



Columbia ParCar Corp.

SERVICE MANUAL

Expediter™

EX21-24S

EX21-24A

EX21-48A

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.

To the best knowledge of Columbia ParCar Corp., the material contained herein is accurate as of the date this publication was approved for printing. Columbia ParCar Corp. is not liable for errors in this manual or for incidental or consequential damages that result from the use of the material in this manual. Columbia ParCar Corp. reserves the right to change specifications, equipment or designs at any time without notice and without incurring obligation.

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, 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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CHANGE HISTORY- EX-21

DATE	DESCRIPTION	BY
12/9/13	Issued	TS



Service Manual

Section 1

Safety



Section 1 - Safety

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.

⚠ DANGER

Danger indicates a hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING

Warning indicates a hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION

Caution indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

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

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

consequences of each way, we have not undertaken any such broad evaluation.

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

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.

⚠ WARNING

Any modifications or changes to the vehicle that affect the stability or increases vehicle speed beyond factory specifications could result in severe personal injury or death. Always, remove keys and turn the master disconnect switch counterclockwise to the OFF position before servicing or repairing your vehicle. See *Section 8-Batteries*, for specific details.

⚠ WARNING

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

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

⚠ DANGER

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

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

⚠ DANGER

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. Avoid contact with skin, eyes, or clothing. Wear full face shield and rubber gloves when working on or near batteries.

⚠ DANGER

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

⚠ DANGER

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

⚠ WARNING

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.

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

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

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

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

CAUTION

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

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

This vehicle is designed to transport one (1) operator and one passenger.

SAFETY PREPARATIONS

DANGER

Before performing any service on the vehicle, always turn Power keyswitch to OFF and remove. Turn. Directional knob to NEUTRAL. Block tires.

DECAL

All decals should be ordered and replaced as soon as they are discovered to be illegible or missing.

Section 1 - Safety

Part number for the Warning/Operating decal set is 53282-96 (Figure 1-1).

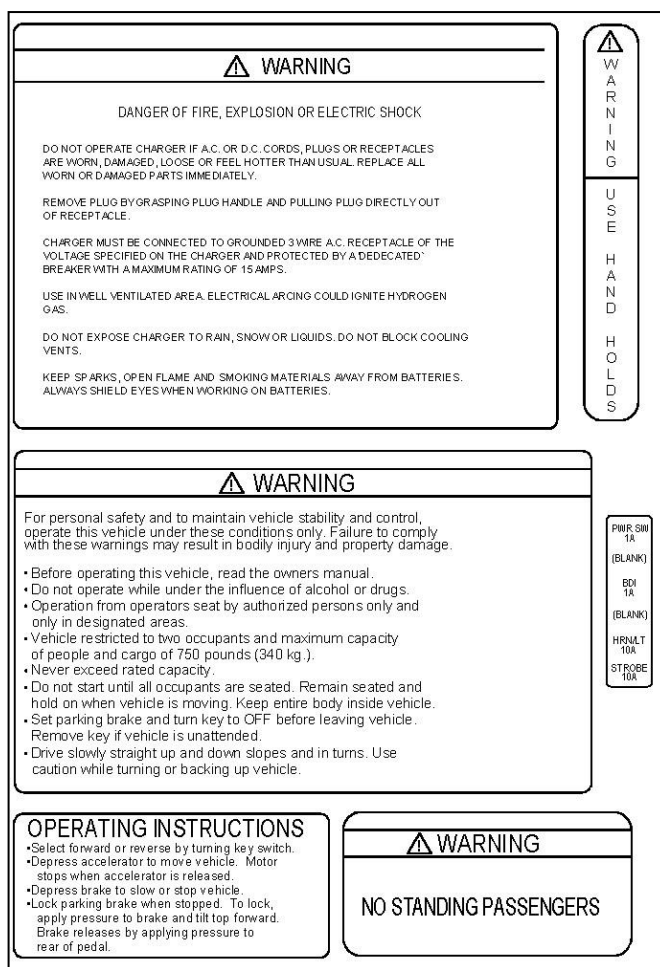


Figure 1-1

Part number for a Power Information decal is 71527-04 (Figure 1-2).



Figure 1-2

To remove a decal, use a heat gun or hair dryer to soften up and remove any damaged sticker. Peel off backing of the new decal and carefully position in place.



Columbia ParCar Corp.

Service Manual

Section 2

General Information



Columbia ParCar Corp.

VEHICLE DESCRIPTION

⚠ CAUTION

Do not remove any nameplate, warnings, or instructions affixed to your Columbia Industrial Vehicle. Promptly replace any that become damaged or removed.

The EX-21 Expediter is an electric three or four wheel vehicle. It is designed for one person and load or two persons (one facing the rear).

This vehicle is designed to be driven over smooth surfaces in and around places such as warehouses, factories, industrial sites, motels, parks, and resorts. It is not approved for use on public highways.

It is designed to conform to requirements for Type E vehicles as described in O.S.H.A. Standard Section 1910.178 (Powered Industrial Trucks) and with all applicable portions of the American National Standard for Personnel and Burden Carriers (ANSI B56.8 2006 Part III).

VEHICLE IDENTIFICATION NUMBER (VIN)

Identification Number (VIN). The VIN describes facts and features of the vehicle and contains thirteen (13) digits.

The VIN number can be found in two locations. Under the rear deck, stamped in the right front corner of the rear body chassis as shown in Figure 2.1. It is also on the vehicle nameplate located on the vertical panel below the seat as shown in Figure 2.2.

The nameplate has important information such as model, vehicle weights and rated capacity (load, operator and passenger). Do not exceed this rated capacity. Read carefully.

To ensure prompt service when repairs or adjustments are required, your Columbia Dealer must have the VIN.



Each vehicle is assigned a unique Vehicle

Figure 2-1



Figure 2-2

VIN MATRIX

ET2C2-3ZG1234 is an example of a current

Digit 1 thru 3 = Abbreviation (Model)	ET2 (Three Wheel) EF2 (Four Wheel)
Digit 4 = Power System	E = Sep Ex, Regen: (ACEplus)
Digit 5 = System Voltage	2 = 24V (4 – 6 V) B = 48V (4 – 12V)
Digit 6 = VIN Spacer	- = normal # = Special Product
Digit 7= Controller Amperage	3 = 300 Amp 4 = 400 Amp
Digit 8 = Axle/Brake System	Z = Rear Mechanical
Digit 9 = Build Year	L = 2012, M = 2013, N = 2014, etc.
Digit 10 Thru 13 – Build Sequence	1234

VIN.

SAFETY COMMITTEE

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

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

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

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

OPERATION

NOTICE: Each control should operate smoothly and easily without sticking or requiring excessive effort.

1. Set the power key switch to the ON position.
2. Set the directional key switch to the desired direction of travel (F=Forward, R=Reverse).
4. Depress accelerator with the right foot.
5. To stop the vehicle, release the accelerator pedal and apply the brake pedal slowly and completely.

CAUTION

To avoid injury, speed in reverse should always be kept at a minimum.

Be sure the direction selector is in the desired direction of travel before depressing the accelerator pedal.

VEHICLE SPECIFICATIONS

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

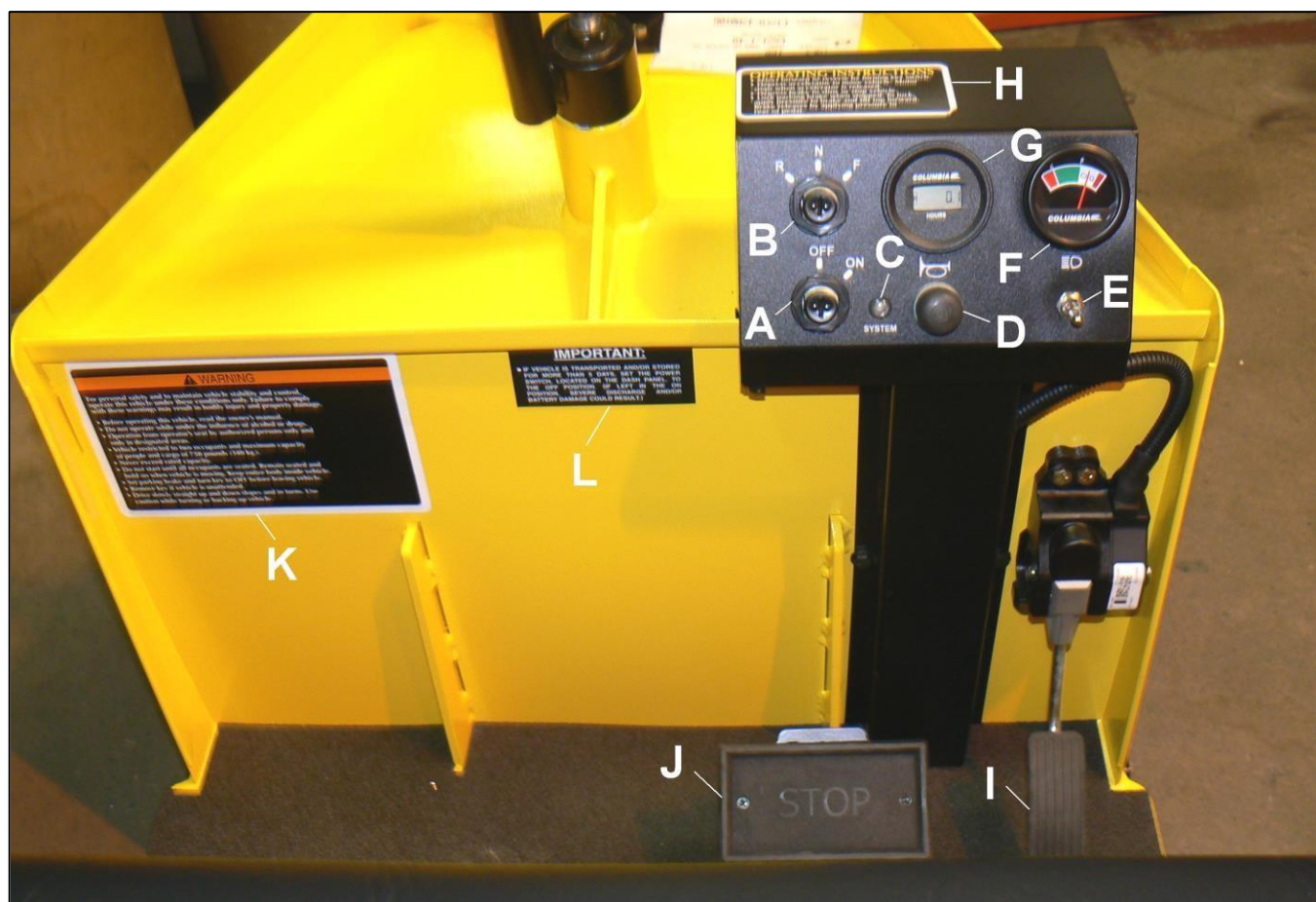
	EX21 T 24	EX21 F 24	EX21 T 48	EX21 F 48
Passenger Capacity	One or Two			
Max. Speed	8 mph			
Turning Curb to Curb (in)	127	175	127	175
Turning Intersecting Aisle (in)	66	83	66	83
Ground Clearance (in)	4			
Wheelbase (in)	53.5			
Overall Length (in)	84			
Overall Width (in)	28.5			
Overall Height (in)	46.5			
Bed Size L x W (in)	21.5 x 26.0			
Weight (lbs)	855	940	1100	1183
Rated Capacity	750 lbs.			
Towing Capacity	1000 lbs.			
Horsepower	5.2 HP @ 875 rpm		15.3 HP @ 1750 rpm	
Differential	12.44:1		16.99:1	
Battery (Deep Cycle)	Four 6V, 225 amp hour		Four 12V, 145 amp hour	
Controller Rating	300 amp		400 amp	
Controller Type	Programmable, solid state, reduced speed reverse w/diagnostic LED & calibrator interface			
Charger	Built in, micro-processor controlled, fully sealed, global 110-240 V AC, 50/60 Hz			

Motor Braking Mode	Regenerative & accelerator pedal proportional
Directional Control	Fully electronic direction switching with console selector switch
Drive Unit	Automotive style, helical gears in oil bath, direct to motor
Brakes	Auto adjusting, mechanical rear drum/foot parking brake

Tires	4.8x8, LRB (Recommend 50 psi.) 4.8x8 Foam Filled 4.0x8 Solid Non-marking 4.8x8, Non-marking (Recommend 50 psi.)
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C - SYSTEM STATUS LIGHT
D - HORN BUTTON
E - LIGHT SWITCH (option)
F - BATTERY DISCHARGE METER (BDI) G - HOUR METER INDICATOR (option)
H - OPERATING INSTRUCTION
I - ACCELERATOR PEDAL
J - BRAKE PEDAL/PARKING BRAKE

VEHICLE CONTROLS


K - WARNING LABEL
A - POWER KEYSWITCH
L – IMPORTANT POWER INFORMATION
B - DIRECTION SELECTOR

PRE-OPERATION INSPECTIONS

Each vehicle has been inspected and adjusted to factory specifications before delivery. Upon receipt of vehicle, perform a predelivery 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.

⚠ CAUTION

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

⚠ WARNING

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

PRE-OPERATION CHECKLIST

ITEM	PROCEDURE
Batteries	Fully charged or adequately charged to provide power for duration of operations.
	The AC cord is disconnected from the vehicle.
	Electrolyte level in each cell covers the top of cell plates.
	(See Section 4.11 if vehicle is equipped with a Single Point Battery Watering System.)
	Batteries are secure and free of corrosion.
	All terminals and connections are tight.
Tire	See page 2.2 recommendations for tire pressure. Free from damage.
Lights, Horn and Reverse Buzzer	If equipped, turn lights on and make sure they illuminate.
	Press horn button to sound horn.
	Reverse buzzer operating. (Operator seat must be occupied.)
Brakes	Brake pedal has firm pedal pressure with minimal travel.
	Brake light illuminates.
	Parking brake has proper engagement and release.
Steering	Responsiveness and absence of excessive free play. See Section 6.
Cargo	Load secured, balanced and not too heavy.
Obstacles	Path of intended travel is free for obstructions.
Labels	All warning and operation labels in place.
Accelerator	Check for smooth operation.
Vehicle Body	Visually check for damaged or loose hardware. See Section 8.



Service Manual

Section 3

Maintenance

⚠ WARNING

Always turn power key to off, directional keyswitch 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 vehicle. Refer to maintenance check-list for frequency of service. Perform only those maintenance instructions described in this manual. If major repairs are needed, contact the local Columbia dealer for assistance. Columbia dealers have the technical experience, training and original Columbia vehicle parts for the vehicle.

Always use original Columbia vehicle parts when servicing the vehicle.

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

NOTICE: When performing Monthly, Quarterly, SemiAnnual 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. The following calendar is one example of how scheduling routine maintenance can be managed.

PERIODIC SERVICE CALENDAR		
JANUARY Monthly	FEBRUARY Monthly	MARCH Quarterly
APRIL Monthly	MAY Monthly	JUNE Semi-Annual
JULY Monthly	AUGUST Monthly	SEPTEMBER Quarterly
OCTOBER Monthly	NOVEMBER Monthly	DECEMBER 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 ¹	Weekly ^{1,2}	Monthly ²	Quarterly ² (25 Hours)	Semi-annual ² (50 Hours)	Annual ²
Body, Seat & Frame	Visually inspect for damage or tears.	X					
Hardware	Tighten as needed.		X				
Vehicle & Undercarrage	Wash as needed.		X				
Clean Body & Seat	Wash as needed.		X				
Warning & Operating Labels	In place and readable	X					
EXT21-F Front Steering	Lubricate				X		
Brake Pedal	Lubricate				X		

¹ Service done by owner. ² 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	X					
	Check electrolyte level		X				
	Apply equalization charge to battery pack		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					
<i>* Service done by Owner</i> <i>† Service done by trained maintenance personnel</i>							

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					
	Pressure - See page 2.2 recommendations	X					
	Damaged rims			X			
Front wheel alignment	Check & adjust as needed.					X	
Wheels	Check lug nuts	X					
	Wheel bearing, repack, replace as needed.						X
	Check axle nuts for tightness & torque					X	
Steering linkage	Check for excessive movement & that hardware is secure		X				
<i>* Service performed by Owner</i> <i>† Service performed by trained maintenance personnel</i>							

MAINTENANCE SCHEDULE CHECKLIST – FLUIDS							
Component	Procedure	Daily¹	Weekly^{1,2}	Monthly²	Quarterly² (25 Hours)	Semi-annual² (50 Hours)	Annual²
Differential lubricant	Check level						X
¹ Service done by owner. ² Service done by trained maintenance personnel							

MAINTENANCE SCHEDULE CHECKLIST – ELECTRIC MOTOR

Component	Procedure	Daily ¹	Weekly ^{1,2}	Monthly ²	Quarterly ² (25 Hours)	Semi-annual ² (50 Hours)	Annual ²
Operation	Test drive for proper operation	X					
Motor	Inspect brush length & remove carbon dust Inspect & apply anti-seize to splines						X

¹ Service done by owner. ² Service done by trained maintenance personnel

necessary. For stubborn or imbedded dirt, a soft bristle brush may be used.

BATTERIES

Batteries may be recharged if vehicle has been driven 15 minutes or more since the previous charge. Before charging, be sure master 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 Wheel Hubs – EXT21-F

The vehicle has 2 grease fittings, one in each wheel hub. See *Section 6 - Front Wheels and Hubs*.

Brake Pedal

The brake pedal assembly has one fitting located under the vehicle. See *Section 5 – Accelerator and Brake System*.

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

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 and body 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 CLEANING

Proper cleaning will extend the life of the vehicle seat. Use mild soap or detergent and a soft sponge to clean whenever

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

LIFTING INSTRUCTIONS
WARNING

Use extreme caution lifting or working around lifted vehicle. Vehicle should be lifted only when parked on a flat, hard and level surface. Do not work under the vehicle unless it is firmly supported on jack stands. When lifting the vehicle for service, use a sturdy lifting device such as a floor jack or hydraulic lift. Always, wedge wheels and set parking brake of the vehicle to keep it from rolling. When using a 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. 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

HOIST LIFTS

If a hoist is used to lift the vehicle, check that the hoist is rated at a capacity greater than the vehicle weight. Lift the vehicle sufficiently from the floor, 10° to 25° angle, to allow the placement of jack stands to support the weight of the vehicle during service. See figure 3-1.

HOISTING THE REAR OF VEHICLE

1. To lift the rear, connect the lifting eyes/hooks to rear frame tubes at right and left sides. Do not use the bumper for lifting. Hoist vehicle sufficiently to place jack stands underneath frame.
2. Place jack stands under frame at right and left sides to allow access under the vehicle.
3. When work is completed, lift the vehicle and remove the jack stands, then lower vehicle to the floor.

HOISTING THE FRONT OF VEHICLE

1. To lift the front, connect the lifting eye/hooks to front frame tubes at right and left sides. Do not use the bumper for lifting.
2. Place jack stands under frame at right and left sides to allow access under vehicle.
3. When work is completed, lift the vehicle and remove the jack stands, then lower vehicle to the floor.

FLOOR JACK PROCEDURE

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.

LIFTING THE REAR OF VEHICLE

- 1 To lift the rear, place floor jack under the rear axle housing. Do not use the bumper for lifting. Raise vehicle sufficiently to place jack stands underneath frame.
2. Place jack stands under frame at right and left sides to allow access under the vehicle.
3. When work is completed, place floor jack under rear axle housing, lift the vehicle and remove the jack stands, then lower vehicle to the floor.

LIFTING THE FRONT OF VEHICLE

1. To lift the front, place floor jack under the heavy leaf spring retainer plate. Do not use the bumper for lifting. Raise vehicle sufficiently to place jack stands underneath frame.
2. Place jack stands under frame at right and left sides to allow access under the vehicle.
3. When work is completed, place floor jack under leaf spring retainer plate, lift the vehicle and remove the jack stands, then lower vehicle to the floor.

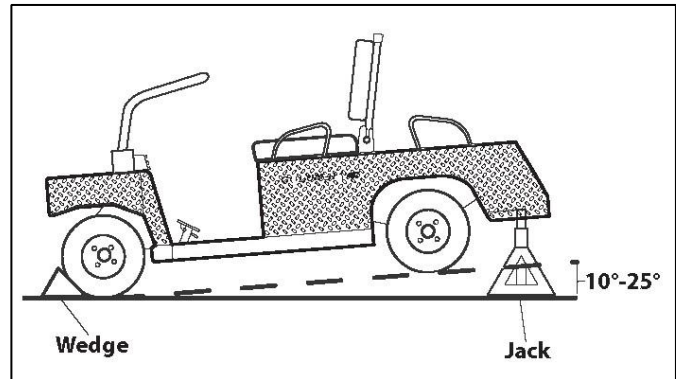


Figure 3-1

JACK STANDS

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

VEHICLE STORAGE

⚠ WARNING

Turn Power keyswitch 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. Frozen batteries can explode. Properly dispose of battery.

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.

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

If the Delta-Q is not used:

1. Batteries will "self-discharge" during storage and recharging will be necessary. Frequency for recharging is as follows:

STORAGE TEMPERATURE	CHARGE AT
Below 4° C (40° F)	Every 6 months
4° C - 16° C (40° - 60° F)	Every 2 months
Above 16° C (60° F)	Once a month

2. The specific gravity of the electrolyte should be checked every 6 to 8 weeks and charge as necessary to maintain 1.250 to 1.270 specific gravity.

⚠ DANGER

Batteries in a low state of charge will freeze at higher temperatures than fully charged batteries. Do not attempt to charge a battery that is frozen or if battery case is excessively bulged. Properly dispose of battery, because frozen batteries can explode.

3. Freezing points of batteries at different specific gravities is shown below.

SPECIFIC GRAVITY	FREEZE POINT F/ C
1.260	-70/-57
1.230	-39/-38
1.200	-16/-26
1.117	-2/-19
1.110	+17/-8

o o

NOTICE: Specific gravity readings are at 80 °F. Values need adjustment for electrolyte temperature. Reduce .004 for every 10°F below 80°F. Increase by that amount for every 10°F above.

