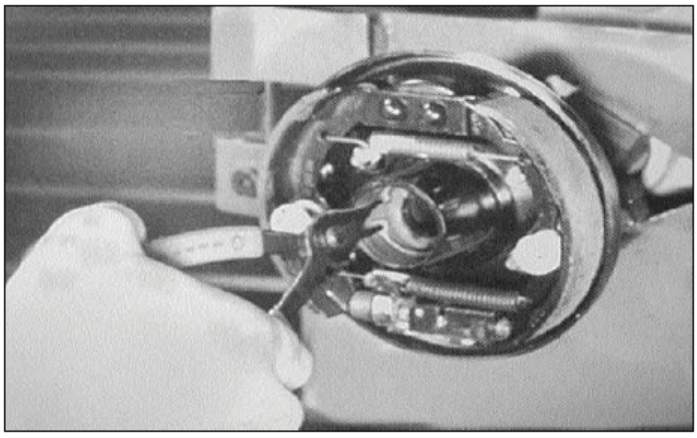

Figure 7-31. Installing Inner Snap Ring

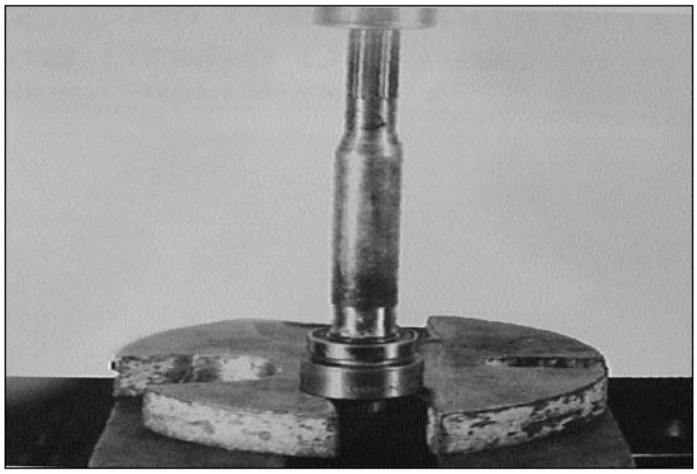

Figure 7-32. Installing Bearings on Axle Shaft

Installing Rear Axle

⚠CAUTION

Rear axle is heavy and awkward to move. Get help lifting and installing axle to prevent possible personal injury.

NOTICE

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

1. Carefully position axle into place through one of the vehicle wheel arches.
2. See Figure 7-7. Secure axle to frame with four bolts (2), washers (3) and nuts (4). Torque nuts to 45 ft. lbs. (16 Nm).
3. See Figure 7-6. Reattach rear brake cables (21) to brake actuator arms with clevis pins (24), new cotter pins (25) and e-rings (23).
4. Position controller mounting bracket (15) to the motor mount flange of the rear axle (Figure 7-4). Check motor shaft for rubber button (13). Open end should point outward.
5. Coat splines of axle input end and motor armature with Anti-Seize.
6. See Figure 7-4. Install motor (14) to motor mounting flange of axle. Secure motor and controller mounting bracket (15) with three bolts (16), lock washers (17) and flat washers (18).

⚠CAUTION

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

7. Refer to Figure 7-34. To evenly draw the face of the motor up to the flange on axle, tighten screws A and B, then tighten screw C. Now, torque screws A and B to 100 in. lbs. (11.3 Nm), then torque screw C to 100 in. lbs. (11.2 Nm).

NOTICE

Studs and jam nuts on the electric motor can be damaged when removing or attaching electrical leads. Hold the terminal jam nut with a thin open end wrench when loosening or tightening the attaching nuts.

8. See Figure 7-5. Reattach wiring to electric motor. Secure cables with flat washer (3), lock washer (2) and nuts (1). See Figure 7-8. Torque nuts at A1 & A2 to maximum of 110 in. lbs. (12.4 Nm). Torque nuts at F1 & F2 to a maximum of 50 in. lbs. (5.7 Nm). Make sure wires are attached per wiring diagram. Refer to *Wiring Diagrams in Appendixes*.
9. Install wheel assemblies and secure with lug nuts (11, Figure 7-1) Tighten lug nuts until snug, using a criss-cross pattern (Figure 7-2).
10. Carefully lower the vehicle to the ground.

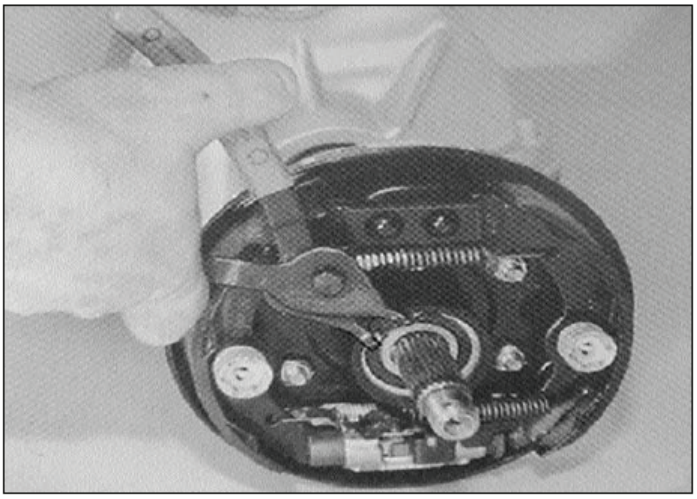

Figure 7-33. Installing Outer Snap Ring

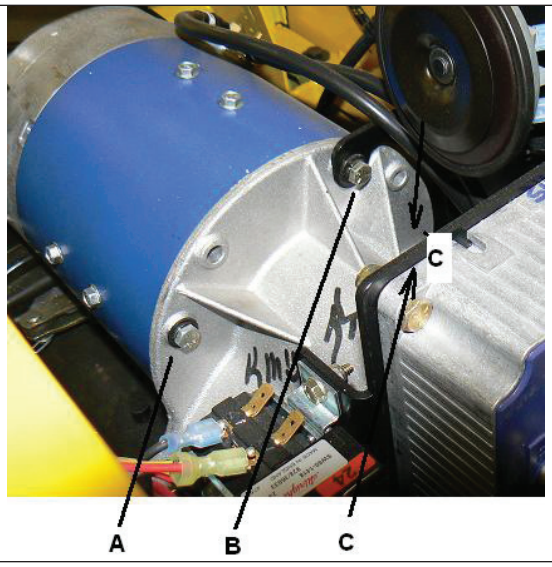

Figure 7-34. Motor Attaching Bolts

11. Torque the lug nuts in a criss-cross pattern to 65 ft. lbs. (23 Nm).
12. Install the batteries (if removed). Make sure battery cables are installed correctly per the wiring diagram. Refer to *Section 9 - Batteries*.
13. Drive the vehicle and test axle operation.

REAR AXLE DIFFERENTIAL OIL

Changing Differential Oil

Differential oil must be changed at least once a year under normal vehicle usage. If vehicle is operated under extreme conditions, or for more than 8 hours a day, oil should be changed twice a year.

It is not necessary to remove the axle to change the differential oil.

⚠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*.

Have an oil drain pan handy.

1. Remove ten cover plate bolts (Figure 7-35).
2. Remove cover and drain oil into drain pan.
3. Clean carrier cover with lint-free rag.
4. 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 7-28).
5. Install cover plate (18) with ten bolts (20). Torque bolts to 16-24 ft. lbs. (21.5-32.5 Nm).
6. Remove fill plug (19) in cover plate (18). Fill axle assembly with 12 ounces (360 ml) of Light Weight Gear Lubricant, SAE 30.
7. Install drain/fill plug. Torque to 25-40 ft. lbs. (6-14 Nm).

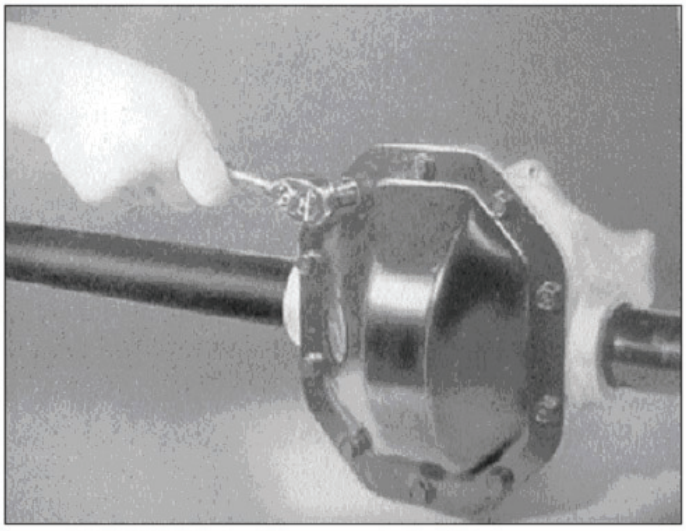

Figure 7-35. Carrier Cover

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ELECTRIC VEHICLE SERVICE

When servicing the electric Columbia Industrial/Commercial vehicle always observe the following:

⚠ SAFETY FIRST ⚠

Always turn Power key to OFF, Directional key switch to Neutral, remove Power key, block tires and disconnect the battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.

COUNTERWEIGHT

Removing Counterweight

1. See Figure 8-1. Remove bolts (5), washers (4), nylon lock nuts (6).

   If vehicle is equipped with optional head light (Figure 8-2), disconnect electrical leads and remove it.

2. Remove counterweight and spacers (3).

Installing Counterweight

1. Position spacers (3) and counterweight over locating hub. If additional counterweights are being added, do not install spacers.
2. Adjust position of counterweight(s) until holes line up. Use an alignment pin or screwdriver if necessary.
3. If optional headlight was removed, connect electrical leads and position over mounting holes.
4. Install bolts (5), washers (4) and lock nuts (6).

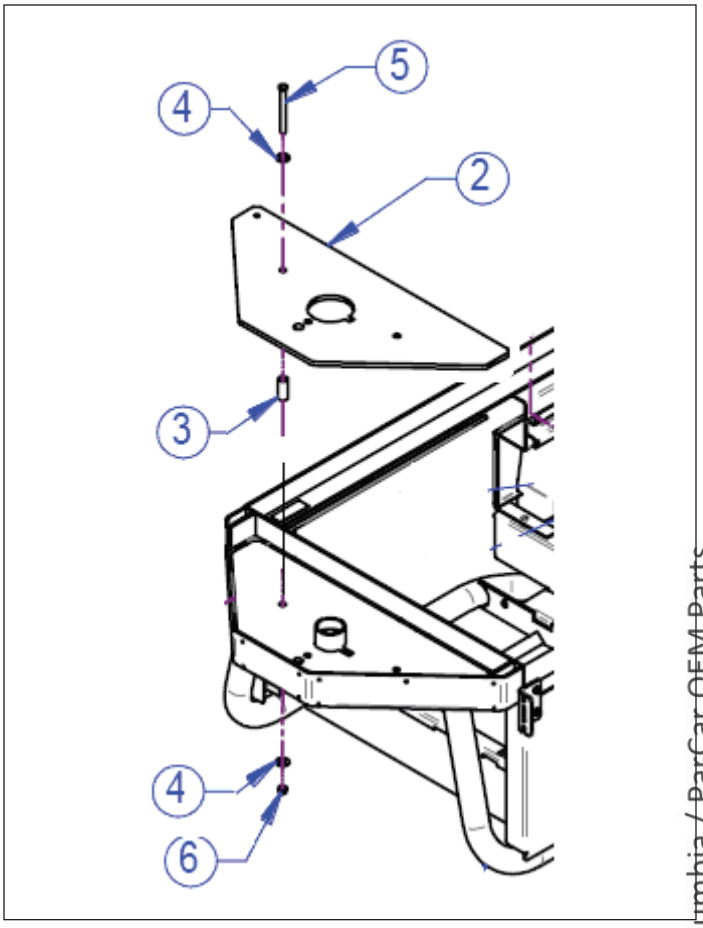

Figure 8-1. Counterweight

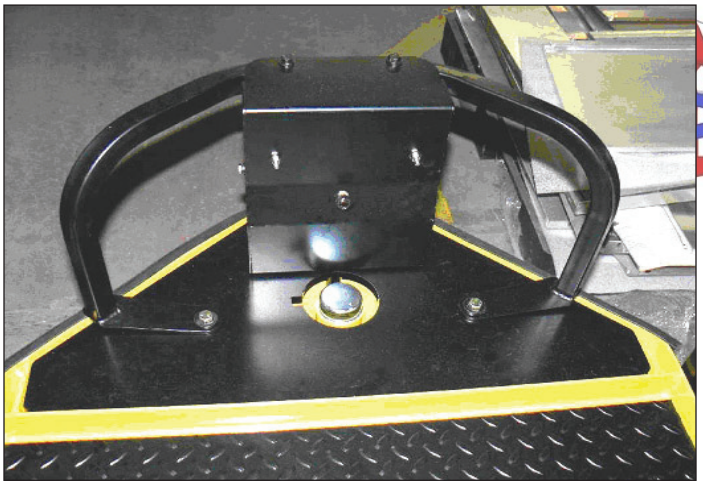

Figure 8-2. Headlight Assembly (optional)

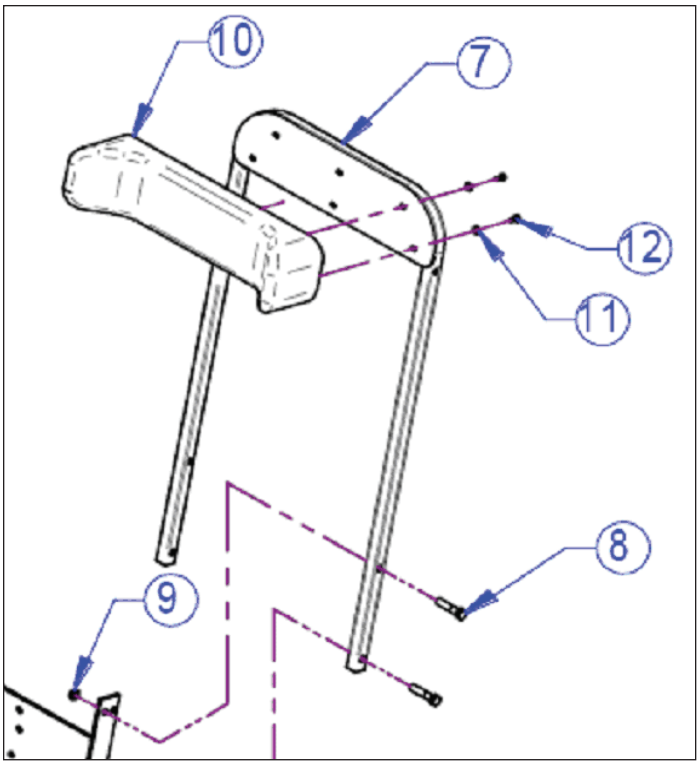

Figure 8-3. Seat Back and Weldment

SEAT BACK AND WELDMENT

1. See Figure 8-2. Remove six bolts (12) and washers (11), and remove seat back cushion from weldment.
2. Remove four nuts (9) and bolts (8), and remove weldment from chassis.
3. Place weldment onto chassis and align mounting holes. Install four bolts (8) and nuts (9). Tighten hardware securely.
4. Position seat back cushion on weldment and align mounting holes. Install six bolts (12) and nuts (11). Tighten hardware securely.

