COLUMBIA ParCar

Service Manual

Gasoline and Electric
Golf and Industrial
Four Wheel Vehicles

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3-00

COLUMBIA ParCar

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FOREWORD

This service manual has been prepared with two purposes in mind. 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 Columbia ParCar vehicles and assist him/her in performing basic maintenance and repair. We sincerely believe that this manual will make your association with Columbia ParCar vehicles more pleasant and profitable.

In addition to the information given in this Service Manual, Service Bulletins are issued to Columbia ParCar Dealers, from time to time, 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 Columbia ParCar vehicles and to protect the vehicles from possible damage resulting from improper service or maintenance, the procedures followed in this manual should always be followed exactly as outlined. Execution of the procedures and trouble-shooting 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 NOTES, CAUTIONS, WARNINGS and DANGER recommendations throughout this manual. See Chapter 1 for additional details.

Preparation For Service

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

Model Identification

Always, give the full vehicle identification number when ordering parts or making inquiries about your Columbia ParCar vehicle.

Use of the full and complete vehicle identification number (VIN) information will assure your dealer or service provider is supplying you with the correct parts for your vehicle. See Chapter 2 for vehicle identification information.

Use Genuine Replacement Parts

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

To ensure a satisfactory and lasting repair job, follow the service manual instructions carefully and use only genuine Columbia ParCar replacement parts. This is your insurance that the parts you are using will fit right, operate properly and last longer. When you use genuine Columbia ParCar 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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CHAPTER 1

OVERVIEW

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

It is important to note that some warnings against the use of specific service methods, which could damage the vehicle or render it unsafe, are stated in this service manual. However, please remember that these warnings are not all inclusive. Since Columbia ParCar could not possibly know, evaluate and advise servicing personnel of all possible ways in which service might be done or of the possible hazardous consequences of each way, we have not undertaken any such broad evaluation. Accordingly, anyone who uses a service procedure or tool which is not recommended by Columbia ParCar must first thoroughly satisfy himself that neither his nor the operator's safety will be jeopardized by the service methods selected.

Danger: Danger indicates an immediate hazard that will result in severe personal injury or death.

Warning: Warnings will indicate an immediate hazard, which could result in severe personal injury.

Caution: Cautions indicate hazards or unsafe practices, which could result in minor personal injury, damage to the vehicle or to other property.

Note: Notes will provides key information to assure procedures are more easily understood or implemented.

It is Columbia ParCar's specific recommendation that the following warnings 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, gasoline and fuel system hazards, battery hazards, etc.) are encountered.

Notes, Cautions, Warnings And Dangers

ALL VEHICLES	
 **Danger**	Any modifications or changes to the vehicle that affect the stability or increases vehicle speed beyond factory specifications could result in severe personal injury or death. Always, remove key and disconnect the battery(s) before servicing or repairing your vehicle. See Battery, Chapter 8, for details. All batteries used in gas or 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. Keep sparks and flames away from batteries. Battery charging should only be done in a well-ventilated area. See Batteries, Chapter 8, for details. If any problems are found during scheduled maintenance or inspections, DO NOT operate vehicle until repairs are made. Failure to make necessary repairs could result in fire, property damage, severe personal injury, or death.

Notes, Cautions, Warnings And Dangers

ALL VEHICLES

Warning

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

Proper service and repair is important for safe, reliable operation of all Columbia ParCar 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.

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

Working on Columbia ParCar vehicles without following proper procedures and using proper lifting equipment may result in vehicle damage or personal injury. See Lifting Instructions in Chapter 2 for detailed instructions.

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

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

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

The modification of golf cars for use in other than golf play is not recommended.

Caution

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

Note

Notes appear throughout this manual to provide key information to assure procedures are more easily understood or implemented.

GASOLINE-POWERED VEHICLES

Danger

Gasoline is extremely flammable and highly explosive under certain conditions. When refueling or servicing gasoline-powered vehicles, always, stop engine. Do not smoke, and keep away from open flame or sparks.

DO NOT operate when the smell of gasoline is present or other explosive conditions exist which could result in severe personal injury or death.

DO NOT operate vehicle in an enclosed area without proper ventilation. Engines produce carbon monoxide, which is a colorless, odorless and deadly gas.

BATTERY - Is poisonous! Contains acid which causes severe burns! Avoid contact with skin, eyes or clothing.

GASOLINE-POWERED VEHICLES (CONTINUED)

Danger:	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. Call a physician immediately. - EYES: Flush with water for fifteen minutes. Call a physician immediately. Any modifications or changes to the vehicle that affect the stability, or increases the speed beyond factory specifications, could result in severe personal injury or death.
Warning:	Only trained maintenance professionals should repair or service this vehicle. Persons doing even simple repairs or service should have working knowledge and experience in general electrical and mechanical repair. Follow all procedures exactly and observe all warnings stated in this manual. Use caution and common sense. To avoid accidental starting of the vehicle, always, turn key switch OFF, remove key, disconnect battery negative (-) cable and remove spark plug wire from spark plug prior to servicing. Hot engine and exhaust system! DO NOT attempt to service while hot. Failure to observe this warning could result in severe burns. DO NOT refuel indoors where area is not well-ventilated. Outdoor fueling is recommended. DO NOT store, spill or use gasoline near open flame or stoves, furnaces or water heaters that use a pilot light, or device which causes a spark that could ignite a fire. DO NOT fill fuel tank while engine is hot. Allow engine to cool for 2 minutes before refueling. Store all fuels in properly marked containers. DO NOT operate engine if gasoline is spilled. Push vehicle away from the spill and avoid creating any possible ignition until the spill has evaporated or has been properly taken care of.
Caution:	Cautions appear throughout this manual indicating possible hazards or unsafe practices that may result in minor personal injury, damage to vehicles or property.
Notes	Notes appear throughout this manual to provide key information to assure procedures are more easily understood or implemented.

ELECTRIC-POWERED VEHICLES

Danger	When working around batteries, use approved insulated tools, remove jewelry such as rings, watches, chains, etc. and place an insulating material (wood, plastic, rubber, etc.) over batteries covering all connections. BATTERY - Is poisonous! Contains acid! Causes severe burns. Avoid contact with skin, eyes, or clothing. 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. Call a physical immediately. - EYES: Flush with water for fifteen minutes. Call a physician immediately.
Warning	Only trained maintenance professionals should repair or service this vehicle. Persons doing even simple repairs or service should have working knowledge and experience in general electrical and mechanical repair. Follow all procedures exactly and observe all warnings stated in this manual. Use caution and common sense. Always turn key switch to OFF, remove key, block tires and disconnect the battery negative (-) cable on XP and XP Plus models before performing any vehicle service to avoid accidental start-up of vehicle and possible injury. To prevent accidental starting of the Power Master model, turn tow switch to tow position, disconnect the battery positive cable (+), turn key to reverse position until warning buzzer is silent. HOT! - DO NOT attempt to service hot motor or resistors. Failure to observe this warning could result in severe burns.
Caution	Cautions appear throughout this manual indicating possible hazards or unsafe practices that may result in minor personal injury, damage to vehicles or property.
Notes	Notes appear throughout this manual to provide key information to assure procedures are more easily understood or implemented.

CHAPTER 2

GENERAL AND MAINTENANCE INFORMATION — PAGE

CHAPTER 2

GENERAL AND MAINTENANCE INFORMATION — PAGE

VEHICLE AND MODEL INFORMATION

Model	Vin Prefix	Name	Use Type	Power System
P4G	8E	Eagle	Golf	Gas 4 Cycle 9 HP Briggs & Stratton
P4E	3E	Eagle	Golf	Battery 36/48 Volt System
P5E	E	Eagle	Golf	Battery 36/48 Volt System
FG	8F	Foursome	Golf	Gas 4 Cycle 9 HP Briggs & Stratton
FE	4F	Foursome	Golf	Battery 36/48 Volt System
GU4	8U	Utilitruck	Utility	Gas 4 Cycle 9 HP Briggs & Stratton
EU4	4E	Utilitruck	Utility	Battery 36/48 Volt System
GUXB	8X	Utilitruck Extended Bed	Utility	Gas 4 Cycle 9 HP Briggs & Stratton
EUXB	4X	Utilitruck Extended Bed	Utility	Battery 36/48 Volt System
GU2400	9J	Utilitruck	Utility	Gas 4 Cycle 13 HP Briggs & Stratton
EU2400	5J	Utilitruck	Utility	Battery 36/48 Volt System
GU2400XB	9N	Utilitruck Extended Bed	Utility	Gas 4 Cycle 13 HP Briggs & Stratton
EU2400XB	5N	Utilitruck Extended Bed	Utility	Battery 36/48 Volt System
GD4	8D	Utilidump	Utility/Dump	Gas 4 Cycle 9/13 HP Briggs &Stratton
ED4	4D	Utilidump	Utility/Dump	Battery 36/48 Volt System
C6G	8S	Shuttle	People Mover	Gas 4 Cycle 9 HP Briggs & Stratton
C6E	4S	Shuttle	People Mover	Battery 36/48 Volt System
C10G	9H	Tram	People Mover	Gas 4 Cycle 13 HP Briggs & Stratton
C10E	5H	Tram	People Mover	Battery 36/48 Volt System
911G	8Z	Ambulance	Medical Transport	Gas 4 Cycle 9 HP Briggs & Stratton
911E	4Z	Ambulance	Medical Transport	Battery 36/48 Volt System

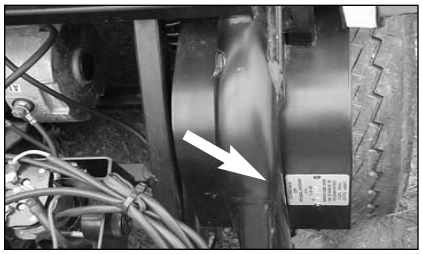
The Vehicle Identification Number (VIN) of each vehicle, describes many different facts or features of the vehicle. Refer to the VIN Chart below to determine unique features of your vehicle.

Vehicle Identification Number (VIN) Matrix				
VIN, Four Character System			Sequential Serial #	Suffix (when used)
1st Character Power System	**2nd Character Model Code Designation**	**3rd & 4th Characters Factory Modifications/Options to Standard Vehicle**	**5 Numeric Characters**	**1 Alpha/1 Numeric**
3=PowerMaster System	C=Classic	A=36 volt high speed motor	Example=12345	Decade D=1900 E=2000
4=Std XP Power System	D=Utilidump	D=48 volt Power System 8 6V batteries		Year 8=1998 9=1999 0=2000 1=2001
5=XP+ Power System	E=Eagle	E=48 volt Power System 6 8V batteries		SP, when used indicates this is a Special Vehicle having been significantly modified from model indicated by model prefix.It is critical when ordering parts for any vehicle that you give the entire vehicle VIN to Columbia ParCar customer service to ensure correct service parts are ordered and supplied.
8=9 HP 4 cycle engine	F=Foursome	S=Special Product Modification		
9=13 HP 4 cycle engine	H=Tram	W=Front wheel hydraulic disc brakes		
	J=Utilitruck 2400	X=4 wheel hydraulic disc brakes		
	N=Utilitruck 2400XB	Y=Rear wheel hydraulic disc brakes		
	S=Shuttle	Z=Custom Carts model		
	U=Utilitruck			
	X=UtilitruckXB			
	Z=Ambulance			

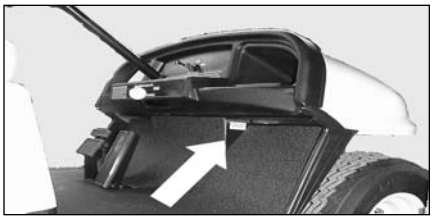
Note: ALWAYS, provide the complete VIN when contacting your Dealer for technical assistance or maintenance and repair parts. For golf and commercial vehicles, the VIN number is printed on a white label located in the upper right inside floorboard or stamped on a metal name plate affixed to the rear fender (under the rear body). On Industrial models, the VIN name plate is located at the front right corner of the rear body.

1996~1999 Eagle

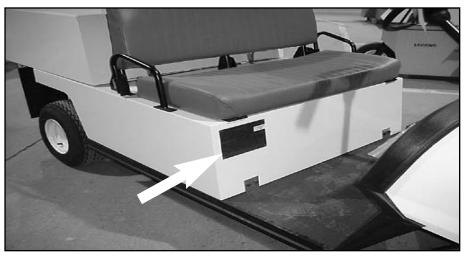
VIN Plate Location



1996~1999 Shuttle



2000 Eagle & Shuttle



Utility/Tram/Ambulance

General Vehicle Specifications

Item	Specifications	Vehicle							
		P4G	P4E	FG	FE	GU4	EU4	GUXB	EUXB
Power Source									
Engine	9 HP 4 cycle, Single cylinder, fan air cooled, OHV Briggs & Stratton	*		*		*		*	
	13 HP 4 cycle, Single cylinder, fan air cooled, OHV Briggs & Stratton								
Motor	36 Volt, DC series wound, Reversible, NEMA Class H insulation, 3.2 HP @2800 RPM		*		*		*		*
Drive	Direct coupled to helical geared differential		*		*		*		*
Speed Control	Infinitely variable, solid state maintenance free, 275 AMP		*		*		*		*
Transmission	Fully automatic torque sensing variable speed with overdrive	*		*		*		*	
Transaxle[1]	12.44:1 Helical gear reduction with integral differential		*		*		*		
	13.32:1 Helical gear reduction with integral differential	*		*		*		*	
	13.25:1 Helical gear reduction with integral differential, Heavy duty								*
Electrical	Solid state voltage regulator, 12 volt heavy duty battery	*		*		*		*	
Batteries[2]	36 Volt: Six 6-volt, Heavy duty, 220Ah, deep cycle		*		*		*		*
	48 Volt: Eight 6-volt, Heavy duty, 220 Ah, deep cycle		*		*		*		*
Charger	Lestronic II 36/48 Volt, 25 AMP (Portable) or 30 AMP (Built-in)		P		P		B		B
Directional Control	Dash mounted safety directional keyswitch, forward, reverse and off		*		*		*		*
	Dash mounted safety directional shift control, forward, reverse and off	*		*		*		*	
Air Intake	Micro-clean primary and safety element	*		*		*		*	
	Brakes, Steering and Suspension								
Brakes[3]	Auto adjusting mechanical drum rear, Automatic release parking brake	*	*	*	*	*	*	*	*
	Hydraulic drum brakes on rear, hand operated parking brake								
Steering	Automatic adjusting, speed balanced, Automotive rack and pinion	*	*	*	*	*	*	*	*
Suspension	Front-multi-leaf spring with dual shock absorbers Rear-Independent dual coil springs with dual shock absorbers	*	*	*	*	*	*	*	*
	Body and Chassis								
Tires[4]	G=Golf, 18x8.5-8 Classic St (Std) I=Industrial 5.70x8 Industrial Service (Std)	G	G	G	G	I	I	I	I
Frame	Mig-welded tubular steel, electrostatic powder coated	*	*	*	*	*	*	*	*
	Capacities								
Fuel tank	7 U.S. Gallon Capacity[5]	*		*		*		*	
Capacity	Total number of occupants and cargo not to exceed _lbs.	2 750 lbs.	2 750 lbs.	4 1100 lbs.	4 1100 lbs.	2 1200 lbs.	2 1100 lbs.	2 1200 lbs.	2 1100 lbs.

General Vehicle Specifications (Continued)

Item	Specifications	Vehicle							
		GU 2400	EU 2400	GU 2400XB	EU 2400XB	GD4	ED4	C6G	C6E
Power Source									
Engine	9 HP 4 cycle, Single cylinder, fan air cooled, OHV Briggs & Stratton							*	
	13 HP 4 cycle, Single cylinder, fan air cooled, OHV Briggs & Stratton	*		*		*			
Motor	36 Volt, DC series wound, Reversible, NEMA Class H insulation, 3.2 HP @2800 RPM		*		*		*		*
Drive	Direct coupled to helical geared differential		*		*		*		*
Speed Control	Infinitely variable, solid state maintenance free, 275 AMP		*		*		*		*
Transmission	Fully automatic torque sensing variable speed with overdrive	*		*		*		*	
Transaxle[1]	12.44:1 Helical gear reduction with integral differential								
	13.32:1 Helical gear reduction with integral differential		*		*	*	*	*	*
	13.25:1 Helical gear reduction with integral differential, Heavy duty	*		*					
Electrical	Solid state voltage regulator, 12 volt heavy duty battery	*		*		*		*	
Batteries[2]	36 Volt: Six 6-volt, Heavy duty, 220Ah, deep cycle		*		*		*		*
	48 Volt: Eight 6-volt, Heavy duty, 220 Ah, deep cycle								
Charger	Lestronic II 36/48 Volt, 25 AMP (Portable) or 30 AMP (Built-in)		B		B		P		P
Directional Control	Dash mounted safety directional keyswitch, forward, reverse and off		*		*		*		*
	Dash mounted safety directional shift control, forward, reverse and off	*		*		*		*	
Air Intake	Micro-clean primary and safety element	*		*		*		*	
	Brakes, Steering and Suspension								
Brakes[3]	Auto adjusting mechanical drum rear, Automatic release parking brake					*	*	*	*
	Hydraulic drum brakes on rear, hand operated parking brake	*	*	*	*				
Steering	Automatic adjusting, speed balanced, Automotive rack and pinion	*	*	*	*	*	*	*	*
Suspension	Front-multi-leaf spring with dual shock absorbers	*	*	*	*	*	*	*	*
	Rear-Independent dual coil springs with dual shock absorbers								
	Body and Chassis								
Tires[4]	G=Golf, 18x8.5-8 Classic St (Std) I=Industrial 5.70x8 Industrial Service (Std)	I	I	I	I	I	I	I	I
Frame	Mig-welded tubular steel, electrostatic powder coated	*	*	*	*	*	*	*	*
	Capacities[5]								
Fuel tank	7 U.S. Gallon Capacity	*		*		*		*	
Capacity	Total number of occupants and cargo not to exceed _lbs.	2 2400 lbs.	2 2400 lbs.	2 2400 lbs.	2 2400 lbs.	2 1200 lbs.	2 1100 lbs.	4 1200 lbs.	4 1100 lbs.

	General Vehicle Specifications (cont.)				
Item	**Specifications**	**Vehicle**			
		C10G	**C10E**	**911G**	**911E**
Power Source					
Engine	9 HP 4 cycle, Single cylinder, fan air cooled, OHV Briggs & Stratton			*	
	13 HP 4 cycle, Single cylinder, fan air cooled, OHV Briggs & Stratton	*			
Motor	36 Volt, DC series wound, Reversible, NEMA Class H insulation, 3.2 HP @2800 RPM		*		*
Drive	Direct coupled to helical geared differential		*		*
Speed Control	Infinitely variable, solid state maintenance free, 275 AMP		*		*
Transmission	Fully automatic torque sensing variable speed with overdrive	*		*	
Transaxle[1]	12.44:1 Helical gear reduction with integral differential				
	13.32:1 Helical gear reduction with integral differential			*	
	13.25:1 Helical gear reduction with integral differential, Heavy duty	*			
Electrical	Solid state voltage regulator, 12 volt heavy duty battery	*		*	
Batteries[2]	36 Volt: Six 6-volt, Heavy duty, 220Ah, deep cycle		*		*
	48 Volt: Eight 6-volt, Heavy duty, 220 Ah, deep cycle				
Charger	Lestronic II 36/48 Volt, 25 AMP (Portable) or 30 AMP (Built-in)		B		B
Directional Control	Dash mounted safety directional keyswitch, forward, reverse and off		*		*
	Dash mounted safety directional shift control, forward, reverse and off	*		*	
Air Intake	Micro-clean primary and safety element	*		*	
	Brakes, Steering and Suspension				
Brakes[3]	Auto adjusting mechanical drum rear, Automatic release parking brake			*	*
	Hydraulic drum brakes on rear, hand operated parking brake	*	*		
Steering	Automatic adjusting, speed balanced, Automotive rack and pinion	*	*	*	*
Suspension	Front-multi-leaf spring with dual shock absorbers Rear-Independent dual coil springs with dual shock absorbers	*	*	*	*
	Body and Chassis				
Tires[4]	G=Golf, 18x8.5-8 Classic St (Std) I=Industrial 5.70x8 Industrial Service (Std)	I	I	I	I
Frame	Mig-welded tubular steel, electrostatic powder coated	*	*	*	*
	Capacities[5]				
Fuel tank	7 U.S. Gallon Capacity	*		*	
Capacity	Total number of occupants and cargo not to exceed _lbs.	10 2000 lbs.	10 2000 lbs.	3 1200 lbs.	3 1100 lbs.

Notes from General Vehicle Specifications:

[1]Optional transaxles may be used for different applications.

[2]Six, 8-volt batteries may be used for 48-volt system.

[3]Other brake options are available depending on application. Contact your Columbia ParCar Dealer.

[4]Other tire styles and sizes are available for different applications.

[5]For a full list of dimensions and capacities, refer to your vehicle owner's manual.

Columbia ParCar golf cars are designed to conform to ANSI standards and OSHA standards.

Columbia Utilitrucks are designed to conform to ANSI B56.8 and OSHA standards.

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

Safety Committee

If the Gasoline or Electric, Golf or Industrial 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 not limited to, the following:

a. Define where the vehicles should and should not be driven and utilized.
b. Ensure all proper warnings as to driving hazards are properly displayed and visible.
c. Safety signage concerning hills, turns, blind crossings or intersections is highly recommended.
d. Enforcement of safe driving and operating rules.
e. Provide driver training for first time operators, and review safe operating recommendations regularly.
f. Maintain vehicles in a safe operating condition. Maintain a schedule for daily, weekly, and monthly vehicle inspections.
g. Who, when and how should pre-operation inspections be conducted.
h. Define who should and who should not drive the vehicles.
i. What to do should an unsafe condition or operating problem be discovered.

Note: Refer to OSHA regulations for additional requirements regarding operator training.

These basic rules of operation, combined with courtesy and common sense, will help make driving your Columbia ParCar vehicle a safe and pleasant experience. The safety committee should be made up of managers and/or supervisors in charge or responsible for the operation and maintenance of the vehicles.

Controls and Operation

Location of Controls

Figure 1 shows location of your vehicle's controls.

Simple controls make it easy to operate a Columbia ParCar Golf or Columbia Industrial Vehicle. To drive, move the Safety Directional Keyswitch/Shift Control to desired position and depress accelerator with right foot. Depress brake pedal to slow or stop vehicle.

Warning: On electric vehicles, be sure safety directional keyswitch is in desired direction of travel before depressing accelerator. On gasoline vehicles, be sure the safety directional shift control is in the desired direction of travel before depressing accelerator.

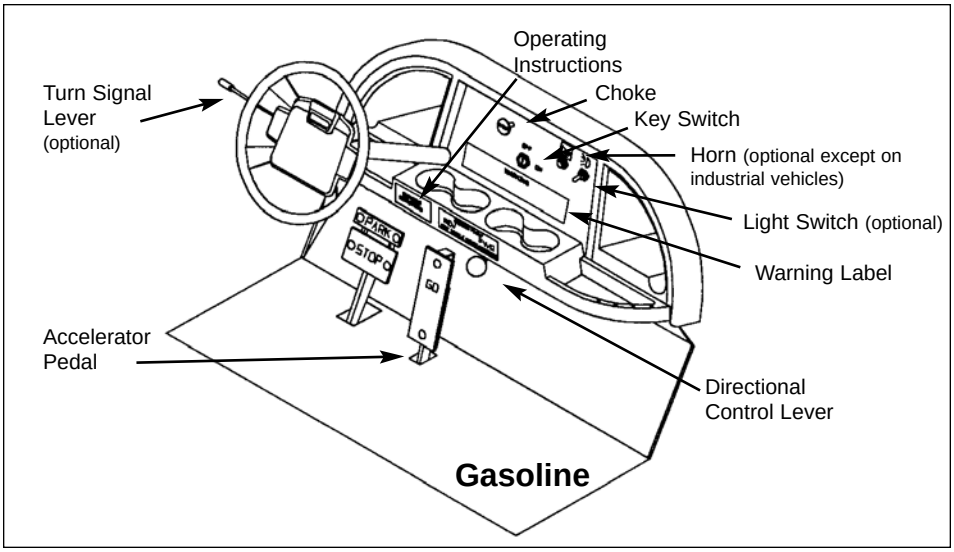
Caution:

Golf Cars:

* **Golf cars are to be used for golf play only.**
* **It is hazardous to use golf cars anywhere other than on designated car paths and car areas.**
* **This vehicle is designed for transporting no more than (2) golfers and their equipment. The only exception is the foursome vehicle designed to handle four (4) golfers and their equipment.**
* **Never exceed the rated load capacity or vehicle stability, reliability and control will be reduced.**

Industrial Vehicles:

* **Industrial vehicles are designed to transport no more than two (2) people unless adequate provisions have been factory installed to accommodate additional passengers.**
* **Never exceed the rated load capacity or vehicle stability, reliability and control will be reduced. See vehicle identification plate for capacities.**
* **Before operating vehicle, ALWAYS, distribute and secure loads.**



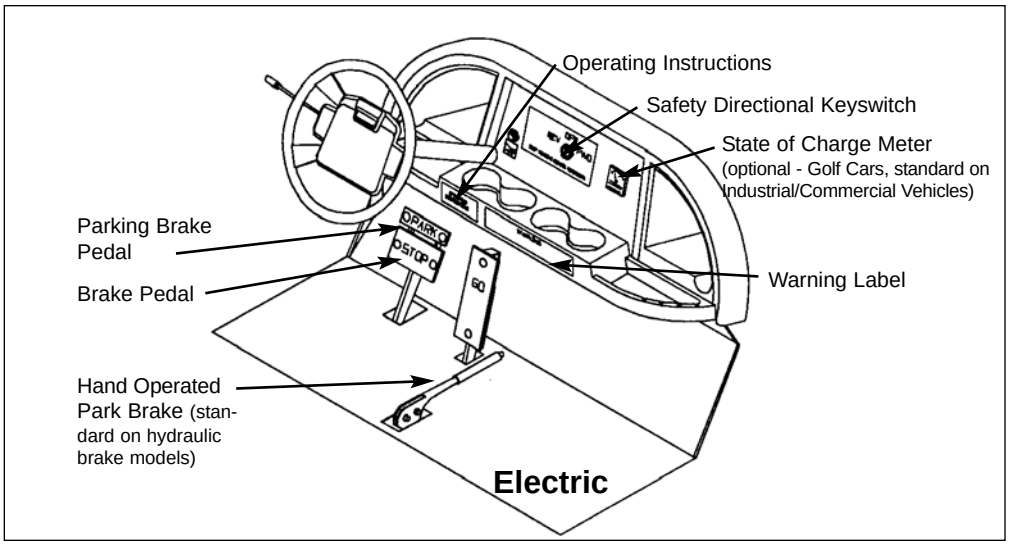


Figure 1- Location of Controls

Pre-Operations Inspections

Your Columbia ParCar vehicle has been inspected and adjusted to factory specifications before delivery. Upon receipt of vehicle, make 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 proper working order.

Warning: Only trained maintenance professionals should service or repair this vehicle. Persons doing even simple repairs or service should have 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.

Note: Controls should operated smoothly and easily without sticking or requiring undue effort. The service manual contains maintenance procedures necessary to perform maintenance on your vehicle. Maintenance and/or repair to fuel metering systems, air induction systems, ignition system, exhaust system (including connectors and assembling) could affect emissions controls on the engine. Contact your Columbia ParCar Dealer or Columbia ParCar at (800) 222-4653 for instruction and/or recommendations before proceeding.

	Pre-Operations Check List	
Service Item	**Service Method/Check**	**Manual Reference**
Vehicle Body	Visually, check for damaged and loose hardware.	See note.
Steering and Linkages	Test drive, check for free movement and proper operation.	See note.
Brake Operation	Test drive, check free travel and braking action.	Refer to owner's manual for specifications, Section 5.1.
Parking Brake	Test drive, check latching and proper release.	Refer to owner's manual for specifications, Section 5.1.
Warning Labels	Visually, inspect all labels for readability or missing.	Verify labels are in place and readable.
Tires	Visually, check for wear or damage.	Refer to owner's manual for specifications, Section 5.2.4.c.
Engine	Test drive, check for proper operation.	See note.
Accelerator/Governor Linkage	Test drive, check for free movement.	See note.
Reverse Warning Buzzer	Test drive, check for proper operation.	Verify an audible sound heard.
Air Intake Screen	Visually, check for clogged screen.	Refer to owner's manual for specifications, Section 5.2.4.a.
Fuel System	Visually, check tank, lines, pump and carburetor for fuel leakage.	See note.
Charger Plug and Receptacle	Check for damage and snug fit.	Refer to owner's manual for specifications, Section 5.3.1.a.
Batteries	Charge.	Refer to owner's manual for specifications, Section 5.3.1.a.

What to do if you find a problem:

1. If vehicle has just been delivered, report any physical damage or missing items to the Shipping Company and your local Columbia ParCar Dealer.

    * Look for body damage, jagged edges etc. that may cause personal injury.
    * Check for damaged or leaking batteries.
    * Verify bumpers are not bent out or protruding and are attached properly.

2. Daily, before operation, assess what affect the problem has on the safe operation of the vehicle.

    * If the safe operation of the vehicle is affected, remove the vehicle from service until the problem has been corrected. Report the problem to the individual(s) responsible for correction and/or repair.

    * If the safe operation of the vehicle is not affected, record the problem and report it to the individual(s) responsible for correction and/or repair.

3. Report any service item problems to the individual(s) responsible for correction and/or repair or contact your local Columbia ParCar Dealer for service.

    * Refer to Pre-Operations Checklist.

Danger: If any problems are found, DO NOT operate vehicle until repairs are made. Failure to make necessary repairs could result in fire, severe personal injury, property damage or death. Consult your local Columbia ParCar Dealer for professional service.

Torques and Metric Conversion Factors

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

Torque Table

Torque to the value in this table unless specified otherwise.

Fine or course 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 P.S.I.	Low Carbon Steel	6	11	19	30	45	66	90	150	202	300
Cap Screw	S.A.E. 3 Steel	100,000 P.S.I.	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 P.S.I.	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												
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 P.S.I.	Low Alloy or Med. Carbon Steel Quenched Tempered	11	20	34	54	81	119	167	269	427	644
Cap Screw	S.A.E. 6 Steel	133,000 P.S.I.	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 P.S.I.	Med. Carbon Alloy Quenched Tempered	13	28	46	75	115	165	225	370	591	893

Conversion Factors

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

Lifting Instructions

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

When lifting the vehicle for service, use a sturdy lifting device such as a hoist, 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. After the vehicle is lifted to a 10° to 25° angle, place jack stands under vehicle frame to support vehicle weight for added safety. Watch for cables, linkages or wire harness.

Note: Jack stands should be of sufficient rated weight capacity to hold vehicle safely. See General Vehicle Specifications for empty weights.

Cautions: 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.

Hoist Lifts

Caution: Before lifting, ALWAYS, wedge wheels and set parking brake.

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 2.

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. Place jack stands under frame at right and left sides to allow access under vehicle. When work is completed, lift vehicle and remove jack stands. Then, lower vehicle to the floor.

To lift the front, connect the lifting eyes/hooks to front frame tubes. DO NOT use the front suspension or front bumper to lift the vehicle. Place jack stands under frame at the right and left sides. Then, lower vehicle to allow access under vehicle. When work is completed, lift vehicle and remove jack stands. Then, lower vehicle to the floor.

Floor Jack

Caution: Before lifting, ALWAYS, wedge wheels and set parking brake.

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, 10° to 25° angle, to allow the placement of jack stands and hold the weight of the vehicle during service.

To lift the rear, place the floor jack under the rear axle housing, and lift vehicle until jack stands can be placed under the frame at right and left sides to allow access under vehicle. Lower vehicle on to stands and remove floor jack. When work is completed, reuse floor jack, lift vehicle, and remove jack stands. Then, lower vehicle to the floor.

To lift the front, place the floor jack under the leaf spring retainer plate, and lift vehicle. Place jack stands under the frame at right and left sides to allow access under vehicle. Lower vehicle on to stands, and remove floor jack.

When work is completed, reuse floor jack, lift vehicle, and remove jack stands. Then, lower vehicle to the floor.

Hydraulic Floor Lift - Frame Lift

Position vehicle over lift. Place lift arms under frame of vehicle, and lift for servicing.

Jack Stands

Jack stands need to be of sufficient rated load capacity to hold the vehicle safely. See General Vehicle Specifications for vehicle empty weight.

Warning: DO NOT work under your vehicle unless it is firmly supported on jack stands

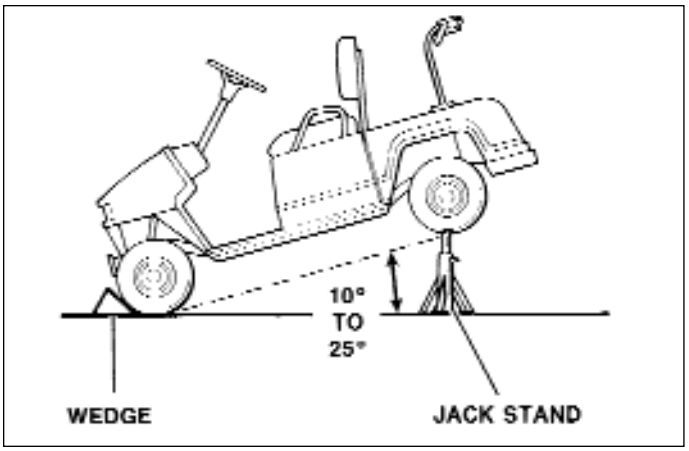


Figure 2 - Lifting Recommendations

VEHICLE STORAGE

Warning: Turn key switch "OFF" and remove key during storage to prevent unintentional starting of vehicle.

Gasoline Vehicles

Danger: DO NOT operate gasoline vehicle in an enclosed area. Gasoline engines produce carbon monoxide, which is an odorless deadly gas. Be sure to clean up any spilled gasoline before operating vehicles. Store gasoline in an approved gasoline container only. Store in a well-ventilated area away from sparks, open flames, heaters or other heat sources. DO NOT siphon gasoline from vehicle.

Warning: 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.

Caution: Batteries in a low state of charge will freeze at higher temperatures than fully charged batteries.

Preparing Vehicle For Extended Storage

Store the vehicle in a cool, dry place. This will prevent self-discharge of the battery. If the battery appears to be weak, have it charged using an automotive type 12-volt battery charger, rated at 10 Amps or less.

1. Drain carburetor and seal the tank.
   a. Remove drive belt.
   b. Disconnect fuel line from the gas tank side of the fuel pump.
   c. Run the engine until fuel remaining in carburetor and fuel lines is consumed and the engine stalls.
   d. Reconnect fuel line to fuel pump
2. To protect the engine, remove the spark plug and pour ½ ounce of SAE 10 weight oil into the engine through the sparkplug hole. Be sure to rotate the engine's crankshaft several times, then replace the spark plug.
3. Add a good quality fuel stabilizer to the remaining fuel in the tank per the manufacturer's recommendation on the container. We use Fresh Start™ gas additive from Briggs & Stratton and strongly recommend its use.

Fresh Start™
   a. Promotes quick starting.
   b. Keeps carburetor and fuel systems clean.
   c. Reduces gum and varnish build-up.
   d. Improves engine performance.
   e. Stabilizes gasoline up to 24 months.

4. Maintain tire pressure at 20 psi during storage for 18 x 8.5 x 8 tires and at 50 psi for 5.70 x 8 tires.
5. Grease front suspension and continue quarterly lubrication during storage period. Refer to Periodic Maintenance page 2-14.
6. Clean vehicle body, seats, battery compartment and vehicle underside.
7. DO NOT engage park brake. Block wheels to prevent movement.

Returning Vehicle To Service

1. Recharge battery if required. See Battery Testing, Chapter 8.

2. Restore fuel system to operation.

   a. Crank the engine until fuel is pumped into the carburetor and fuel lines and the engine starts. When running the engine for the first time after storage, it may smoke excessively do to the oil placed into the spark plug hole of the engine prior to storage.

   b. Reinstall drive belt.

3. Readjust tire pressure to 20 PSI for 18 x 8.5 x 8 or 50 PSI for 5.70 xy 8 tires.

4. Perform initial maintenance per Periodic Maintenance page 2-14.

Electric Vehicles

Warning: Turn key switch "OFF" and remove key during storage to prevent unintentional starting of vehicle. 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.

Caution: Batteries in a low state of charge will freeze at higher temperatures than fully charged batteries. If battery terminals are or wires are damaged or corroded, they should be cleaned or replaced as necessary. Failure to do so may cause them to overheat during operation.

Preparing Vehicle For Extended Storage

Electric vehicles stored over six (6) to eight (8) weeks must be protected to maintain battery life. Several guidelines should be observed when storing your electric vehicle.

1. Fully charge batteries. With electrolyte full in all cells, store batteries in a cool place. If stored above 50° F (27° C), check state of charge every four (4) to six (6) weeks and charge as necessary to maintain 1.250 to 1.270 specific gravity. If vehicle is stored in temperatures below 40° F, check state of charge every 15 to 18 weeks. Use the below chart to determine freezing point of battery and maximum recommended storage temperature. Refer to owner's manual section 5.3.1.a for charging procedure.

2. Wash off any corrosion around the terminals with a solution of baking soda and water. DO NOT allow this solution to enter batteries.

3. Store vehicle in a cool dry place to prevent battery discharge and remove battery (+) terminal.

4. Maintain tire pressure at 20 psi during storage for 18 x 8.5 x 8 tires and at 50 psi for 5.70 x 8 tires.

5. Grease front suspension and continue quarterly lubrication during storage period. Refer to Periodic Maintenance page 2-14.

6. Clean vehicle body, seats, battery compartment and vehicle underside.

7. DO NOT engage park brake. Block wheels to prevent movement.

Returning vehicle to service

Note: Vehicles equipped with Power Master System require additional preparation after storage.

a. Reconnect battery B+ terminal.

b. Switch the ‘tow/run’ switch to ‘run’ position.

1. Fully recharge batteries.

2. Check tire pressure and readjust if necessary.

3. Perform initial maintenance per Periodic Maintenance page 2-14.

Note: Vehicles equipped with the Power Master System require additional preparation for storage.

a. Switch the ‘run/tow’ switch to the ‘tow’ position.

b. Disconnect battery B+ lead.

Specific Gravity	**1.260**		**1.230**		**1.200**		**1.117**		**1.110**	
Freezing Point of Electrolyte	**F -70**	**C -57**	**F -39**	**C -38**	**F -16**	**C -26**	**F -2**	**C -19**	**F +17**	**C -8**

Towing and Transporting Vehicles

Towing Your Vehicle

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

Caution: Use caution and common sense while towing disabled vehicle.

* Use a tow chain, strap or towing device long enough to provide a safe distance between vehicles.
* Connect the selected towing device to the front tubular frame undercarriage.
* Connect the towing device to the towing vehicle frame.
* On electric vehicles, turn the key to the off position. On the gasoline vehicle, turn the key to off and set the safety directional shift control in forward.

Note: See special towing instructions for Power Master Models.

* Disengage the parking brake.
* DO NOT exceed 5 MPH (8 KPH) while towing.
* Allow ONLY one person in the towed vehicle to steer and apply additional braking, as necessary.
* Tow only one vehicle at a time unless a multiple vehicle towing bar system is used.
* Avoid sudden stops, sudden starts and sharp turns while towing.

PowerMaster Towing Instructions

The PowerMaster system is used to offer controlled speed reduction characteristics not normally found on electric vehicles. This is often referred to as “Regen-Breaking.” Vehicles using this PowerMaster system will decelerate (rather than free wheel) as the accelerator pedal is released. One additional feature is referred to as the “anti-rollaway” function. Once the vehicle with this system comes to a stop, this function prevents the vehicle from accidentally rolling away undetected. Should for any reason the vehicle begin to roll, the PowerMaster system will engage preventing the vehicle from exceeding one or two miles per hour and the reverse warning alarm will sound. This function is active with the key on or off.

* Connect the vehicle to be towed as described before.
* Lift mid-body and locate the tow/run switch (middle of solenoid panel).
* Set the tow/run switch in the tow position (down) allowing the vehicle to be towed.
* Reset the tow/run switch to the run position when completed.

Transporting Your Vehicle

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

When transporting (trailering) your vehicle over long distances or on the highway, observe the following:

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

Note: The key should be removed from the vehicle and the parking brake firmly locked.

* On vehicles equipped with windshield, cab or suntop, be certain windshield, cab or suntop is secured properly to the vehicle to prevent loss or damage while trailering.
* Secure vehicle body to chassis as it may rise as a result of airflow under suntop while transporting.
* Removal of the windshield is recommended.

Caution: Increased transporting speed adds undo stress to windshield, cab or suntop and will increase chance of loss, damage, accident or injury.

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. Golf and Industrial vehicles are not rated to withstand this level of stress sand parts could be blown from top or cab, causing accident or injury.

Periodic Maintenance

A good planned maintenance program is important for the safe, reliable operation of all Columbia ParCar vehicles. The service procedures recommended and described in this service manual are effective for performing service operations.

Note: Some procedures require the use of tools specially designed for this purpose. These special tools should be used when and where as recommended.

Note: When performing monthly, quarterly, semi-annual, or annual maintenance, ensure that daily and weekly inspections are included.

Note: The operating environment of your golf or industrial/commercial vehicle varies widely. Service operations will require periodic maintenance recommendations to be adjusted to shorter time intervals. Examples of service would include the following:

1. Dusty or Sandy locations such as cement plant, lumber for flourmills, coal dust or stone-crushing areas.
2. High Temperature Areas such as steel mills, foundries, etc.
3. Sudden Temperature changes such as continuous indoor-outdoor movement, as in refrigeration plants, etc.

The calendar below is one example of how columns scheduling routine maintenance can be managed. Do not depend on your memory as day to day interruptions could cause scheduled maintenance to be overlooked. Numbers located in chart are page number from this service manual.

Periodic Service Calendar		
January	**February**	**March**
Monthly	Monthly	Quarterly
April	**May**	**June**
Monthly	Monthly	Semi-Annual
July	**August**	**September**
Monthly	Monthly	Quarterly
October	**November**	**December**
Monthly	Monthly	Annual

Note: Daily maintenance must be performed before operating any vehicle. Weekly maintenance must be performed on a weekly basis to include all daily maintenance and is performed by the owner, operator, or trained maintenance personnel.

Maintenance Schedule Checklist							
Service/Check	**Procedure**	**Daily**	**Weekly**	**Monthly[1]**	**Quarterly[2]**	**Semi-Annual[3]**	**Annual[4]**
Body, Frame, and Chassis							
Body, Seats and Frame	Visually inspect for damage or tears	*					
Hardware	Tighten as needed		*				
Windshield	Inspect for damage	*					
Wash engine compartment and undercarriage			*				

Maintenance Schedule Checklist							
Service/Check	**Procedure**	**Daily**	**Weekly**	**Monthly[1]**	**Quarterly[2]**	**Semi-Annual[3]**	**Annual[4]**
Clean Body and Seats	Wash as needed		*				
Lubricate chassis	Lubricate body hinges					2-17, 2-25	
Lubricate front suspension and steering	Lubricate				2-17, 2-25		
Warning and operating labels	Ensure labels in place and readable	*					
Operating Controls							
Steering and Linkages	Check for free movement	*					
Accelerator Linkage	Check for free movement and return	*					
	Check micro switch adjustment						2-22
Brakes	Check brake operation	*					
	Check parking brake latching and release	4-2, 4-7					
	Check brake cables for damage			4-3			
	Clean and adjust brakes					4-2, 4-6	
	Check rear brake drum/ axle nut torque (6.5 ft. lbs.)						4-4
Safety directional keyswitch	Check for smooth operation Forward and Reverse	*					
Safety directional shift control (Gas Car)	Check for smooth operation Forward and Reverse	*					
Turn Signal (optional)	Check for operation	*					
Light Switch (optional)	Check for operation	*					
Tires and Wheels							
Tires	Check for wear and damage Tire Pressure	3-7					
	Check for dented or damaged rims			*			
Front Wheel alignment and Camber	Visually check, adust as necessary					3-6	
Lug nuts	Check for tightness	3-7					
Tie Rods/Linkage	Check for excessive movement, tightness of hardware			3-1			
Electrical							
Batteries	Check charge (fill cells prior to charging)	8-17					
	Check electrolyte level		8-17				
	Clean terminals and wash battery case		*				
	Test batteries						8-15, 8-18
Electrical Wires	Check for tightness or damage		*				
Ground wires	Check for tightness or damage		*				
Reverse warning buzzer	Check for operation (use keyswitch or shift control and key)	*					
Fluids							
Engine Oil	Check level	2-20					
	Check for leakage			*			
	Change engine oil					2-20	
Differential lubricant	Check level					2-21, 2-25	

Maintenance Schedule Checklist							
Service/Check	**Procedure**	**Daily**	**Weekly**	**Monthly[1]**	**Quarterly[2]**	**Semi-Annual[3]**	**Annual[4]**
Gasoline Engine/Electric Motor							
Operation	Test drive for proper operation	*					
Air intake	Check fan housing intake screen	2-20					
	Check air hose for leaks				*		
Exhaust system	Check for leaks			*			
Belts	Check Starter/Generator belt tension, adjust if necessary					8-13	
	Inspect Drive belt, replace if necessary					5-1	
Spark Plug	Check spark plug wire and boot for damage and proper routing					7-30	
	Inspect spark plugs, clean and regap if necessary						7-27
Gaskets	Check cylinder head and exhaust connection gasket					*	
Filters	Check and replace air filter						2-18
	Replace fuel filter						7-26
Brushes	Inspect starter/generator brush length and remove carbon dust						8-9, 8-27

1 Service done by owner.

2 Due every 50 golf rounds or 25 hours of operation. Service done by owner or trained maintenance.

3 Due every 100 golf rounds or 50 hours of operation performed by trained maintenance personnel.

4 Due every 200 golf rounds or 100 hours of operation performed by trained maintenance personnel.

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

GAS VEHICLES

Chassis Lubrication

1. Place a couple drops of oil upon each of the rear body hinges

2. Vehicles have nine (9) grease fittings. Two on each A-arm assembly, one on each steering arm, one on each tie rod end, and one on the brake pedal pivot, which should be greased with a high quality chassis grease.

Note: Remove all weight from the front suspension before lubricating to ensure proper grease distribution to suspension components.

Engine Cooling

Engine Air Intake

Air is pulled, via the fan, through the fan intake screen and spread across the cooling fins surrounding the engine cylinder thus cooling the engine. Remove debris from cooling air intake screen in front of engine, particularly after operating vehicle through grass clippings, dry dandelions, weeds, etc. continued operation with a clogged cooling system can cause severe overheating and possible engine damage. Refer to Figure 7 for view of screen and fins.

Air Filtration System

Air Cleaner

The Micro-Clean air filtration system is located next to the left rear tire under the rear body assembly.

Your Columbia ParCar gasoline vehicle is equipped with the exclusive Micro-Clean^{sm} air filtration system. Service the Air Cleaner (Figure 3) monthly or more often under dirty operating conditions or if power loss is noted.

Caution: If air cleaner primary and secondary elements are not tightened firmly against their gaskets, contaminants will enter the engine. This will damage the engine and void the warranty.

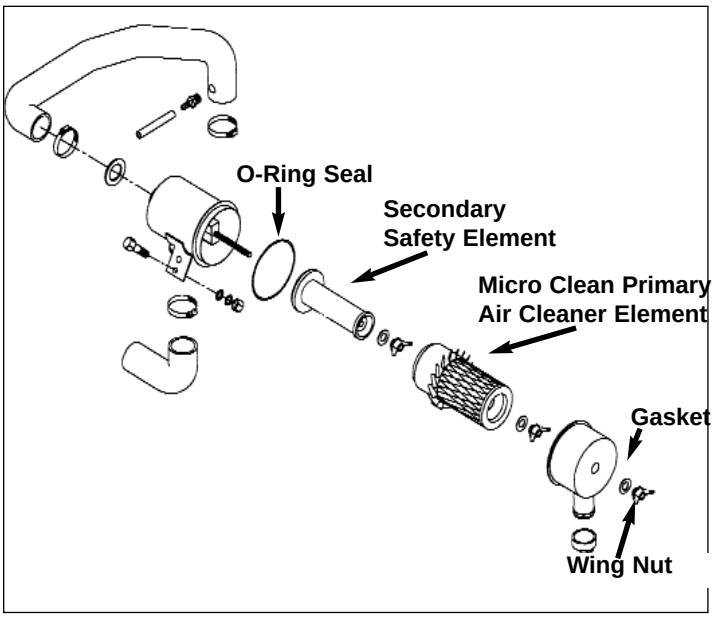


Figure 3 - Air Cleaner Assembly

To replace the primary air cleaner element, (part #29131-96), observe the following seven steps:

1. Remove the Old Element Carefully

Gently pull the dirty primary element straight out of its housing. Avoid tapping or bumping the filter while removing it - this will ensure that no dirt or dust is dropped into housing before the new filter can do its job.

Inspect inner (secondary) element. If it appears dirty, remove and replace it. The secondary element may not be cleaned, it must be replaced, (part #29146-96), when it becomes dirty.

2. Clean the Inside of the Housing Thoroughly

To protect your engine, the housing must be perfectly clean. Particles left in the clean air side of the housing cannot be trapped by the new filter element, and that spells trouble for your engine. Use a clean, damp cloth and wipe every surface clean.

3. Clean the Gasket Sealing Surfaces of the Housing

Properly fitted gaskets prevent dirt from getting into the housing. Use a clean, damp cloth to remove any hard ridges of dirt around the old gasket sealing area on the top and bottom of the housing.

4. Inspect the Old Element for Uneven Patterns of Dirt

Uneven patterns of dirt on the clean side of the old element are a sure sign that the gasket seal was not perfect. If you do Step 3 properly, and you still see tell-tale dirt patterns, check your housing carefully for an even sealing area.

5. Test the New Gasket for Resilience

Apply pressure to the new filter gasket with your finger. When you let up, the gasket should spring back instantly to its original shape.

6. Make Sure the Gasket Seats Firmly

When you slide in the new filter, the gasket should form a perfect seal on the housing. If it doesn't, make sure that the sealing surface is clean and that you have the correct replacement filter part #29131-96. Remember, without a perfect seal, no filter can protect an engine.

7. Inspect All Connections and Ducts for a Leak-Proof Fit

From the clean air side of the air cleaner to the engine, all clamps, flange and duct joints, and air cleaner mounting bolts must be securely tightened. If you find a leak, seal it immediately to prevent dirt from directly entering the engine.

8. To Service the Air Cleaner Element Properly, Observe the Following Five "Don'ts":

(1.) Don't Rap an Element to Clean It

Shaking or rapping a filter to remove dirt actually does more harm than good. Leave your old filter alone until you install a replacement.

(2.) Don't Judge an Element's Life by Appearance.

A filter apparently full of dirt and dust may have plenty of life left in it. The reverse may be true when the filter may be contaminated with carbon which cannot be detected by a visual inspection. For optimal engine protection, monitor your filter changes with a restriction gauge or use a time-interval service program.

(3.) Don't leave an Air Cleaner Open any Longer Than Necessary.

An open air cleaner is an open invitation for dirt to get into your engine. When you take out an old filter, put the new one in right away. If an open cleaner is not serviced or reassembled immediately, cover the opening.

4.) Don't Install a Defective Element.

A new element that has been dented or punctured will not protect your engine from contamination. A dented element may not seal properly and may also have damaged paper.

(5.) Don't Use the Wrong Replacement Part

A fraction of an inch difference in the length of an element - invisible to the eye- can make a firm seal impossible. It's better to keep using a dirty element than to replace it with the wrong replacement part. Use only original Columbia ParCar replacement parts available from your Columbia ParCar Dealer.

FUEL AND OIL RECOMMENDATIONS

Gasoline

Danger: Gasoline is extremely flammable and highly explosive under certain conditions. When refueling or servicing gasoline-powered vehicles, always, stop engine. Do not smoke and keep away from open flame or sparks.

We recommend the use of clean, fresh, lead-free gasoline. Leaded gasoline may be used if lead-free is not available. A minimum of 85 octane is recommended. The use of lead-free gasoline results in fewer combustion deposits and longer valve life.

Note: We DO NOT recommend the use of gasoline which contains alcohol, such as gasohol. However, if gasoline with alcohol is used, it MUST NOT contain more than 10 percent Ethanol and MUST be removed from the engine during storage. DO NOT use gasoline containing Methanol.

We also recommend gasoline be purchased in small quantities, not more than a 30 day supply. FRESH gasoline minimizes gum deposits and also will ensure fuel volatility tailored for the season in which the engine will be operated.

Note: The use of a fuel additive, such as Briggs & Stratton Gasoline Additive, Part #5041, or equivalent, will minimize the formation of fuel gum deposits during storage. Such an additive may be added to the fuel tank or storage container.

Engine Oil

4-CYCLE (Overhead Valve) ENGINE OIL RECOMMENDATIONS 5

SAE VISCOSITY GRADES

We recommend the use of Briggs & Stratton "warranty certified" high quality detergent oil Part #100005 (SAE 30). If not available, use a high quality detergent oil classified "For Service SC, SD, SE, SF, or SG." Detergent oils keep the engine cleaner and retard the formation of gum and varnish deposits. No special additives should be used with recommended oils.

* Air cooled engines run hotter than automotive engines. Use of multi-viscosity oils (10W-30, etc.) above 40° F (4° C) will result in high oil consumption and possible engine damage. Check oil level more frequently if using these types of oils.

** SAE 30 oil, if used below 40° F (4° C), will result in hard starting and possible engine bore damage due to inadequate lubrication.

BE SURE OIL LEVEL IS MAINTAINED.

Note: DO NOT MIX OIL WITH GASOLINE.

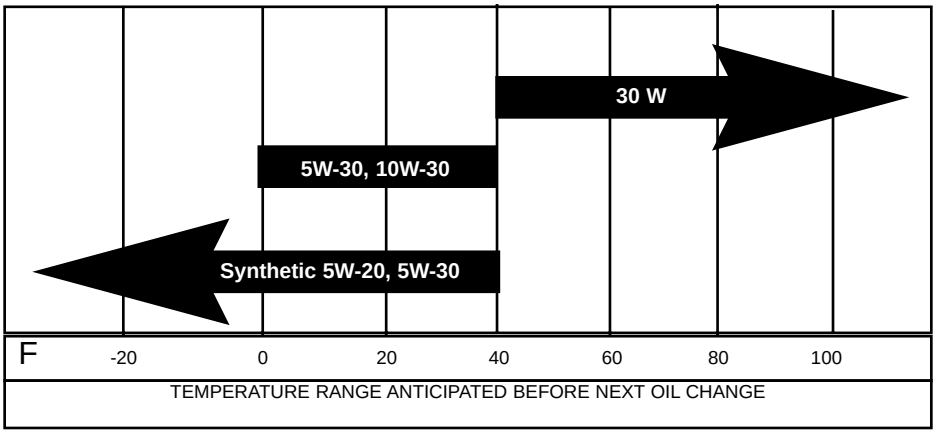


Figure 4 - SAE Oil Viscosity Chart

MAINTENANCE

Engine Oil, Lubrication

Oil has four purposes.

- •It cools,
- •It cleans,
- •It seals,
- •It lubricates.

During normal operation, small particles of metal from the cylinder walls, pistons, bearings, and combustion deposits will gradually contaminate the oil. Dust particles from the air also contaminate the oil. If oil is not changed regularly, these foreign particles can cause increased friction and a grinding action which shortens the life of the engine. Fresh oil also assists in cooling. Old oil gradually becomes thick and loses its cooling ability as well as its lubricating qualities.

Change Oil (Crankcase)

1. BE SURE OIL LEVEL IS MAINTAINED. CHECK OIL LEVEL EVERY EIGHT (8) HOURS OR DAILY. EQUIPPED WITH DIPSTICK/OIL FILL TUBE, SCREW DIPSTICK IN SLOWLY UNTIL IT BOTTOMS. CHANGE OIL AFTER FIRST EIGHT (8) HOURS OF OPERATION.

Note: On 9 or 13 H.P. engines, when removing combined oil fill plug and dipstick, do not screw dipstick into crankcase cover when checking oil level.

2. Thereafter, change oil every one hundred (100) hours of operation or every fifty (50) hours of operation if operated under heavy load or in high ambient temperatures.
3. Remove oil drain plug, Figure 5, and drain oil while engine is still warm.
4. Install drain plug. See Figure 5.
5. Remove fill or oil dipstick and refill slowly with new oil of proper service classification and viscosity grade. DO NOT OVERFILL. See Figures 5 and 6.
6. Start and run engine at low RPM to check for oil leaks.
7. Recheck oil level, and add oil if required.

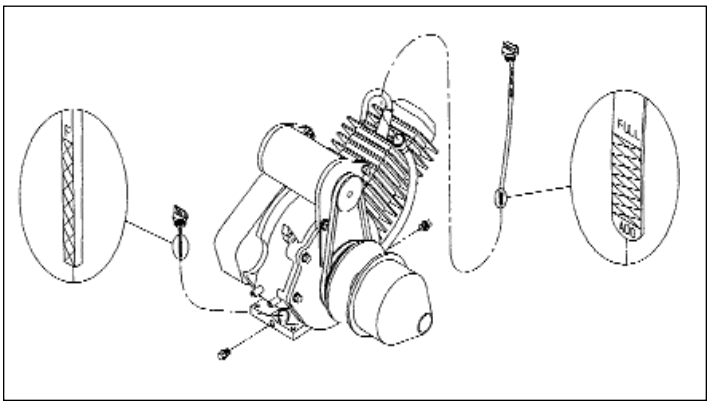


Figure 5- Oil Fill and Drain Plugs

Chapter 7 contains additional maintenance and repair information.

Note: **LONG DIPSTICK** - Always screw long dipstick in completely to check oil level. See Figure 5.
SHORT DIPSTICK - Set short dipstick into opening. Do not screw in to check oil level. See Figure 6.

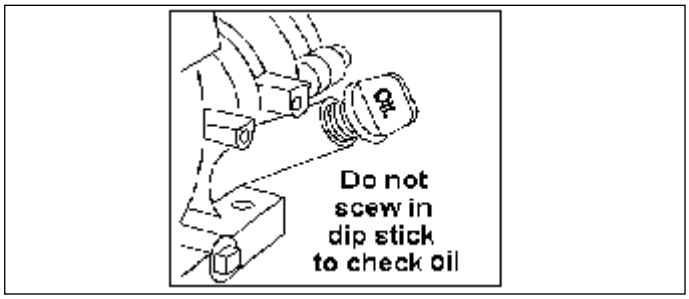


Figure 6- Check Oil Level

Approximate Crankcase Oil Capacity (Dry)	
Model	**Capacity**
9 H.P. And 13 H.P. Engines	41 oz. (1.2 liters)

Cooling System

Grass particles, chaff, or dirt can clog the air cooling system, especially after prolonged service in very dusty conditions or when cutting dry grass. Continued operation with a clogged cooling system can cause severe overheating and possible engine damage.

Figure 7 shows the areas to be cleaned. This should be a regular maintenance operation, performed yearly or every 200 hours, whichever comes first, and more often under dusty conditions or when airborne debris is present.

Figure 7 - Clean Regularly

Rear Axle Oil

Gas Axle Assembly, Std.

Check only if signs of leakage are detected,- then, check oil level. For check plug, see Figure 6.

Change oil every 24 months or 2000 km (1250 miles), whichever occurs first.

Capacity - 1.5 quarts (1.4 L.), SAE 30 wt. Below 0°F (-17°C), use 10-30Wt.

Gas Axle Assembly, Tram and 2400 lb. Utility

Oil Check and change intervals.

Check only if signs of leakage are detected, then, check oil level.

change oil every 24 months or 2000 km (1250 miles), whichever occurs first.

Capacity - 20-24 ounces (529 ml.), SAE 30 wt.

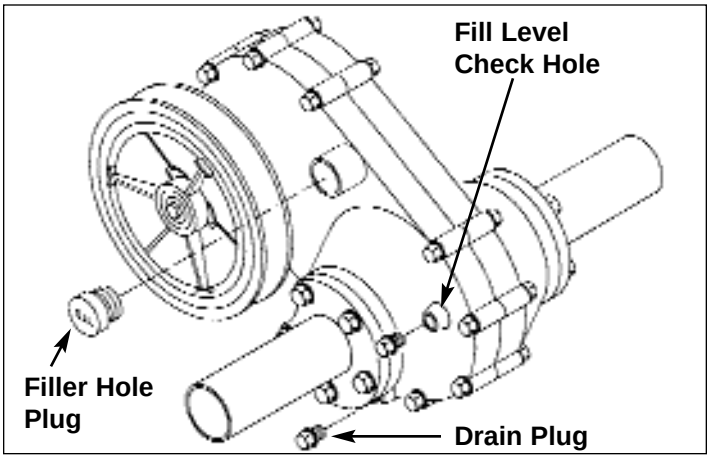


Figure 8 - Differential Oil Fill and Check Hole

ACCELERATOR MICRO SWITCH ADJUSTMENT

Adust Accelerator Micro Switch

Note: Refer to Figure 9 and 10.

1. Adjust system to operate in the order listed below.

   Correct Sequence of Operation

   A. Depress accelerator pedal.
      1. Micro switch (Figure 10, #1) clicks, energizing solenoid.
      2. Then, throttle opens.

   B. Release accelerator.
      1. Throttle completely closes.
      2. Micro switch clicks, de-energizes solenoid, stopping engine as accelerator is depressed.

2. Quickly, after depressing accelerator pedal, spring pin (#7) on bell crank arm (#8) will release the micro switch (#1) to start the engine. To adjust, disconnect the clevis (#9) at bell crank arm (#8). Thread clevis in or out to move spring pin toward or away from accelerator micro switch. Be sure switch "clicks" when accelerator is depressed and again as accelerator is released fully.

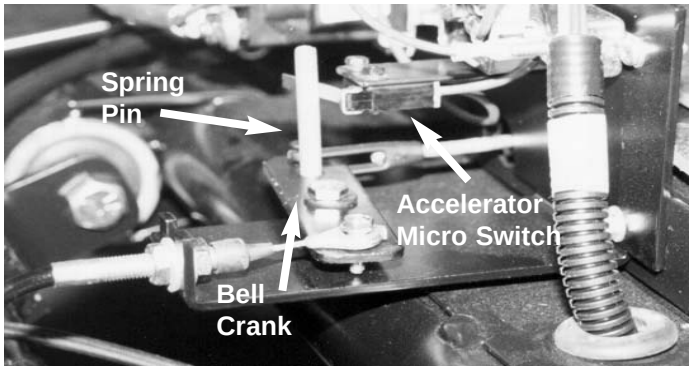


Figure 9 - Accelerator Linkage and Micro Switch

Note: If micro switch “clicks” too late as accelerator is depressed, throttle will partially open when engine starts. This will cause abrupt starts and occasional backfire.

Note: See brake adjustment. Park brake must release before micro switch closes to enable ignition. This requires a mechanical adjustment to brake linkage.