4. For vehicles with a single point watering system, check water levels quarterly per *Section 9*.
5. Charge batteries fully then check fluid levels. Store batteries in as cool place as possible.
6. Disconnect battery negative terminal.
7. Wash off any corrosion around the terminals with a solution of baking soda and water. Do not allow this solution to enter batteries.
8. Do not engage parking brake. Block wheels to prevent movement.

RETURNING VEHICLE TO SERVICE:

1. Reconnect battery negative terminal.
2. Fully recharge batteries and check fluid levels.

For vehicles with a single point watering system: After the batteries have been fully charged, connect the system to its water supply for 3-5 seconds then disconnect regardless of whether or not the batteries are completely full. Return the vehicle to its regular service. Place the vehicle back into its regular watering schedule (waiting at least 1 week until next watering)

3. Check tire pressure and readjust if necessary.
4. Perform initial maintenance per periodic maintenance in the beginning of this section.
6. Return the vehicle to its regular service.

TRANSPORTING A VEHICLE

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

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

1. Use trailers specifically designed to carry your Columbia ParCar vehicle that meets all federal, state and local requirements.
2. Secure vehicle to the trailer following trailer manufacturer's instruction.
3. The key should be removed from the vehicle, the parking brake firmly locked, and the wheels blocked.
4. On vehicles equipped with high or wide additions or accessories be certain they are secured properly to prevent loss or damage.

⚠ 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 off, causing accident or injury.

3-5

3-6

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

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	millimeter	in.	0.0394
foot	m	0.3048	meter	ft.	3.281
miles	kilometers	1.6	kilometers	miles	0.621
Liquid Volume Measurements					
fluid ounces	milliliters	29.57	milliliters	fluid ounces	0.034
pints	liters	0.473	liters	pints	2.113
quarts	liters	0.95	liters	quarts	1.06
gallons	liters	3.8	liters	gallons	0.26
Temperature					
Fahrenheit	°C	$^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8$	Celsius	°F	$^{\circ}\text{F} = 1.8^{\circ}\text{C} + 32$



Service Manual

Section 4

Troubleshooting

⚠ WARNING

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

PRE-TROUBLESHOOTING STEPS

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

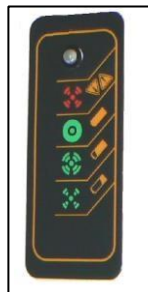
- Ensure the vehicle is safe for service. Visually inspect for any obvious signs of hazards such as sharp edges in the body or other parts, open wire insulation or wire connections, or discolored parts of the vehicle indicating heat or chemical presence.
- Record the VIN. This number is necessary to obtain technical help or support, submit warranty, and is essential in order to understand completely the vehicle that is being serviced.

BATTERY TESTING

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

Inspect/Test Condition	Corrective Action
------------------------	-------------------

Perform a visual examination of batteries and connections. Examine for signs of corrosion and clean/or replace any affected terminals or cables.	The batteries can be cleaned by hose washing with a standard garden hose or with a soft bristle brush (ensure battery caps are present and tight before washing batteries).
Examine the battery hold-down. If the material from the hold-down has been dissolved by the sulfuric acid in the batteries, the hold down can act as a drain on the battery pack.	Replace the hold-down if it appears damaged.
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 and negative post of each battery. Write down the reading from each battery. Each should contain at least 6.0 volts and no battery should be more than .5 volts lower than the highest reading. If any battery tests low on charge, charge the battery individually with an 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 arrow Figure 41). If one or more batteries still test low, the battery should be tested individually and replaced as necessary. <i>NOTE: It is recommended that all batteries in a system be changed together to ensure the batteries are the same brand, vintage, and service life.</i>
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.
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.


Figure 4-1

TROUBLESHOOTING SPECIFIC COMPLAINTS

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

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

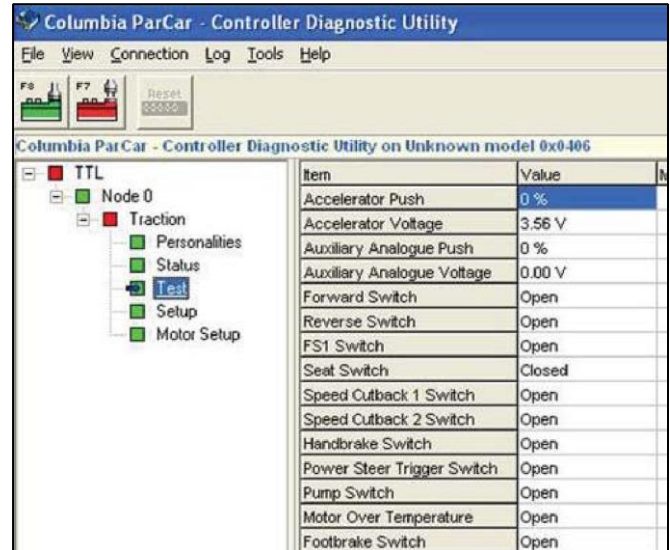
- Vehicle will not move; forward or reverse
- Vehicle operates slowly
- Vehicle drives in forward or reverse only
- Vehicle drives but operation is jerky or inconsistent
- Vehicle power cuts out

NOTICE: 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-

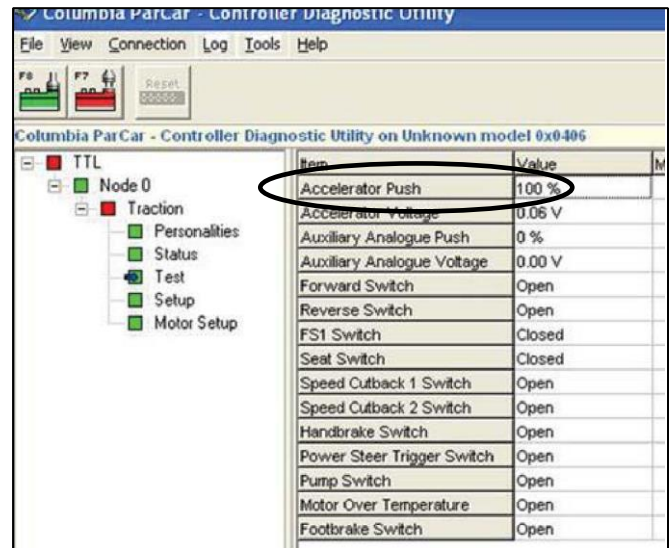
TROUBLESHOOTING WITH PCPAK

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 4-3).

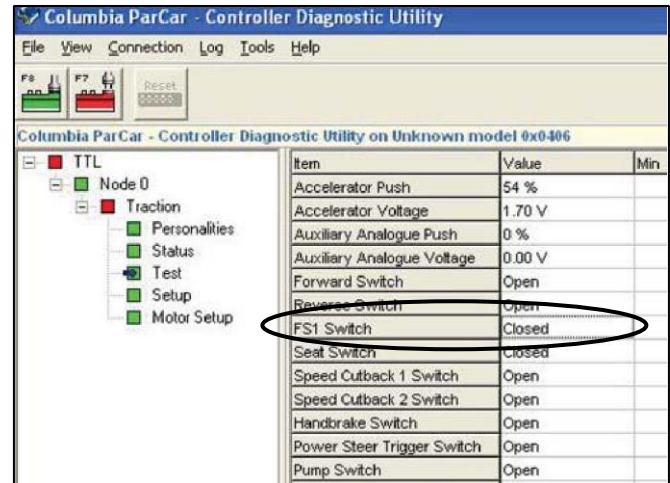

Figure 4.3

2. With the Forward / Reverse knob 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 4-4). 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.

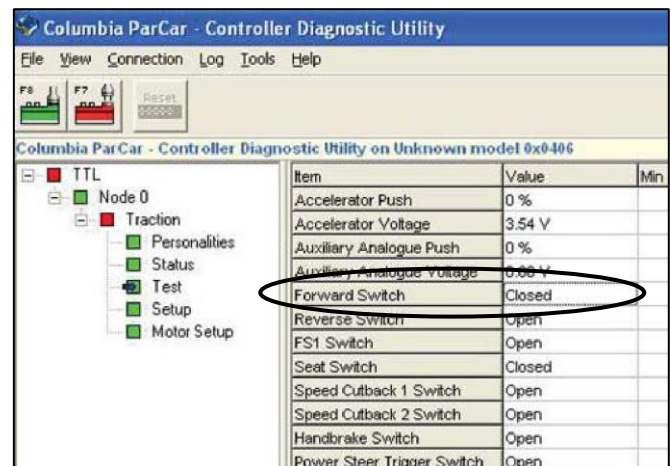

Figure 4.4

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 4-5). 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 4-5

4. Check the direction input to the controller. Observe the value of the "Forward Switch" item while turning the direction selection knob to "Forward" and to "Neutral". The switch should read "open" when the knob is in neutral and "closed" when in forward (Figure 4-6). 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 4-6

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.

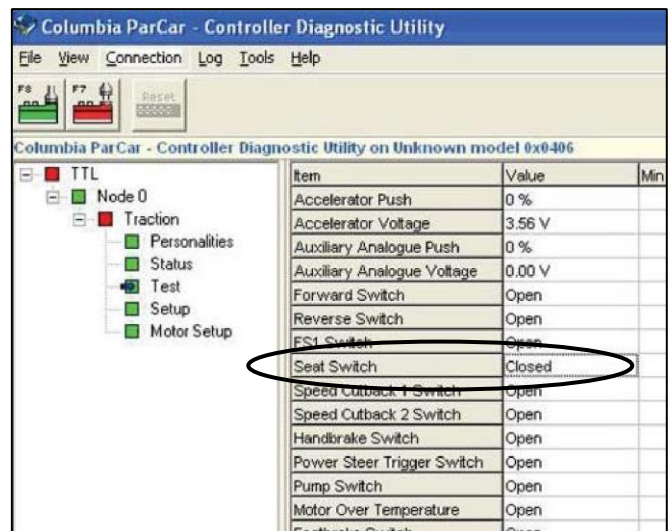


Figure 4-7

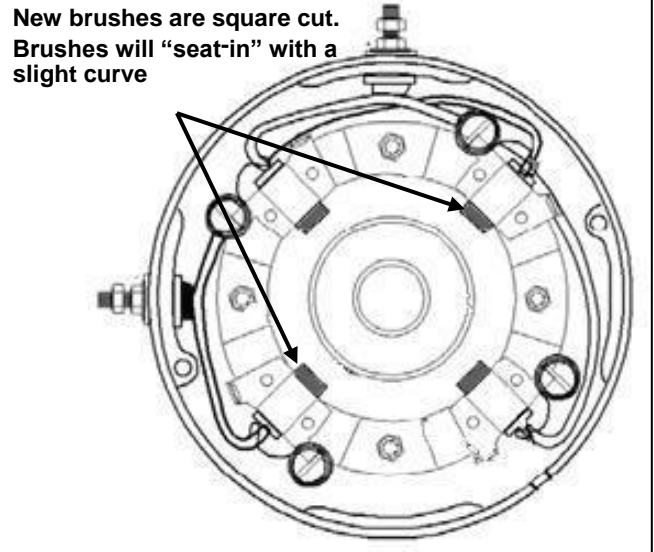
TROUBLESHOOTING WITH THE HANDHELD CALIBRATOR

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 knob 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 <i>Troubleshooting with Handheld Calibrator</i> above.
3 Flash	Check all wire connections. Disconnect all electrical accessories (strobe lights, heaters, etc.) External or internal wiring faults will cause 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 48 volt main solenoid. Check all wiring. Plug in Calibrator and read location 13.01 for more precise fault cause(s).
5 Flash	Motor stall fault. Check motor for damage. Plug in Calibrator and read location 13.10 for more precise fault cause(s).
6 Flash	Accelerator fault. Check all wiring pertaining to the accelerator switch. Perform steps 1, 3 and 4 under <i>Troubleshooting with Handheld Calibrator</i> above.
7 Flash	Low or high battery voltage. Check battery voltage with a voltmeter. If battery voltage drops below 32 volts (48 volt system), the controller will shut down. Read pack voltage both stationary and under hard acceleration if possible. If voltage is good while static, but drops significantly while accelerating, weak or damaged batteries may be the cause.
8 Flash	Over temperature cutout. Call Columbia Technical Support.
9 Flash	Out of range. Call Columbia Technical Support.
10 Flash	Bench test 48 volt main solenoid. Check all wiring. Plug in Calibrator and read location 13.01 for more precise fault cause(s).

VEHICLE DRIVES SLOWLY

- Check for all physical/visual signs of damage, low tire pressure or jammed linkages.
- Check for brake drag by turning vehicle power off, releasing parking brake, and attempting to roll vehicle a short distance.
- Plug in the Handheld Calibrator and check 5.01, 6.01 and 7.01 for appropriate values (maximum speed settings). While driving check speed incrementally at 14.01 on the handset. Also check the encoder pull up resistor and encoder connector.



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*.

Figure 4-8

VEHICLE DRIVES BUT OPERATION IS JERKY OR INCONSISTENT

- Check speed switch carefully with analog ohmmeter for gradual, smooth resistance sweep.
- Check motor brushes. Replace if bad or worn (Figure 4-8).

Call Columbia Technical Support if problem persists. Have the following information ready:

- VIN
- Vehicle Checksum (19.15)
- Direction of travel where 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.

FLASH CODES AND CORRECTIVE/INVESTIGATIVE ACTION

Flash Code	Description	Action	Handset ID fault number	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	13.01	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.
Flash 1	Personality out of range	Check personality Checksum	81 /71	51.91	Controller replacement required, contact Tech Support
Flash 2	Seat Switch Fault	Check seat switch & seat switch circuit	7	80.91	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
Flash 3	Auxiliary wiring short	Disconnect auxiliary electrical components and retry	-	13.01	Controller replacement required, contact Tech Support
	Armature Short Detected	Clean and Check motor and wiring for faults	23	13.01	Motor replacement may be required, contact Tech Support
	Internal controller fault	Disconnect auxiliary electrical components and retry	27	13.01	Controller replacement required, contact Tech Support. Some aftermarket devices with a high capacitance such as a DC DC converter or inverter can cause a 3 Flash
Flash 4	Contactor failed or stuck	Bench test contactor	91	13.01	Replace Solenoid, If good - Controller replacement required, contact Tech Support
	Contactor Failed or contactor wiring fault	Bench test contactor and test contactor wiring	20	13.01	Repair or replace failed connection or component
	Motor open circuit or brushes fault	Clean and Check motor and wiring for faults	22	13.01	Motor replacement may be required, contact Tech Support
Flash 5	Motor stall detected	Clean and Check motor and wiring for faults review application	15	13.01	Motor replacement may be required, contact Tech Support
Flash 6	Input wire disconnected	Check wiring to speed switch & FS1	4	13.01/19.01/10.91	Repair or replace failed connection or component
	Speed switch out of adjustment	Check speed switch range	11	13.01/19.01/19.02	Repair or replace failed connection or component

	Pedal depressed at start up	Ensure Accelerator Pedal returns to 0 (rest) position	8 or 9	13.01/19.01/19.07	Repair or replace failed connection or component
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4-6

FLASH CODES AND CORRECTIVE/INVESTIGATIVE ACTION (CONTINUED)

Flash Code	Description	Action	Handset ID fault number	Calibrator reference loc	Correction – If fault does not clear
Flash 7	Battery voltage low	Check Static battery voltage and voltage while operating	12 / 13 or 16	13.01/15.01	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	13.01/15.01	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	13.01/15.02	Contact tech support with reading from 15.02
8 Flash	Over Temperature cut - out	Review application and allow vehicle to cool	1	13.01/18.01	Contact Tech Support
	Current Cut - Back	Review application and allow vehicle to cool	3	13.01/18.01	Contact Tech Support
Flash 9	Internal motor 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	-	13.01	Contactor or Controller replacement may be required, contact Tech Support
	Value out of range	Check personality Checksum	43	13.01/51.91	Controller replacement may be required, contact Tech Support
	Internal controller fault	Disconnect any electrical accessories and retry	34	13.01	Controller replacement may be required, contact Tech Support

COMPONENT TROUBLESHOOTING

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

Battery Discharge Indicator (BDI)

- Fuse failed. Check fuse and replace if failed.
- Open wiring or failed connection. Check wiring and connections.
- Inoperable BDI gauge. Replace gauge
- Weak or failed batteries. Test batteries and charge as necessary.

Brake Lights and Auxiliary Switch

- Fuse failed. Check fuse and replace if failed.
- Open wiring or failed connection. Check wiring and connections.
- Bulb failed. Replace bulb.
- Misadjusted or inoperable brake light switch. Check switch adjustment, replace switch if necessary.

Reverse Beeper

- Fuse failed. Check fuse and replace if failed.

- Open wiring or failed connection. Check wiring and connections.
 - Inoperable reverse buzzer. Replace buzzer.
 - Weak or failed batteries. Test batteries and charge as necessary.
 - Controller set wrong. Check controller setting using hand held. Reset if necessary.
- Head Light & Tail Light**
- Fuse failed. Check fuse and replace if failed.
 - Open wiring or failed connection. Check wiring and connections.
 - Bulb burnt out. Replace.
 - Failed power key switch. Test and replace contactor as necessary.
 - Inoperable switch. Replace switch.
 - Check Dc-DC convertor fusing and voltage.

Power Outlet

- Fuse failed. Check fuse and replace if failed.
- Open wiring or failed connection. Check wiring and connections.
- Inoperable power outlet. Replace power outlet.

Brake Light

- Fuse failed. Check fuse and replace if failed.
- Open wiring or failed connection. Check wiring and connections.
- Bulb burnt out. Replace bulb.
- Failed power key switch. Test and replace contactor as necessary.

BRAKES**Slow or Incomplete Release of Brakes**

- Shoes and linings. Shoes improperly adjusted. Shoes are self-adjusting; check parts for wear. Shoes distorted or incorrect. Replace with new parts.
- Mechanical parts. Damaged or weak return springsreplace.
- Cables and linkage sticking, dirty or corroded. Lubricate with a commercial solvent like WD40, PB Blaster, etc. Make sure not to contaminate brake pads with solvent.

Wheel Bearings

- Damaged or contaminated-replace.

4-7

- Grabbing or pulling-replace.

Air in Hydraulic Lines

- Bleed hydraulic lines.

Severe Reaction to Pedal Pressure and Uneven Stopping

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

Brakes Squealing, Clicking or Scraping Noises

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

4-8



Service Manual

Section 5

Accelerator & Brake System

⚠ WARNING

Always turn keyswitch to OFF and remove. Turn direction knob to Neutral, block tires and disconnect the battery negative (-) cable before performing any vehicle service to avoid accidental startup of vehicle and possible injury.

ACCELERATOR PEDAL

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

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

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

MECHANICAL BRAKE SYSTEM GENERAL

The mechanical braking system consists of two rear wheel drum brakes, the brake pedal, springs and brake linkage to operate the brakes.

These brakes are self-adjusting and should not require adjustment if shoe-to-drum clearance is within normal limits. When brakes are applied, shoes expand outward to drum. If brake shoe travel is excessive, brake adjuster will advance to compensate for wear. When brakes are released, adjuster returns to normal position.

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

The parking brake is applied by depressing the parking brake pad at the top of the brake pedal which locks the brakes in place. Brakes are released when the accelerator or brake pedal is depressed. If brakes fail to hold the car in position when parking brake is applied, see *Mechanical Brake Adjustments*.

PERIODIC BRAKE INSPECTION

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

⚠ CAUTION

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

Periodic inspection should always include the following:

1. With vehicle stationary, depress the brake pedal and check for 1/4" pedal free travel before resistance is felt. Maximum pedal free travel should not exceed 2" measured from floor board to top of pedal. If pedal free travel is excessive, see *Mechanical Brake Adjustments*.
2. Inspect brake parts under vehicle for physical damage, corrosion, or cable fraying. Inspect dust boot at brake actuating lever located behind each rear wheel. If cracked or split, replace dust boot.
3. 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 safely support it with jack stands positioned under main frame tubes. See Section 3 - Lifting Instructions.

1. Perform steps 1 & 2 under *Mechanical Rear Drum Brake Disassembly*.
2. Inspect drum for excessive or uneven wear. Look for cracks radiating from stud holes. 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 Drum Service*.
3. Inspect brake shoes for thickness, uneven wear or physical damage. If brake shoe lining at any point is measured to be less than 1/16" (1.6 mm), brake shoes must be replaced. See *Mechanical Rear Drum Brake Disassembly*.
4. Inspect for oil or grease contamination. Replace brake shoes that are contaminated. See *Mechanical Rear Drum Brake Disassembly*.
5. Inspect dust boot at brake actuating lever. If cracked or split, replace dust boot.
6. Wash mud, brake shoe debris, and dirt from brake assemblies and drum. Apply white lithium grease to

contact points between brake shoe and brake back plate. Remove excess grease to prevent brake shoe contamination.

⚠ WARNING

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

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

MECHANICAL REAR DRUM BRAKE

DISASSEMBLY

NOTICE: 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.

1. Engage the brake. Remove four lug nuts and remove rear wheel/tire assembly. Repeat for other rear wheel.
2. See Figure 5-1. Remove and discard cotter pin and axle nut. Release brake and remove, brake drum and wheel hub.

Refer to Figure 5-2 for steps 3 - 7.

3. Using good, quality brake pliers, remove auto adjuster spring.
4. To remove brake shoes, hold 1/4 turn fastener with a brake spring tool, rotate 1/4 turn and remove fastener and spring. Repeat for other 1/4 turn fastener.
5. 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.
6. Slide the automatic adjuster screw and automatic adjuster nut from brake assembly. Clean these parts thoroughly.
7. Wash any mud, brake debris, and dirt from brake plate.