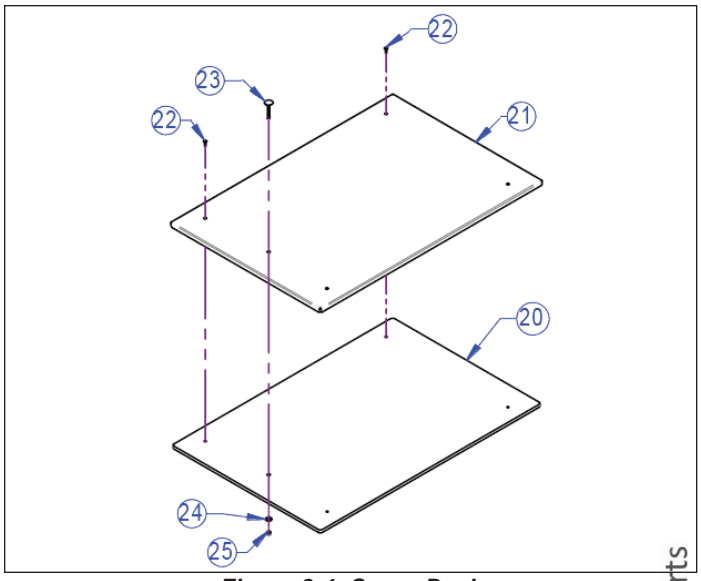

Figure 8-4. Cargo Deck

CARGO DECK

The deck plate assembly (plywood deck and deck plate) is not attached to the vehicle but rests in the recess of the frame.

1. If plywood deck is damaged and requires replacement, remove the nut (25), washer (24) and lifting screw (23). Remove four wood screws (22). See Figure 8-4.
2. Attach new plywood deck to deck plate with four wood screws. Install lifting screw (23), washer (24) and nut (25).
3. Place cargo deck into position in frame recess.

STEERING WHEEL & CONSOLE

Removal

1. Remove pin (26) using a soft drift of the same size (Figure 8-5). Pull steering wheel from sprocket.
2. Remove four screws (14) on sides of console and pull console away from frame, exposing the upper and lower steering groups.

Installation

1. Set console into place on frame and attach using four screws.
2. Set steering wheel onto sprocket shaft and align with mounting hole.
3. Drive in roll pin to secure steering wheel.

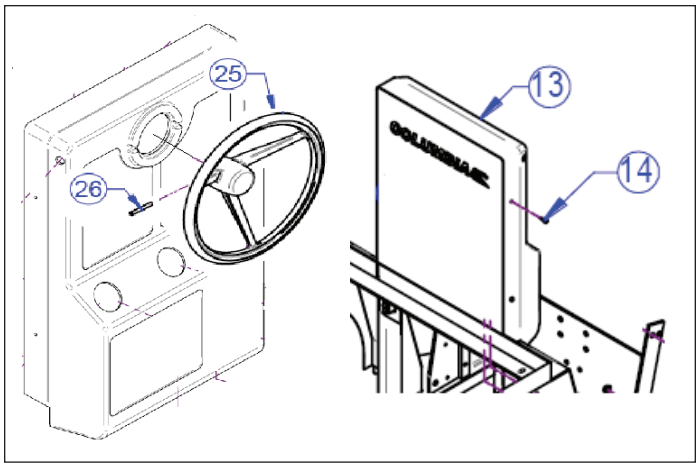

Figure 8-5. Steering Wheel and Console

HOUR METER

Replacement

Note and record time on hour meter before removing it.

1. Remove steering wheel and console.
2. Remove wires from back of hour meter. Figure 8-6. Remove retainer from back side of console and remove hour meter.
3. Position new hour meter to face of console and secure with retainer on back side of console (Figure 8-7).
4. Reconnect wires to back of hour meter.
5. Install console and steering wheel.
6. Reconnect battery negative cable and insert power key.
7. Turn power key to ON position. Using a volt meter, check that hour meter is receiving full battery voltage from depressed speed switch.

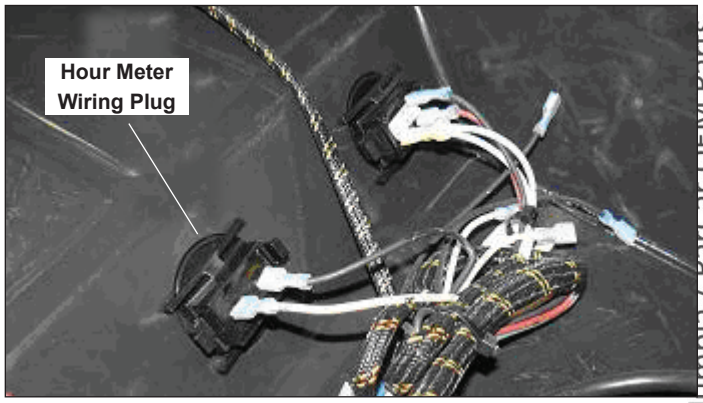

Figure 8-6. Hour Meter Wiring

BATTERY CHARGER INDICATOR (BDI)

Replacement

1. Remove steering wheel and console.
2. Remove wires from back of BDI. Figure 8-8. Remove retainer from back side of console and remove BDI.
3. Position new BDI to face of console and secure with retainer on back side of console (Figure 8-9).
4. Reconnect wires to back of BDI.
5. Install console and steering wheel.
6. Reconnect battery negative cable and insert power key.
7. Turn power key to ON position. Check that light is illuminated on BDI display.

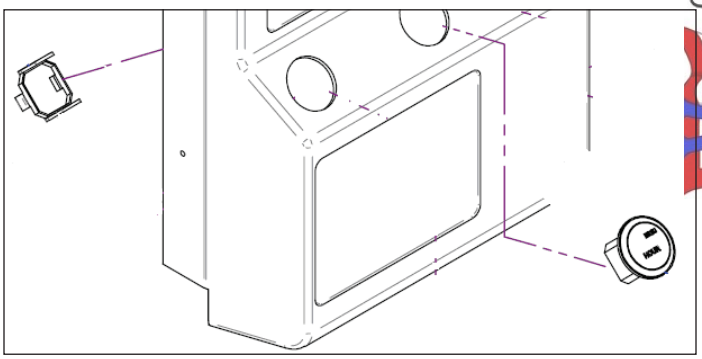

Figure 8-7. Hour Meter Mounting

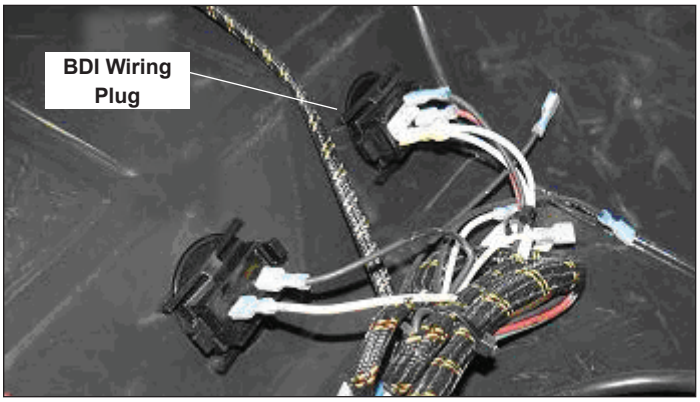

Figure 8-8. BDI Wiring

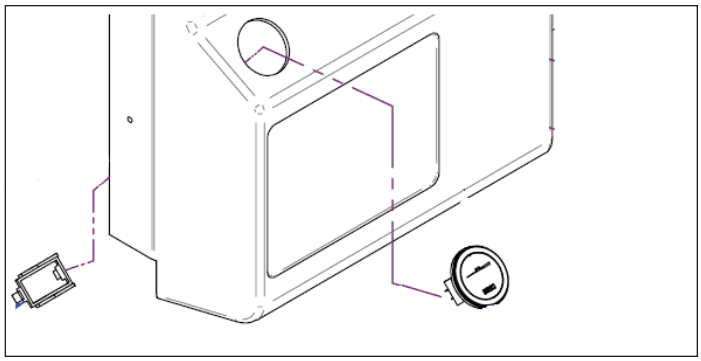

Figure 8-9. BDI Mounting

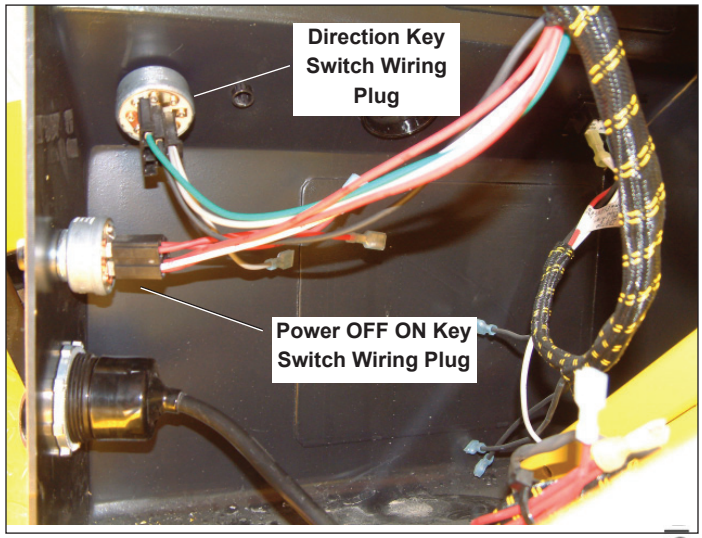

Figure 8-10. Directional Key Switch Wiring

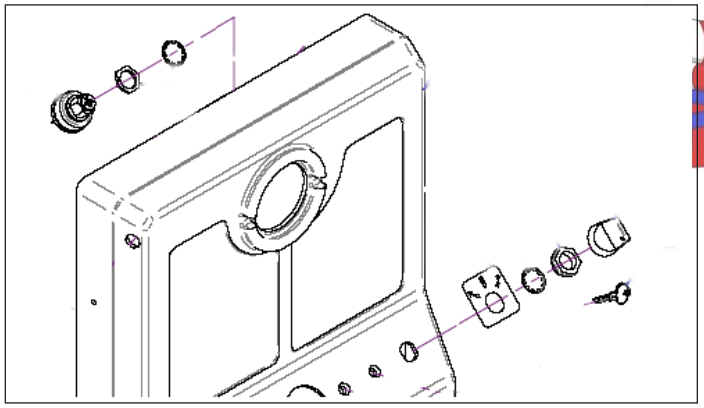

Figure 8-11. Directional Key Switch and Power Key Switch Mounting

DIRECTIONAL KEY SWITCH

Replacement

Directional key switch comes standard with a non-removeable key. Once it is installed in the switch, it cannot be removed without breaking it. A removable key is optional.

1. Remove steering wheel and console.
2. Remove wires from back of directional key switch (Figure 8-10).
3. Remove hex nut and tooth washer (Figure 8-11) and remove key switch out the back of the console.
3. Position new directional key switch into console from the backside and secure tooth washer and hex nut.
4. Reconnect wires to back of key switch (Figure 8-10).
5. Install console and steering wheel.
6. Reconnect battery negative cable and insert power key.
7. Turn power key to ON position. Check the operation of the directional key switch.

POWER KEY SWITCH

Replacement

1. Remove steering wheel and console.
2. Remove wires from back of power key switch (Figure 8-10).
3. Remove hex nut and tooth washer (Figure 8-11) and remove key switch.
3. Position new power key switch into console and secure with tooth washer and hex nut (Figure 8-11).
4. Reconnect wires to back of key switch.
5. Install console and steering wheel.
6. Reconnect battery negative cable and insert power key.
7. Turn power key to ON position. Check the operation of the power key switch.

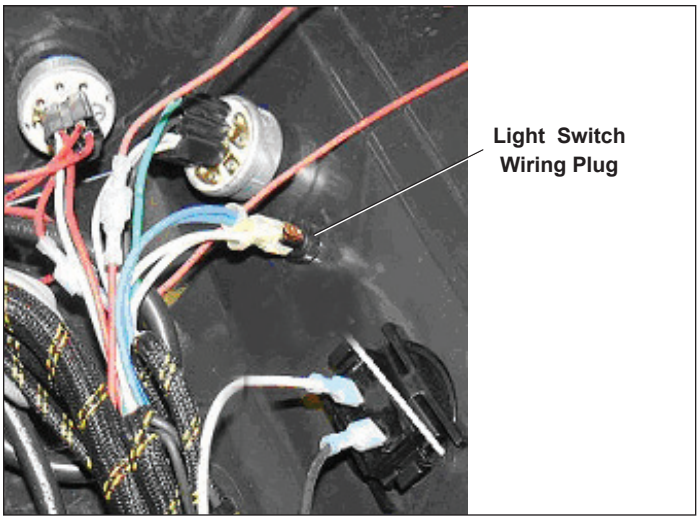

Figure 8-12. Light Switch Wiring

LIGHTS ROCKER SWITCH

Replacement

1. Remove steering wheel and console.
2. Remove wires from back of light rocker switch (8-12).
3. Remove round plastic nut on back of console (Figure 8-13) and remove key switch.
3. Position new rocker switch into console and secure with round plastic nut.
4. Reconnect wires to back of switch (Figure 8-12).
5. Install console and steering wheel.
6. Reconnect battery negative cable and insert power key.
7. Turn power key to ON position. Check the operation of the switch.

POWER INLET PLUG

Replacement

1. Remove steering wheel and console.
2. Disconnect power inlet cable plug from battery charger pigtail. Cut cable ties to free cable.
3. Remove retainer nut on back of console (Figure 8-15) and remove power inlet plug.
3. Position new power inlet plug into console and secure with retainer nut (Figure 8-14).
4. Reconnect power inlet plug cable to battery charger pigtail. Secure with new cable ties.
5. Install console and steering wheel.
6. Reconnect battery negative cable.