Accelerator/Throttle System Overview

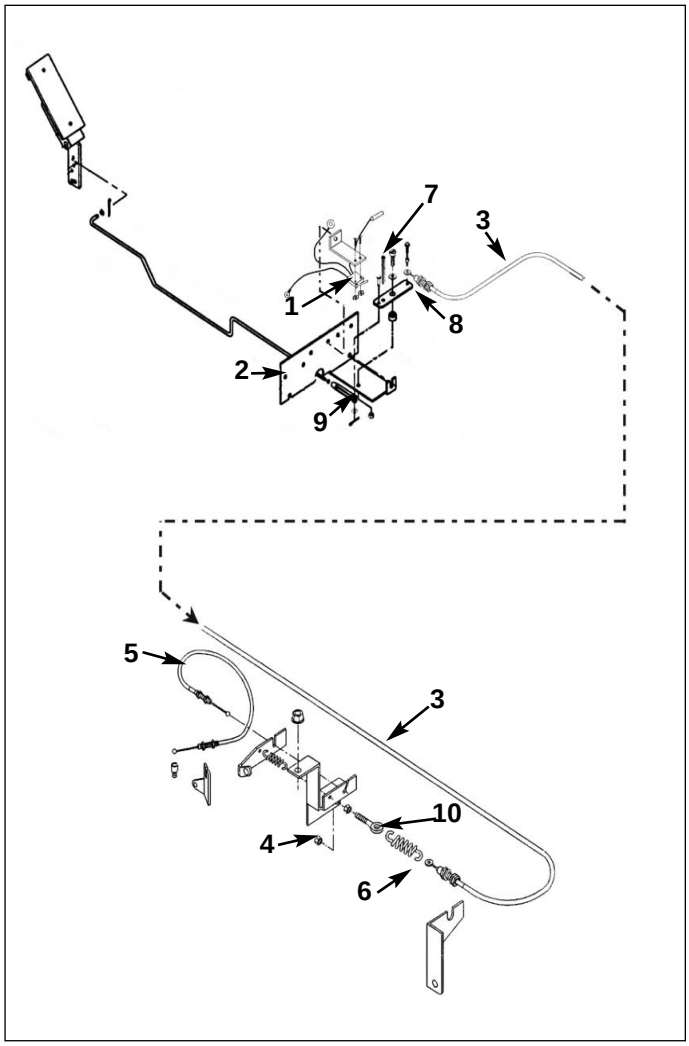


Figure 10 - Accelerator Linkage and Accelerator

As accelerator is depressed to full throttle position, throttle lever at carburetor opens completely for maximum performance and acceleration. As maximum governed speed is achieved, force from internal centrifical weights (within the rear axle) begin to exceed the ability of the governor spring to hold the throttle open. As the governor spring is overcome by the centrifical forces in the transaxle, the governor arm rotates, stretching spring and closing throttle on carburetor in order to prevent vehicle from accelerating beyond maximum governed speed. As accelerator pedal is released to medium speed positions, centrifical force form transaxle is no longer greater than the accelerator cable/governor spring capacity. This allows for full range of smooth consistent accelerator operation.

Adjust Accelerator Cable

1. As accelerator pedal is depressed, the long accelerator cable will begin to pull the governor spring and governor arm towards the rear of the vehicle. See Figure 10 (#4 and #6). The accelerator cable must not have slack or free play.

Note: Too much slack or free play will prevent vehicle from achieving normal governed speed. If cable is too tight, throttle will open to soon causing abrupt starting and back fire.

2. Accelerator cable is adjusted with bulkhead fitting at either end. Loosen jam nuts and adjust cable housing toward cable end to add slack or away from cable end to remove slack. Thumb screw (#10) can also be used to adjust cable.

Note: Always, leave enough threads on cable housing for cable dust boots to fit securely.

Removal

To remove accelerator cable, slide dust boot off fitting at cable mount on rear axle. Loosen jam nuts and slide cable out of slotted bracket. Unhook cable from spring (#6). Remove front end of cable from electrical panel.

Installation

Reinstall new cable in reverse order and adjust. Always, check cable adjustment after installation.

Adjust Throttle Cable

There should be 1/8-1/4" of slack between throttle cable ball and governor bracket (Figure 10, #4). This slack ensures that micro switch activates before carburetor opens.

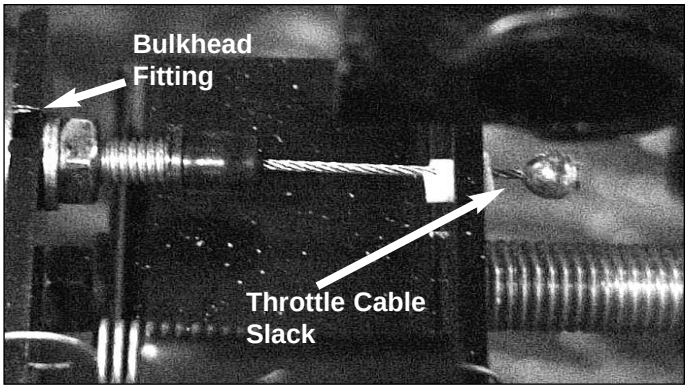


Figure 11 - Throttle Cable

Adjustment

Throttle cable is adjusted at bulkhead fitting, at either end of the cable. Loosen jam nuts and adjust cable housing toward cable end to add slack or away from cable end to remove slack.

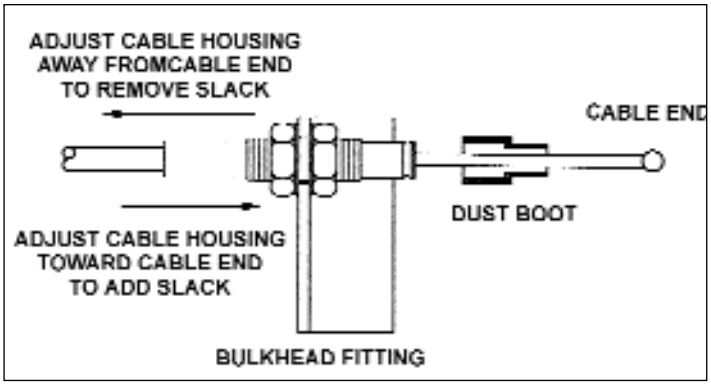


Figure 12 - Cable Adjustment - Typical

Note: Enough threads on cable housing must extend through cable brackets to install cable dust boot.

Removal

Throttle cable is installed into snap fitting at carburetor. Carburetor end of cable has formed "L" hook which is pushed into snap fitting, locking throttle cable into carburetor throttle lever. See Figure 13.

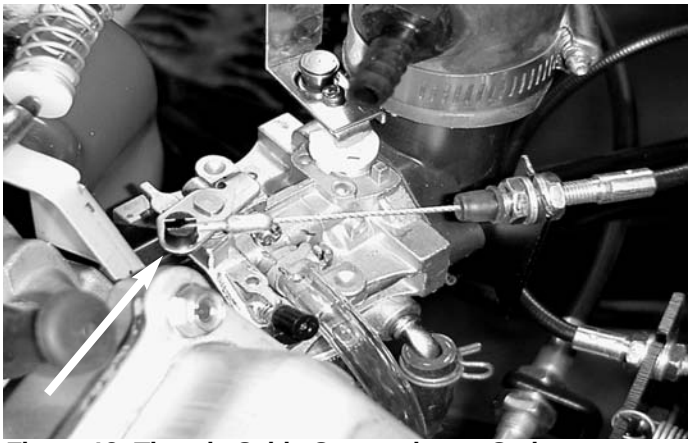


Figure 13- Throttle Cable Connection to Carburetor

To remove throttle cable, use a straight edge screwdriver to lift the cable end from the throttle lever snap fitting. See Figure 13. Loosen the bulk head fittings at both ends of throttle cable, and lift from mount brackets. Push white plastic lock bushing out of governor arm, and lift cable from governor arm slot.

Installation

Reinstall new cable in reverse order and adjust. Always, check cable adjustment after installation.

GOVERNOR SYSTEM

Overview and Operation

Gasoline powered vehicles use a ground speed sensing governor system to maintain speed appropriate to accelerator pedal position. This system consists of an external governor spring (attached to accelerator cable), governor arm, governor shaft (from transaxle), and centrifical fly weight mechanism (inside transaxle).

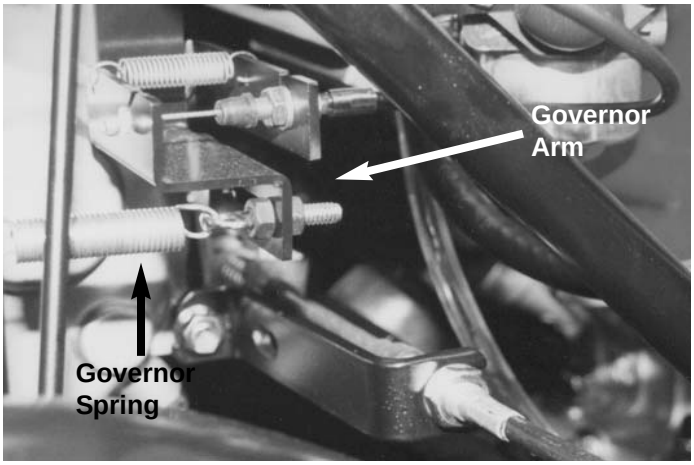


Figure 14 - Governor Arm & Spring

In Figure 10, this system consists of an accelerator pedal with linkage, micro switch (#1), electrical panel (#2), accelerator cable (#3), governor spring (#6), governor arm (#4), and throttle cable (#5).

1. As the accelerator pedal is pressed, the accelerator micro switch (#1) is released, energizing the starting solenoid. At the same time, the accelerator cable pulls the governor spring (#6), pulling the governor arm (#4). The governor arm then pulls the short throttle cable, opening the carburetor.

2. The internal centrifical weights (#23) are spun outwards as the vehicle accelerates. See Figure 15. This movement causes the governor shaft to rotate counterclockwise, pulling the governor arm forward. As the governor arm moves forward, the carburetor throttle closes preventing the vehicle from exceeding the top governed speed.

   As the ground speed is reduced (ascending hills or grades), the governor spring and accelerator cable, pulls the governor arm back, opening the carburetor. This creates more power to maintain the set speed. Alternately, if less power is required (on flat areas or descending grades), the governor arm will pull forward again (stretching the governor spring) and closing the carburetor throttle adequately to prevent excessive speed.

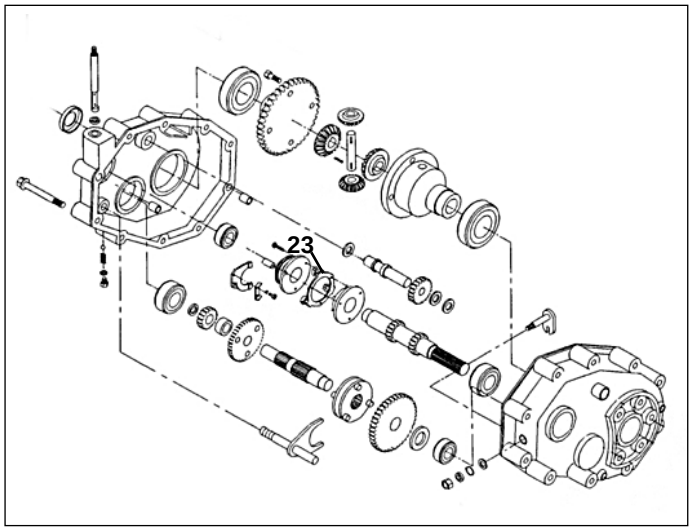


Figure 15 - Governor Components

Periodic Maintenance and Inspection

The components of the governor system rarely require routine maintenance. Refer to page 2-22, for Accelerator Cable and Throttle Cable Adjustments. These adjustments are crucial for speed control proper performance and governor.

Periodic inspection should include:

a. Checking for smooth operation of accelerator and throttle cable.

b. Inspection for damage to cables.

c. Signs of tampering with governor system components.

d. Check maximum governor speed, and adjust if required only after accelerator and throttle cable adjustment have been corrected.

Governor Adjustment

Caution: Always raise rear wheels of vehicle and safely support on jack stands before performing this service.

Note: The components of the governor system rarely require adjustment. Never adjust governor before first verifying that accelerator and throttle cable adjustments are correct. See Accelerator/Throttle Cable Adjustment, page 2-21.

To adjust governor, locate thumb screw and jam nuts securing accelerator cable/governor spring to governor arm. This thumb screw is mounted into a slot on governor arm. If ground speed correction is required to decrease top vehicle speed, slide thumb screw towards transaxle in slot, and retighten jam nuts. If ground speed correction is required to increase vehicle top speed, slide thumb screw and jam nuts away from transaxle, and tighten jam nuts. See Figure 16.

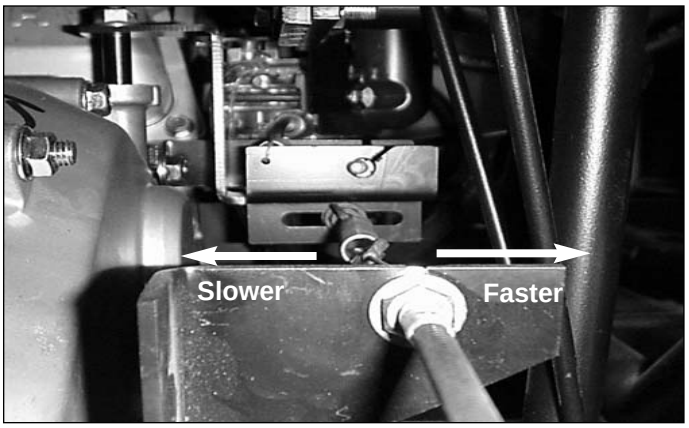


Figure 16 - Governor Adjustment

Warning: The factory has preset the governed ground speed to approximately 14-15 MPH (17 MPH Industrial/Commercial Vehicles), in accordance with A.N.S.I. standards. Adjustment of top governed speed above this standard is not recommended and could cause accident and/or injury.

For service of internal centrifical mechanism, see Transaxle Assembly, Chapter 6.

Electric Vehicle Service

When servicing your electric Columbia ParCar vehicle, always observe the following:

DANGER: When adding water or acid to battery, always wear eye and hand protection.

Batteries contain sulfuric acid. Avoid contact with skin, eyes or clothing.

Antidote:

External- Flush with water for 15 minutes and get immediate medical attention.

Internal- Drink large quantities of milk or water followed by milk of magnesia, vegetable oil or beaten eggs. Call doctor immediately.

Eyes- Flush with water for 15 minutes and get immediate medical attention.

Warning: Always turn vehicle to "OFF", remove key, block tires, and disconnect the negative battery cable before performing any vehicle service to avoid accidental start-up of vehicle and possible personal injury.

Always wear eye protection when servicing the vehicle.

Use only insulated tools when working around batteries or electrical connections. Remove watches and rings to avoid electric shock.

Caution: Do not overcharge battery. Overcharging could cause damage to battery cells.

Battery wire terminals that are damaged or corroded should be replaced or cleaned as necessary. Failure to do so may cause them to overheat during operation.

Electric Vehicle (EV) Charger Operation (Automatic Charger)

a. Battery Charging

Danger: Batteries produce explosive hydrogen gas at all times, especially when being charged. To avoid personal injury, keep cigarettes, open flame and sparks away from the battery at all times. Ventilate area when charging battery. Raise body or seats over batteries while charging vehicle to allow hydrogen gas to escape freely.

Ventilation fans should be located at the highest point in the room, and must be capable of changing the total volume of air in the room five (5) times per hour. Consult a local HVAC engineer.

Warning: Each charger should have its own dedicated 20 ampere (15 ampere in Canada) maximum branch circuit protection (circuit breaker or fuse) in accordance with the National Electrical Code ANSI/NFPA 70, and local codes and ordinances.

Do not use an adapter to plug the charger with a three-prong plug into a two-prong outlet or extension cord. Improper connection of the equipment-grounding conductor can result in a fire or an electrical shock.

Only trained technicians should repair or service the charger. Contact your Columbia ParCar Dealer.

Do not operate the charger if it has received a sharp blow, was dropped, or otherwise damaged in any way.

Have worn, cut or damaged power cords or wires replaced immediately.

Do not use near fuels, grain, dust, solvents, thinners, or other flammables. Chargers can ignite flammable materials and vapors.

Do not expose to rain or any liquid. Keep the charger dry.

Warning: Never push objects of any kind into the charger through cabinet slots. They may touch dangerous voltage points or cause an electrical short that could result in fire or electrical shock.

Do not disconnect the DC outplug from the battery receptacle when the charger is on. The resulting arcing and burning could damage the plug and receptacle and could cause batteries to explode. If the charger must be stopped, disconnect the AC supply plug from the wall outlet before disconnecting the charger DC output plug.

Caution: Do not block or cover slots and openings in the back and bottom cabinet. They provide ventilation and protect the charger from overheating.

Do not allow clothing, blankets, or other material to cover the charger. Provide adequate ventilation for the charger.

Do not leave DC plug plugged in while unattended for more than two (2) days in a row. Severe overheating and damage to the batteries may result if the charger does not turn off.

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

Each electric vehicle is supplied with a fully automatic battery charger as standard equipment. The AC cord to each charger is to be connected to a source capable of supplying 10 amperes minimum per charger.

The battery charger must be grounded to reduce the risk of electrical shock. The charger is equipped with an AC electric cord having an equipment-grounding conductor and a grounded type plug and is for use on a nominal 115 volt 60 Hertz circuit, unless otherwise noted on the charger.

The plug must be grounded to an appropriate dedicated receptacle that is properly installed and grounded in accordance with the National Electric Code ANSI/NFPA 70, and all local codes and ordinances.

The use of an extension cord with the charger should be avoided. If an extension cord must be used, use a three conductor No. 12 AWG heavy duty with a ground conductor in good electrical condition. Keep it as short as possible (no more than twelve (12) feet). Locate all cords so that they will not be stepped on, tripped over, or otherwise subject to damage or stress.

Ventilation fans should be located at the highest point in the room, and must be capable of changing the total volume of air in the room five (5) times per hour. Consult a local HVAC engineer. Correct charging methods extend battery life and vehicle range between charges.

Charge brand new EV batteries completely before they are used for the first time. Charging time will vary based on conditions noted below but will probably be at least 12 hours. New batteries need up to four hours more charging time than “mature” batteries.

Schedule enough charging time, if possible, so that the charger shuts off automatically. Charging time is affected by age of battery, condition of battery, state of discharge, temperature of electrolyte, AC line voltage level, and other variables.

Limit the use of brand new batteries between charging for the first 15-20 cycles. New batteries have less capacity than batteries which have been broken in. New golf car batteries should be limited to 18 holes between charges. New industrial vehicle batteries should not be discharged more than 20-30% (37.38-37.08 volts) before recharging. Following this practice will prevent premature battery failure.

b. Prolonging Battery Life

Whenever possible, for longest battery life, recharge EV batteries as soon as they become 20% discharged (1.1233 SG/37.38 volts). Never allow EV batteries to fall below 80% discharged (1.148 SG/35.94 volts). Deep discharging significantly reduces battery life.

Batteries in storage self-discharge and should be recharged whenever the specific gravity falls below 1.240. Refer to Chapter 8 for proper battery storage.

Battery state-of-charge can be determined by using a hydrometer, or by connecting the charger and observing the charging rate. If the charger ammeter needle jumps smartly to 20-25 amps and then tapers below 14 amps within 15 minutes, the battery is fully charged.

If performance service per charge is affected by the charger electrical supply, check facility for proper wire size, and that the circuit breaker is adequate for charging while giving protection from overload. Check charger instructions, local codes, and your Columbia ParCar Dealer for full details.

Electric Vehicle Recommended Maintenance Procedures

The following maintenance procedures are recommended when servicing your Columbia ParCar electric vehicle. Refer to maintenance checklist for frequency of service. Perform only those maintenance instructions described in this manual. If major repairs are ever needed, contact your local Columbia ParCar Dealer for assistance. Your Columbia ParCar Dealer has the technical experience, training and original Columbia ParCar parts for your vehicle. Always use original Columbia ParCar parts when servicing your vehicle.

Warning: Always turn vehicle to "OFF", remove key, block tires, and disconnect the negative battery cable before performing any vehicle service to avoid accidental start-up of vehicle and possible personal injury.

Always wear eye protection when servicing the vehicle.

Use only insulated tools when working around batteries or electrical connections. Remove watches and rings to avoid electric shock.

The following maintenance procedures are recommended when servicing your Columbia ParCar Electric Vehicle.

a. Battery Charging

Batteries may be recharged if vehicle has been driven 15 minutes or more since the previous charge. Before charging, be sure keyswitch is off, key is removed from the switch, and that the park brake is set. Refer to Chapter 8 for correct charging procedure.

Check electrolyte level. If it is low, add sufficient distilled or low-mineral-content water to cover plates before charging (refer to Chapter 8, page 8-17). Do not fill to the marker until the battery is charged. Electrolyte expands during charging and could overflow if filled to the marker before charging.

Danger: When adding water or acid to battery, always wear eye and hand protection.

Batteries contain sulfuric acid. Avoid contact with skin, eyes or clothing.

Antidote:

External- Flush with water for 15 minutes and get immediate medical attention.

Internal- Drink large quantities of milk or water followed by milk of magnesia, vegetable oil or beaten eggs. Call doctor immediately.

Eyes- Flush with water for 15 minutes and get immediate medical attention.

b. Battery Watering

Correct watering procedures extend battery life.

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

Do not overfill batteries. Electrolyte expands and can overflow during charging. Water added to replace the spillage dilutes the electrolyte and reduces its specific gravity. Cells with lower specific gravity have lower charging capacity. Make sure the electrolyte covers the plates before charging and fill cells to the markers only after batteries are charged.

Use only **distilled water.** Electric vehicle batteries may use up to 16 quarts of water during their useful lives and non-distilled water may contain harmful minerals that will have a cumulative adverse effect on battery performance.

c. Battery Cleaning

Acid-soaked dirt on the battery tops causes current leakage, reduced battery efficiency and higher self-discharge during storage.

Hose wash battery tops periodically with clean, low-pressure water to keep them free of acid spillage, dirt, grass cuttings and other debris. Make sure vent caps are secure before washing. DO NOT hose wash electronic controllers, switches, solenoids, and other electrical control devices.

Wash the tops with a baking soda mixture (1/2 cup per quart of water) and a stiff 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.

Make sure that the battery tops are clean and dry before putting them into storage.

Chassis Lubricaton:

* Place a couple of drops of oil upon each of the rear body hinges.

* Vehicles have seven (7) grease fittings located in the front of the vehicle.

* Three on each A-frame assembly and one on the brake pedal pivot, which should be greased with a high quality chassis grease.

Note: Remove the weight from the front suspension before lubricating to ensure proper grease distribution to suspension components.

Electric Axle Assembly, Std. Tram and & 2400 lb. Utility

Oil check and change intervals.
Check only if signs of leakage are detected, then, check oil level.

Change oil every 24 months or 2000 km (1250 miles), whichever occurs first.

Capacity - 12 ounces (354.8 ml.), SAE 30 wt.

BODIES, SEATS & COMPONENTS

Front Body Removal

Note: Do not remove ParCar or Columbia nameplate on front body as this is not necessary and results in added expense to repair.

1. Remove fasteners from lower edge of bumper cover See Figure 17.

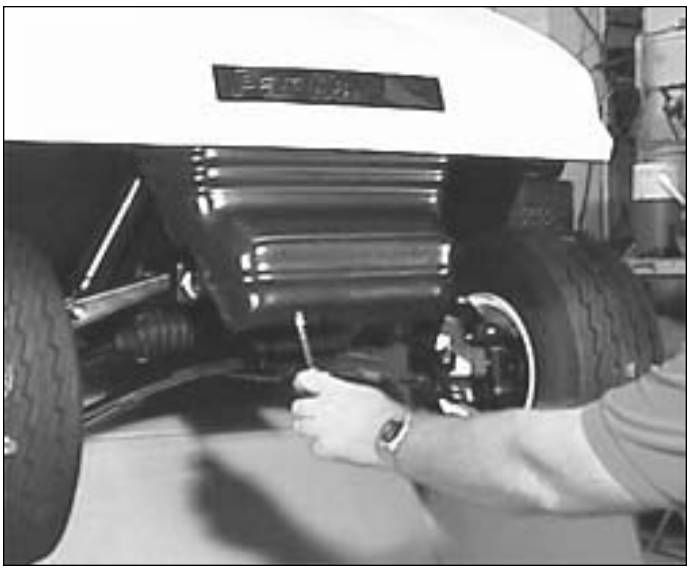


Figure 17 - Front Bumper Cover Removal

2. Reaching under body, remove (2) nuts that attach bumper cover to top shock absorber bolts.
3. Pull bumper cover forward and away from chassis.

Note: Body uses ridged tabs, which extend into slots in console and lock front body in place.

4. Push in on front body where first tab engages console, while lifting front edge of body with other hand. Tab will snap out of console, Figure 18.

5. Locate next tab and repeat operation. Continue until body is completely disengaged from console.

To install front body, perform above procedures in reverse order. Check to ensure that body fits inside of vehicle side trim, before locking into place.

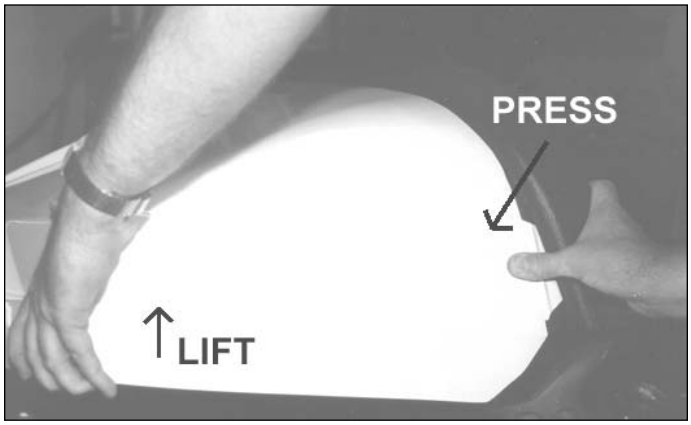


Figure 18 - First Tab on Front Body

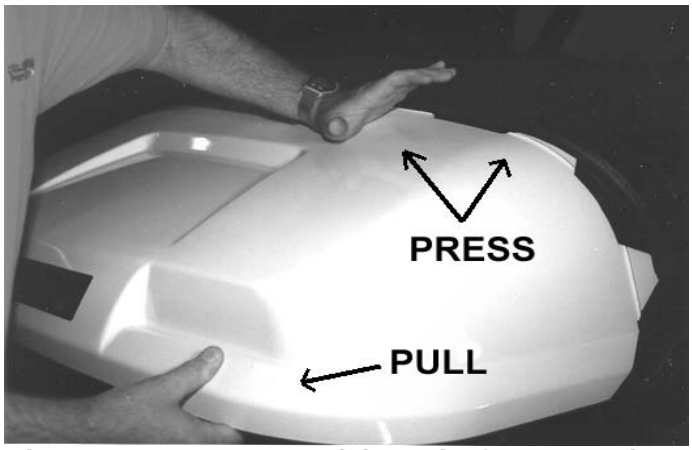


Figure 19 - Remove Remaining Tabs from Console

Refinishing

The Columbia ParCar front body can be refinished, using standard automotive paints and flexible additives.

Repair of cuts, scrapes, and gouges can be accomplished by using “flexible bumper repair” materials. Your local body and paint supply experts will have specific recommendations for materials and procedures.

For best results, follow closely all manufacturers recommendations.

Installation

Install front body and bumper cover in reverse order. Make certain that sides of body are behind side trim, and push into place until lock tabs “snap” securely in place.

SEAT AND HANDRAIL

Seats

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

Note: Do not use harsh chemicals or abrasives to clean seats. Cracking, splitting, or “melting” of materials may occur.

If seat becomes torn or split, seat cover or seat assembly should be replaced.

Handrails

Warning: Never operate Columbia ParCar vehicles without handrails in place. Operation of vehicles without handrails in place could cause accident, injury, or death.

Check occasionally that handrails are securely fastened to bodies.

Should handrails become scratched or nicked, repaint as required to prevent rust from forming.

BAG RACK

Inspection

Periodically inspect bag rack vinyl cover, bag rack buckles and bag strap for damage. Frayed belts or damaged bag rack buckles should be replaced whenever damage is observed. See Figure 20.

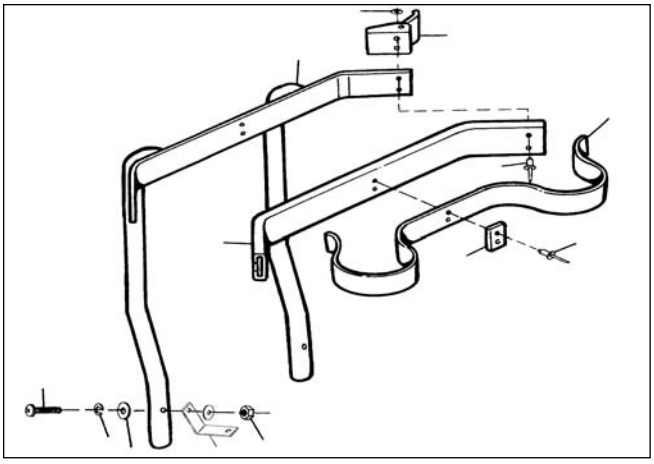


Figure 20 - Bag Rack Assembly

MID AND REAR BODIES

Mid-Body - Golf/Commercial (Fiberglass)

Removal

The fiberglass mid-body, on golf and many commercial passenger vehicles, is designed for quick removal and access for servicing.

To remove mid-body:

1. Locate mid-body restraint strap and remove lock nut securing strap to vehicle chassis.

2. Lift evenly on mid-body to unlock tabs from chassis floor. Set mid-body aside.

Installation

1. Set mid-body into place. Pivot mid-body forward and engage body tabs into slots in floor board.

2. Secure body restraint strap to the chassis. **Do not** overtighten lock nut.

Rear Body (Fiberglass)

The rear body is designed for easy opening for service access. When removal is required, use the following steps:

Removal

1. Lift and open mid-body, then, rear body. Locate body restraint strap, and remove nut securing strap to bag rack. See Figure 21.

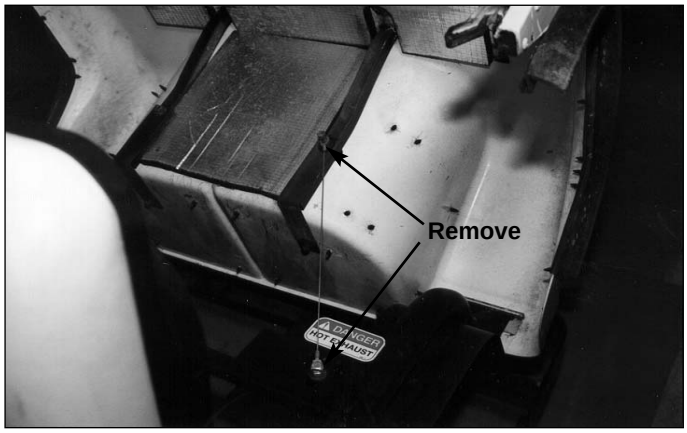


Figure 21 - Rear Body Restraint

2. Close body and remove bolts securing rear body to rear hinges See Figure 22.

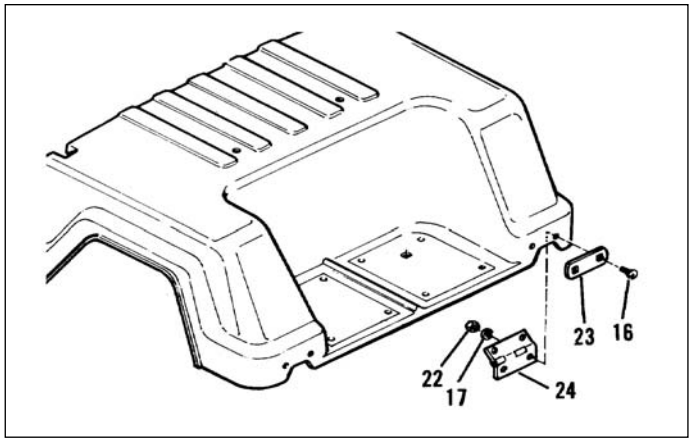


Figure 22 - Rear Body Hinge

3. Lift body from vehicle, and set aside

Installation

1. Set rear body in place on vehicle, making sure that body guide clips are correctly positioned on chassis supports. See Figure 23.

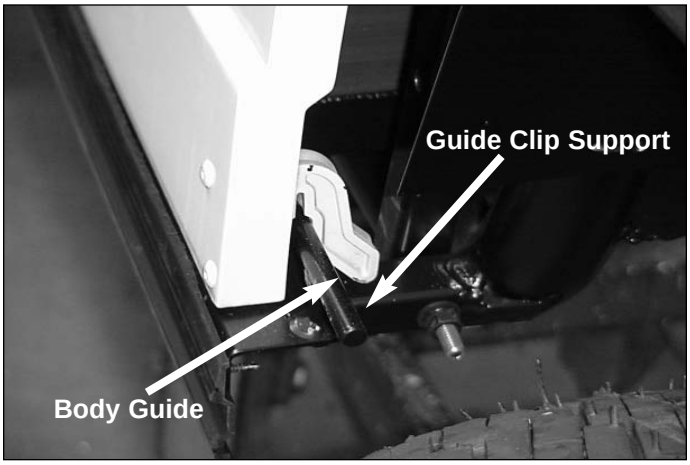


Figure 23-Body Guides

2. Align rear body to hinges. Install mounting bolts from outside, through doubler plates (Figure 22, #23). Tighten hardware.

3. Raise body carefully enough that rear body restraint strap can be connected to chassis. See Figure 21.

Industrial Rear Bodies (Steel Body)

The steel rear body used on the utilitruck and tram vehicles, is designed for easy removal should major servicing be required.

Note: Tram vehicles will require some disassembly of floorboard supports before rear bodies can be removed.

Removal

1. Lift the seat base and remove from vehicle.

   Release four (4) 1/4 turn fasteners, and lift deck plate from vehicle.

2. At front of rear body, locate and remove bolts securing two (2) front hinge brackets to body. See Figure 24, Front Hinge Brackets.

Figure 24 - Front Hinge Brackets

3. Remove bolts at rear of body, securing body to chassis. See Figure 22, Rear Body to Chassis Mounting.

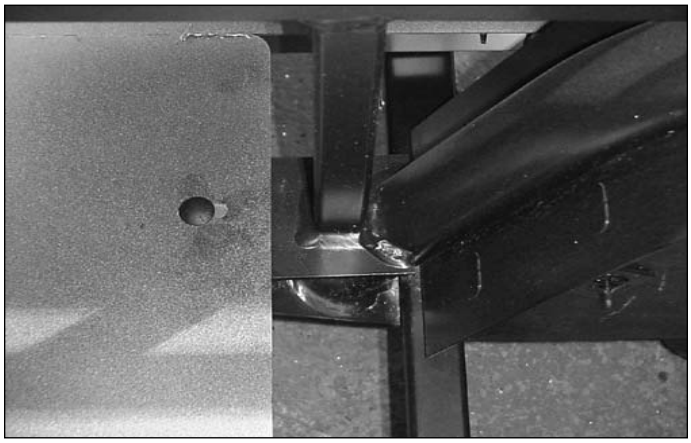


Figure 25 - Rear Body Mount

4. Check to see that wiring for tailights, overhead strobe lights, or other accessories are disconnected before proceeding.

Caution: Use a hoist or additional persons to aid in lifting rear body to prevent damage or personal injury.

Installation:

Caution: Use a hoist or additional persons to aid in lifting rear body to prevent damage or personal injury.

1. At rear of vehicle, position body squarely over chassis so that rear wheels are equally spaced under rear body. Install rear body mounting bolts through rear of body and chassis. Leave loose at this time.

2. At front of rear body, insert front hinge brackets up through slots in floor board, and secure with four (4) bolts.

3. Recheck that rear body is positioned squarely over chassis, and tighten front and rear mounting bolts.

4. Replace seat bottom cushion.

CHAPTER 3

STEERING, SUSPENSION, & FRAME — PAGE

CHAPTER 3

STEERING, SUSPENSION, & FRAME — PAGE

STEERING AND SUSPENSION

Adjustment and Service Specifications

Note: Always completely inspect all vehicles steering and suspension components before making adjustments.

All worn, broken or damaged parts must be replaced before proper adjustment can be performed.

Warning: Always remove key from key switch, and disconnect battery negative cable before performing service on any front suspension steering system. Also, block rear wheels to prevent possibility of vehicle movement during repair.

Warning: Raise vehicle, safely support on jack stands. See Lifting Instructions, Chapter 2.

If your vehicle experiences difficulty with the ball joints on the rack and pinion or the rod ends connected to the steering arms, you must examine front suspension before making alignment adjustments. Check A-arm bushings for wear. Worn, broken or damaged parts must be replaced before attempting steering or alignment adjustments.

Steering Gear Rack and Pinion
(Automotive type totally enclosed lifetime lubrication)

Camber-Mechanical Adjustment.....0°
(Wheels at right angle (90°) to ground)

Toe in Adjustment.....1/4 in. (6.4mm) toe-in

Tie Rod Castle Nuts.....Torque to 25 to 28 ft. lbs. (3.5-3.9 kgm)

Steering Gear Unit
Frame Mounting Bolts.....Torque to 31-33 ft.lbs. (4.3-4.6 kgm)

Clamp Bolts.....Torque to 10-15 ft.lbs. (1.4-2 kgm)

Leaf Spring to King Pin Bolt...Torque to 35-40 ft.lbs. (4.8-5 kgm)

STEERING SYSTEM

Steering Wheel

Steering system is operated by rotating the steering wheel. The steering wheel, in turn, rotates the steering shaft connected to the rack and pinion steering assembly. The rack and pinion steering assembly pushes and pulls on tie rods and tie rod ends, to control front wheel steering. See General information, Chapter 2, for maintenance recommendations and lubrication.

Removal

1. Remove score card holder from steering wheel, by removing two (2) screws under steering wheel. Also, remove two screws securing lower steering wheel cap to underside of steering wheel, allowing cap to slide down steering column.

2. Mark steering wheel and steering shaft in order that steering wheel can be repositioned in original setting when reassembled. Remove nut securing steering wheel to steering shaft.

3. Using an automotive type steering wheel puller, and adapter shown below, remove steering wheel as shown in Figure 1.

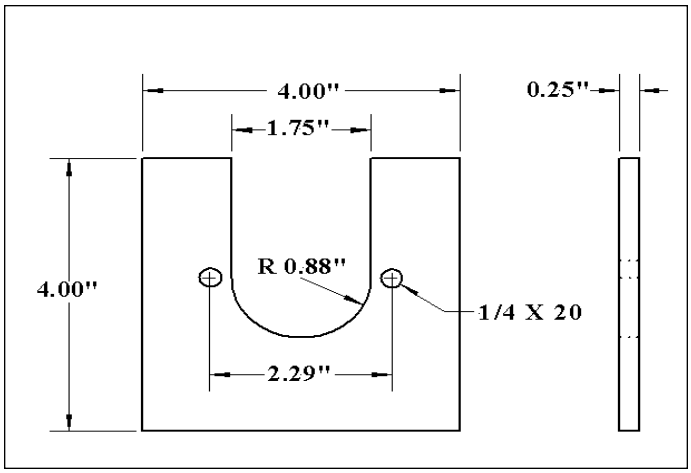


Figure 1 - Steering Wheel Removal

Installation

1. Apply anti-seize compound on to steering shaft splines.

Note: Steering wheel alignment was incorrect originally or if steering system repairs have been performed and must be reset, use the following:

   a. Set steering wheel loosely on steering shaft, and lightly install nut on to steering wheel. Do not torque.

   b. On smooth, level ground, operate vehicle briefly to verify wheels are pointed directly forward, and vehicle is steered straight.

   c. Loosen steering nut, lift steering wheel from shaft and reinstall steering wheel in centered (aligned) position.

   d. Proceed to step 3.

2. Align marks made previously on steering wheel with marks on steering shaft. Install steering wheel on to shaft.

3. Torque steering wheel nut to 22 to 25 ft.lbs. (3.0 to 3.5 Kgm).

Rack And Pinion Steering Assembly

Removal

1. Remove front body as described in Chapter 2.

2. Remove steering shaft clamp bolt securing steering shaft to pinion gear of rack and pinion assembly. See Figure 2.

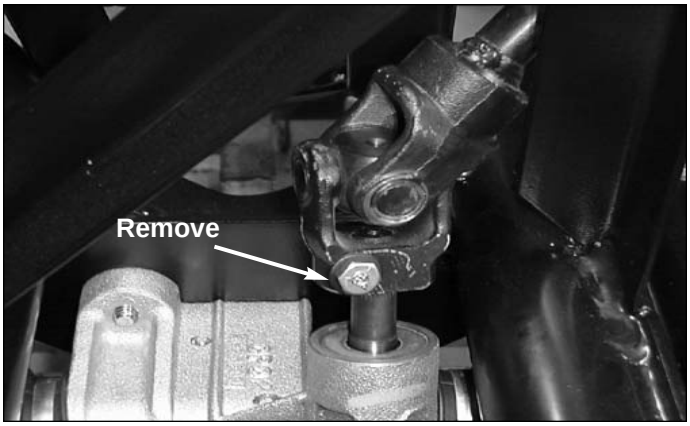


Figure 2 - Disconnect Steering Shaft

3. Move nuts securing each tie rod end to left and right steering arm assemblies. Lift tie rod end from steering arms. See Figure 3.

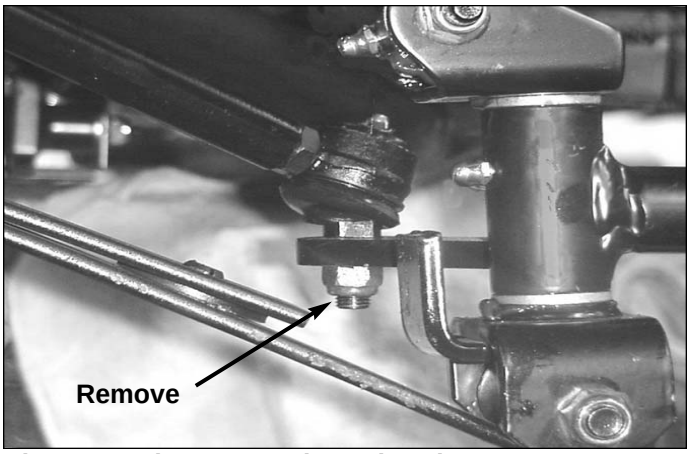


Figure 3 - Disconnect Tie Rod Ends

4. Remove three bolts securing rack and pinion steering assembly to frame. See Figure 4.

5. Remove steering assembly from frame.

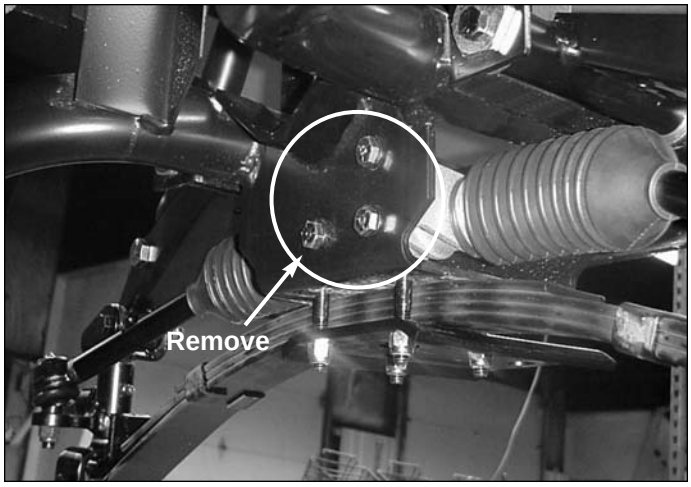


Figure 4 - Remove Steering Assembly

Installation

1. Insert steering assembly into frame. Do not install mounting bolts at this time.

2. Insert steering assembly pinion gear into steering shaft clamp, install clamp bolt. Torque to 10 to 15 ft. lbs. (1.4 to 2 Kgm).

3. Install three (3) rack and pinion mounting bolts through frame and into steering assembly housing. Torque to 31 to 33 ft. lbs. (4.3 to 4.6 Kgm).

4. Insert tie rod ends through steering arm assembly. Install nut, and torque to 25 to 28 ft. lbs. (3.5 to 3.9 Kgm).

5. Install front body, see Chapter 2.

Front Wheels And Hubs

Removal

1. Remove four nuts securing front wheel rim to front hub. Remove wheel.

2. Using a blunt chisel or rod, remove grease cap covering the hub center and bearings.

3. Remove cotter pin securing axle nut, and remove axle nut. See Figure 5.

4. Remove inner seal from front hub, and remove wheel bearings.

Note: Bearings must be replaced whenever removed from wheel hubs.

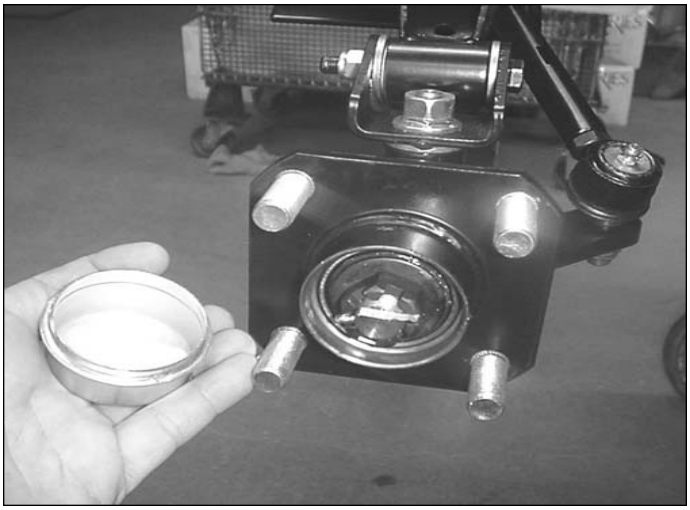


Figure 5 - Front Hub Removal

Assembly & Installation

1. Install new bearings into wheel hub. See Figure 6.

Note: Install bearing with larger inside diameter (Figure 6, #9) to inside of wheel hub. Bearing with smaller inside diameter (Figure 6, #5), to outside of wheel of hub.

2. Apply a quality wheel bearing grease to inside of wheel hub and around bearings. Install grease seal to inside hub.

3. Apply grease to lip of seal (Figure 6, #10), and insert onto hub.

4. Install nut (Figure 6, #2) and washer (Figure 6, # 4), torque nut gently. Spin hub to check for free rotation. If hub does not rotate freely, check that bearings are seated completely in wheel hub.

5. Align slots in nut to cotter pin hole in steering arm, install new cotter pin (Figure 6, # 3).

6. Install grease cap (Figure 6, # 1).

7. Install wheel, lightly tighten wheel nuts in a criss-cross pattern.

8. Torque wheel nuts to 65 ft. lbs. (9 Kgm) in a criss-cross pattern.

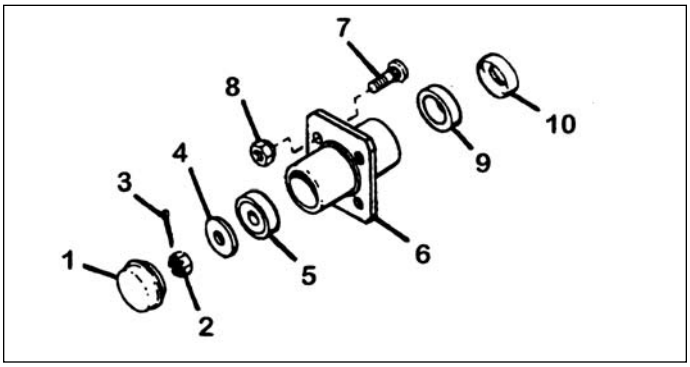


Figure 6 - Front Wheel Hub

Front Suspension

Removal

1. Remove front hub as described in previous section.

2. Remove tie rod end from steering arm.

3. Remove kingpin nut at top of steering arm. See Figure 7, #21.

4. Lift A-arm bracket and A-arm, remove steering arm from kingpin.

5. Remove bolt holding kingpin to leaf spring. See Figure 7, #5.

6. Remove kingpin bracket and bearing spacer from A-arm. See Figure 7, #11 & #19.

7. Remove two bolts holding shock absorber to frame and A-arm. Remove shock absorber. See Figure 7, #26 & #22.

Note: Replace shock absorber if dampening affect is not present when collapsed and extended, or signs of oil leakage are present.

8. Remove long bolt (#12), holding A-arm and camber adjuster to frame. Remove A-arm (# 16), camber adjusters (#18) and washers (#17). See Figure 7.

9. Remove four bolts holding leaf spring retaining plate and leaf spring. Leaf spring can now be removed.

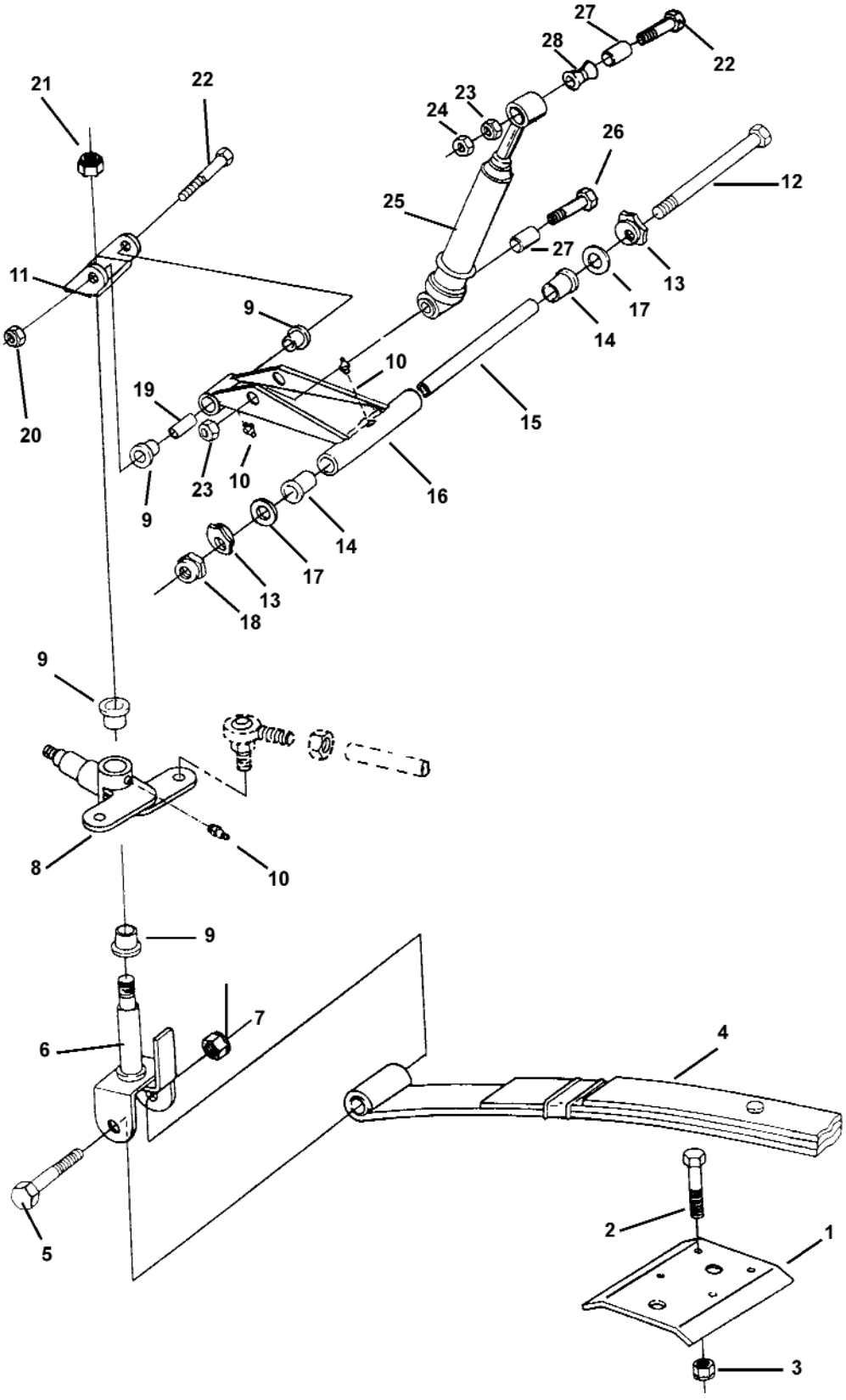


Figure 7 - Front Suspension

Bearing Replacement

Steering arm and A-arm bushings are replaceable. If bushings are worn excessively, replace bushing before reassembly.

1. Using a long blunt punch, drive bushing from steering arm or A-arm.

2. Clean all parts in cleaning solvent.

3. Using a press or vise with soft jaws, press bushing into steering arm or A-arm making sure bearing are seated completely.

4. Insert kingpin into A-arm to check that kingpin moves freely without binding. Insert Spacer into A-arm to check that spacer moves freely without binding.

Note: If binding occurs bearing may not be correctly seated or bearing may have been damaged during installation.

Installation

1. Hold leaf spring and leaf spring retaining plate under frame, insert four bolts down through frame and retaining plate. Snug four bolts evenly in a criss-cross pattern, making sure that leaf spring center bolt is centered in frame opening. Torque bolts to 30 ft. lbs. (4.1 Kgm). See Figure 8.

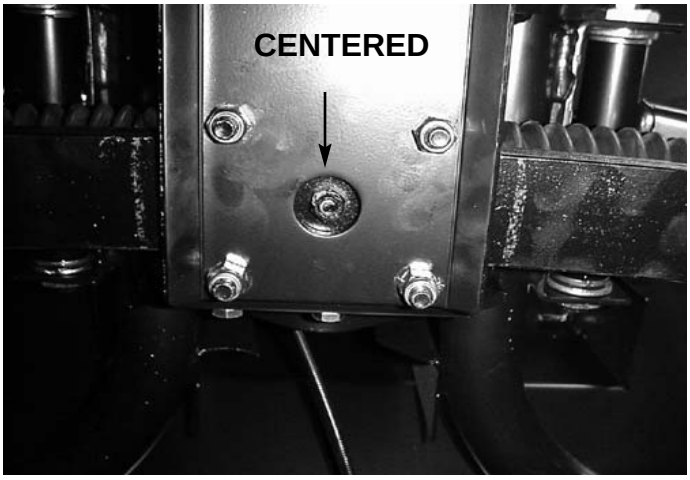


Figure 8 - Center Leaf Spring

2. Assemble A-arm with long and short spacer (#15 & #19), camber adjusters (# 13), washers (#17) and long bolt (#12) into frame. Do not torque at this time. See Figure 7.

3. Install shock absorbers (#25). See Figure 7.

4. Install kingpin bracket, and torque to 30 ft. lbs. (4.1 Kgm).

5. Install kingpin on leaf spring. Do not torque at this time.

6. Slide steering arm onto kingpin, insert kingpin through kingpin bracket. Install kingpin nut, torque to 30 ft. lbs. (4.1 Kgm). Now torque leaf spring bolt to 40 ft. lbs. (5.52 Kgm).

7. Install front hub as described on page 3-3.

8. Install front wheels as described on page 3-7.

9. See page 3-6 for adjustment of camber and steering toe in.

Rack and Pinion Assembly Repair

Disassembly

1. Remove oil seal from pinion gear. See Figure 9 #15.

2. Remove large retained ring from steering housing and lift pinion gear from housing (Figure 9 #14).

3. Remove tie rod ends with jam nuts from tie rods.

4. Remove clamp from boot at each end of housing (Figure 9 #2). Slide boots (Figure 9 #1) from housing.

5. Using a chisel, drive both lock tabs away from both tie rod ball joints. Unscrew tie rod ball joints from rack gear.

6. Remove rack gear (Figure 9 #7) from steering housing.

7. Clean all parts in cleaning solvent.

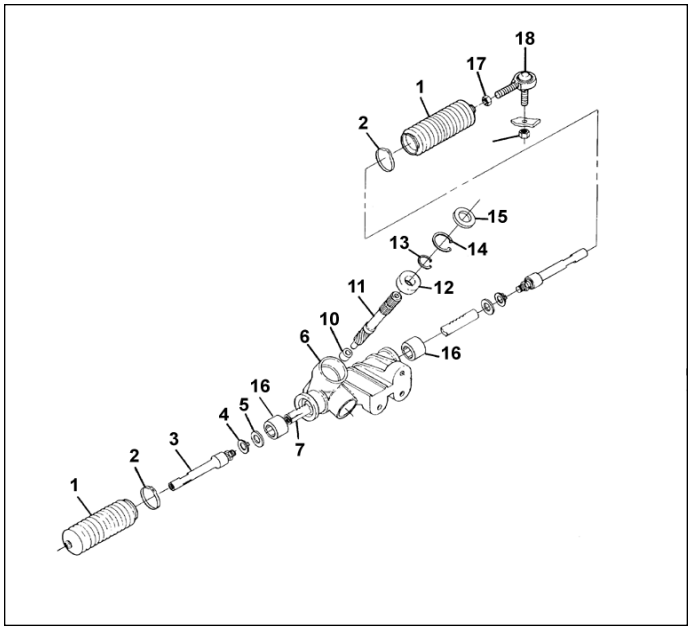


Figure 9 - Rack and Pinion Assembly

Assembly

1. Using a quality wheel bearing grease liberally lubricate all steering parts and inside of steering housing.

2. Insert rack gear (Figure 9 #7) into housing. Insert pinion gear (Figure 9 #11) into top of steering housing, align pinion gear to rack gear.

3. Insert retaining ring (Figure 9 #12) to lock pinion gear and bearing into steering housing

Note: Check that retaining ring is fully seated into housing before continuing.

4. Install additional grease over pinion bearing, insert oil seal (Figure 9 #15) into housing over pinion gear.

5. Thread tie rod with retaining washer (Figure 9 #5) and lock washer (Figure 9 #4) into rack gear ends. Use locktite on threaded area. Torque ball joint and bend lock tab against ball joint to prevent loosening. Repeat on opposite side.

6. Liberally, grease ball joints. Slide boots over tie rods and clamp to housing.

7. Install tie rod ends with nuts, to tie rods and leave loose.

8. See steering adjustment section for correct steering adjustment.

Note: See Page 3-2 for Rack and Pinion Steering Assembly Installation.

STEERING AND SUSPENSION ADJUSTMENT

For steering and suspension adjustment, always place vehicle on flat, level surface. Position front wheels to point directly forward.

Note: Always check that camber is correct before proceeding to wheel toe adjustment.

Warning: Always remove key and disconnect battery negative cable before servicing vehicle.

Camber Adjustment

1. Loosen camber adjusting bolt. Each camber adjuster has a dimple in the same position. Check that both camber adjusters (dimples) are set in the same position.

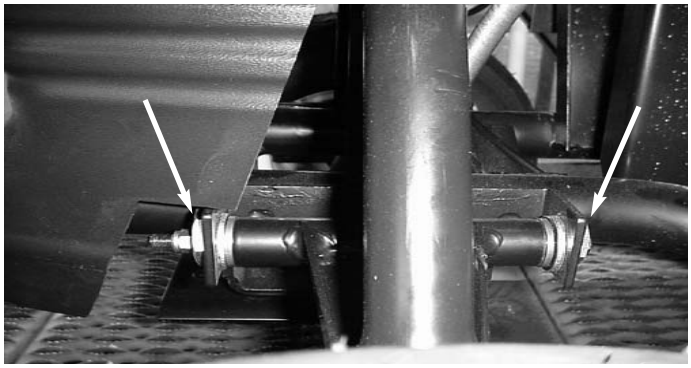


Figure 10 - Camber Adjusters

2. Place carpenters square against each front wheel one at a time. Check that each wheel is straight up and down.

3. If wheel is not vertical, rotate both chamber adjusters on one A-arm equally until wheel is vertical. Repeat process on opposite front wheel.

4. Torque front A-arm and chamber adjusting bolt to 25 ft. lbs. (3.5 Kgm).

Toe In Adjustment

For best results, perform toe adjustment on flat, level surface. Do not raise vehicle when checking adjustment.

1. With wheels pointed directly forward, loosen jam nuts on tie rod ends.

2. Using a rod or stick approximately 27 to 27 1/2 inches long, check distance between front of front wheels. Using the same stick or rod, gauge the distance between the rear of front tires.

3. The distance between tires at the front should be 1/4 inch to 1/8 inch less than the distance between tires at the rear.

4. If distance between tires (toe in or toe out) is not correct, rotate tie rod to adjust as required.

5. Torque jam nuts against tie rods when adjustment is complete.

6. Recheck to verify that vehicle has 1/8 to 1/4-inch toe in.

Tire And Wheel Assembly

Maximum tire life and good handling qualities are directly related to the wheels and tires. See routine maintenance schedule (Chapter 2) for inspection intervals.

Removal

1. Remove hubcap and slightly loosen wheel mount nuts.

2. Lift vehicle her lifting instructions, Chapter 2.

3. Remove wheel mounting nuts and tire and wheel assembly.

Installation

1. Install tire and wheel assembly to hub with mounting nuts. Snug mounting nuts in a criss-cross pattern.

2. Install wheel nuts in a criss-cross pattern. Torque to 65 to 70 ft. lbs. (9.0-9.7 Kgm).

Tires

General

Note: In the event of a flat tire, remove wheel per this section. Inflate tire to 20 P.S.I. (1.33 Atm.). Immerse tire and rim in water to determine point of leak. Mark point where air escapes. Leak could be due to any of the following: Puncture of sidewall or trend area, faulty valve core, valve stem leaking at rim, or tire bead improperly seated.

When reason for loss of air as been determined, removal of tire from rim may be necessary. Always clean and lube bead before remounting tire to wheel.

Removal

Important: Tire must be removed or installed from valve stem side of rim.