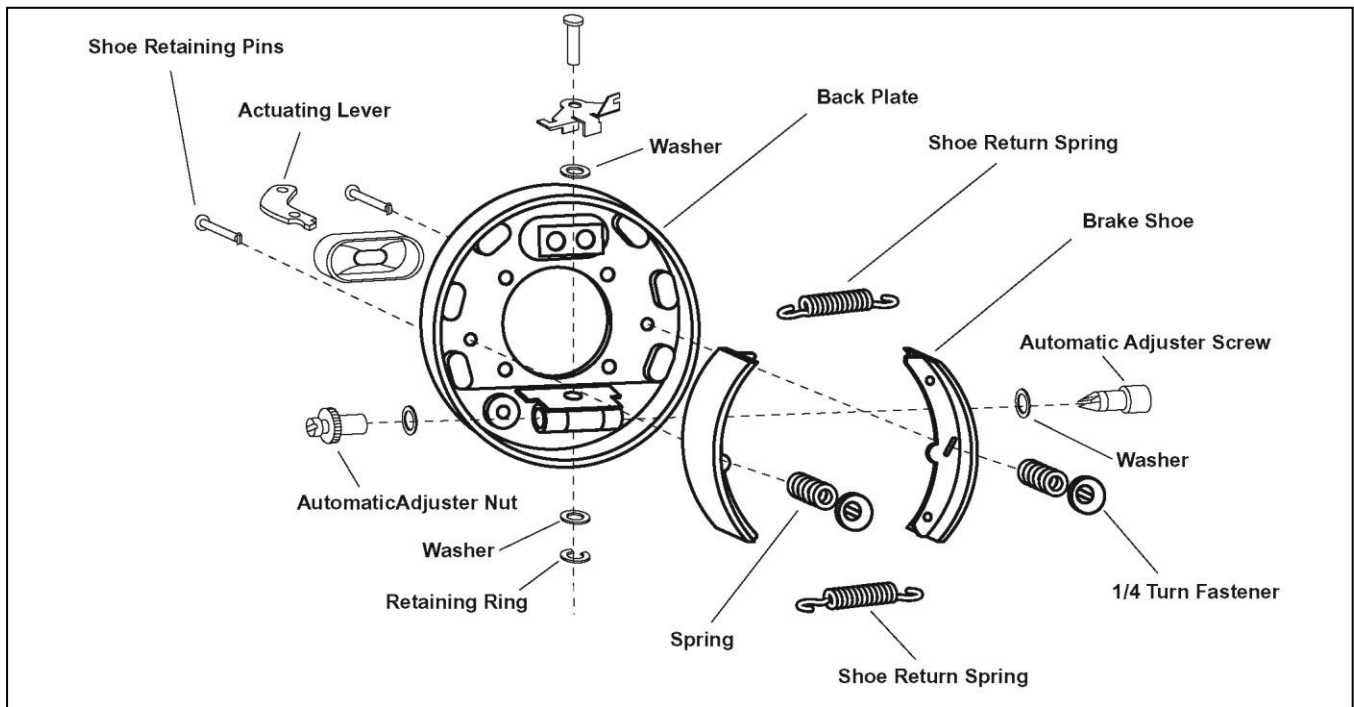
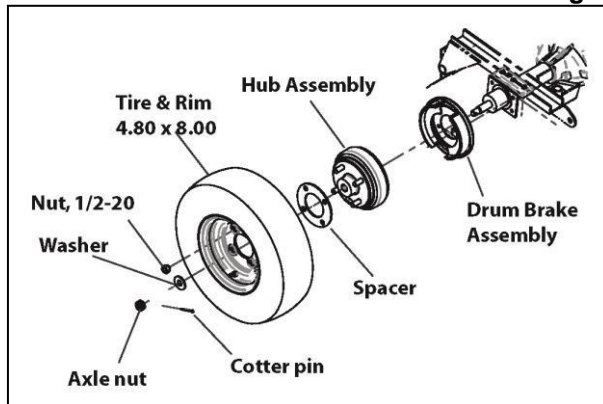


Figure 5-2

Figure 5-1



BRAKE DRUM SERVICE 1.

Rebore or replace

drum:

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

if inside diameter of drum at open end exceeds inside diameter at closed end by more than .010". if surface variance exceeds .005" on the side.

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

if heat checking is plainly visible or can be felt with a fingernail.

If checks are severe, replace drum.

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

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

3. Rebore limit is .060" over original drum diameter.

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

CAUTION

Never rebore a drum to maximum wear or discard diameter.

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

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. See Figure 5-2. 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. Using a flat blade screwdriver, turn the adjuster nut away from the backing plate. Check to make sure the shoes are spreading further apart. Make sure the brake drum still slides on easily.

5. Install the brake drum 3/4 over the brake assembly and using a brake spoon or brake adjusting tool, rotate the brake adjuster until drag is felt against the brake drum. Push the drum fully onto the assembly.

6. Apply pressure to the brake pedal and release, then check to see if additional adjustment is required to create drag on the drums.

7. When adequate drag is achieved (very slight drag), install wheel hub and drum fully onto brake assembly. Engage brake and install a new axle nut. Tighten axle nut to a minimum 65 ft. lbs. (23 Nm) Install new cotter pin.

8. Reinstall rear wheel/tire assembly and four lug nuts. Engage brake and tighten lug nuts in a criss-cross pattern to a maximum 65-70 ft. lbs. (23-25 Nm) (Figure 5-3). Repeat for other rear wheel. Recheck lug nut torque with vehicle on the ground.

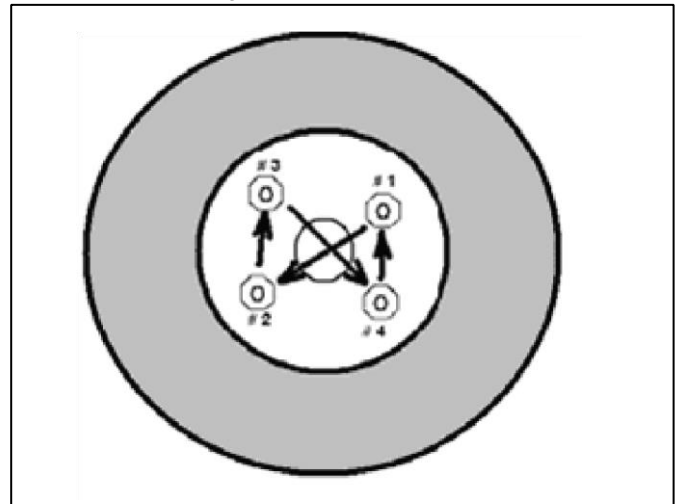


Figure 5-3

BRAKE STRIP REPLACEMENT**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. At rear brake assembly (Figure 5-4), remove cotter pin and clevis pin from brake strips at rear brake drum. Discard cotter pin and e-ring.

2. Remove cotter pin and clevis pin securing brake strips to brake cross member. Discard cotter pin and e-ring.
3. Repeat for other brake strips.
4. Secure brake strips to rear axle brake actuator arms (Figure 5-4) with new clevis pins and new cotter pins.
5. Secure brake strips to brake cross member with new clevis pins and new cotter pins.
6. With vehicle stationary, depress the brake pedal and check for 1/4" pedal free travel before resistance is felt. Maximum pedal free travel should not exceed 2" measured from floor board to top of pedal. If adjustment is required, see *Mechanical Brake Linkage Adjustment* below.
7. 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.

MECHANICAL BRAKE ADJUSTMENTS

LINKAGE ADJUSTMENT

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

1. Loosen jamnuts on brake rod connecting brake pedal to equalizer.
2. Rotate brake rod to shorten or lengthen it. Adjust length of brake rod until free brake pedal movement is less than 1/4".
3. Tighten jamnuts.

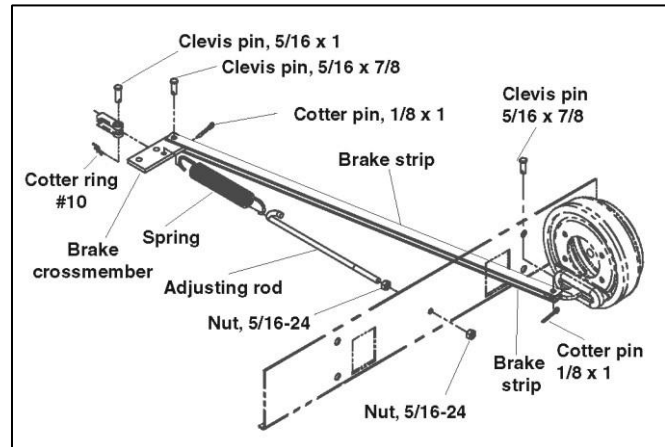


Figure 5-4

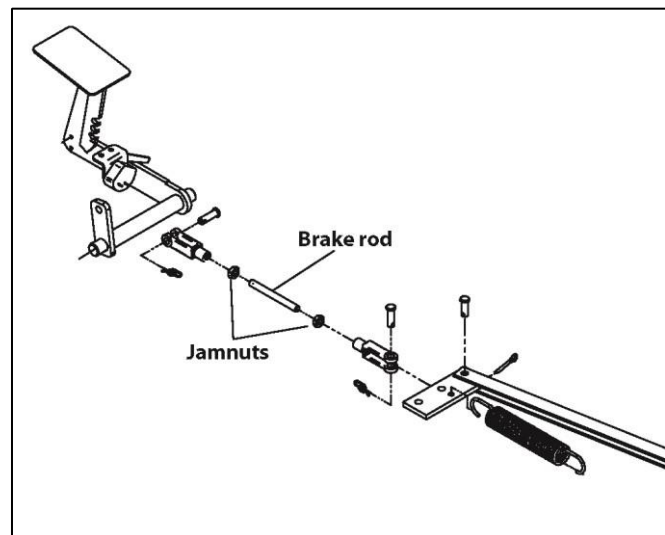


Figure 5-5

PARKING BRAKE PEDAL ADJUSTMENT

After rear brake operation is tested, and brake linkage and cables are properly adjusted, check and adjust the parking brake as follows:

1. Look through the floor opening while gently pressing on the brake pedal. The gap between the brake ratchet end and the brake ratchet pawl should be no greater than 1/16"-1/8" (Figure 5-5).
2. If adjustment is required, remove the clevis pin securing the brake rod to the brake pedal. If the gap between the parking brake ratchet and the brake pawl is less than 1/16", shorten the rod slightly to adjust. If the gap is greater than 1/8", lengthen the rod to adjust.
3. Reconnect the brake rod to the parking brake pedal. Recheck the space to verify correct gap.

4. Depress the parking brake pedal until the first click is heard. At this setting the vehicle should not roll when on a slight incline. Depress the pedal to the second click, or notch. With the parking brake set, the vehicle should not roll on a steep incline or hill.
5. With the gap properly set, if the vehicle does move on when performing steps 4 & 5, perform the *Mechanical Brake Linkage Adjustment* above.

DRUM BRAKE SHOE ADJUSTMENT

These brakes are self-adjusting and require no manual adjustment. If brakes do not adjust automatically, check brake cable adjustment or inspect brake assembly for internal damage or friction.



Service Manual

Section 6

Front Wheels, Fork & Steering

⚠ WARNING

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

GENERAL

Three wheel models utilize a suspension mount front fork or a non-suspension front fork. Both can be coupled with either a loop tiller control bar, a handle control bar or steering wheel with a rack and pinion steering assembly.

Four wheel models are operated by a loop tiller control bar, a handle control bar or steering wheel, connected to the rack and pinion steering assembly.

The rack and pinion assembly pushes and pulls on tie rod ends

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

to control front wheel steering.

FRONT WHEELS AND HUBS

Removing 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 Maintenance - Lifting Instructions*.

1. Before raising vehicle, with wheels on the ground, break loose the lug nuts.
2. 3-Wheel Model with suspension fork. See Figure 6-1.
Remove lug nuts and wheel assembly from the hub. Remove the hub components shown in Figure 6-1.
- 3-Wheel Model with non-suspension fork. See Figure 6-2. Remove the screw, washer and jam nut. Remove lug nuts and wheel assembly from the hub. Remove the hub components shown in Figure 6-2.
3. 4-Wheel Models: See Figure 6-3. Remove lug nuts and wheel assembly from the hub. Remove the spacer and hub components shown in Figure 6-3. Repeat for the other front wheel.

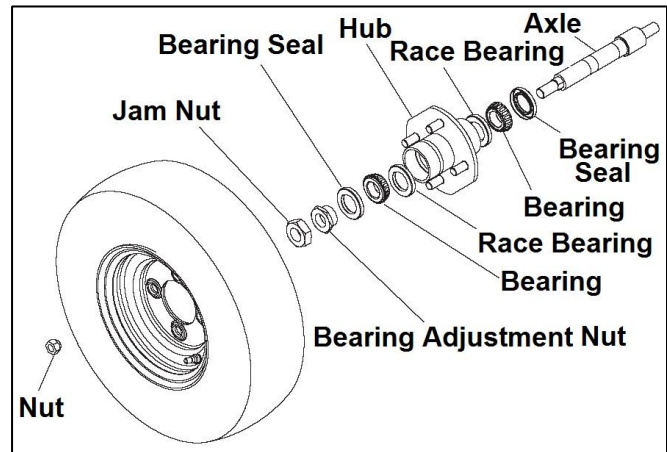


Figure 6-1

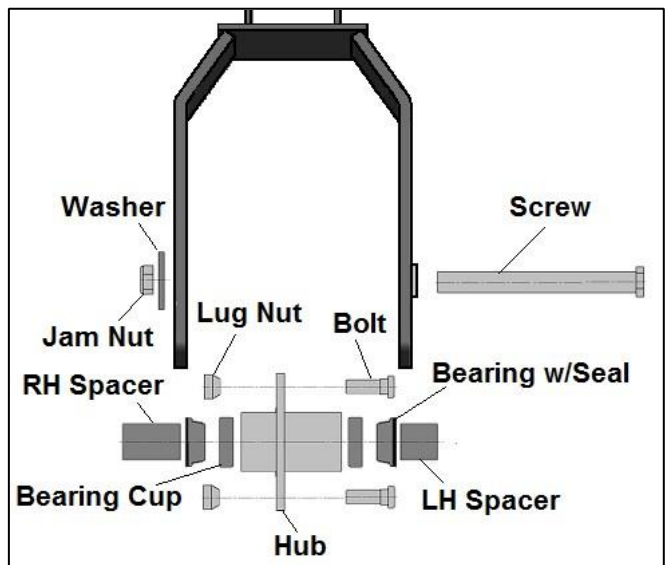


Figure 6-2

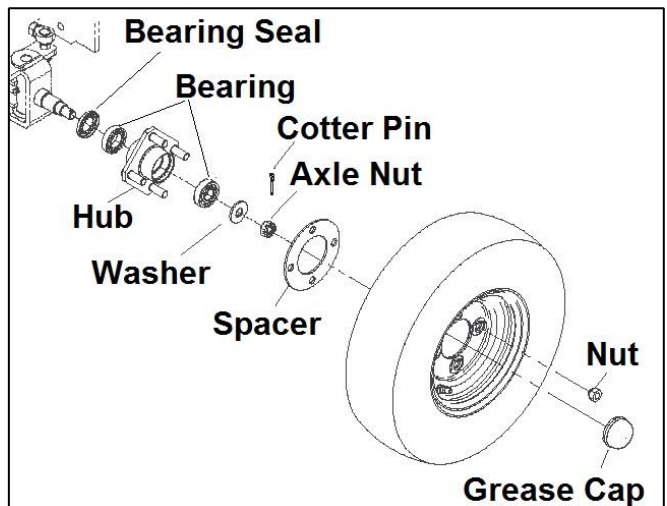


Figure 6-3

6-1

INSPECTING/REPLACING WHEEL HUB BEARINGS

ROLLER BEARINGS

Roller bearings should be replaced whenever wheel hub is removed.

Pack bearings with wheel bearing grease before installing.

INSTALLING FRONT WHEEL HUBS AND WHEELS

1. 3-Wheel Model with suspension fork. See Figure 6-1. Clean spindle. Apply a thin coating of grease and install hub onto the spindle. Install inner bearing seal and bearing, hub, bearing, bearing seal and adjusting nut. Tighten adjusting nut until resistance is felt when turning the wheel hub, then back off slightly. While holding adjusting nut, install and tighten jamnut. Place wheel assembly on the hub studs. Tighten four lug nuts by hand and wrench until snug using a criss-cross pattern.
2. 3-Wheel Model with non-suspension fork. See Figure 6-2. In the hub install the bearing cups, roller bearing with seals and the spacers. The smaller spacer is to the left side. Tighten four lug nuts by hand and wrench until snug using a criss-cross pattern. Install hub assembly in wheel and place in fork. Attach with screw, washer and jam nut. Tighten until resistance is felt.
3. 4-Wheel Models. See Figure 6-3. Install bearing seal and inner bearing, hub, bearing, washer and axle nut. Tighten axle nut until resistance is felt when turning the wheel hub, then back off until cotter pin can be inserted, then install new cotter pin. Install spacer and grease cap. Repeat for other wheel. Place wheel assembly on the hub studs. Tighten four lug nuts by hand and wrench until snug using a criss-cross pattern.
4. Lower the vehicle to the ground and torque the lug nuts to 65 ft. lbs. (23 Nm) using the same criss-crossing pattern.

TIRES

In the event of a flat tire, remove wheel assembly from vehicle and follow standard tire repair procedures.

TILLER EQUIPPED MODEL

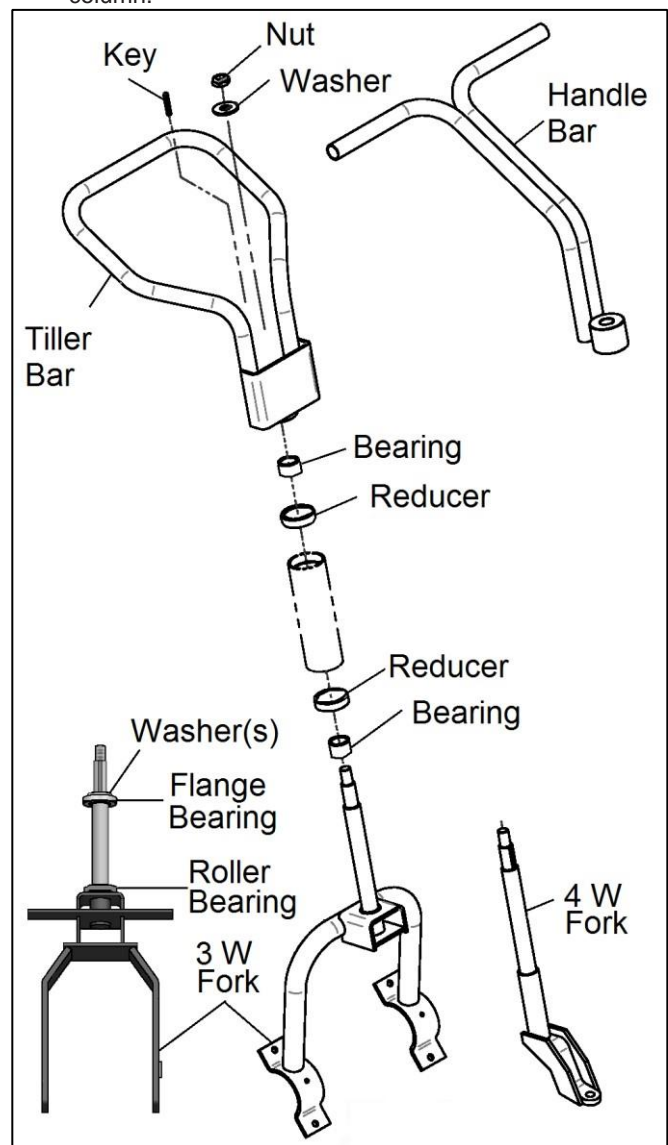
REMOVING TILLER

1. Remove steering wheel lock nut and washer from center of the tiller.
2. Pull tiller from keyed shaft.

NOTICE: If bearing appears worn, or steering is not smooth, continue with steps 3 - 5 and replace the bushing and bearings (Figure 6-4).

REPLACING STEERING SHAFT BEARINGS

3. On 4-wheel models, remove lock nut securing steering shaft to tie rod end. Tie rod is left-hand thread. Using a soft mallet, tap the steering shaft free of the steering column.


Figure 6-4

⚠ 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 Maintenance - Lifting Instructions*.

On 3-wheel models, use a soft mallet to tap the steering shaft and front fork assembly free of the steering column.

4. Grease new bearings and tap into steering column.
5. Re-install steering shaft and washers.

INSTALLING TILLER

1. Make sure wheels are pointed straight ahead.
2. Apply Anti-Seize to steering shaft. Install square key and tiller on steering shaft and torque to 22-25 ft. lbs. (3-3.5

Kgm).

STEERING WHEEL EQUIPPED MODEL**REMOVING STEERING WHEEL**

1. Remove scorecard holder by carefully prying out from steering wheel.
2. Remove two Phillips head screws securing steering wheel to collar (Figure 6-7).
3. Remove steering wheel lock nut from center of steering wheel.
4. Pull steering wheel from splined shaft.

NOTICE: If bearing appears worn, or steering is not smooth, continue with steps 5 - 8 and replace the bushing and bearings (Figure 6-5).

REPLACING STEERING SHAFT BEARINGS**⚠ 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 Maintenance - Lifting Instructions*.

5. Remove screw and nut and disconnect steering shaft from the pinion sprocket.
6. Using a soft mallet, tap the steering shaft free of the steering column.
7. Grease new bearings and tap into steering column.
8. Re-install steering shaft and bushing.

INSTALLING STEERING WHEEL

1. Make sure wheels are pointed straight ahead.
2. Apply Anti-Seize to steering shaft. Install steering wheel centered on splined shaft.
3. Install steering wheel nut and torque to 22-25 ft. lbs. (3-3.5 Kgm).
4. Connect collar to steering wheel with two Phillips head screws.
5. Install scorecard holder.

UPPER STEERING GROUP**DISASSEMBLY (FIGURE 6-5)**

1. Remove steering wheel as described above. Remove steering column guard.
2. Remove master link from chain and remove chain.
3. Remove lock nut and screw securing steering shaft to pinion sprocket. Remove pinion sprocket and nylon washers from tripod. If nylon bushing appears worn, replace it.
4. Remove jamnut, washer and steering sprocket.
5. If bearings appear worn and require replacement, disconnect front fork from the upper tie rod. Use a rubber mallet and tap the front fork from the frame tube. Grease new bearings and tap into frame tube.