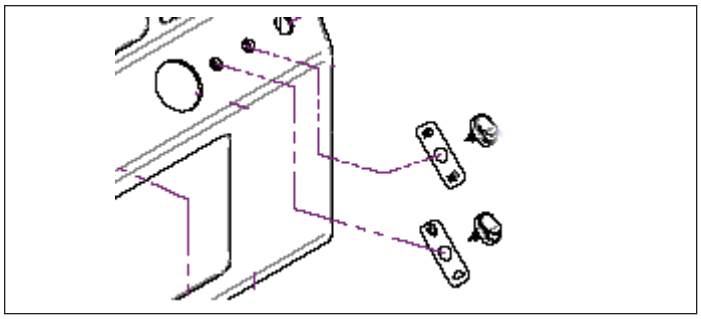

Figure 8-13. Light Switch Mounting

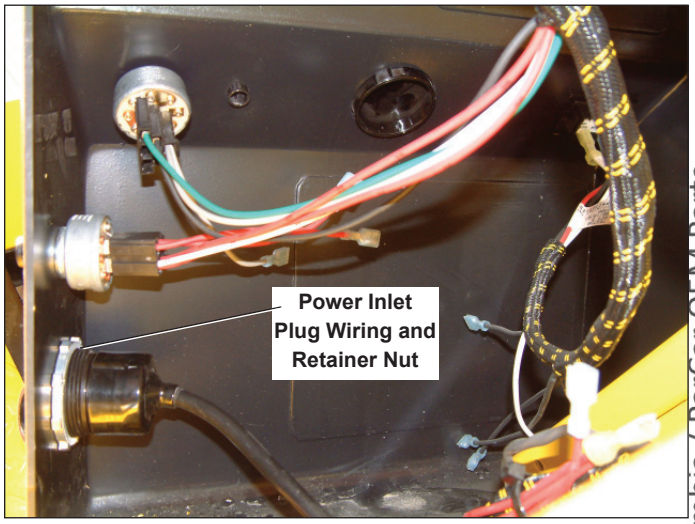

Figure 8-14. Power Inlet Plug Wiring

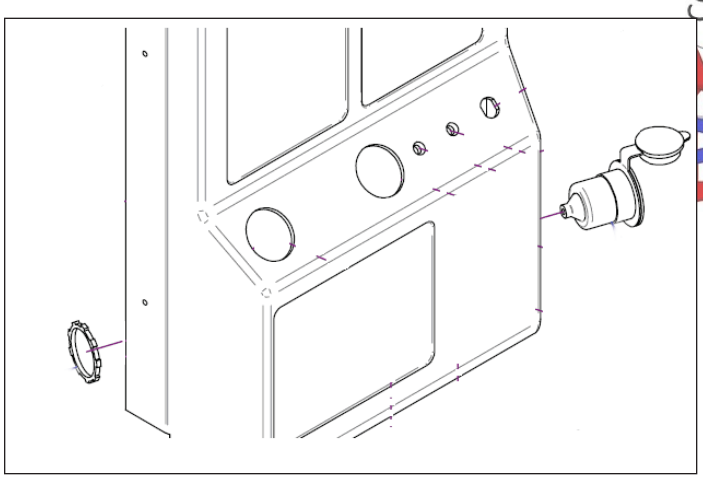

Figure 8-15. Power Inlet Plug Mounting

HORN

Switch Replacement

1. Remove steering wheel and console.
2. Disconnect wires to back of horn switch.
3. Unscrew flat hex nut which holds the horn switch (2) to the console. Remove horn switch (2, Figure 8-16).
4. Install new switch, reconnect wires.
5. Install console and steering wheel.

Horn Replacement

1. Remove cargo deck.
2. Disconnect wires from horn.
3. Remove horn from mounting bracket (Figure 8-17).
4. Install new horn to mounting bracket and reconnect wires.
5. Install cargo deck.

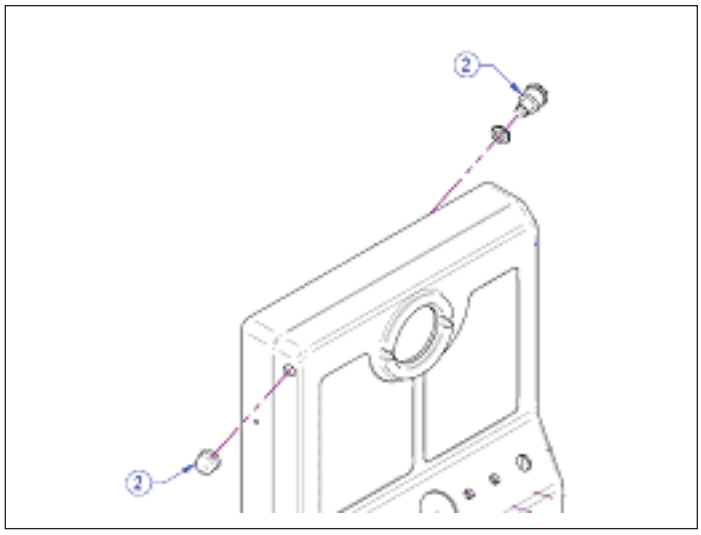

Figure 8-16. Horn Switch Mounting

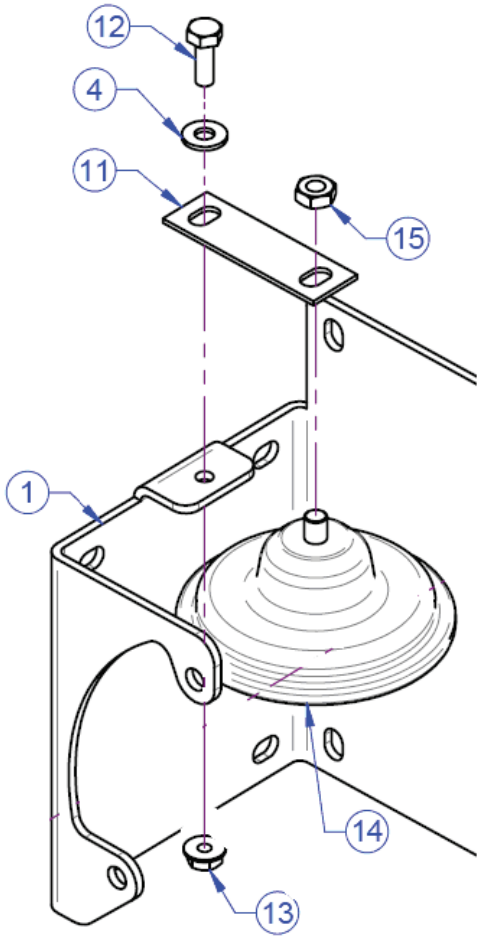

Figure 8-17. Horn Mounting

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ELECTRIC VEHICLE SERVICE

When servicing the electric Columbia Industrial/Commercial vehicle always observe the following:

⚠ SAFETY FIRST ⚠

Always turn Power key to OFF, Directional key switch to Neutral, remove Power key, block tires and disconnect the battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.

SAFETY

⚠CAUTION

Only deep cycle batteries designed for electric vehicle service should be used.

⚠WARNING

Batteries contain sulfuric acid which is highly corrosive and can cause chemical burns.

Avoid contact with skin, eyes or clothing.

Always wear approved eye protection when working around batteries. Do not smoke around batteries.

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 9-Batteries* for details.

Battery is poisonous and emits explosive gases. Do not smoke. Keep sparks and flames away from the vehicle and service area. Ventilate when charging or operating in an enclosed area. Refer to *Section 9-Batteries* for details.

Contains acid! Causes severe burns. Avoid contact with skin, eyes, or clothing. Wear full face shield and rubber gloves when working on or near batteries.

ANTIDOTES TO BATTERY ACID CONTACT:

- **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.**

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.

⚠WARNING

The gases produced by a storage battery on charge are highly explosive.

To prevent possible personal injury, charge batteries in a well-ventilated area, keep fire and flame away from battery charging area.

⚠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.

GENERAL INFORMATION

Battery Types

DEEP CYCLE, LEAD ACID, FLOODED CELL

Columbia recommends: U. S. Battery, model 2200, XB or XC, 225 amp hour, or U. S. Battery, model 145, XC, 244 amp hour.

24 VOLT SYSTEMS

225 amp hour, 115 minute, 6-volt, 4 each, or

244 amp hour, 145 minute, 6-volt, 4 each.

48 VOLT SYSTEMS

225 amp hour, 115 minute, 6-volt, 8 each, or

244 amp hour, 145 minute, 6-volt, 8 each.

NOTICE

The IT34 TUGR uses 244 Amp hour batteries only.

ELECTRIC VEHICLE BATTERY

The storage battery receives, stores, and delivers electrical power. This receiving, storing, and delivering of electrical power is called a cycle.

Receive- Charging vehicle batteries.

Store- Vehicle standing idle.

Deliver-Driving vehicle.

Batteries furnished for electric vehicle operation are specially constructed for this type of service.

Automotive batteries are designed to furnish high current draws for short duration, and are kept in a near fully charged state by the charging system.

Electric vehicle batteries must be able to furnish currents up to 50 amperes for long durations, and also be able to supply that current while in a partially discharged condition. This type of service requires a deep cycle battery - a battery that is durable enough to withstand repeated complete cycling.

For this reason, electric vehicle batteries are constructed with heavier plates and cells with a greater capacity for electrolyte.

⚠CAUTION

Only deep cycle batteries designed for electric vehicle service should be used.

BATTERY INSPECTION

Batteries should be carefully inspected every 8 hours of operating time, or weekly, whichever comes first.

This procedure should also be followed before any tests are performed on the batteries.

- Battery must be clean and dry. Dirt and electrolyte on top of battery causes battery to self discharge. Clean battery top with baking soda (sodium bicarbonate) and water solution (5 teaspoons baking soda per quart water). Do not allow solution to enter cap vent holes.
- Inspect battery posts, clamps and cables for breakage, loose connections and corrosion. Clean battery posts and clamps.
- 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.
- 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.
- Check electrolyte level. Sufficient distilled water would be added to cover plates before charging, then after charging, remaining distilled water can be added to bring electrolyte to correct level.
- Inspect battery case for cracks or leaks.

BATTERY CLEANING

Battery terminal connections should be individually cleaned and maintained annually. More frequent cleaning may be required under heavy use, or as batteries age.

NOTICE

Make note of any accessory wire connections before disconnecting batteries. Refer to wiring diagrams for proper connection.

1. Remove battery cables and wire connections from all battery terminals.
2. Brush battery cable and wire connections clean using soft brass wire brush.
3. Replace battery cable terminals that are damaged or corroded.
4. Hose off the tops of the batteries and all around the batteries to flush out the battery box/tray. The batteries supplied with the vehicle are flooded cell, with electrolyte (acid) inside. Replenish with distilled water only to top of plates.

5. Keep the batteries clean, fully charged, properly secured and terminal connections tight. Do not over tighten connections. Acid soaked dirt on the battery tops causes current leakage, reduced battery efficiency and promotes rapid self-discharge during storage.
6. Hose wash battery tops periodically with clean, low-pressure water to keep them free of acid spillage, dirt and other debris. If vented batteries are used, make sure vent caps are secure before washing. Do not hose wash electronic controllers, switches, solenoids, and other electrical control devices. Direct water away from these components, covering them if necessary.
7. Wash battery tops with a baking soda mixture (1/2 cup per quart) of water) and a stiff non-metallic bristle brush if a low-pressure hose does not remove the direct. Rinse with clean water. Take care to ensure that the baking soda mixture does not enter the vent opening in the battery caps.
8. Make sure that the battery tops are clean and dry before putting the batteries into storage.

BATTERY SERVICE (WATER)

General

The operating environment of the industrial / commercial vehicle could vary widely. Severe service operations will require that periodic maintenance recommendations be adjusted to shorter time intervals.

Examples of severe service would include the following:

- 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 indoor-outdoor movement, as in refrigeration plants, bakeries, etc.

Adding Water To Battery

US Battery, the brand that comes in the new Columbia electric vehicle, features SpeedCap™ battery cell caps. See Figure 8-1.

To open SpeedCap™

1. Locate the two tabs on either side of the center cell of the battery.
2. Move these tabs in the directions shown in Figure 8-1.

NOTICE

Do not use SpeedCaps™ as handles to lift or move battery.

3. Check the electrolyte level on brand new batteries before putting them into service, and at least weekly on batteries in service. Water use increases as batteries age.
4. Never allow the electrolyte level to fall below the top of the plates. If the plates are exposed, add only enough distilled water to cover the plates before charging.

Figure 9-1. Opening SpeedCap™ Battery Cell Caps

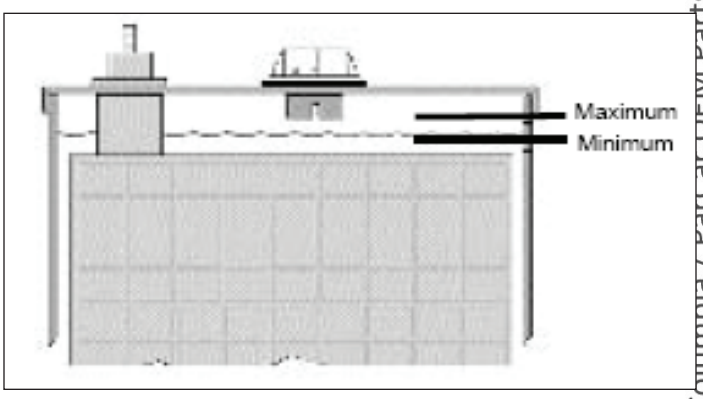


Figure 9-2. Electrolyte Levels

5. Do not overfill batteries. Do not fill the water level up into the well of the filler tube of the cell. Electrolyte expands and can overflow during charging. Water added to replace the spillage dilutes the electrolyte and reduces its specific gravity. Cells with lower specific gravity have lower charging capacity.
6. Make sure the electrolyte covers the plates before charging. Fill cells to the markers only after batteries are charged. See Figure 9-2.
7. Use only distilled water. Electric vehicle batteries may use up to 16 quarts (4 gallons) (15.2 liters) of water during their useful lives. Non-distilled water may contain harmful minerals that will have a cumulative adverse effect on battery performance.

Special Order Single Point Watering System - Factory or Dealer Installed

A high quality on-board watering system can be installed on the batteries in the vehicle.

To water batteries, after charging, follow this procedure:

1. Insert the pump into a jug of distilled water.
2. Remove the dust cover from the single point coupler. Mate the pump coupler to the single point coupler.
3. Squeeze the hand pump bulb with firm pressure to pump water into the battery cells.
4. When the bulb becomes firm, all cells are full.
5. Disconnect the couplers. Replace the dust cover on the single point coupler. Contact the Columbia Customer Service representative for more information or to order. See Figure 9-3.

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.

This Columbia electric vehicle is equipped with a new, solid state, on-board, fully automatic, Delta-Q Battery Charger as standard equipment. See Figure 9-4.

It is important to be aware of the differences and improvements over prior chargers, which are explained in the Delta-Q Charger Operating Instructions that accompany every vehicle.

Correct charging methods extend battery life and vehicle range between charges. Before the first 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 first 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 specific; 24, 36 or 48 volts. However, chargers can be programmed at the factory for different types of batteries, as well as different brands and capacities of batteries. Refer to Battery Brand Algorithms for Charger Programming, See Figure 9=5.

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.