1. Remove tire and wheel assembly, this section.

2. Remove valve cap and valve core to free air from tire.

3. It tire machine is unavailable, use tire irons to work the ball of wheel in small steps. See Figure 11.

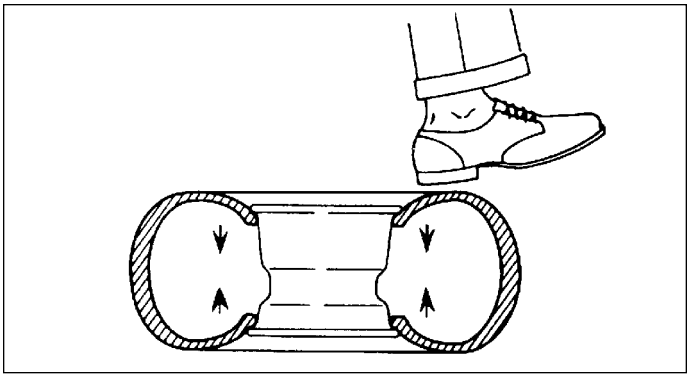


Figure 11 - Break Bead of Tire From Wheel

4. Push tire off wheel flange into wheel well. See Figure 12

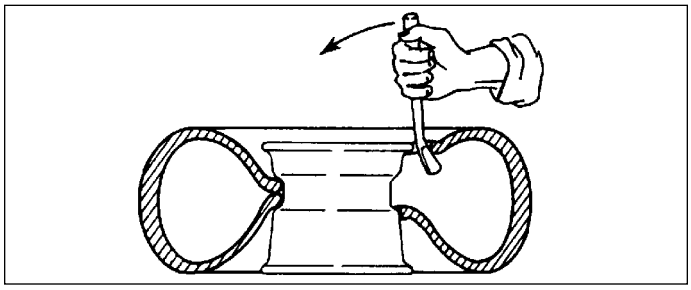


Figure 12 - Drop Tire to Center

5. Apply tire-mounting lubricant to tire bead.

6. With valve stem side up, carefully start upper bead for edge of rim with tire tool. See Figure 13.

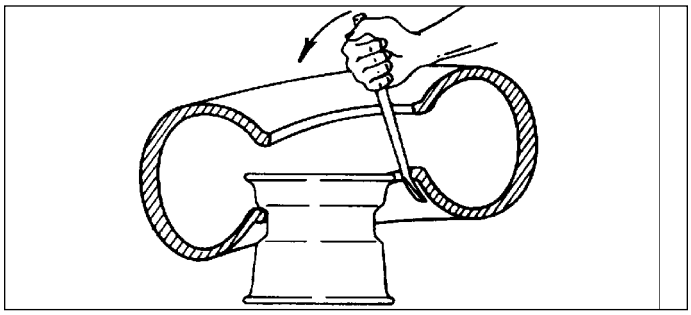


Figure 13 - Remove Tire

Caution: Do not use excessive force when starting the edge of wheel, or tire bead may be cut and damaged.

7. When top bead is free from wheel, shift lower bead into wheel well on one side of wheel and insert tire tool on opposite side. Pry lower bead over wheel flange. Tire can be removed by hand.

Installation

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

1. Clean tire beads to remove dirt and foreign matter.

2. Use a wire brush to clean wheel where tire beads seat.

3. Check valve stem. Replace worn or leaking valve stems.

4. **Important:** Cleaning tire and wheel is very important, as tubeless tires require a perfect seat to seal.

5. Apply liberal amount of tire mounting solution to both tire and wheel.

6. Install tire on wheel from valve stem side. If tire machine is unavailable, use rubber mallet and tire iron to install tire on wheel. See Figures 12 & 13.

7. Remove valve stem core and position tire so tire bead is seated on bead area.

8. Place tire upright against wall and push against tire on side opposite wall. This 3-point contact will tend to bring bead out to contact wheel so that internal pressure is formed end beads snap into place as air is applied through valve stem. See Figure 14.

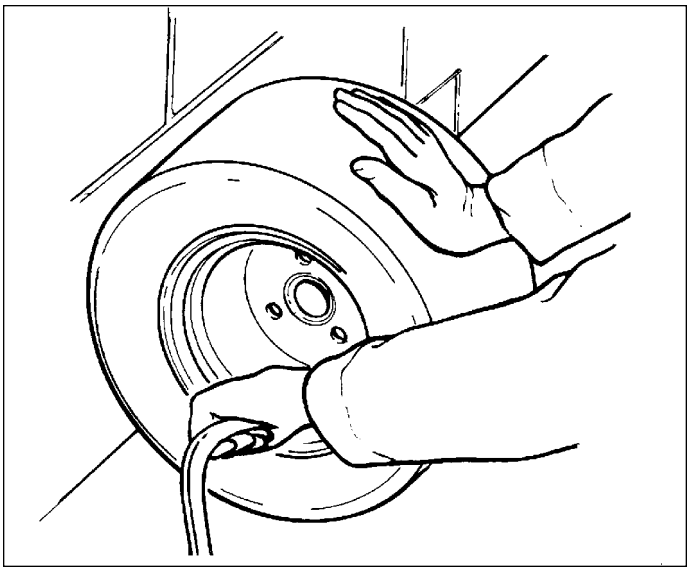


Figure 14 - Tire Inflation

Warning: Caution must be used when inflating a tire to a high-pressure air supply. Due to low pressure requirements of a small tire, over inflation may be reached in a matter of 2 or 3 seconds. Over inflation could cause tire to explode resulting in possible personal injury.

9. Apply high-pressure air through valve stem. 30 to 35 P.S.I. should be used to seat tire bead to space.

10. Quickly, remove air pressure and install valve stem-core.

11. Inflate tire to correct pressure and immerse in water to check for leaks.

12. Install tire and assembly per instructions on page 3-7.

REAR SUSPENSION

Warning: Always, secure body in upright position to avoid possible personal injury due to accidentally closing of rear body. Always, remove body for rod from clip and insert into slot in rear frame, to safely support rear body when servicing.

Shock Absorbers

Inspection

Check the shock absorbers for fluid leakage at the point where shaft enters body. Leaking shock absorbers should be replaced. Remove as follows.

Removal

1. Remove upper and lower mounting bolts. See Figure 15.

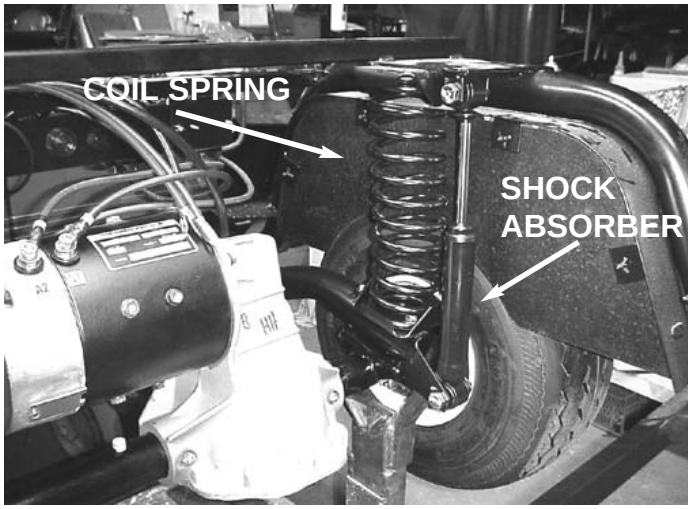


Figure 15 - Rear Shock Absorber and Spring

2. Remove shock absorber.

Installation

1. To install the shock absorbers, extend to full length.

2. Place lower end of shock absorber into mount bracket on rear fork. Install bolt and nut.

3. Extend shock absorber, and insert upper end into top mount bracket in rear frame. Install bolt and torque to 50 ft. lbs. (6.9 Kgm).

Rear Springs

Note: Coil springs are rated by the force needed to compress them one inch. For example; the standard straight wound rear spring, rated at 80 pounds per inch, will compress one inch under a force of 80 pounds. A similar force would be required to compress the spring an additional inch, and so on.

Removal

1. With vehicle raised and the rear fork supported on jack stands (see page 6-5, Figure 8), remove two shock absorber bolts. See Figure 15.

2. Using a floor jack, raise the frame from the axle and suspension rear fork.

Caution: Use care when raising frame or lowering axle, control cables or electrical wiring could be damaged if frame and rear fork are separated excessively.

3. Lift springs from retaining brackets on rear fork.

Installation

1. With frame raised, set rear springs into retaining brackets on rear fork.

2. Slowly lower frame until top of springs are retained in frame retaining brackets.

Caution: Use care to avoid fingers or other body parts from becoming pinched between frame and springs.

3. Lift shock absorber ends into frame brackets. Insert shock absorber bolts and torque to 50 ft. lbs. (6.9 Kgm).

Rear Fork

Removal

1. Lift vehicle per lifting instructions.

2. Remove battery from vehicle.

3. Remove rear axle as described on page 6-4.

4. On gas vehicles, remove exhaust as described on page 7-58.

5. On gas vehicles, remove engine as described on page 7-32.

6. On gas vehicles, disconnect the wire harness from electrical panel and electrical components.

7. Remove rear shock absorbers and springs per previous section.

8. Remove two bolts with washers from rear fork mounts. Separate fork from frame. See Figure 16.

9. On gas vehicles, remove engine mount plate and engine plate suspension mounts.

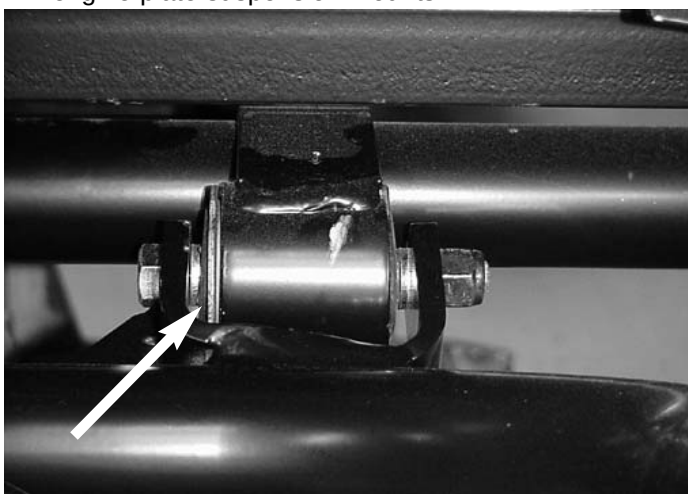


Figure 16 - Rear Fork Bushing and Bolt

Danger: Rear fork bushings are installed under extreme pressure. If bushings require replacement, specialized equipment will be required to press old bushings from frame and new bushings into frame.

Installation

1. On gas vehicles, install engine mount plate and suspension mounts. See Figure 17.

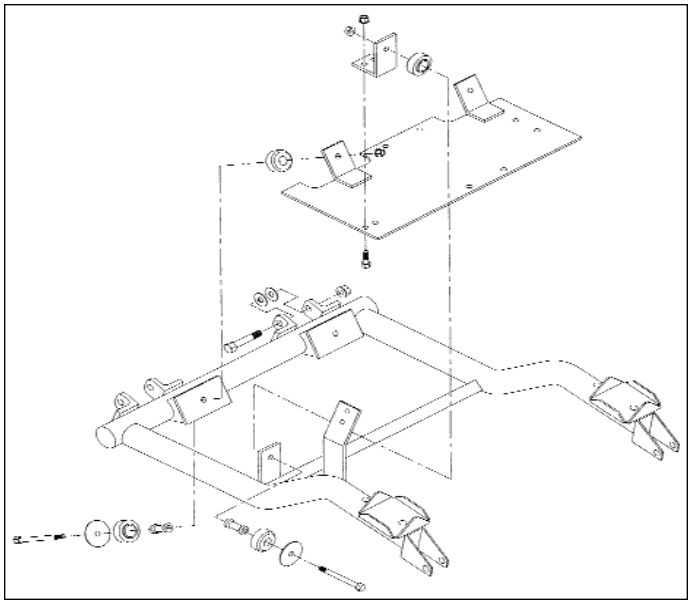


Figure 17 - Engine Mount Plate Assembly

2. Place rear fork into frame and align fork mounts to frame. Insert bolts using spacer washers as required to take up clearance between mounts and bushings. Install lock nuts.

3. Torque to 45 ft. lbs. (6.2 Kgm).

4. Install rear shock absorbers and springs. See Page 3-8.

5. On gas vehicles, reconnect the wire harness to electrical panel and electrical components.

6. Install engine. See Chapter 7, page 7-33.

7. Install exhaust. See Chapter 7, page 7-59.

8. Install axle assembly. See Chapter 6, page 6-12.

9. Install battery into vehicle.

Frame

Servicing

If incorrect frame alignment is suspected, contact Columbia ParCar Technical Service Department for frame specifications.

Warning: For maximum safety and reliability, replace vehicle if frame is severely bent or damaged. Factory repair is not available and only qualified welding technicians must perform field welding or repair.

CHAPTER 4

CHAPTER 4

BRAKE SYSTEMS — PAGE

MECHANICAL BRAKING SYSTEM

System Overview

The mechanical braking system consists of two wheel rear drum brakes. This system is standard on all vehicles except trams and vehicles with a 2400 lb. load capacity.

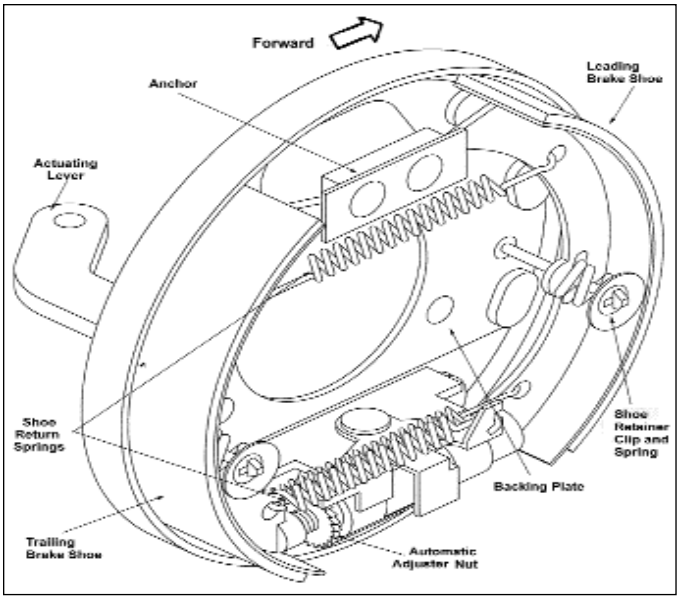


Figure 1 - Mechanical Drum Brake Assembly

Mechanical Brake Assembly (Figure 1) includes these components:

a. Brake shoe anchor
b. Brake drum (not shown)
c. Backing plate and dust boot (not shown)
d. Two lined brake shoes attached backing plate
e. Shoe return springs, retainer spring, and clip parts. Shoe toward front of vehicle is called leading shoe and shoe toward rear is called trailing shoe. Leading shoe normally has a shorter lining than trailing shoe lining.
f. Automatic Adjuster Assembly
g. Mechanical actuating lever

Note: Mechanical drum brakes are self adjusting and do not require manual adjustment.

Operation

1. Rear drum brakes are actuated by foot brake pedal and mechanical linkage.

2. A brake equalizer is used to evenly pull both brake cables. The brake equalizer floats to create equal tension to each brake cable. See Figure 2.

3. Brake shoe to drum adjustment is automatic and does not require manual adjustments. Each time brakes are applied, shoes expand outward to drum. If brake shoe travel exceeds minimum, adjuster will advance to compensate for wear. As brakes are released, adjuster returns to normal position to repeat the process as necessary. No adjustment occurs if shoe to drum clearance is within normal limits.

4. Parking brake is applied by depressing parking brake pad at top of brake pedal. See Figure 2. Pressing on park brake pad applies brakes and locks pedal in applied position. Parking brake is released by depressing on main brake pedal or by depressing accelerator pedal

Periodic Inspection

Interval between brake service and inspection may vary depending on factors such as:

1. Driving habits
2. Type of driving (stop and go)
3. Road and climate conditions
4. Vehicle load

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

Periodic inspection should always include the following:

a. With vehicle stationary, depress pedal and monitor for minimum 1/4 inch pedal free travel before resistance is felt. Maximum pedal free travel not to exceed 2 inches measured from floor board to top of pedal.

b. Inspect cables under vehicle for physical damage, corrosion, or fraying.

c. Operate vehicle on level ground, applying brakes to ensure that both rear brakes apply equally. Also, check that excessive force is not required to apply brakes. Excessive force required to apply brakes could indicate malfunctioning brake cables or excessive wear to brake shoes.

Annual Maintenance Inspection

To perform this service, raise vehicle using floor jack and safely support with jack stands positioned under main frame tubes.

1. Remove rear wheels. Remove cotter pin at axle nut, and remove axle nut.

2. Remove brake drums. For brake drum removal, it may be necessary to retract the brake shoes. The brake adjuster can be accessed through an inspection opening in the back side of the brake drum.

3. Inspect drum for excessive or uneven wear. Maximum drum inside the diameter equals 6.635 inches (168.4 mm). If drum is worn beyond service limit or uneven wear is observed, drum must be replaced.

4. Inspect brake shoes for thickness, uneven wear or physical damage. If brake shoe lining, at any point, is measured to be less than 1/16 inch (1.6 mm), brake shoes must be replaced. Also, inspect for oil or grease contamination, and replace brake shoes if contamination is present.

5. 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.

6. Install brake drum. Torque axle nut to minimum 65 ft. lbs. Tighten additionally, as required, to align cotter pin slot with cotter pin hole in axle. Install cotter pin and bend ends to secure axle nut.

7. Install rear wheels. Lightly torque four lug nuts evenly. Then, retorque in criss-cross fashion to 65 to 70 ft. lbs.

8. Inspect dust boot at brake actuating lever. If cracked or split, replace dust boot.

Adjustments

Mechanical Brake Linkage

Note: Correct rear brake operation should be confirmed before adjustments are made to cables and mechanical linkage. Also, check to ensure corrosion has not caused excessive resistance in the operation of brake cables before cable and linkage is adjusted.

Depress brake pedal. If pedal travels in excess of 2 inches, adjustment of linkage and cables will be required.

1. Locate, under the vehicle, the brake rod connecting brake pedal to brake equalizer. Loosen jam nuts at each end.

2. Rotate brake rod to shorten the length from brake pedal to equalizer.

3. Adjust length of brake rod until free brake pedal movement is less than 1/4 inch.

4. Secure jam nuts to prevent rod from rotating.

Note: Excessive brake rod and cable tension could cause automatic adjusters in the rear brakes to become inoperative.

Mechanical Park Brake Adjustment

Once the rear brake operation has been confirmed and brake linkage and cables have been adjusted, the park brake adjustment can be checked and corrected if necessary.

1. View down through the opening of the floor board while gently pressing on the brake pedal pad. As you press on the brake pedal pad, observe the space or gap between the brake ratchet end and the brake ratchet pawl (Figure 2). This gap should be no greater than 1/8 inch and no less than 1/16 inch.

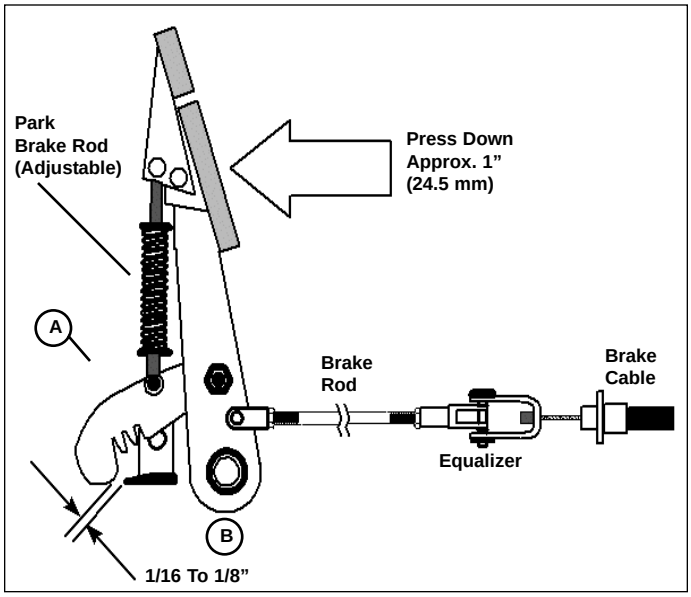


Figure 2 - Brake and Park Brake Adjustment

2. If adjustment is required, remove the clevis pin from the park brake pad, securing the park brake rod. This threaded rod can be lengthened or shortened to adjust its length. If the observed gap between the park brake ratchet and the park brake pawl is less than 1/16 inch, the rod must be shortened slightly to adjust. If the gap between the park brake ratchet (A) and the park brake pawl (B) is in excess of 1/8 inch, the park brake rod should be lengthened to adjust.

3. Reconnect the park brake rod to the park brake pad or pedal. Recheck space between park brake ratchet and park brake pawl to verify correct gap of 1/16 to 1/8 inch.

4. Depress the park brake pedal, and push pedal assembly down until the first click is heard. At this setting, the vehicle should not roll on a slight incline. Depress the park brake pedal down to the second click or notch. With the park brake set at the second click or notch, the vehicle should not roll on a steep incline or hill.

5. If when checked on a steep incline, or on a subtle incline, the vehicle's park brake would not hold as described above, refer to mechanical brake linkage for brake cable and brake rod adjustment.

Mechanical Drum 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.

Brake Cables

Removal/Installation

Raise the vehicle using a floor jack, support the vehicle with jack stands positioned on frame members, and block wheels to prevent vehicle from rolling accidentally.

1. At rear brake assembly, remove cotter pin and clevis pin from brake cable.

2. Remove "e" clips from brake cable housing, and remove cable from brake cable bracket at rear wheel.

3. Locate "e" clip at front end of brake cable, and remove "e" clip.

4. Slip ball end of brake cable from equalizer, and remove cable from vehicle.

5. Install new cable in reverse order.

Note: Refer to mechanical brake adjustment section for adjustment of brake cables.

Note: Some vehicles use retainer clamps to hold brake cables to rear fork of vehicle. These must be removed before cable removal begins, and installed after replacement cables are in place.

Brake Assembly Service

Disassembly and Assembly Tips

General

1. Before removal of existing parts, note location of colored springs and other parts for correct reassembly.

2. Always, use brake spring tool to remove and install springs.

3. Always, lay out brake shoes and other parts in order as removed. Reinstall in same order. Refer to Figure 3 for correct assembly.

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

5. Always, replace brake shoes which have been contaminated with oils or lubricants. Always, replace cotter pins and similar crimp type fasteners upon removal.

6. Always, replace any springs which appear to have been stretched or deformed.

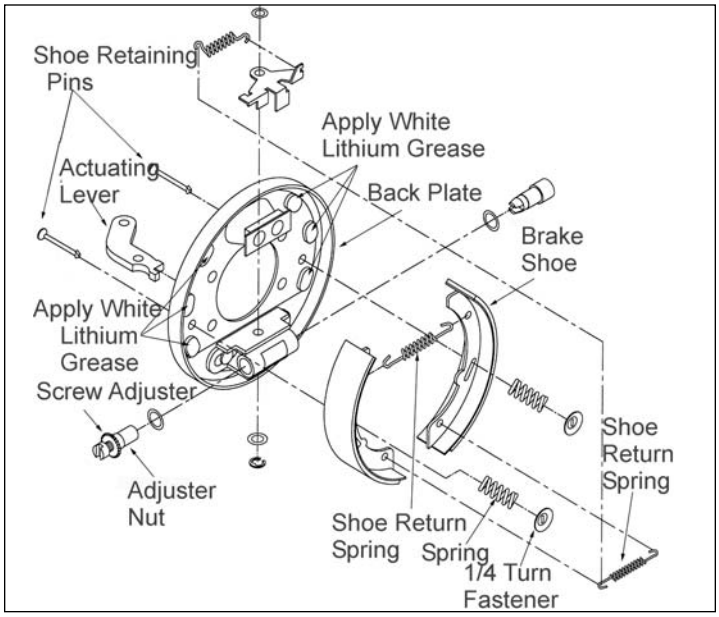


Figure 3 - Mechanical Drum Brake Components

Disassembly

1. Refer to annual maintenance inspection (Page 4-1) for brake drum removal.

2. To remove brake shoes, locate the shoe retainer springs and 1/4 turn fasteners. Holding the 1/4 turn fasteners with pliers, rotate them 1/4 turn, and the fastener and spring can be removed.

3. Grasp the two brake shoes at the centers and pull them outward and they will fold away from the back plate. Next, lift one shoe at a time from the brake anchor and the springs and shoes can be removed from the brake back plate assembly. Be sure to lay your parts out in the same order as removed. This will ease reassembly. Also, slide the automatic adjuster screw and automatic adjuster nut from the brake assembly.

4. Wash any mud, brake debris, and dirt from the brake plate.

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

Assembly

1. Before assembly, remove the automatic adjuster screw from the automatic adjuster nut and clean the parts thoroughly. A small amount of white lithium grease can be used on the threads of the automatic adjuster screw before reassembly. Wipe the brake plate dry, and apply a small amount of white lithium grease to the contact points where the brake shoes rest against the brake plate.

2. Install the automatic adjuster screw and nut into the automatic adjuster assembly. Reconnect the original springs, top and bottom shoe return springs, to the new brake shoes in the same order as removed. The brake shoes may not be exactly equal in length. The shoe with the shorter brake lining will always be on the side of the brake assembly closest to the front of the vehicle. The shoe with the longer lining will always be to the rear of the vehicle.

3. With the springs attached to the brake shoes, first hook the bottom of each brake shoe, one at a time, into the slots on the automatic adjuster screw and opposing retainer. Next, hook the top end of each brake shoe behind the anchor at the top of the brake plate. Then, fold the ends of the shoes inward towards the brake plate and secure them in place with the brake shoe pin, retainer spring, and 1/4 turn fastener.

4. Install the brake drum, castle nut or axle nut, and torque to a **minimum** of 65 ft. lbs. If necessary, continue tightening nut until cotter pin slot aligns with axle hole. Install cotter pin.

Trouble Shooting
Drum Brakes

Dragging Brakes

(Slow or incomplete release of brakes)

1. Shoes and Linings
   a. Shoes improperly adjusted - adjust.
   b. Shoes distorted or incorrect - replace with new brake shoes.
   c. Linings soiled with grease or oil - replace with new brake shoes.

2. Mechanical Parts
   a. Return springs incorrect or weak - replace.
   b. Torque spider loose - tighten.
   c. Cables and linkage sticking, dirty or corroded - free up and lubricate.

3. Wheel Bearings
   a. Damaged or grease contaminated - replace
   b. Grabbing or Pulling - replace

Severe reaction to pedal pressure and uneven stoping

1. Shoes and Lining
   a. Shoes improperly adjusted - adjust.
   b. Shoes distorted or incorrect; linings incorrect, loose or soiled - replace with new brake shoes.

2. Mechanical Parts
   a. Shoe return springs weak, broken, improperly installed -- replace or install correctly.
   b. Wheel bearings loose - adjust.

3. Drums
   a. Thin (expanding when hot): oversize (beyond .030 inch) of original specification -- replace.
   b. Scored, out-of-round - replace.
   c. Noise and Chatter - replace

Squealing, clicking or scraping noises upon application of brakes

1. Shoes and Lining
   a. Shoes twisted, distorted, incorrect, or broken; cracked welds - replace with new brake shoes.
   b. Linings worn out, glazed, incorrect, loose or soiled; foreign matter embedded in linings; incorrect - replace with new brake shoes.

2. Mechanical Parts
   a. Shoe return springs weak; backing plate loose or failed; hold-down parts failed - replace.

3. Drums
   a. Thin; cracked; loose; scored: -- replace.

HYDRAULIC BRAKING SYSTEM

System Overview

2400 lb. Utilitruck and Tram vehicles come standard with hydraulically operated drum brakes.

2400 lb. Utilitruck and Tram vehicles can be equipped with additional disc brakes on front wheels. See Disc Brake Section for details.

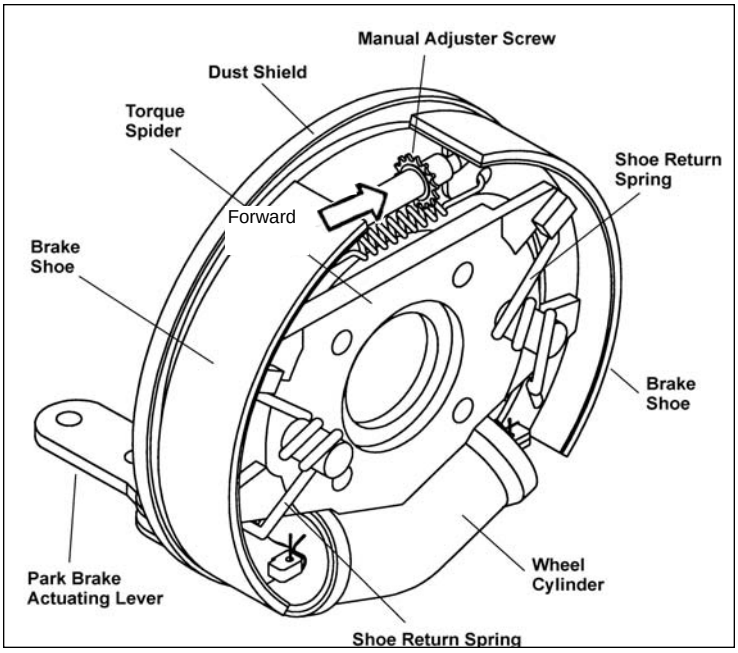


Figure 4 - Hydraulic Drum Brake Assembly

Hydraulic drum brake assembly (Figure 4) includes these major components:

a. Brake drum (not shown)
b. Cast torque spider (mounting plate) wheel cylinder
c. Two lined brake shoes
d. Shoe return springs. Shoe toward front of vehicle is called leading shoe, and shoe toward rear is called trailing shoe. Leading shoe lining is shorter than the trailing shoe lining.
e. Actuating lever for Park Brake
f. Manual Adjuster screw to compensate for lining wear
g. Wheel Cylinder/(cast into torque spider)

Hydraulic drum brakes are not self adjusting and require manual adjustment.

Operation

Hydraulic drum brake systems utilize a combination of mechanical and hydraulic components. A mechanical brake pedal and linkage is utilized to actuate a master cylinder. The master cylinder is used to create hydraulic fluid pressure which operates the drum or disc brakes. Hydraulic brake systems require a separate mechanical parking brake. A hand operated parking brake, mechanical linkage and cables are utilized to mechanically lock the rear brakes for parking. An optional hydraulic pressure sensor is used on some vehicles to operate rear brake lights. See Figure 5.

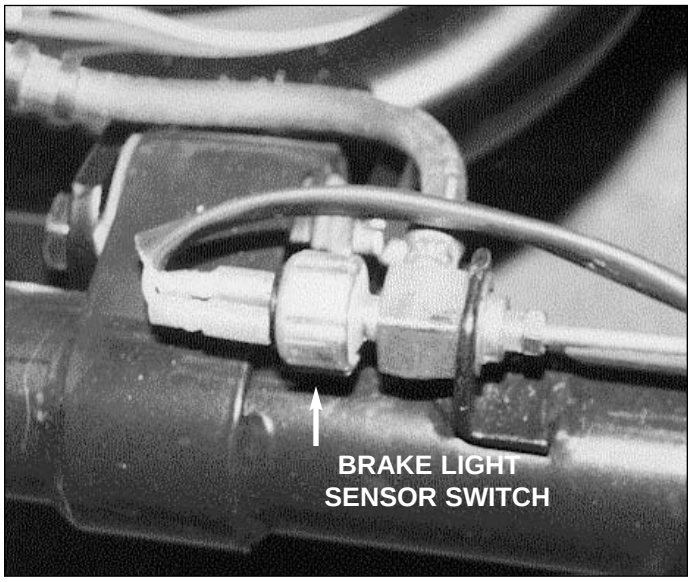


Figure 5 - Light Switch Pressure Sensor

Periodic Inspection

Interval between brake service and inspection may vary depending on factors such as:

1. Driving habits
2. Type of driving (stop and go)
3. Road and climate conditions
4. Vehicle load

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

Periodic inspection should always include the following:

a. With vehicle stationary, depress pedal and monitor for minimum 1/4 inch pedal free travel before resistance is felt. Maximum pedal free travel not to exceed 2 inches measured from floor board to top of pedal.

b. Inspect cables under vehicle for physical damage, corrosion, or fraying.

c. Operate vehicle on level ground, applying brakes to ensure that both rear brakes apply equally. Also, check that excessive force is not required to apply brakes. Excessive force required to apply brakes could indicate malfunctioning brake cables or excessive wear to brake shoes.

Periodic Maintenance Inspection

1. Depress brake pedal, check to see that some detectable free play is present. Continue depressing pedal, pedal should not travel in excess of 2 1/2 inches as measured from floor board with a ruler. As pedal is depressed, if pedal travels in excess of 2 1/2 inches before resistance is felt or if pedal feels spongy and soft, repair or maintenance will be required.

2. Visually, inspect brake master cylinder and adjoining brake lines for signs of fluid leakage. Remove cover from master cylinder reservoir. Check that fluid is clean and clear and fluid level is within 1/2 inch of top.

3. Check park brake operation. Pull hand brake lever to confirm no more than 3 1/2 inches travel from floor. Check that ratchet mechanism holds park brake handle in up position automatically. Check that park brake push button release frees park brake lever and lever returns to full down position.

4. Operate vehicle on level surface, depress pedal, and check that rear brakes operate evenly.

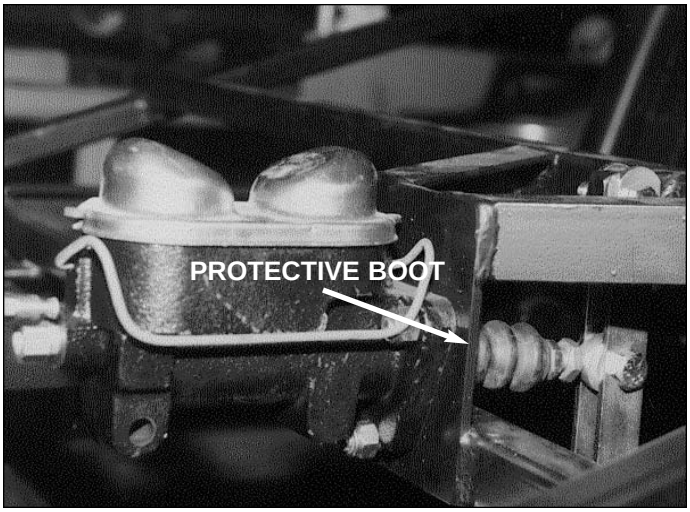


Figure 6 - Master Cylinder Protective Boot

Annual Maintenance Inspection

To perform this service, raise vehicle using floor jack and safely support with jack stands positioned under main frame tubes.

1. Remove rear wheels.

2. Remove Tinnerman fasteners on lug bolts holding brake drum. Remove brake drums. It may be necessary to retract brake shoes. Adjuster can be accessed through inspection opening on brake drum.

3. Inspect wheel cylinder area for fluid leakage. Inspect also, axle and axle tube area for leakage from axle bearing.

4. Inspect brake shoes for fluid contamination, physical damage, or excessive wear. Measure brake lining thickness at narrowest point. Lining should measure no less than 1/16th inch. If worn beyond service limit, brake shoes must be replaced.

5. Wash brake assembly, removing mud, brake shoe debris, and dirt.

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

6. Install brake drums and Tinnerman fasteners. Rotate brake drum and operate brake. Adjustment of brake can be accomplished using a brake spoon, accessing adjuster through brake drum inspection hole.

7. Install rear wheels and lug nuts, torque to 65 ft. lbs.

Adjustments

Hydraulic Brake Linkage

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

2. To adjust brake linkage:
   a. Remove cotter pin and clevis pin from brake clevis at brake rod.
   b. Rotate brake rod clevis accordingly to decrease free play or increase free play as required.
   c. Reconnect brake rod clevis with clevis pin, and install new cotter pin.
   d. Recheck park brake pedal for correct free movement.

Hand Operated Parking Brake

Lift on park brake handle to monitor the amount of travel. You should normally hear the handle click or ratchet two or more times before resistance is felt and park brake is set. If the park brake handle rises in excess of 3 1/2 inches from its original down position, brake cable and linkage adjustment will be required. For brake cable and linkage adjustment:

a. Locate the rod connecting the park brake handle to the brake linkage equalizer. See Figure 8.

b. Remove the cotter pin and clevis pin from the brake clevis on the parked brake rod. Loosen the jam nut securing the brake clevis to the rod, rotate the clevis to shorten the rod length, and retighten jam nut.

c. Install brake rod and clevis, clevis pin, and new cotter pin to reconnect brake rod assembly.

d. Recheck park brake operation to confirm adjustment is correct.

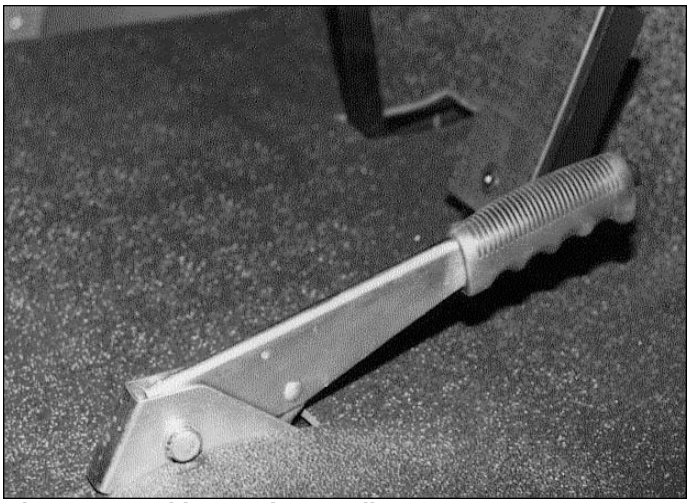


Figure 7 - Parking Brake Handle

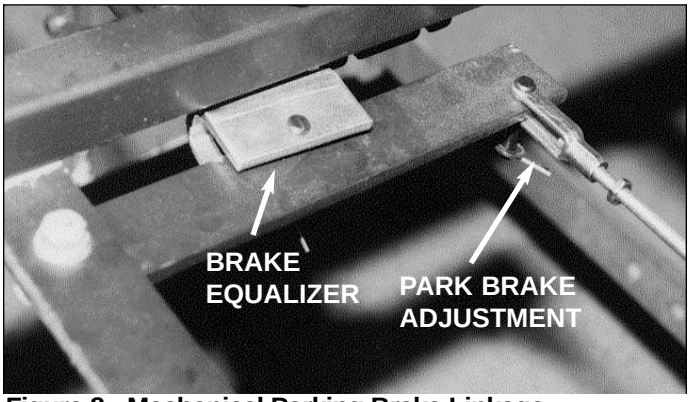


Figure 8 - Mechanical Parking Brake Linkage

Brake Shoe Adjustment

a. To check rear brake shoe adjustment, depress brake pedal. Pedal should move approximately 1/2 to 1 inch of travel before resistance is felt. If pedal travel exceeds 2 - 2 1/2 inches, brake shoe adjustment will be required. To adjust rear brake shoes, lift the rear of the vehicle with a floor jack, and support the vehicle using jack stands positioned at main frame tubes.

b. Remove rear wheels from vehicle.

c. Rotate rear brake drum so that brake adjustment or inspection hole is at the top. Using a brake spoon or brake adjustment tool with a flat end, reach through the inspection hole and rotate the brake adjuster several notches. See Figure 9.

d. Depress the brake pedal 1 to 3 times, then rotate the rear drums to check for drag or resistance.

e. Repeat process until drag or resistance is felt between brake shoes and drums.

f. Using the brake tool, reverse the brake adjuster until the rear drum is allowed to turn freely. Some touching of brake shoes against drum is acceptable as long as resistance does not become excessive.

g. Reinstall rear wheels, installing the lug nuts snugly at first, then tightening in a criss-cross fashion to a final torque 65 to 70 ft. lbs.

h. Depress brake pedal to confirm adjustment is correct.

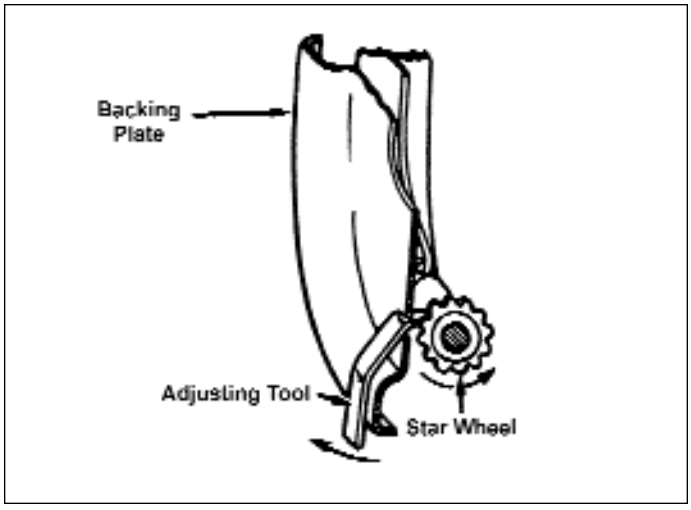


Figure 9 - Brake Shoe Adjustment

Caution: Failure to adjust brakes as indicated could result in accelerated lining wear and possible brake failure.

Disassembly & Reassembly

Note: It is not recommended that the hydraulic drum brake assembly be removed for repair or service. For removal, refer to Chapter 7 for Rear Axle Removal.

General

1. When removing brake drums, brake adjusters should be loosened to provide brake shoe to drum clearance.

2. Use a brake spring tool for removal or installation of brake return springs.

3. Keep the springs, shoes, and other parts separate and laid out in order as removed. Do not mix right side brake parts with left side.

4. Always, replace any crimped fasteners or cotter pins. Replace any springs which appear to be stretched or deformed.

5. Never use petroleum base cleaners or lubricants on hydraulic brake parts as it will contaminate the brake fluid.

Brake Shoe Service

To perform this service, raise vehicle using floor jack and safely support with jack stands positioned under main frame tubes.

1. Remove the rear wheel, and brake drums.

2. Locate the red and green brake shoe return tension springs. Using a pry tool, carefully pry the top of each spring from behind its tab on the torque spider. Unhook each spring from the torque spider and brake shoe and set it aside. Now, remove the blue spring holding the top of each brake shoe together against the adjuster. Remove the adjuster screw and nut. See Figure 10.

3. Gently, remove each clip securing the brake shoes to the park brake actuating levers. The shoes can now be removed.

Caution: While brake shoes and drum are removed from vehicle, do not depress brake pedal. Pistons will be forced from the wheel cylinders causing fluid leakage and damage.

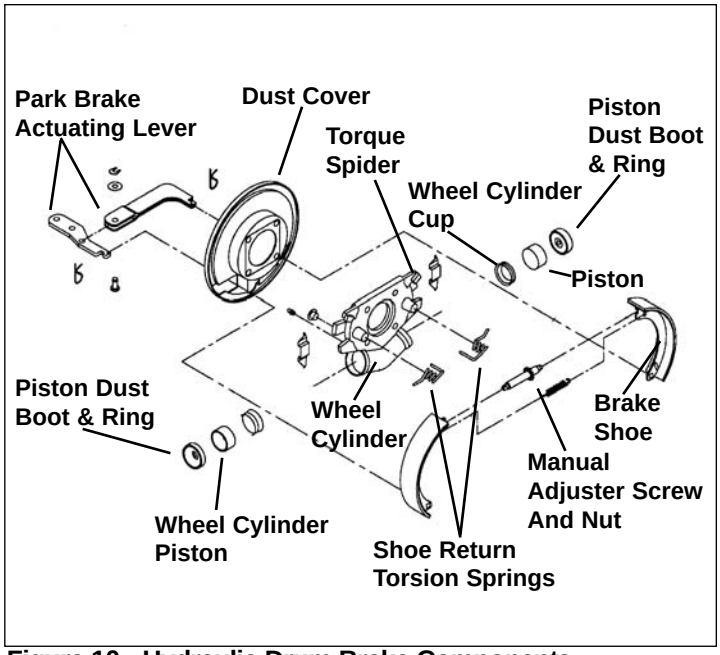


Figure 10 - Hydraulic Drum Brake Components

4. Clean the brake assembly to remove brake debris, dust, dirt, and mud. **Do not use solvents or other chemical cleaners unless formulated for cleaning brake parts.**

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

5. Place replacement brake shoes into position on brake actuating lever tabs. Insert retaining clips.

6. Screw adjuster assembly into minimum length position and insert between the tops of each brake shoe. Install blue spring under adjuster.

7. Insert the red spring into the left shoe as you face the brake assembly, onto its mounting post on the brake spider, and using a brake spring pry tool, pry the top end of the red spring into position behind the torque spider retaining tab. Repeat this process with the green spring, mounted on the right side of the brake spider as you view it.

8. Check that the brake shoes are correctly positioned into the slots provided in each master cylinder piston.

9. Install the brake drum over the brake assembly, and rotate until access or inspection hole is at the top. Using a brake spoon or brake adjusting tool, rotate the brake adjuster until drag is felt against the brake drum. Apply pressure to the brake pedal, pumping it 2-3 times and releasing, then recheck to see if additional adjustment is required to create drag on brake drums.

10. Once the shoes have been adjusted to create drag on brake drum, rotate the brake adjuster in the opposite direction only until the brake drum will rotate freely. Some sound of brake shoes contacting drum may be heard. This is normal and should not cause concern.

11. Check brake pedal movement. Pedal should move approximately 1/4 to 1/2 inch but no greater than 2 inches before firm resistance is felt. If greater than 2 inches of pedal travel is observed, recheck adjustment before proceeding.

Brake Drum Service

1. Rebore or replace drum if rubbing surface is rough or ragged or if depth of scoring exceeds .010 inch.

2. Rebore or replace drum if inside diameter of drum at open end exceeds inside diameter at closed end by more than .010 inch.

3. Rebore or replace drum if surface variance exceeds .005 inch on the side.

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

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

6. Rebore or replace drum if out-of-round condition exceeds .006 inch total indicator reading or if pedal pulsations or brake roughness is noticeable.

7. To measure a drum diameter, use a micrometer gauge. To measure 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).

8. Rebore limit is 0.060 inch over original drum diameter.

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

Caution: Never rebore a drum to maximum wear or discard diameter.

10. When reboring a drum, remove only enough metal to obtain a smooth, true 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.

Wheel Cylinder Service

The wheel cylinder is 9 one piece cast assembly, and part of the torque spider. Removal of the torque spider and wheel cylinder is recommended only when replacement is required. Refer to Chapter 7, Rear Axle Disassembly for details.

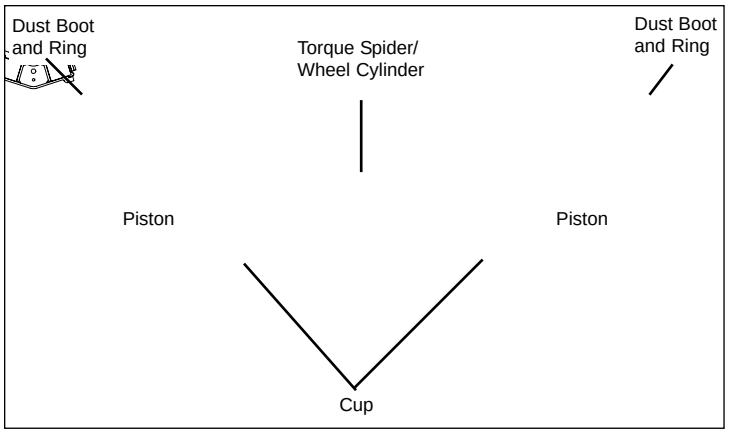


Figure 11 - Wheel Cylinder Components

Service Procedures

1. Rebuild or replace wheel cylinder/torque spider whenever brake shoes are replaced, or more often when required to correct leaking cylinder.

2. When servicing, removal of wheel cylinder from vehicle is not necessary.

Cleaning and Inspection

1. Whenever a wheel cylinder is disassembled, always inspect the cylinder bore for scoring, pitting and corrosion. A hard, crystal-like substance sometimes forms a ring in the cylinder bore near the place where the piston stops when the brakes are released.

2. Fine grade crocus cloth (or an approved cylinder hone) may be used to remove light roughness or deposits from the bore. Hone lightly and use brake fluid as a lubricant while honing. If the bore does not clean up readily, replace the cylinder.

3. After using crocus cloth or a hone, flush inside of cylinder with clean alcohol or brake fluid, and wipe dry with a lintless cloth. Be sure all dust and grit are removed and bleeder screw and brake tube passages are clean and open.

4. The clearance between cylinder bore wall and pistons must be checked after the cylinder is cleaned up. If a narrow (1/8 to ¼ inch wide) .006 inch feeler gauge can be inserted between the bore wall and a new piston, the clearance is excessive, and the wheel cylinder must be replaced.

Note: If the clearance between the pistons and the bore wall exceeds .005 inch, a condition known as heel drag may exist. This causes rapid cup wear and may cause the pistons to retract very slowly when the brakes are released.

5. Tips for Assembly:

   a. Always use new wheel cylinder repair parts to rebuild wheel cylinder.

   b. Dip the pistons and cups in clean brake fluid. Coat the cylinder bore with clean brake fluid.

   c. Refer to Figure 10 for assembly.

   d. After reassembly is completed, hydraulic brake system must be bled.

Hydraulic Master Cylinder

Brake Fluid Maintenance

Caution: Do not handle hydraulic system parts with greasy hands or permit parts to come in contact with oil or grease. Just a trace of grease or oil in the hydraulic system may cause damage to rubber parts.

1. Maintain fluid level within ¼" of master cylinder filler opening.

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

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

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

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

   a. Drain old fluid from the system.

   b. Replace cups and seals.

   c. Flush hydraulic system with clean brake fluid.

   d. Refill system with clean brake fluid.

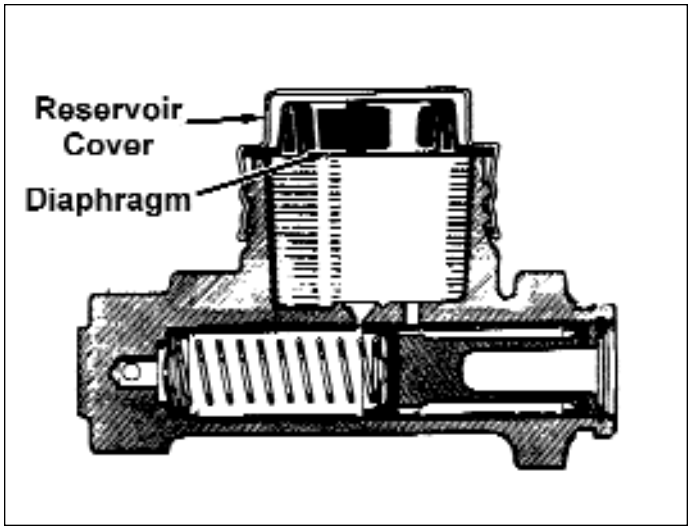


Figure 12 - Master Cylinder

4. Handling and Storing Brake Fluid

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

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

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

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

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

   f. Store brake fluid containers in a clean, dry place.

Bleeding Hydraulic System

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

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

2. Install a length of appropriate size plastic tubing over wheel cylinder bleeder fitting, located next to wheel cylinder line connection. See Figure 13.

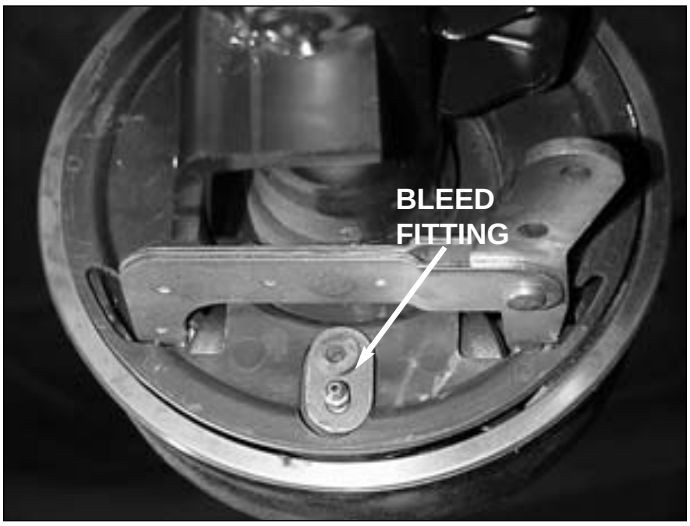


Figure 13 - Bleeder Fitting

3. Place the other end in any clear glass jar containing about 1/2 inch of brake fluid.

4. Bleed right wheel first. Open bleeder nipple by rotating it counterclockwise about ½ turn. With master cylinder full of fluid at all times, slowly depress foot pedal repeatedly until fluid flows from bleeder nipple free of air bubbles.

5. Add fluid to master cylinder to bring to ¼ inch from cover. Close bleeder nipple. Repeat above procedure on left wheel.

6. **Do not** re-use fluid unless it is clear and free of sediment. If it is impossible to bleed all air from system, master cylinder is faulty and a master cylinder repair kit should be installed.

Trouble Shooting

Dragging Brakes

(Slow or incomplete release of brakes)

1. Shoes and Linings
   a. Shoes improperly adjusted - adjust.
   b. Shoes distorted or incorrect - replace with new brake shoes.
   c. Linings soiled with grease or brake fluid - replace with new brake shoes.

2. Mechanical Parts
   a. Return springs incorrect or weak - replace.
   b. Torque spider loose - tighten.
   c. Cables and linkage sticking, dirty or corroded - free up and lubricate.

3. Wheel Bearings
   a. Damaged or grease contaminated - replace.
   b. Grabbing or Pulling - replace.

Severe reaction to pedal pressure and uneven stoping

1. Shoes and Lining
   a. Shoes improperly adjusted - adjust.
   b. Shoes distorted or incorrect; linings incorrect, loose or soiled - replace with new brake shoes.

2. Mechanical Parts
   a. Torque spider loose, worn, or distorted - tighten or replace.
   b. Shoe return springs weak, broken, improperly installed -- replace or install correctly.
   c. Wheel bearings loose - adjust.

3. Drums
   a. Thin (expanding when hot): oversize (beyond .030 inch) of original specification -- replace.
   b. Scored, out-of-round - replace.
   c. Noise and Chatter - replace

Squealing, clicking or scraping noises upon application of brakes

1. Shoes and Lining
   a. Shoes twisted, distorted, incorrect, or broken; cracked welds - replace with new brake shoes.
   b. Linings worn out, glazed, incorrect loose or soiled; foreign matter embedded in linings; incorrect - replace with new brake shoes.

2. Mechanical Parts
   a. Shoe return springs weak; torque spiders loose or defective; hold-down parts defective, - replace.

3. Drums
   a. Thin: cracked: loose: scored: -- replace.

HYDRAULIC DISC BRAKE

System Overview

All light duty gas & electric (golf or industrial/commercial) vehicles can be equipped with optional hydraulic rear disc brakes or front & rear hydraulic disc brakes.

Hydraulic Disk Brake (see Figure 14) includes the following components:

1. Brake disc.
2. Brake caliper.
3. Brake caliper pistons.
4. Brake pads.
5. Bleed fittings.
6. Banjo bolt fitting.
7. Piston dust boots.
8. Piston sealing O-rings.

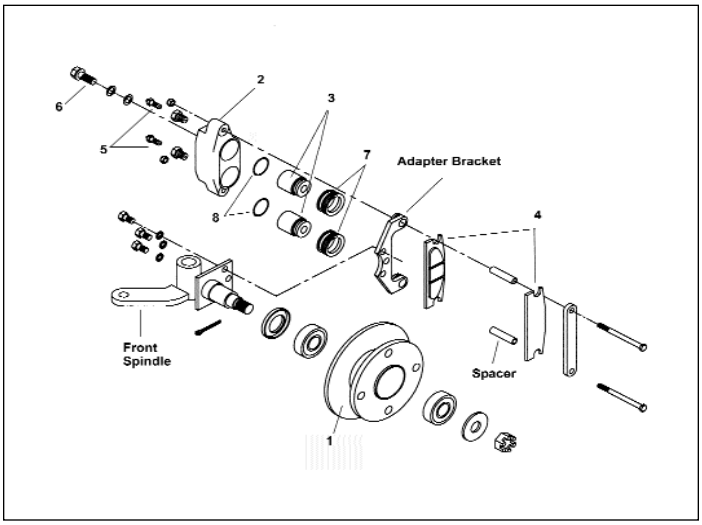


Figure 14 - Disc Brake Components

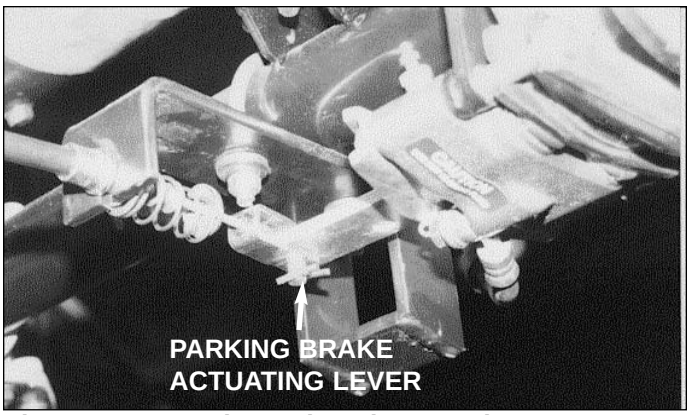


Figure 15 - Rear Disc Park Brake Actuating Lever

Operation

Hydraulic brake systems utilize a combination of mechanical and hydraulic function. Mechanical brake pedal and linkage is utilized to actuate a master cylinder. The master cylinder is used to create hydraulic fluid pressure which operates the drum or disc brakes. Hydraulic brake systems require a separate mechanical parking brake. A hand operated parking brake, mechanical linkage and cables are utilized to mechanically lock the rear brakes for parking. See Figure 17 & 18. An optional hydraulic pressure sensor is used on some vehicles to operate rear brake lights. See Figure 16.

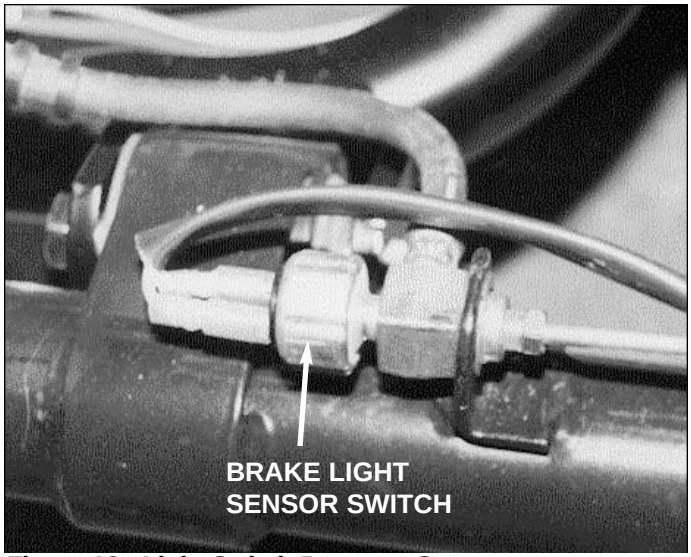


Figure 16 - Light Switch Pressure Sensor

Periodic Inspection

Interval between brake service and inspection may vary depending on factors such as:

1. Driving habits
2. Type of driving (stop and go)
3. Road and climate conditions
4. Vehicle load

For periodic brake inspection intervals, see Chapter 2, Periodic Maintenance.

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

Periodic inspection should always include the following:

a. With vehicle stationary, depress pedal and monitor for minimum 1/4 inch pedal free travel before resistance is felt. Maximum pedal free travel not to exceed 2 inches measured from floor board to top of pedal.

b. Inspect cables under vehicle for physical damage, corrosion, or fraying.

c. Operate vehicle on level ground, applying brakes to ensure that both rear brakes apply equally. Also, check that excessive force is not required to apply brakes. Excessive force is not required to apply brakes. Excessive force required to apply brakes could indicate malfunctioning brake cables or excessive wear to brake shoes.

Periodic Maintenance Inspection

1. Depress brake pedal, check to see that some detectable free play is present. Continue depressing pedal. Pedal should not travel in excess of 2 1/2 inches as measured from floor board with a ruler. As pedal is depressed, if pedal travels in excess of 2 1/2 inches before resistance is felt or if pedal feels spongy and soft, repair or maintenance will be required.

2. Visually, inspect brake master cylinder and adjoining brake lines for signs of fluid leakage. Remove cover from master cylinder reservoir, check that fluid is clean and clear and fluid level is within 1/2 inch of top.

3. Check park brake operation. Pull hand brake lever to confirm no more than 3 1/2 inches travel from floor. Check that ratchet mechanism holds park brake handle in up position automatically. Check that park brake push button release frees park brake lever and lever returns to full down position.

4. Operate vehicle on level surface, depress pedal, and check that rear brakes operate evenly.

Annual Maintenance Inspection

To perform this service, raise vehicle using floor jack and safely support with jack stands positioned under main frame tubes.

1. Remove wheels to inspect brake discs. Inspect brake disc for grooves, damage or uneven wear. Inspect for fluid leakage around brake pads and at hydraulic fittings to brake caliper. If brake pad wear exceeds service limit, pads must be replaced.

2. Inspect for fluid leakage around axles at axle housing. Refer to Chapter 7 for Drive Axle Repairs.

3. Visually, inspect brake pad thickness. Minimum material thickness equals 1/16 inches (1.6 mm).

4. Wash mud, brake debris, and dirt from brake assembly and brake disc.

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

5. Install rear wheels and lug nuts snuging lightly. Tighten lug nuts in a criss-cross pattern, torque nuts to 65 to 70 ft. lbs.

Adjustments

Hydraulic Brake Linkage Adjustment

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

2. To adjust brake linkage:

   a. Remove cotter pin and clevis pin from brake clevis at brake rod.

   b. Rotate brake rod clevis accordingly to decrease free play or increase free play as required.

   c. Reconnect brake rod clevis with clevis pin, and install new cotter pin.

   d. Recheck brake pedal for correct free movement.

Hydraulic Hand Operated Parking Brake Adjustment

Lift on park brake handle to monitor the amount of travel. You should normally hear the handle click or ratchet two or more times before resistance is felt and park brake is set. If the park brake handle rises in excess of 3 1/2 inches from its original down position, brake cable and linkage adjustment will be required.
For brake cable and linkage adjustment:

a. Locate the rod connecting the park brake handle to the brake linkage equalizer. See Figure 18.

b. Remove the cotter pin and clevis pin from the brake clevis on the parked brake rod. Loosen the jam nut securing the brake clevis to the rod. Rotate the clevis to shorten the rod length, and retighten jam nut.

c. Install brake rod and clevis, clevis pin, and new cotter pin to reconnect brake rod assembly.

d. Recheck park brake operation to confirm adjustment is correct.