ASSEMBLY (FIGURE 6-5)

1. Install front fork, washers (top and bottom of fork), square key, steering sprocket, washer and jamnut. Tighten jamnut.
2. Install nylon washers and pinion sprocket.
3. Install chain and master chain link to steering sprocket and pinion sprocket.
4. Attach steering shaft to pinion sprocket with screw and lock nut.
5. Install steering wheel as described on this page.

6. Install steering column guard.

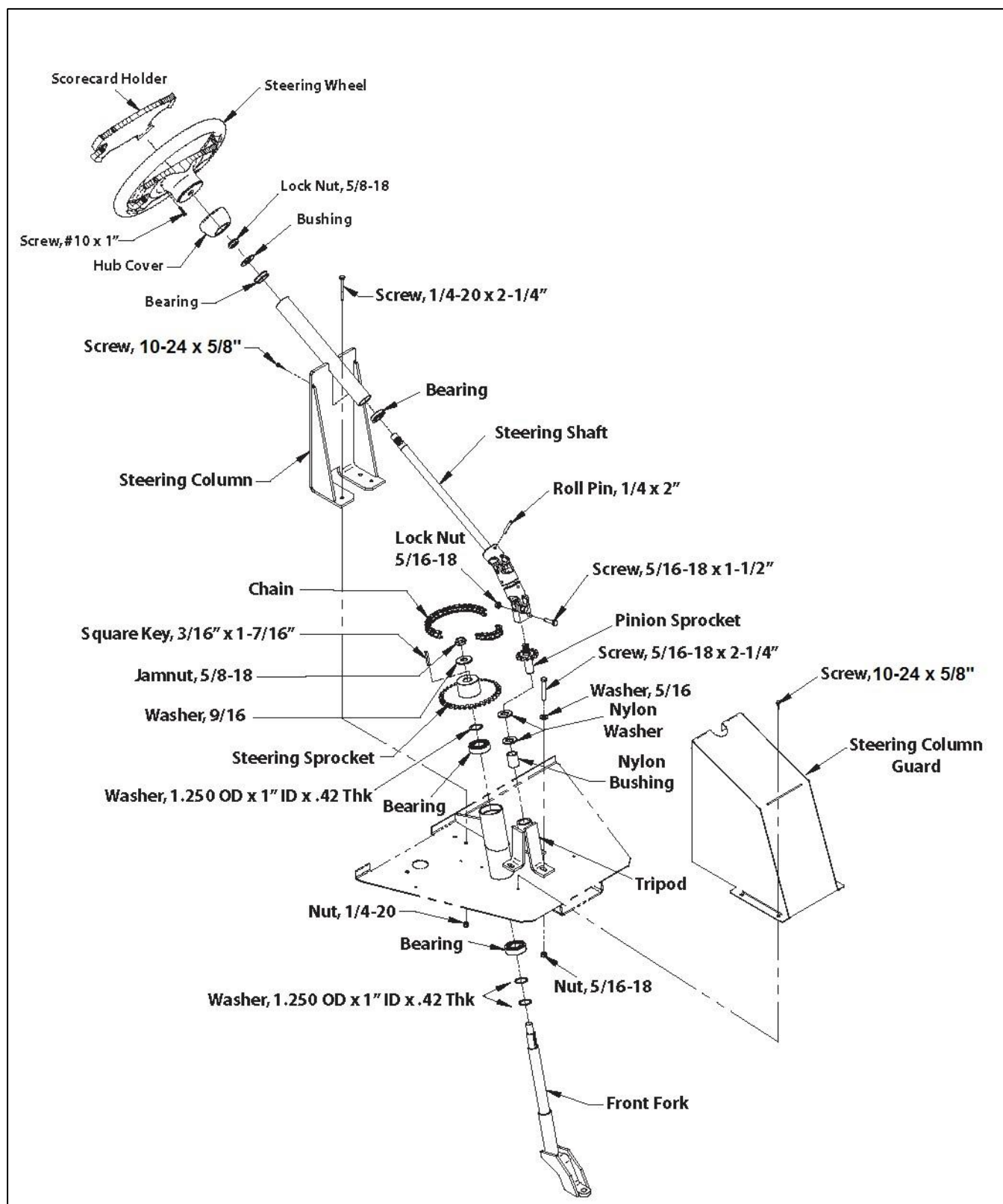


Figure 6-5

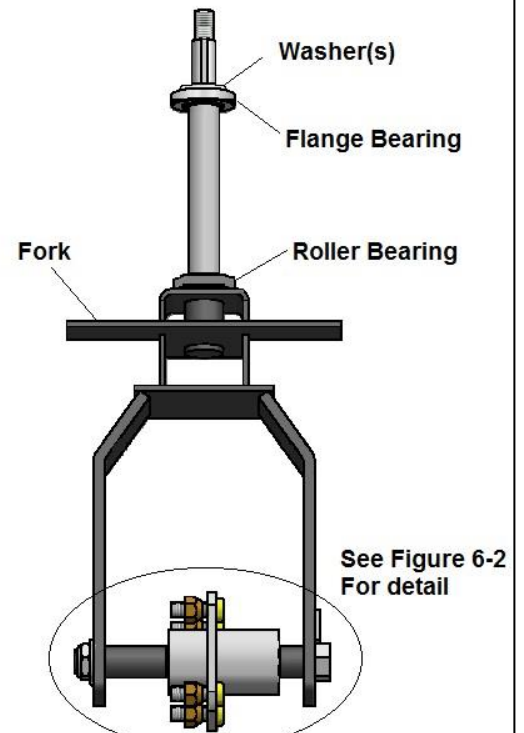
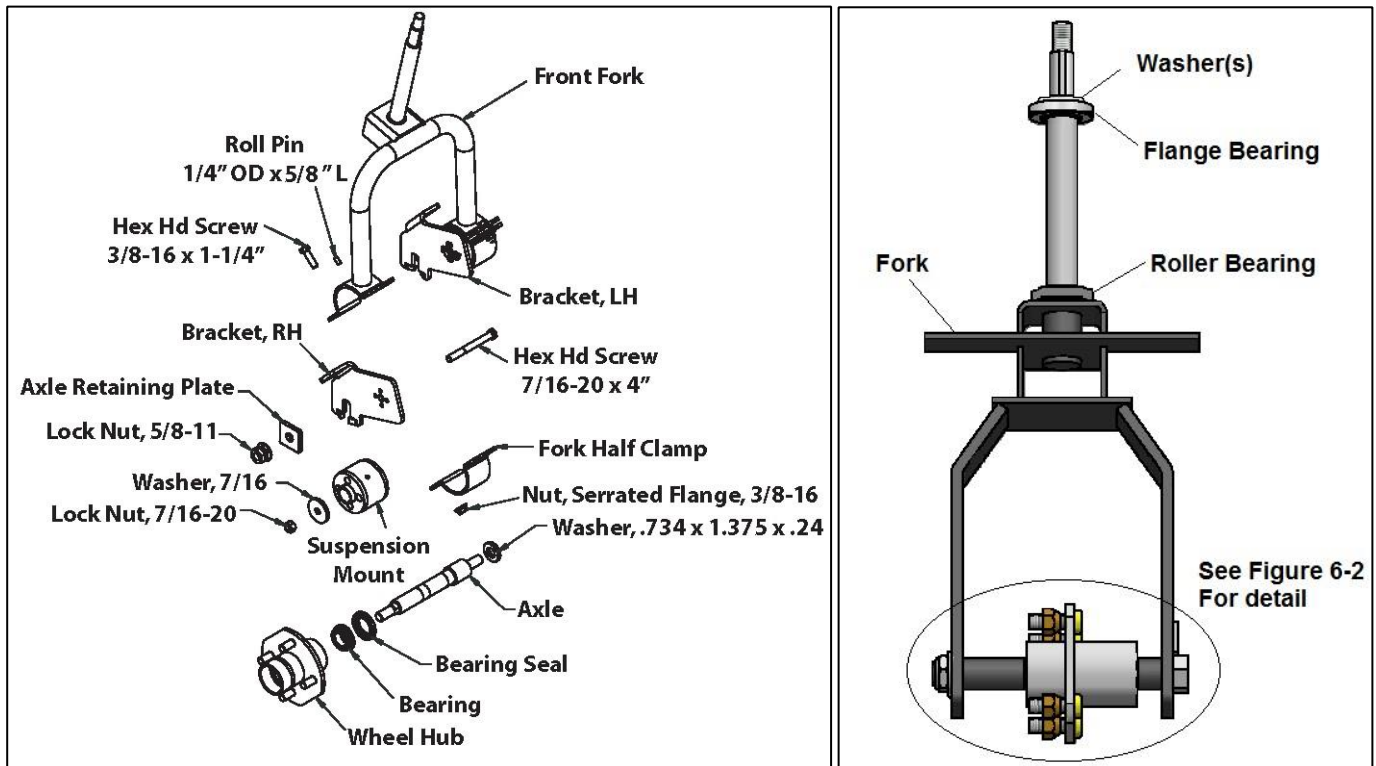


Figure 6-6**⚠ WARNING**

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

FRONT SUSPENSION FORK – 3 WHEEL

See Figure 6-6

REMOVAL

1. Remove front wheel.
2. If steering bearings are to be replaced, see *Tiller – Replacing Steering Shaft Bearings* above.
3. Remove lock nut, axle retaining plate, axle and washer from right- and left-hand brackets.
4. Remove hex head screws, washers, locknuts and brackets from suspension mounts.
5. Remove hex head screws, nuts, fork half clamps and suspension mounts from fork assembly.
7. Clean all parts (except suspension mounts) in cleaning solvent. Replace suspension mounts if worn.

Figure 6-7**INSTALLING**

1. Install hex head screws, nuts, fork half clamps and suspension mounts to fork assembly.
2. Install hex head screws, washers, locknuts and brackets to suspension mounts.
3. Install lock nut, axle retaining plate, axle and washer to right and left-hand brackets.

FRONT NON-SUSPENSION FORK – 3 WHEEL

See Figure 6-7

1. Remove the screw, washer and jam nut attaching the wheel.
2. If steering bearings are to be replaced, see *Tiller – Replacing Steering Shaft Bearings* above.
3. Install with screw, washer and jam nut. Tighten until resistance is felt.

FRONT SUSPENSION – 4-WHEEL**REPLACING TIE RODS (Figure 6-8)**

NOTICE: If 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 end threads or count the number of threads as you remove the tie rod ends.

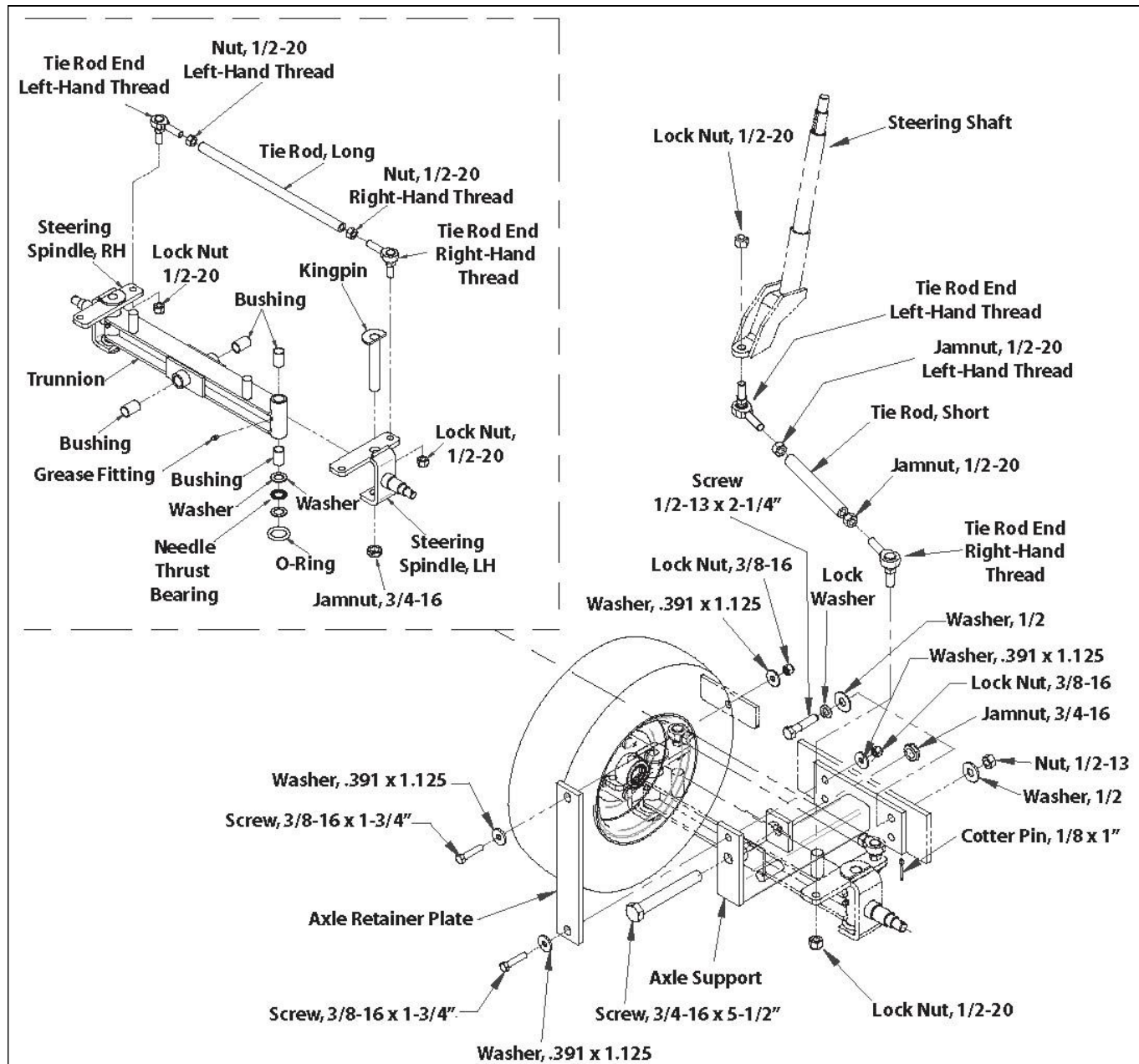


Figure 6-8

1. **For short tie rod**, disconnect tie rod end from steering shaft. Take note that tie rod end is left-hand thread. Disconnect tie rod end from trunnion. Take note that tie rod end is right-hand thread.
2. Replace parts as necessary. Install new tie rod end and/or tie rod ends in same as orientation as previously marked.
3. Secure tie rods with new nuts.

For long tie rod, disconnect tie rod end from right-hand spindle. Take note that tie rod end is left-hand thread. Disconnect tie rod end from left-hand spindle. Take note that tie rod end is right-hand thread.

REPLACING BUSHINGS (Figure 6-8)

1. Remove front wheels.
2. Remove tie rods as described previously in *Tie Rod Replacement*.
3. Remove screw, washers and lock nut securing axle retaining plate to axle support.
4. Remove screw and jamnut securing trunnion to axle support.
5. Remove kingpins and jamnuts securing steering spindles to trunnion.
6. Replace bushings.
7. Install steering spindles to trunnion with kingpins and jamnuts.
8. Install trunnion to axle support with screw and jamnut.
9. Install axle retaining plate to axle support with screw, washers and lock nut.
10. Install tie rods as described previously in *Tie Rod Replacement*.
11. Reinstall front wheels.

COLUMBIA **Columbia ParCar Corp.****Service Manual****Section 7*****Rear Wheels, Rear Suspension & Axle Assembly***



Columbia ParCar Corp.

Section 6 – Front wheels, Fork & Steering

2013 EX-21 Service Manual

⚠ WARNING

Always turn power key to off, directional keyswitch 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.

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 Maintenance - Lifting Instructions*.

REMOVING REAR WHEELS

1. Before raising vehicle, with wheels on the ground, break loose the lug nuts.
2. Raise the vehicle and engage the brake. Remove four lug nuts and remove rear wheel/tire assembly. Repeat for other rear wheel.
3. Repeat steps 1 - 2 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 *Disassembling Rear Axle* for bearing replacement procedures.

INSTALLING REAR WHEELS

1. Place wheel assembly on the hub studs.
2. Tighten four lug nuts by hand and wrench until snug using a criss-cross pattern.
3. Lower the vehicle to the ground and torque the lug nuts to 65 ft. lbs. using the same criss-crossing pattern.

TIRES

In the event of a flat tire, remove wheel assembly from vehicle and follow standard tire repair procedures.

REAR SUSPENSION**⚠ 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 Maintenance - Lifting Instructions*.

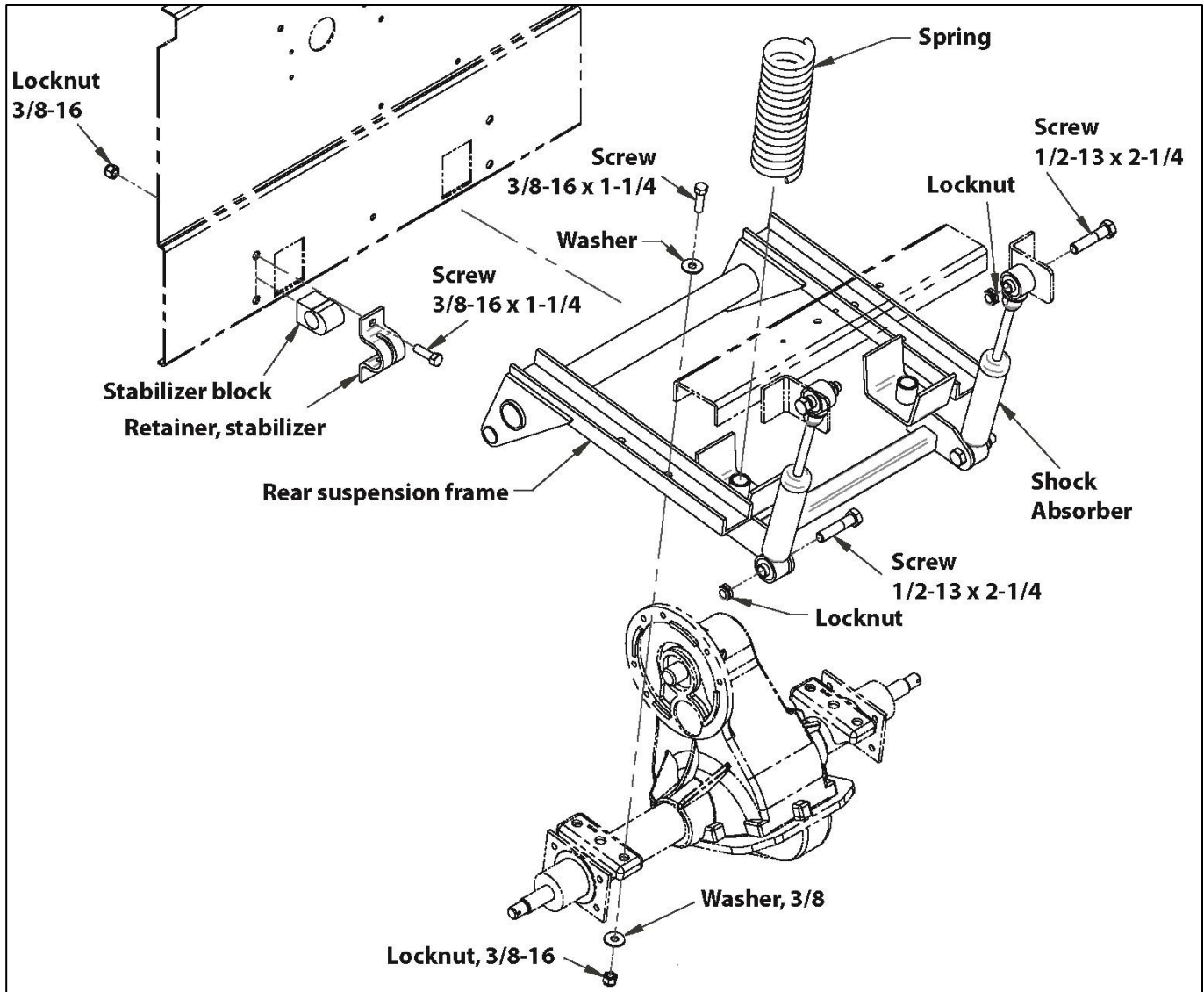
REPLACING REAR SHOCK ABSORBER

Replace shock absorber if dampening effect is not present when shock absorber is collapsed or extended, or there are signs of oil leakage.

1. Raise the rear body.
2. Remove upper and lower mounting bolts and nuts securing shock absorber (Figure 7-3).
3. Install new shock absorber and secure with mounting bolts and new nylock nuts. Torque to 45 ft. lbs. (61 Nm).
4. Lower the rear body.

REPLACING REAR SPRINGS

1. Place a hydraulic jack under the rear carrier assembly.
2. Remove rear shock absorbers as described above.
3. Slowly lower the rear carrier/axle assembly until springs can be removed (Figure 7-3).
4. Install new springs and raise rear carrier/axle assembly to seat the springs.
5. Reinstall shocks.

**Figure 7-1****REAR AXLE ASSEMBLY**

4. Remove rear shock absorbers and springs as described

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 Maintenance - Lifting Instructions*.

REMOVING REAR AXLE

1. Before raising vehicle, with wheels on the ground, break loose the lug nuts.
2. Raise the vehicle and engage the brake.
3. Remove lug nuts and remove rear wheel/tire assemblies. Remove and discard cotter pin and axle nut. Release brake and remove washer, spacer and rear wheel hub (Figure 7-2). Repeat for other side.
5. Remove the traction motor as described in *Section 10 Traction Drive System*. Remove U-bolt securing rear axle to traction drive motor mounting plate.
6. See Figure 7-3. Remove cotter pins and clevis pins. Disconnect brake strips from brake assemblies on the rear axle. Remove screws and rear brake drums.
7. Remove nuts, washers and screws securing rear axle to rear frame.