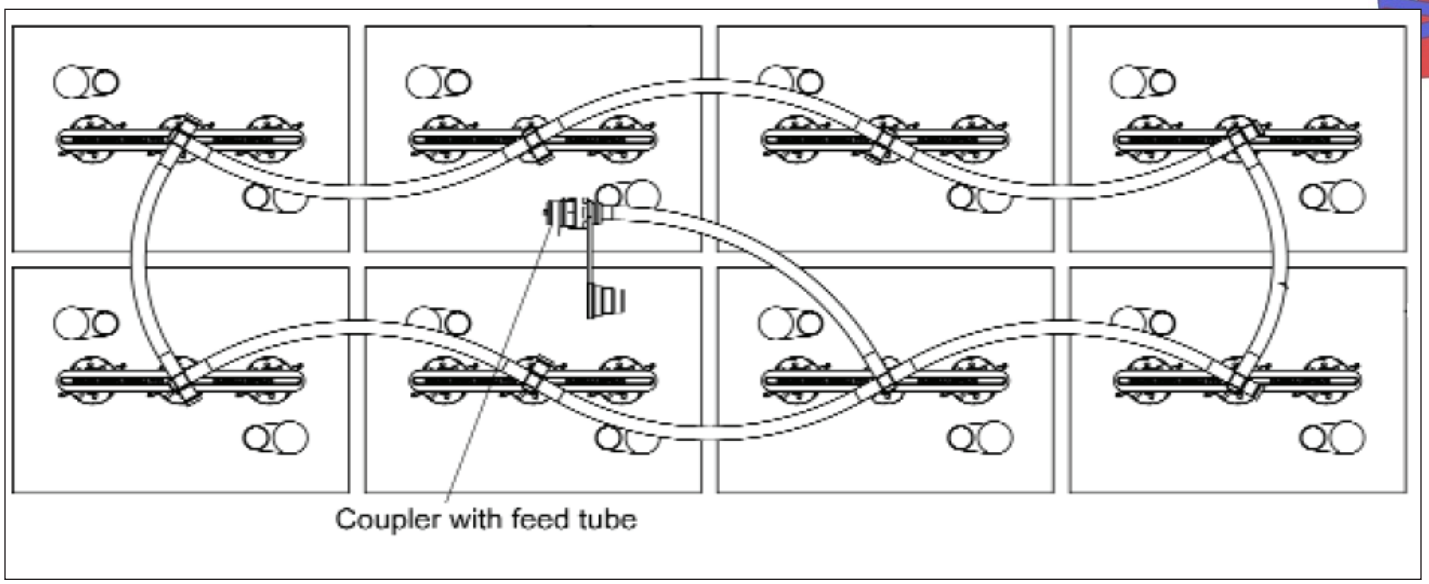


Figure 9-3. Special Order Single Point Watering System

- Charge batteries in a well ventilated area.
- Ventilation fans should be located at the highest point in charging area, and must be capable of changing the total volume of air in the room five times per hour. Consult a local HVAC engineer.
- Do not use an adapter to plug the charger with a three-prong plug into a two-prong outlet or extension cord. Improper connection of the equipment-grounding conductor can result in a fire or an electrical shock.
- Only trained technicians should repair or service the charger. Contact the Columbia dealer for assistance.
- Immediately replace worn, cut or damaged power cords or wires.
- Do not connect the power cord near fuels, grain dust, solvents, thinners, or other flammables. The spark can ignite flammable materials and vapors.
- Do not disconnect the plug from the vehicle end when the charger is on. The resulting arcing and burning could damage the plug and receptacle and could cause batteries to explode. If the charger must be stopped, disconnect the AC supply plug from wall outlet first, only, and ensure adequate ventilation of battery gases. Remove watches and rings to avoid electric shock or sparks.
- Do not cover charger cabinet cooling fins. They provide ventilation and protect the charger from overheating.
- Do not allow clothing, blankets, or other material to cover the charger. They could block adequate ventilation for the charger.
- Install surge arrestors on incoming AC power lines. Surge arrestors will help protect electrical/electronic components in charger and vehicle from all but direct or "close proximity" lightning strikes.
- Battery terminals that are damaged or corroded should be replaced or cleaned as necessary. Failure to do so may cause them to overheat during operation.
- When using ordinary automotive chargers, do not overcharge batteries. Overcharging could cause additional damage to battery cells.
- Failure to maintain and clean battery terminal connections may cause them to overheat during operation or charging.
- Do not work around charging battery with tools that could cause a short circuit resulting in a spark.

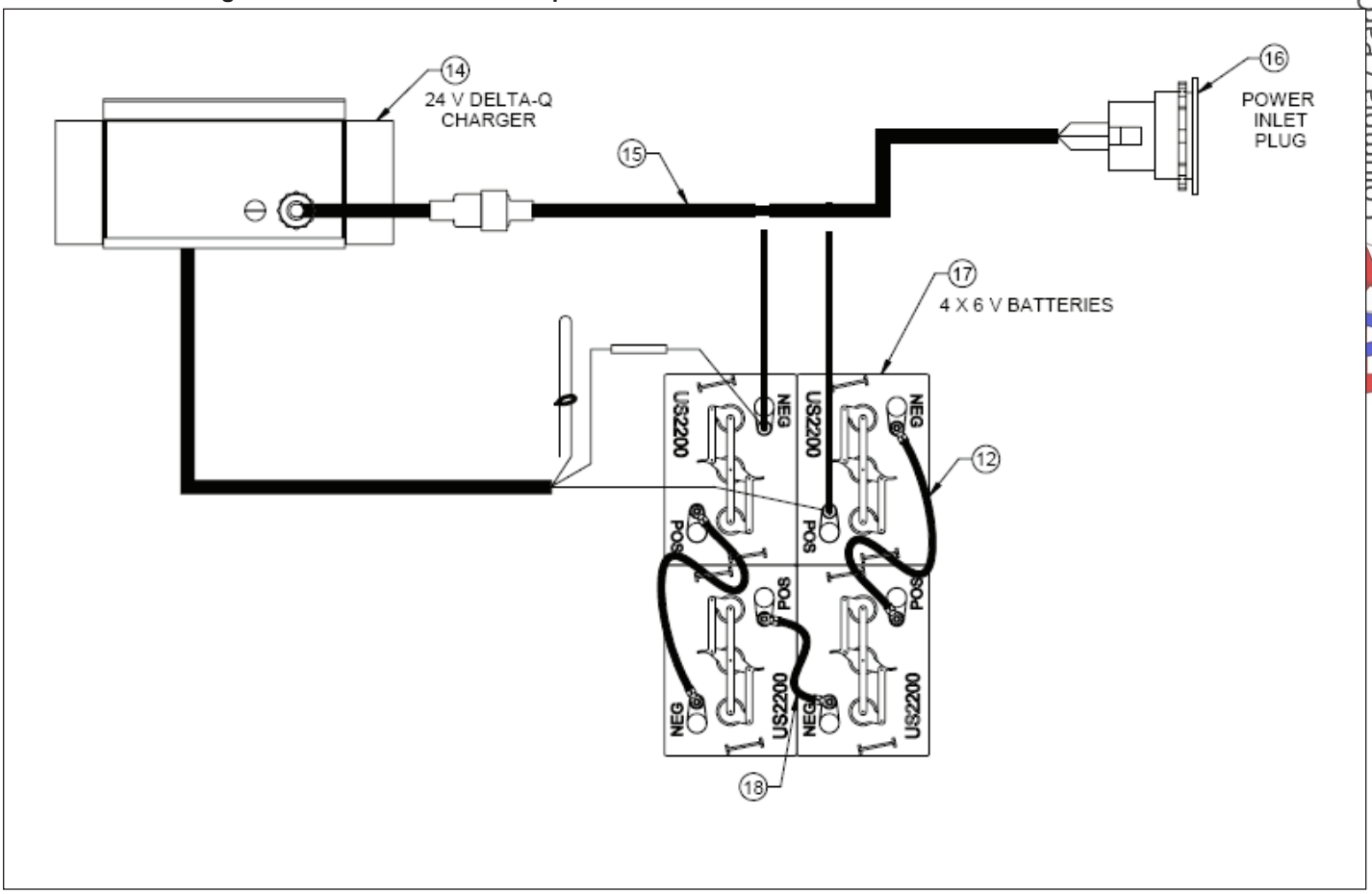


Figure 9-4. 24 Volt Charging System

Algorithm ID	Algorithm description	Amp hour	Type	Designed for	Compatible with
1	Trojan flooded	225	flooded	Trojan T105	Trojan 150 Ah – 260 Ah flooded
2	Trojan T105 tapped	225	flooded	Trojan T105	Trojan 150 Ah – 260 Ah flooded
3	Trojan T105 constant power dv/dt	225	flooded	Trojan T105	Trojan 150 Ah – 260 Ah flooded
4	US Battery flooded	225	flooded	US 2200	US Battery 165 Ah - 245 Ah flooded
5	Trojan 30 XHS	130	flooded	Trojan 30 XHS	Trojan 85 Ah – 150 Ah 12 V flooded, Exide Orbital AGMs
6	Deka 8G31 Gel	100	gel	Deka 8G31	Deka 75 Ah – 100 Ah gel
7	Trojan J305 constant power dv/dt	305	flooded	Trojan J305 series	Trojan 250 Ah – 400 Ah flooded US Battery 250 Ah – 400 Ah flooded
8	Concorde 10xAh AGM	100	AGM	Concorde 100 Ah Range AGMs	-
11	Generic flooded constant power dv/dt (parallel enabled)	230	flooded	US Battery US 125	All 200 - 255 Ah flooded
12	Exide gel	240	gel	Exide DF06240	Exide/Sonnenschein 200 Ah – 300 Ah gel
21	Exide flooded	210	flooded	Exide 3ET200, FF06255, 185PZB210	Exide 200 Ah - 300 Ah flooded
23	Douglas constant power dv/dt	200	flooded	-	T105, T125, T145, T875, T890, 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	flooded	Crown CR-325	Crown 225 Ah – 350 Ah flooded
32	Deka EV31 dv/dt	110	flooded	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/ 48 v charger	225	flooded	Trojan T105	Trojan 150 Ah – 260 Ah flooded
38	Trojan 1275 113%	150	flooded	Trojan T1275	Trojan 130 Ah – 180 Ah flooded
41	Crown CR395	395	flooded	Crown CR-395	Crown 350 Ah – 400 Ah flooded
43	Discover AGM	300	AGM	Discover EVL16A, EVGC6A	Discovery 200 Ah – 400 Ah AGM
47	Generic 20Ah VRLA pulse	20	AGM	-	-
51	Exide 180 Ah gel	180	gel	Sonnenschein 180Ah gel	-
52	Exide 105 Ah gel	105	gel	Sonnenschein 105Ah gel	-
57	Sacred Sun AGMs	170	AGM	Sacred Sun 140-200 Ah AGMs	-

Figure 9-5. 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 9-6) 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 right side of the vehicle's console. 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 9-6).
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 9-6) indicates 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 (7, Figure 9-6). (*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, 6, Figure 9-6). Repeated "short charging", leaving the charge short of 100%, will shorten operating cycle distance and reduced battery life.

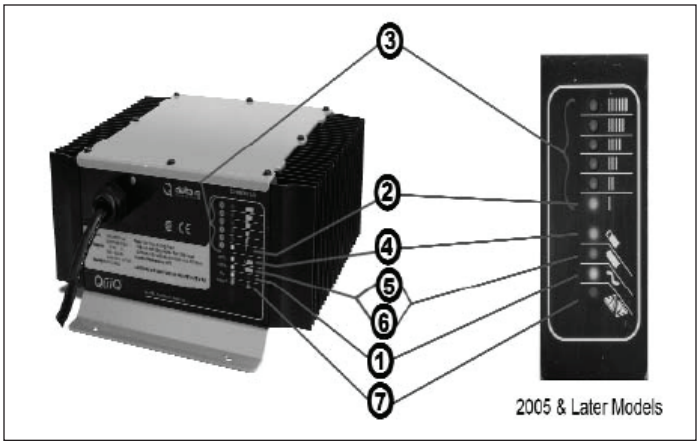


Figure 9-6. Delta-Q Charger and Lights

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 (6, Figure 9-6). 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 (7, Figure 9-6) 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.

CHARGING PROCEDURE

1. Check electrolyte level in all cells. Add distilled water as necessary to cover tops of plates. Do not over fill, as electrolyte expands during charging.
2. Be sure charger is turned OFF. Insert electrical plug into vehicle's charger receptacle.
3. Charger will start automatically. Check that amp meter rises fully when charger starts. If charger needle only rises to half scale or does not rise at all, check AC outlet for proper power supply or check charger owner's manual for testing and repair information.
4. Whenever a manual charger is used, refer to the following table for battery condition/ state of charge testing.

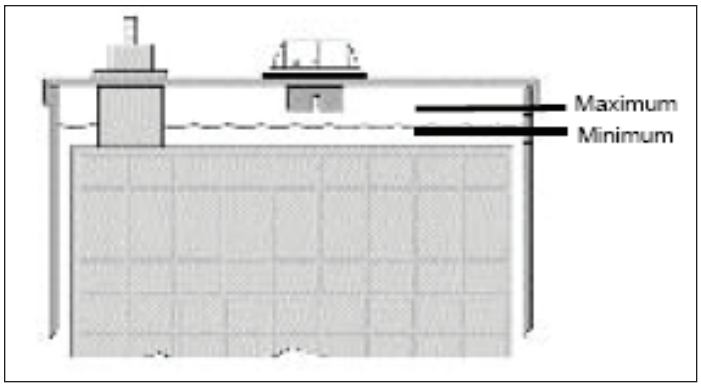


Figure 9-7. Electrolyte Levels

State of Charge vs. Specific Gravity	
State of charge	Specific gravity @ 80º F (26º C)
100%	1.250 – 1.270
75%	1.220 – 1.240
50%	1.190 – 1.210
25%	1.160 – 1.180
Note: Specific gravity taken from at least 2 cells of each battery.	

The specific gravity check is most accurate for determining battery state of charge. Charger function is totally automatic. Charger will determine proper charge time.

5. After charging, check electrolyte level. Add water as necessary. Water must be over the battery plates while still under the bottom of the caps. See Figure 9-7.

⚠CAUTION

Avoid further charging after the batteries are fully charged and equalized. Practical charging time maximum is 12 hours, except for new batteries. New batteries may require up to 4 additional hours charge time.

Conditions That Affect Charging

- If vehicle is used only occasionally, a refresher charge should be given prior to using the car. Use specific gravity reading to determine if charge is required. Charger will determine length of charge required.
- Fleet vehicles should be rotated so that all vehicles are used equally.
- Battery efficiency is affected by temperature. See the following table.

Power percentage available from fully charged batteries at various temperatures	
State of charge	Temperature
100%	80°F (26°C)
65%	32°F (0°C)
40%	0°F (-18°C)

- As batteries age, they finish 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.
- If batteries are unusually hot at the end of normal charge with heavy deposits of moisture around the filler caps and/or water use is high, this may indicate one or more defective cells or that the batteries are nearing the end of their useful life. See *Testing Batteries* in this section.
- If the batteries do not respond to normal charging, one or more cells may be defective and all should be checked. See *Testing Batteries* in this section.

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

The charger can be used to determine the overall condition of the battery bank after charging. Compare the finish charge rate with the specific gravity readings of the batteries. See the table below.

SPECIAL CHARGING PROCEDURE FOR EXCESSIVELY DISCHARGED BATTERIES

NOTICE

The Delta-Q Automatic Battery Charger will not charge a dead battery. Each battery will need to be brought up to an acceptable state of charge, and establish that it does not have an internal fault or bad cell. If a battery has remained too long in a discharged state, it may be internally damaged and not capable of accepting a charge. It must be replaced.

If the Delta-Q Battery Charger does not reach the full charging mode, identified by a steady LED in the upper region of the Bar Graph display (18/15/12...), or the RED Fault Light is lit, it may indicate that the minimum voltage is not present to allow the charger to control the charging of the complete set of batteries. If the electrolyte specific gravity is low (less than 1.140 SG), or the individual battery voltage is less than 5.25 volts for three cells (or 10.50 volts for 6 cells), it will need to be recharged with an ordinary automotive style trickle charger at a rate of 3 to 6 amps for several hours each. Follow specific charger instructions.