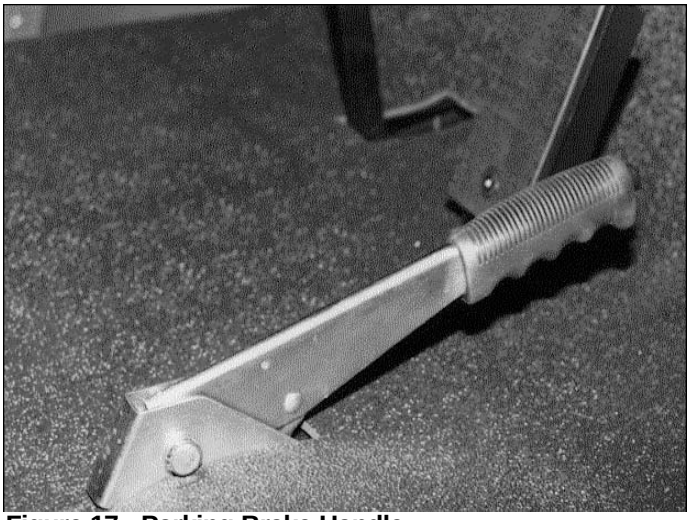


Figure 17 - Parking Brake Handle

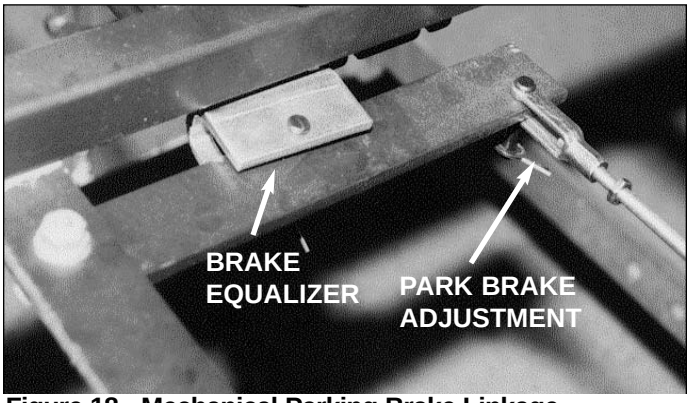


Figure 18 - Mechanical Parking Brake Linkage

Hydraulic Disc Brake Adjustment

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

Disc Brake Service

Brake Disc Service

1. If the brake disc or pads require replacement, remove only one holding bolt that retains the caliper. See Figure 19.
2. The discs must be flat, with no warpage or hot spots.
3. Runout in a disc brake is like eccentricity (out-of-roundness) in a drum brake. It causes a loss of brake pedal height because of extra lining clearances. Moreover, runout wears the caliper pistons and their seats rapidly because of the high-speed pulsations created whenever the brakes are applied. Runout tolerances are critical, usually only about .002 inch.

Note: Usually, as much as .015 inch of metal can be removed from each side of the disc without exceeding specifications. In some cases, even greater removal is permitted. If removing the maximum specified amount will not clean up a disc's problems, install new discs.

Brake Caliper Service

Removal

1. The pistons must be removed from their bores; using hydraulic pressure to force them out is the easiest method.
2. With the pads removed from the calipers, the caliper still bolted to the vehicle, and the hydraulic lines connected, press brake pedal until both pistons slide out of their bores. Normally, they will not come entirely out of their bores. Push one side out, then remove piston from the other side.
3. To prevent brake fluid from squirting out, cover the calipers with a cloth. Sometimes, additional brake fluid must be added to the master cylinder to make the pistons contact the discs.

Cleaning and Repair

1. Now, remove the seals, boots, and pistons. Clean them in alcohol, wipe them dry with a clean, lint-free cloth. Always blow out all drilled passages with compressed air. Rubber dust boots and seals should always be replaced whenever disassembled.
2. Inspect cylinder bores in both sides of the caliper housing for scoring or pitting. Bores that show light corrosion can usually be cleaned with fine grit crocus cloth. Caliper bores with deep scratches or scoring should be honed with a ¼ inch electric drill. (The same attachment is used for honing wheel cylinders on drum brakes.)
3. The caliper cylinder must not be honed out larger than the manufacturer's specifications, not more than .002 inch oversize.
4. Black stains on the bore caused by the piston seals are not harmful and need not be removed.
5. After honing, take great care in cleaning the caliper parts. Flush them with alcohol, wipe dry, then flush and dry again. Clean mating surfaces with No. 400 wet-or-dry sandpaper, never with a file.

Assembly

1. After all internal caliper areas are cleaned completely, lubricate internal areas, pistons, and piston sealing o-rings with clean new brake fluid.
2. Assemble caliper assembly as illustrated in Figure 14.
3. Caliper bolts should be torqued to 15 ft. lbs. Check to see that the caliper floats freely on the mounting bolts and spacers. Never reuse lock nuts.
4. Bleed hydraulic system before operating vehicle.

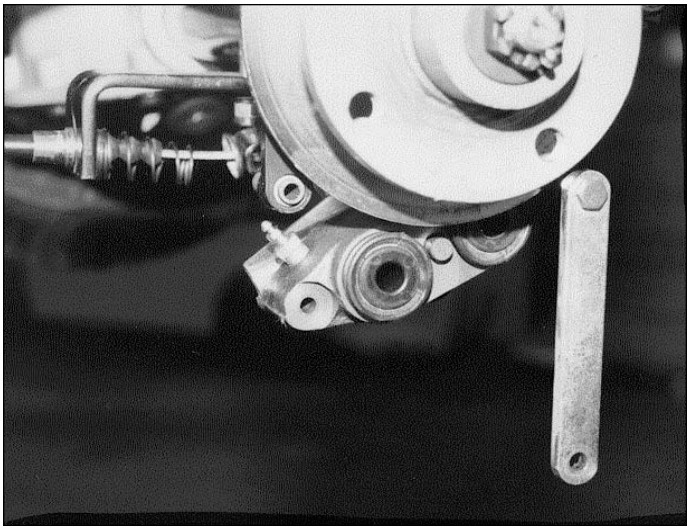


Figure 19 - Remove Disk Brake Pad

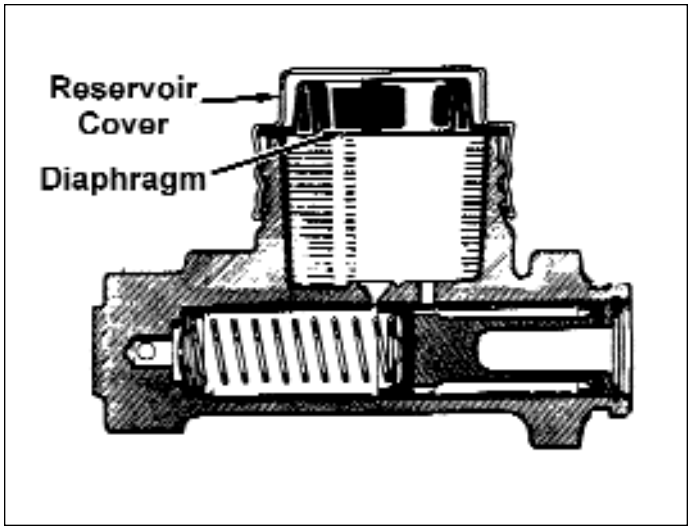


Figure 20 - Master Cylinder

Hydraulic System Master Cylinder

Brake Fluid Maintenance

Caution: Do not handle hydraulic system parts with greasy hands or permit parts to come in contact with oil or grease. Just a trace of grease or oil in the hydraulic system may cause damage to rubber parts.

1. Maintain fluid level within ¼" of master cylinder filler opening.

2. Changing Brake Fluid

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

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

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

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

   a. Drain old fluid from the system.

   b. Replace cups and seals.

   c. Flush hydraulic system with clean brake fluid.

   d. Refill system with clean brake fluid.

4. Handling and Storing Brake Fluid

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

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

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

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

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

   f. Store brake fluid containers in a clean, dry place.

Bleeding Hydraulic System

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

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

2. Insert the end of a length of appropriate size plastic tubing over wheel cylinder bleeder nipple, located next to wheel cylinder line connection. See Figure 3.

3. Place the other end in any clear glass jar containing about 1/2 inch of clean brake fluid.

4. Bleed right wheel first. Open bleeder nipple by rotating it counterclockwise about ½ turn. With master cylinder full of fluid at all times, slowly depress foot pedal repeatedly until fluid flows from bleeder nipple free of air bubbles.

5. Add fluid to master cylinder to bring to ¼ inch from cover. Close bleeder nipple. Repeat above procedure on left wheel.

   Do not re-use fluid unless it is clear and free of sediment. If it is impossible to bleed all air from system, master cylinder is faulty and a master cylinder repair kit should be installed.

6. To purge the hydraulic system of remaining air bubbles, remove the bolts securing the caliper mounting bracket. Without removing the caliper and pads from the disc, rotate the caliper to position the bleed nipple in a vertical position. While holding caliper in this position, bleed system one last time.

7. Remount caliper to caliper mounting bracket.

DISC BRAKES

1. Most common complaint is noise when brakes are applied and vehicle is rolling slowly.

   a. Brake pads may require replacement.

   b. Brake disc may require resurfacing.

CHAPTER 5

TORQUE CONVERTOR TRANSMISSION

Operation

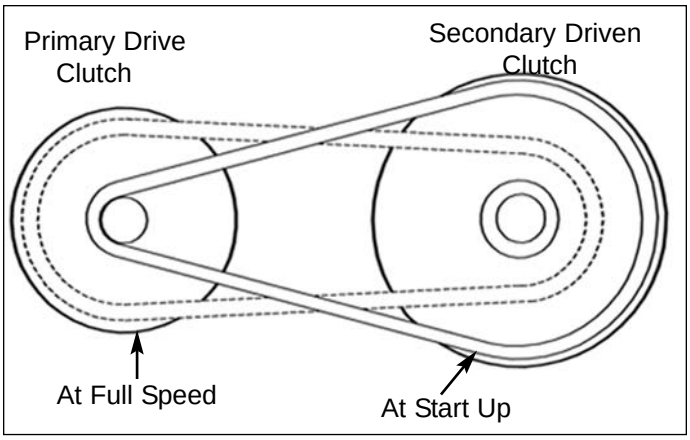


Figure 1 - Operation of Drive System

The torque convertor transmission consists of a primary drive clutch, a secondary driven clutch, and drive belt. The primary drive clutch is initially open, totally releasing the drive belt when engine is stopped. When engine RPM rises, internal centrifical weights force the primary drive clutch to close, engaging the drive belt. As engine RPM continues to increase, centrifical force continues closing primary drive clutch, forcing drive belt higher between pulleys. This is often referred to as “up-shifting.”

As accelerator is released, engine RPM is reduced. Centrifical force on primary drive clutch weights is reduced and an internal spring forces the drive clutch to open. As primary drive clutch opens, drive belt lowers between pulleys until original position is achieved and engine stops. When ascending a hill or suddenly increasing throttle opening, the secondary driven clutch responds to improve hill climbing or acceleration. The secondary driven clutch utilizes an internal spring and “cam” device to force the pulleys closed sufficiently to promote “down-shifting”.

Drive Belt

The drive belt is the linkage connecting primary drive clutch to secondary driven clutch. As the drive belt wears, engine RPM will increase to compensate for this wear, maintaining the vehicle’s original maximum govern speed. If the drive belt becomes excessively frayed, glazed, or worn, it should be replaced. The drive belt is approximately 1 13/16 inches wide. Remove at its widest point. After 1/16 inch has been worn from the drive belt (measured at the widest point), it should be replaced.

Removal

Caution: Always turn key to off position, remove key, and disconnect battery negative able before continuing.

1. Grasp drive belt firmly between primary drive and secondary driven clutch, lifting briskly to create slack in belt.
2. Roll the slack in belt over the top edge of secondary driven clutch.
3. Once freed from secondary driven clutch, slip drive belt off of primary drive clutch.

Inspection

1. Inspect belt for cracks, splits or frayed cords. Replace if damage is observable.
2. Check belt width at various points around the belts diameter. The difference between the widest and narrowest points should not be greater than if the difference exceeds 1/32.
3. The minimum width of the drive belt is 1 1/16. If the belt measures less than 1 1/16, replace the drive belt.

Installation

1. Position new drive belt over primary drive clutch, and pull slack towards rear of vehicle.
2. Slip belt into bottom of secondary driven clutch, and roll clutch in order that belt drops between pulleys.

Drive Clutch

Removal

Caution: Turn key switch off, remove key, and disconnect negative battery cable before proceeding.

1. Remove drive belt as described in previous section.
2. Loosen (but do not remove) 3 bolts holding starter/generator to mounting bracket and adjustment bracket. Push starter/generator down to loosen belt, and slip belt from pulleys.
3. Remove single bolt holding primary drive clutch to engine crankshaft.
4. Pull clutch from engine crank shaft, gentle prying may be required using screw driver or small, thin pry bar. Use care not to damage starter/generator belt pulley.

Note: An earlier version of clutch puller (P.N. 94452-92), can be used to aid in primary clutch removal if required. This tool will not fit exactly and the floating half pulley must be removed.

Disassembly

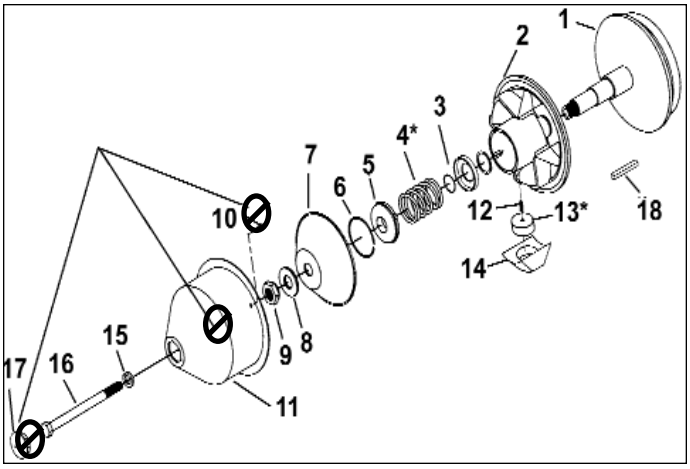


Figure 2 - Primary Drive Assembly

1. Remove jam nut, washer, and straight cap (Figure 2, # 9, 8, & 7).

2. Lift centrifical blocks, weights and springs from three positions in sliding half pulley (Figure 2, #12, 13, & 14). Remove weight(#13) and anti-noise spring (#12) from centrifical block (#14).

3. Slip sliding half pulley from fixed half pulley and shaft (Figure 2, #2).

4. Using an arbor press, hold the plastic bushing down in sliding half pulley to remove retaining ring (Figure 2, # 5 & 6). Carefully, release pressure from plastic bushing, allowing spring tension to be released. Remove plastic bushing, spring, and shoulder washer. Note the location of any shims which might be found in the sliding half pulley or on the fixed half pulley shaft.

Cleaning and Inspection

1. Clean all parts in water and mild detergent.

Note: Do not use harsh solvents or cleaning chemicals, as they may damage the sliding half pulley bushing. Avoid using abrasives to clean sliding half pulley bushing.

2. Using a straight edge, check the belt contact surface of the fixed half pulley and sliding half pulley for wear. If wear exceeds .060 inches (1.52 mm.), floating half pulley, fixed half pulley, or primary drive clutch assembly should be replaced. See Figure 3.

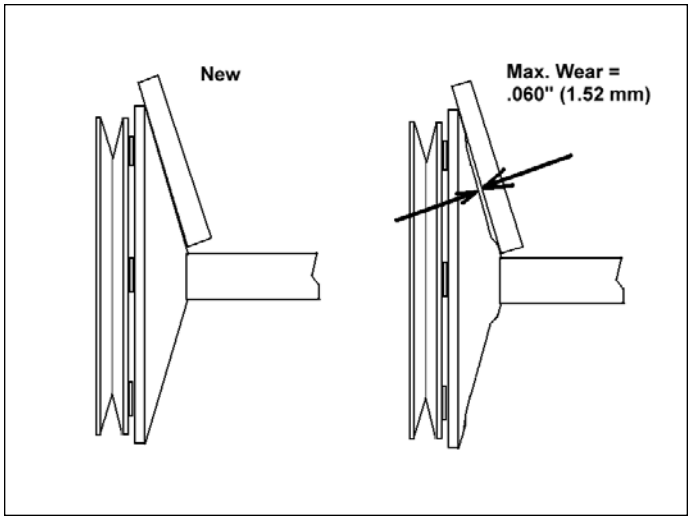


Figure 3 - Clutch Sheave Wear

Reassembly

Note: Do not lubricate any components of the primary drive clutch. Use of lubricants will cause dirt and debris to stick to clutch and cause premature wear to bushing and components.

1. Insert shoulder washer, spring, and plastic bushing into sliding half pulley. Using an arbor press, press spring and plastic bushing into place. Holding plastic bushing and spring in place, insert retaining ring. Carefully, release pressure, and check that retaining ring is properly seated. See Figure 2.

2. Install anti-noise springs into weights. Install centrifical weights into centrifical blocks. Insert three blocks into three slides in sliding half pulley.

3. Install sliding half pulley assembly onto fixed half pulley and shaft. Install straight cap using care to properly align centrifical weights between guide shoes in straight cap.

Note: Use care when installing straight cap that “D” shaped backing washer is correctly aligned to “D” shape of fixed half pulley shaft.

4. Holding straight cap securely down in position on fixed half pulley shaft, install flat washer and nut. Torque nut to 60-65 ft. lbs. (81.3 to 88 N.m.).

Installation

1. Paint crankshaft end with anti-seize compound.

2. Insert woodruff key into crank shaft key slot (Figure 2, #18).

3. Insert primary drive clutch onto crank shaft, carefully aligning woodruff key to key slot in drive clutch. Push clutch all the way onto the crankshaft until fully seated.

4. Install single mounting bolt, torque to 45-49 ft. lbs. (61 to 66 N.m.).

5. Install starter/generator belt, lift starter/generator and snug 3 mounting bolts.

6. Check that starter/generator belt tension is no greater than 110 lbs., but no less than 90 lbs. Retention belt if necessary.

7. Install drive belt to primary drive clutch. Slip under secondary driven clutch and roll onto clutch.

Secondary Driven Clutch

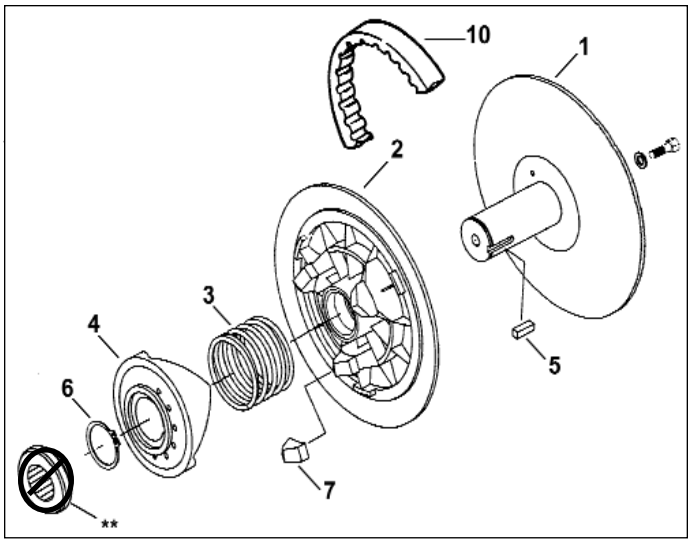


Figure 4 - Secondary Driven Clutch

Removal

1. Remove drive belt per page 5-2.

2. Remove 2 bolts securing air cleaner assembly to air cleaner support on rear fork. Without disconnecting the air cleaner hose, lift the air cleaner and set aside.

3. Remove center bolt securing secondary driven clutch to transaxle input shaft.

4. Grasp driven clutch and slide off transaxle input shaft.

Disassembly

1. Using a large diameter socket, press gently on the cam to allow retaining ring removal. Using external snap ring pliers, remove the retaining ring (Figure 4, #6).

2. Place an appropriate size hex socket onto the center shaft. Using a mechanics three jaw puller, (jaws turned inward) grasp the cam (Figure 4, #4) and press against the hex socket, to remove secondary driven clutch cam.

Caution: Keep fingers away from cam and moving half pulley during this process. Cam and spring will release violently resulting in personal injury.

3. Tighten center bolt on three jaw puller until cam releases and is removed.

4. Lift off spring. Lift sliding half pulley from fixed half pulley shaft.

Cleaning and Inspection

1. Clean all parts in water and mild detergent.

Note: Do not use harsh solvents or cleaning chemicals as they may damage sliding half pulley bushing. Avoid using abrasives to clean sliding half pulley bushing.

2. Inspect cam for wear. Replace if worn.

3. Inspect cam shoes for wear. Replace if worn. See Figure 5.

Caution: If worn cam shoes are not replaced, cam shoes will fail causing driven clutch spring to unwind. Continued use will cause noisy operation, poor hill climbing and vibration. Damage to floating half pulley and spring will result.

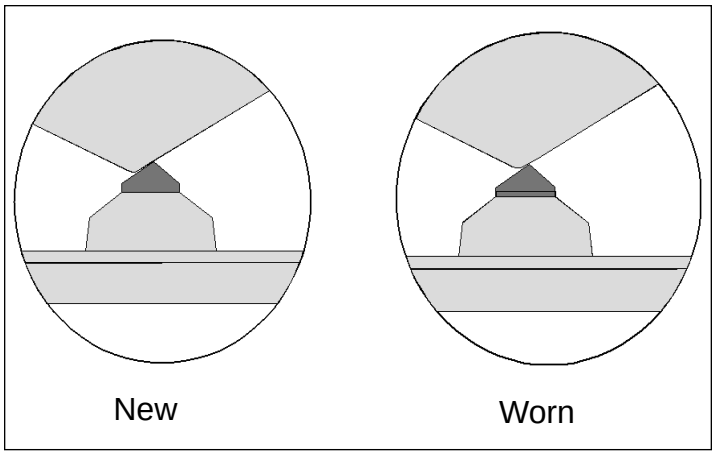


Figure 5 - Cam Shoe Inspection

4. Using a straight edge, inspect fixed half pulley and moving half pulley for wear. Replace if wear to pulley face exceeds .060 inches (1.52 mm.). See Figure 5.

5. Inspect bearing in sliding half pulley (Figure 4, item 2). With your hand, grab sliding half pulley flange and check for side movement. If sheave moves greater than 3/32 inches, replace sliding half pulley.

6. Inspect shaft from fixed half pulley. Replace fixed half pulley if worn, scratched, or dented.

Assembly

Caution: Use care when assembling secondary driven clutch components, avoid accidental release of sprung parts. Some parts may have sharp edges. Use of heavy gloves during reassembly is recommended.

1. If cam shoes are to be replaced, press replacement cam shoes into position on sliding half pulley.

2. Install sliding half pulley onto fixed half pulley shaft. Insert spring into spring detent hole in sliding half pulley.

3. Insert woodruff key into key slot of fixed half pulley shaft. Position just below retaining ring groove.

4. Place cam over fixed half pulley shaft and index spring into number three hole position. Using an arbor press, begin pressing cam onto fixed half pulley shaft, aligning cam key slot with woodruff key.

5. While pressing the cam into place, rotate the sliding half pulley clockwise 1/3 rotation.

6. While holding cam in place, install retaining ring and check that it is seated securely before releasing pressure. Hit end of fixed half pulley shaft with mallet until cam seats against retaining ring.

Installation

1. Apply anti-seize to input shaft.

2. Slide secondary driven clutch onto transaxle input shaft.

Note: 1999 and newer models fit to a straight transaxle input shaft and use a square key to lock its position.

3. Install mounting bolt, and special washers, to 26-28 ft. lbs. (35 to 38 N.m.).

4. Install air cleaner assembly onto air cleaner mounting bracket.

5. Always check primary drive to secondary driven clutch alignment after service. Refer to page 7-34.

6. Slip drive belt over primary drive clutch, slide belt under secondary driven clutch and roll onto secondary driven pulley.

Torque Converter/Transmission Alignment

At any time the engine transaxle or torque converter/transmission is removed or repositioned, engine alignment must be checked and corrected. If engine realignment is not performed, vehicle could exhibit poor transmission performance, excessive vibration or excessive belt wear.

Warning: Remove key from key switch and disconnect battery negative cable from battery before proceeding.

1. With drive belt removed, place rear of Columbia ParCar alignment tool (PN 12345-96) into driven clutch mounted to rear transaxle.

Note: Engine alignment tool is adjustable for use on 1996 through early 1997 models (with shorter rear suspension fork), or mid 1997 through current (longer rear fork) vehicles. Refer to parts reference book for detailed V.I.N. information

2. Make certain tool is firmly aligned between the pulley halves of the secondary driven clutch before proceeding. Slowly drop front end of tool into drive clutch on engine. If engine position is correct, front end of tool will rest exactly on center shaft of drive clutch (between pulley halves). If tool does not align correctly with the drive clutch, slide or twist engine as required to correctly align engine to tool.

3. With alignment tool in place and engine aligned to transaxle, torque four engine mount bolts to 25 to 35 ft. lbs. (34 to 47 N.m.) in the crossing pattern.

4. Recheck engine alignment to transaxle. If engine moved while mount bolts or torqued, loosen mount bolts and return to step 2.

5. Remove alignment tool and install drive belt.

Danger: Never operate engine with drive belt removed. Governor (located in rear transaxle) will not function, and engine damage will result. Maximum engine speed could be exceeded causing debris to be thrown from engine, resulting in serious injury or death.

CHAPTER 6

TRANSMISSION SHIFT SYSTEM AND FINAL DRIVE AXLES Page

TRANSMISSION SHIFT SYSTEM

Overview of OperatIon

The shift system is dependent on separate subsystems. Each plays a significant role in the operation of the directional transmission.

a. Console shifter assembly
b. Rear transaxle assembly
c. Shift cable and components

Console shift assembly is a side to side shift lever with an “over-center” system to ensure full transaxle gear engagement. For safety, a starting system lockout is used to prevent the vehicle from starting if transmission is not fully engaged. See Figure 1.

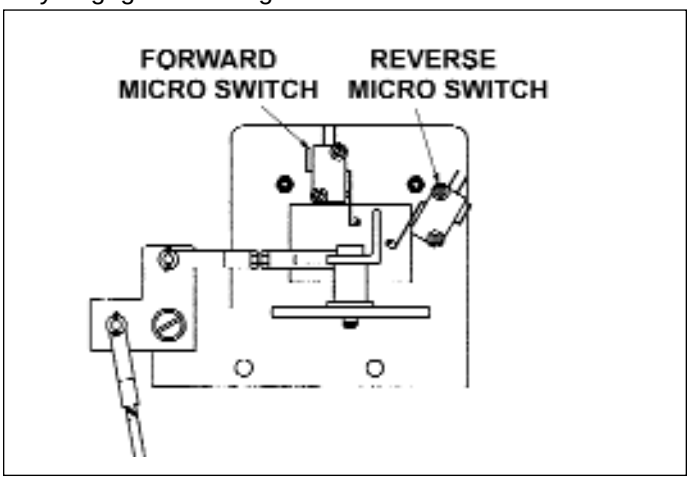


Figure 1 - Starting System Lockout

As shift lever is moved past center, it is intentionally designed to produce significant push or pull force against the shift cable. This offers the operator a sense that shifting has been completed. If the system should jam or something should prevent it from shifting correctly, the starting system lockout will prevent the vehicle from starting.

Rear transaxle assembly uses a shift fork and pin clutch to select forward or reverse gears. Mounted on the transaxle center shaft, the pin clutch (Figure 2, #30) is forced from side to side, engaging the reverse gear (Figure 2, #28) or the forward gear (Figure 2 #32). Protruding pins on the pin clutch will engage into openings in each gear in order to lock the transmission into forward or reverse.

Shift cable and components are used to connect the console shift assembly to the rear transaxle assembly, for directional control. As the console shifter assembly is moved from side to side, this movement is translated into push and pull movement of the shift cable. A pair of springs and a spring retaining bracket is used to connect the shift cable to the rear transaxle shift shaft. These components are used to create push or pull force against the transaxle shift lever and to maintain spring tension against those components.

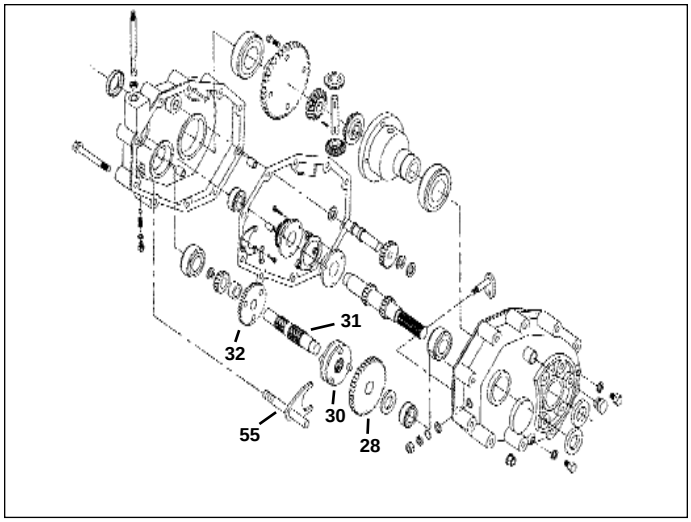


Figure 2 - Pin Clutch

The pin clutch (on occasion) will not fully engage into an opening in the forward or reverse gear. Externally, the console shift assembly, shift cable, shift spring bracket and springs will maintain push or pull tension against the transaxle shift lever. This ensures complete gear engagement internally as the engine or rear axles begin to rotate.

Console Shift Assembly

Removal and Installation

Caution: Always, remove key from key switch, and disconnect battery negative lead from battery before attempting any repair.

1. Remove front body (refer to Front Body Removal, Chapter 2).

2. Loosen jam nut under shift lever knob. See Figure 3. Unscrew knob from shift arm.

3. Disconnect wire harness from starting system lockout micro switches. See Figure 1.

4. Remove cotter pin, flat washer, and clevis pin securing shift cable clevis to shifter bell crank. See Figure 3.

5. Remove two bolts securing console shifter assembly to chassis. Remove shifter assembly from vehicle.

6. Install in reverse order.

Console Shifter Adjustment

1. Tension springs are used to create over-center action in console shifter assembly. To adjust console shifter tension springs, position shift lever in forward or reverse position. Loosen the two jam nuts securing one of the tension spring eye bolts. Adjust the length of one eye bolt so that light spring tension is felt. See Figure 3.

   Loose fitting springs will cause incomplete shifting. Excessively tight springs will cause difficult shifting and will not enhance shifting operation.

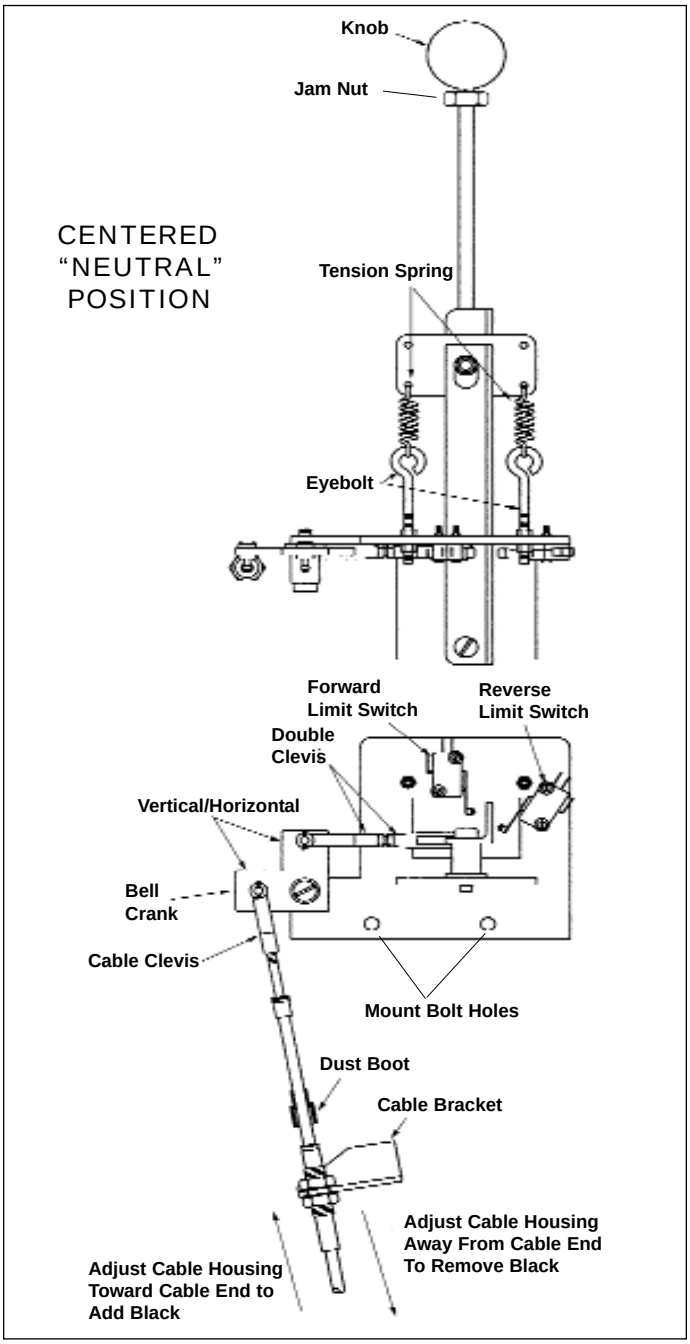


Figure 3 - Console Shifter Assembly

2. Micro switch adjustment should only be performed after the complete shift system has been adjusted. To adjust micro switches, select forward position. Locate forward micro switch and loosen mounting screws. Rotate switch so that switch lever is depressed completely by shift lever arm. See Figure 3. Snug mounting screws. Repeat process for reverse micro switch. Finally, shift vehicle to forward and rock vehicle back and forth.

Note: You may see the shift lever move slightly as the transmission engages into forward gear. Note that forward micro switch should be contacted just **before** the shift lever comes to rest in the forward position. Shift to reverse, and check that reverse micro switch is contacted just before lever comes to rest in reverse position.

Caution: If micro switch is adjusted too close to shift lever arm, micro switch arm will be damaged. If micro switch to shift lever arm is not adequately depressed, intermittent starting will occur. When this occurs, the shift lever will have to be bumped" or the car re-shifted before starting circuit will engage.

Remove and Install Shift Cable

1. At front of vehicle, remove cotter pin, washer, and clevis pin, securing shift cable clevis to console shifter assembly. See Figure 3. Loosen two jam nuts securing shift cable to floor board cable bracket.

2. Shift cable is secured to main frame at several points along its length. Locate and remove cable clamps.

3. At rear transaxle, locate and loosen jam nuts securing cable housing to transaxle shift cable bracket. Next, remove the single nut securing the shift lever to the transaxle shift shaft. Carefully, pry the transaxle shift lever from the shift selector shaft.

4. The shift cable assembly, tension springs, and spring bracket can be removed from vehicle. Note routing of the cable over rear fork, and, also, the routing over main frame and upward to console shifter assembly. See Figure 4.

5. To remove transaxle shift lever, tension springs, and spring bracket from cable, remove jam nut from end of cable. Unthread shift lever assembly, spring bracket and springs from shift cable. See Figure 5.

Caution: Once cable is removed, springs and components are under tension and could be "ejected" when disassembled.

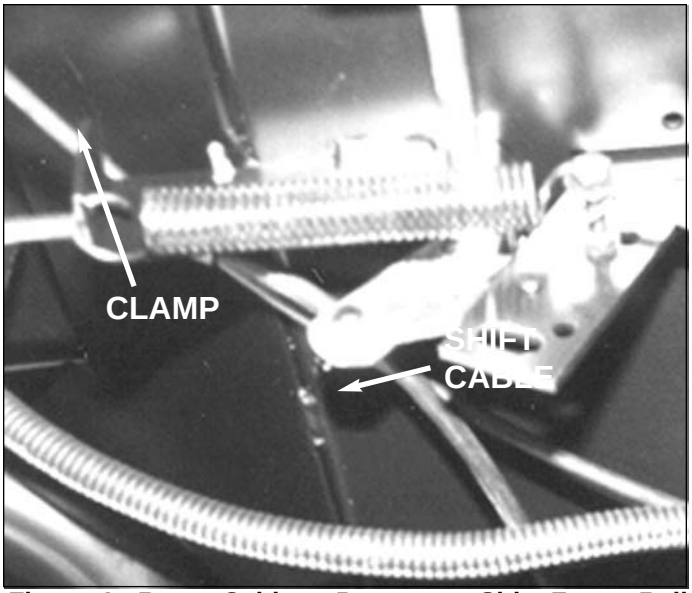


Figure 4 - Route Cable to Passenger Side, Frame Rail

6. Reassemble in reverse order. Use care to preassemble shift lever bracket and pin, shift springs and spring bracket. See Figure 5. Slide cable through shift lever and spring assembly, threading into opposite hole. Install jam nut.

Caution: Damage will occur if transaxle shift lever is not correctly aligned to transaxle shift shaft before nut is tightened.

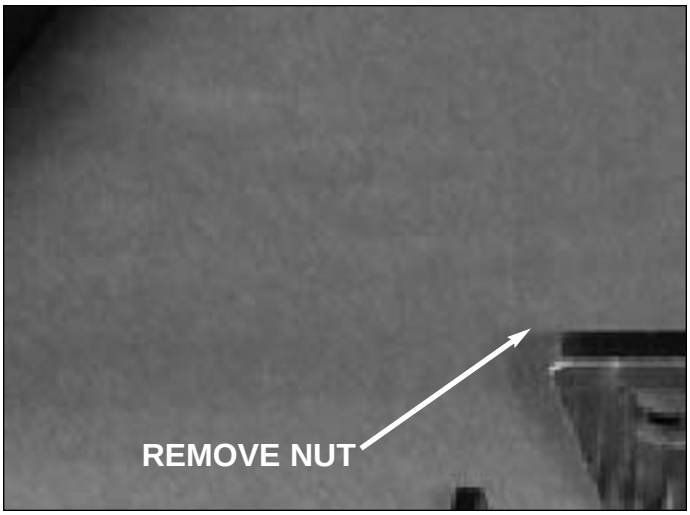


Figure 5 - Transaxle Shift Bracket and Springs

Shift Cable Adjustment

Minor Adjustment

If occasional minor readjustment is required, use the following adjustment method:

1. On flat, level ground, shift the console shift lever from forward to reverse and back again, rocking the vehicle each time you shift. Determine if the shifter feels solid in forward and weak shifting to reverse or if the shifter feels weak in forward and solid when shifted to reverse.

2. Locate the shift cable where mounted to the transaxle shift cable bracket. If more positive shifting to reverse is required, rotate two cable jam nuts to move cable housing away from transaxle. If more positive forward shift is required, rotate shift cable jam nuts to adjust cable housing towards the transaxle. Tighten jam nuts.

3. Recheck feel of console shifter assembly, and repeat process until forward to reverse shift feel is equal and balanced.

Complete Adjustment

Whenever cable replacement or shifter system repairs have occurred, use the following adjustment procedure to ensure cable adjustment is correct:

1. Remove shift cable from console mounted shifter by removing cotter pin, washer, and clevis pin from shift cable clevis at console shifter bell crank. See Figure 3.

2. Manually position the rear transaxle shift lever into the neutral position. See Figure 3.

3. Adjust shift cable at transaxle cable bracket so that threaded length is centered on shift cable bracket.

4. Carefully, balance console shift lever assembly into center (neutral) position. At front of vehicle, adjust cable housing at floor board cable bracket so that cable clevis (above) aligns with clevis pin hole at console shifter bell crank. Cable clevis can be adjusted up or down on shift cable in order to “fine tune” this alignment. Install clevis pin securing shift cable clevis to shifter assembly bell crank, using flat washer and new replacement cotter pin.

5. With vehicle on flat level surface, shift console shifter assembly to forward position, and rock vehicle back and forth. Shift console shifter assembly to reverse, and rock the vehicle back and forth. Check that in each direction, a slight amount of vehicle travel is observed before you note a “click” as the transaxle engages into gear. Check that the **feel** of the shifter assembly is equal in forward and reverse.

   If in operating the shifter, you feel firm or solid action when shifting to forward, and weak or vague action to reverse, adjust cable housing downward away from the console shifter assembly at cable bracket. If shifting feels weak or vague in forward and strong or solid in reverse, adjust shift cable upward towards the shifter assembly at cable bracket. Recheck shifter **feel** to ensure that balanced and equal shifting is observed in forward and reverse.

GAS VEHICLE FINAL DRIVE AXLE ASSEMBLY

Service Procedure for Transaxle Assembly

Removal of Transaxle

Caution: Always, remove key and disconnect the negative battery cable before performing any service to this vehicle. Raise the rear of vehicle and support on approved jack stands.

1. Open rear body and disconnect body restraint cable from bag rack. See Figure 6. Close rear body and unbolt two hinges from rear body. See Figure 7. With hinges unbolted, grasp rear body by the bag rack and set aside.

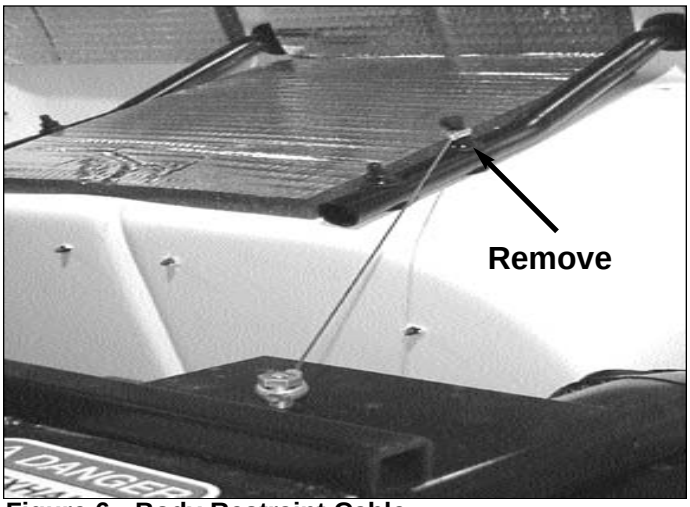


Figure 6 - Body Restraint Cable

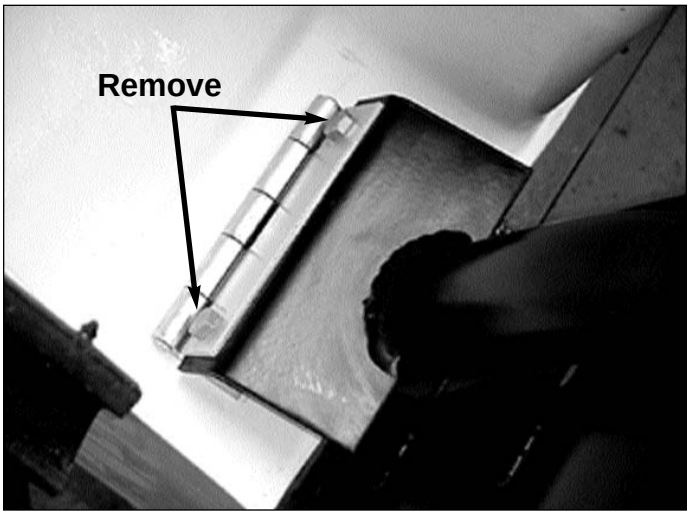


Figure 7 - Body Hinge

Note: This service can be performed without removing muffler, however, improved clearance and ease of disassembly will result if removed. See Chapter 7, Exhaust System Service, for removal and replacement procedure.

2. Slide dust boot off accelerator cable. Remove jam nut completely, and slide cable from slotted accelerator cable bracket. See Figure 8.

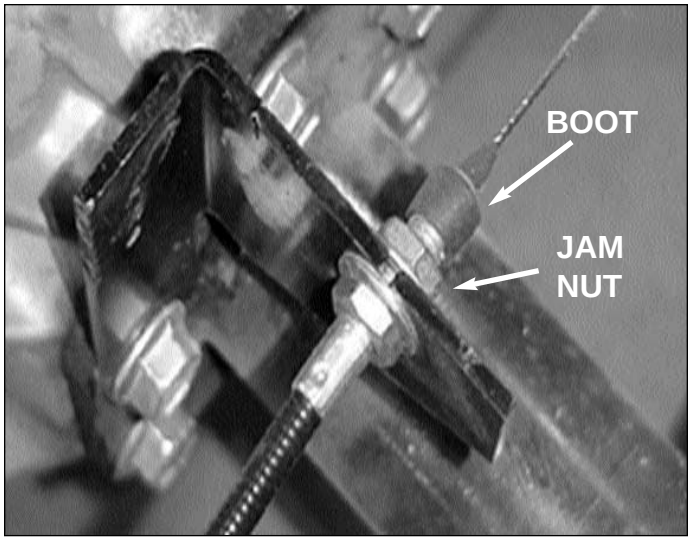


Figure 8 - Accelerator Bracket

3. Remove nut at top of governor shaft, then remove governor arm from shaft.

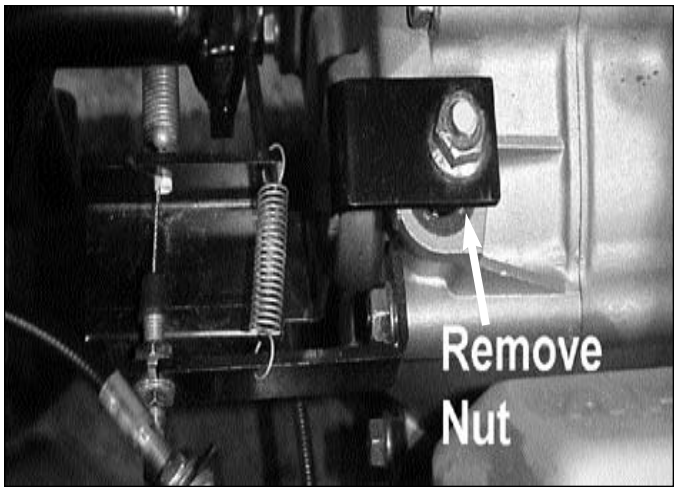


Figure 9 - Remove Governor Arm

4. Remove cable lock bushing from throttle cable bracket. Early models use pinch weld over this slot in governor arm to prevent cable from popping out of position. Later models use a plastic lock bushing to retain throttle cable in governor arm. See Figure 10.

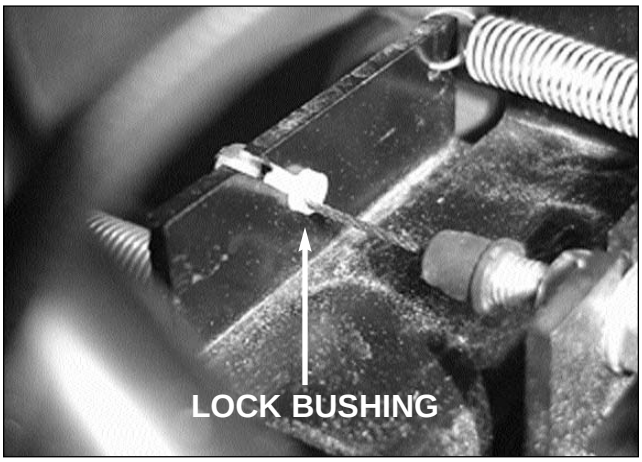


Figure 10 - Throttle Cable

5. Remove spring from governor arm, and remove throttle cable from throttle cable bracket.

6. Disconnect shifter lever bracket from transaxle shift shaft. Pry equally around bracket to remove from transaxle shaft..

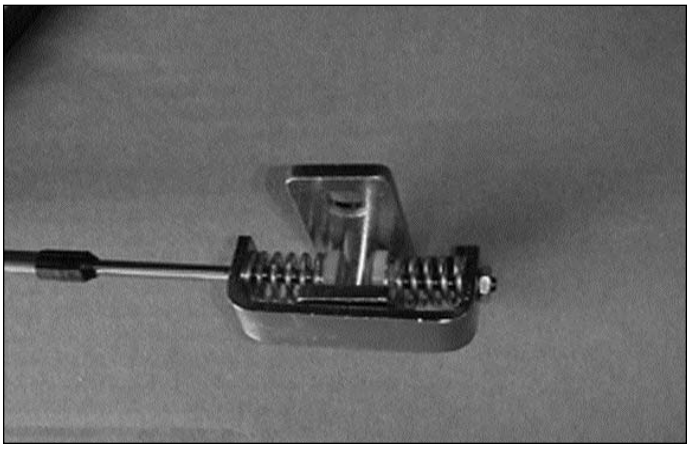


Figure 11 - Transaxle Shift Lever and springs

7. To remove drive belt, loosen air cleaner wing nut and rotate air cleaner dust unloader away from secondary transmission. Lift drive belt and roll towards rear, sliding belt off secondary transmission. See Figure 12.

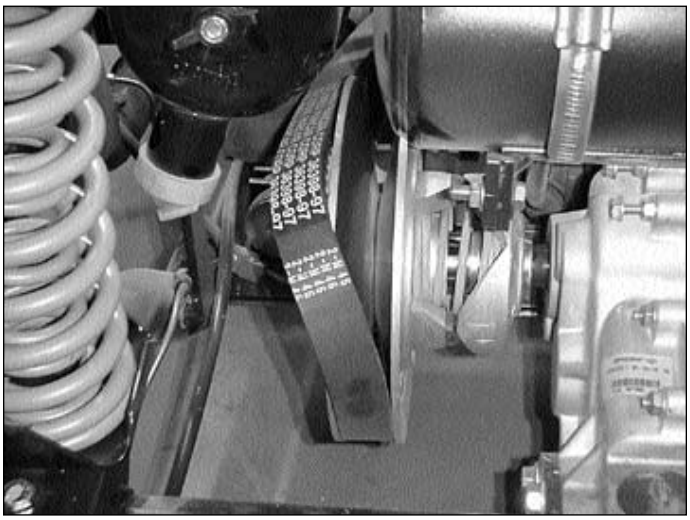


Figure 12 - Remove Drive Belt

8. Remove the single bolt securing secondary transmission to transaxle input shaft. With this bolt removed, the secondary transmission should slide off the input shaft. If necessary, use a pry bar to evenly pry clutch from shaft.

9. Position a floor jack under transaxle gearbox. See Figure 14. Be sure the lifting pad of jack engages gearbox so it will not slip off. Block ahead and behind front tires. Then, raise vehicle enough to position jack stands under rear fork tubes as shown. See Figure 8.

Caution: Be sure jack stands fully engage fork tubes and set squarely against floor as weight of vehicle will be lowered onto stands. Lower complete weight of vehicle onto stands. Keep floor jack under transaxle to prevent it from falling as axle mounting hardware is removed. See Figures 13 and 14.

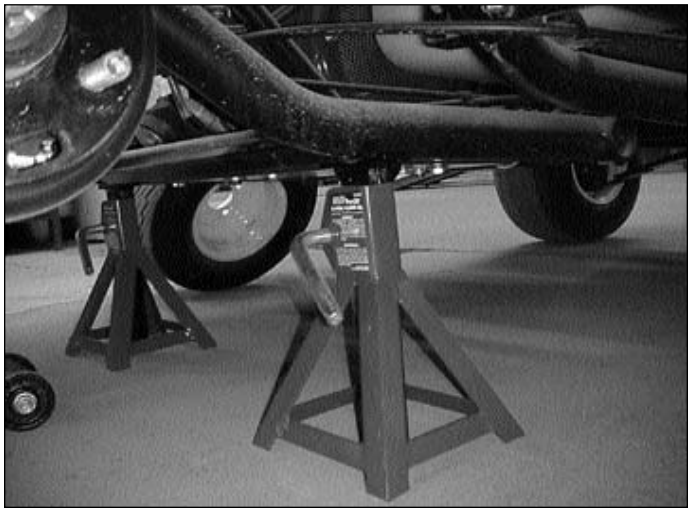


Figure 13 - Jack Stand Under Fork Tube

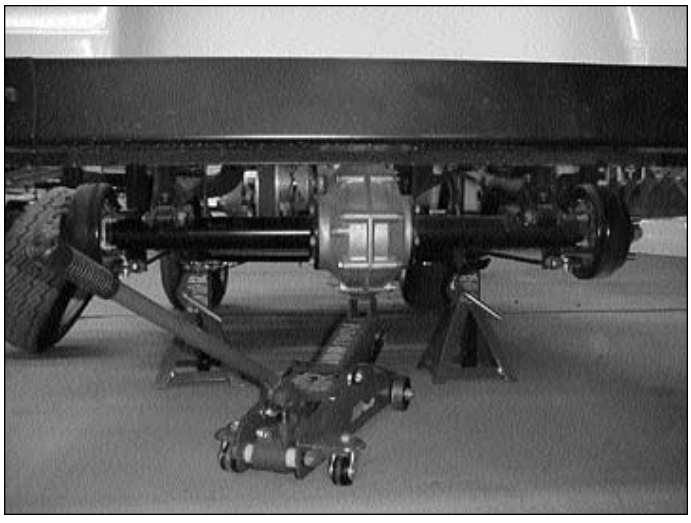


Figure 14 - Floor Jack Under Transaxle

10. Remove wheel rim mounting nuts, and remove the wheels from transaxle. See Figure 10.

Figure 15 - Remove Wheel

11. Remove brake cable housing from brake cable bracket by first removing the "E" clip. Remove cotter pin, clevis pin, and slide brake cable from brake cable bracket.

Important: Do not reuse "E" clips or cotter pins. Always replace with new when reassembling. See Figure 16.

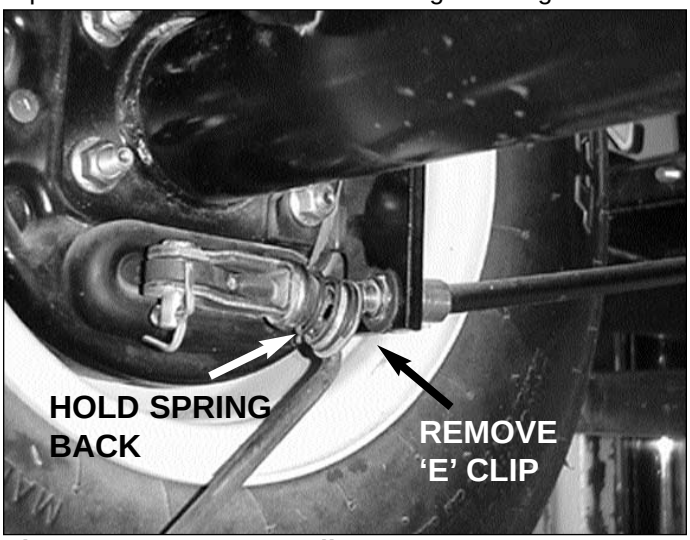


Figure 16 - Remove 'E' Clips

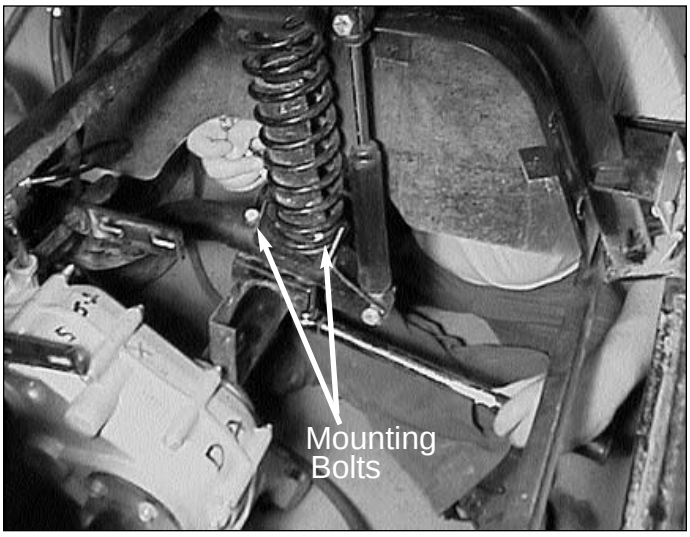


Figure 17 - Remove Transaxle Mount Bolts

12. Remove the two (2) nuts and bolts securing transaxle to each end of rear fork. See Figure 17.

13. Have a helper steady the axle while lowering floor jack. Use floor jack to roll axle out from under vehicle.

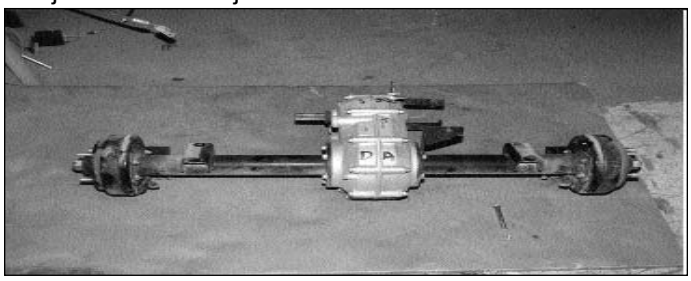


Figure 18 - Transaxle Removed

Disassembling Transaxle

1. Remove the oil drain plug (M14) and drain the oil from transaxle. Always, drain oil into a clean pan in case inspection is required. Replace gasket if damaged. See Figure 19.

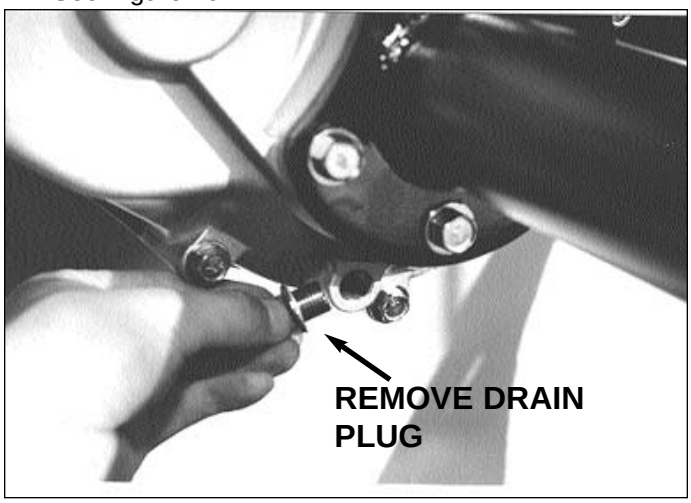


Figure 19 - Drain Oil

2. Remove the M10x12 mm bolt over shift detent. Remove the spring and steel ball. Replace gasket if damaged. See Figure 20.

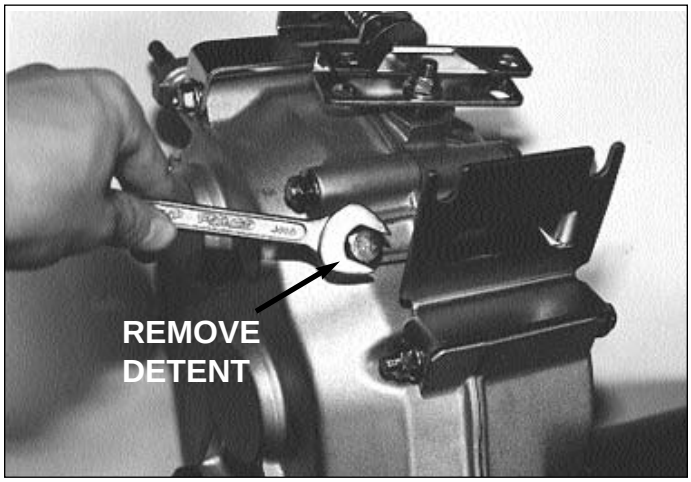


Figure 20 - Shaft Detent Bolt

3. Wind vinyl tape on the splined portion of the input shaft to protect the seal lip. See Figure 21.

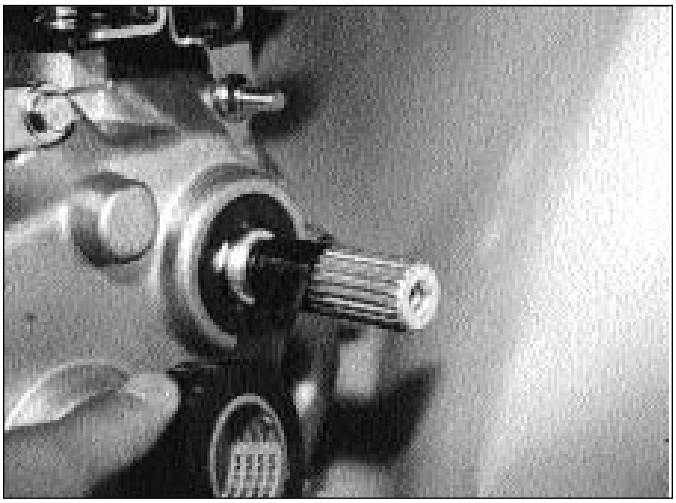


Figure 21 - Protect Shaft

4. Support transaxle by gear case with input shaft pointing down. Loosen and remove all case bolts. See Figure 22.

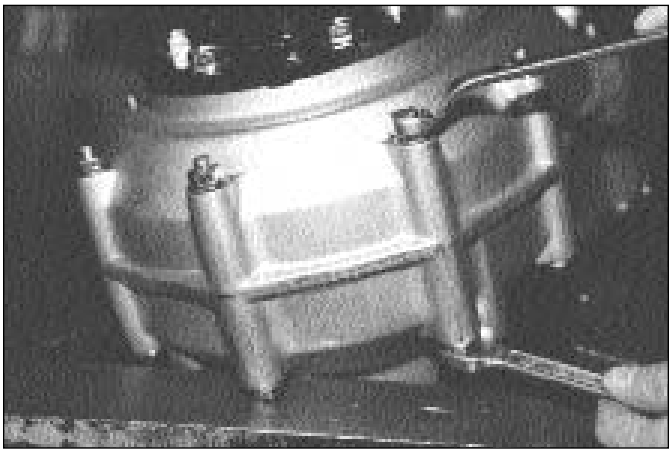


Figure 22 - Case Bolts

5. Remove the right (top) case half by grasping the axle housing and gently tapping governor boss with a plastic mallet. See Figure 24. **Do not** pry cases apart with screw drivers as damage to gear case gasket surfaces will result. See Figure 23.

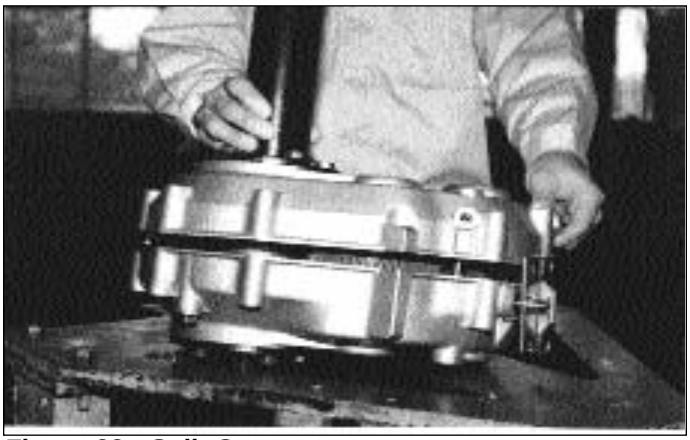


Figure 23 - Split Case

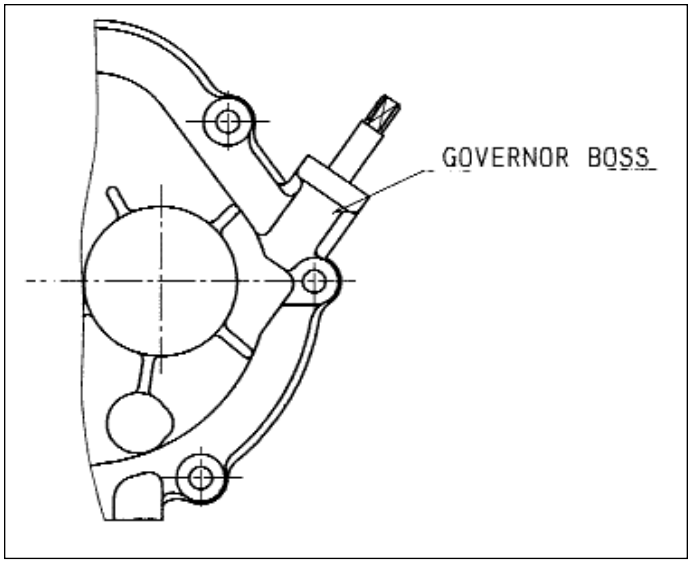


Figure 24 - Governor

6. Pull out counter shaft, and remove counter gear. Remove spacer located under counter gear. See Figure 25.

Figure 25 - Remove Counter Shaft, Gear and Spacer

7. All three gear assemblies must be lifted together to allow clearance for removal. Lift differential assembly and center shaft assembly together, enough to remove input shaft.