CAUTION

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

GENERAL

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

DANGER

on the previous page.

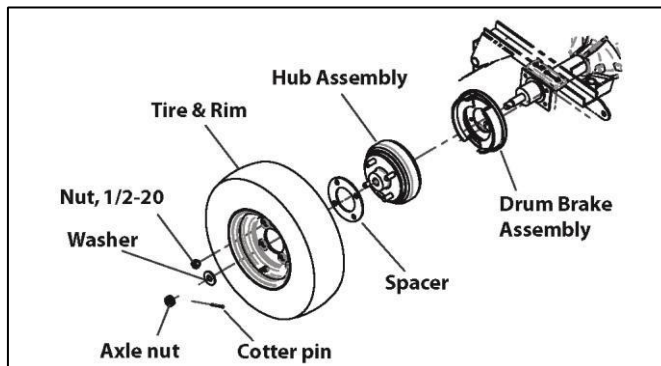


Figure 7-2 wheel hub (Figure 7-2). Repeat

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.

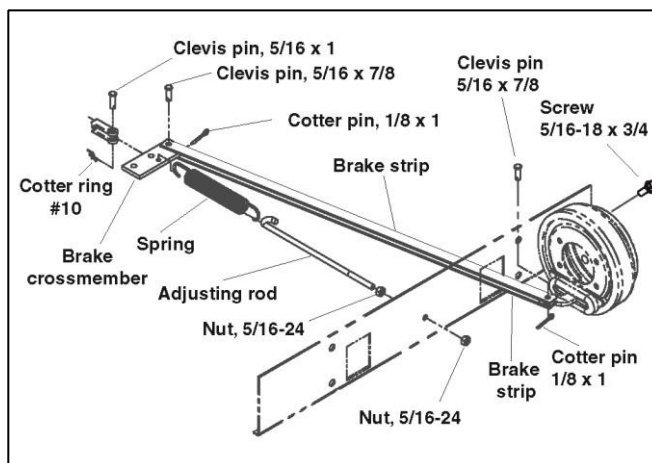


Figure 7-3

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

Cover plate screws 16-24 ft.lbs.

Fill plug 25-40 ft.lbs.

Brake bolts - 160

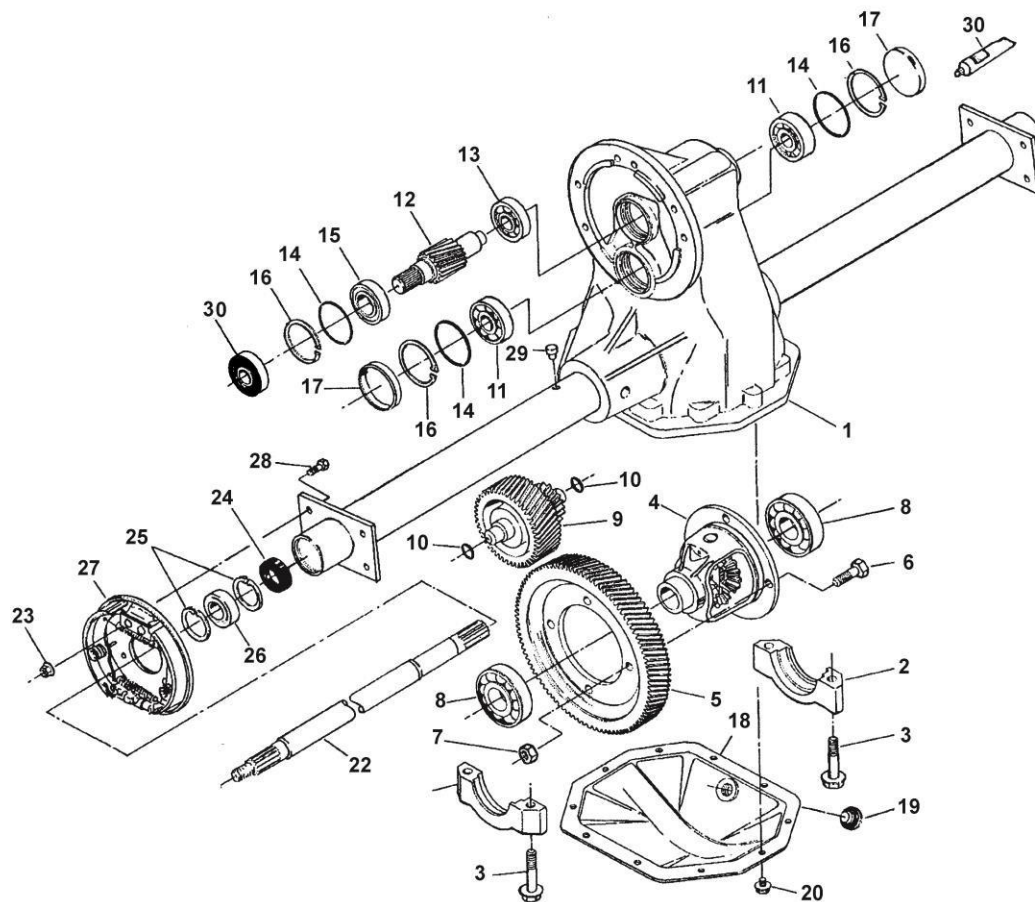
mm brakes 15-19 ft.lbs.

Spindle nut 95-115 ft. lbs.

TORQUES

Differential bearing cap 35-45 ft.lbs.

Ring gear bolts 35-45 ft.lbs.



Item	Qty.	Description	Item	Qty.	Description	Item	Qty.	Description
1	1	Carrier Sub-Assy.	11	2	Bearing, ball	21	1	Sealant, anaerobic
2	2	Bearing cap	12	1	Input shaft	22	1	Axle shaft
3	4	Bolt, bearing cap	13	1	Bearing, ball	23	8	Nut, brake, 160mm
4	1	Diff. Case Assy.	14	3	O-ring	24	2	Oil seal
5	1	Gear, output	15	1	Bearing, ball	25	4	Snap ring
6	4	Cap screw	16	3	Snap ring	26	2	Bearing
7	4	Nut	17	2	Plug, cup	27	1	Brake Assy.
8	2	Bearing, ball	18	1	Cover, carrier	28	8	Bolt, brake, 160mm
9	1	Intermediate Shaft & Gear	19	1	Plug, fill	29	1	Vent
10	2	O-ring	20	10	Screw, cover plate	30	1	Oil seal

Figure 7-4

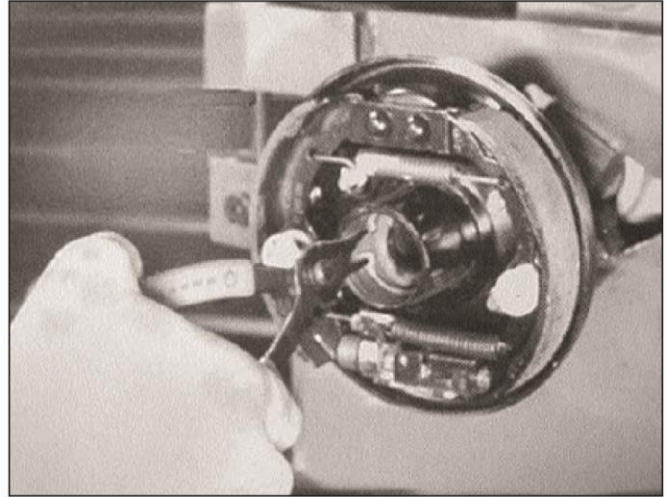
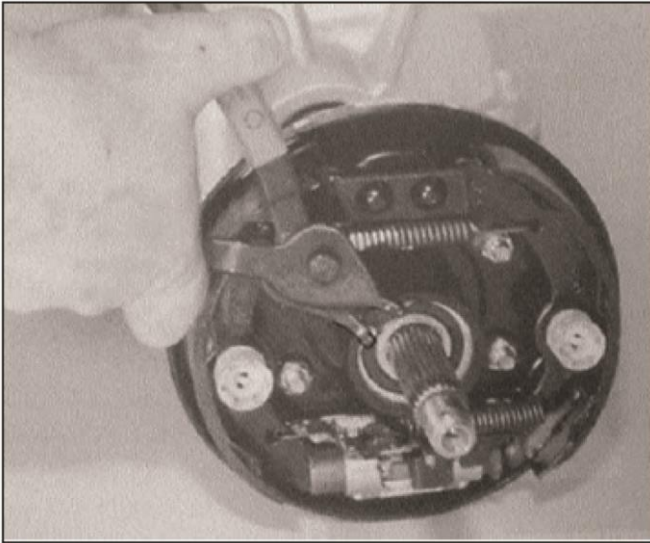
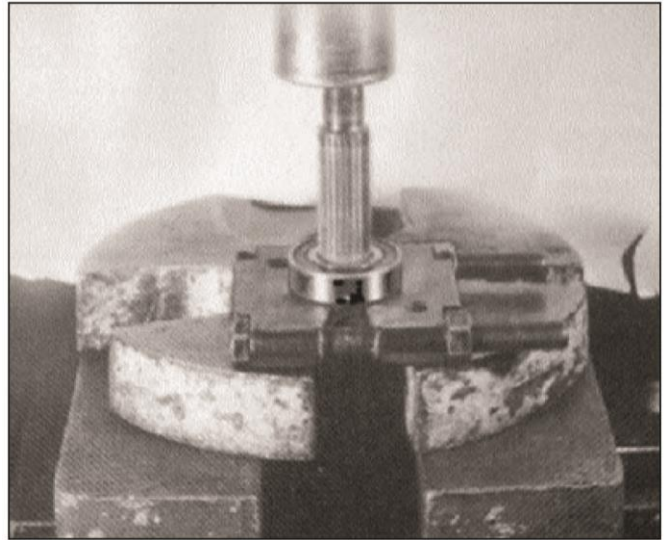
**Figure 7-6**

Figure 7-5
DISASSEMBLING REAR AXLE

WARNING

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

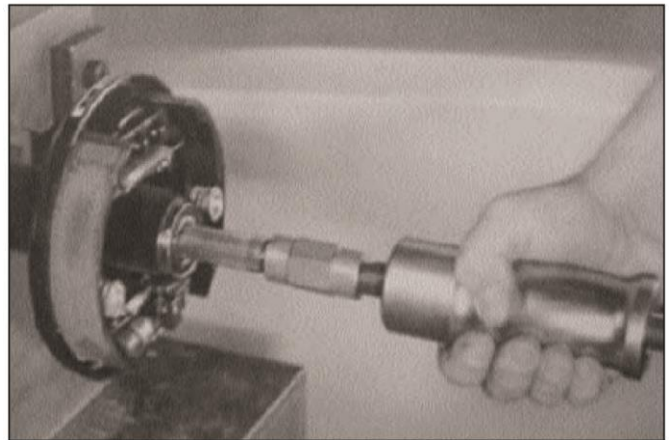


All callout numbers in steps refer to Figure 7-4.

1. Remove outer snap ring (25). See Figure 7-5.
3. Using a slide hammer attached to the threaded end of the axle shaft (22), remove axle shaft and bearing (26) assembly. See Figure 7-6.
4. Remove inner snap ring (25). Use care to not damage bearing surfaces. See Figure 7-7.
5. Remove the bearing (26) 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 7-9.
the other shaft.
6. Repeat steps 1-5 to remove and disassemble
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 7-9). 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 7-10.

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 7-9

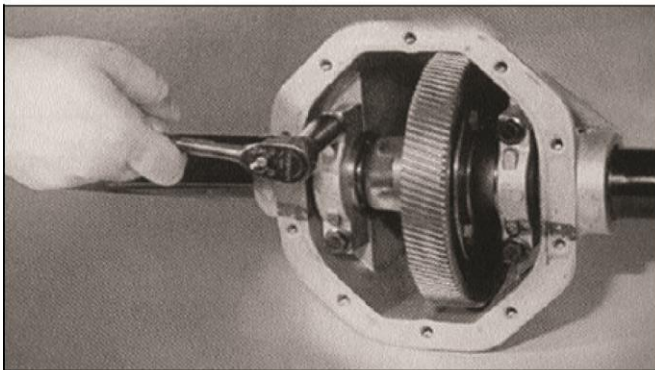


Figure 7-10

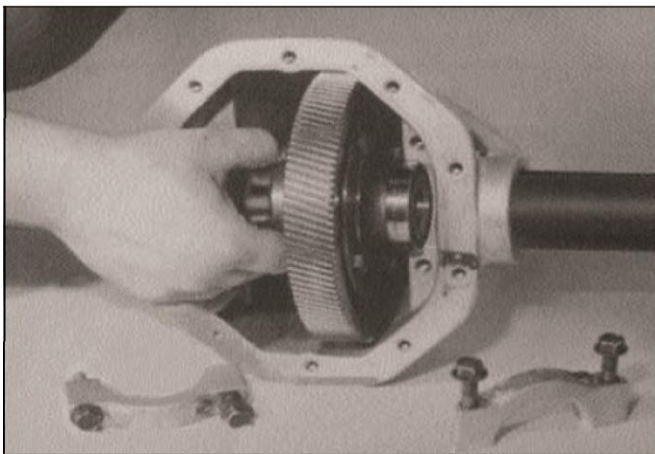


Figure 7-11

Figure 7-8

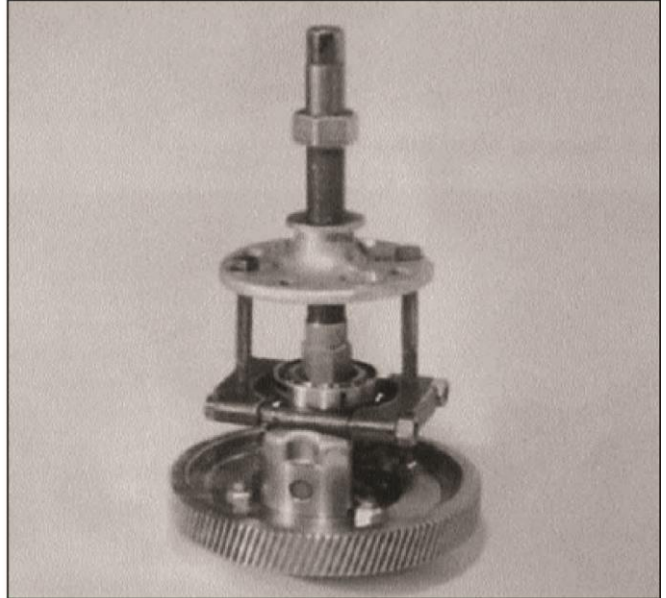


Figure 7-12

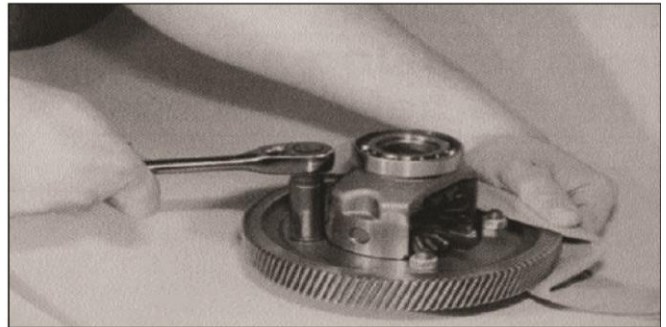


Figure 7-13

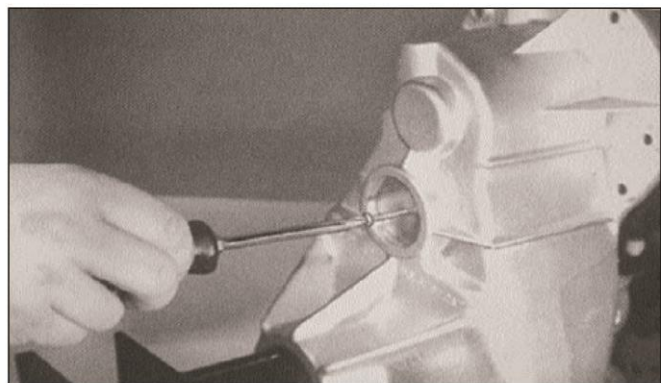


Figure 7-14

10. Using a bearing puller, remove differential bearings (8) from each side of the differential case. See Figure 7-12.
11. Remove four bolts (6) and nuts (7) from the final drive output gear (5). Remove gear from differential case. Use care not to damage gear teeth. See Figure 7-13.

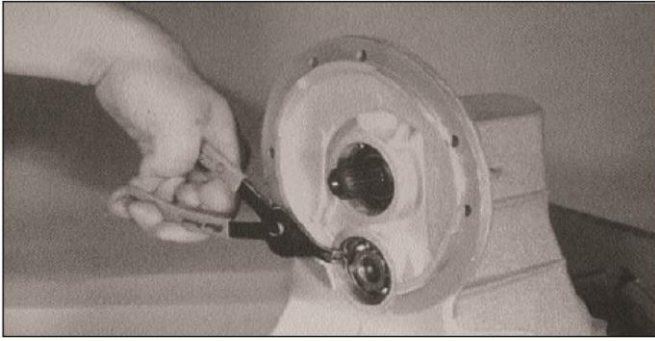


Figure 7-15

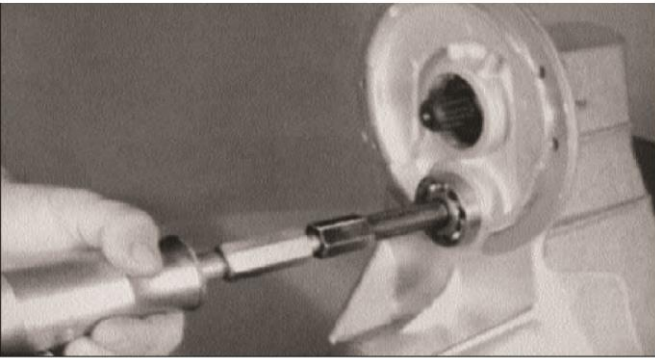


Figure 7-16

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 7-14.
13. Remove snap rings (16) from each intermediate bore. See Figure 7-15.

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.

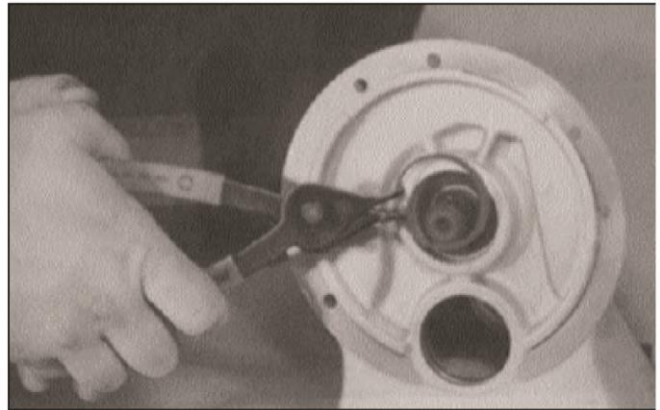


Figure 7-17

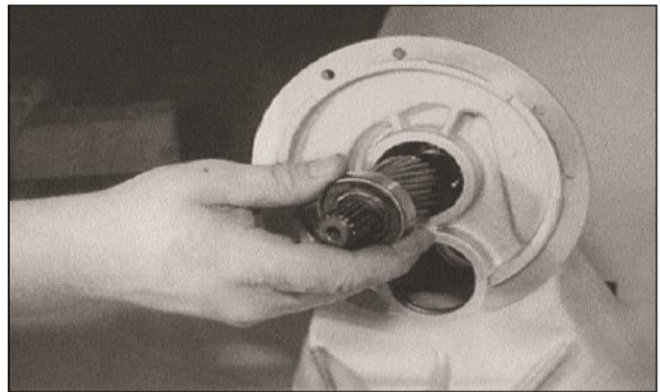


Figure 7-18

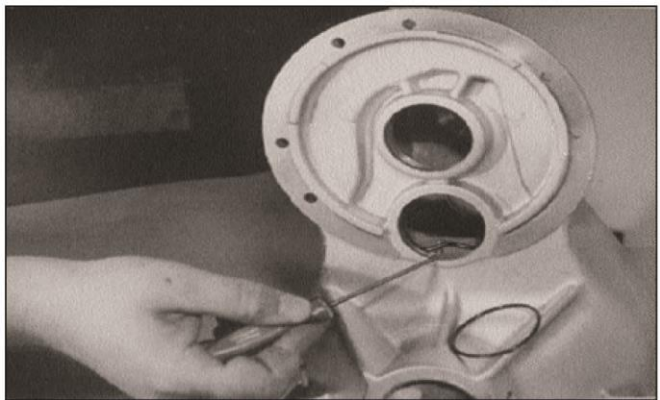


Figure 7-19

15. Using an I.D. bearing puller attached to a slide hammer,
14. Using a brass drift pin, drive the intermediate shaft (9) from the flange side of housing. Shaft should travel far enough to allow engagement of I.D. bearing puller.

remove

intermediate bearing (11) from flange side of housing. See Figure 7-16. 18 Pull input shaft assembly (12) from housing. The input shaft assembly should slide out easily. If resistance is

16. Repeat steps 1-15 for intermediate bearing on opposite side. If resistance is encountered, a slide hammer may be required. See Figure 7-18.
17. Remove oil seal (30 not shown) and snap ring (16) from

input shaft bore (12). See Figure 7-17.

- 19 Remove O-rings from outer input bearing bore and both intermediate bores. See Figure 7-19.

20. Remove O-rings (10) at each end of intermediate shaft on bearing shoulders. See Figure 7-2.

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

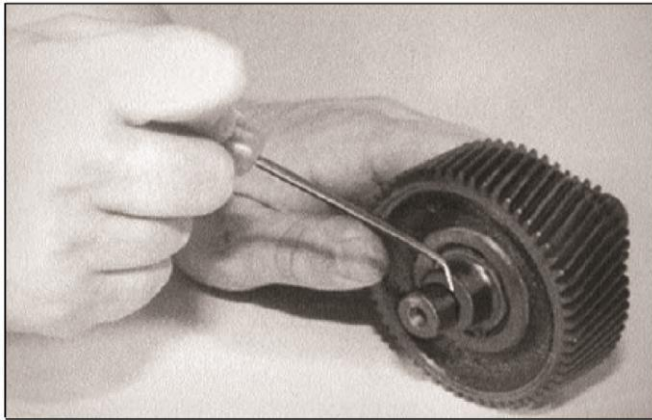


Figure 7-20

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

21. Clean the axle housing and carrier cover (18) with lintfree 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 7-4.