It is not necessary to disconnect the battery cables, as the alligator style clips can be connected to each positive and negative battery post.

⚠ WARNING

Always disconnect the AC power first when moving the positive/negative alligator clips to prevent a spark from igniting the gas emitted from the batteries.

Be sure to charge all of the batteries in the set. Each battery may require 2-3 hours of charging to bring it back to serviceable condition. Measure the Specific Gravity (SG) of each cell after this charging procedure is completed, to verify that the battery is OK for use. Replace any batteries that can not be re-charged (no change or improvement in SG). After all batteries have been individually charged, and with the temporary automotive charger removed, try operating the Automatic On-Board Delta-Q Charger again to verify operation. Allow onboard Delta-Q Charger to complete a full charge cycle for proper equalization of batteries. If the 6 Flash Fault persists; an internal fault may be present and the charger will need to be replaced by a qualified dealer technician. A STEADY RED FAULT LED confirms an internal electrical fault of the Delta-Q, and also requires charger replacement and return.

TESTING BATTERIES

Testing with a Charger

The charger can be used to give an overall test of the battery bank after it has received a full charge. The finish charge rate of a good set of batteries is 3-5 amps as read on the charger ammeter.

1. Connect on board charger to an AC power source and turn on.
2. Charger ammeter needle should jump to 15 amps or more and then taper into the 1-3 amp area within 15 minutes, indicating good fully charged batteries.
3. Battery banks failing this test should be tested with hydrometer and/or load tester. See *Specific Gravity Test*.

Specific Gravity Test

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 1,200, 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.

Figure 9-8. Typical Commercial Load Tester

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.

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

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.

⚠CAUTION

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

Check specific 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 specific 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 specific gravity of electrolyte is kept above 1.125 specific 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

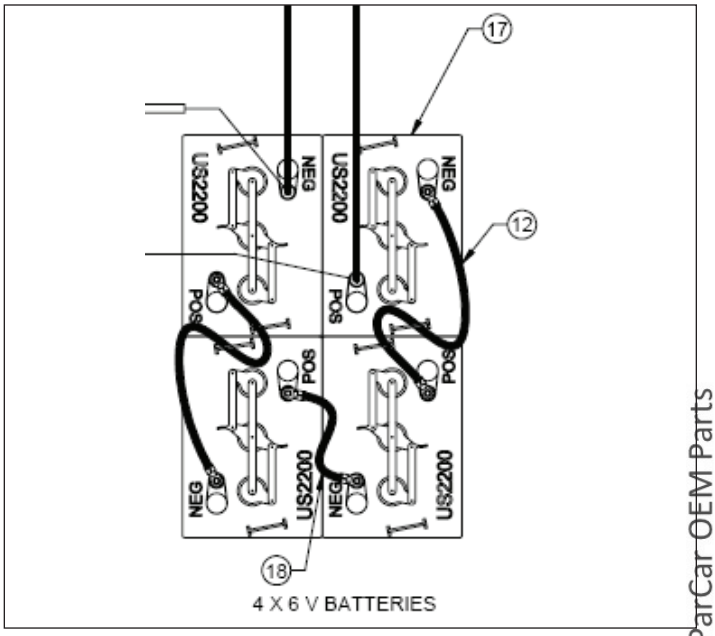


Figure 9-9. Battery Cables

REPLACING BATTERIES

Removing Batteries

1. Remove nuts, washers and cables (12) and (18), positive lead and negative lead interconnecting batteries (17). See Figure 9-9.
2. Remove nuts (6), flat washers (5), hold down plates (4) and rods (3). See Figure 9-10. Quantities depend on number of batteries in electrical system.

   24 volt system = 4 batteries (2), 1 nut (6), 1 flat washer (5), 1 hold down plate (4), and 1 rod (3).

   48 volt system = 8 batteries (2), 3 nuts (6), 3 flat washers (5), 3 hold down plates (4), and 3 rods (3).
3. Remove 4 batteries (or 8 batteries) (2).

Installing Batteries

1. Install four batteries (24 volts) or eight batteries (48 volts).
2. Install rods (3) and hold down plates (4).
3. Install flat washers (5), nylock nut (6).

BATTERY BOX

Removal

1. Remove battery hold downs and batteries (Figure 9-10).
2. Remove 4 nuts (9), 8 flat washers (8), 4 bolts (7) and battery box (1). See Figure 9-11.

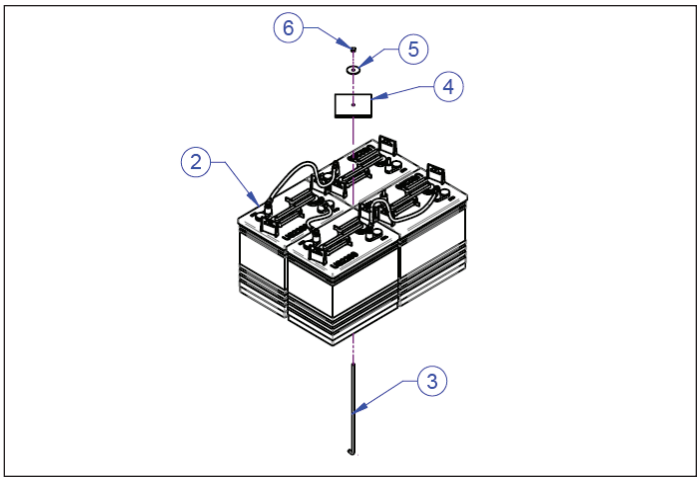


Figure 9-10. Battery and Hold Downs

Installation

1. Position new battery box (1) to frame.
2. Secure battery box with 4 bolts (7), 8 flat washers (8) and 4 nuts (9).

BATTERY CHARGER

Removal

NOTICE

There are four wires in the output lead from the charger; black and white together to battery B-; red wire to battery B+; green wires to connector on red wire #14 on the interlock circuit. The black and white wires are terminated in a thermistor. Take extra care when handling the thermistor.

1. Disconnect 4 wires in charger output lead from battery B-, battery B+ and wire 14. Unplug power inlet cable from charger pigtail. See Figure 9-13.
2. Remove four nuts (13), four washers, (12), four bolts (11) and defective charger (15). See Figure 9-12.

Installation

1. Position new charger (15), to mounting bracket (10). See Figure 9-12.
2. Secure new charger with four nuts (13), four washers (12) and four bolts (11). Tighten charger attaching hardware.
3. Install charger output electrical leads as follows; black and white to controller B-, red wire to battery B+, green wire to red wire #14 from interlock harness. See Figure 9-13. Plug in cord from power inlet to charger pigtail. Tape the two plugs together so they cannot accidentally separate.
4. Bundle up the excess charger output cable and secure it neatly with wire ties.
5. Reconnect battery negative cable. Install Power key.
6. Power key ON. Check BDI display.

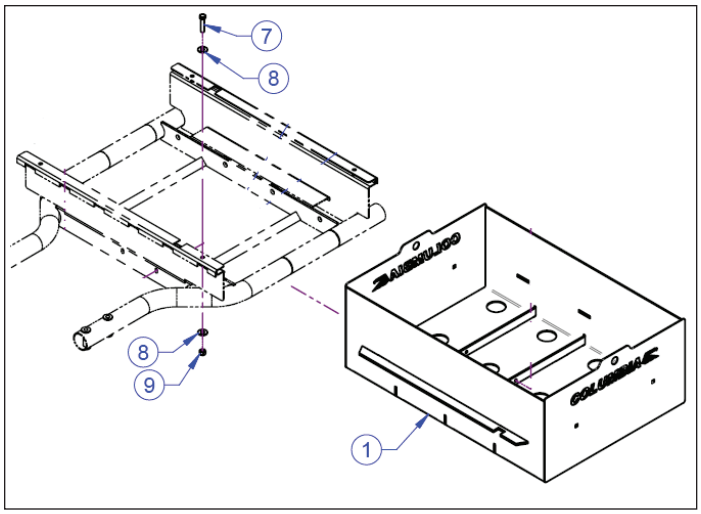


Figure 9-11. Battery Box

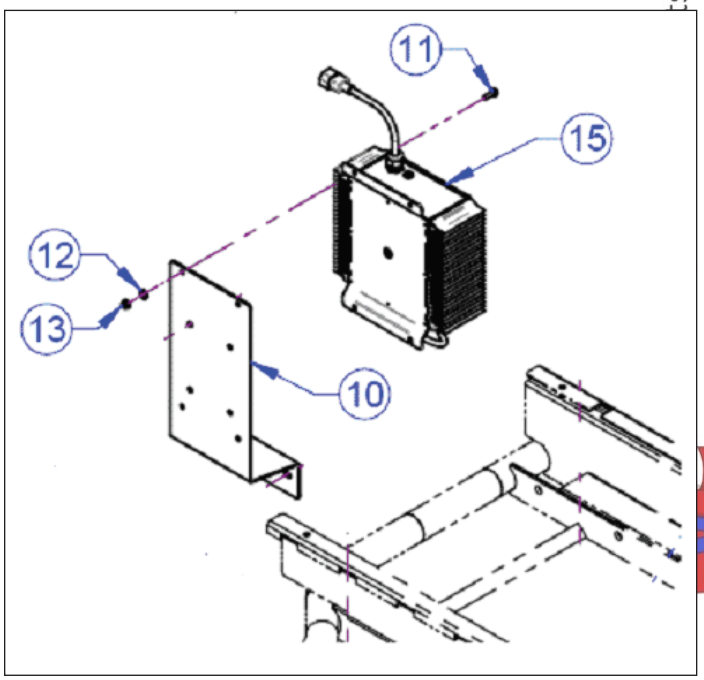


Figure 9-12. Charger and Bracket

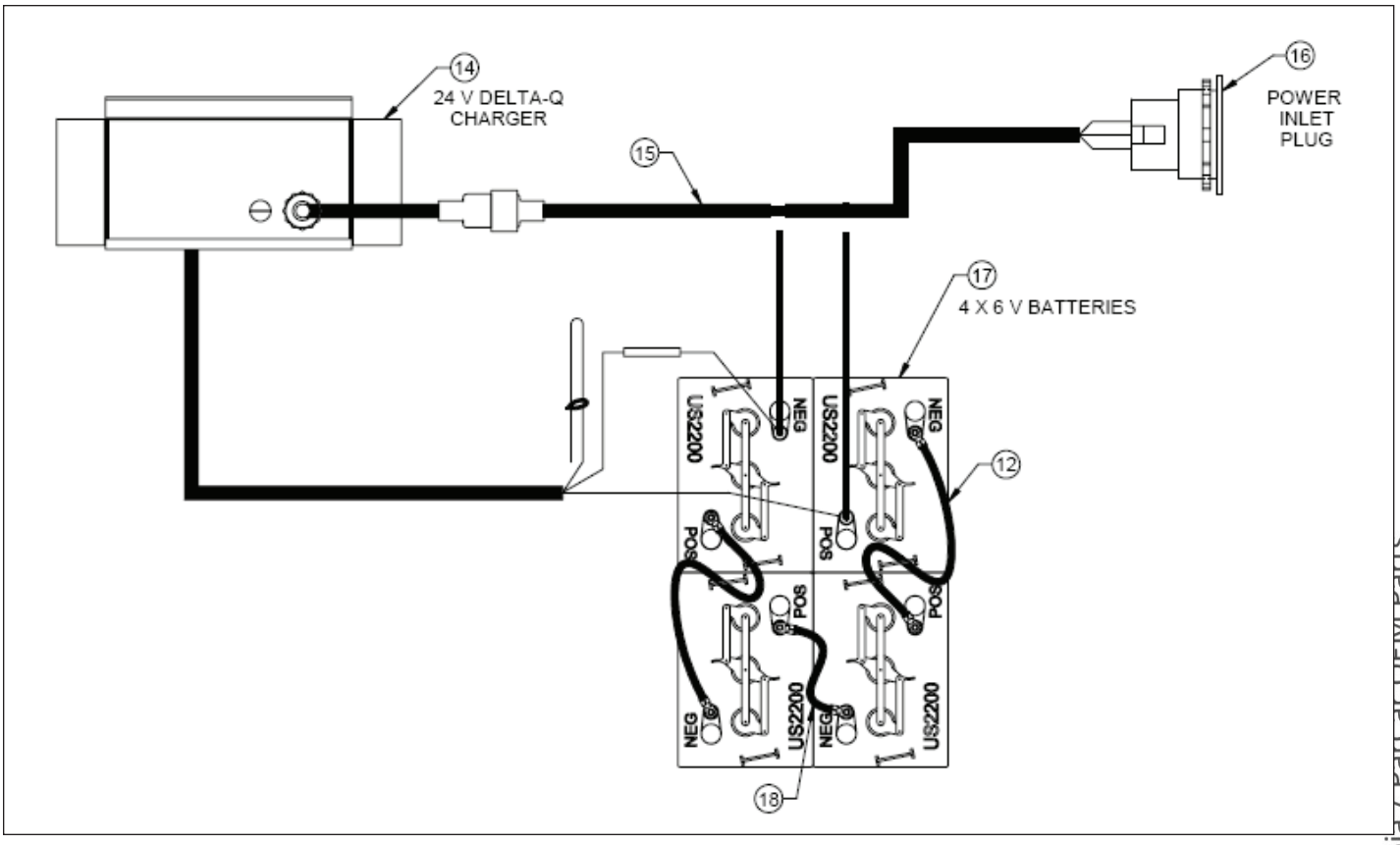


Figure 9-13. Charger Wiring

ELECTRIC VEHICLE SERVICE

When servicing the electric Columbia Industrial/Commercial vehicle always observe the following:

⚠ SAFETY FIRST ⚠

Always turn Power key to OFF, Directional key switch to Neutral, remove Power key, block tires and disconnect the battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible personal injury.

TRACTION DRIVE SYSTEMS

Smart*drive* Traction Motor System

The Smart*drive* system uses a separately excited motor and Sevcon Controller with solid state forward/reverse control and plug braking. Plug braking is non-regenerative power absorbing deceleration. It is distinguished by a 5 post controller. This system is better suited for flat terrain and reduced braking requirements.

This is the standard traction control system for Industrial Electric Vehicles: IS12 StockChaser, IR23 ROVR and IT34 TUGR.

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.

This is one of the optional traction control systems offered on Columbia ParCar Industrial Electric vehicles; IS12 StockChaser, IR23 ROVR and IT34 TUGR models.