   Next, remove differential assembly and center gear assembly last. If you have difficulty in removal, hold the gear assembly and tap the case gently with a plastic mallet. Be careful not to damage the oil seal when removing input shaft assembly. See Figure 26.

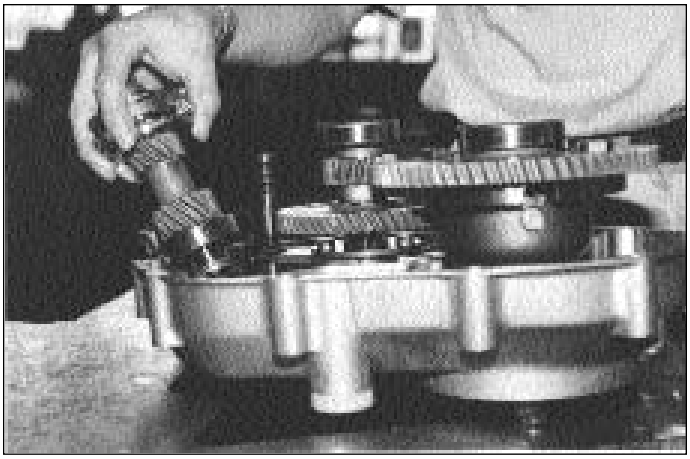


Figure 26 - Removing Input Shaft

8. Remove the axles from the gear case halves. See Figure 27.

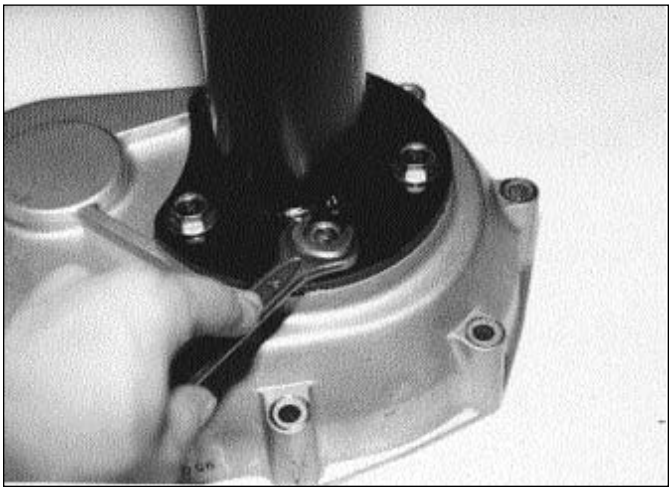


Figure 27 - Remove Axle from Case

9. To remove axle from axle housing, remove retaining rings at outer end of axle housing. Pull outward to remove axle. **Do not** re-use retaining rings. See Figure 28.

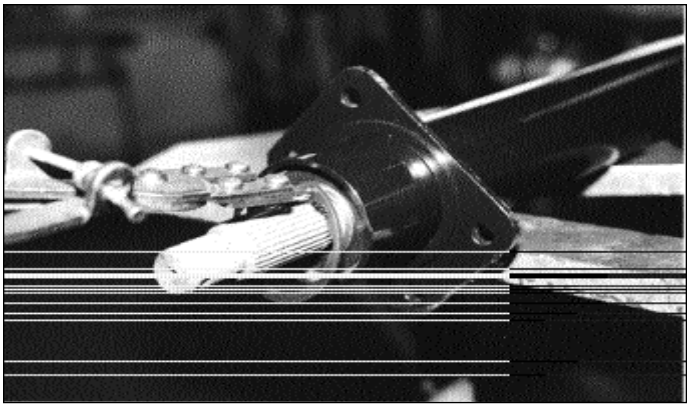


Figure 28 - Remove Snap Ring from Axle Housing

10. To disassemble input shaft, remove governor sleeve and bearing. A puller will be required to remove bearing. Use a new bearing when reassembling. See Figure 29.

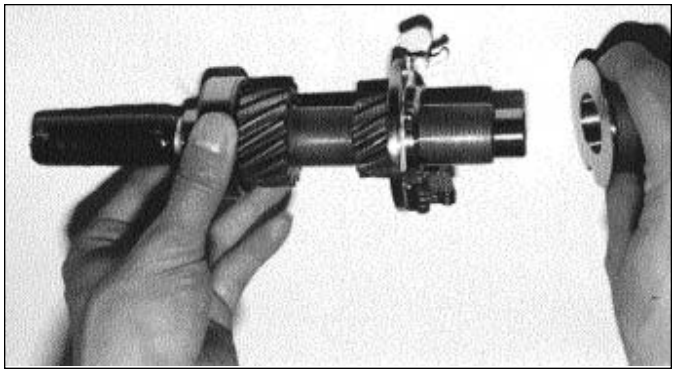


Figure 29 - Input Shaft Assembly

11. Remove the three screws holding governor plate and weights to collar on the input shaft assembly. Use caution not to damage screws which are assembled with locktite. See Figure 30.

    Tightening Torque:
    12 to 15 inch-lb.
    (14-18Kgf. cm)
    (1.37-1.76 N.m)

Figure 30 - Input Shaft Assembly when Disassembled

12. To disassemble center shaft assembly, press off bearings (6204 & 6304), slide two gears, clutch collar and spacers from shaft. Note the removal order for reassembly of these components, or refer to illustrations in your parts manual. **Always,** use new bearings when reassembling. See Figures 31 and 32.

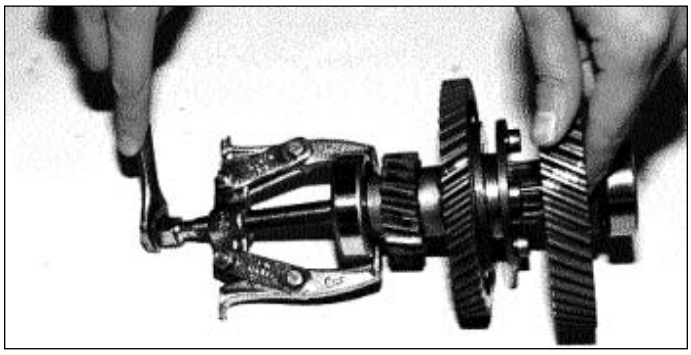


Figure 31 - Center Shaft Assembly

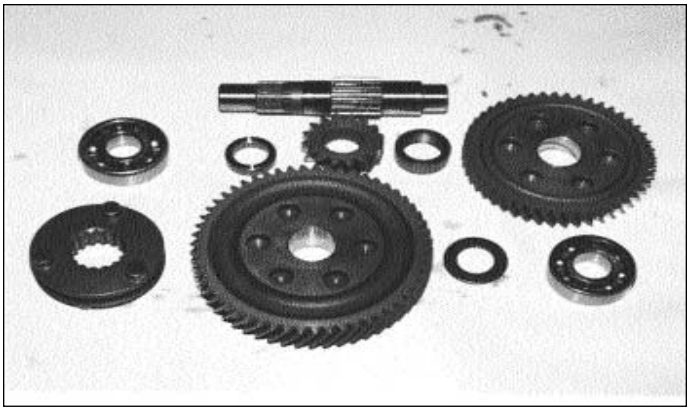


Figure 32 - Center Shaft Assembly when Disassembled

13. To remove differential gear from differential housing, first remove four (4) bolts. See Figure 33.

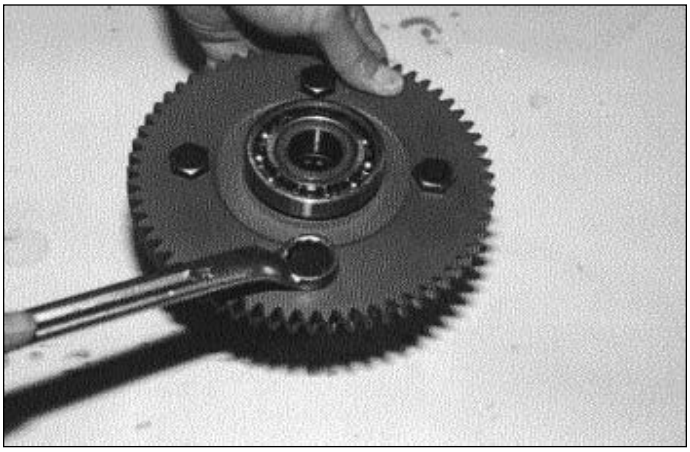


Figure 33 - Differential

Then, drive out the spring pin using a 5/32 inch (3.8-4.0mm) punch, from back side of housing. Always use a new spring pin when reassembling. See Figure 34.

Figure 34 - Differential Components

14. Remove differential shaft and differential gears from inside housing.

15. Remove two screws holding stopper plate and governor fork to the governor shaft. Remove fork and pull the shaft out of gear case using care not to damage the seal. Use care in removing screws. Locktite was used to prevent loosening. See Figure 35. Remove bearing (6204) from behind governor fork.

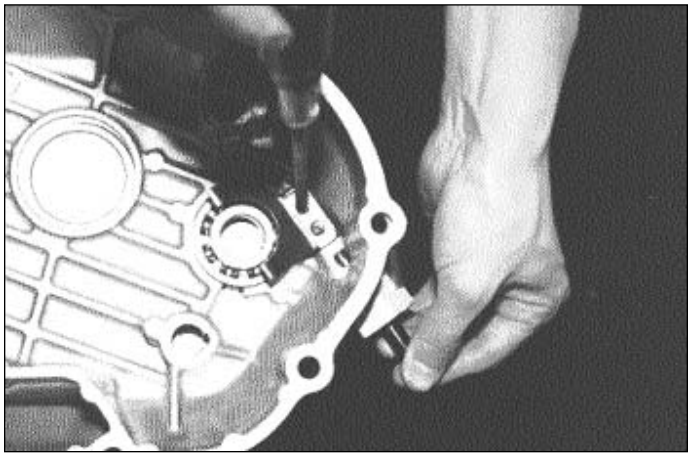


Figure 35 - Governor Yoke

16. Remove seal from shift selector shaft. Remove retaining clip, washer, and shift selector. Shaft can now be removed from gear case. See Figure 36.

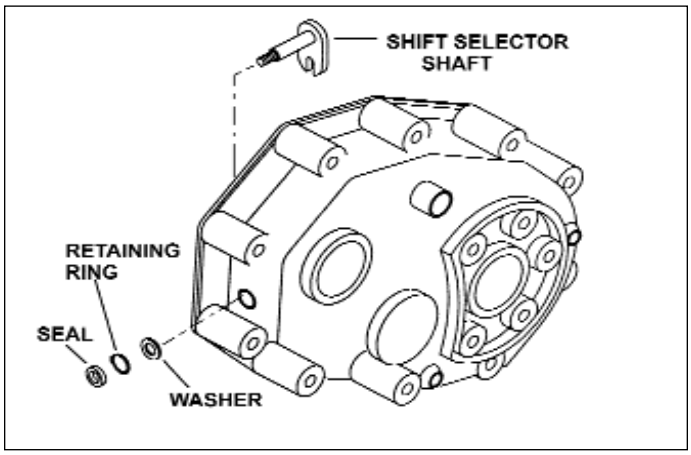


Figure 36 - Shift Selector Shaft

Assembly of Transaxle

1. Install shift selector shaft, washer and new retaining ring. Install oil seal. See Figure 36.

2. Install the governor plate to input shaft with three screws.

Note: Apply locktite thread adhesive to the screws to prevent loosening. Clean & prime threads if necessary, for proper adhesion.

3. Press a new bearing (6205) on to input shaft using an arbor press.

Note: Apply force using a hollow mandrel, to the inner race of bearing only, to prevent damage. See Figure 37.

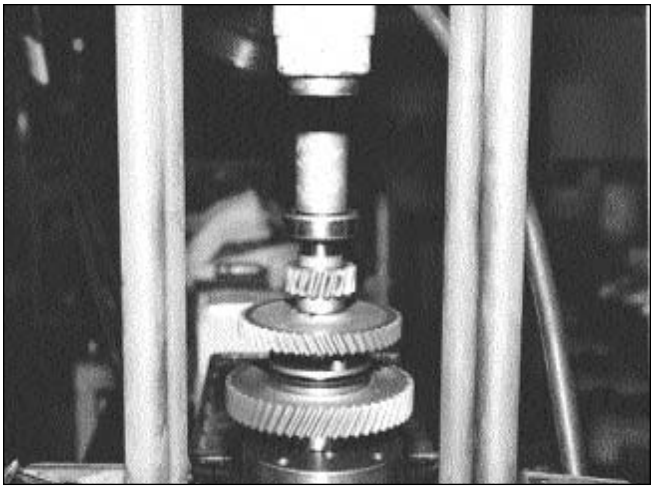


Figure 37 - Using a Hollow Mandrel to Press Bearings, Center Shaft Assembly Illustrated

4. Apply moly grease to bore of governor sleeve, and slide it onto input shaft. Lift weights and position them over collar on sleeve.

5. Apply moly grease to bore of two center shaft gears. Slide two gears, clutch collar and spacers onto center shaft and then press two bearings (6204 & 6304) onto shaft using an arbor press. Use new bearings, refer to Figure 38 to verify correct order of assembly.

Note: Apply force, using a hollow mandrel, to inner race of bearings only (to prevent damage).

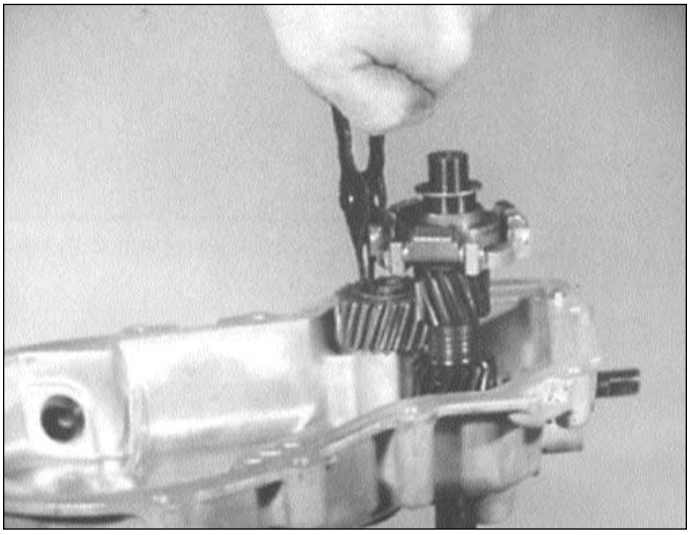


Figure 38 - Center Shaft Assembly

6. Lightly coat hubs and teeth of differential gears with moly grease and assemble them with differential shaft in differential housing. See Figure 39. Drive in a new spring pin to retain shaft. See Figure 41.

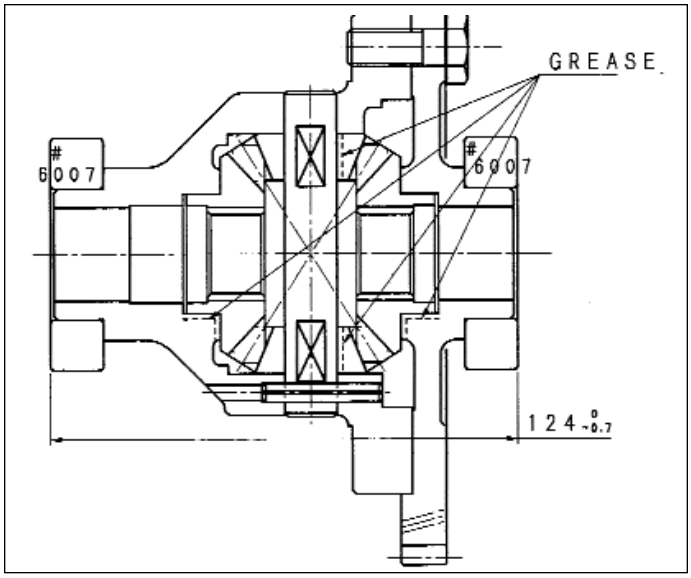


Figure 39 - Assembly Input Shaft

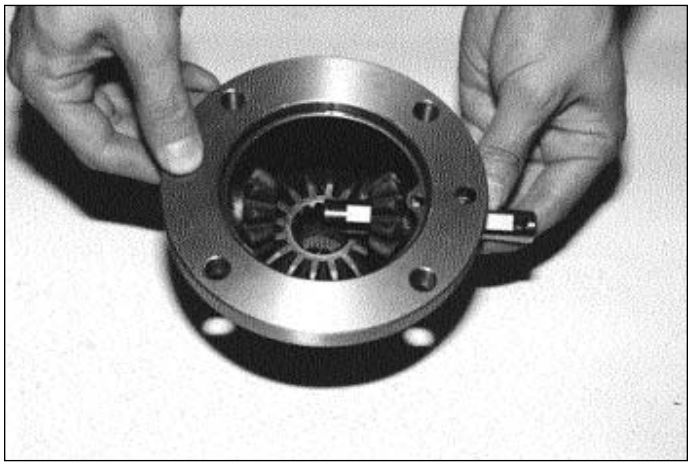


Figure 40 - Differential Assembly

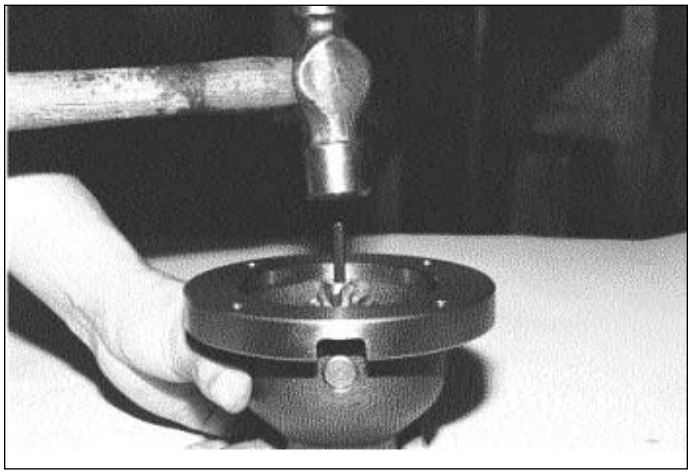


Figure 41 - Spring Pin

7. Bolt differential gear to outside of housing with four bolts. See Figure 42.

Tightening Torque:
40 to 46 ft. lbs.
550-630Kgf. cm
(54-61.7N.m)

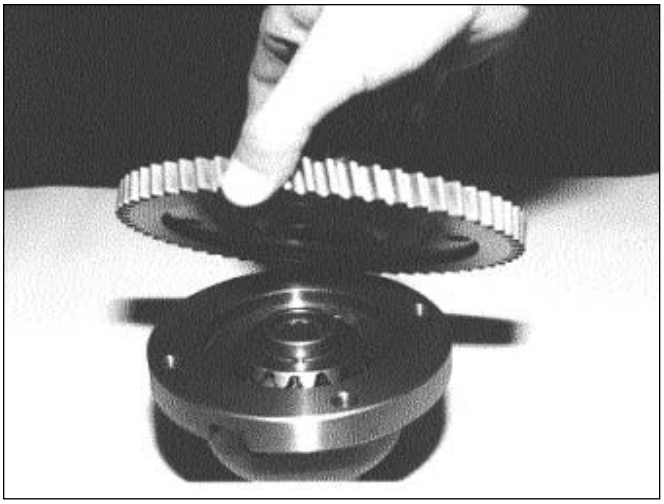


Figure 42 - Differential Gear

8. Tap a new bearing (6204) into the gear case bore (under shift fork). See Figure 35. Coat the governor shaft with grease, and slide through the bearing and into the case as illustrated.

   Install the fork so it is centered over the bearing in the gear case. Adjust the keeper plate to limit the end play of the governor shaft to less than 0.5mm. See Figure 38.

Note: Use care not to damage oil seal. Bolt the governor fork and keeper plate to the shaft with two new M4 screws. Use locktite thread adhesive to prevent the screws from loosening.

Tightening Torque:
12 to 15.5 inch lb.
14-18Kgf. cm
(1.37-1.76N.m)

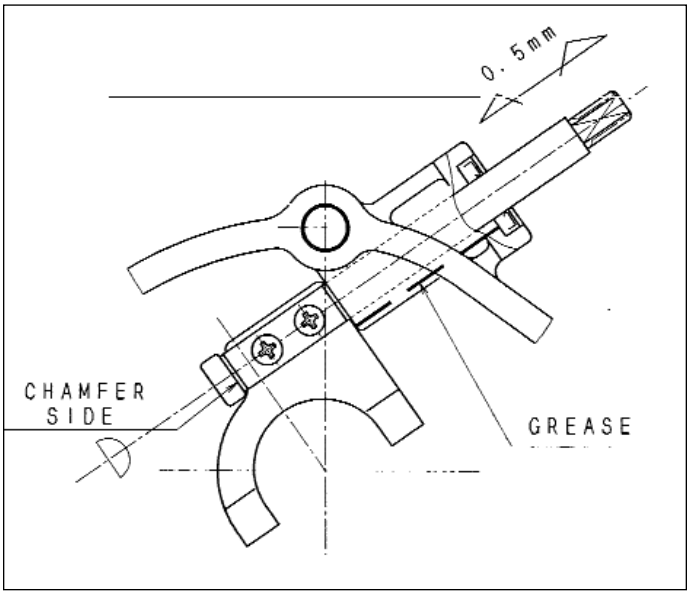


Figure 43 - Governor Fork Assembly

9. Install the axle shafts and bearings (6205DD) into the axle housings. Use care not to damage oil seal in the axle housing when installing axle shafts. Secure in the housing with a new 52 mm snap ring. See Figure 28.

   Guide the other, splined end, of the axle shaft into the differential assembly. Bolt the axle housing flange to the gear case with five M10x23 mm bolts. See Figure 27.

   Tightening Torque: 25 to 31 ft. lb.
   (34.3-42.2N.m)
   (3.45 - 4.3 Kgm.)

Important: The axle housings are not identical. The cut-out faces toward the middle of the gear case and the left hand axle is longer than the right hand axle.

10. Insert the shift fork into the groove on the clutch collar as shown. See Figure 44.

Figure 44 - Center Shaft Assembly with Shift Fork

11. Install the input shaft assembly, center shaft assembly and differential gear assembly into gear case at the same time. See Figure 45.

Note: Be sure that shifter shaft arm engages the pin on shift fork during assembly.

Figure 45 - Assemble Gear case

12. Place the spacer on counter shaft bore in lower case with the oil groove to the top side. See Figure 46.

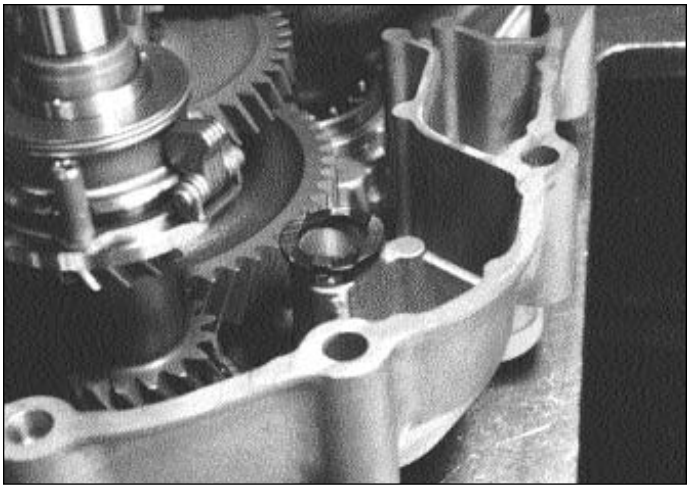


Figure 46 - Position Spacer

13. Apply grease to the bore of the counter gear and place it over the spacer. Slide the counter shaft through the gear, spacer, and into the case bore. See Figure 47.

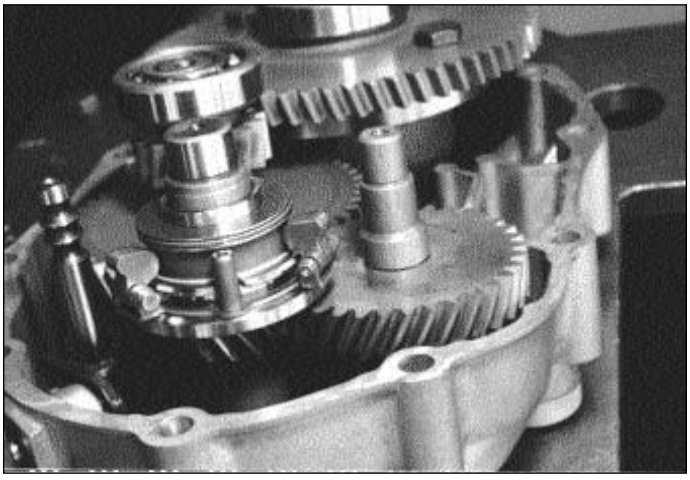


Figure 47 - Install Counter Shaft Assembly

14. Clean the sealing surfaces of the two case halves with a cloth, and install a new gasket.

Note: Make sure two dowel pins are in place, aligning gear case gasket and preventing it from slipping out of place during assembly.

Position the upper case half with axle bolted to it above the lower gear assembly. Lower the upper half into position on the lower half and bolt together with eight (8) 100 mm bolts, one (1) 110 mm bolt. See Figure 48.

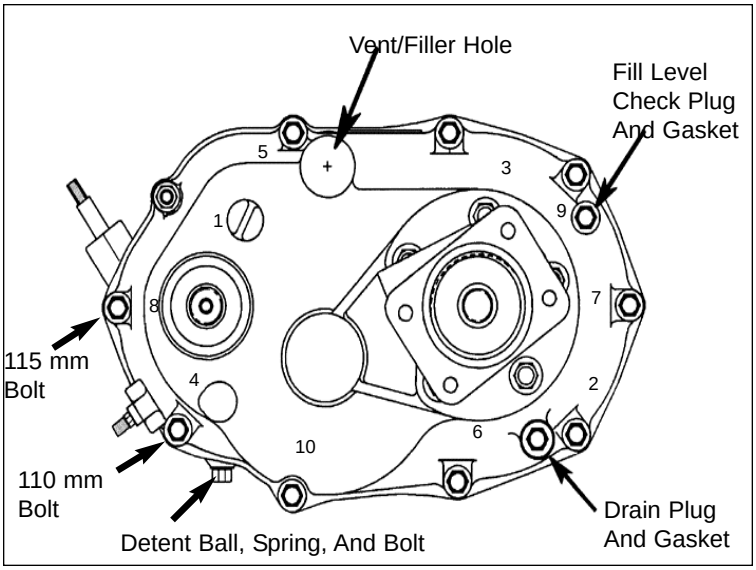


Figure 48 - Bolt Diagram

Note: Hold the governor shaft to keep the bearing (6204) in the proper position in gear case.

15. Install shift cable bracket on to 110mm bolt. Install throttle cable bracket on to 115mm bolt. Torque all 10 gear case bolts in order shown above. See Figure 48.

    Tightening Torque:
    15.2 to 18.8 ft. lb.
    (2.1 to 2.6 Kgm)

16. Install the detent spring and steel detent ball. Install the M10x12mm bolt with gasket over the detent spring.

    Tightening Torque:
    11.6 to 15.1 ft.lb
    (1.6 to 2.1 Kgm)

17. Install a new gasket on the drain plug if old one is damaged, and install drain plug.

    Tightening Torque:
    11.5 to 15 ft. lb.
    (2.1 to 2.6 Kgm)
    Oil: 30Wt. Engine Oil
    Oil Quantity: 3 to 3.1 Quarts (1.4 L ± 0.1 Liter)

Installation of Axle Assembly

1. Place the axle onto a floor jack and slide into position under the rear of the vehicle. Have a helper steady the axle and raise it to the four (4) mounting bolts from the lower coil spring saddles. These bolts can be reused, but the NYLON LOCKING NUTS MUST BE REPLACED with new ones. This is a critical connection. See Figure 17.

Tightening Torque:
40 to 45 ft. lb.
(5.5 - 6.2 Kgm)

2. Secure the brake cable housing to each brake cable bracket using an "E" clip.

Important: Do not reuse "E" clips or cotter pins. Always replace with new ones when reassembling. See Figure 16.

3. Connect the cable to the rear brake lever with clevis pin and new cotter pin. Always, use new cotter pins.

Note: Always, readjust brake cables before operating vehicle. See Chapter 4 (Brakes) for details.

4. Install the wheels and four (4) lug nuts per wheel. Snug in a criss-cross pattern. Then, torque nuts to 65 ft. lb. (9 Kgm) in a criss-cross pattern.

5. Raise the vehicle from jack stands, remove stands and lower vehicle to the floor.

6. Install secondary driven clutch onto transaxle input shaft.

Note: Very early vehicles used a 1/4" spacer between the input shaft and secondary driven clutch. If this clutch is replaced with a new driven clutch, this spacer must be discarded and not used.

Caution: Use of the early driven clutch spacer with a replacement driven clutch will damage the driven clutch and transaxle input shaft. Do not reuse the spacer if driven clutch is replaced.

7. Install driven clutch bolt, lock washer, and flat washer. Torque to 26 to 28 ft. lb. (35 To 38 N.m.).

Caution: Do not substitute hardware for driven clutch installation. Original equipment hardware must be used to prevent loosening or damage to components.

8. Install transaxle shift-lever and cable assembly to transaxle shift selector shaft. Install lock nut.

Note: Check that transaxle shift lever is correctly aligned to selector shaft before nut is torqued.

Tightening Torque:
95 to 139 inch lb.
(10.8 to 15.7 N.m.)

See page 6-3 for Shift Cable Adjustment.

9. Install governor arm on to transaxle governor shaft.

Tightening Torque:
115 to 135 inch lb.
(10.8 to 15.7 N.m.)

10. Install accelerator cable bracket on to right axle case.

Tightening Torque:
25 to 31 ft.lb.
(3.5 to 4.3 Kgm)

11. Secure accelerator cable into accelerator cable bracket on right axle case. See Figure 8.

12. Install throttle cable on to throttle cable bracket. See Chapter 3 for Throttle Cable Adjustment.

13. Install muffler cradle and muffler. See Chapter 9 for installation recommendations.

Caution: Proper order of assembly is crucial for exhaust system. Failure to assemble in proper order will cause muffler or engine head pipe damage.

14. Install drive belt.

15. Rotate air cleaner cover to point dust unloader straight downward. Tighten wing nut on cover.

16. Lower vehicle from jack stands or support and set on level ground.

Remove fill level/check plug and yellow vent/filler plug. Add oil only until oil level reaches fill level. Check plug hole. See Figure 48.

Oil: 30 Wt. Engine oil
Below 0° F (-17°C), use 10-30Wt. Engine oil

17. Install fill level. Check plug and gasket.

Tightening torque:
11.5 to 15 ft. lb.
(15.7 to 20.6 N.m.)

GAS VEHICLE FINAL DRIVE ASSEMBLY TRAM AND 2400 LB. MODELS

General

Precautions for Disassembly

The rear axle is a precision assembly, and as such any repair or replacement of parts must be done with great care in a clean environment. Before attempting to perform any service on the axle, read and understand all of the following text and photographs.

Handle all gears with extreme care.

Cleanliness

The axle assembly should be degreased prior to disassembly. Dirt is abrasive and will cause premature wear of bearings and other parts. We suggest that mechanics have a small wash tank to clean parts prior to reassembly.

Bearings and Seals

It is recommended that whenever a bearing, seal or "0" ring is removed, it be replaced with a new one regardless of mileage. Always, wipe the seals and "0" rings with light oil before installing.

Bearings and seals should be removed with pullers designed for this purpose.

Snap Rings

Snap rings must be removed and installed with care to prevent damage to bearings, seals, and bearing bores.

Cleaning and Inspection

Torque Chart

Tube Mounting Bolts	25-35 ft. lbs.
Carrier Bolts	100-120 in. lbs.
Ring Gear Bolts	35-45 ft. lbs.
Brake Bolts	
160 mm Brakes	15-19 ft. lbs.
7x1-3/4" Brakes	16-20 ft. lbs.
Spindle Nut	95-115 ft. lbs.
Detent Screw*	

* Tighten detent screw to achieve a shift torque of 8-14 in. lbs. on shift actuator assembly.

Cleaning

Parts should be cleaned with emulsion cleansers or petroleum based cleaners. Clean, inspect and lubricate all bearings just prior to reassembly. Clean all sealing surfaces of old gasket material.

Drying

Use soft, clean, lint-free towels or rags to dry components after cleaning. 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 coated with a light coat of lubricant or rust preventive to prevent damage from corrosion. If parts are to be stored for a period of time, they should be wrapped.

Inspection

Prior to reassembly, inspect parts for signs of wear or damage.

Bearing and seal surfaces should be inspected for pitting, wear, or overheating.

Inspect gears for pitting, wear or scoring.

Inspect axle shafts for worn splines, bends or cracks. Replacement of these parts can prevent premature failure.

Oil Check and Change Intervals

Checking - only if signs of leakage are detected - then check oil level.

Changing - change oil every 24 months or 2000 km (1250 miles) whichever occurs first.

Capacity -20-24 ounces (592 ml.), SAE 30 wt.

IMPORTANT SAFETY NOTICE

Proper service and repair is important to the sale, reliable operation of all motor vehicles or driving axles whether they be front or rear. 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 the purpose. The special tool should be used when and as recommended.

It is important to know, evaluate, and advise the service trade of all conceivable ways in which service might be done, or of the possible hazardous consequences of each way.

Accordingly, anyone who uses a service procedure or tool, which is not recommended, must first satisfy himself thoroughly that neither his safety nor vehicle safety will be jeopardized by the service methods he selects.

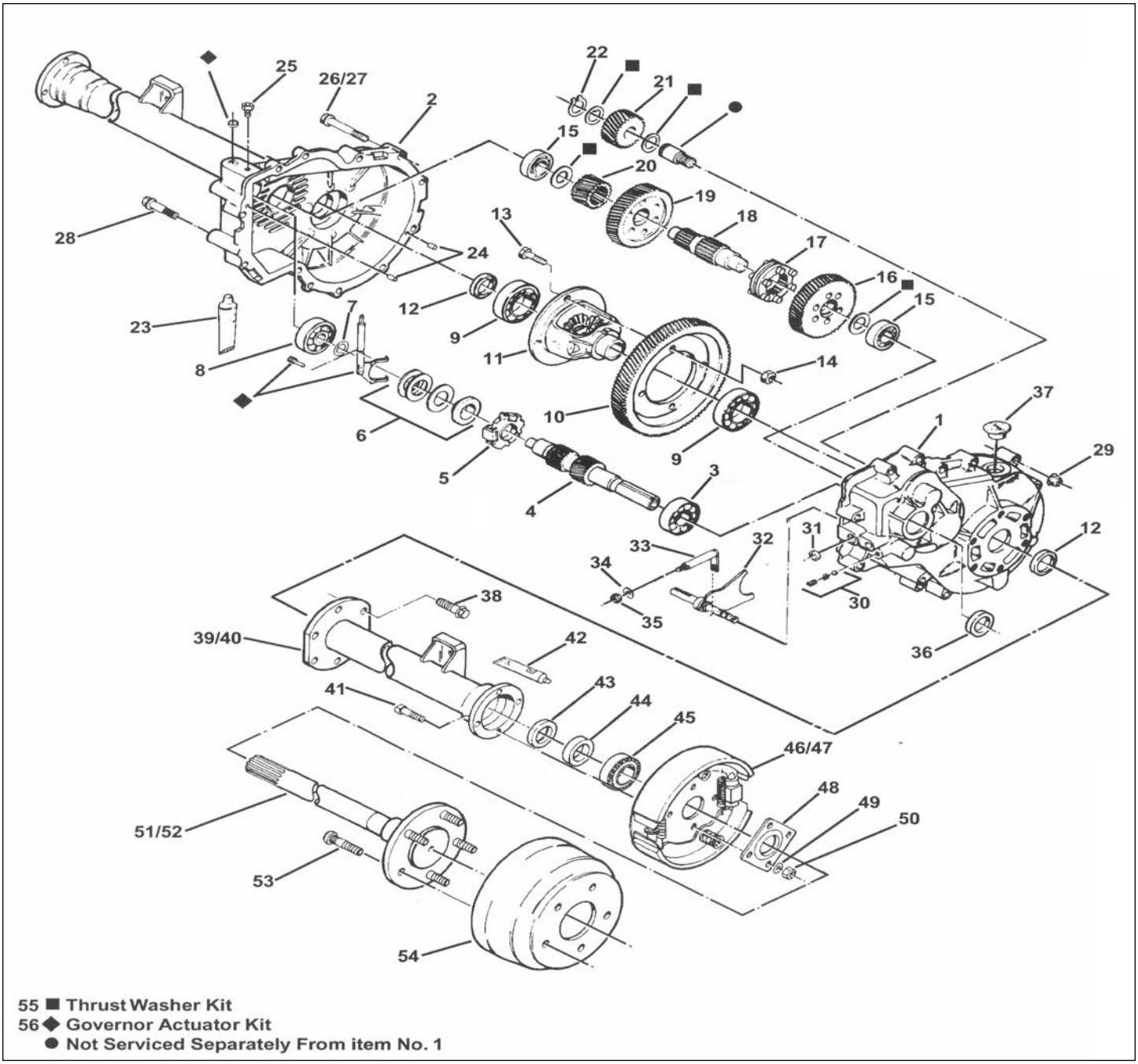


Figure 49 - Exploded View

ITEM	DESCRIPTION	QTY
1	Housing, Axle (Rh.)	1
2	Housing Axle (Lh.)	1
3	Bearing, Ball	1
4	Shaft, Input	1
5	Backing Plate Assm.	1
6	Actuating Sleeve Assm	1
7	Shim Kit	1
8	Bearing, Ball	1
9	Bearing, Ball	2
10	Gear, Final Drive (Ring)	1
11	Differential Assm.	1
12	Seal, Oil	2
13	Screw Cap	4
14	Nut, Lock	4
15	Bearing, Ball	2
16	Gear Assm., Drive	1
17	Gear, Clutch	1
18	Shaft, Intermediate Finish	1

ITEM	DESCRIPTION	QTY
19	Gear Assm., Drive	1
20	Gear, Final Drive (Pinion)	1
21	Gear Assm., Idler	1
22	Ring, Snap	1
23	Sealant (Non-Silicone	A/R
	Based Gasket Eliminator	1
24	Seal, Oil	2
25	Vent	1
26	Screw, Flange Hd (Long)	2
27	Screw, Flange Hd (Short)	11
28	Screw, Flange Hd (Short)	2
29	Nut, Lock	13
30	Detent Kit (Items Not Serviced Separately)	1
31	Seal, Oil	1
32	Rod Assm., Shift	1
33	Actuator Assm., Shift	1
34	Washer	1

ITEM	DESCRIPTION	QTY
35	Nut, Lock	1
36	Seal, Oil	1
37	Plug, Rubber	1
38	Screw, Flange Hd	12
39	Tube Assm., (Rh)	1
40	Tube Assm., (Lh)	1
41	Ring, Snap	4
42	Bearing, Ball	2
43	Axle Shaft (Rh)	1
44	Axle Shaft (Lh)	1
45	Nut, Spindle	2
46	Pin, Cotter	2
47	Thrust Washer Kit (Item Not Serviced Separately)	1
48	Governor Actuator Kit (Items Not Serviced Separately)	1

Should an axle assembly require component parts replacement, it is recommended that "Original Equipment" replacement parts be used. They may be obtained through your local service dealer, or other original equipment manufacturer parts supplier. The use of non-original equipment replacement parts is not recommended as their use may cause unit failure and or affect vehicle safety.

Disassembly

Note: Brake and axle shaft can remain assembled with axle tube, and axle tube remains attached to carrier half when disassembling carrier. Appropriate fixturing will be required to hold carrier half with tube attached.

Drain all oil from carrier before disassembly.

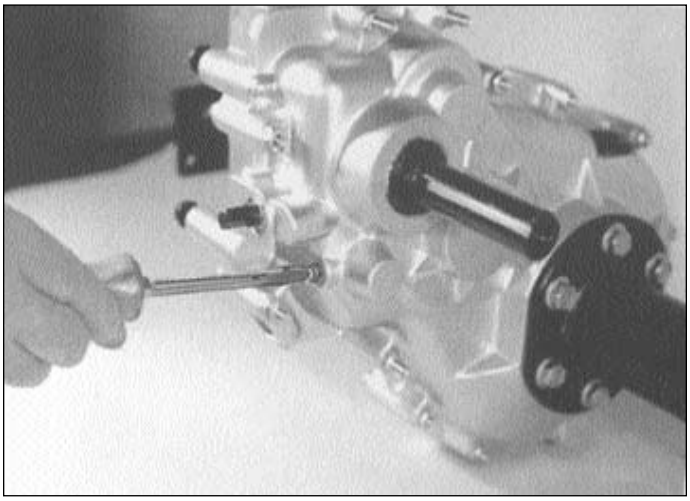


Figure 50 - Remove Detent Screw

1. Remove detent screw. Using a magnet, remove the spring and detent ball from the bore. See Figure 50.

Note: The detent spring and ball may fall out of the housing when the detent set screw is removed.

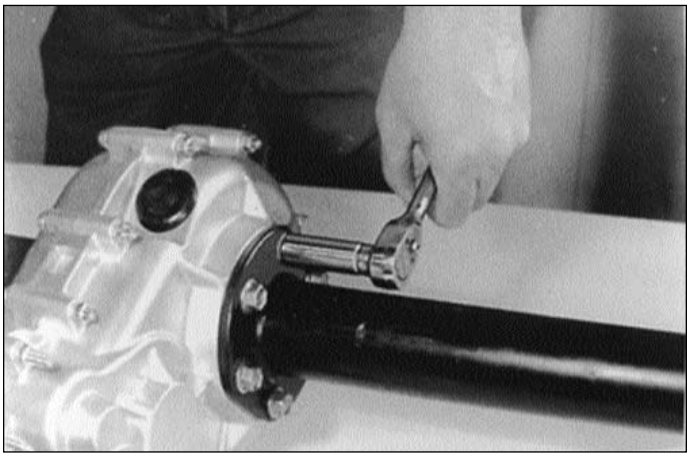


Figure 51 - Remove Axle and Axle Housing

Remove (6) bolts from the tube flange. Remove tube from carrier assembly. Repeat on opposite side.

Note: Tubes and axle shafts do not have to be removed prior to housing half separation.

Note: The axle shaft can remain in the tube when removing or installing the tube on the carrier.

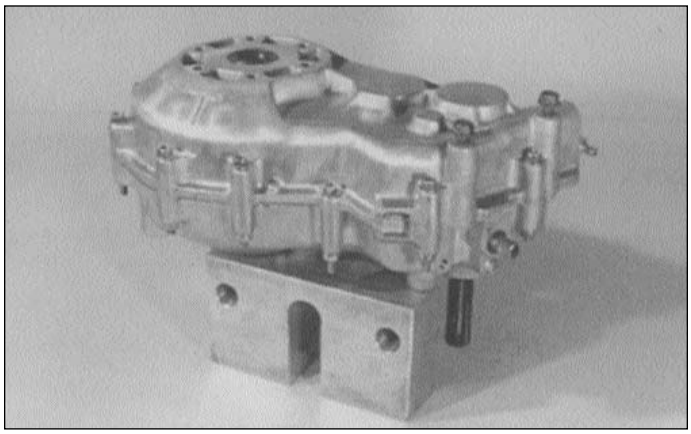


Figure 52 - Support With Input Shaft Down

The carrier should be disassembled/assembled with the carrier horizontal, and with the input shaft side down.

Note: Carrier shown with tubes removed.

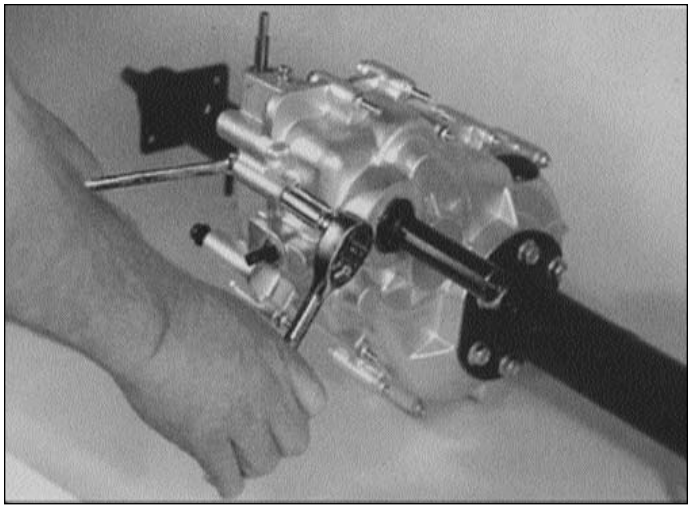


Figure 53 - Remove Housing Bolts

2. Remove all housing bolts.

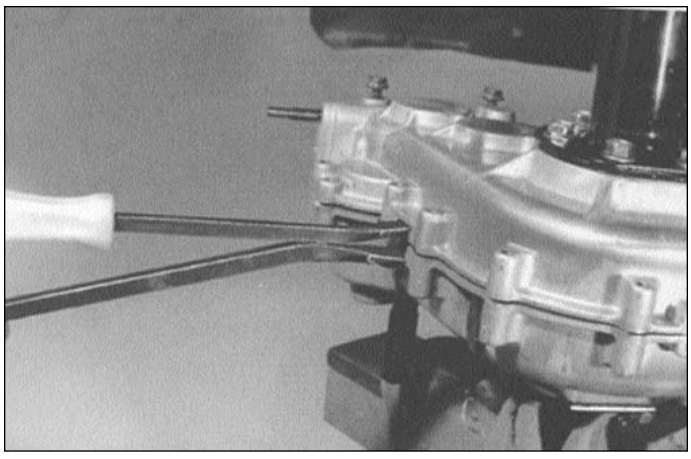


Figure 54 - Separate Cases

3. Use two pry bars and the pry notches in the carrier housing, separate the housing halves. Apply equal pressure at all three notches to separate without causing damage to internal parts. Remove the top half of the housing.

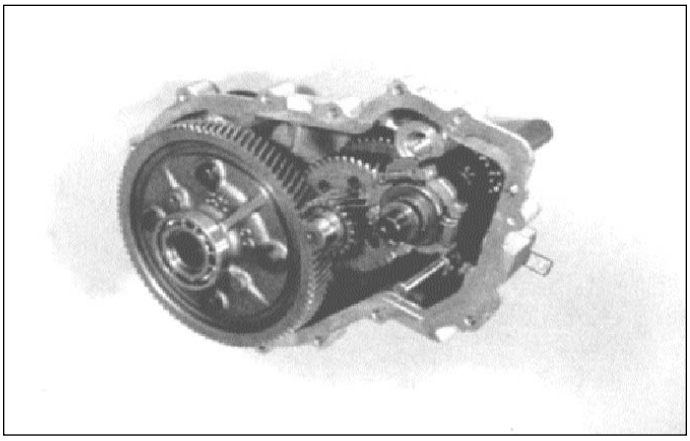


Figure 55 - Carrier Assembly With Right Case

Carrier shown with top half of the housing removed.

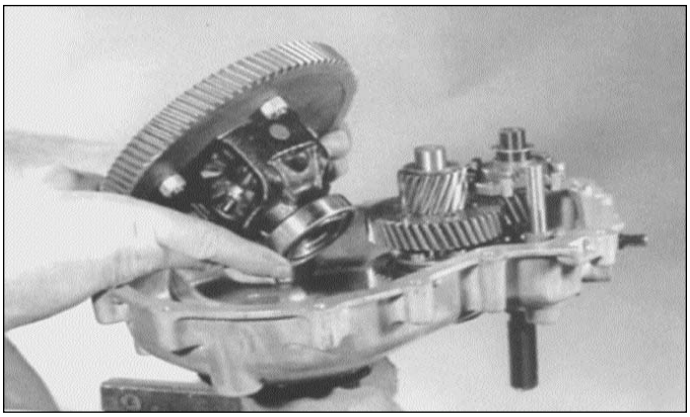


Figure 56 - Remove Differential

4. Remove the differential case. Place the differential case with the ring gear off to the side on clean shop rags so the ring gear teeth are not damaged from the table surface. The differential bearings may come out with the differential case.

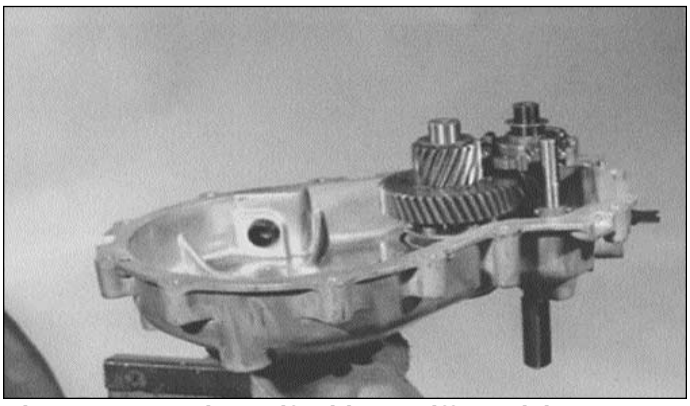


Figure 57 - Carrier Half Without Differential

5. Shown is the carrier half with the differential removed. Note all washer, shim and gear locations on the intermediate and input shafts before removal.

Note: Be sure to check gears to see how they are arranged. The recessed side of the gear should face the clutch. Failure to be arranged like this will result in shifting problems.

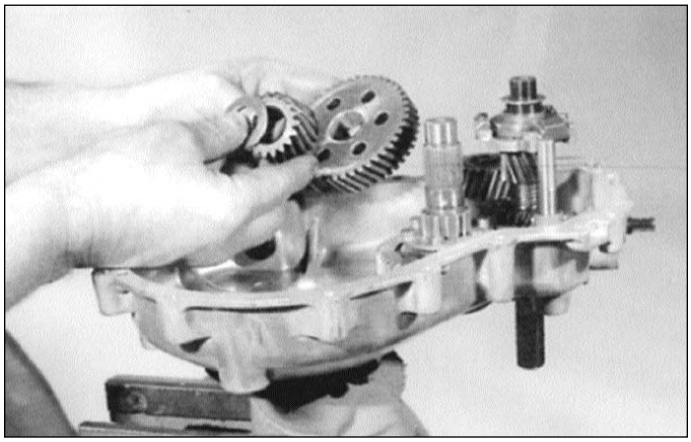


Figure 58 - Disassemble Intermediate Shaft

6. Remove the outer thrust washer, final drive gear (small gear) and the reverse gear from the intermediate shaft. Place the gears on clean shop towels to prevent damage from occurring to the gear teeth.

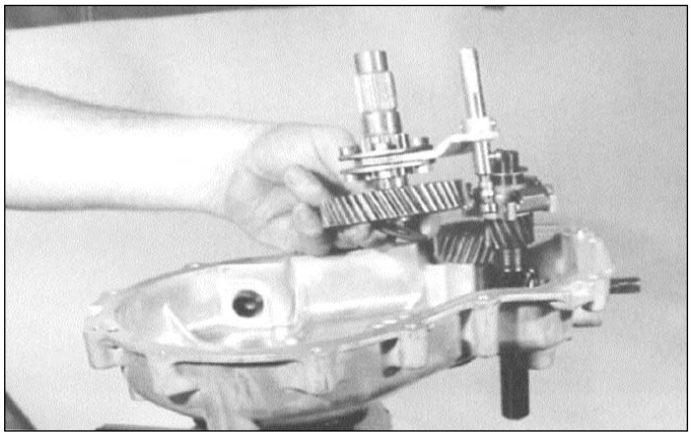


Figure 59 - Remove Intermediate Shaft

7. Raise the input shaft slightly to remove the intermediate shaft, forward gear, shifting clutch, shifter and inner washer from the carrier housing. Place all parts on a clean shop towel to prevent damage.

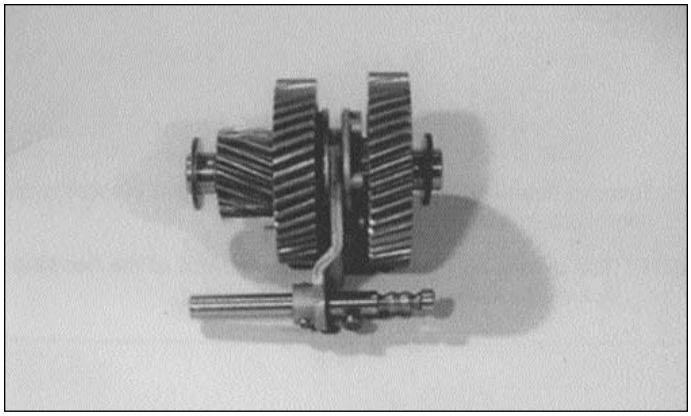


Figure 60 - Intermediate Shaft Assembled

Intermediate shaft with all components assembled. Note location of washers.

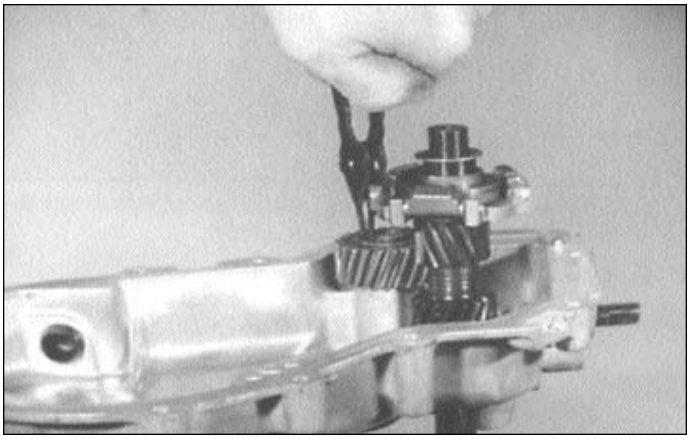


Figure 61 - Remove Snap Ring

8. Remove the snap ring from the socket head screw with snap ring pliers.

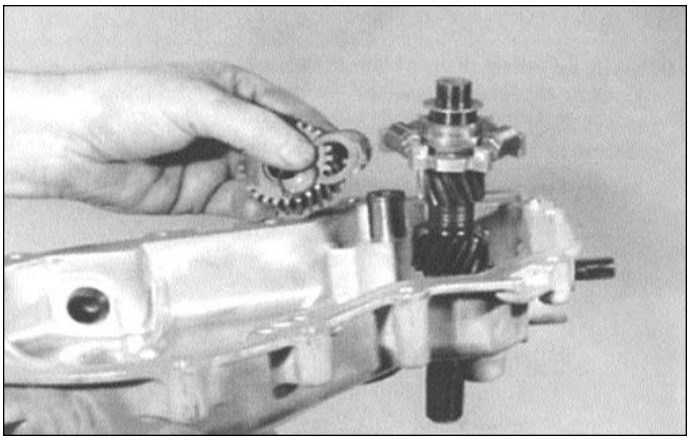


Figure 62 - Remove Reverse Idler Gear

9. When disassembling, the input shaft must be raised slightly to remove thrust washer, idler gear and bottom thrust washer from the socket head screw.

Note: If socket head screw is damaged, a new housing half must be ordered with screw pre-assembled.

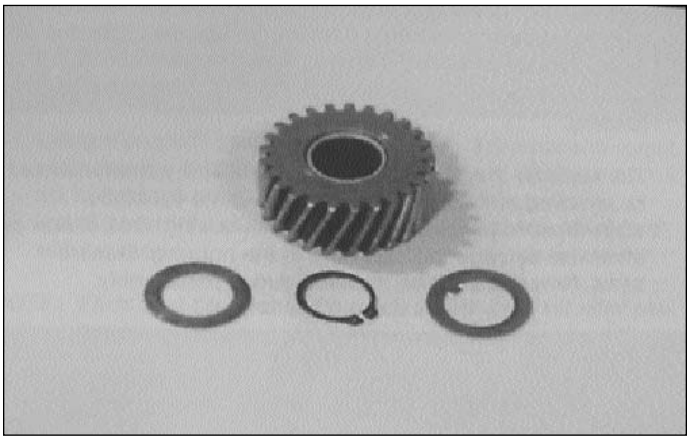


Figure 63 - Reverse Idler Gear and Washer

10. Idler gear with thrust washers and snap ring. Be sure thrust washer with tab is installed on top of the gear, next to the snap ring.

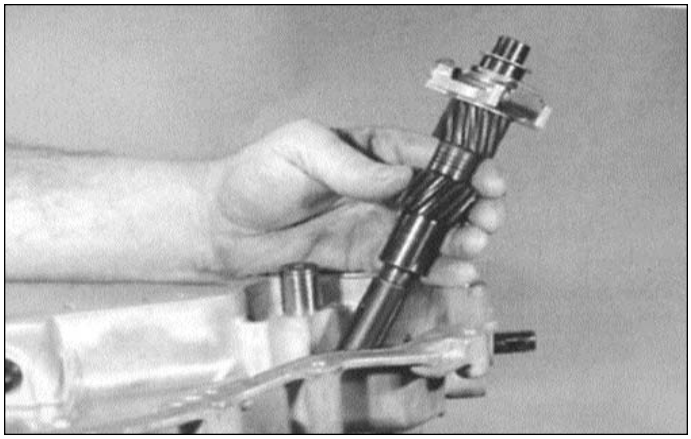


Figure 64 - Remove Input Shaft

11. Remove the input shaft from the carrier housing. Place parts on a clean shop towel to prevent damage.

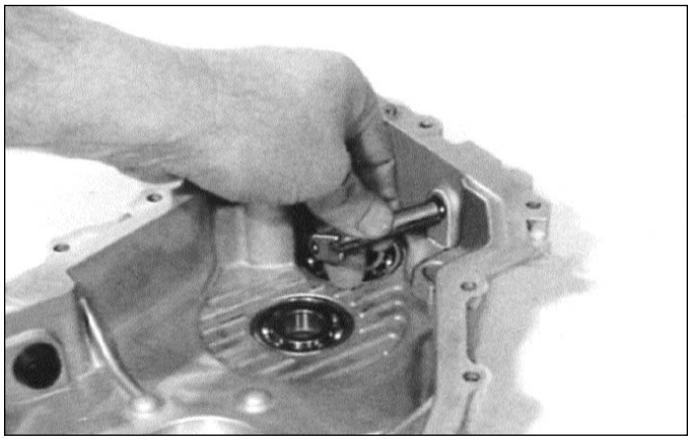


Figure 65 - Remove Shift Actuator Shaft

12. Remove the nut and washer from the shift actuator. Then, remove the shift actuator shaft from the carrier housing by pulling it into the housing as shown.

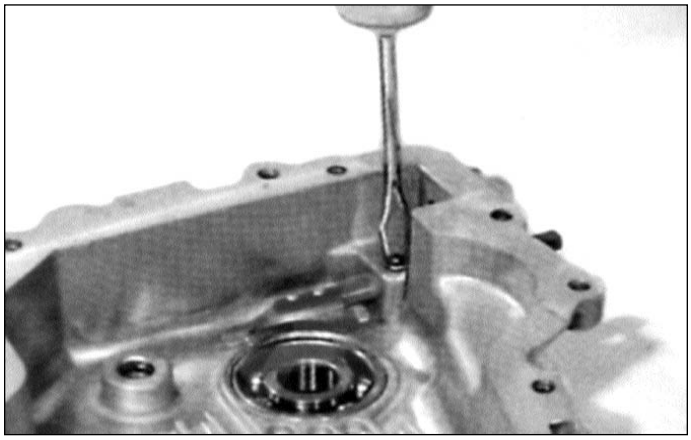


Figure 66 - Remove Governor Shaft Lock Pin

13. Remove the shaft-locking pin that holds the governor actuator in the carrier housing.

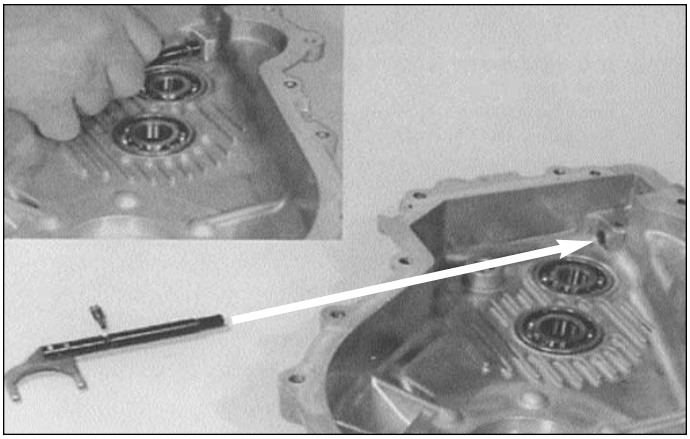


Figure 67 - Remove Governor Shaft

14. Clean dirt, corrosion, etc. from the outer portion of the governor actuator shaft, then remove the governor actuator shaft by pulling it into the carrier housing. Note that the shaft locking pin has a pin on the end that matches a groove in the governor actuator.

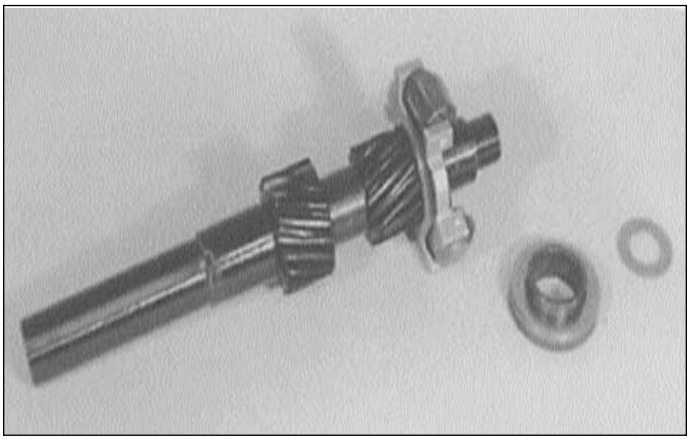


Figure 68 - Input Shaft and Components

Input shaft with governor actuating sleeve and shim removed.

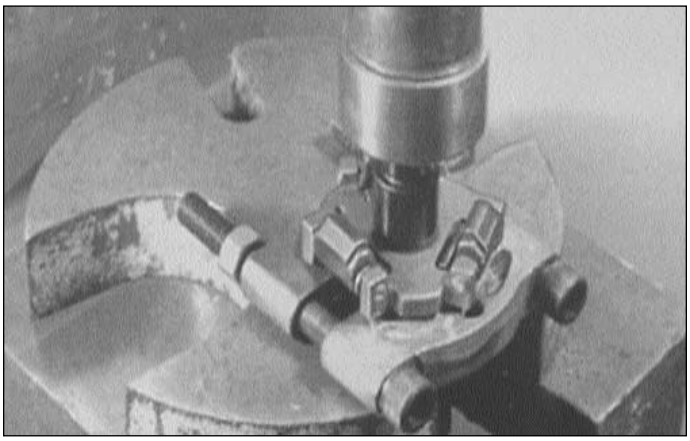


Figure 69 - Remove Governor Backing Plate

15. To replace governor backing plate assembly, it must be pressed off the input shaft. Use an arbor press with appropriate fixturing to support the governor backing plate assembly. Do not allow input shaft to fall loosely from the press. Catch the input shaft.