- 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. See Figure 7-21.
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.

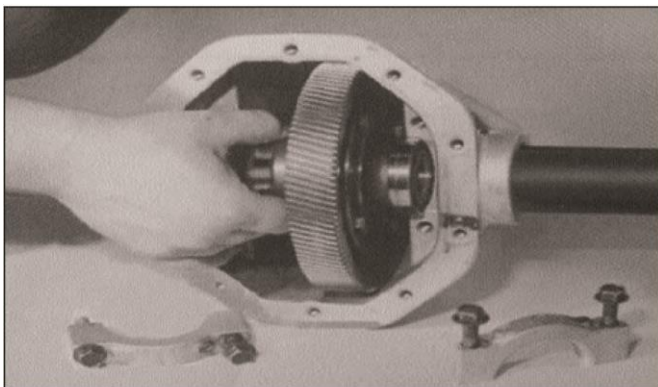
4. Install input shaft (12). Bearings (13, 15) and shaft should slide easily into housing. If resistance is encountered, use a plastic or leather mallet to tap shaft into position. See Figure 7-18.
5. Install outer snap ring (16) at input shaft bore. See Figure 7-19.

**Figure 7-21**

To seat the bearing past the O-ring, a leather or plastic mallet may be required.

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

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

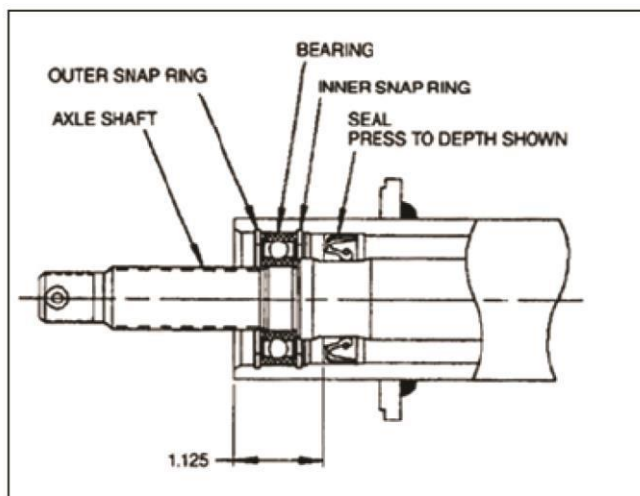
**Figure 7-22****Figure 7-23**

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. (4761 Nm). See Figure 7-24.
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- 25.

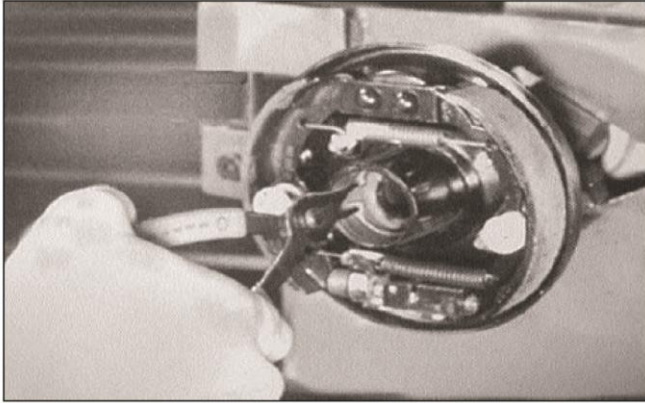
NOTICE: Bearing caps are marked for identification. Letters or numbers are stamped in horizontal and vertical position. When reassembling, install caps back in their original positions, using these stamps as a guide.

12. Install differential bearing caps (2) with bolts (3). Torque bolts to 35-45 ft. lbs. (47-61 Nm).
13. Place a small bead of RTV (non-acidic) silicone sealant to flange of cover plate (18). Sealant should be applied to inside of cover plate mounting holes (Figure 7-26).
14. Install cover plate (18) with ten bolts (20). Torque bolts to 16-24 ft. lbs. (21.5-32.5 Nm).
15. Install new intermediate cup plug (17) to both sides of housing (1). Use Loctite Safety Solvent #75559 to clean bores, then apply Loctite RC 609 to housing bores. Cup plugs can be installed by using a properly sized driver and hammer. Cup plugs should be firmly seated against snap rings (16). See Figure 7-27.
16. With properly sized seal driver, install shaft oil seals (24) Press seals to depth of 1.125" (28.5 m). See Figure 728.
17. Install inner snap ring (25) to both right and left tubes. See Figure 7-29).
18. Press bearings (26) onto axle shafts (22). Bearing should seat on shoulder. Use appropriate driver to install bearings. See Figure 7-30.
19. Coat lip of seal (24) with SAE 30 oil before inserting axle shaft (22). Insert axle shaft assemblies into tubes. Using a properly sized bearing driver, tap axle shaft assembly until it is seated firmly against inner snap ring (25). Shaft may have to be rotated to engage differential splines during installation.
20. Install outer snap ring (25) in each tube (Figure 7-31).


Figure 7-26

Figure 7-27

Figure 7-28

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 a threaded plug, torque to 25-40 ft. lbs. (6-14 Nm).


Figure 7-29

22. Apply Anti-Seize compound to the splines before installing the drum/hub.

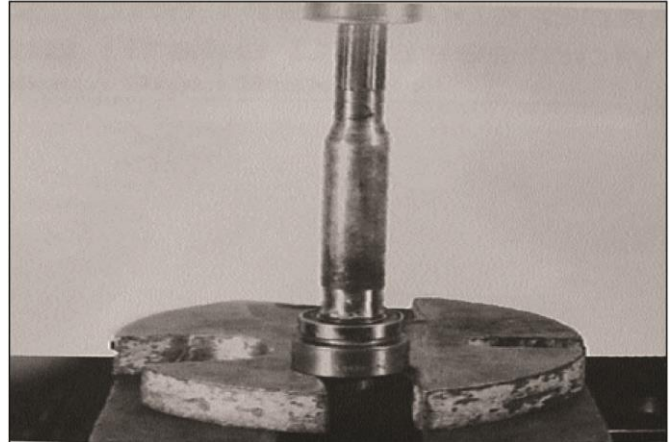
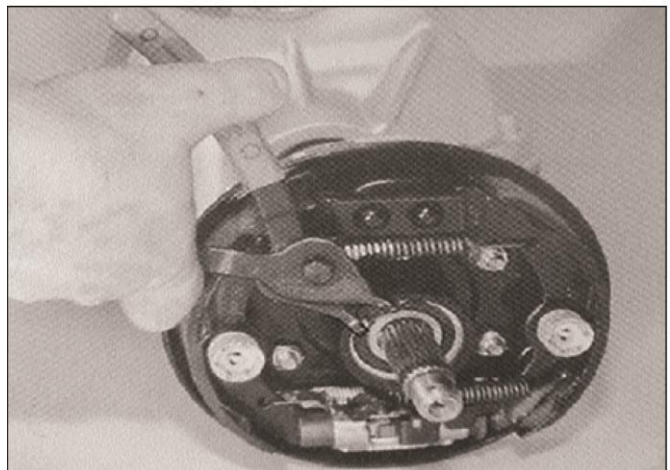
INSTALLING REAR AXLE

CAUTION

Rear axle is heavy and awkward to move. Get help lifting and removing 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.
2. Secure axle to frame with four bolts, washers and nuts. Torque nuts to 45 ft. lbs. (16 Nm).
3. See Figure 7-5. Connect brake strips to brake assemblies using new cotter pins and clevis pins.
4. Install U-bolt securing rear axle to traction drive motor mounting plate.
5. Install the traction motor as described in *Section 10 Traction Drive System*.
6. Install rear shock absorbers and springs as described previously in this section.
7. Install washer and new axle nut. Engage brake and tighten axle nut to a minimum 65 ft. lbs. (62 Nm). Install new cotter pin. Install rear brake drum (Figure 7-5). Repeat for other side.
8. Install spacers and wheel assemblies as described previously in this section.
9. Drive the vehicle and test axle operation.


Figure 7-30

Figure 7-31

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 Maintenance - Lifting Instructions*.

Have an oil drain pan handy.

1. Remove ten cover plate bolts (Figure 7-32). 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 7-26).
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).

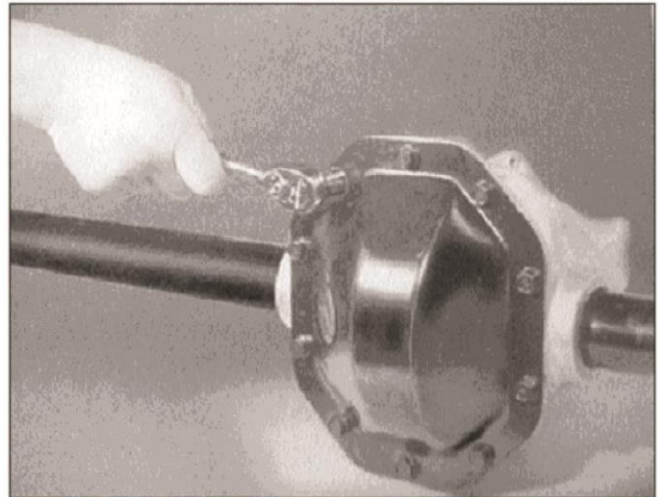


Figure 7-32



Service Manual

Section 8

Body and Chassis

⚠ WARNING

Always turn power key to off, directional keyswitch 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.

COLUMBIA 

Columbia ParCar Corp.

Section 8 – Body and Chassis

FRONT BUMPER

The front bumper attaches to the body with three bolts, washers and nuts (Figure 8-1).

HORN

The horn is mounted under the front of the body. It is secured to a rubber bumper stud with a 1/4-20 nut.

CARGO DECK

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

CONTROLS & CONSOLE

See Figure 8-3. Remove three screws (one on the side, two in back) securing controls console to the body (Figure 8-3) to access controls for replacement.

BATTERY CHARGER INDICATOR (BDI)

1. Remove wires from back and remove the two nuts and washers from the retaining bracket. Remove it from front of console.
2. Position new BDI to face of console and secure with retaining bracket, nuts and washers. Reconnect wires to BDI.

HOOR METER (Not Shown)

1. Remove wires from back and squeeze the tabs on the retaining bracket. Remove it from front of console.
2. Position new meter to face of console and secure with retaining bracket. Reconnect wires to BDI.

OFF/ON KEY SWITCH

1. Remove retainer nut from front of key switch.
2. Disconnect wires from back of switch and install on new switch.
3. Secure new switch to console with retainer nut.

DIRECTIONAL KEY SWITCH

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

1. Remove wires from back of key switch. Remove retainer nut from front of key switch and remove it.
2. Connect wires to new key switch and install it with retainer nut.

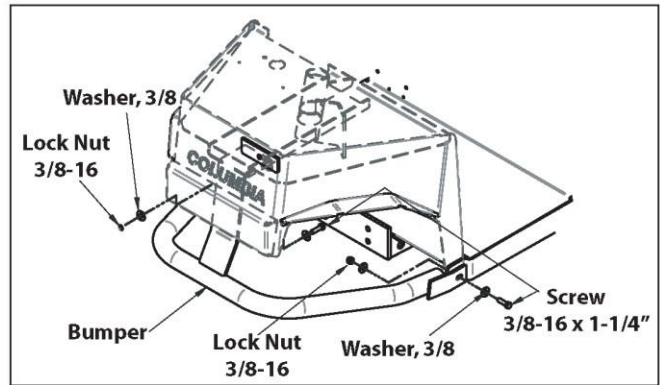


Figure 8-1

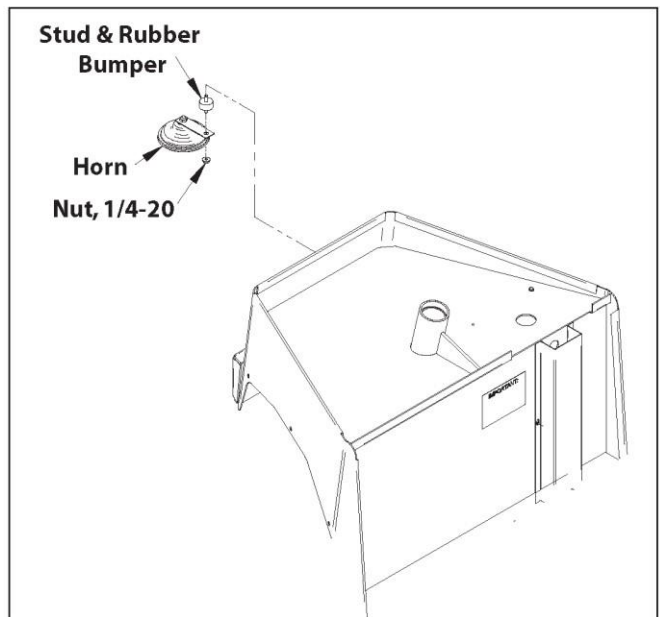


Figure 8-2

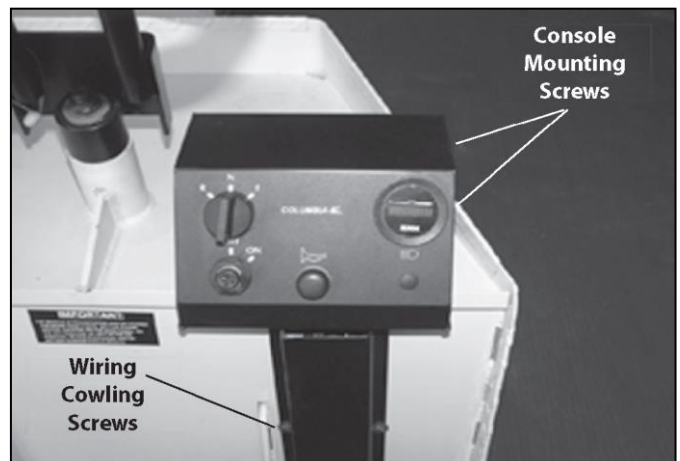


Figure 8-3

HORN BUTTON

1. Remove wires from back of horn button. Remove retainer nut from front of button and remove it.
2. Connect wires to new horn button and install it with retainer nut.

SEAT

Tilt the seat forward to gain access to the battery compartment.

To remove the seat, disconnect the wiring harness connectors. Remove the hinge screws, then remove the seat.

To re-install, attach the seat to the hinges using the hinge screws, then reconnect the wiring harness connectors.

SEAT BACK

The seat back can be reclined to carry a passenger. Lift up on the seat back assembly and lay flat (Figure 8-5). To put the seat back in the upright position, lift seat back up and forward and engage the retaining pins into the mounting plate slots while pushing down on the seat back.

To remove seat back, remove the screws, washers, bushings and lock nuts. Remove the seat back.

To re-install, attach the seat back to the seat back mounting plates using the original hardware. Make sure bushings are positioned between seat back rail and mounting plates.

HANDRAILS

The handrails are attached to the body using 5/16- 18 x 7/8" screws and 5/16-18 lock nuts (Figure 8-5).

BRAKE LIGHT

To replace the brake light, disconnect the brake light wiring harness and pull the light through the rubber grommet. Install new light and plug in the wiring harness (Figure 8-6).

FUSE BLOCK

located in the battery compartment and is attached with 10-24 nylok nut and 10-24 x 5/8 screw.

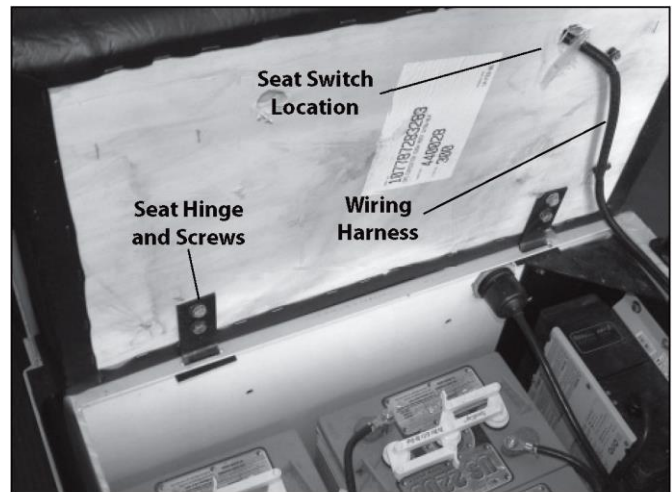
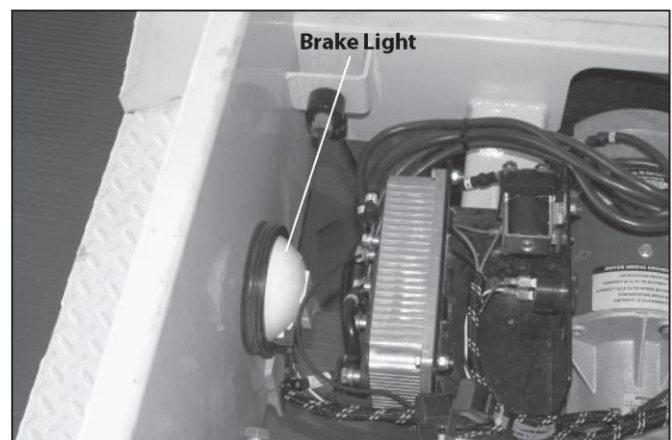
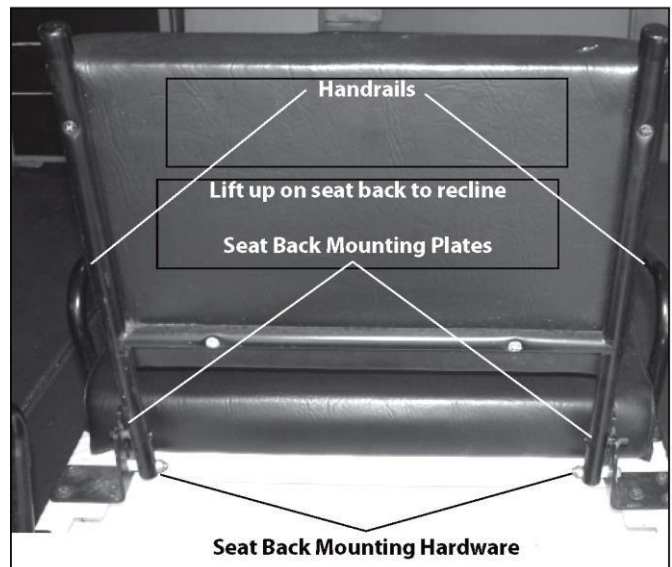
**Figure 8-4****Figure 8-5**

Figure 8-6

8-2



Service Manual

Section 9

Battery and Battery Charger

IMPORTANT INFORMATION

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

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

SAFETY INFORMATION

⚠ DANGER

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. Avoid contact with skin, eyes, or clothing. Wear full face shield and rubber gloves when working on or near batteries.

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.

⚠ WARNING

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

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

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

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

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.

BATTERY INSPECTION & MAINTENANCE

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

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

Weekly inspect battery posts, clamps and cables for breakage, loose connections and corrosion. Replace any that are damaged.

Check to see that battery cap vent holes are clear. Plugged vent holes will not permit gas to escape from the cell and could result in battery damage.

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. 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.
5. Hose wash battery tops periodically with clean, lowpressure 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.
6. 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 dirt. Rinse with clean water. Take care to ensure that the baking soda mixture does not enter the vent opening in the battery caps.
7. Make sure that the battery tops are clean and dry before putting the batteries into storage.

BATTERY SERVICE (WATER)

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

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

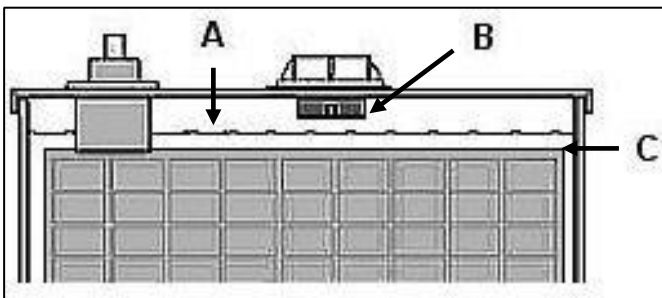
Watering intervals are dependent on the local climate, charging methods, application, and age of batteries. After the initial watering of new batteries, it is recommended that batteries be checked once a month until you get a feel for your water consumption rate.

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

ADDING WATER (See Figure 9-1)

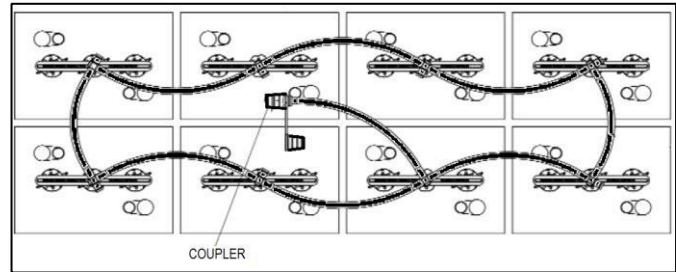
- Check the electrolyte level on brand new batteries before putting them into service, and at least weekly on batteries in service. Water use increases as batteries age.

- Never allow the electrolyte level to fall below the top of the plates (A). If the plates are exposed, add only enough distilled water to cover the plates before charging.
- 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 (B). Water added to replace the spillage dilutes the electrolyte and reduces its specific gravity. Cells with lower specific gravity have lower charging capacity.
- Make sure the electrolyte covers the plates before charging (C). Fill cells to the markers only after batteries are charged.


Figure 9-1
SINGLE POINT WATERING SYSTEM

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

These vehicles may have a Single Point Watering System (Figure 9-2) used for adding water to the battery pack. It consists of a fill tube, one end having a filter screen, the other having a female coupler and a rubber squeeze bulb.