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 the operating environment of industrial/commercial equipment varies widely, the following recommendations are suggested for periodic maintenance inspection:

Normal service – 8 hours per day use

- Routine inspection every 1,000 hours

Severe service – 16+ hours per day use

- Routine inspection every 500 hours

IS12 StockChaser (14.76 axle ratio optional)

24 volt Smart drive , 8.5 MPH maximum rated speed
300 amp, neutral motor braking control system
Motor - 5.2 HP @ 875 RPM, Drive Ratio - 12.44:1
Rated Capacity: 1,200 lbs. maximum

24 volt ACE plus , 8.5 MPH maximum rated speed
300 amp, regenerative and accelerator pedal proportional
motor braking control system with top speed limiting
Motor - 5.2 HP @ 800 RPM, Drive Ratio - 12.44:1
Rated Capacity: 1,200 lbs. maximum

48 volt Smart drive , 10 MPH maximum rated speed
300 amp, neutral motor braking control system
Motor - 12.7 HP @ 1880 RPM, Drive Ratio - 12.44:1
Includes 48V DC to 12V DC converter
Rated Capacity: 1,000 lbs. maximum

48 volt ACE plus , 10 MPH maximum rated speed
400 amp, regenerative and accelerator pedal proportional
motor braking control system with top speed limiting
Motor - 15.3 HP @ 1750 RPM, Drive Ratio - 12.44:1
Includes 48V DC to 12V DC converter
Rated Capacity: 1,000 lbs. maximum

IR23 ROVR (16.99 axle ratio optional)

24 volt ACE plus , 6 MPH maximum rated speed
300 amp, regenerative and accelerator pedal proportional
motor braking control system with top speed limiting
Motor - 5.2 HP @ 875 RPM, Drive Ratio - 14.76:1
Towing Capacity: 2,000 lbs. maximum on flat level surface

48 volt ACE plus , 6 MPH maximum rated speed
400 amp, regenerative and accelerator pedal proportional
motor braking control system with top speed limiting
Motor - 15.3 HP @ 1,750 RPM, Drive Ratio - 14.76:1
Towing Capacity: 4,000 lbs. maximum on flat level surface

IT4 TUGR

48 volt ACE plus , 6 MPH maximum rated speed
400 amp, regenerative and accelerator pedal proportional
500 amp, optional
motor braking control system with top speed limiting
Motor - 15.3 HP @ 1,750 RPM, Drive Ratio - 16.99:1
Towing Capacity: 4,000 lbs. maximum on flat level surface

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.

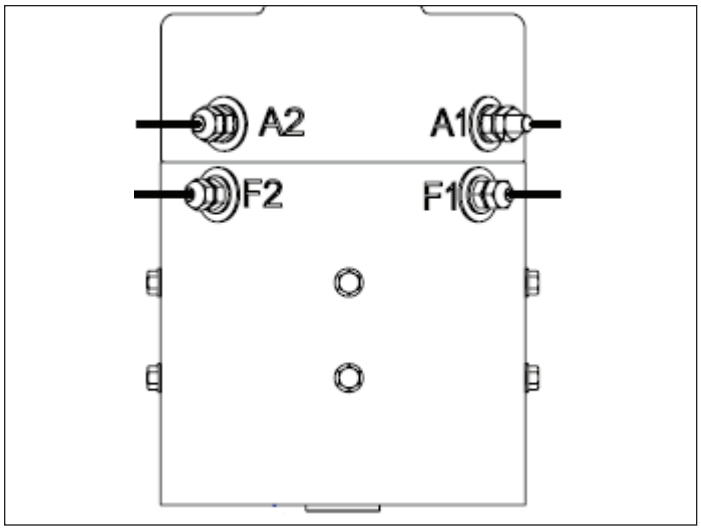


Figure 10-1. Traction Motor Cables Labels

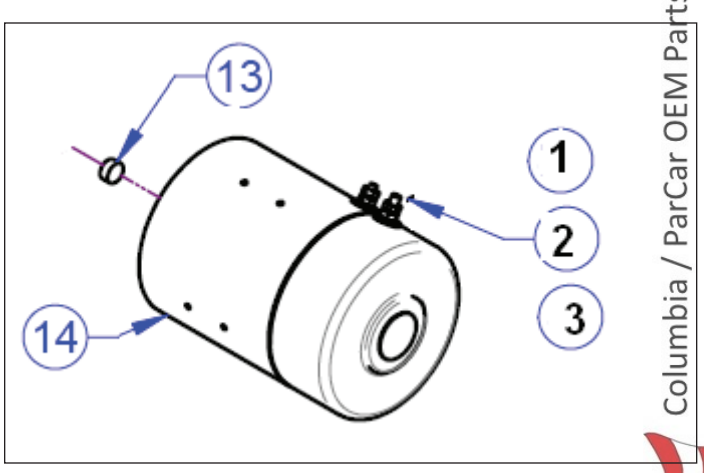


Figure 10-2. Traction Motor Terminal Hardware

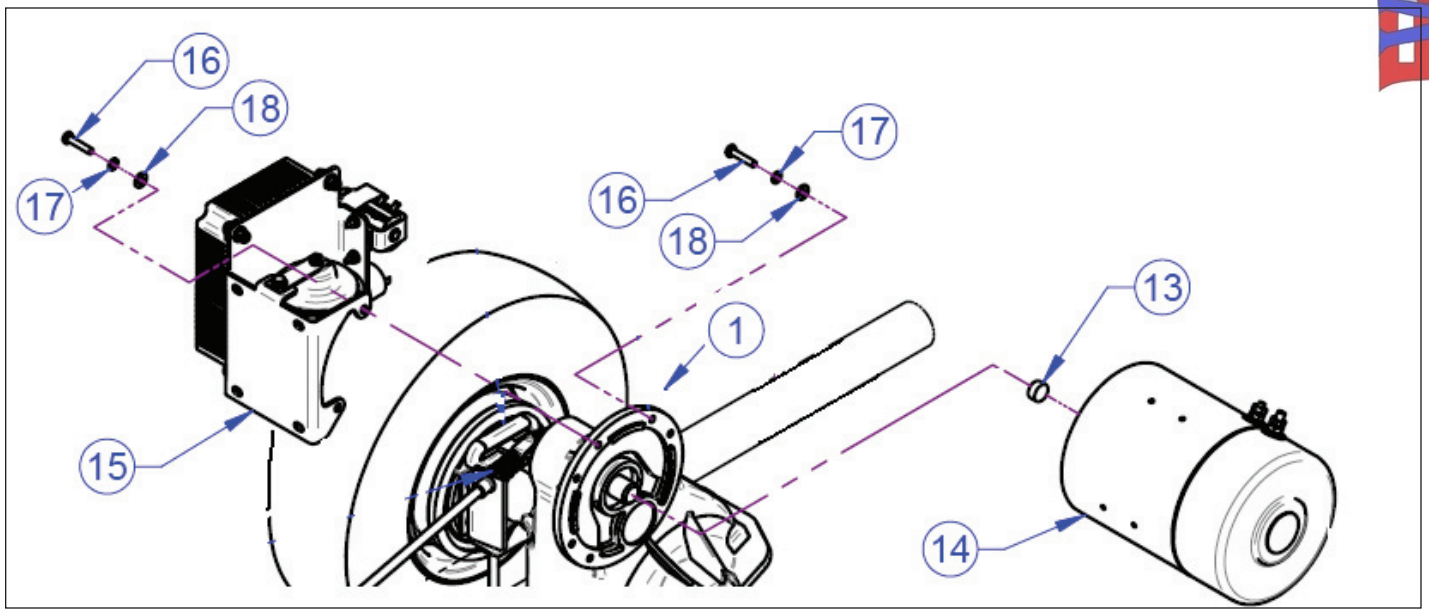


Figure 10-3. Traction Motor Mounting

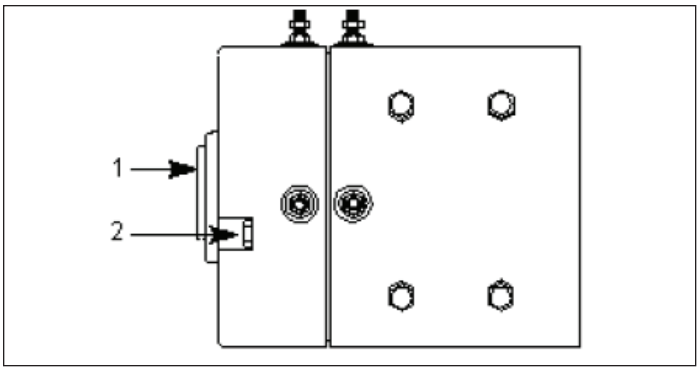


Figure 10-4. Traction Motor Terminal Hardware

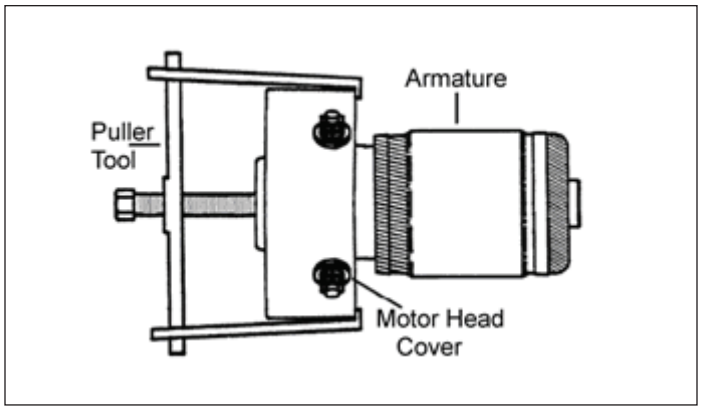


Figure 10-5. Removing Motor Head

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 10-1.
2. F1 and F2 terminals are 1/4-20 UNC. A1 and A2 terminals are 5/16-18 UNC.

   Refer to Figure 10-2. Hold terminal jam nut with a thin open end wrench when loosening and removing hex nuts (1), lock washers (2) and flat washers (3) securing electrical cables to traction motor (14).
3. See Figure 10-3. Carefully support motor to prevent it from falling, and loosen and remove three bolts (16), lock washers (17) and flat washers (18) securing motor (14) to rear axle/differential housing (1). 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 four long bolts (2). Remove motor head hole plug (1). See Figure 10-4.
2. 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.
3. Place puller around the motor head. Use the center of the shaft to locate puller. See Figure 10-5.
4. Pull motor head assembly off of armature assemblymaintaining equal pressure on all sides of head.
5. Move brush springs behind spring hooks shown in Figure 10-6.

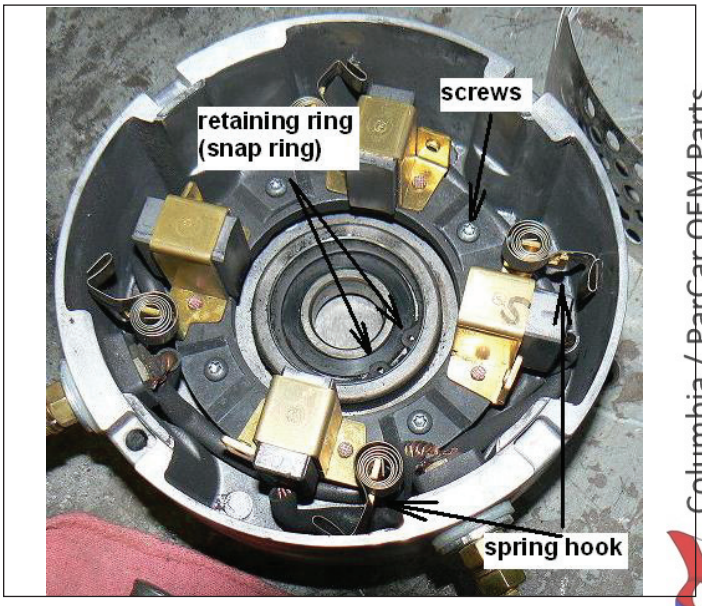


Figure 10-6. Spring Hooks for Brush Springs

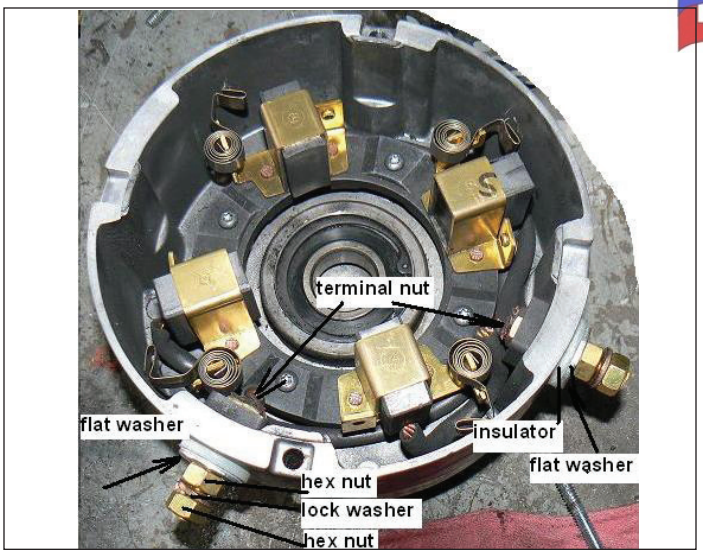


Figure 10-7. Brushes and Terminal Attaching Parts

6. Remove 1 hex nut, 1 lock washer, 1 hex nut, 1 flat washer and 1 insulator at each brush terminal, A1 and A2. Figure 10-7.
7. Remove 4 brush plate screws (Figure 10-8). Push brush terminal studs through, into the center of the head as the brush box, brushes and terminal assemblies are removed. (See also exploded view Figure 10-10).
8. Remove bearing retainer (snap ring) shown in Figure 10-6. Carefully press out the bearing from motor head. Replace the bearing.
9. Remove all the brush dust from motor frame, brush box, and motor head.

Armature Inspection

1. Measure the diameter of the armature part of the motor (Figure 10-9).For the separately excited motor used in 2007 IR, IR, IT vehicles:

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

2. Support the armature at both bearing journals. Check run-out of commutator with a dial indicator. Total indicated run-out should not exceed 0.005 inch (0.12 mm). If the readings fall outside this limit, commutator must be turned and re-undercut. Figure 10-11.