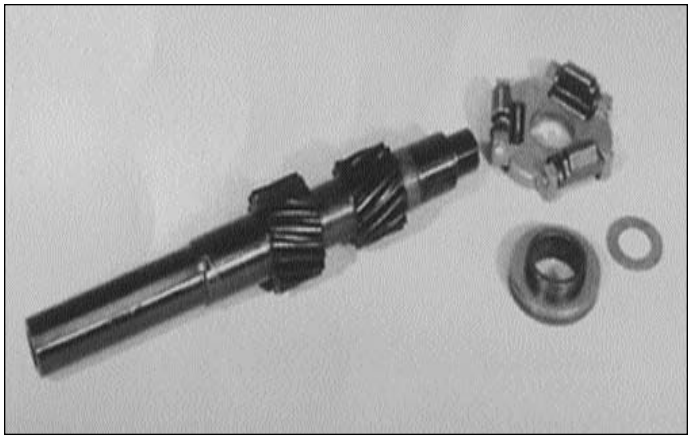


Figure 70 - Input Shaft and Components

Shown is the input shaft with governor backing plate, governor actuating sleeve and shim removed.

Note: If the governor backing plate is damaged or removed from the input shaft, or a new input shaft is used, a new governor backing plate assembly should be installed on the input shaft.

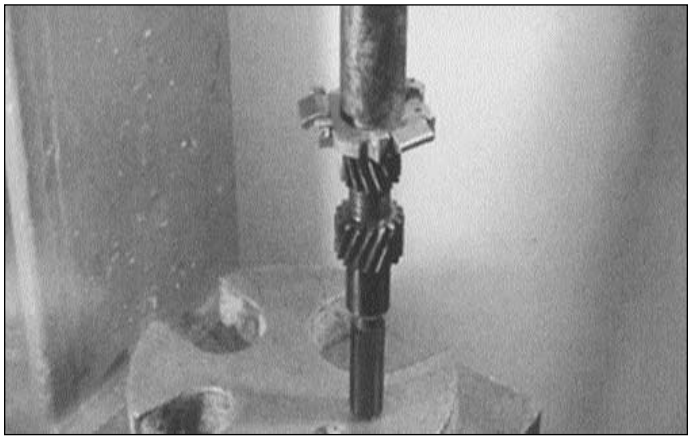


Figure 71 - Assemble Governor Backing Plate

16. Use an arbor press to press the governor backing plate onto the input shaft. Use fixturing that will fit over the input shaft. Be sure the governor backing plate assembly is square on the shaft. The governor weights should not be pressed on during installation of the governor backing plate assembly.

Note: Upon inspection of the bearings and seals, if replacement is needed, follow steps 17 and 18. If not replacing bearings and seals, go to Carrier Assembly.

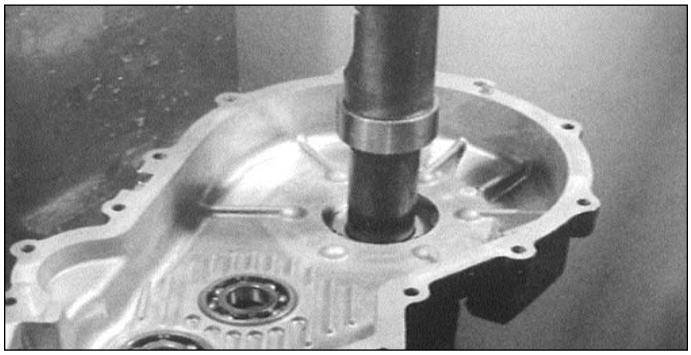


Figure 72 - Remove Oil Seals

17. Use an arbor press and a tool of appropriate diameter to remove seals and bearings from carrier housing. Discard old seals. New seals will be installed during reassembly of unit. Do not scar or otherwise damage the seal bore in the carrier housing.

    The seals for the governor actuator and shift actuator should be removed and new seals installed. Use a flat blade screwdriver to pry each seal from the housing. Do not scar or otherwise damage the seal bore in the housing. Discard seals. New seals will be installed during reassembly.

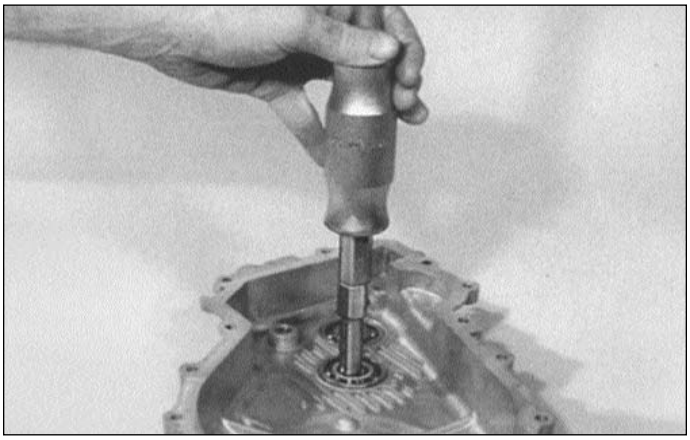


Figure 73 - Remove Bearings

18. Use an ID bearing puller attached to a slide hammer to remove bearings from the housing. Discard bearings. New bearings will be installed during reassembly.

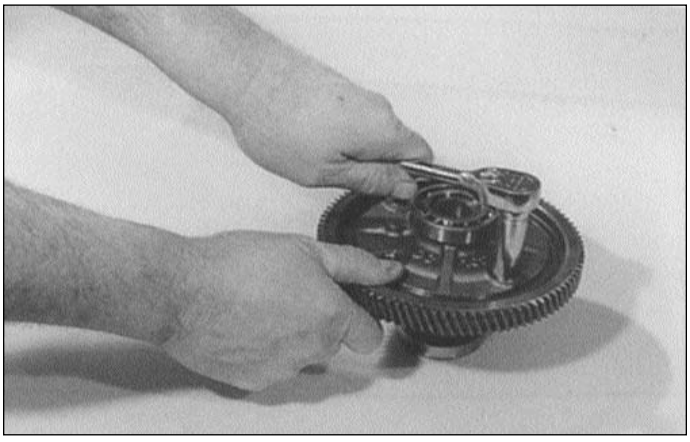


Figure 74 - Remove Differential Gear

19. Remove (4) bolts and nuts holding the ring gear on the differential. Discard bolts and nuts. New bolts and nuts will be installed at reassembly. Place ring gear on a clean shop towel to avoid damage to the gear teeth.

Note: The teeth on the gear may be sharp when handling.

20. Remove the bearings from the differential case. Discard bearings. New bearings will be installed at reassembly.

    For axle housing, axle & bearing and hydraulic brake removal and assembly, refer to page 6-32.

Assembly

Note: Prior to assembly, all parts should be inspected for signs of wear or damage. Bearing and seal surfaces should be inspected for pitting, wear or overheating. Inspect the gears for pitting, wear, or scoring. Inspect the axle shafts for worn splines or cracks. Replacing these parts can prevent premature failure.

If seals and bearings were not removed, skip Steps 19 and 20.

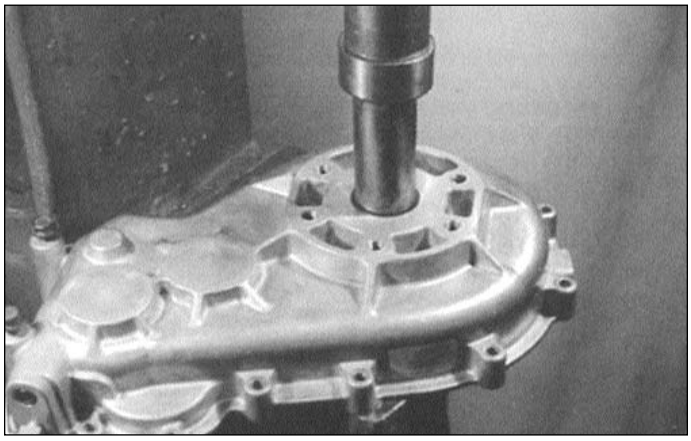


Figure 75 - Install Oil Seals

21. Using a properly sized seal driver, press the input and output seals into the housing to a depth of .020 +/- .020. Use caution not to damage seals during installation.

    Install governor actuator and shift actuator seals, press flush with housing.

Note: Each seal lip should be coated with light oil after seal has been pressed into housing.

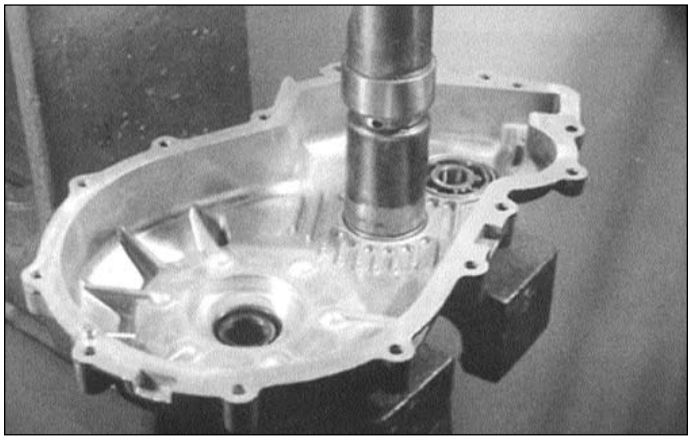


Figure 76 - Install Bearings

22. Press output shaft and intermediate shaft bearings into housing. Bearings should seat to shoulder in housing. Use the appropriate diameter tool, apply force only to the outer race of the bearing.

Note: Before installing the governor actuator shaft, apply light oil to both the seal lip and the actuator shaft.

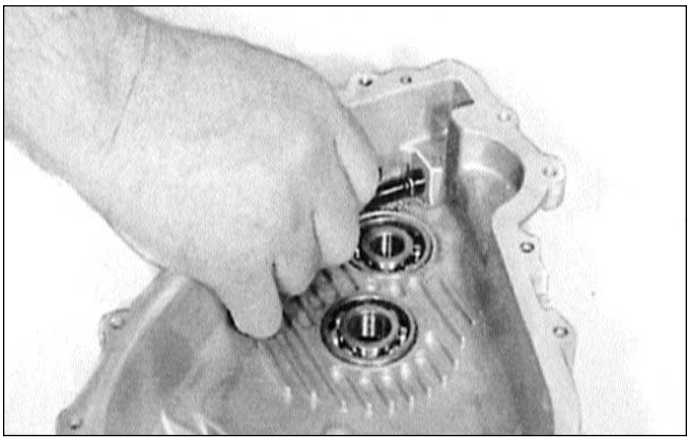


Figure 77 - Install Governor Shaft

23. Slide the governor actuator in until the groove in the actuator shaft aligns with the shaft locking pin hole in the housing. Do not damage the seal lip during shaft installation.

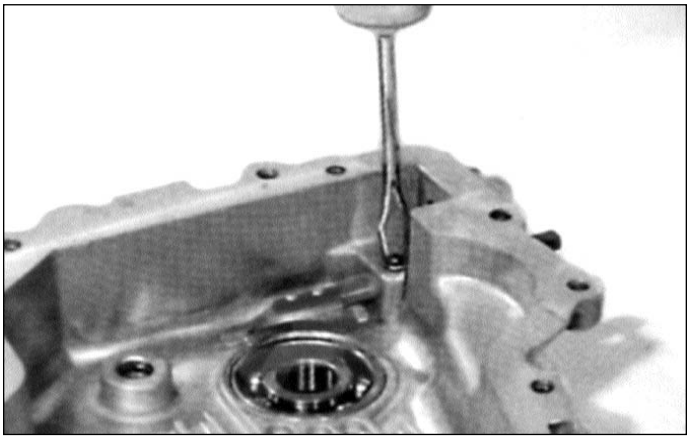


Figure 78 - Install Governor Lock Pin

24. Install the shaft locking pin as shown. Be sure the groove in the actuator shaft aligns with the pin tip. Screw pin into housing until tight.

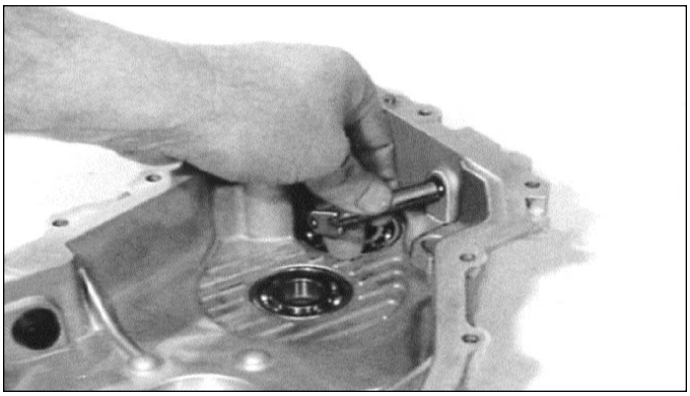


Figure 79 - Install Shift Actuator Shaft

Note: Before installing the shifting actuator, apply light oil to the seal lip and to the actuator shaft.

25. Install the shifting actuator into the housing. The shifting fork should be facing up for later assembly.

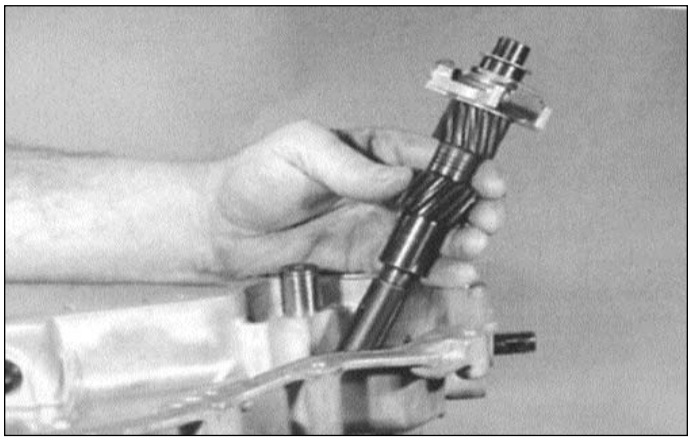


Figure 80 - Install Input Shaft

Note: Before installing the input shaft, apply light oil to the seal lip and to the input shaft.

26. Install the input shaft. Place the actuating sleeve and the thrust washer on the shaft at this time. Do not damage the seal lip when installing the shaft.

Note: Before installing gears, check inner bushings for wear. Discoloration or scoring of a non-circular form, are indications that a gear should be replaced. Forward and reverse gears are identified with "F" or "R", and the bores are also different diameters.

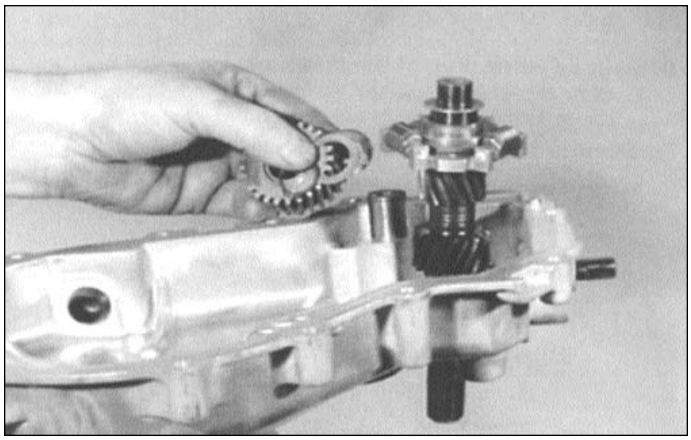


Figure 81 - Assemble Reverse Idler

27. Raise the input shaft slightly to install the inner thrust washer, idler gear and outer thrust washer (washer with tab) onto the shaft.

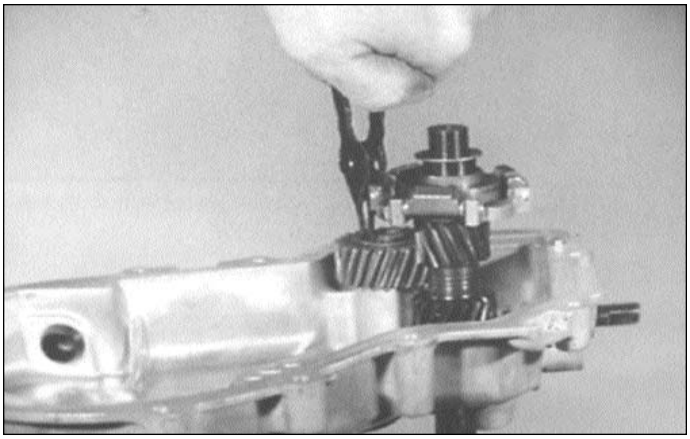


Figure 82 - Install Snap Ring

28. Install the snap ring into the snap ring groove on the shaft.

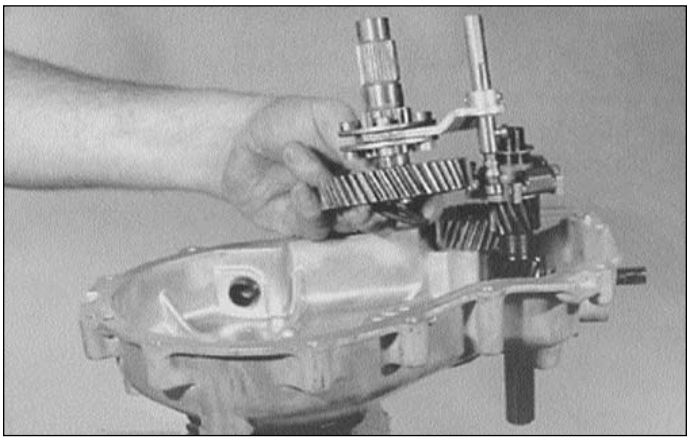


Figure 83 - Install Intermediate Shaft and Fork

29. When assembling, the input shaft should be lifted slightly to install the inner thrust washer, forward gear, clutch, and shift rod into housing. When installing, be sure the shift actuator and shift rod are engaged via the pin on the shift rod. Be sure the bottom thrust washer is in place before continuing assembly.

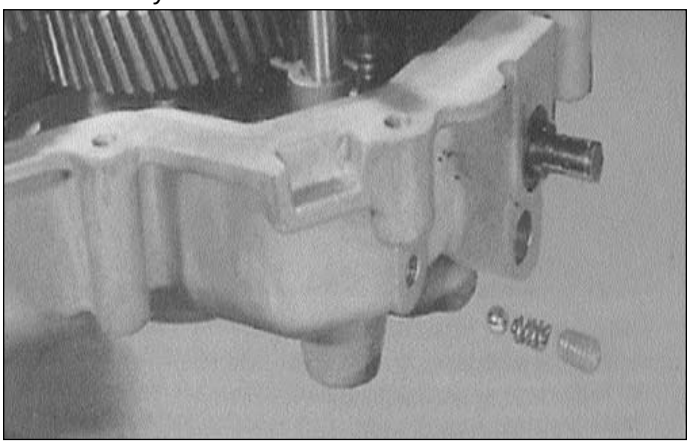


Figure 84 - Install Detent Ball, Spring and Screw

30. Install detent ball, spring, and set screw into housing after shift rod has been installed. Tighten set screw approximately halfway. The shift rod should move up and down into three detent positions. Move the shift rod to the "reverse" position (the third detent when sliding the rod into the housing). This will aid further assembly.

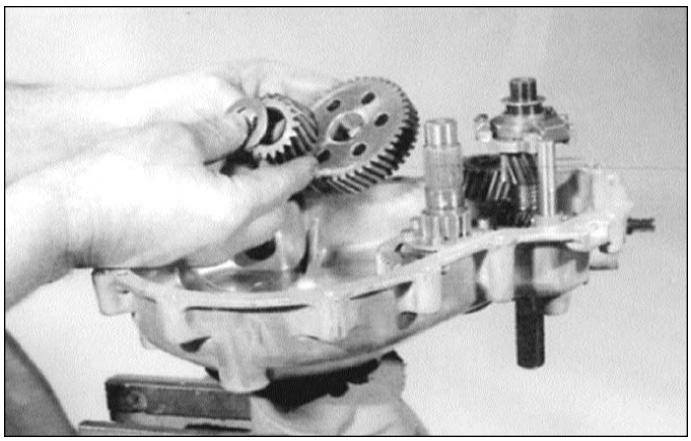


Figure 85 - Install Intermediate Shaft Components

31. Install the reverse gear, final drive gear and outer thrust washer on the intermediate shaft. The input shaft must be raised slightly to allow assembly of these parts.

    The input shaft should rotate freely. If not, check gears to see that they are meshing correctly.

32. Using a properly sized tool, press the bearings onto the differential case. Be sure to press on the inner race of bearing.

Note: Check the ring gear for damage before installing it. Replace if necessary.

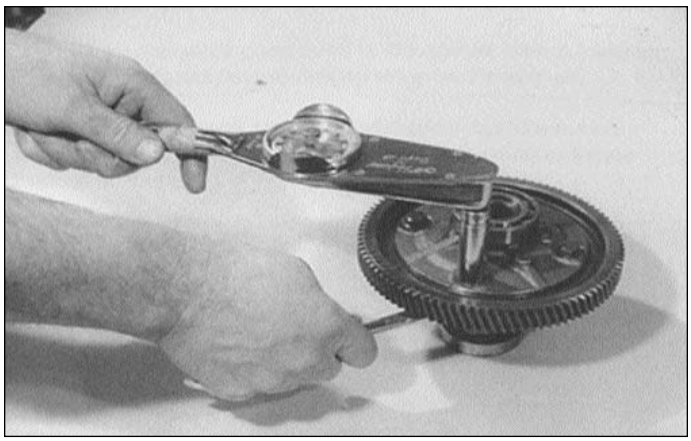


Figure 86 - Install Differential Gear

33. Place the ring gear onto the new differential case, aligning the holes in the ring gear and the differential case.

34. Insert the new bolts into the differential case and ring gear. Bolts should be installed through the flange on the differential case.

35. Torque the bolts in the ring gear.
    Torque 35-45 ft. lb.
    (47 To 61 N.m.)

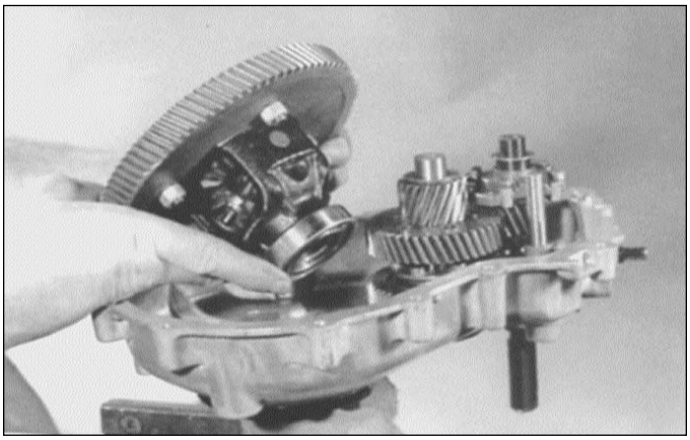


Figure 87 - Install Differential Assembly

36. Install the differential into the carrier housing, meshing the gear with the final drive gear on the intermediate shaft.

    The input shaft and all components should rotate freely. If not, check gear mesh or check for interference of parts inside the housing. If interference or incorrect gear mesh is happening, tear down the assembly and reassemble.

Note: When assembling the housing halves, use rigid form liquid gasket material to seal the joint. The gasket material should be non-silicone based. Loctite 518 gasket material is recommended. Silicone base gasket material will cause damage to internal components.

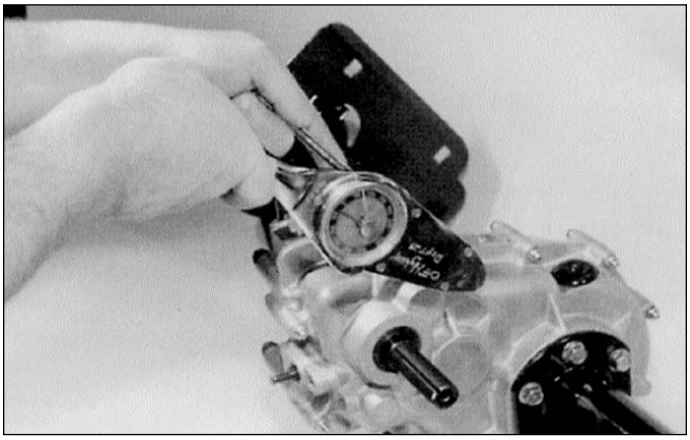


Figure 88 - Torque Carrier Bolts

37. Place a bead of gasket material around the lip of one housing half. Apply the material around the inside of bolt holes and around the outside of dowel pinholes. Join halves, aligning dowel pins to holes. Install bolts and nuts.

    Torque 100-120 in. lb.
    (11.2 To 13.4 N.m.)

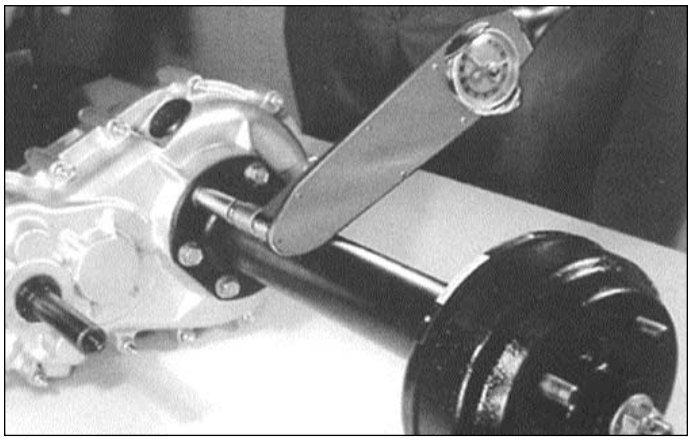


Figure 89 - Torque Axle Housing Bolts

38. Install (6) bolts through tube flange into carrier housing.
    Torque 25-35 ft. lb.
    (33.8 To 47.4 N.m.)

Note: The bolts should be started by hand to avoid cross threading into the carrier.

ELECTRIC VEHICLE FINAL DRIVE AXLE ASSEMBLY

General Precautions for Disassembly

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 service on the axle, read and understand all for the following text and paragraphs.

Handle all gears with extreme care.

Cleanliness

The axle assembly should be degreased prior to disassembly.

Dirt is abrasive and will cause premature wear of bearings and other parts. We suggest that mechanics have a small wash tank to clean parts just prior to reassembly.

Bearings/Seals

It is recommended that whenever a bearing, seal or "O" ring is removed, it be replaced with a new one regardless of mileage. Always, wipe the seals and "O" rings with a light oil before installing.

Bearings and seals should be removed with pullers designed for this purpose.

Snap Rings

Snap rings must be removed/installed with care to prevent damage to bearings, seals, and bearing bores.

Torque Chart

Differential Bearing Cap……35-45 Ft. Lbs.
Ring Gear Bolts……...35-45 Ft. Lbs.
Cover Plate Screws……...16-24 Ft. Lbs.
Fill Plug……...25-40 Ft. Lbs.
Brake Bolts-160MM Brakes……...15-19 Ft. Lbs.
7" x 1-3/4" Brakes.....16-20 Ft. Lbs.
Spindle Nut……95-115 Ft. Lbs.

Cleaning and Inspection

Cleaning

1. Parts should be cleaned with emulsion cleaners or petroleum based cleaners.

2. Clean, inspect, and lubricate all bearings just prior to reassembly.

3. Clean all sealing surfaces of gasket material.

Drying

1. Use soft, clean, lintless towels or rags to dry components after cleaning. Bearings should NOT be dried by spinning with compressed air. This can damage mating surfaces due to lack of lubrication.

2. After drying, parts should be coated with a light coat of lubricant or rust preventative to prevent damage from corrosion. If parts are to be stored for a prolonged period they should be wrapped.

Inspection

1. Prior to reassembly, inspect part for signs of wear or damage.

2. Bearing and seal surfaces should be inspected for pitting, wear or overheating.

3. Inspect gears for pitting, wear or scoring.

4. Inspect axle shafts for worn splines, bends, or cracks.

Note: Replacement of these parts can prevent premature failure.

Oil Check and Change Intervals

Checking - only if signs of leakage are detected - then check oil level.

Changing - change oil every 24 months or 2000 km (1250 miles) whichever occurs first.

Capacity -12 ounces (354.8 ml.), SAE 30 wt.

SAFETY GLASSES SHOULD BE WORN AT ALL TIMES WHEN ASSEMBLING OR DISASSEMBLING

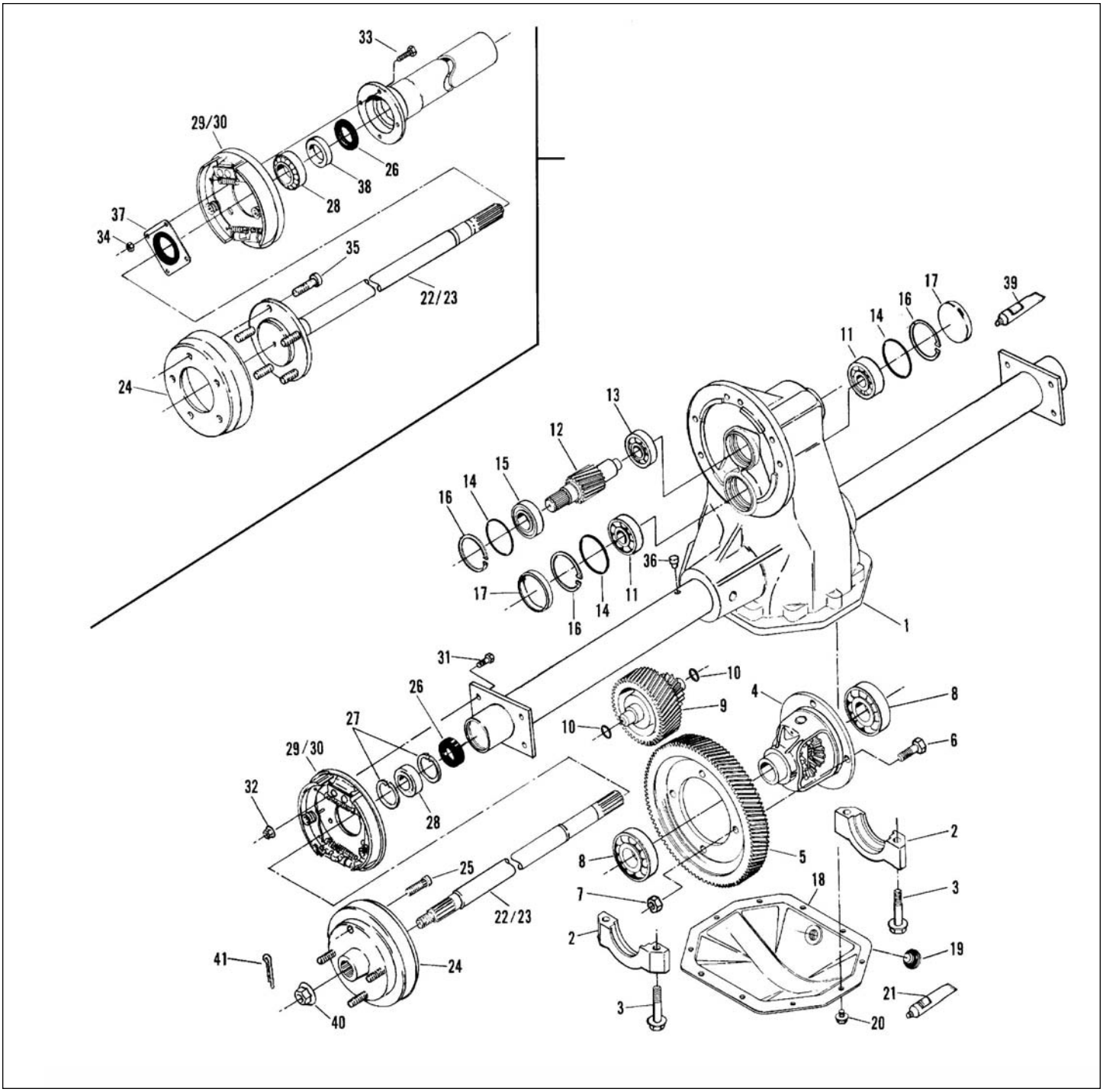


Figure 90 - Exploded View

Item	Description	Qty.
1	Carrier Sub-Assembly	1
2	Bearing Cap	2
3	Bolt-Bearing Cap	4
4	Diff. Case Assembly	1
5	Gear - Output	1
6	Cap Screw	4
7	Nut	4
8	Bearing - Ball	2
9	Intermediate Shaft & Gear Assy.	1
10	“O” Ring	2
11	Bearing - Ball	2
12	Input Shaft	1
13	Bearing - Ball	1
14	“O” Ring	3

Item	Description	Qty.
15	Bearing - Ball	1
16	Snap Ring	3
17	Plug - Cup	2
18	Cover - Carrier	1
19	Plug - Fill	1
20	Screw - Cover Plate	10
21	Sealant - Cover Plate	1
22	Shaft - Axle, L.H.	1
23	Shaft - Axle, R.H.	1
24	Hub Assembly	2
25	Bolt - Wheel (160mm Brake)	*
26	Oil Seal	2
27	Snap Ring	4
28	Bearing	2

Item	Description	Qty.
29	Brake Assembly, L.H.	1
30	Brake Assembly, R.H.	1
31	Bolt - Brake (160mm Brake)	8
32	Nut (160mm Brake)	8
33	Bolt - Brake (7 x 1-3/4 Brake)	8
34	Nut (7 x 1-3/4 Brake)	8
35	Bolt - Wheel (7 x 1-3/4 Brake)	*
36	Vent	1
37	Seal	2
38	Retaining Ring	2
39	Sealant - Anaerobic	1
40	Nut - Axle Shaft	2
41	Cotter Pin	2

*** See specific Bill of Material for each axle.**

Disassembly

Axle Shaft, Bearing, and Oil Seal

1. Remove cotter pin, then remove drum/hub nut from end of axle shaft.

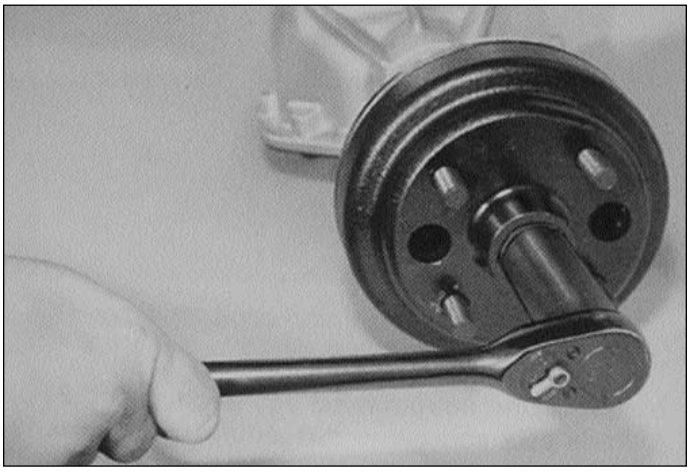


Figure 91 - Spindle Nut Removal

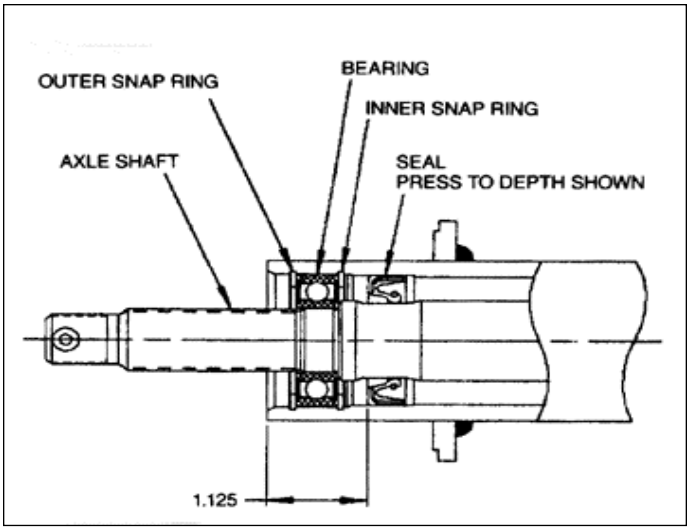


Figure 92 - Axle Components

2. Remove outer snap ring.

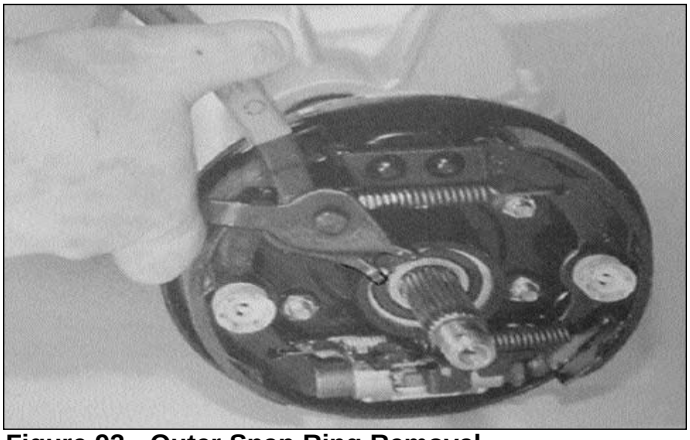


Figure 93 - Outer Snap Ring Removal

3. Using a slide hammer attached to the threaded end of the axle shaft, remove axle shaft and bearing assembly.
4. Remove inner snap ring. Use caution as not to damage bearing surfaces.

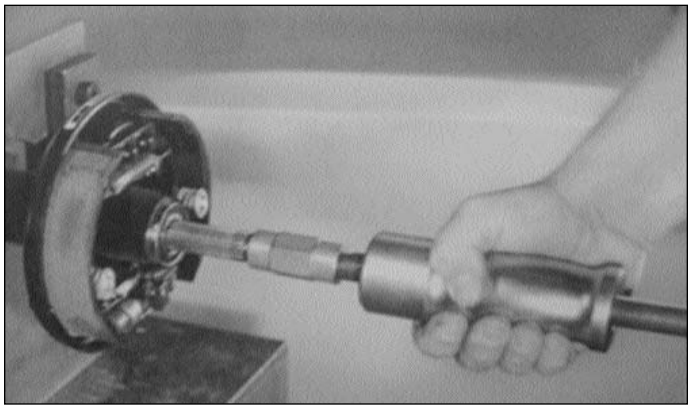


Figure 94 - Axle Shaft & Bearing Assembly Removal

5. Using an oil seal puller, attached to a slide hammer, remove oil seal. Use caution as not to damage the seal seating surface.

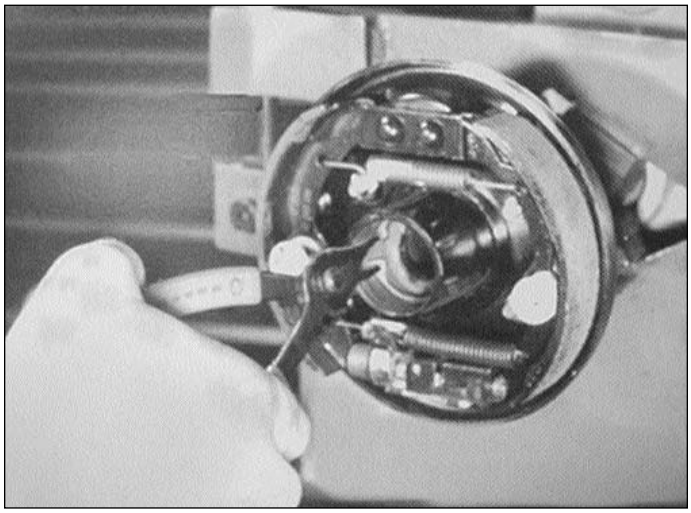


Figure 95 - Inner Snap Ring Removal

6. Remove the bearing from the axle shaft by supporting the inner race of the bearing on an arbor press. Apply pressure to the threaded end of the axle shaft.

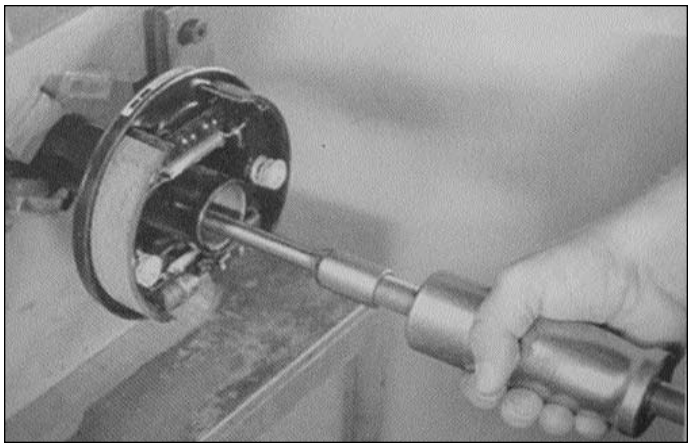


Figure 96 - Oil Seal Removal

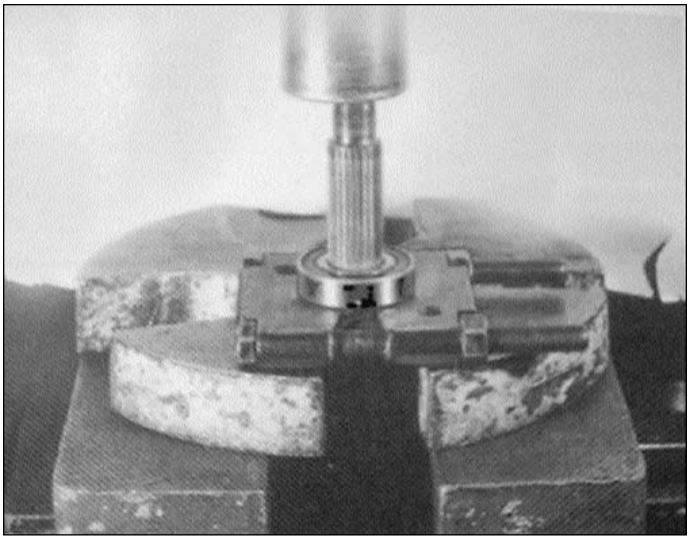


Figure 97 - Axle Bearing Removal

7. After removing left and right axle shafts (See Axle Shaft, Bearing, and Oil Seal Disassembly Section):

   a. Remove ten (10) cover plate screws.

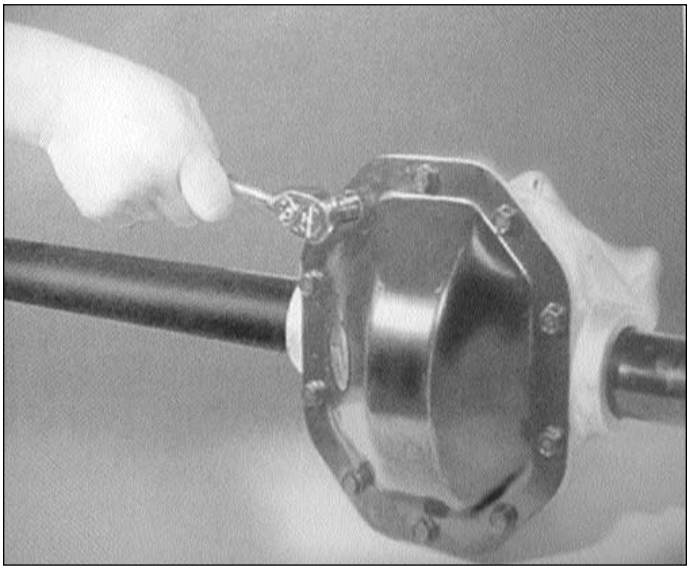


Figure 98 - Cover Plate Screws Removal

   b. Position the axle housing and a cover plate over a drain pan. Using a putty knife, separate the cover plate from the housing. Use caution as not to damage the housing sealing surface or deform the cover plate.

8. Remove four (4) bearing cap screws, and remove bearing caps.

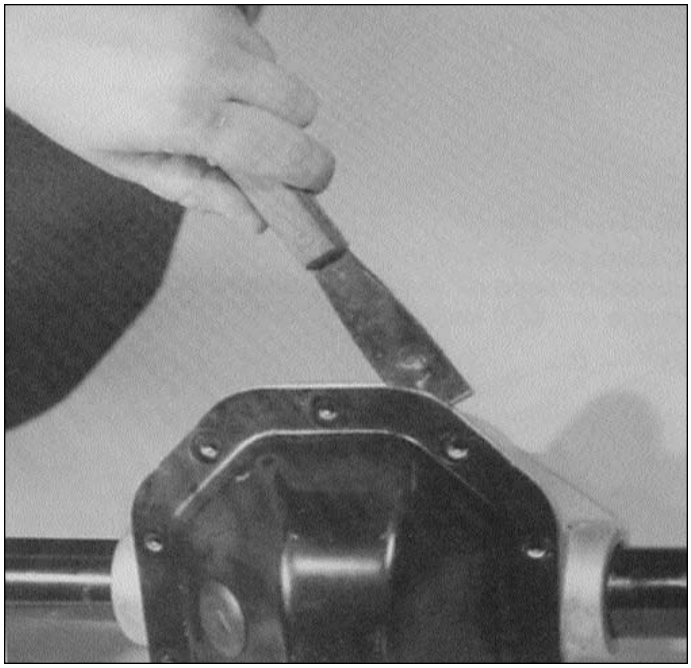


Figure 99 - Separate Cover Plate From Housing

Note: Bearing caps are marked for identification. Letters or numbers are stamped in horizontal and vertical position. During reassembly, place them back in their original positions.

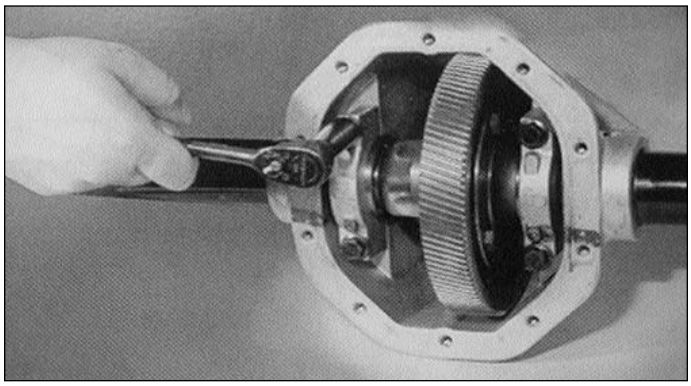


Figure 100 - Bearing Caps Removal

9. Remove differential case assembly from housing.

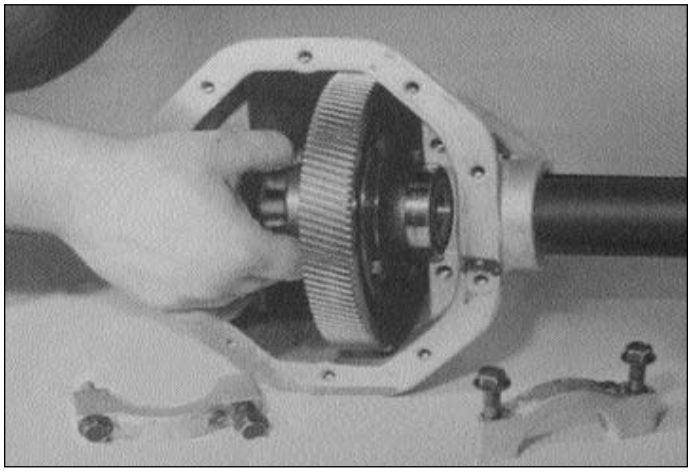


Figure 101 - Differential Case Assembly Removal

10. Using a bearing puller, remove differential bearings from each side of differential case.

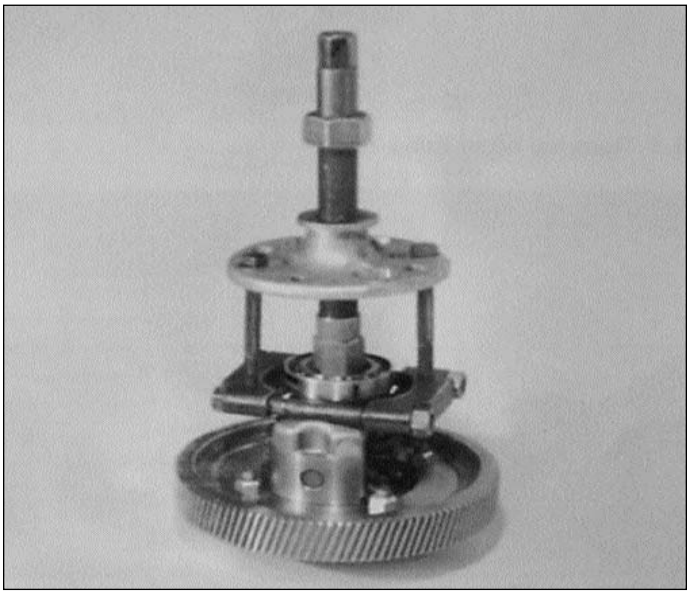


Figure 102 - Differential Bearings Removal

11. Remove four (4) bolts and nuts from the final drive gear. Remove gear from differential case using caution not to damage gear teeth.

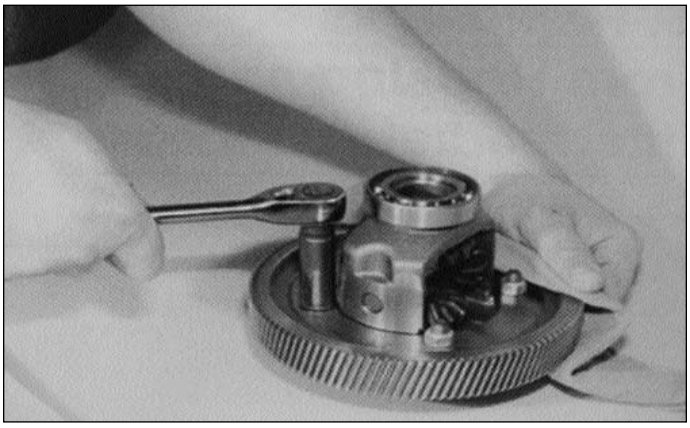


Figure 103 - Remove Gear from Differential Case

12. Punch or drill approximately a 1/8" diameter hole near the center of each intermediate bore plug. Insert a suitably sized sheet metal screw until the metal bore plug is forced out of the bearing bore.

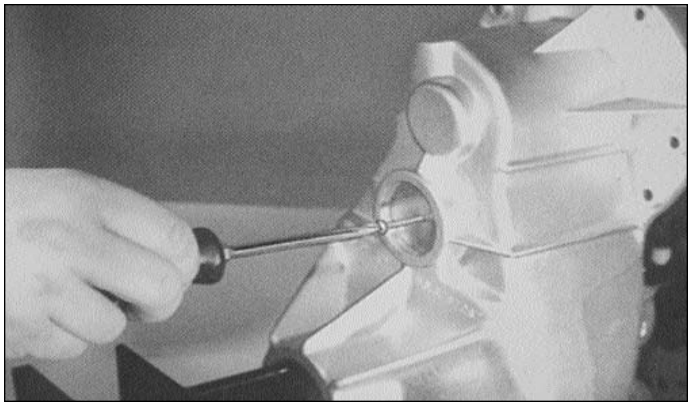


Figure 104 - Remove Dust Cover

13. Remove snap rings from each intermediate bore.

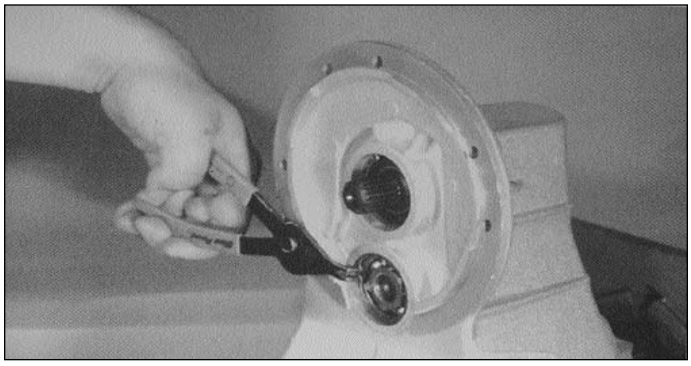


Figure 105 - Snap Ring Removal

14. Using a brass drift pin, drive the intermediate shaft from the flange side of housing. Shaft should travel far enough to allow engagement of I.D. bearing puller.

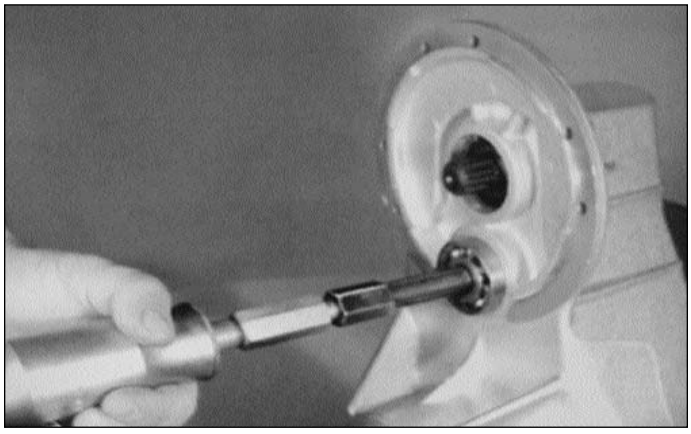


Figure 106 - Intermediate Shaft Removal

15. Using an I.D. bearing puller attached to a slide hammer, remove intermediate bearing from flange side of housing.

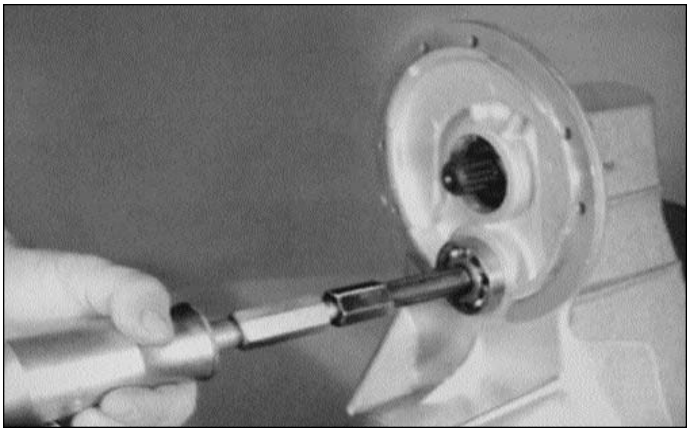


Figure 107 - Intermediate Bearings Removal

16. Repeat step 3-3 for intermediate bearing on opposite side.

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

Note: Small end of intermediate shaft and gear assembly must be tilted toward opening in bottom of housing for removal. Use caution as not to damage gear teeth.

17. Remove snap ring from input shaft bore.

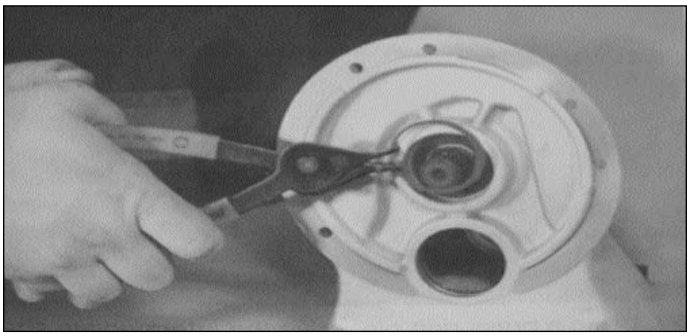


Figure 108 - Snap Ring Removal

18. Pull input shaft assembly from housing. The input shaft assembly should slide out of the housing easily. If resistance is encountered, a slide hammer may be required. Use caution as not to damage gear.

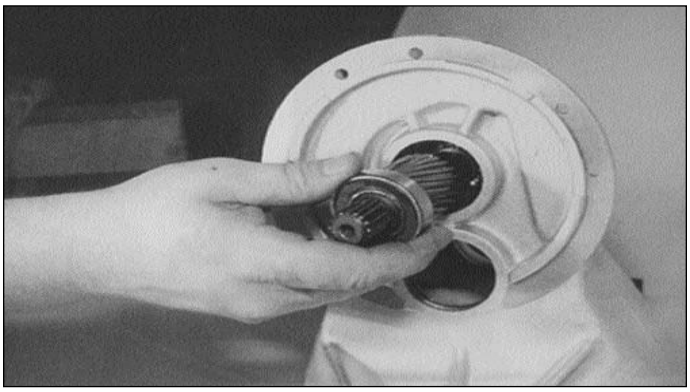


Figure 109 - Input Shaft Removal

19. Remove "O" rings from outer input bearing bore, and both intermediate bearing bores.

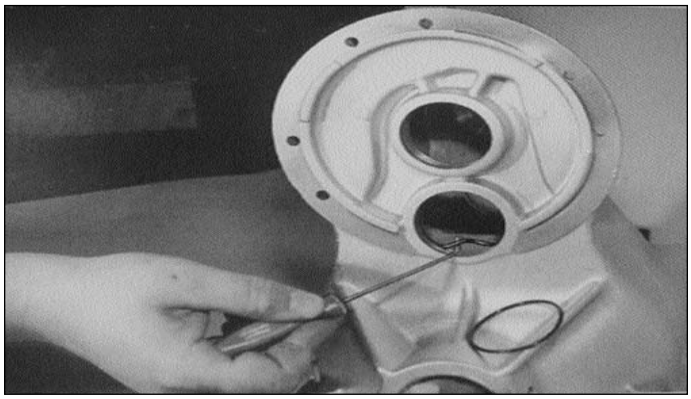


Figure 110 - 'O' Rings Removal

20. Remove "O" rings at each end of intermediate shaft on bearing shoulders.

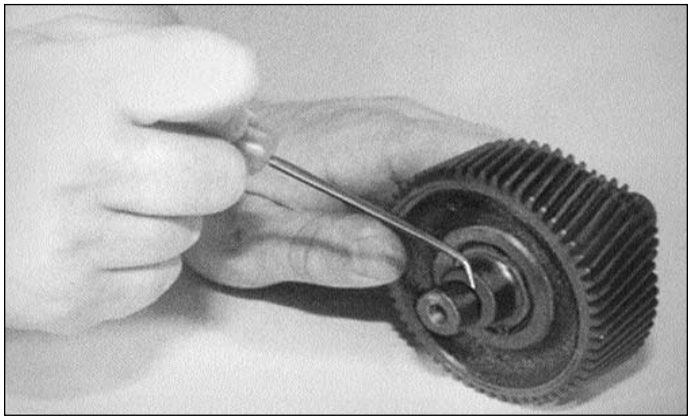


Figure 111 - Intermediate Shaft "O" Ring Removal

21. Refer to page 1 for cleaning and inspection of components.

22. Install new "O" rings into outer pinion bearing bore, intermediate bearing bores and intermediate shaft and gear assembly. Prior to installing, wipe "O" rings with light oil or "O" ring lubricant.

23. Press inner and outer bearings on input shaft until seated against bearing shoulders.

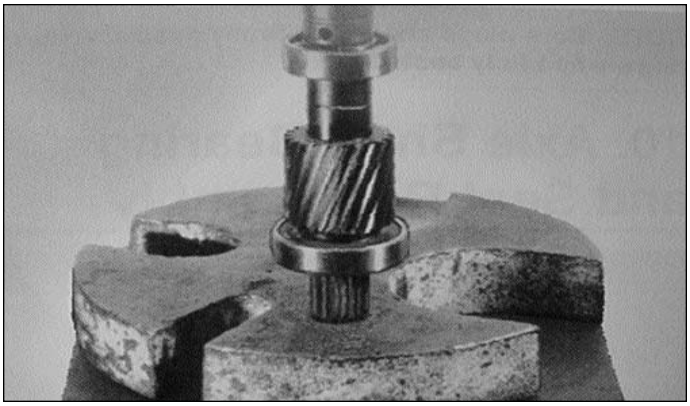


Figure 112 - Input Shaft Bearing Installation

24. Install new "O" ring into bearing bore. Lightly oil "O" ring at installation.

25. Reinstall input shaft. Bearings and shaft should slide easily into housing. If resistance is encountered, a plastic or leather mallet could be used to tap the shaft into its correct position. Using caution not to damage gear teeth.

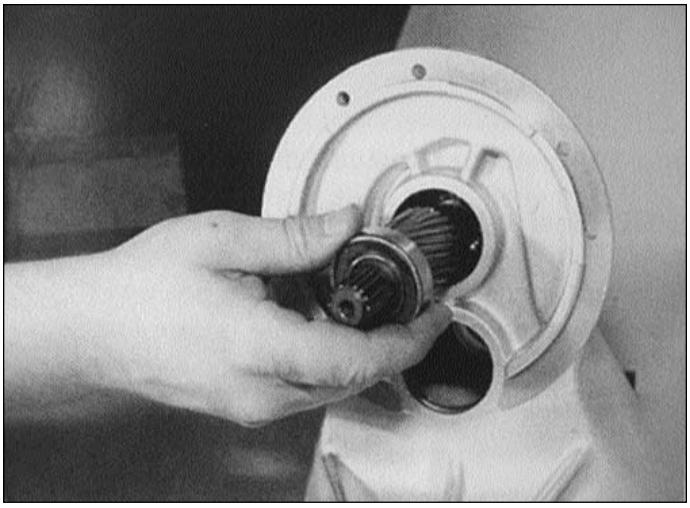


Figure 113 - Reinstall Input Shaft

26. Install outer snap ring at input shaft bore.

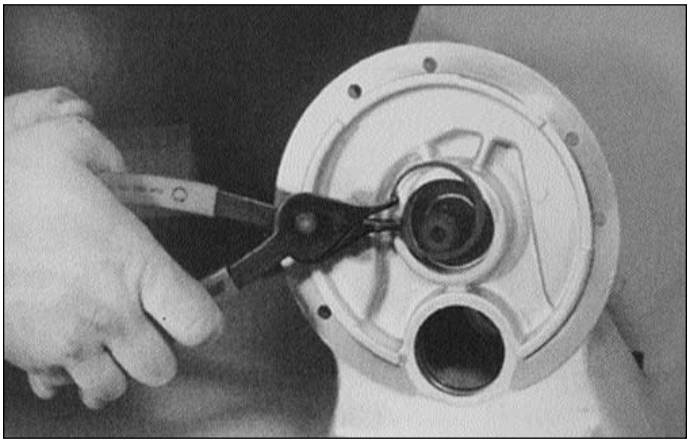


Figure 114 - Install Outer Snap Ring

27. After "O" ring installation on shaft and in housing, install intermediate shaft and gear assembly through bottom opening in housing.