Figure 9-2

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

When using this system, check the battery pack water level weekly by:

- Inserting the fill tube filter end in a distilled water supply.
- Attaching the female coupler to the battery pack male coupler.
- Squeeze the rubber ball until firm which indicates that filling is complete. Immediately disconnect the couplers by depressing the push button on the female coupler. If the water supply is left connected after the filling process is finished it could lead to an overflow.

Some US Batteries features SpeedCap™ battery cell caps. To open SpeedCap™ locate the two tabs on either side of the center cell of the battery. Move these tabs in the directions shown in Figure 9-3.


Figure 9-3

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

BATTERY CHARGING**⚠ DANGER**

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

Columbia electric vehicles are equipped with a solid state, onboard, fully automatic, Delta-Q Battery Charger as standard equipment. See Figure 9-3.

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 their 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 Table 1.

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

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

CHARGER SAFETY INFORMATION**⚠ WARNING**

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

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

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

BATTERY BRAND ALGORITHMS
Table 1

ALGORITHM ID	ALGORITHM DESCRIPTION	AMP HOUR	TYPE	DESIGNED FOR	COMPATIBLE WITH
1	Trojan Flooded	225	Flooded	Trojan T105	150 - 260Ah 6V, 8V, 12V flooded golf
3	Trojan Constant Power dv/dt	225	Flooded	Trojan T105	150 - 260Ah 6V, 8V, 12V flooded golf
5	Trojan Group 31 Flooded	130	Flooded	Trojan 30XHS, 31XHS	85 - 150Ah 12V flooded "marine" Exide Orbital AGMs, Optima AGMs
6	Deka 8G31 Gel	100	Gel	Deka 8G31	Deka 98 - 120Ah gel
7	Trojan 305 Constant Power dv/dt	305	Flooded	Trojan L16	Trojan J305
8	Concorde 100Ah AGM	100	AGM	Concorde 104Ah AGM	Concorde 80-150Ah AGM
11	200 - 255Ah Flooded Constant Power dv/dt	230	Flooded	US Battery US125 & 225	200 - 255Ah flooded golf
12	Exide Gel	240	Gel	Exide DF06240	200 - 300Ah gel
21	Exide Flooded	210	Flooded	Exide 3ET200, FF06255, 185PZB210	Exide200 Ah – 300 Ah Flooded
26	Deka 8GGC2 Gel	180	Gel	Deka 8GGC2	Deka 150 - 230Ah gel
35	Concorde 200Ah AGM	200	AGM	Concorde 233Ah AGM	Concorde 200 - 255Ah AGM
38	Trojan 12V Golf 113%	150	Flooded	Trojan T1275	120 - 170Ah 8V, 12V flooded golf
42	Discover 80 - 150Ah AGM	100	AGM	Discover EV31A	other 80 - 150Ah AGM
43	Discover 200 - 400Ah AGM	300	AGM	Discover EVL16A, EVGC6A, EV185A	Discovery 200 Ah – 400 Ah AGM
51	Exide 180Ah Gel	180	Gel	Sonnenschein 180Ah Gel	150 - 200Ah gel
52	Exide 105Ah Gel	105	Gel	Sonnenschein 105Ah Gel	80 - 130Ah gel
62	Trojan Group 31 Flooded dv/dt	130	Flooded	Trojan 30XHS, 31XHS	85 - 150Ah 12V flooded "marine"
71	140 - 200Ah Flooded Constant Power dv/dt	170	Flooded	US Battery 8V-GC	140 - 200Ah Flooded
72	250 - 335Ah Flooded Constant Power dv/dt	305	Flooded	US Battery US305HC	250 - 320Ah Flooded
73	400Ah Flooded Constant Power dv/dt	415	Flooded	US Battery L16HC	330 - 425Ah Flooded
93	Trojan 12V Golf	150	Flooded	Trojan T1275	120 - 170Ah 8V, 12V flooded golf
125	Fullriver 160-220Ah AGM	180	AGM	Fullriver DC180-6, DC224-6	Fullriver 160 - 220Ah AGM
126	Fullriver 85-145Ah AGM	110	AGM	Fullriver DC11512	Fullriver 85 - 145Ah AGM
141	Fullriver 300-370Ah AGM	335	AGM	Fullriver DC335-6	Fullriver 300 - 370Ah AGM
151	Fullriver 220-290Ah AGM	250	AGM	Fullriver DC250-6	Fullriver 220 - 290Ah AGM

DELTA-Q CHARGER OPERATION

These vehicles are equipped with a remote panel (Fig. 9-4 A) with a single LED which indicates the Delta Q status. The remote panel will be located near the drivers position.

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.

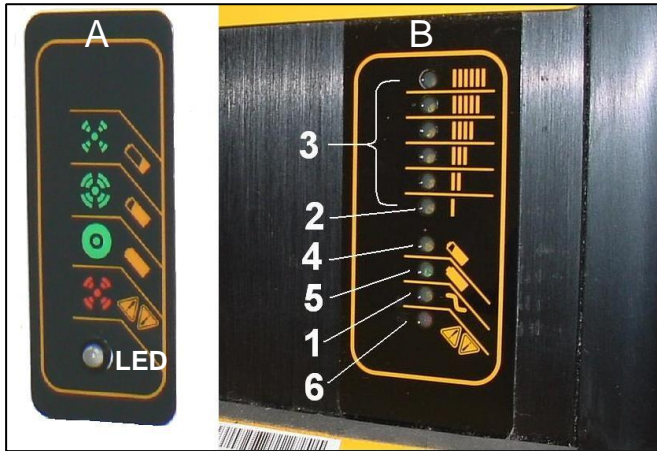


Figure 9-4

3. The Yellow AC power LED (No. 1, Fig. 9-4B) should remain illuminated while the Charger is plugged into an AC source. If Yellow LED is not lit, before replacing Charger, recheck the AC connection and the AC source fuse or breaker. If this fails to correct the problem, contact your Columbia Dealer for assistance.
4. Charger will automatically turn on and conduct a short self-test and battery pack test. All LED's will flash in sequence and then a trickle current will be applied to batteries until a minimum voltage is reached. In Figure 9-4B No. 3 indicates the Bar Graph and No. 2 indicates the lowest LED. Three (3) amperes is displayed as the lowest LED on the Bar Graph
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 Bar Graph LED's indicate the electrical current being 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.

NOTICE: If the batteries are excessively discharged, the Delta-Q will not be able to charge the complete set of batteries. The Delta-Q will have the RED FAULT LED (No. 6, Fig. 9-4B) flashing red (see RED LIGHT CHARGER ERROR CODES). It will then be necessary to follow the instructions in EXCESSIVELY DISCHARGED BATTERIES.

6. When the Yellow LED (No. 4, Fig 9-4B) 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).

NOTICE: You can terminate charging at this point if necessary. The vehicle can be used, but completing the charge cycle is highly recommended.

7. Charge completion is when the 100% Green LED is lit, (No. 5, Fig. 9-4B). Repeated "Short Charging" leaving the charge short of 100% will shorten operating cycle distance and reduced battery life.
8. A low current "finish-charge" phase returns and maintains batteries to maximum capacity. The 100% Green LED will blink until "finish charge" phase is complete.
9. A 100% Green LED continuously lit indicates the batteries are completely charged. The Charger may now be unplugged from the AC source. If the batteries will not be used for a length of time, check monthly for the charge level. It is also acceptable to leave the Charger plugged in. The Delta-Q has the capability to test and recharge if necessary.
10. A fault occurring while charging causes the RED FAULT LED 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 for a minimum of 11 seconds.

NOTICE: A Yellow (Amber) blinking LED in the upper Bar Graph (No. 3, Fig. 9-4B) usually indicates the thermostatic control has limited the Charger output due to ambient temperature conditions. It is still charging, but at a reduced rate.

SINGLE LED DISPLAY (Figure 9-4A)

SOLID GREEN – Charging complete, in maintenance mode

FLASHING GREEN – Short < 80% charge
Long > 80% charge

GREEN when battery not connected – Algorithm number

FLASHING YELLOW – Reduced power mode: low AC voltage or high internal charger temperature.

FLASHING RED – Charger error. Reset charger power and see RED LIGHT CHARGER ERROR CODES.

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.

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.

TESTING BATTERIES**SPECIFIC GRAVITY TEST**

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

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

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

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

HYDROMETER TEST

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

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

Above 80°F: Add .004 to the specific gravity readings for each 10° above 80°F (26°C).

Below 80°F: Subtract .004 from the specific gravity readings for each 10° below 80°F (26°C).

Results Interpretation

State of charge. Check specific gravity of each cell. See Table 2 & 3.

Specific Gravity vs, State of Charge	
SG Reading at 80° F.	State of Charge

1.250 – 1.270	100%
1.220 – 1.240	75%
1.190 – 1.210	50%
1.160 – 1.180	25%

Table 2

Specific Gravity vs. Action Required				
	SG Reading			Action
Battery	Cell 1	Cell 2	Cell 3	
1	1.100	1.100	1.100	Charge & recheck
2	1.260	1.180	1.250	Cell 2 bad – replace battery
3	1.250	1.260	1.250	Good
4	1.190	1.170	1.120	Charge & recheck Suspect cell 3

Table 3

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.

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.

Use an appropriate volt tester that gives voltage and minutes of discharge.

TEST PREPARATION

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.

TEST PROCEDURE

⚠ WARNING

Discharge Load Test must be performed in well ventilated area.

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

All individual battery voltage readings must be made as rapidly as possible to be accurate.

- 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.

RESULTS INTERPRETATION

- 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.
- 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. 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 & Time

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

Table 4

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 80°F (26°C), will discharge faster and require recharge every few weeks. Batteries stored at or below 0°F (-12°C) 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 5.

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

Table 5

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.

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 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 Delta-Q Charger again to verify operation. Allow the 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.

REPLACING BATTERIES

The batteries are located under the seat.

REMOVING BATTERIES

1. Remove nuts, washers and cables, positive lead and negative lead interconnecting batteries.
2. Remove nut, flat washer, hold down plate and rod.
3. Remove batteries.

INSTALLING BATTERIES

1. Install batteries.
2. Install rod and hold down plate.
3. Install flat washer, nylock nut.
4. Install nuts, washers and cables, positive lead and negative lead interconnecting batteries.

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 at battery B- 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.
2. Remove four nuts, four washers, four bolts and charger. See Figure 9-5.

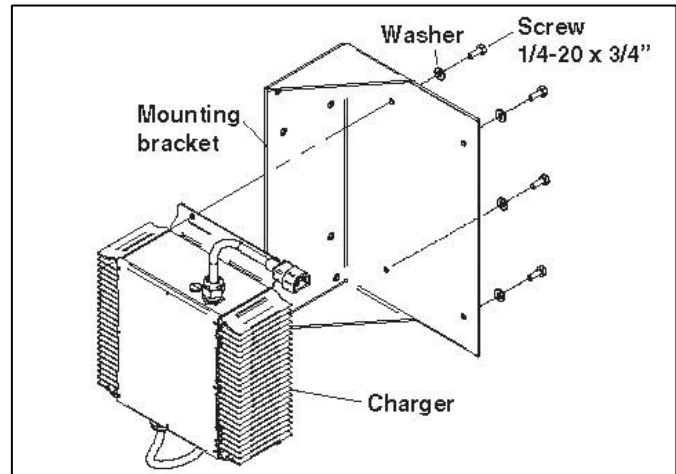


Figure 9-5

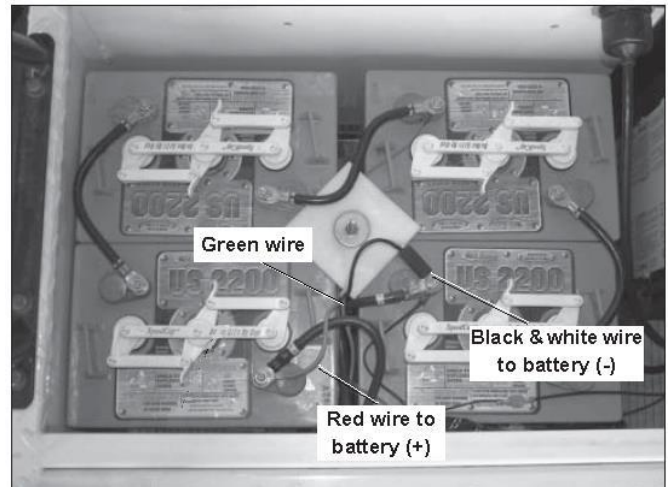


Figure 9-6

INSTALLATION

1. Position new charger to mounting bracket.
2. Secure new charger with four nuts, washers and bolts. Tighten charger attaching hardware.
3. See Figure 9-6. Install charger output electrical leads as follows; black and white to battery B-, red wire to battery B+, green wire to red wire #14 from interlock harness. 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.



Columbia ParCar Corp.

Service Manual

Section 10

Traction Drive System

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

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

Normal service – 8 hours per day operation

- Routine inspection every 1,000 hours

Severe service – 24 hours of daily operation

- Routine inspection every 500 hours

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

EXTERNAL 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 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.

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, A1 and A2 terminals are 5/16-18. Hold terminal jam nut with a thin open end wrench when loosening and removing hex nuts, lock washers and flat washers securing electrical cables to traction motor.

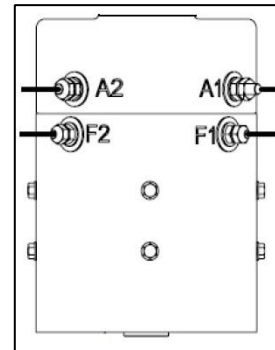


Figure 10-1

3. Carefully support motor to prevent it from falling.
4. See Figure 10-2. Loosen and remove the three 1/4" bolts, lock washers and flat washers securing motor to rear axle/differential housing.
5. Pull motor away from rear axle housing and clear of the vehicle.

CAUTION

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

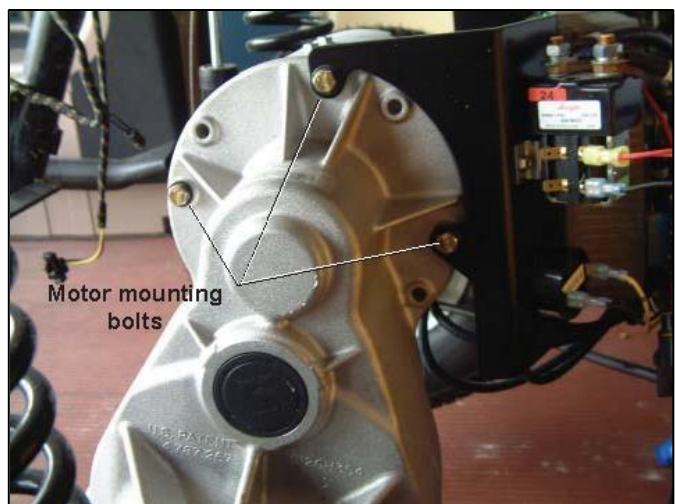


Figure 10-2

DISASSEMBLY

1. Remove long bolts. Remove motor head hole plug. See

Figure 10-3.

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 10-4.
4. Pull motor head assembly off of armature assembly maintaining equal pressure on all sides of head.
5. Move brush springs behind spring hooks shown in Figure 10-5.
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 10-6.
7. Remove 4 brush plate screws (Figure 10-7). Push brush terminal studs through, into the center of the head as the brush box, brushes and terminal assemblies are removed. (See exploded view Figure 10-9).
8. Remove bearing retainer (snap ring) shown in Figure 105. 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 (Figure 10-8).

Max dia. when new 2.92-2.93" (74 mm)

Min dia. for re-slotting 2.81" (71 mm)

Replacement dia. 2.76" (70 mm)

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

4. Clean commutator with dry, compressed air.

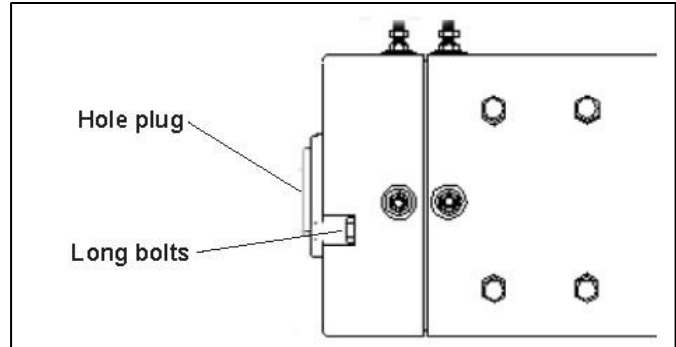


Figure 10-3

Recheck commutator runout.

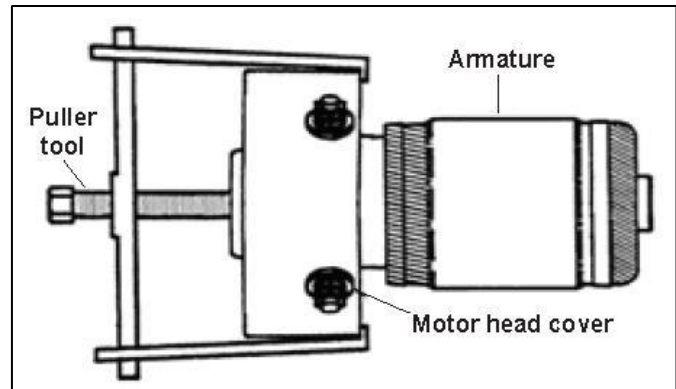


Figure 10-4

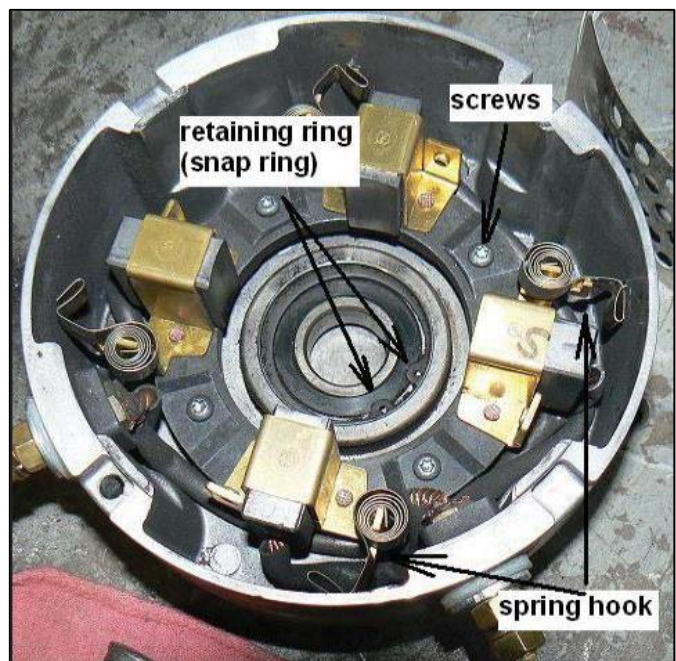


Figure 10-5

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 10-11.
2. For short circuit connection, use a hacksaw blade to locate any shorted windings. Rotate armature slowly in growler jaws and hold a hacksaw blade in parallel against top of armature. The steel blade will be attracted to the core and will vibrate when two shorted armature coils are located. See Figure 10-12.

BRUSHES

Brushes should be inspected for uneven wear and signs of overheating, such as discolored brush leads and brush springs. Check brush box for physical damage. Make sure brush holders are not loose on the brush box assembly. See Figure 10-9.

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

New brush length: 1.20" (30.5 mm)

Minimum brush length: 0.60" (15.2 mm)

Replacement brush length: less than 0.60" (15.2 mm) If any brushes are worn to the point that replacement is necessary, the complete brush set should be replaced. Never replace just one pair of brushes. Do not substitute brushes. The brushes are matched to the motor type and application to provide the best service. Substituting brushes of the wrong grade can cause commutator damage or excessive brush wear.

BRUSH SPRINGS

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

Use the following procedure for checking brushes for proper tension. See Figure 10-13.