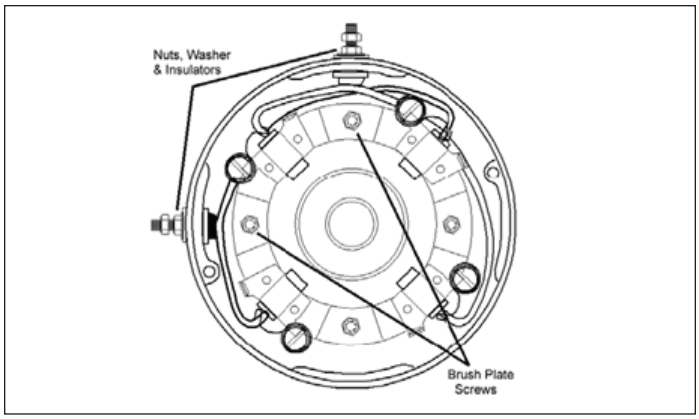


Figure 10-8. Brush Box and Brushes

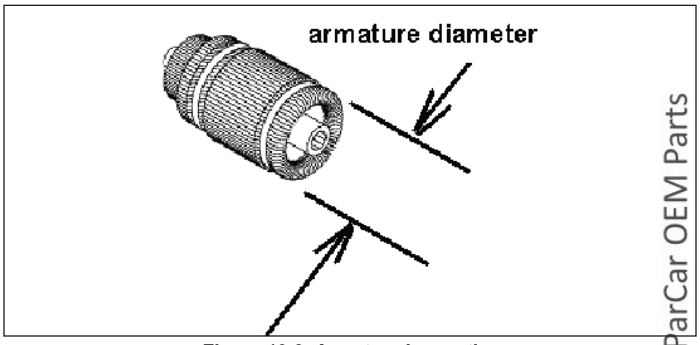
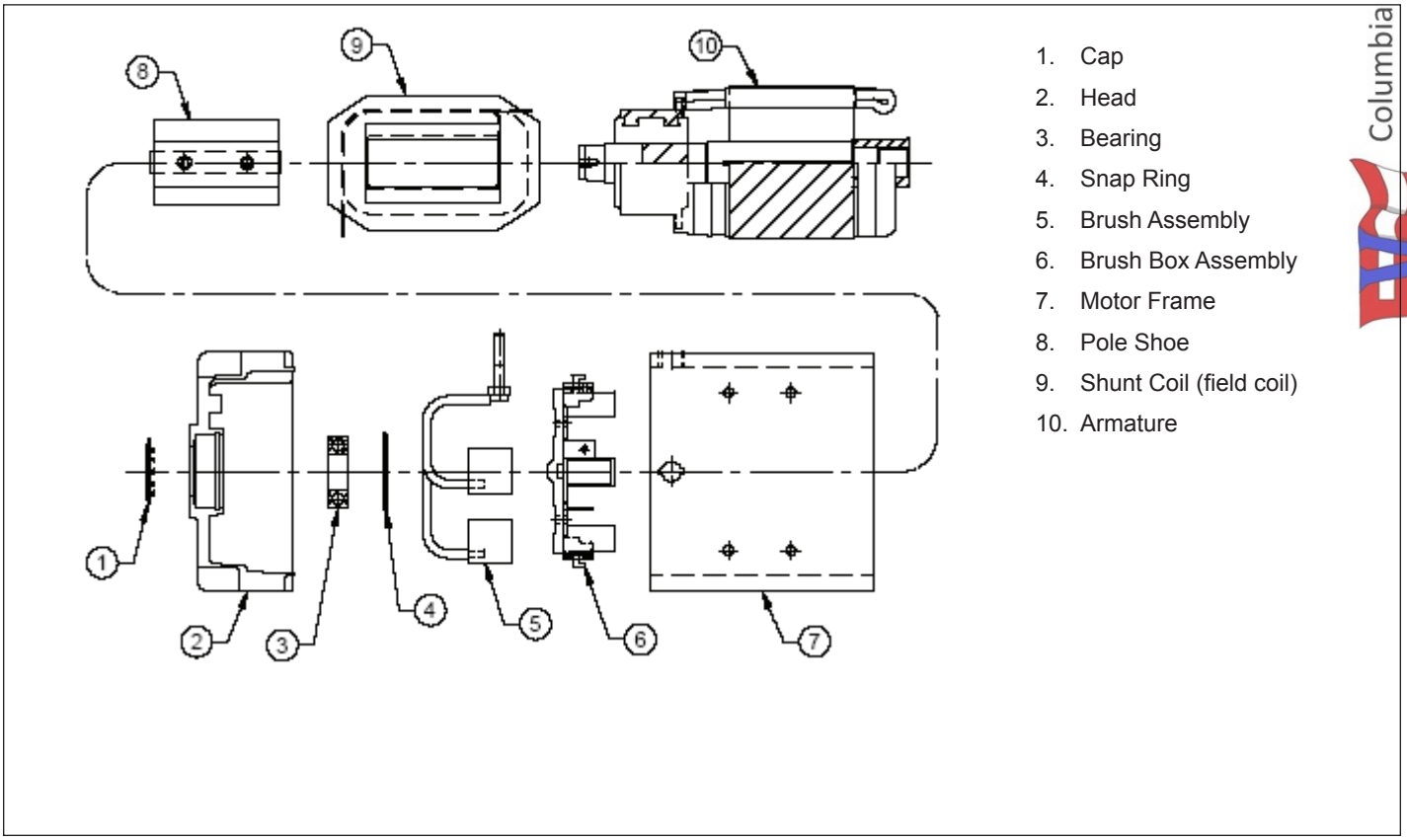


Figure 10-9. Armature Inspection



1. Cap
2. Head
3. Bearing
4. Snap Ring
5. Brush Assembly
6. Brush Box Assembly
7. Motor Frame
8. Pole Shoe
9. Shunt Coil (field coil)
10. Armature

Figure 10-10. Traction Motor

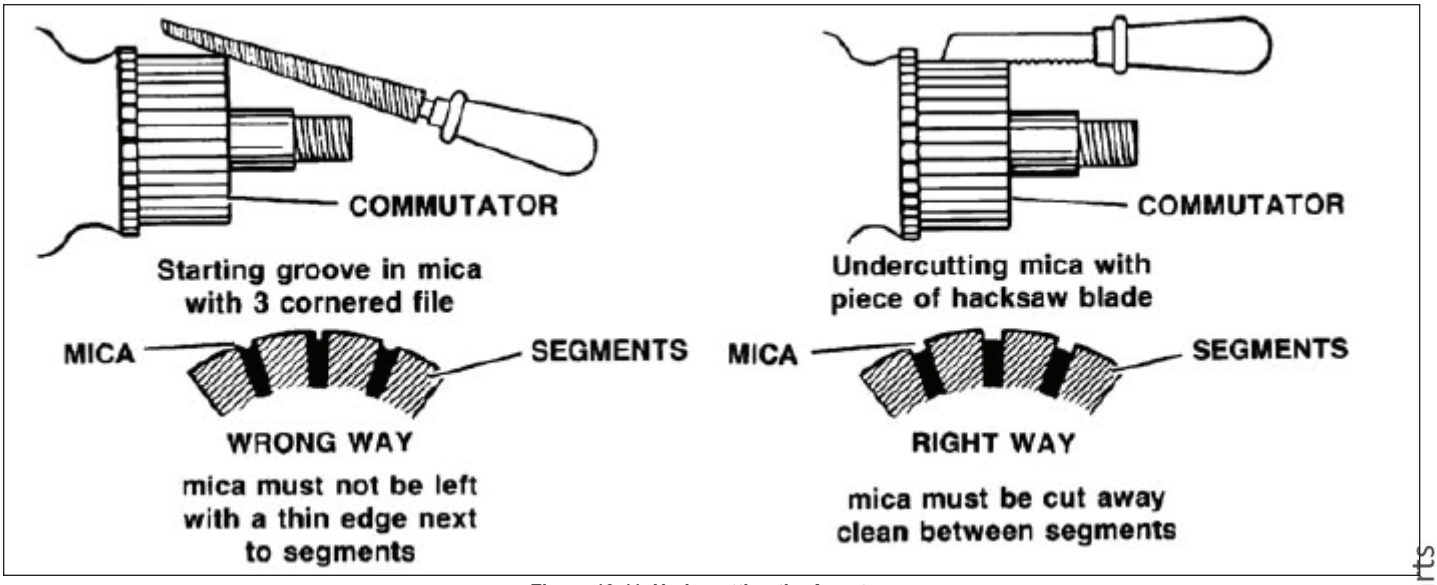


Figure 10-11. Undercutting the Armature

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.

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 flash. A flash indicates failed insulation between core and armature wiring. See Figure 10-12.
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 9-13.

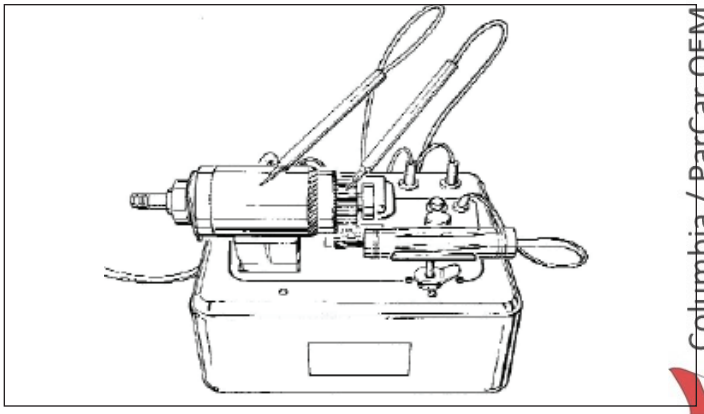


Figure 10-12. Checking Armature for Grounded Circuits

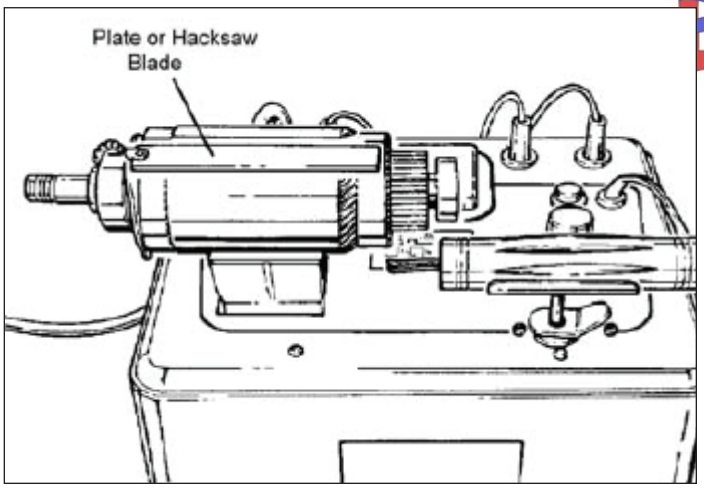


Figure 10-13. Checking Armature for Shorted Windings

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 10-10.

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

For the separately excited motor used in 2007 IR, IR, IT vehicles:

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. Figure 9-7.

Procedure for checking brushes for proper tension. See Figure 10-14.

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

Separately excited motor	new	64 ounces (1792 grams)
	worn	40 ounces (1120 grams)

Bearing

After the motor has been disassembled, it is recommended that a new bearing is installed. Bearing may have been damaged during removal, although the bearing may appear and feel good. See Figure 10-10.

Frame and Field Coils

NOTICE

Do not remove the field coils (9, Figure 10-10), 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 (7) of the motor and field coil (9) (Figure 10-10). Set the volt ohm meter (VOM) to measure Ohms. See Figure 10-15.

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 field assembly. It is not uncommon that the frame and field of a motor becomes 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 10-16. Install snap ring to retain bearing. Figure 10-17.