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

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

29. After flanged side bearing is seated past snap ring groove, install snap ring. Repeat procedure for opposite side bearing and install snap ring. Use caution as not to damage gear.

30. Position differential case assembly with flanged side trunnion down on work surface. Align final gear mounting holes with differential case and install four (4) bolts and nuts. Bolts should be installed from the differential flange side. Torque to 35 to 45 ft. lbs. (47 To 61 N.m.).

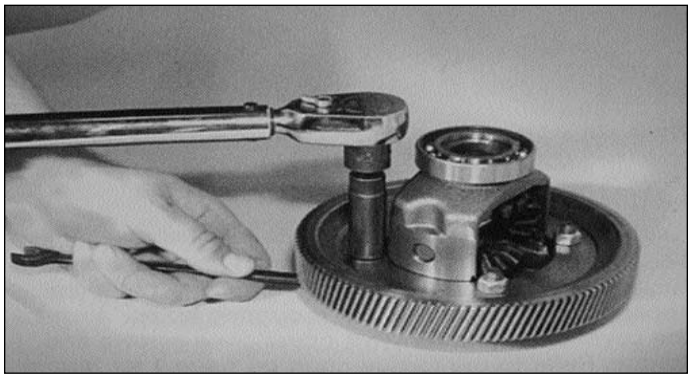


Figure 115 - Differential Gear Assembly

31. Differential bearings can be installed on differential before or after installing ring gear. Use caution as not to damage differential bearings or ring gear when installing the opposite component.

32. Position housing with opening up and insert differential case, final drive gear and bearing assembly into housing. Install differential bearing caps.

Note: Bearing caps are marked for identification. Letters or numbers are stamped in horizontal or vertical position. During reassembly, they must return to their original positions.

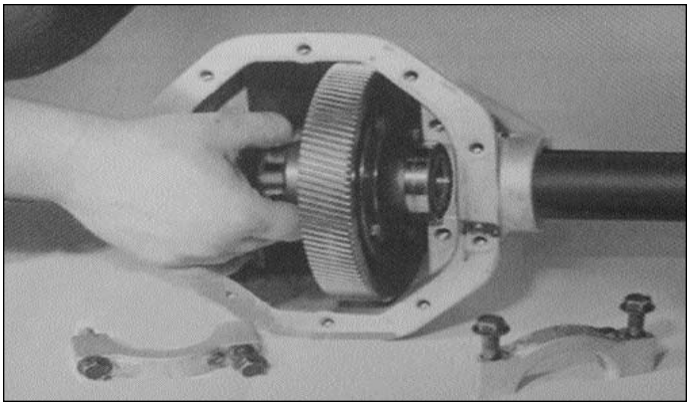


Figure 116 - Install Differential Case

33. Install four (4) screws into bearing caps and torque. Torque to 35 to 45 ft. lbs. (47 to 61 N.m.).

34. Place a small bead of RTV (non-acidic) silicone sealant to flange of cover plate. Sealant should be applied inside of cover plate mounting holes. Install the cover plate and ten (10) cover plate screws and torque. Torque to 16 to 24 ft. lbs. (21.5 to 32.5 N.m.).

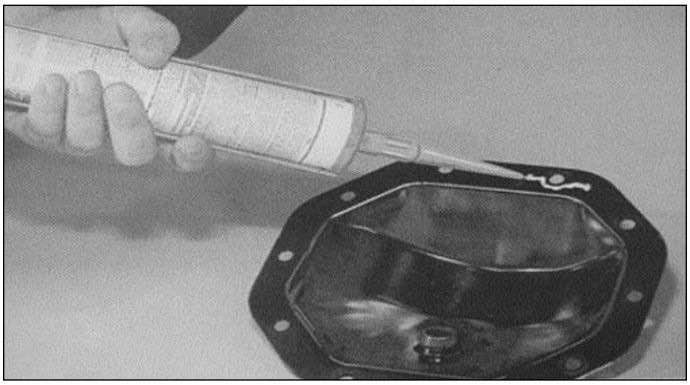


Figure 117 - Seal And Install Cover Plate

35. Install new intermediate bore plug to both sides of housing. Use Loctite Safety Solvent #75559 to clean bores, then apply Loctite RC 609 to housing bores. Dust cover plugs can be installed by using a properly sized driver and a hammer.

Note: Bore plugs should be firmly against snap rings, when fully seated.

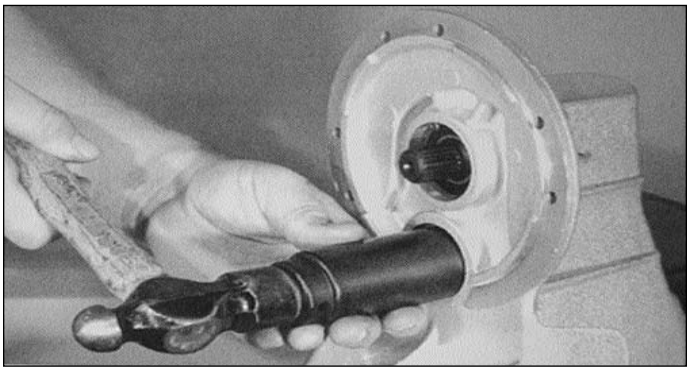


Figure 118 - Install Dust Cover Plugs

36. With properly sized seal driver, install shaft seals.

Note: Seal to be installed to dimension shown in axle shaft, bearing, and oil seal disassembly, Figure 92, page 6-26. Seal lip should be coated uniformly with light oil or grease before inserting axle shaft.

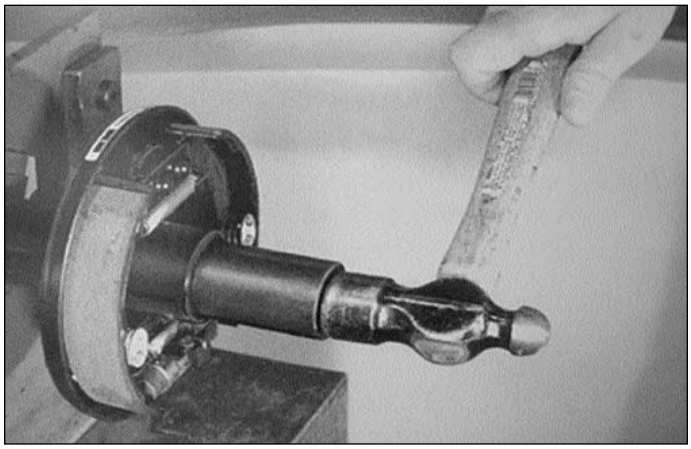


Figure 119 - Install Shaft Seals

37. Install inner snap ring to both right and left hand tubes.

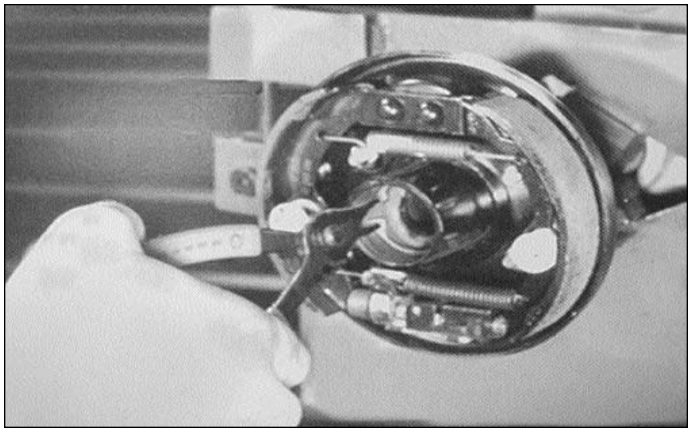


Figure 120 - Install Inner Snap Ring

38. Press bearings onto axle shafts. Bearing should seat to shoulder. Use appropriate drive to install bearing.

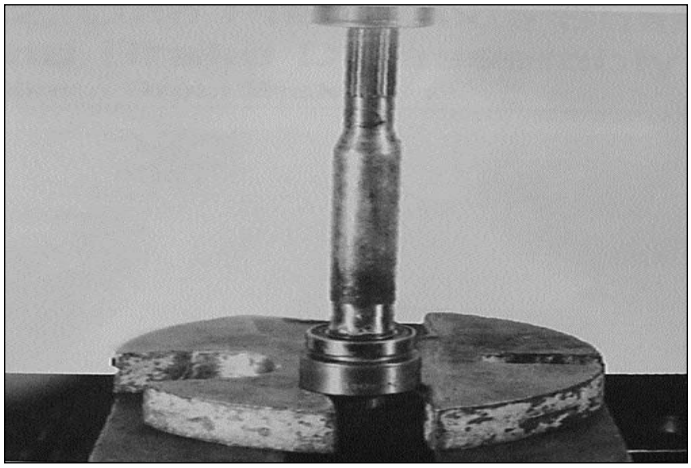


Figure 121 - Install Axle Bearings

39. Insert axle shaft assemblies into tubes. With a properly sized hearing driver, tap assembly until it is seated firmly against inner snap ring. Refer to Figure 92, page 6-26.

Note: Rotation of shaft may be required to engage differential splines during installation.

40. Install outer snap ring in each tube. See Figure 122.

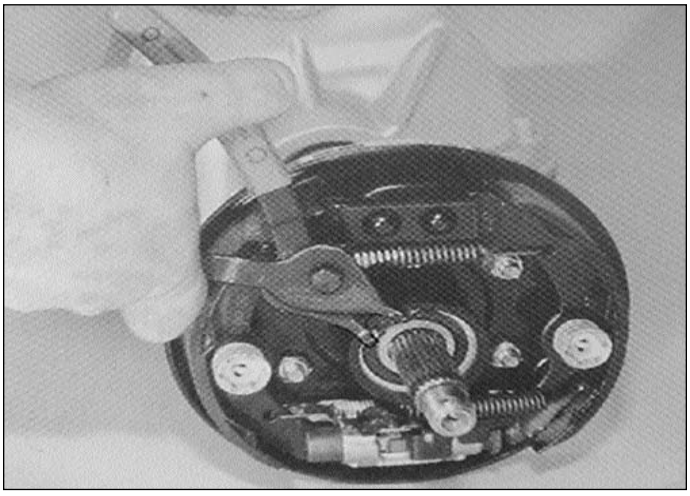


Figure 122 - Install Outer Snap Ring

41. Remove fill plug in cover plate. Fill axle assembly with correct type and amount of lubricant as recommended by O.E.M. Install rubber fill plug into cover plate. If threaded fill plug. Torque to 25 to 40 ft. lbs. (34 to 54 N.m.).

42. Apply an anti-seize compound to the splines before installing the drum/hub. This will reduce fretting wear on splines.

43. Reinstall the hub on the spline and install spindle nut on the threaded end of shaft. Torque to 95 to 115 ft. lbs. (128.7 to 155.8 N.m.).

GAS & ELECTRIC HEAVY DUTY AXLE SHAFT & BEARING SERVICE

One-Piece Axle Shaft Assembly with 7 x 1-3/4 Brakes (Tram and 2400 Lb. Capacity Utility Vehicles)

One-piece axle shaft:

22/23……Shaft
26……Seal
28……Bearing
33……Bolt
34……Nut
35……Bolt
37……Seal
38……Retaining Ring
39……Sealant

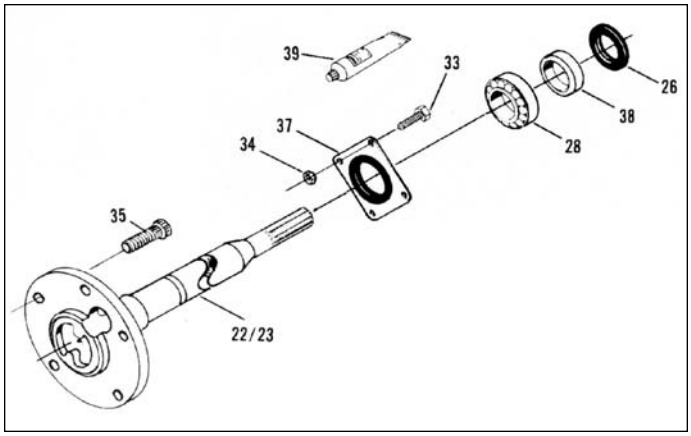


Figure 123 - Components of the One-Piece Shaft Removal

1. After the wheel has been removed, remove the brake.

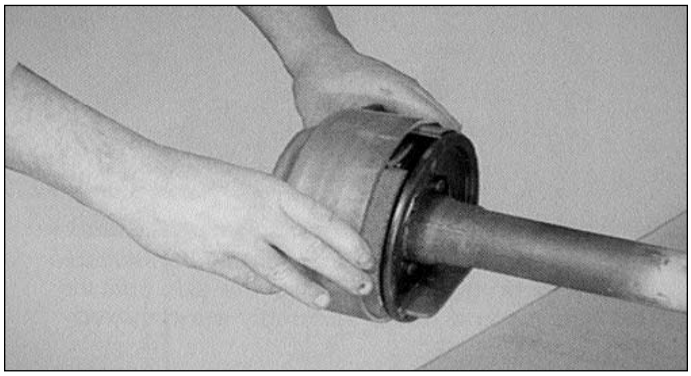


Figure 124 - Brake Drum Removal

2. Using a ½" socket, line up the hole in the axle shaft flange to remove the backing plate nuts which hold the axle shaft assembly to the axle.

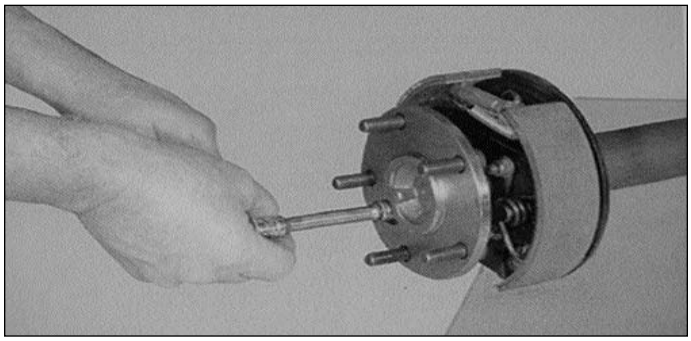


Figure 125 - Remove Brake Assembly Hardware

3. To remove the axle shaft assembly, grasp the assembly with both hands (the assembly includes the shaft, oil seal, brake assembly, and retainer) and pull it free.

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

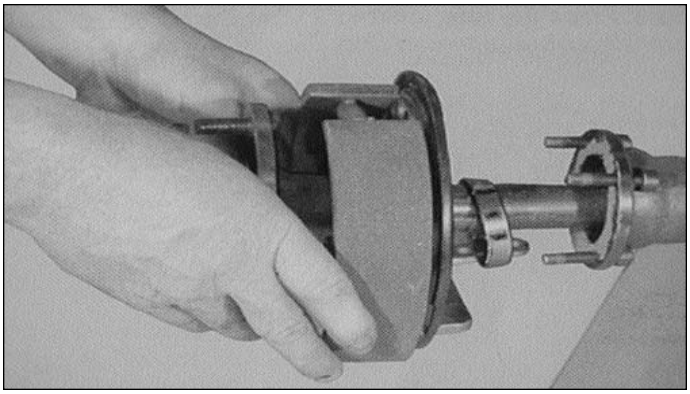


Figure 126 - Remove Axle and Brake Assembly

4. Use an internal puller to remove the inner axle shaft seal. Discard the seal.

Note: Avoid contacting seals with cleaning solvent during cleaning operation.

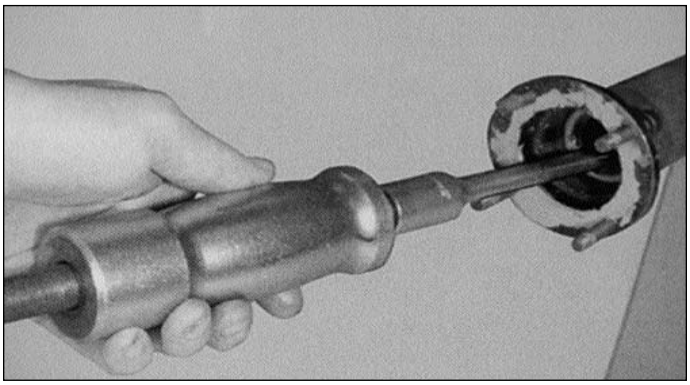


Figure 127 - Inner Axle Shaft Seal Removal

5. Place the axle shaft in a vise. Center punch the outside of the retaining ring.

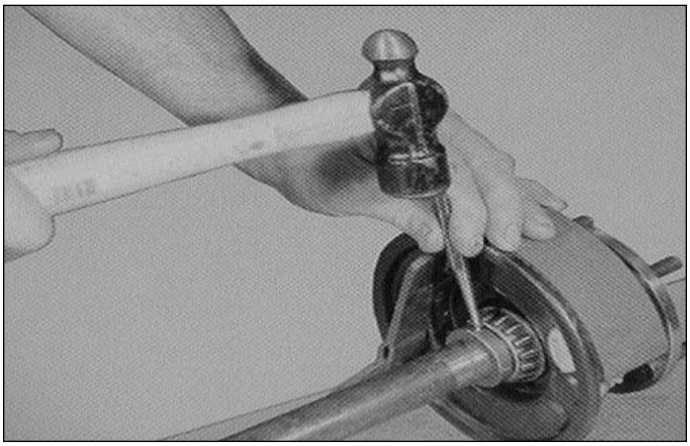


Figure 128 - Center Punch Retaining Ring

6. Drill a ¼" hole in the outside of the retaining ring approximately ¾ through the ring. Do not drill through the ring, axle shaft damage will result.

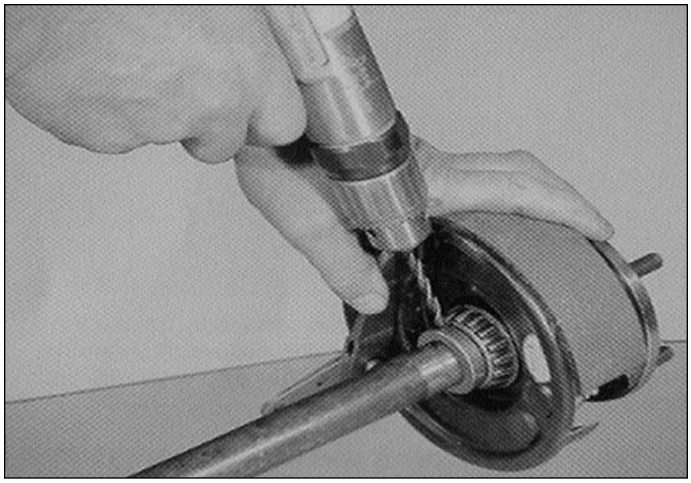


Figure 129 - Drill Retaining Ring

7. Use a chisel to split and remove the retaining ring. A new ring will be installed at reassembly.

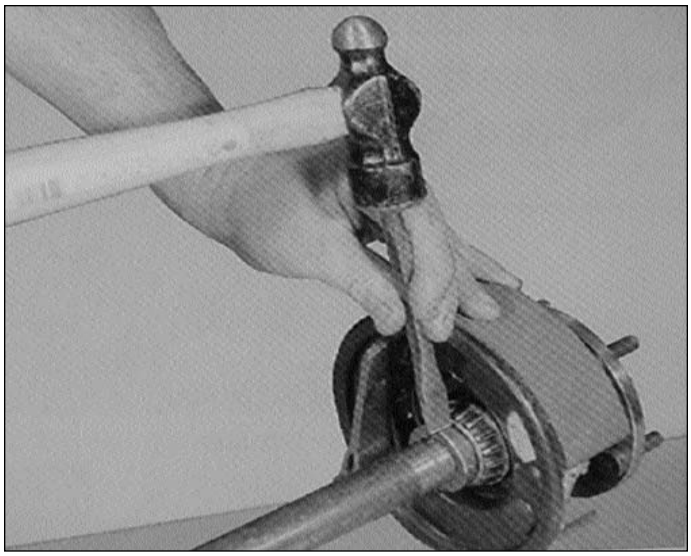


Figure 130 - Retaining Ring Removal

8. Support the axle shaft assembly in a suitable press. Press on the upper end of the axle until the wheel bearing and brake assembly are removed.

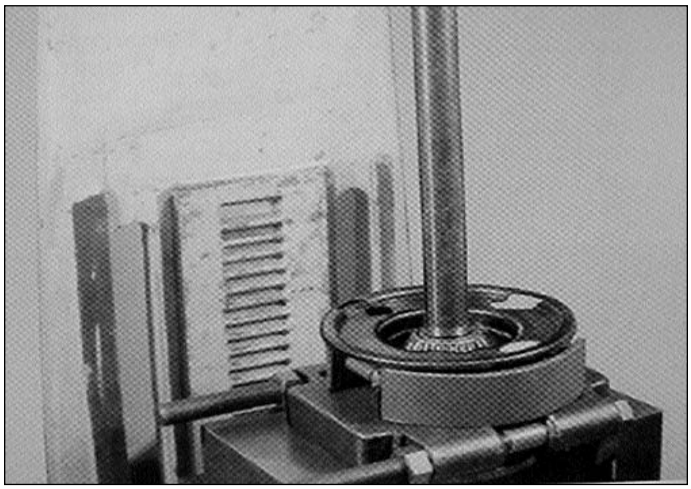


Figure 131 - Press Brakes And Bearings From Axle

Assembly

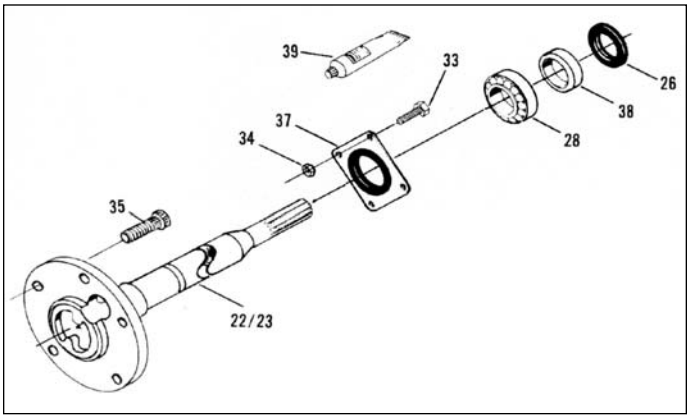


Figure 132 - Components of One-Piece Axle Shaft

One-piece axle shaft:

22/23.....Shaft, Left or Right
26.....Seal, Inner
28.....Bearing and Race
33.....Bolt
34.....Nut
35.....Bolt
37.....Seal, Outer
38.....Retaining Ring
39.....Sealant

Important: Notice the order of components for axle shaft assembly, especially note the correct orientation for the bearing assembly.

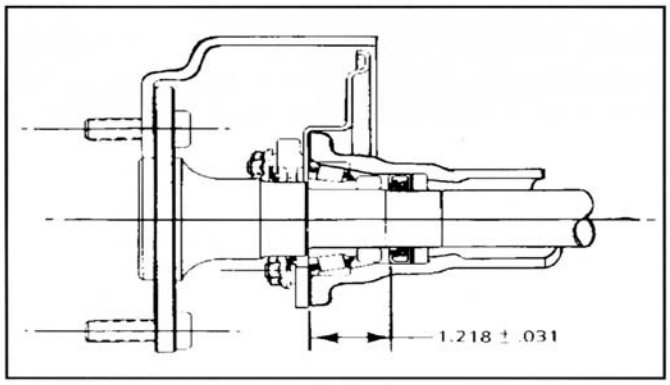


Figure 133 - One-Piece Axle Shaft

1. Inspect the axle shaft for damage. In the following order place these parts on the axle shaft: new oil seal, brake assembly, and a new grease packed bearing assembly (with a unit bearing rib ring toward flanges end of shaft).

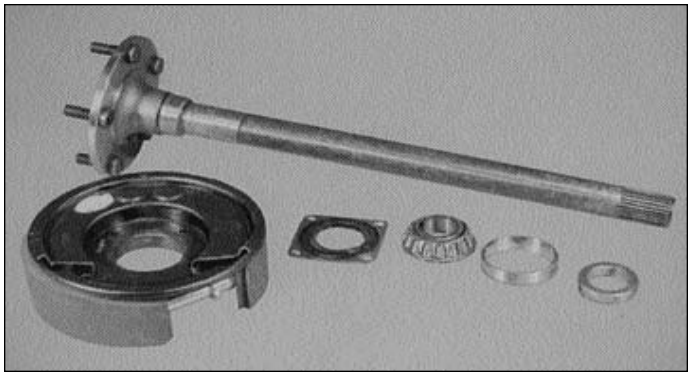


Figure 134 - Axle And Brake Assembly Components

2. Support the bearing assembly in a suitable press.

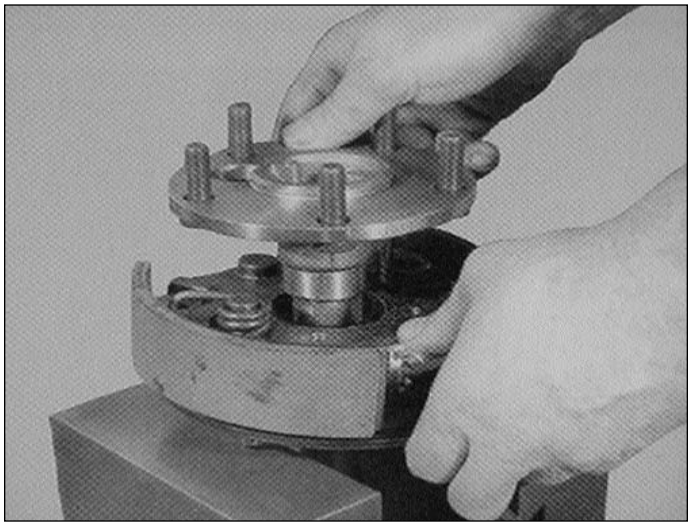


Figure 135 - Support Bearing Assembly

3. Press on the axle flange center until the bearing is firmly seated against the axle shaft shoulder.

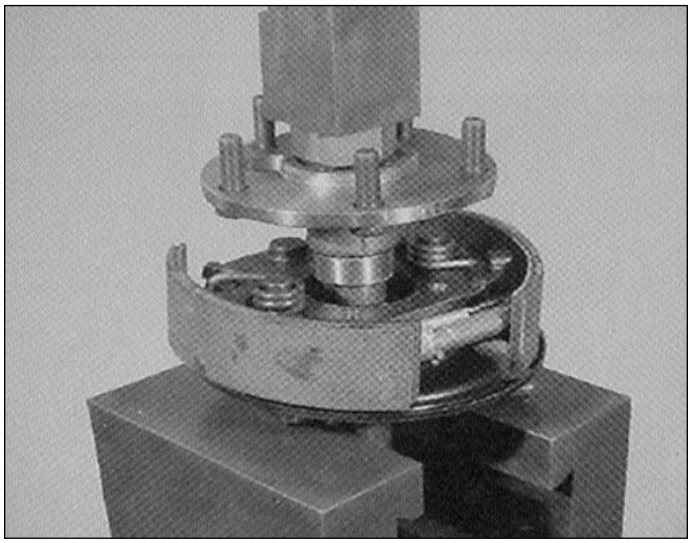


Figure 136 - Press Bearing On To Axle

4. Slide a new retaining ring on the axle shaft and reposition the assembly in the press.

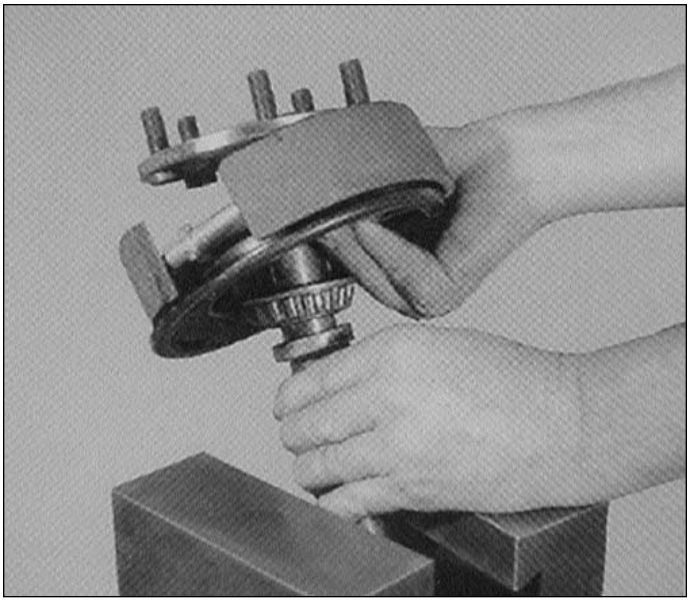


Figure 137 - Place Retaining Ring On To Axle

5. Press the retaining ring firmly against the bearing.

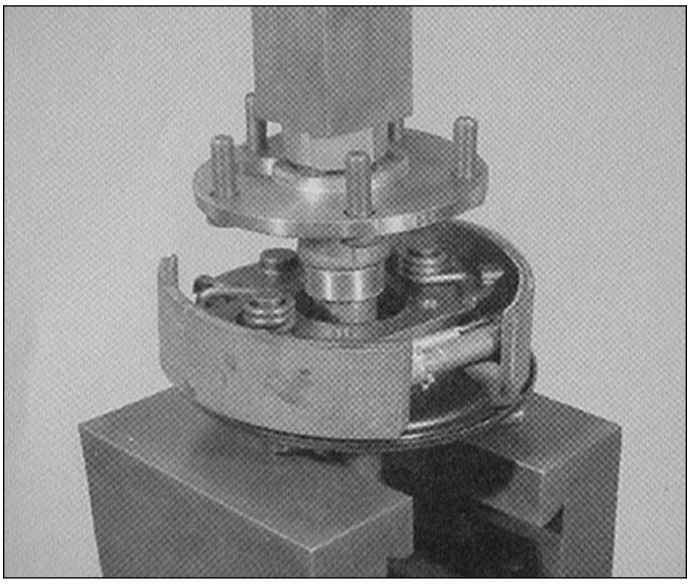


Figure 138 - Press Retaining Rings

6. Assemble a new grease seal into the axle housing to a depth of 1.218 +/- .031. After seal has been seated, grease the lip of the seal.

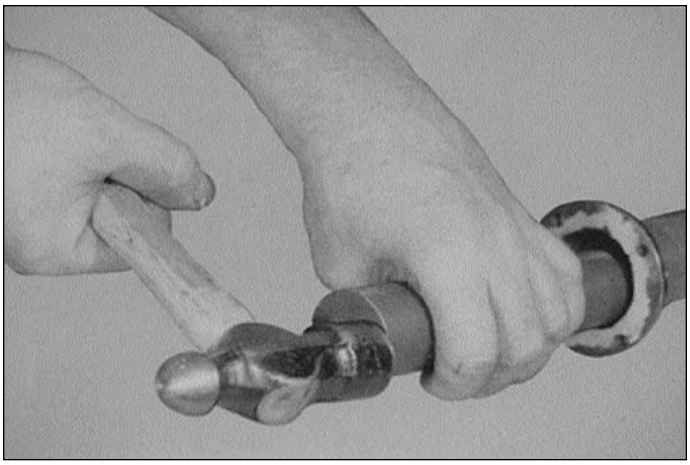


Figure 139 - New Grease Seal Assembly

7. Assemble bearing retainer bolts and new gasket material on the axle housing. Then, install axle shaft assembly into axle housing. Care should be taken not to damage oil seal. Push axle shaft as far as possible into axle housing.

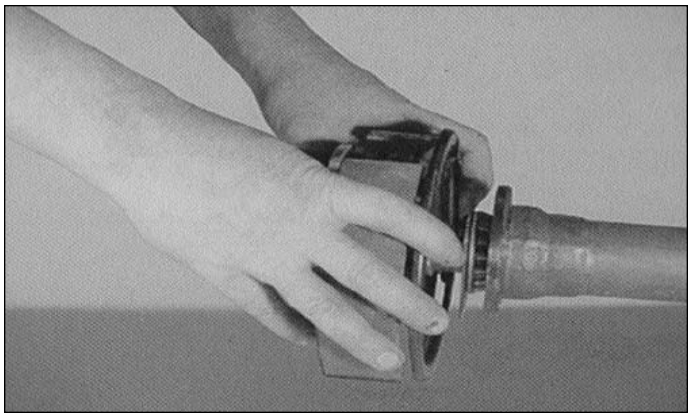


Figure 140 - Install Axle And Brake Assembly

8. Start nuts on bolts by hand. Tighten nuts in a manner that assures the seal and bearing assembly are drawn evenly into the axle housing. When assembling, head of screw should be held away from the tube with a putty knife or flat blade screwdriver to avoid head turning into radius. Torque to 16 to 20 ft. lbs. (21.5 to 27.1 N.m.).

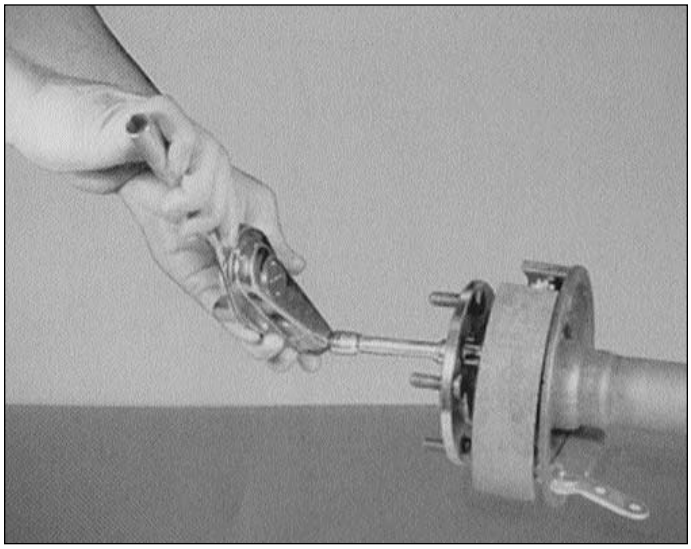


Figure 141 - Torque Brake Assembly Hardware

CHAPTER 7

CHAPTER 7

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CHAPTER 7

FOREWORD

The information, procedures and specifications provided in this chapter of the repair manual are current as of the date of publication and subject to change without notice. Appropriate changes will be included in the next revision of this manual.

Note: Manufacturing standards may vary from service specifications. Always refer to the service procedures and specifications in this manual when engine service is required.

Before attempting a Single Cylinder OHV engine overhaul or a tune-up, it is necessary that your shop be equipped with proper tools, equipment and mechanics who are thoroughly familiar with Briggs & Stratton engine design and construction. With your shop thus equipped, this book will serve as a guide in performing the various steps necessary to do a complete and satisfactory job.

In order to keep all tables as simple as possible, only the basic engine models are listed unless there is a difference between them and special models.

To make inspection of parts simple and accurate, only the sizes at which they should be rejected are shown. This eliminates the necessity for figuring allowances for wear, etc. If a part is worn larger (inside dimension such as magneto bearing) or smaller (such as crankshaft journal surfaces) than the given sizes, they should be rejected and replaced with new parts.

The term "Inspect," "Check," "Test" and "Replace" are used as follows:

INSPECT - Visual inspection - look for signs of wear, scoring, cracks, stripped threads, etc.

CHECK - Measure by means of plug gauges, feeler gauges, micrometer, scale, etc.

TEST - Analyze with proper testing equipment.

REPLACE - This usually means to take off the old part and re-assemble it or replace with a new one.

Illustrations do not necessarily designate a particular model, and should only be used to identify repair procedures.

Note: All fasteners are metric threads except for crankshaft P.T.O., Flange Mounting, and flywheel puller holes.

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Columbia ParCar Corp.

HANDY REPAIR CHECK CHART

COMMON SPECIFICATIONS FOR OHV SINGLE CYLINDER ENGINES

1. Spark Plug Gap: .030" .76 mm All Models

Table 1

Engine	Idle RPM	Torque Specifications				Valve Clearance		Armature Air Gap Inches (MMm)
		Flywheel Nut Ft. Lbs. (Nm)	Cylinder Head In. Lbs. (Nm)	Conn. Rod In. Lbs. (Nm)	Crankcase Cover or Sump In. Lbs. (Nm)	Intake Inches (MM)	Exhaust Inches (MM)	
9 H.P.	None	60 (81.36)	300 (33.9)	175 (19.8)	175 (19.8)	.002 .004" (0.05 0.10)	.002 .004" (0.05 0.10)	.012 .020" (0.31 0.51)
13 H.P.	None	60 (81.36)	35 Ft. Lbs. (47.5 Nm)	175 (19.8)	175 (19.8)	.004 .006" (0.10 0.15)	.004 .006" (0.10 0.15)	.008 .012" (0.20 0.31)

2. Top Governed Speed: See Governor System, See Chapter 2, Governor.

Table 2

Engine	Cylinder Bore Std. Inches (MM)	Stroke Inches (MM)	Crankshaft				Spark Plug		Initial Carburetor Adjustment
			Reject Sizes Inches (MM)			End Play Inches (MM)	Champion	Autolite	
			Mag. Journal	Crankpin Journal	PTO Journal				
9 H.P.	3.1496 3.1504" (80.00 80.02)	2.325" (59.06)	Ball	1.3368" (33.99)	Ball	.001 .008" (0.03 0.20)	RC12YC	3924	1-1/4
13 H.P.	3.5047 3.5039" (89.02 89.00)	2.480" (63.00)	Ball	1.4953" (37.98)	Ball	.001 .008" (0.3 0.2)	RC12YC	3924	1-1/4

HOW TO READ BRIGGS & STRATTON MODEL, TYPE AND CODE NUMBERS

All Briggs & Stratton engines have a unique numerical designation system. Each engine is identified be a Model, Type and Code number. Example:

Model	Type	Code
185430	009901	95100649

The model number identifies the engine configuration. Information included in this model number includes:

First Digit After Displacement		Second Digit After Displacement	Third Digit After Displacement	Fourth Digit After Displacement
Cubic Inch Displacement	**Basic Design Series**	**Crankshaft, Carburetor, Governor,**	**PTO Bearing, Reduction Gear, Auxiliary Drive, Lubrication**	**Type of Starter**
6	0	0 - Horizontal Shaft Diaphragm Carburetor Pneumatic Governor	0 - Plain Bearing/DU Non-Flange Mount	0 - Without Starter
8	1		1 - Plain Bearing Flange Mounting	1 - Rope Starter
9	2	1 - Horizontal Shaft Vacu-Jet Carburetor Pneumatic Governor	2 - Sleeve Bearing Flange Mounting Splash Lube	2 - Rewind Starter
10	3		3 - Ball Bearing Flange Mounting Splash Lube	3 - Electric Starter Only 120 Volt Gear Drive
11	4	2 - Horizontal Shaft Pulso-Jet Carburetor Pneumatic or Mechanical Governor	4 - Ball Bearing Flange Mounting Pressure Lubrication on Horizontal Shaft	4 - Electric Starter/Generator 12 Volt Belt Drive
12	5		5 - Plain Bearing Gear Reduction (6 to 1) CW Rotation Flange Mounting	5 - Electric Starter Only 12 Volt Gear Drive
13	6	3 - Horizontal Shaft Flo-Jet Carburetor Pneumatic Governor	6 - Plain Bearing Gear Reduction (6 to 1) CCW Rotation	6 - Alternator Only
16	7		7 - Plain Bearing Pressure Lubrication on Vertical Shaft	7 - Electric Starter 12 Volt Gear Drive With Alternator
17	8	4 - Horizontal Shaft Flo-Jet Carburetor Mechanical Governor	8 - Plain Bearing Auxiliary Drive (PTO) Perpendicular to Crankshaft	8 - Vertical Pull Starter or Side Pull Starter
18	9		9 - Plain Bearing Auxiliary Drive Parallel to Crankshaft	
19	A to Z	5 - Vertical Shaft Vacu-Jet Carburetor Pneumatic or Mechanical Governor		
22				
23		6 - Vertical Shaft		
24		7 - Vertical Shaft Flo-Jet Carburetor Pneumatic or Mechanical Governor		
25				
26		8 - Vertical Shaft Flo-Jet Carburetor Mechanical Governor		
28				
29		9 - Vertical Shaft Pulsa-Jet Carburetor Pneumatic or Mechanical Governor		
30				
32				
35				
40				
42				

The type number identifies certain unique features such as the crankshaft or governor spring used on an engine.

The code number identifies the assembly date of the engine. In some instances it is necessary to know the code number as well as the model and type number when performing adjustments, repairs or ordering replacement parts for an engine. Here is how it works.

Example: 95100649

A. The first two digits, 95, indicate at the calendar year, 1995.
B. The second two digits, 10, indicate at the calendar month, October.
C. The third two digits, 06, indicate the calendar month day.
D. The last two digits, 49, indicate the assembly line or manufacturing plant.

IN THE INTEREST OF SAFETY

THIS SYMBOL MEANS WARNING OR CAUTION. PERSONAL INJURY AND/OR PROPERTY DAMAGE MAY OCCUR UNLESS INSTRUCTIONS ARE FOLLOWED CAREFULLY.

WARNING

Exhaust gases contain CARBON MONOXIDE which is an odorless and deadly poison. Proper care must be taken to provide adequate ventilation when running an engine indoors.

WARNING: DO NOT

1. DO NOT run engine in an enclosed area. Exhaust gases contain carbon monoxide, an odorless and deadly poison.
2. DO NOT place hands or feet near moving or rotating parts.
3. DO NOT store, spill, or use gasoline near an open flame, or devices such as a stove, furnace, or water heater which use a pilot light or devices which can create a spark.
4. DO NOT refuel indoors where area is not well ventilated. Outdoor refueling is preferred.
5. DO NOT fill fuel tank while engine is running. Allow engine to cool for 2 minutes before refueling. Store fuel in approved safety containers.
6. DO NOT remove fuel tank cap while engine is running.
7. DO NOT operate engine when smell of gasoline is present or other explosive conditions exist.
8. DO NOT operate engine if gasoline is spilled. Move machine away from the spill and avoid creating any ignition until the gasoline has evaporated.
9. DO NOT transport engine with fuel in tank.
10. DO NOT smoke when filling fuel tank.
11. DO NOT choke carburetor to stop engine. Whenever possible, gradually reduce engine speed before stopping.
12. DO NOT run engine at excessive speeds. This may result in injury.
13. DO NOT tamper with governor springs, governor links or other parts which may increase the governed engine speed.
14. DO NOT tamper with the engine speed selected by the original equipment manufacturer.
15. DO NOT check for spark with spark plugs or spark plug wires removed. Use an approved tester.
16. DO NOT crank engine with spark plug removed. If engine is flooded, place throttle in "FAST" position and crank until engine starts.
17. DO NOT strike flywheel with a hard object or metal tool as this may cause flywheel to shatter in operation. Use proper tools to service engine.
18. DO NOT operate engine without a muffler(s). Inspect periodically and replace, if necessary, with muffler/deflector(s) originally specified by equipment manufacturer.
19. DO NOT operate engine with an accumulation of grass, leaves, dirt or other combustible material in the muffler area.
20. DO NOT use this engine on any forest covered, brush covered, or grass covered unimproved land unless a spark arrester is installed on the muffler. The arrester must be maintained in effective working order by the operator. In the State of California the above is required by law (Section 4442 of the California Public Resources Code). Other states may have similar laws. Federal laws apply on federal lands.
21. DO NOT touch hot muffler(s), cylinder, or fins because contact may cause burns.
22. DO NOT operate engine with air cleaner or air cleaner cover removed.

WARNING: DO

1. ALWAYS DO remove the wire from the spark plug when servicing the engine or equipment TO PREVENT ACCIDENTAL STARTING. Disconnect the negative wire from the battery terminal if equipped with a 12 volt starting system.
2. DO wear eye protection when operating or repairing equipment.
3. DO keep cylinder fins and governor parts free of grass and other debris which can affect engine speed.
4. DO pull starter cord slowly until resistance is felt . Then pull cord rapidly to avoid kickback and prevent hand or arm injury.
5. DO examine muffler(s) periodically to be sure it is functioning effectively. A worn or leaking muffler(s) should be repaired or replaced as necessary.
6. DO use fresh gasoline. Stale fuel can gum carburetor and cause leakage.
7. DO check fuel lines and fittings frequently for cracks or leaks. Replace if necessary.
8. DO check fuel tank/tank neck and fuel cap. Replace if damaged or if cap does not seal properly.

NOTE: Use Original Columbia ParCar/Briggs & Stratton Service Replacement Parts when servicing your engine. Briggs & Stratton Authorized Service Centers carry a stock of such parts. The use of Briggs & Stratton parts preserves the original design of your engine. Imitation replacement parts may not fit or function as original Briggs & Stratton parts and can expose the operator to potential personal injury. Contact any Briggs & Stratton Authorized Service Center for Original Briggs & Stratton Replacement Parts.

THEORY OF OPERATION

Briggs & Stratton Single Cylinder OHV engines are of the same basic 4-stroke cycle design used in automobiles, aircraft, trucks, and tractors. As the name indicates, there are four strokes to one complete power cycle:

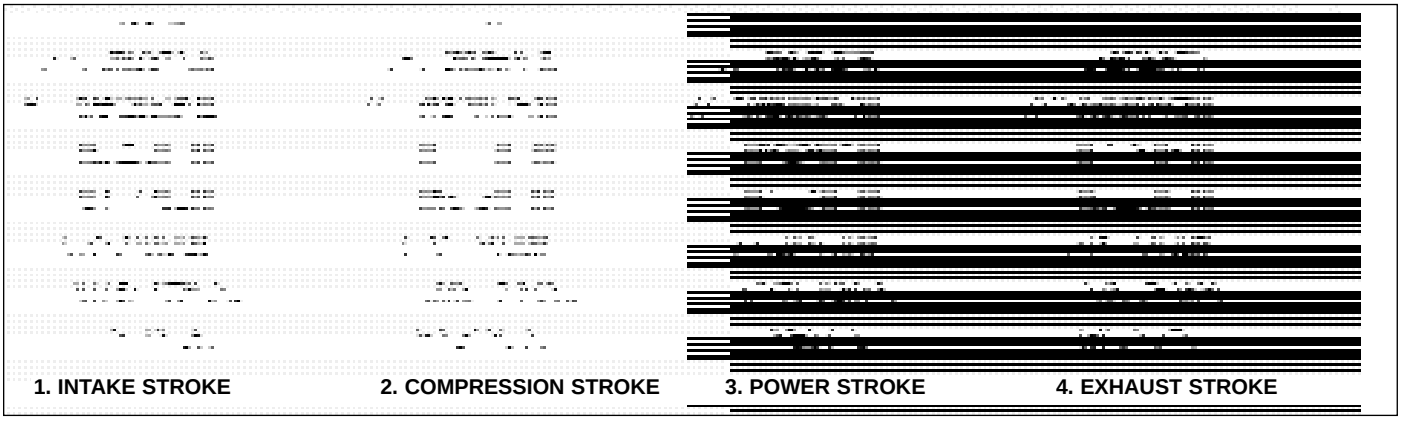


Figure 1 - The 4 Stroke Cycle

1. INTAKE STROKE: As the piston moves down, a vacuum occurs in the cylinder. The intake valve has been opened by the cam gear. Atmospheric pressure pushes the air/fuel mixture through the open intake valve into the cylinder above the piston. At the bottom of the stroke the intake valve closes. The exhaust valve stays closed.

2. COMPRESSION STROKE: As the piston moves up with both valves closed, the air/fuel mixture becomes highly compressed in the space left between the top of the piston and the cylinder head.

3. POWER STROKE: Just before the compression stroke ends, the magneto produces a high voltage arc across the spark plug gap igniting the air/fuel mixture. The rapidly burning mixture expands producing very high pressure, pushing the piston downward.

4. EXHAUST STROKE: As the piston begins to go up, the cam gear opens the exhaust valve and the piston pushes out the burned gases completing the cycle and the first stroke begins again.

FUEL AND OIL RECOMMENDATIONS

Gasoline

We recommend the use of clean, fresh, lead-free gasoline. Leaded gasoline may be used if lead-free is not available. A minimum of 85 octane is recommended. The use of lead-free gasoline results in fewer combustion deposits and longer valve life.

Note: We DO NOT recommend the use of gasoline which contains alcohol, such as gasohol. However, if gasoline with alcohol is used, it MUST NOT contain more than 10 percent Ethanol and MUST be removed from the engine during storage. DO NOT use gasoline containing Methanol.

We also recommend gasoline be purchased in small quantities, not more than a 30 day supply. FRESH gasoline minimizes gum deposits and also will ensure fuel volatility tailored for the season in which the engine will be operated.

Note: The use of a fuel additive, such as Briggs & Stratton Gasoline Additive, Part #5041, or equivalent, will minimize the formation of fuel gum deposits during storage. Such an additive may be added to the fuel tank or storage container.

Engine Oil

4-CYCLE (Overhead Valve) ENGINE OIL RECOMMENDATIONS 5

SAE VISCOSITY GRADES

We recommend the use of Briggs & Stratton "warranty certified" high quality detergent oil Part #100005 (SAE 30). If not available, use a high quality detergent oil classified "For Service SC, SD, SE, SF, or SG." Detergent oils keep the engine cleaner and retard the formation of gum and varnish deposits. No special additives should be used with recommended oils.

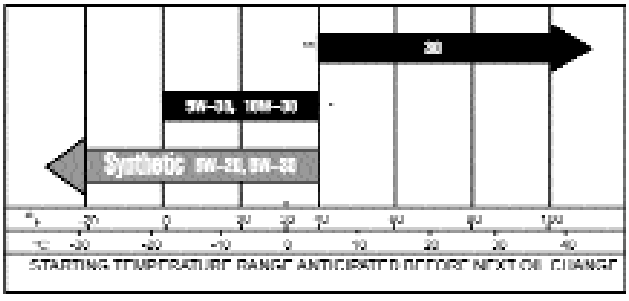


Figure 2 - Oil Viscosity Grades

* Air cooled engines run hotter than automotive engines. Use of multi-viscosity oils (10W-30, etc.) above 40° F (4° C) will result in high oil consumption and possible engine damage. Check oil level more frequently if using these types of oils.

** SAE 30 oil, if used below 40° F (4° C), will result in hard starting and possible engine bore damage due to inadequate lubrication.

BE SURE OIL LEVEL IS MAINTAINED.

Note: DO NOT MIX OIL WITH GASOLINE.

MAINTENANCE

Oil, Lubrication

Oil has four purposes.

- •It cools,
- •It cleans,
- •It seals,
- •It lubricates.

Briggs & Stratton engines are lubricated with connecting rod dipper.

During normal operation, small particles of metal from the cylinder walls, pistons, bearings, and combustion deposits will gradually contaminate the oil. Dust particles from the air also contaminate the oil. If oil is not changed regularly, these foreign particles can cause increased friction and a grinding action which shortens the life of the engine. Fresh oil also assists in cooling. Old oil gradually becomes thick and loses its cooling ability as well as its lubricating qualities.

Change Oil (Crankcase)

1. BE SURE OIL LEVEL IS MAINTAINED. CHECK OIL LEVEL EVERY EIGHT (8) HOURS OR DAILY. EQUIPPED WITH DIPSTICK/OIL FILL TUBE, SCREW DIPSTICK IN SLOWLY UNTIL IT BOTTOMS. CHANGE OIL AFTER FIRST EIGHT (8) HOURS OF OPERATION.

Note: On 9 or 13 H.P. Engines, when removing combined oil fill plug and dipstick, do not screw dipstick into crankcase cover when checking oil level.

2. Thereafter, change oil every one hundred (100) hours of operation or every fifty (50) hours of operation if operated under heavy load and usage or in high ambient temperatures.
3. Remove oil drain plug, Figure 3, and drain oil while engine is still warm.
4. Install drain plug. See Figure 3.
5. Remove fill or oil dipstick and refill slowly with new oil of proper service classification and viscosity grade. DO NOT OVERFILL. See Figures 3 and 4.
6. Start and run engine at low RPM to check for oil leaks.
7. Recheck oil level, and add oil if required.

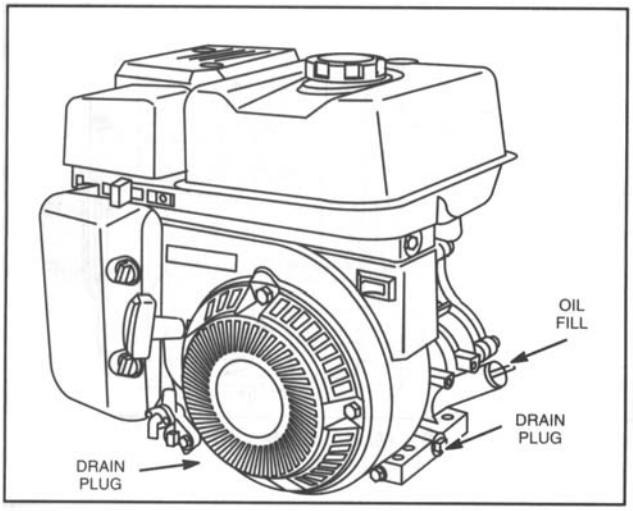


Figure 3 - Oil Fill and Drain Plugs

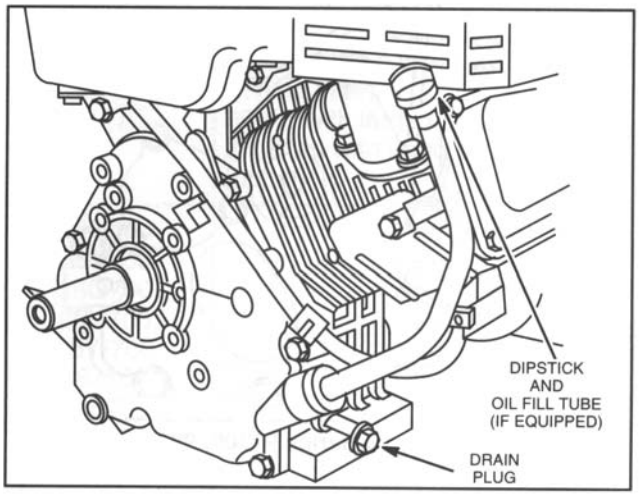


Figure 4 - Dipstick and Oil Fill Tube

Cooling System

Grass particles, chaff, or dirt can clog the air cooling system, especially after prolonged service in very dusty conditions or when cutting dry grass. Continued operation with a clogged cooling system can cause severe overheating and possible engine damage.

Figure 4A shows the areas to be cleaned. This should be a regular maintenance operation, performed yearly or every 200 hours, whichever comes first, and more often under dusty conditions or when airborne debris is present.

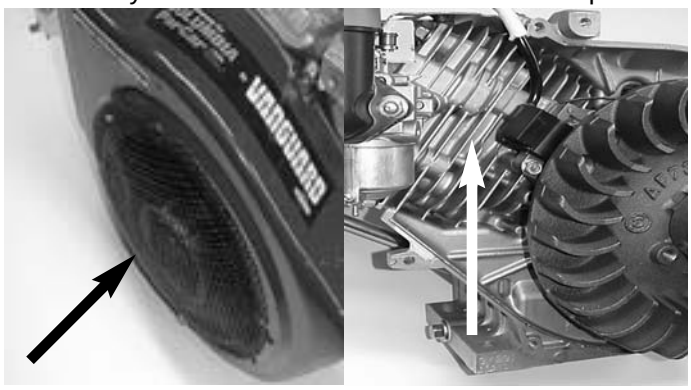


Figure 4A - Clean Regularly

TUNE-UP PROCEDURE

By performing the following steps you will either be sure that the engine is functioning properly or will know what major repairs should be made.

The steps are also covered in the Overhaul Procedure and will normally be performed as a part of the complete overhaul.

Carbon deposits in combustion chamber should be removed every 100 to 300 hours of use (more often when run at steady loads), or whenever cylinder head is removed.

Step No.	Tune-Up Steps
1.	Remove air cleaner, check for proper servicing. Replace if damaged or dirty.
2.	Check oil level and drain oil.
3.	Clean cooling fins and entire engine.
4.	Remove carburetor, disassemble, and inspect for wear or damage. Wash in solvent. Replace parts as necessary and assemble. Set initial adjustment.
5.	Inspect intake elbow for damaged gaskets.
6.	Check for oil seal leakage, both flywheel and PTO sides. Check flywheel key.
7.	Inspect all wires for breaks and/or damaged insulation. Be sure lead wires do not touch flywheel.
8.	Remove spark plug and cylinder head.
9.	Inspect valves for seating.
10.	Clean carbon from cylinder head and piston.
11.	Replace gaskets and install cylinder head. Tighten to specified torque. Adjust valve clearance. Set spark plug gap or replace plug if necessary.
12.	Replace gaskets and install carburetor
13.	Check muffler for restrictions or damage.
14.	Replace oil.
15.	Run engine and adjust carburetor mixture and governed top speed.

OVERHAUL PROCEDURE

The Overhaul Procedure, which follows, is intended to help you become accustomed to a systematic method of repairing Briggs & Stratton OHV engines. Naturally, these steps could be rearranged in different order but efficiency is obtained when the repair operations are performed in the same sequence every time. The exact procedure will vary according to the engine model being repaired.

The Overhaul Procedure can also be used as an index. For information on how to perform most operations listed, refer to the page number or operation. Be careful to locate the instructions covering the specific model being repaired.

Disassembly	
PAGE	**DISASSEMBLY PROCEDURE**
7-34	Check compression
7-6	Drain oil
7-13	Fuel line, Carburetor and linkage, Carburetor intake manifold
7-58	Exhaust manifold, muffler(s)
7-13	Disassemble carburetor
7-28	Blower housing and Flywheel
7-41	Breather and valve cover
7-35	Valves and springs, Rocker arms, Push rods, Cylinder head and shields, Valve guides and seats
8-9	Starter/Generator
7-48	Remove burrs from crankshaft extension, polish crankshaft journals
7-47	Crankcase cover
7-47	Cam gear and tappets
7-44	Connecting rod and piston
7-47	Crankshaft
7-32	Engine Removal

Inspection	
PAGE	**INSPECTION PROCEDURE**
7-15 or 7-21	Inspect carburetor choke, throttle shaft, and bushings for wear and freedom of movement
7-27	Inspect and test ignition coil
7-48	Crankshaft - inspect and check
7-50 & 7-52	Cylinder - check bore, main bearing
7-44	Check piston, rings, connecting rod, and piston pin

Repairs	
PAGE	**REPAIRS PROCEDURES**
7-50	Resize cylinder bore to next oversize, if required
7-37	Replace valve guides - intake or exhaust
7-37	Reface valves, seats, and lap
7-27	Replace ignition armature, if required
7-15	Replace throttle shaft bushings
7-13	Repair carburetor
7-52	Replace main bearings and seals

Reassembly	
PAGE	**REASSEMBLY PROCEDURES**
7-48	Crankshaft
7-45	Piston, piston pin, connecting rod, and rings
7-48	Tappets, cam gear
7-49	Crankcase cover or sump
7-41	Breather
7-29	Flywheel, cup, rotating screen, and fan
7-29	Ignition armature assembly
7-27	Check spark
8-9	Starter/Generator
7-37	Valves, valve stem seals, springs, retainers, rocker arms
7-38	Cylinder head and push rods
7-39	Adjust valve clearance
7-41	Valve cover
7-27	Spark plug - adjust gap to .030"
7-59	Exhaust manifold, mufflers
7-19	Intake manifold
7-19	Carburetor and linkage and governor controls
7-26	Fuel filter, tank, and line
2-17	Clean/replace and assemble air cleaner
7-33	Install engine, align transmission
7-19	Adjust carburetor
2-24	Set governor to obtain correct vehicle speed.
7-6	Fill crankcase with oil.

CHECK-UP

Most complaints concerning engine operation can be classified as one or a combination of the following:

1. Will not start
2. Hard starting
3. Lack of power
4. Vibration
5. Overheating
6. High oil consumption

When the cause of malfunction is not readily apparent, perform a check of the compression, ignition, and carburetion systems. This check-up, performed in a systematic manner, can usually be done in a matter of minutes. It is the quickest and surest method of determining the cause of failure. This check-up will point out possible causes of future failures, which can be corrected at the time. The basic check-up procedure is the same for all engine models.

Check Compression

See page for proper procedure.
If compression is poor, look for:

1. Loose spark plug
2. Loose cylinder head bolts
3. Blown head gasket
4. Burned valves, valve seats
5. Insufficient valve clearance
6. Warped cylinder head or warped valve cover
7. Warped or worn valve stems and guides
8. Worn bore and/or rings
9. Broken connecting rod

Check Ignition (Using Engine Starter)

Warning: Be sure there is no fuel or fuel vapor present, which might be ignited by the spark and cause a fire or explosion.

Attach a #95970-96 Tester to spark plug wire and ground the other end of the tester to the engine block. DO NOT REMOVE SPARK PLUG. Spin the flywheel with the engine starter. If spark jumps the .166" (4.20 mm) tester gap, you can assume the ignition system is performing satisfactorily. See page 7-27 for additional information.
If spark does not occur, look for:

1. Shorted stop switch wire
2. Shorted stop switch
3. Ignition armature failure

Note: If engine runs but misses during operation, a quick check to determine if ignition is or is not at fault can be made by inserting the #95970-96 tester between the ignition cable and the spark plug. A spark miss will be readily seen. See page 7-27.

Check Carburetion

Before making a carburetion check, be sure the fuel tank has an ample supply of fresh, clean gasoline. Be sure that fuel flows freely through fuel line and filter before starting engine. Check fuel pump operation. Inspect and adjust the needle valve. Check to see that the choke closes completely. If engine will not start, remove and inspect the spark plug.

If plug is wet, look for:

1. Over choking
2. Excessively rich fuel mixture
3. Water in fuel
4. Float needle valve stuck open
5. Clogged air cleaner
6. Fouled spark plug

If plug is dry, look for:

1. Leaking carburetor mounting gaskets
2. Gummy or dirty carburetor, fuel filter, fuel lines, shut-off valve or fuel tank
3. Float needle valve stuck shut
4. Inoperative fuel pump

A simple check to determine if the fuel is getting to the combustion chamber through the carburetor is to remove the spark plug and pour a small quantity of gasoline through the spark plug hole. Replace the plug. If the engine fires a few times and then stops, look for the same conditions as for a dry plug.

CARBURETOR, 9 & 13 H.P. ENGINES

Warning: Always turn key switch to off position, and remove key. Lock wheels before servicing vehicle.

Warning: Never operate engine with air cleaner removed, fire can result.

Warning: Use care when working with fuel system. Clean up any spilled fuel immediately before continuing. Never service or repair fuel system near open spark or flame.

Caution: To prevent accidental starting when servicing engine or equipment, always remove spark plug wire from spark plug and prevent wire from contacting spark plug.

Note: Replace air cleaner gaskets and mounting gaskets whenever carburetor is removed for service.

Carburetor, Theory of Operation

One-piece Flo-Jet side-draft carburetors are used on single cylinder OHV Engines.

The following illustrations show typical system operation.

Float System Operation

Fuel is drawn from the fuel tank and delivered to the carburetor by fuel pump. Fuel enters through the inlet tube, past the inlet needle valve, and begins filling the carburetor bowl, Figure 5.