1. Place paper strip between brush face and commutator.

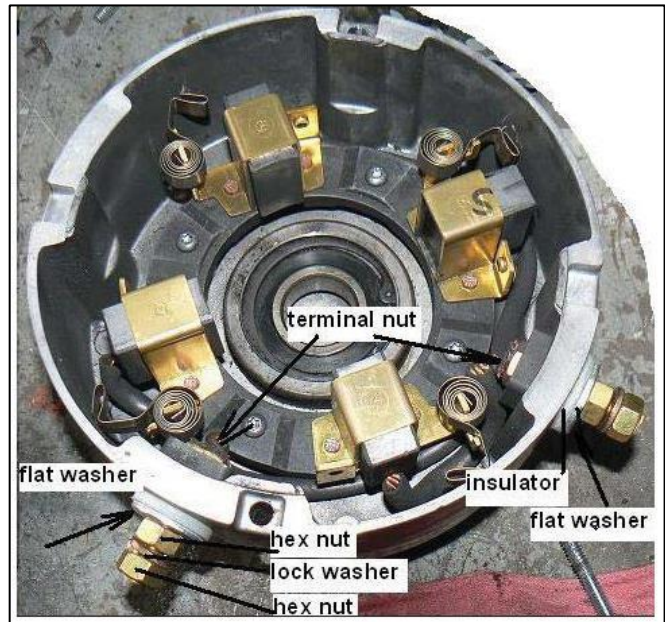


Figure 10-6

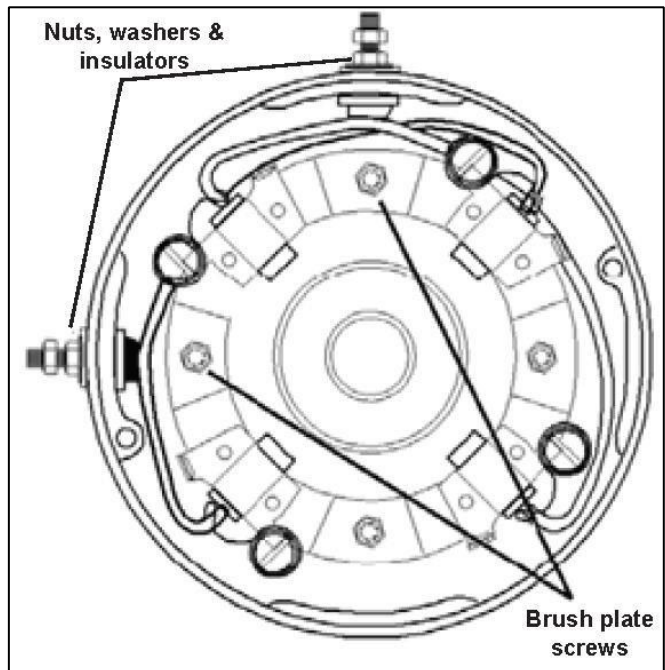
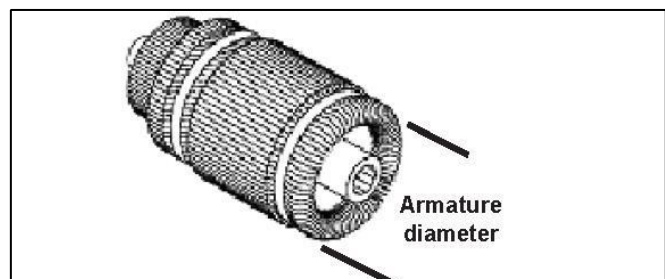
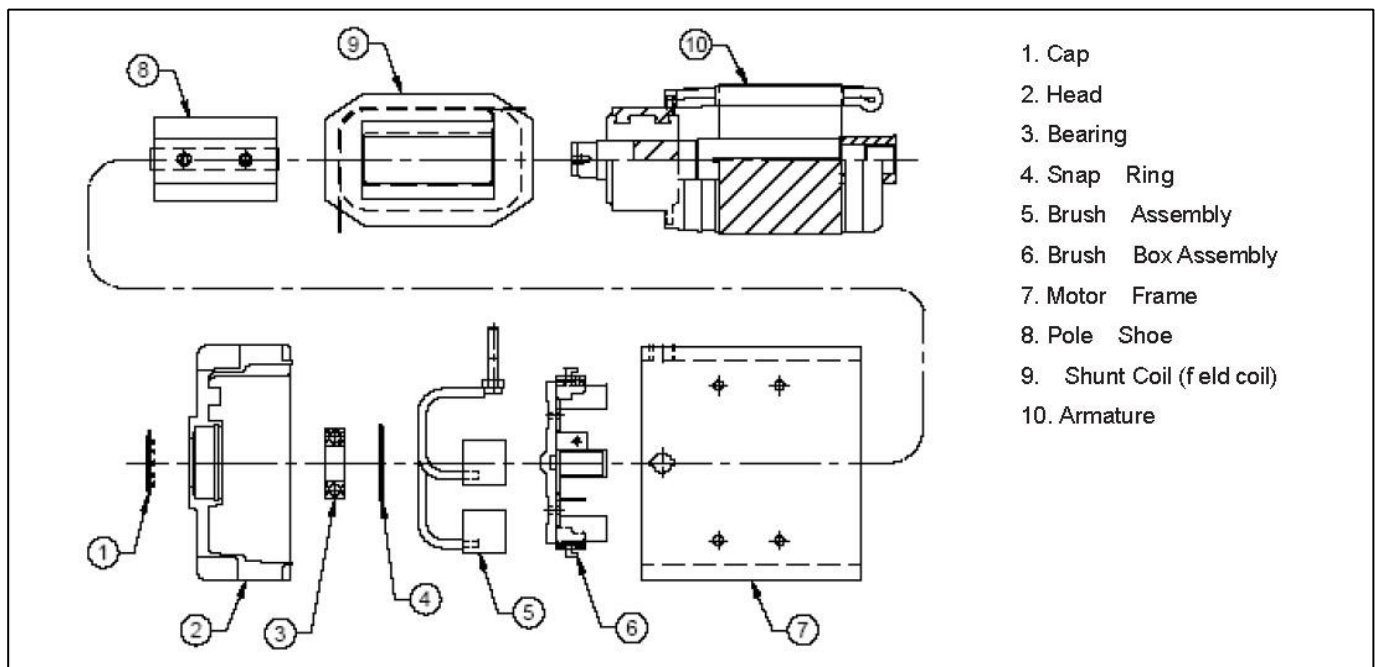


Figure 10-7



2. Hook a commercial spring scale as shown.
3. Pull spring scale on a line directly opposite the spring force.
When paper strip can be moved freely, read spring tension on scale.

Brush spring tension New 64 ounces (1792 grams)
 Worn 40 ounces (1120 grams)

Figure 10-8**Figure 10-9**

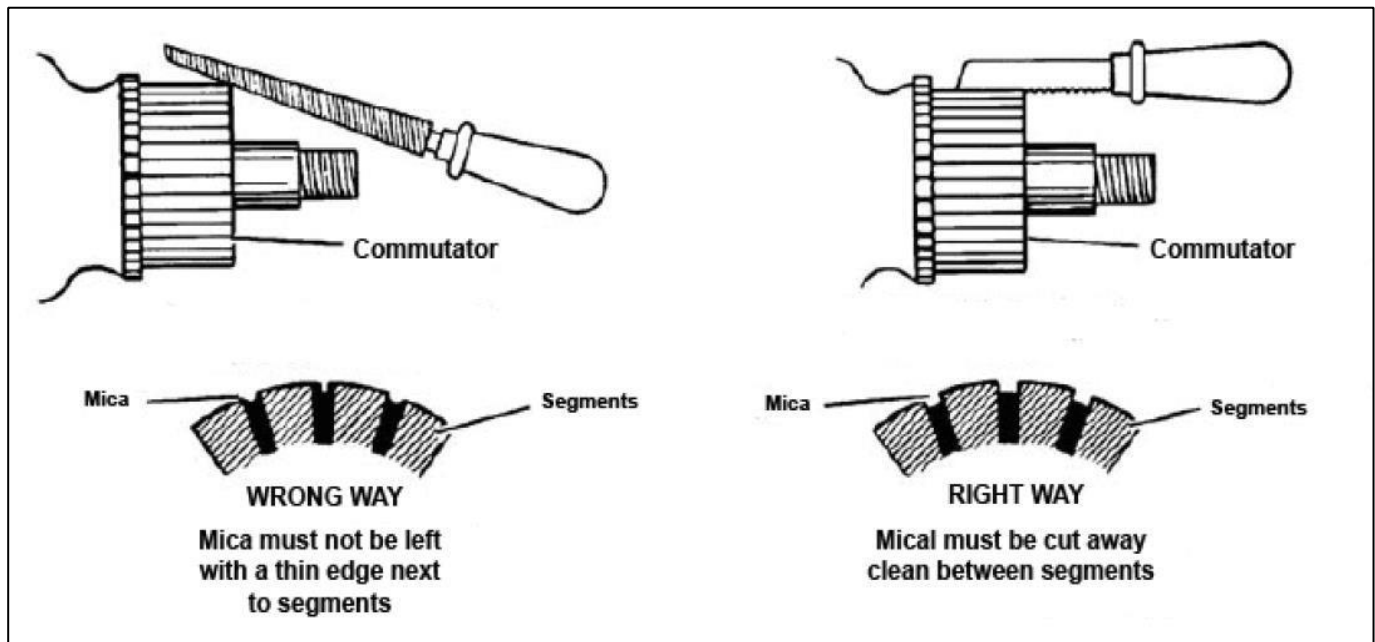
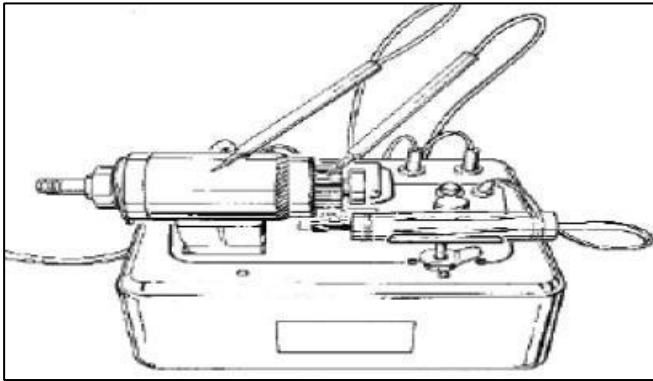


Figure 10-10


Figure 10-11

BEARING

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

FRAME AND FIELD COILS

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

There should be no continuity between the frame of the motor and field coil (Figure 10-9). Set the volt ohm meter (VOM) to measure Ohms. See Figure 10-14.

FIELD COIL MAINTENANCE

NOT recommended by

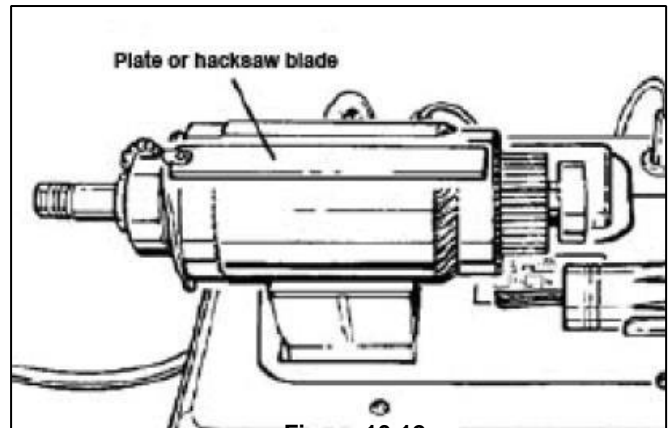
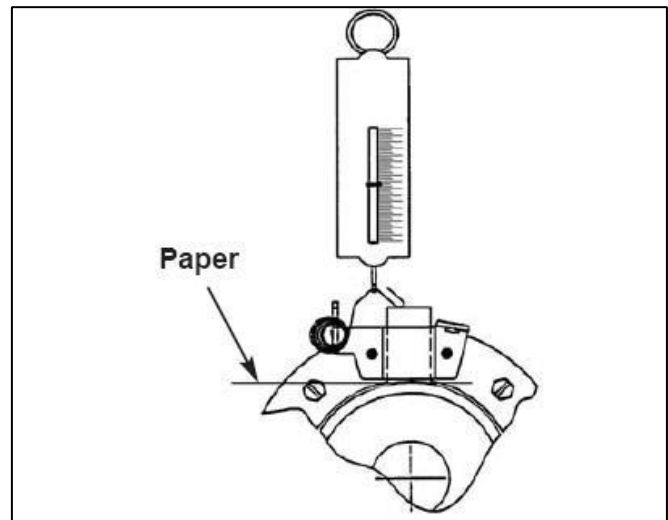
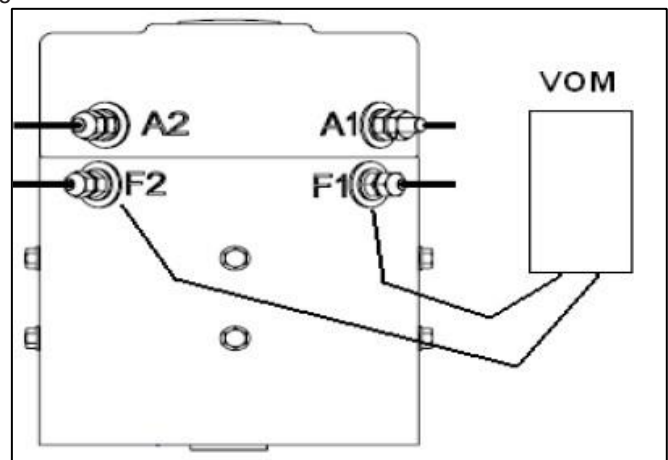
Columbia.

INSPECTION

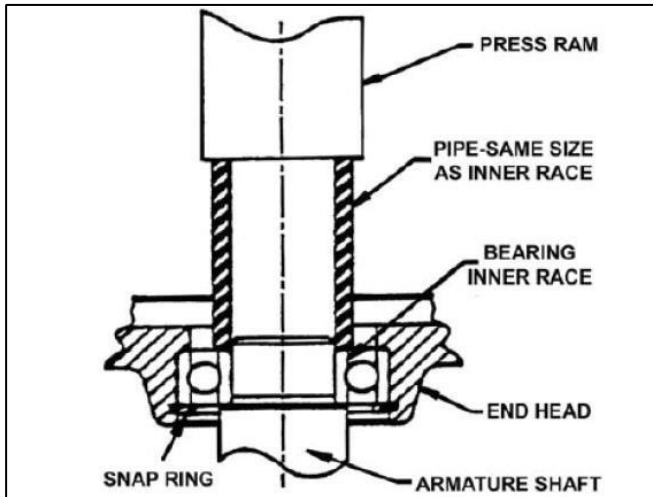
Motors that have been disassembled for servicing should also include a complete inspection of the frame and field assembly. It is not uncommon for the frame and field assembly of a motor to become exceptionally dirty after many hours of operation. This may result in a grounding condition due to dirt,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

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


Figure 10-12

Figure 10-13

Figure 10-14

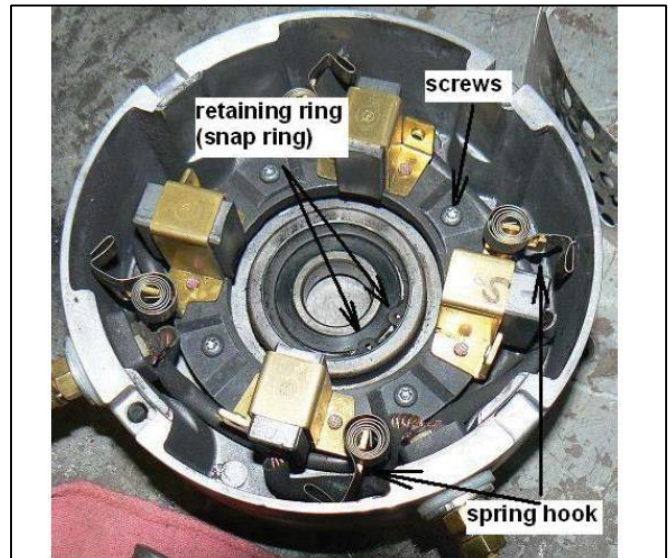
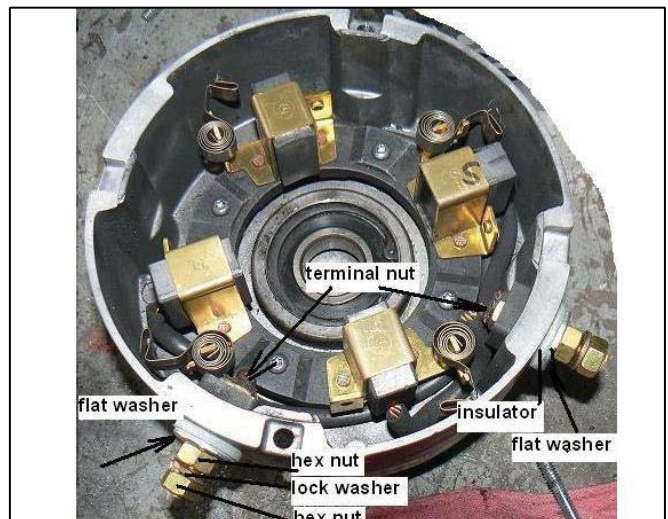
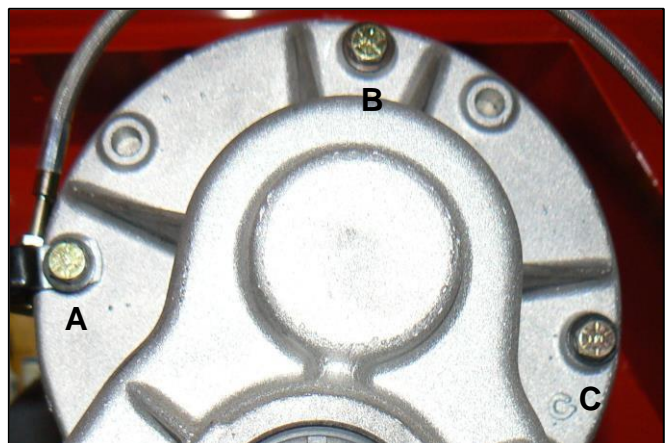
10-5


Figure 10-15

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 10-15.
7. Check that head and bearing rotates freely, without noise or irregular interference. Press brushes inward against armature commutator. Relocate the springs to push on the brushes. Check that brushes ride smoothly on the commutator.
8. Install motor head and armature assembly into 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).

MOTOR INSTALLATION

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


Figure10-16

Figure 10-17


ensure connections are correct.

4. F1 and F2 terminals are 1/4-20 while A1 and A2 terminals are 5/16-18. Attach cables with flat washers, lock washers and hex nuts. Torque A1 & A2 cable attaching nuts to 110 in. lbs. (12.4 N m), while holding the bottom nut, with a thin open-end wrench. Torque F1 & F2 cable attaching nuts to 50 in. lbs. (5.7 Nm), while holding the bottom nut, with a thin open end wrench.
5. Place vehicle on the ground or onto dynamometer to test motor operation.

CAUTION

Do not run motor at full voltage without a load.

CONTROLLER

ACE^{plus} SYSTEM

The ACE^{plus} System is an advanced traction drive system that uses a fully integrated, solid state Sevcon Controller for speed regulation and forward/reverse control. Combined with a separately excited DC motor, the system provides optimized power efficiency through pedal proportional speed control and regenerative braking. This control system is ideal for hilly terrain or areas with multiple ramps. It is also used for towed loads and high braking demands. The ACE^{plus} system is distinguished by a 6 post controller. See Figure 10-19.

TESTING

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

1. Look for the steady green light on the side of the controller. If it is on, the system is OK and ready (Figure 10-20).
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.

REMOVING

- 1 Disconnect battery negative cable and remove Power key.
2. Label/mark controller cables with controller terminal identification, if not already labeled.

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

3. Remove six metric bolts, lock washers, flat washers and all the cables and wires connected to the controller.

Figure 10-18

4. Remove 16 pin controller connector (Figure 10-20).

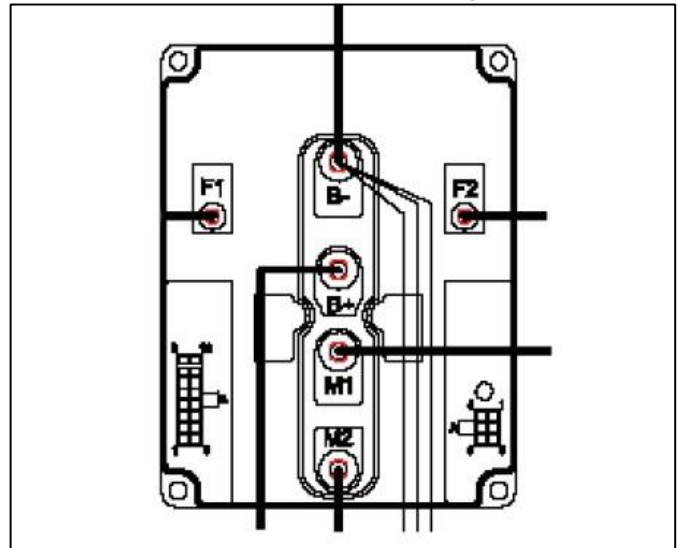


Figure 10-19

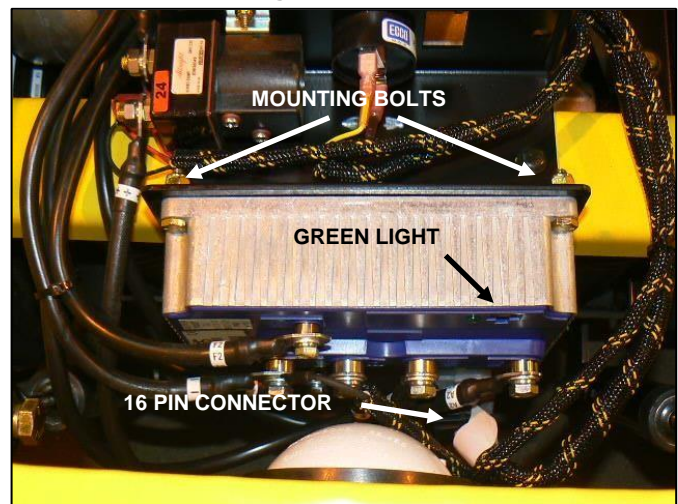


Figure 10-20

5. Remove four nuts, washers and bolts securing controller to the mounting panel.

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

See *Columbia Service Bulletin 06-010* if the wiring harness or connector s are damaged.

INSTALLING

1. Position controller mounting panel and secure with four bolts, washers and nuts.
2. Install cables to controller terminals according 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. 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 and check for steady green light on controller.
5. Perform an operational check of the vehicle's driving abilities

CONTACTOR/SOLENOID

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

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 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

1. Label contactor cables with terminal identification. Refer to schematic for correct wire numbers.
2. Remove two nuts, washers and cables from stud terminals (Figure 10-21 circle).
3. Remove control circuit wires from spade terminals which are located below the stud terminals.
4. Remove two nuts, washers, bolts and contactor (Figure 10-21 arrow).

INSTALLING

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

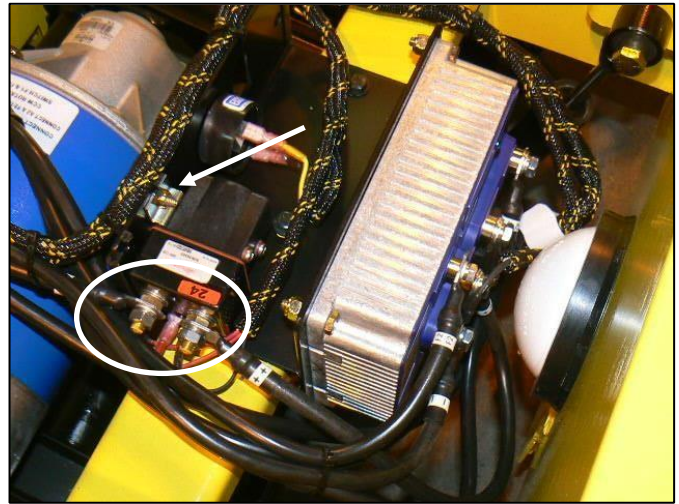


Figure 10-21