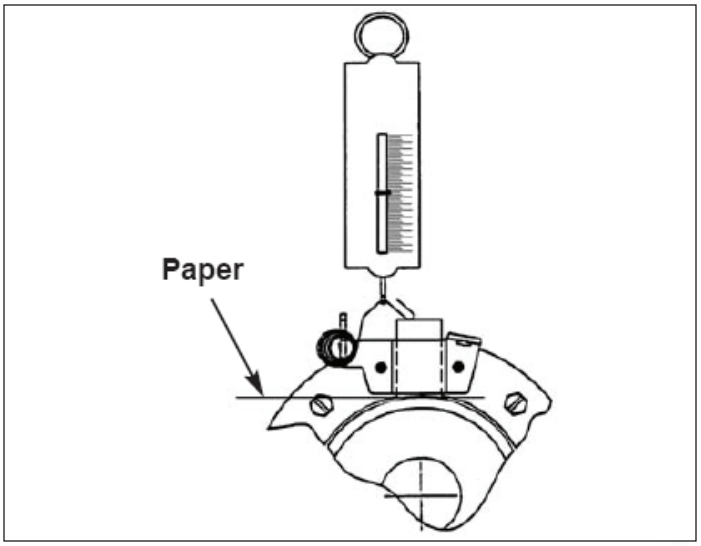


Figure 10-14. Brush Spring Pull Test

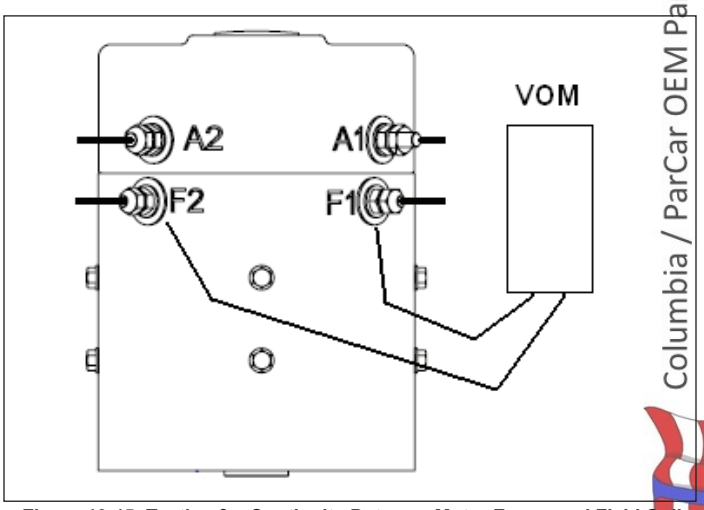


Figure 10-15. Testing for Continuity Between Motor Frame and Field Coil

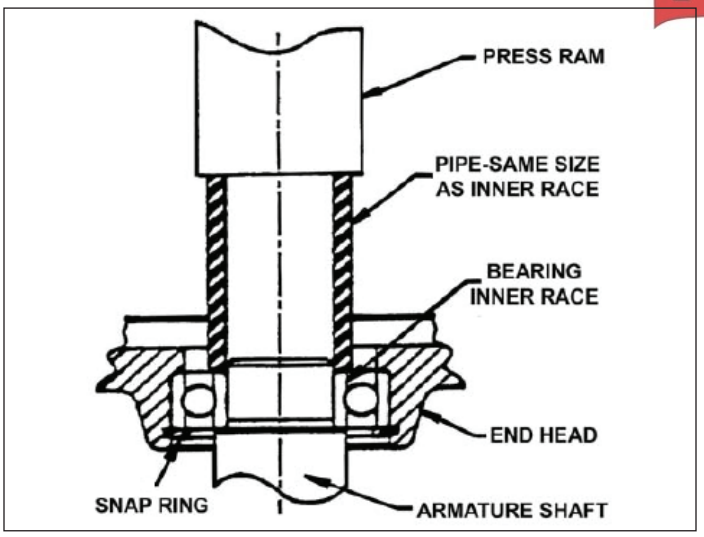


Figure 10-16. Press Bearing and End Cover onto Assembly

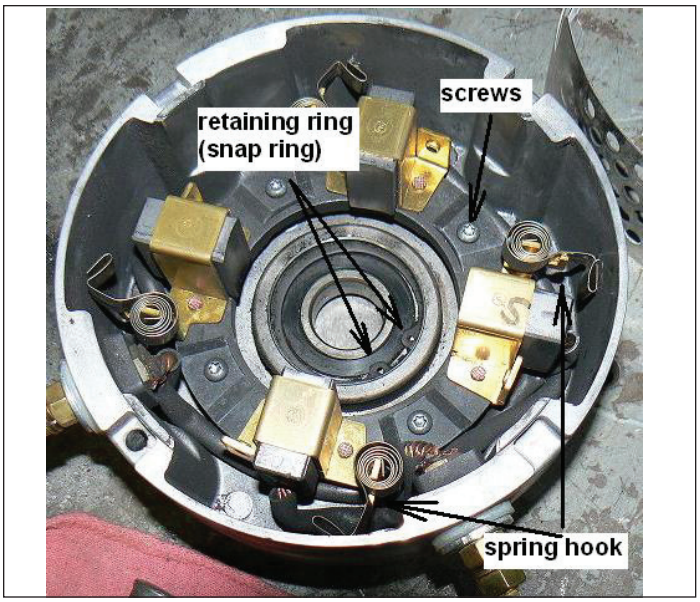


Figure 10-17. Spring Hooks for Brush Springs

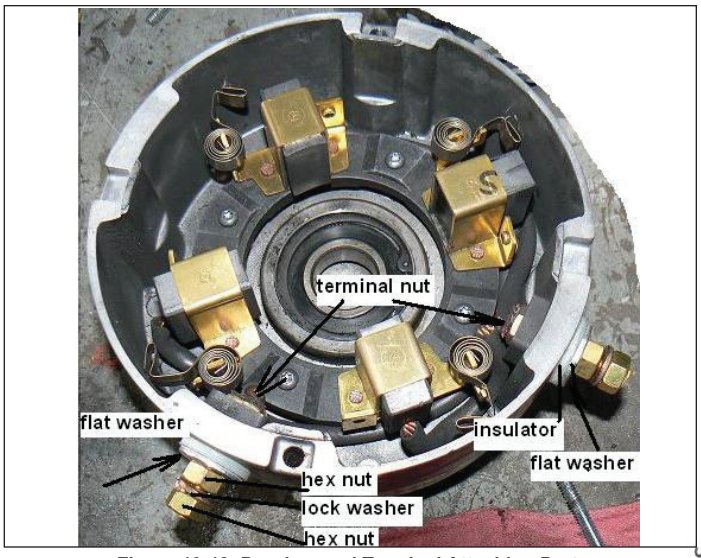


Figure 10-18. Brushes and Terminal Attaching Parts

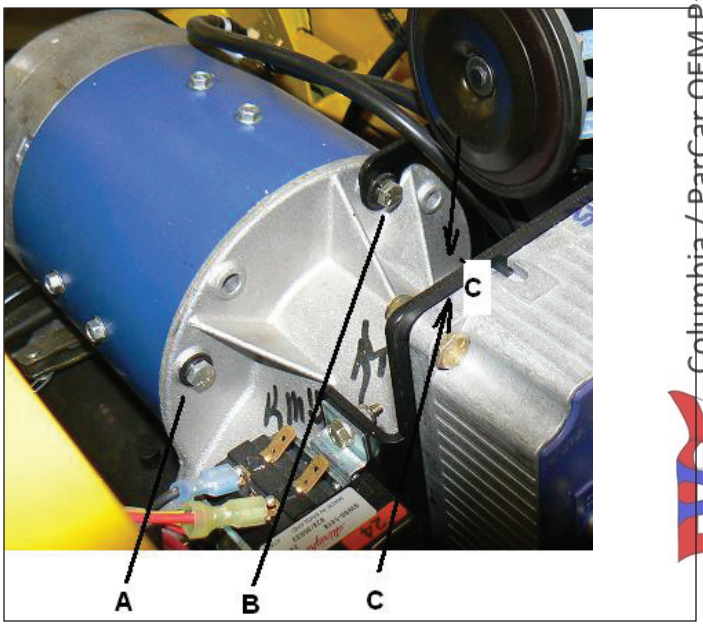


Figure 10-19. Motor Attaching Bolts

2. Assemble brush assemblies (5, Figure 10-10) into brush box assembly (6).
3. Position brush holder into motor head as shown in Figure 10-18. Make sure that the terminals for the brushes are loose and free.
4. Install insulators and brush leads into motor head. See Figure 10-18. Brush motor terminals, A1 and A2, should be torqued to 140 in. lbs. (15.8 Nm). See Figure 10-16.
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 10-16.
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 field coil and frame assembly, aligning armature terminals to field 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. Paint open end of the armature and rear axle input shaft with Anti-Seize compound. Insert a new rubber bumper (13, Figure 10-3), into open end of armature. Place motor into vehicle and onto input shaft.
2. Rotate motor to align bolt holes in motor to axle as shown in Figure 10-19. 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 flange on axle evenly. Torque screws A and B to 100 inch lbs. (11.3 N.m) Then tighten screw C to 100 inch lbs. (11.3 N m).
3. Inspect electrical system cables for terminal identification (A-1, A-2, etc.). See Figure 10-20. Position cables to traction motor, double checking wiring diagram to motor cable installationto ensure connections are correct.

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 (3), lock washers (2) and hex nuts (1) (Figure 10-2).

   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. Place vehicle on the ground or onto dynomometer to test motor operation.

⚠CAUTION

Do not run motor at full voltage without a load.

CONTROLLER

Smart*drive* Traction Motor System

The Smart*drive* system uses separately excited motor and Sevcon Controller with solid state forward/reverse control and plug braking. Plug braking is non-regenerative power absorbing deceleration. It is distinguished by a 5 post controller. This system is better suited for flat terrain and reduced braking requirements. Refer to Figure 10-21.

This is the standard traction control system for Industrial Electric Vehicles: IS11StockChaser (2005 and later) and IS12 StockChaser (2007).

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. See Figure 10-22.

This is one of the traction control systems offered on Columbia ParCar Industrial Electric vehicles; IS12 StockChaser, IR23 ROVR and IT34 TUGR models.

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.
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 Sevcontrol Calibrator or PC Pak computer interface.
3. If the tests indicate that the controller has failed, replace it.

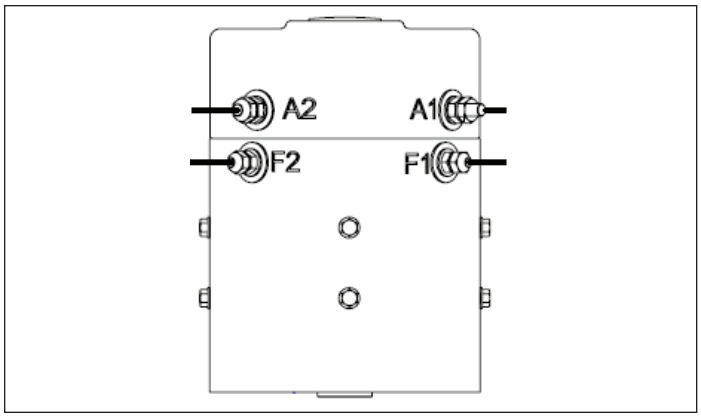


Figure 10-20. Traction Motor Cables Labels

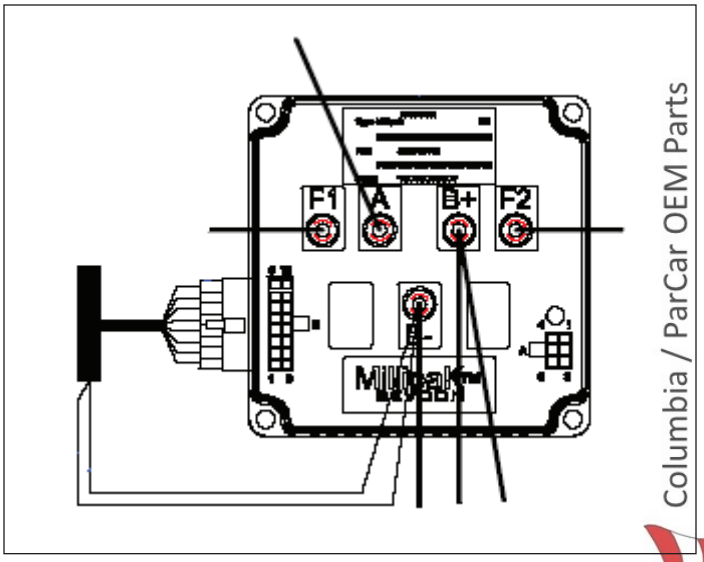


Figure 10-21. 5 Post Smartdrive Controller (LP)

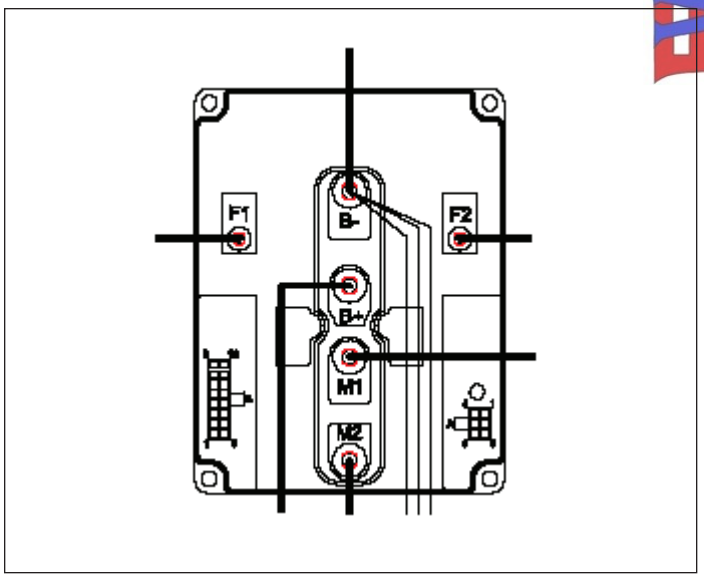


Figure 10-22. 6 Post ACEplus Controller

Removing the Controller

1. Label/mark controller cables with controller terminal identification, if not already labeled. See Figures 10-21 & 10-22.

NOTICE

The controller terminal bolts and washers are Metric. Mechanic will need Metric wrenches to remove the controller cable fasteners. The fasteners that attach the controller to the vehicle frame are SAE U.S.

2. Smart*drive*: Remove 5 Metric bolts, 5 lock washers and 5 flat washers at controller terminals (Figure 10-21). Remove all electrical cables. Remove 16 pin controller connector at port B in the lower left hand corner of the controller. See *Columbia Service Bulletin 010-06* if the wiring harness or connector are damaged.

   ACE*plus:* Remove six metric bolts, lock washers, flat washers and all the cables and wires connected to the controller. See Figure 10-22.

3. These fasteners are SAE. Remove four nuts (5), washers (4), bolts (3) and controller (2). See Figure 10-23.

NOTICE

Do not attempt to disassemble a controller. They are not repairable. There are no repairable parts inside.

Installing the Controller

1. Position new controller (2) to mounting bracket (1). Secure controller (2), with four bolts (3), washers (4) and 4 nuts (5). Figure 10-23.
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 Figures 10-21 7 10-22..

   Some times a cable terminal end has been replaced and the bolt hole may be too big for the flat 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.
6. Perform an operational check of the vehicle's driving abilities.

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, due to magnetism created by the coil and internal contacts, creating a connection between two large terminals, allowing current to pass through the solenoid.

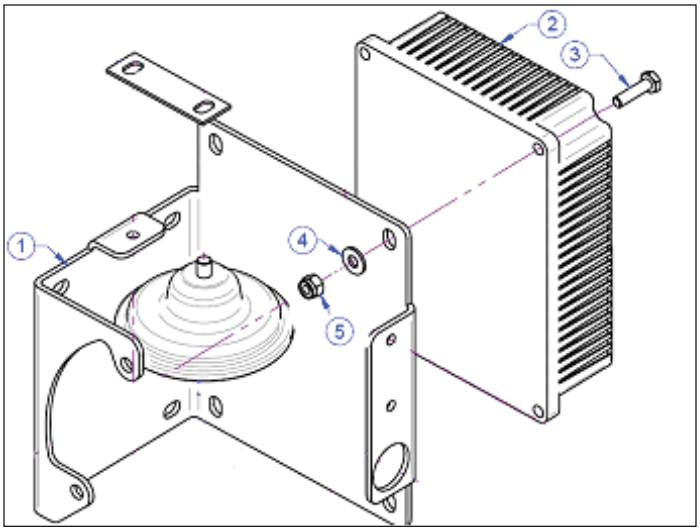


Figure 10-23. Controller Mounting

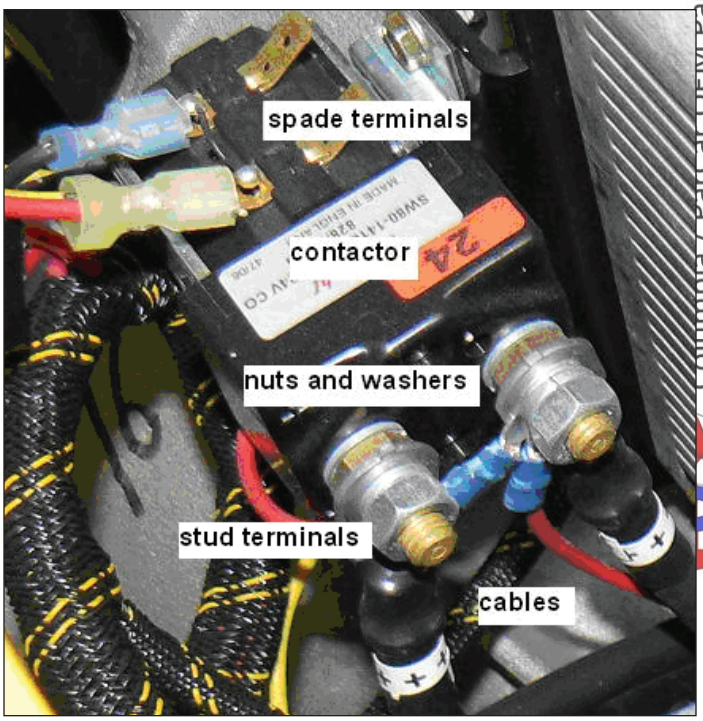


Figure 10-24. Contactor Connections

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 Contactor

1. Label contactor cables with terminal identification. Refer to schematic for correct wire numbers. Figure 10-24.
2. Remove two nuts, washers and cables from stud terminals. See Figure 10-24.
3. Remove control circuit wires from spade terminals.
4. Remove two nuts, washers, bolts and contactor. See Figure 10-25.

Contactor Installation

1. Position new contactor to mounting bracket (Figure10-25).
2. Secure contactor with two bolts, nuts and washers (Figure 10-24).
3. Install heavy cables to stud terminals. Install control circuit wires to spade terminals (Figure 10-25). Double check wiring diagram to ensure connections are correct.
5. Operational Check: Contactor should emit an audible click when the power key switch is set to ON position.

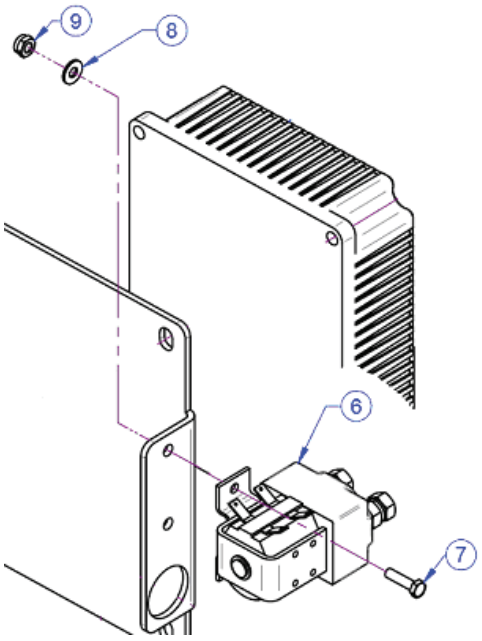


Figure 10-25. Contactor Mounting

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