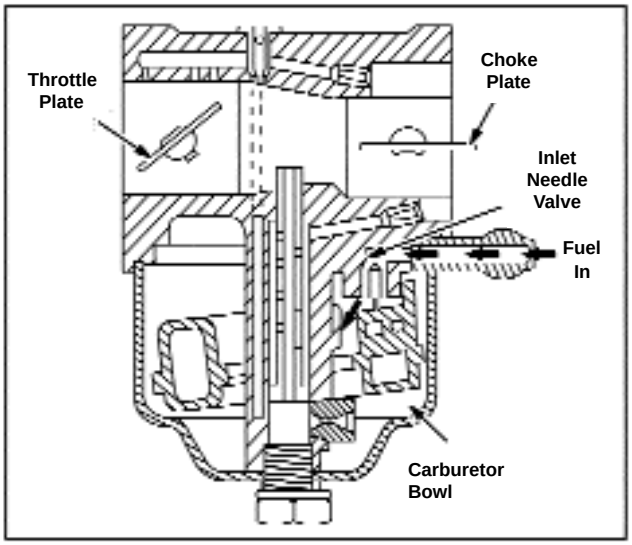


Figure 5 - Fuel Inlet

As the bowl fills, the float rises, moving the inlet needle toward the inlet seat. When the inlet needle contacts the seat, fuel flow into the bowl stops, Figure 6. Fuel remains at this level until engine operation begins to draw fuel from the bowl. As the fuel level drops, the float moves down causing the inlet needle to move away from the inlet seat. Fuel flows into the bowl to maintain a supply for engine use. The air space above the fuel in the bowl is vented to the atmosphere through a passage on the side of the carburetor. (Not illustrated.) This vent allows air to move into and out of the bowl area as the fuel level changes.

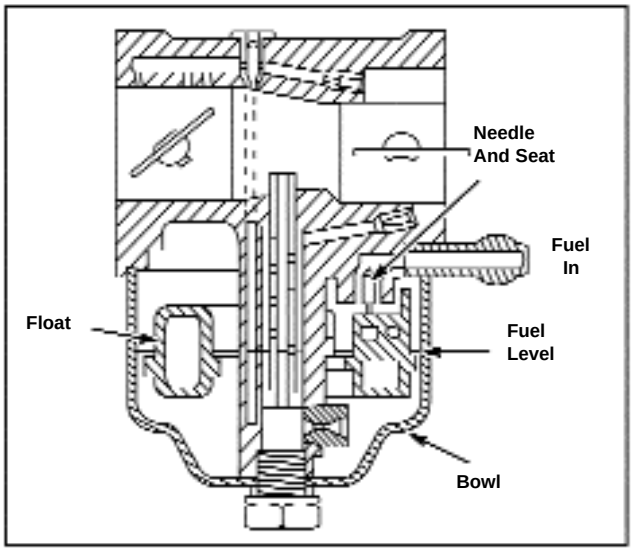


Figure 6 - Normal Fuel Level

Idle System Operation

When the engine is idling, the fuel flows as follows:

As the piston moves down in the cylinder when the intake valve is open, a partial vacuum forms between the throttle plate and the top of the piston. Atmospheric pressure in the carburetor bowl pushes fuel through the fixed main jet and up the idle passage. Atmospheric pressure also pushes air into the throat of the carburetor. Atmospheric pressure also enters through the idle air jet. See Figure 7.

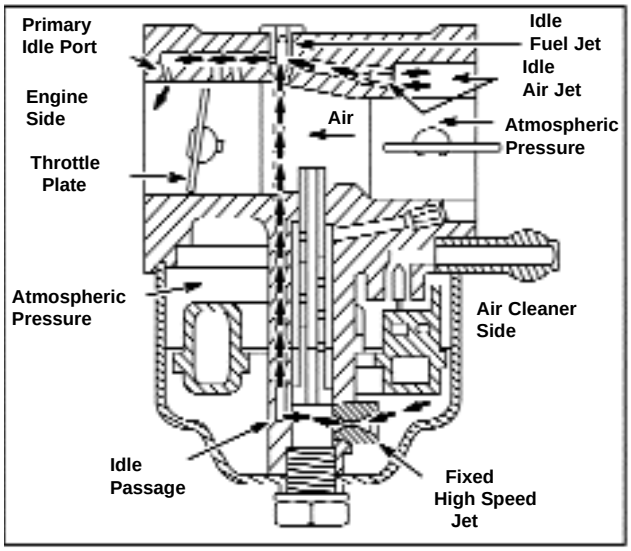


Figure 7 - Idle System Operation

The fuel being pushed up the idle passage enters the center of the idle fuel jet and mixes with air from the idle air jet. This air/fuel mixture then is pushed to the primary idle port and out into the carburetor throat. There it mixes with air flowing through the throat and is carried into the cylinder. See Figure 7.

Part Throttle Operation

As the throttle valve opens and the air/fuel mixture flow increases from the primary and secondary idle ports, engine speed increases. See Figure 8.

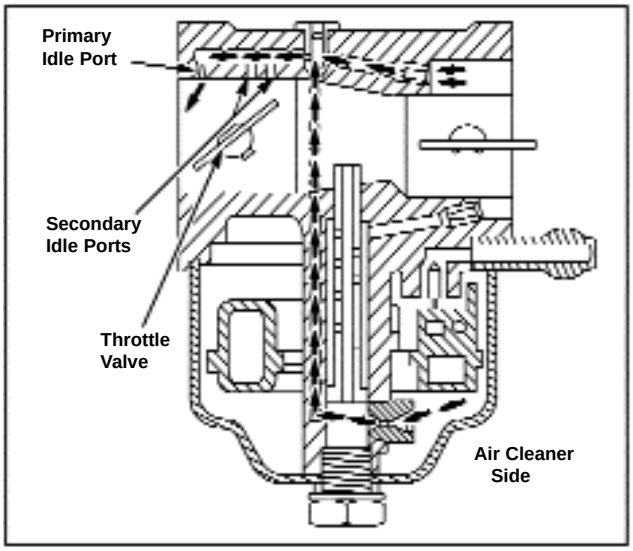


Figure 8 - Part Throttle Operation

High Speed System Operation

When the engine is running with the speed control in the "FAST" position, the fuel flows as follows:

As the intake valve opens, a partial vacuum forms in the carburetor throat. Atmospheric pressure pushes air through the venturi causing a drop in pressure at the venturi throat. Atmospheric pressure also pushes fuel through the fixed high speed jet and up the inside of main pickup tube.

Atmospheric pressure pushes air through the main air jet to the outside of the main pickup tube. This air then enters through the main pickup tube bleed holes and mixes with the fuel coming up the inside of main pickup tube. This air/fuel mixture is pushed up and out of the main pickup tube into the incoming air at the venturi and into the engine through the intake valve. The throttle valve controls the amount of air/fuel mixture entering the engine, as the governor responds to changing loads. See Figure 9.

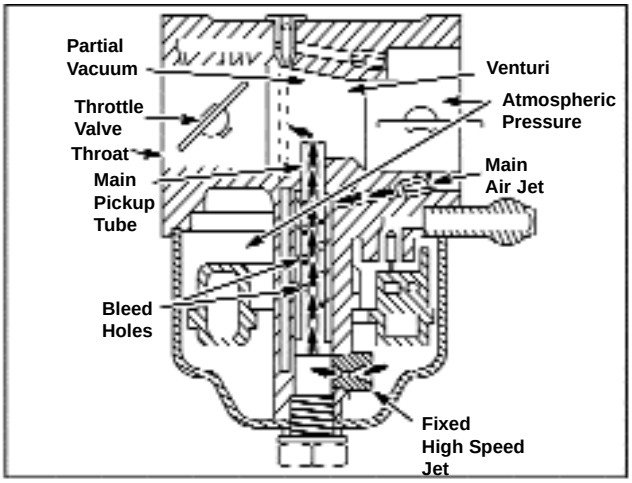


Figure 9 - High Speed Operation

Choke System Operation

When starting a cold engine, the choke valve is closed and the following events occur:

As the intake valve opens, a partial vacuum forms in the carburetor behind the choke valve. Atmospheric pressure acts on the idle and high speed systems allowing fuel to flow as described in both Idle System Operation and High Speed System Operation. See Figure 10.

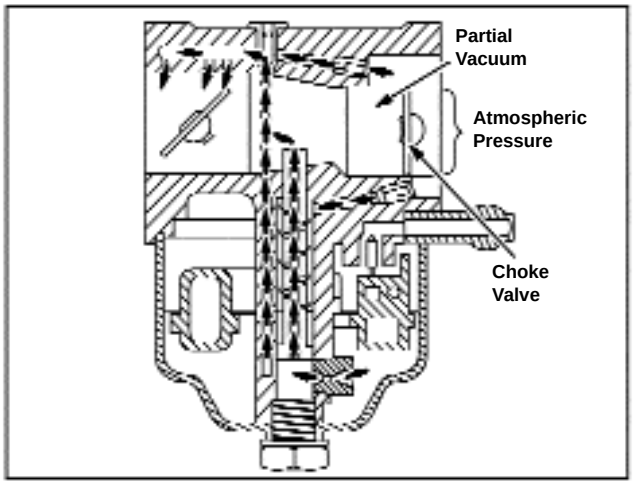


Figure 10 - Choke Operation

SERVICE BRIGGS & STRATTON/ 9 H.P. CARBURETOR - (MIKUNI CARBURETOR)

Removal

Warning: Use care when working with fuel system. Clean up any spilled fuel immediately before continuing. Never service or repair fuel system near open spark or flame.

1. Loosen worm screw clamp, and remove air cleaner hose from air intake elbow.

2. Move hose clamp down, and remove fuel hose from carburetor inlet. See Figure 11.

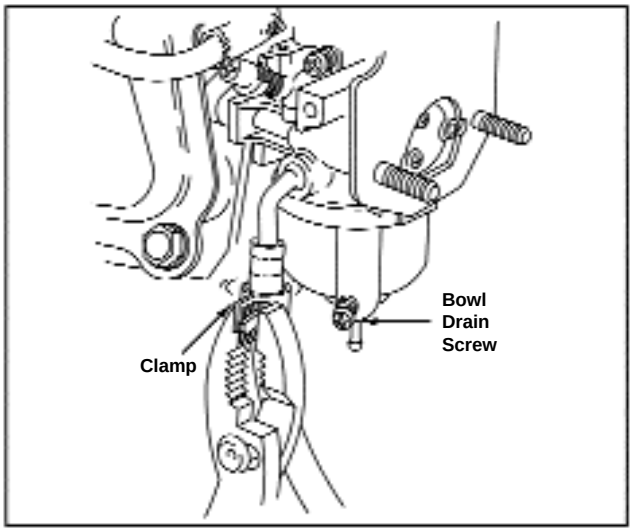


Figure 11 - Removing Fuel Hose and Clamp

3. Open float bowl drain screw, and drain gasoline into an approved container to drain carburetor, Figure 11.

4. Remove two nuts securing air intake elbow to carburetor. Remove, also, throttle cable bracket.

5. Using a screw driver, pry throttle cable from throttle lever swivel.

6. Remove air intake elbow and gasket.

7. Loosen lock screw in choke cable swivel. Remove choke cable.

8. Slide carburetor off from mounting studs.

Disassembly

Remove bowl mounting screw, washer, and bowl, Figure 12. Remove float bowl gasket, Figures 12 and 13.

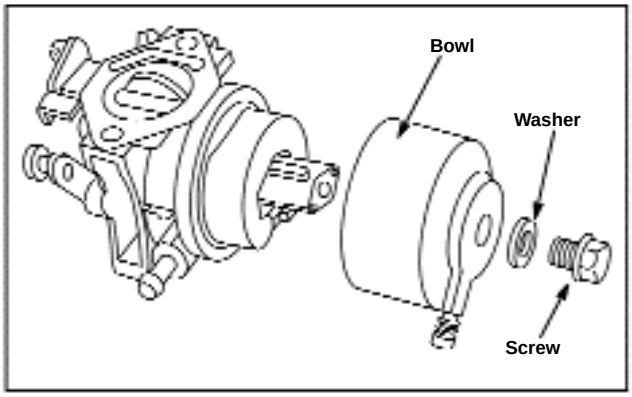


Figure 12 Removing Bowl

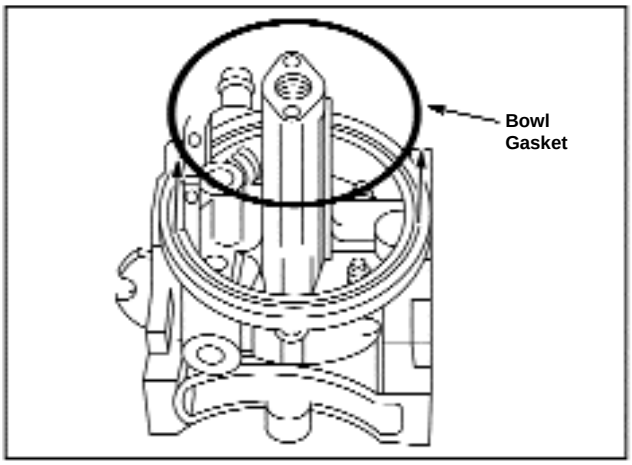


Figure 13 - Removing Bowl Gasket

Remove Float Assembly

Float hinge pin is a press fit. One end of float hinge pin has two (2) flats. Tap opposite end of pin until pin is loose and then remove pin, float and inlet needle assembly. See Figure 14.

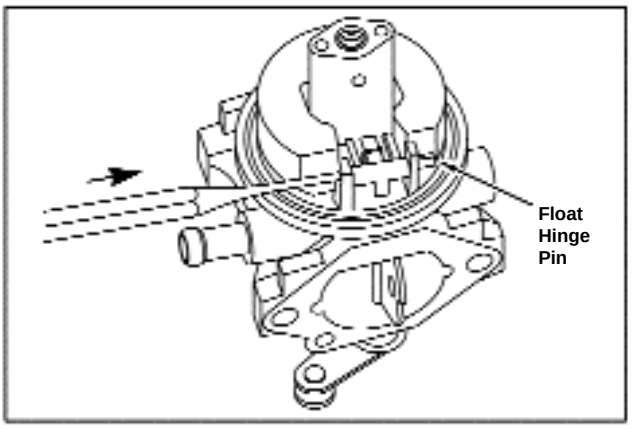


Figure 14- Removing Float Pin

Remove Main Jet and Nozzle - 9 H.P. Mikuni

Remove main jet and then using Tool #19061, Screwdriver, remove carburetor nozzle. See Figures 15 and 16.

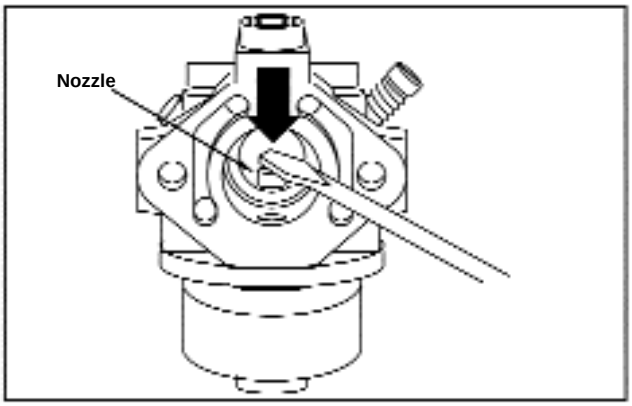


Figure 15 - Nozzle Removal

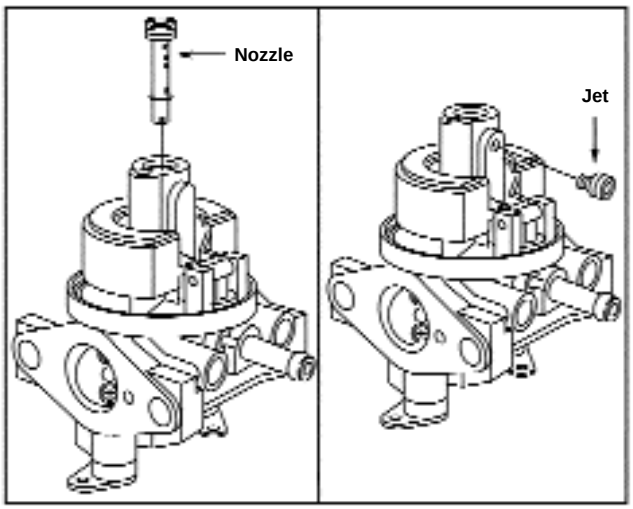


Figure 16 - Removing Main Jet And Nozzle

Remove Pilot Jet -

Using Tool #19062, or Screwdriver, remove pilot jet, Figure 17.

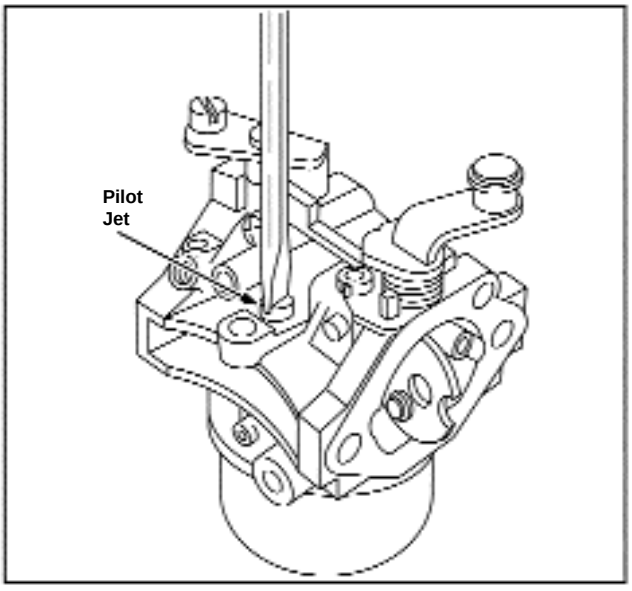


Figure 17 - Removing Pilot Jet

Remove Idle Mixture Valve

Pry off idle mixture valve limiter (when so equipped) and remove idle mixture valve, Figure 18.

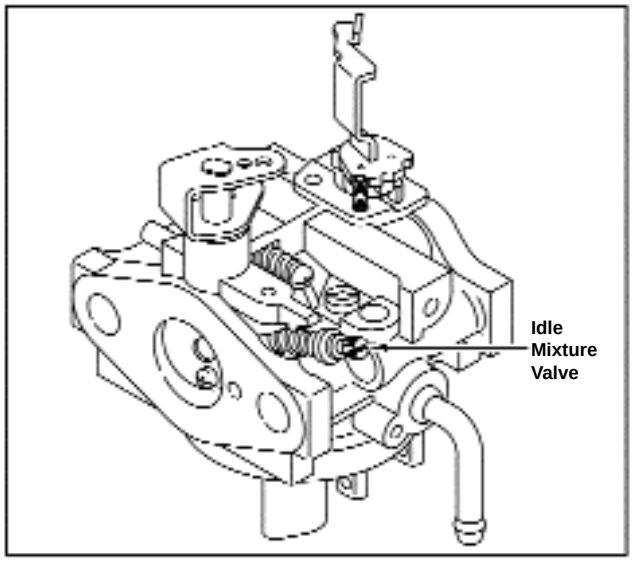


Figure 18 - Removing Limiter and Idle Mixture Valve

Remove Choke Shaft

Note: When removing Choke Valve or Throttle Screws, use a 1/4" Reed Prince Screwdriver instead of a #1 Phillips screwdriver.

1. Remove two (2) screws holding choke valve.

2. Remove choke and lift out choke shaft with both choke shaft bushings, choke shaft seal and choke shaft retainer, Figure 19.

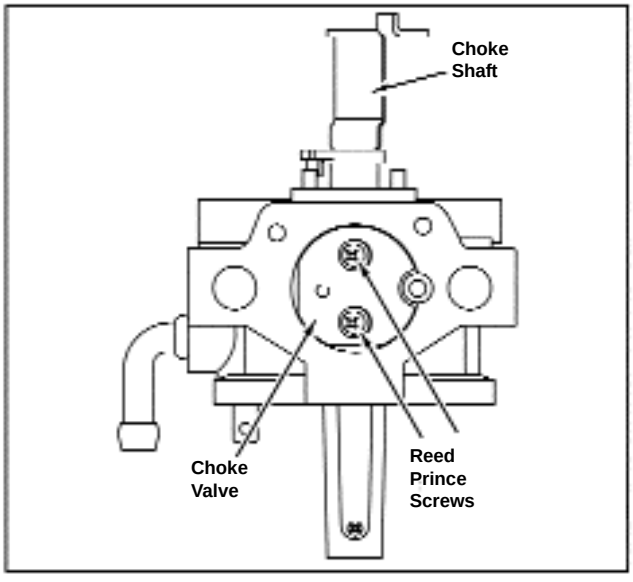


Figure 19 - Removing Choke Valve and Choke Shaft

Remove Throttle Valve and Shaft

1. Remove two (2) screws from throttle valve and remove throttle valve, Figure 20.

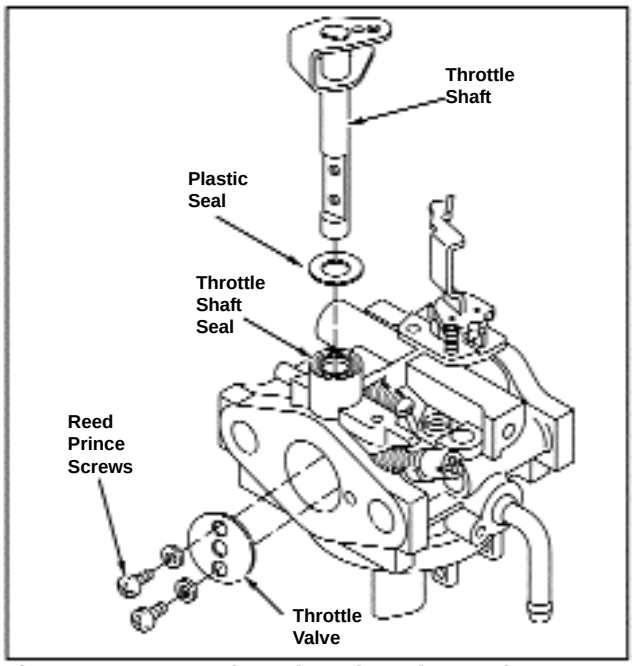


Figure 20 - Removing Throttle Valve and Throttle Shaft with Seats

2. Lift out throttle shaft and plastic seal. Remove throttle shaft seal, Figure 21.

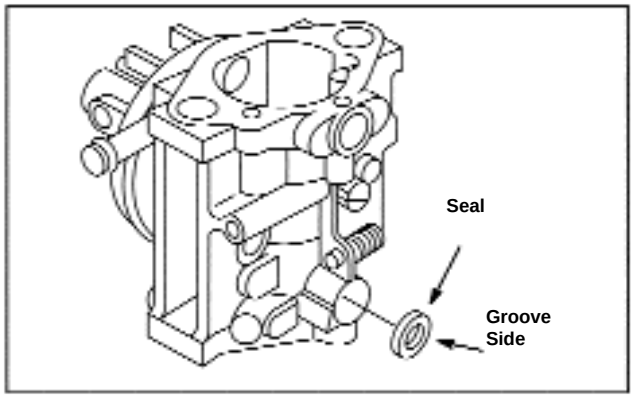


Figure 21 - Removing Seal

Clean Fuel System

Gummy or dirty fuel tanks and carburetors should be cleaned in a carburetor cleaner such as Bendix Carburetor Cleaner or equivalent.

DO NOT soak rubber, neoprene or plastic parts in cleaner.

Clean and Inspect Carburetor and Fuel System

Carburetor can be cleaned in any commercially available carburetor cleaner after removing all plastic and rubber parts.

1. After cleaning, inspect for wear, damage, cracks, or plugged openings.
2. Replace body if any of the above conditions exist.
3. Use only compressed air to clear plugged opening.
4. Inspect idle mixture needle for bent point or a groove in tip of needle. Replace if bent or grooved.

Assemble Carburetor - 9 H.P. Engine

When assembling carburetor, use new seals and gaskets.

Note: When installing Choke Valve or Throttle Valve Screws, use a 1/4" Reed Prince screwdriver instead of a #1 Phillips screwdriver.

1. Install throttle shaft seal in carburetor body. Install seal with grooved side out, Figure 22.

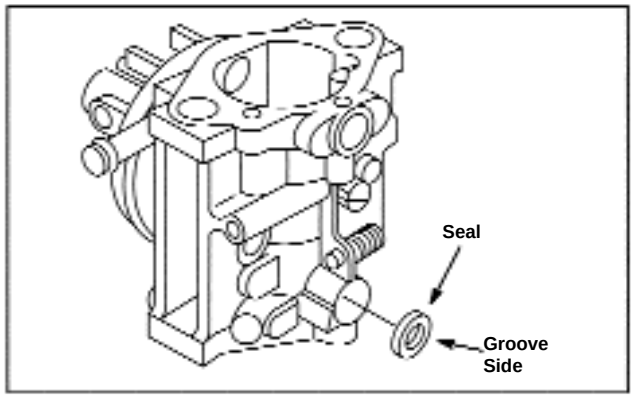


Figure 22 - Installing Seal,

2. Place plastic throttle shaft seal on throttle shaft and install throttle shaft into body, Figure 23.

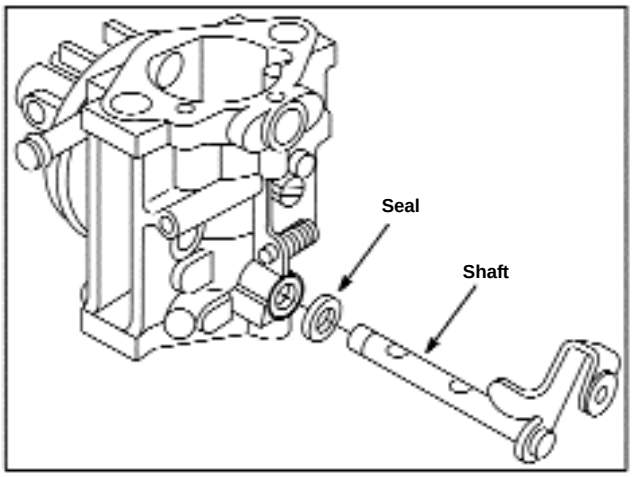


Figure 23 - Installing Throttle Shaft,

3. Rotate throttle shaft until flat on throttle shaft is facing out.
4. Lay throttle valve on shaft with stamped numbers to the left and install two (2) screws with lock washers, Figure 24.

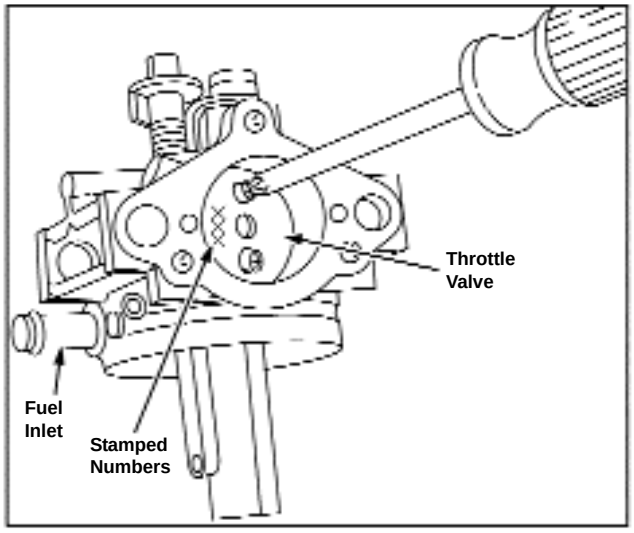


Figure 24 - Installing Throttle Valve,

5. Rotate throttle shaft to check for binding and correct, if needed.

Install Choke Shaft and Valve

1. Place choke shaft retainer on choke shaft with indentations facing toward the slot in the choke shaft lever and the stop facing the bottom of the shaft.

2. Place felt seal on shoulder of long choke shaft bushing and slide on to choke shaft with felt seal toward choke shaft retainer.

3. Place short bushing on bottom of choke shaft and install in carburetor making sure that choke shaft retainer stop is between carburetor body stop and detent spring, Figure 25. This positions shaft to install choke valve.

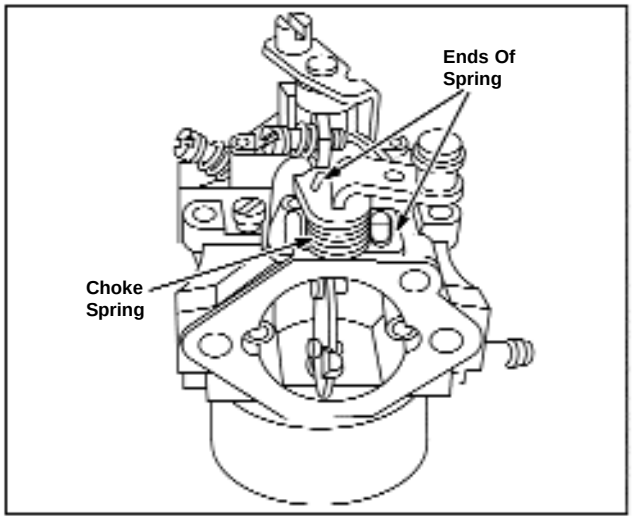


Figure 25 - Installing Choke Spring

4. Place choke valve, with numbers facing out, on choke shaft and install two (2) screws with flat washers.

Install Pilot Jet

Install pilot jet, Figure 26. Tighten securely.

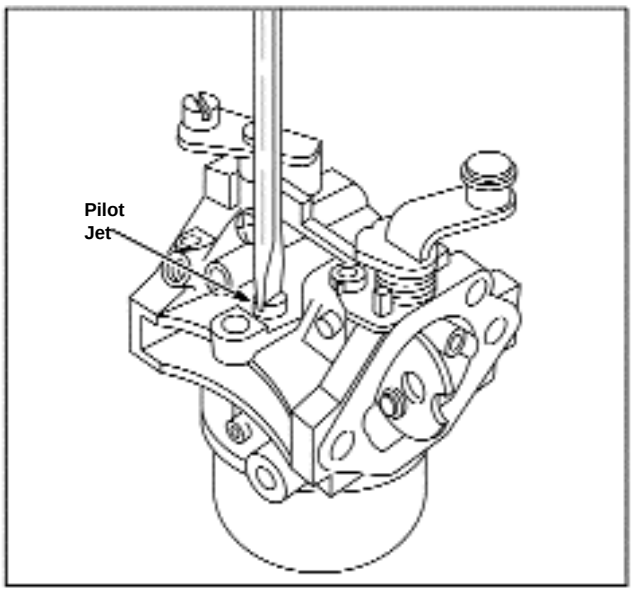


Figure 26 - Installing Pilot Jet

Install Idle Mixture Valve

1. Install idle mixture valve and spring.

2. Turn valve in until valve just seats. Use only finger tip pressure.

3. Then, back off valve 1-1/2 turns, Figure 27.

Note: Do not install limiter cap until final adjustment has been performed (on warm engine).

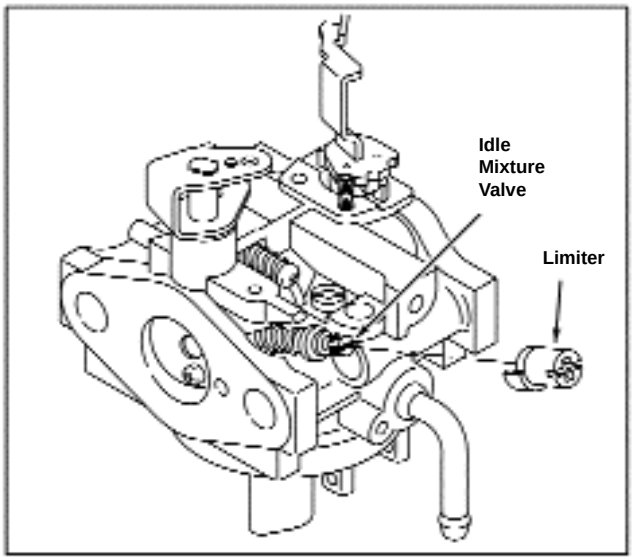


Figure 27 - Installing Idle Mixture Valve and Limiter

Install Float Bowl Gasket

Install carburetor bowl gasket in carburetor body groove, or on flange of carburetor body. See Figure 28. Make sure gasket does not twist or kink.

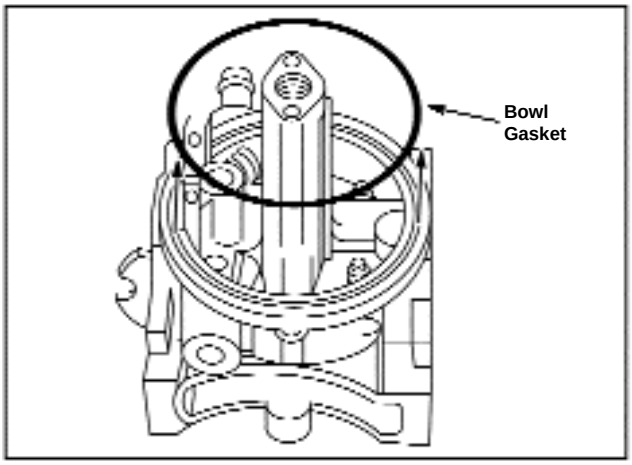


Figure 28 - Installing Bowl Gasket,

Assemble Float Needle and Float

Slide fuel inlet valve assembly onto float tab, Figure 29, and place assembly in carburetor, Figure 30.

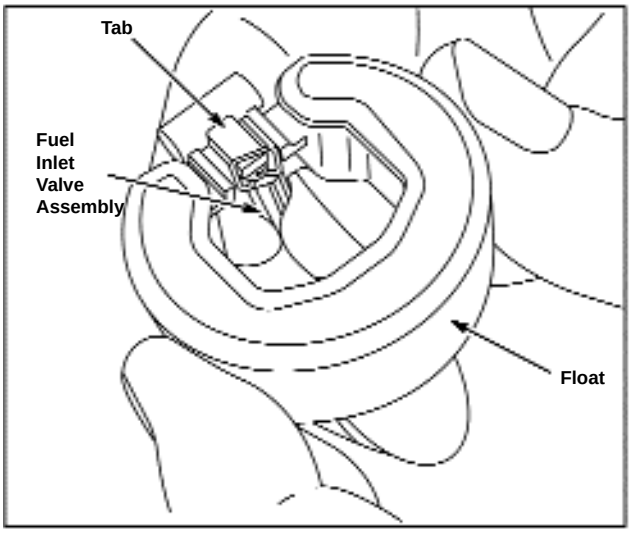


Figure 29 - Installing Spring on Float

Install Float Assembly

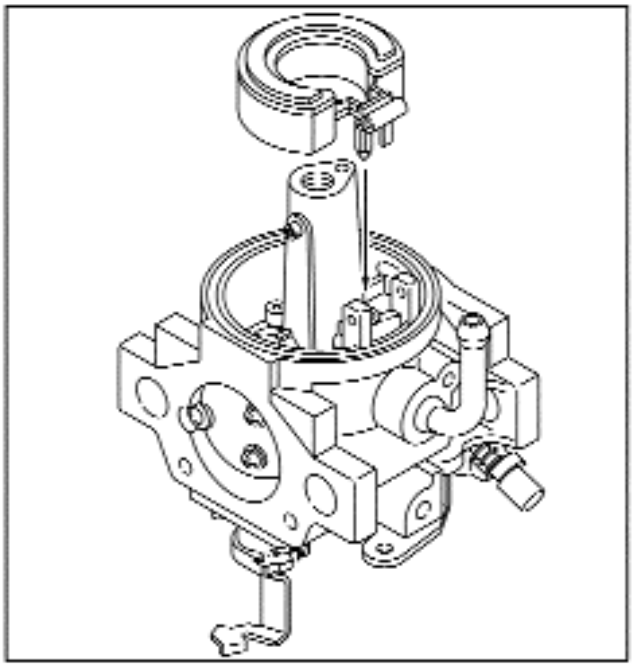


Figure 30 - Installing Float Assembly

Install float hinge pin into place (round end first) as shown, Figures 31 and 32. Round end of hinge pin must NOT extend beyond hinge pin post.

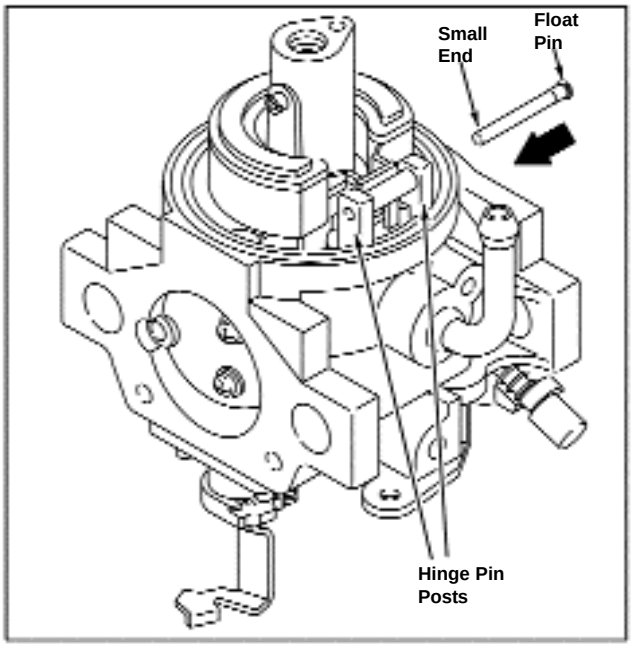


Figure 31 - Installing Float and Hinge Pin

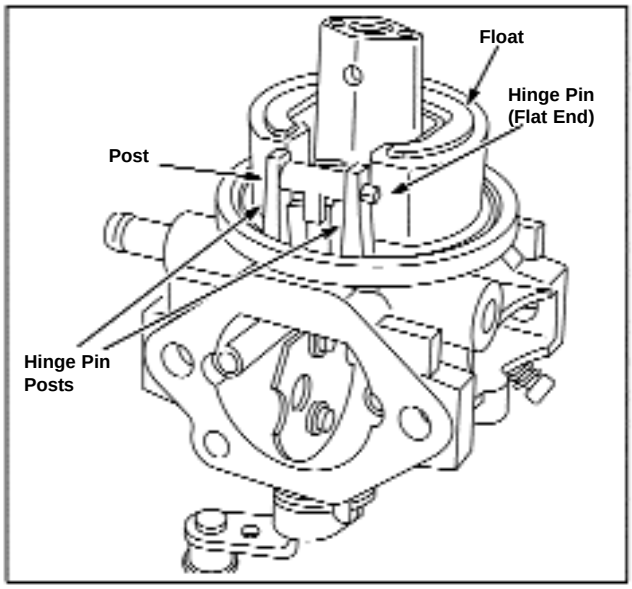


Figure 32 - Installing Float Hinge Pin

Inspect Float Setting

1. With carburetor body upside down, the float should be parallel with carburetor bowl mounting surface. See Figure 33.

2. If not, replace fuel inlet valve, float, and hinge pin.

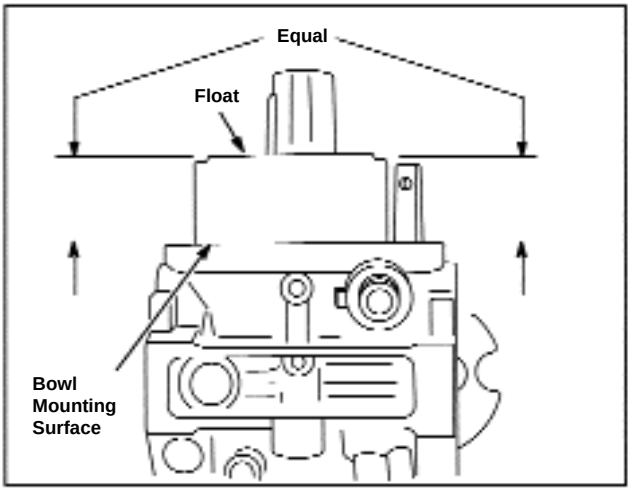


Figure 33 - Inspecting Float

Install Main Nozzle and Jet

3. Install nozzle and then main jet, See Figure 34.

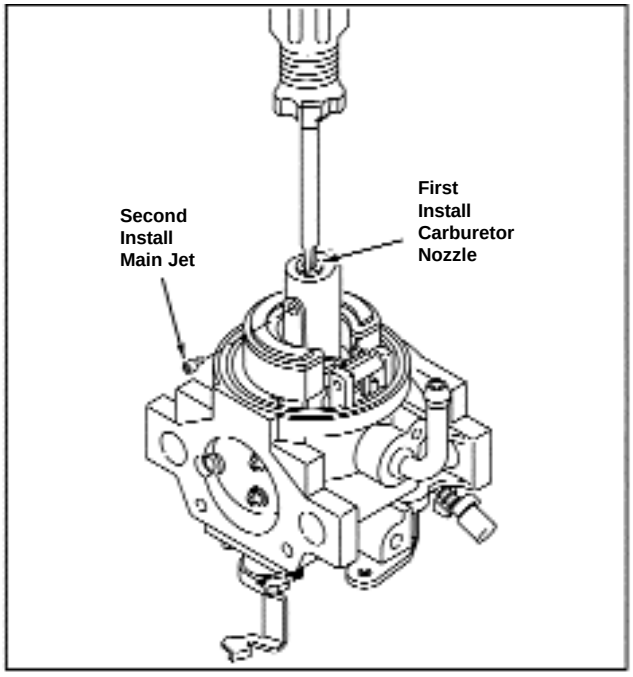


Figure 34 - Installing Carburetor Nozzle and Main Jet, High Altitude Compensation

Table 3 list identification numbers that are stamped on both standard and high altitude jets for these carburetors.

Table 3 - Identifying Main and Pilot Jets - 9 H.P.

Engine	Main Jet	Pilot Jet
0 - 4500 ft.	87.5	40
4500 - 8000 ft.	85.0	40
8000 - 10000	85.0	35

9 H.P. Engine/Mikuni Carburetor
Install Float Bowl

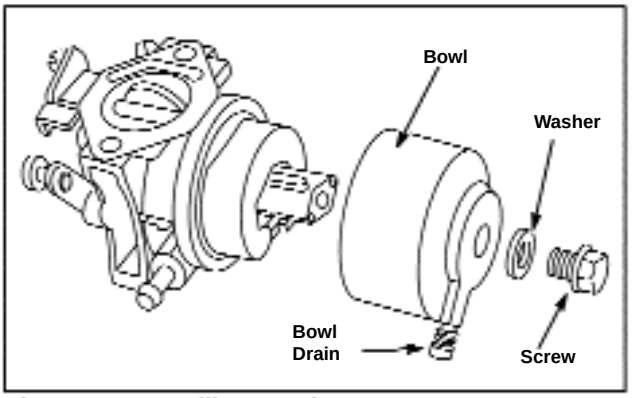


Figure 35 - Installing Bowl

Position bowl drain on carburetor as shown, Figure 35. Tighten screw securely.

Carburetor Installation

1. Place carburetor manifold gasket on carburetor mounting studs. Install carburetor spacer on studs with arrow towards cylinder head See Figure 36.

Note: These gaskets are not interchangeable. **Always** make certain the correct gaskets are used at all three locations.

2. Place new carburetor gasket on carburetor mounting studs. See Figure 36.

3. Slide carburetor onto studs. See Figure 36.

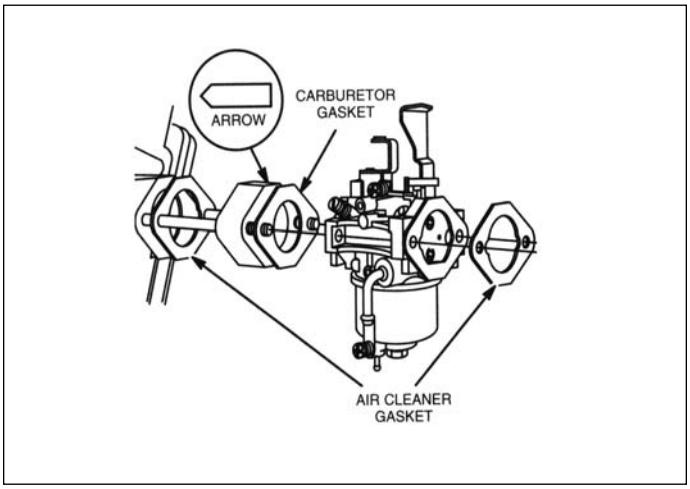


Figure 36 - Installing Carburetor Spacer

4. Place new intake elbow gasket onto studs.

5. Slide intake elbow onto studs.

6. Install throttle cable bracket on rear stud. Install 2 nuts.

7. Torque nuts evenly to 45 inch lbs. (5.1 N.M.).

8. Reconnect air cleaner hose onto intake elbow. Slide down to shoulder, fully covering sealing O-ring.

Note: Do not lubricate rubber parts. Lubricant could cause parts to loosen and slip off during use.

9. Slide clamp to lowest point on air cleaner hose, and tighten clamp, Figure 37.

Note: See Cable Adjustment page 2-21 for cable adjustment procedure.

10. Reconnect breather hose from valve cover, to breather nipple on air cleaner hose. See Figure 37 and 38.

11. Reconnect fuel line from fuel pump. Slide clamp into place to secure hose, Figure 38.

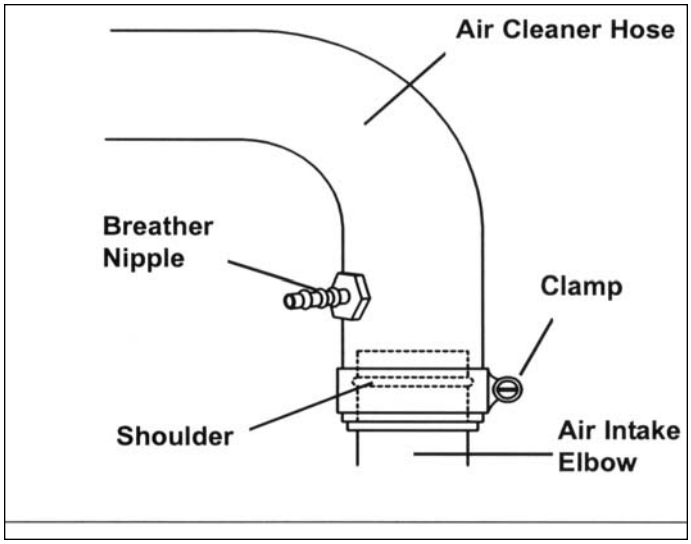


Figure 37- Carburetor Intake Elbow

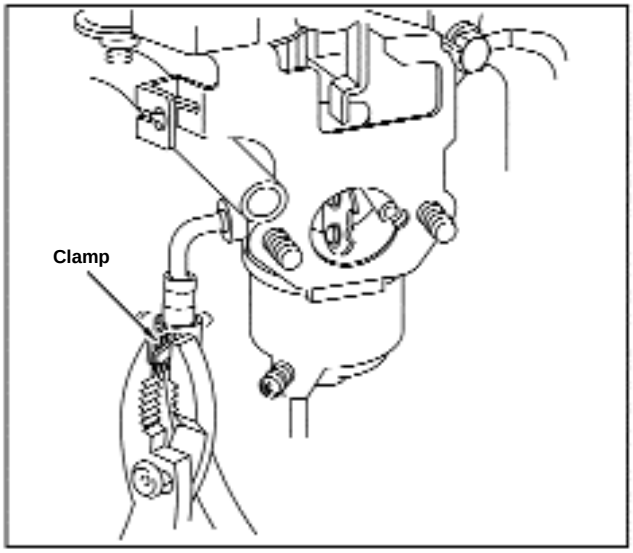


Figure 38 - Installing Fuel Hose and Clamp

Carburetor Adjustment

Caution: When adjusting carburetor, always support rear of vehicle off of ground. Always, use jack stands to support vehicle, to prevent accident or injury.

Warning: While operating engine, keep hands, tools, and clothing away from moving parts. (Clutches, drive belt, etc.) Always, operate vehicle in well ventilated area.

1. Start and warm up engine (approximately 5 minutes) prior to adjustment.

2. Turn idle speed screw counterclockwise until throttle lever is completely closed.

3. Rotate idle speed screw clockwise **ONLY** until adjustment screw lightly contacts throttle lever.

Note: Never allow idle speed screw to hold throttle open. If throttle is held open, backfire and erratic starting will occur.

4. Holding accelerator pedal, allow engine to idle at approximately 1,000-1,100 RPM.

5. While maintaining engine RPM, slowly rotate idle mixture screw clockwise until engine begins to slow. See Figure 39.

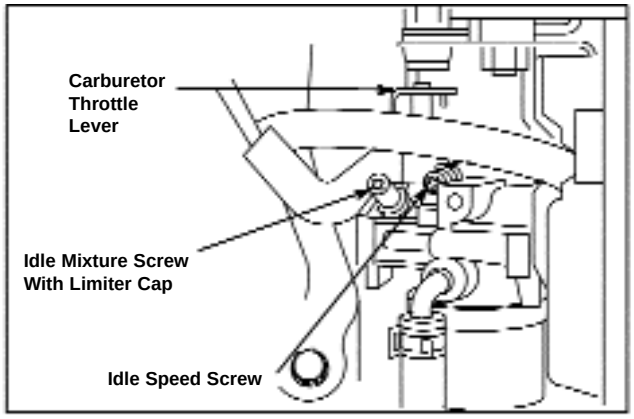


Figure 39 - Adjusting Idle Mixture and Speed

6. Then, turn mixture screw opposite direction (counterclockwise) until engine just begins to slow.

7. Rotate screw back to midpoint.

8. Place idle mixture screw limiter cap on to idle mixture screw, with half moon segment down. See Figure 40.

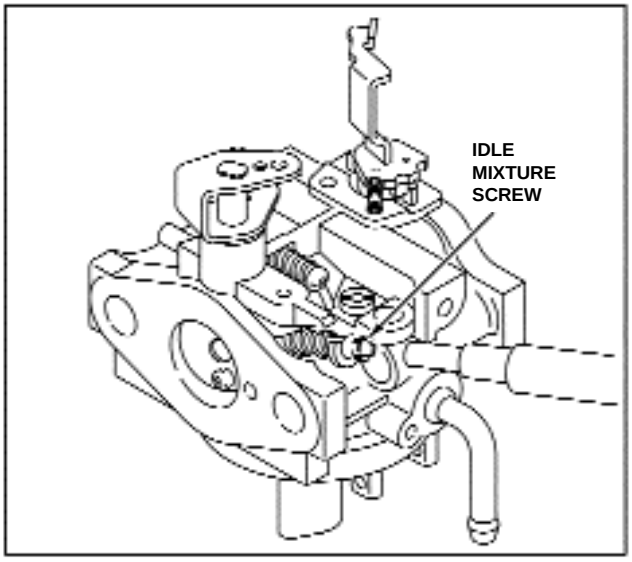


Figure 40 - Installing Idle Mixture Screw, Limiter Cap

9. Assemble onto choke cable, double shoulder spacer, spring, single shouldered spacer.

10. Insert choke cable into choke lever swivel, tighten swivel lock screw.

11. Pull choke knob on console to verify choke operation and adjustment. Readjust if necessary to achieve minimum 7/8 choke valve closing.

SERVICE CARBURETOR - 13 H.P. (WALBRO CARBURETOR)

Warning: Use care when working with fuel system. Clean up any spilled fuel immediately before continuing. Never service or repair near open spark or flame.

This carburetor has a FIXED HIGH SPEED MAIN JET WITH ADJUSTABLE IDLE. See Figures 41 and 42.

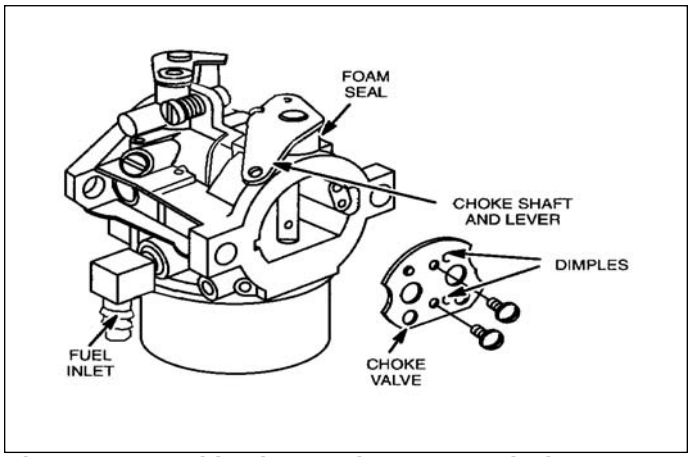


Figure 41 - Outside View, Carburetor - Typical

The letters LMT are cast into the body of the carburetor while identification numbers are stamped into carburetor mounting flange next to idle mixture screw.

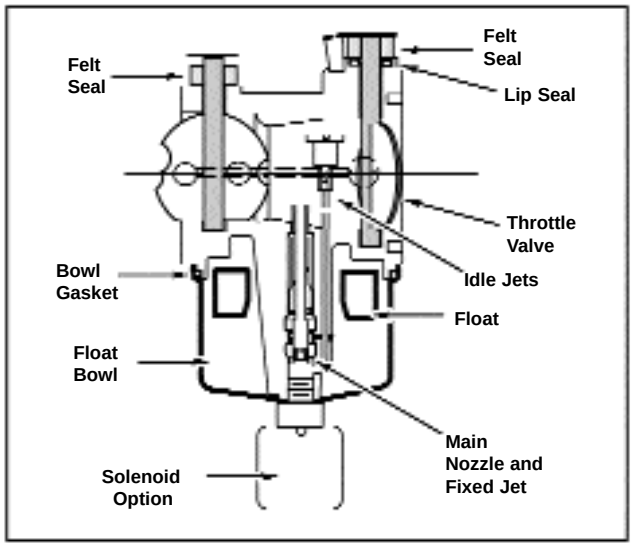


Figure 42 - Cutaway View, Carburetor - Typical

Remove Carburetor - 13 H.P. Engine

1. Loosen swivel screw securing choke cable to choke lever.

2. Remove two hex nuts holding carburetor intake elbow and throttle cable support bracket. Remove throttle cable support bracket and intake elbow.

3. Pry throttle cable from throttle lever swivel.

4. Slide carburetor, carburetor gasket, intake insulator spacer, and insulator gasket from engine mounting studs.

Disassemble Carburetor

1. Remove hex bolt from float bowl. Remove float bowl and float bowl gasket from carburetor. See Figures 12 and 13.

2. Gently tap float pin with small punch to remove. If pin becomes tighter, stop and push from opposite end to remove.

Note: Do not drive pin from carburetor. Float pin standoff holes will be enlarged, causing permanent damage to carburetor.

3. Remove idle mixture screw limiter cap.

4. Remove idle mixture screw with spring. Remove idle speed screw with spring.

5. Hold throttle shaft and lever to closed position, and remove two (2) throttle valve screws. See Figure 43.

6. Remove throttle valve, throttle shaft with lever, foam seal, spring and upper plastic bushing.

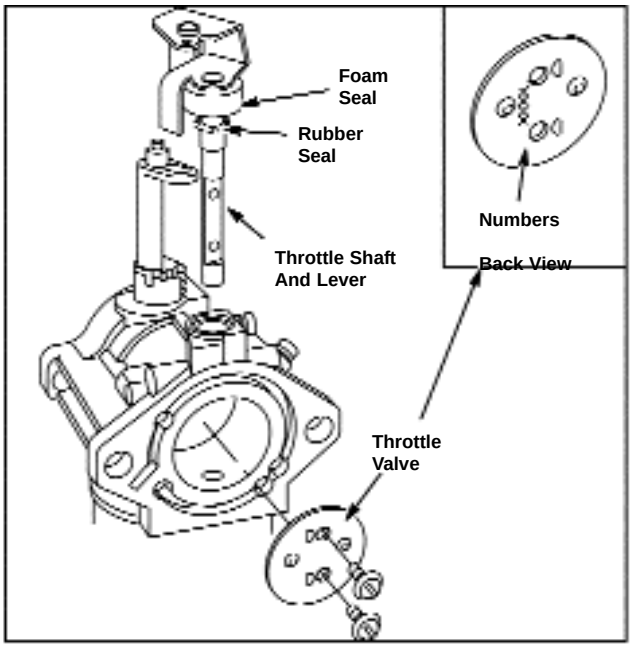


Figure 43 - Removing Throttle Shaft

Choke Shaft

1. Rotate choke shaft and valve to closed position, hold and remove two screws securing choke valve. See Figure 44.

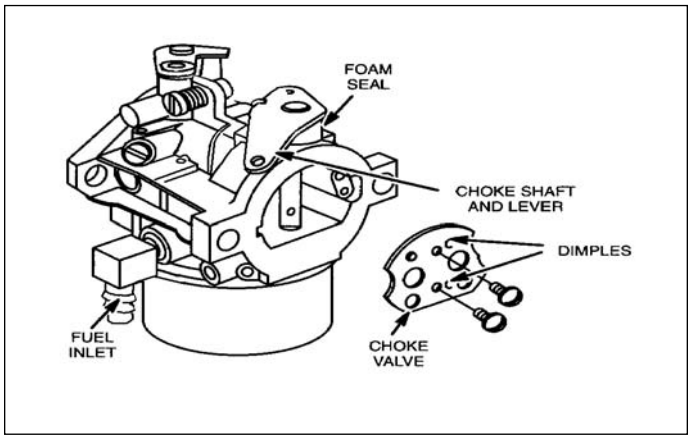


Figure 44 - Removing Choke Shaft

2. Remove choke valve, release tension on choke shaft.

3. Remove choke shaft, foam dust seal, and choke return spring.

4. Remove carburetor main nozzle. See Figure 45.

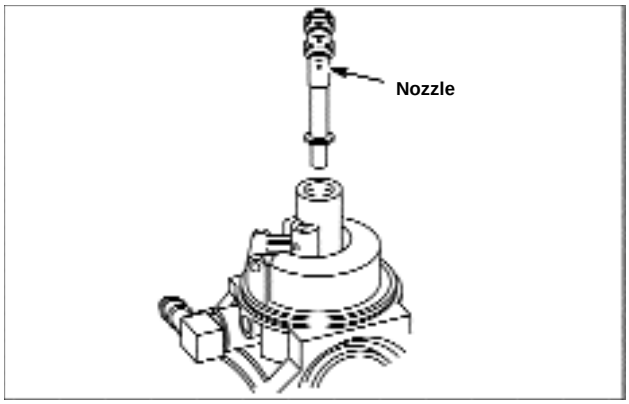


Figure 45 - Removing Jet Nozzle

5. Using a modified 5/16th pin punch or awl, remove welch plug from carburetor body. See Figure 46.

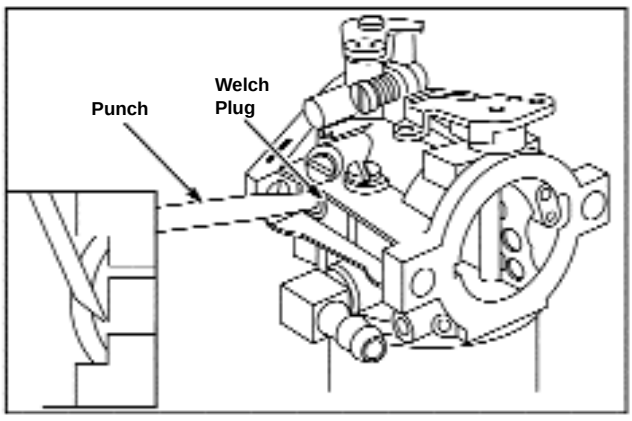


Figure 46 - Removing Welch Plug

Remove Fuel Inlet Seat

1. Use self-threading screw, Flywheel Puller, or 1/4-20 tap.

2. Thread screw or tap into fuel inlet seat 3-4 turns and remove. See Figure 47

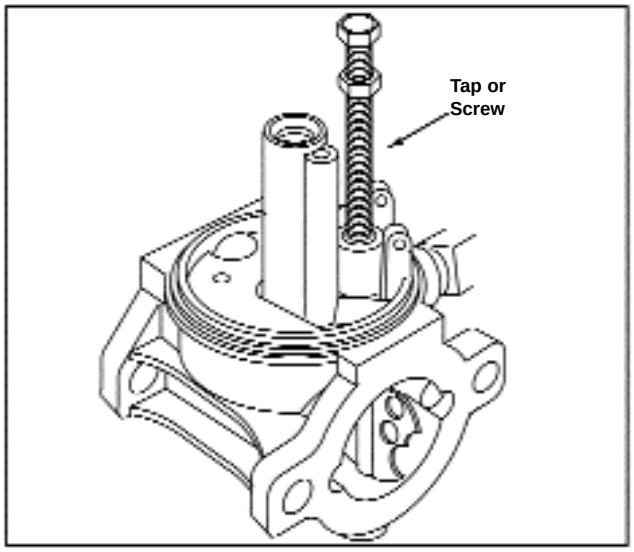


Figure 47 - Threading or Tapping Fuel Inlet Seat

3. Place 1/4" x 20 nut and washer onto puller screw.

4. Place a 1/4" drive 3/8" socket over inlet valve seat.

5. Thread screw into tapped inlet seat until screw bottoms.

6. Thread nut down unto washer and continue turning nut until inlet seat is free from carburetor body. See Figure 48.

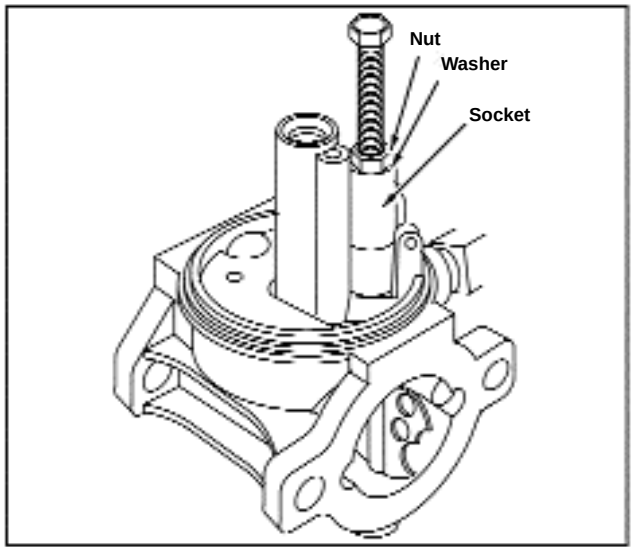


Figure 48 - Removing Fuel Inlet Seat

Clean and Inspect Carburetor

Carburetor can be cleaned in any commercially available carburetor cleaner after removing all plastic and rubber parts.

1. After cleaning, inspect for wear, damage, cracks, or plugged openings.

2. Replace carburetor if any of the above conditions exist.

3. Use only compressed air to clean plugged openings. Air pressure in excess of 20 PSI is not recommended.

Note: Use of air pressure in excess of 20 PSI could loosen carburetor passage plugs, damaging carburetor beyond repair.

4. Inspect idle mixture needle for bent needle point or a groove in tip of needle. Replace if bent or grooved.

Assemble Carburetor

Install Welch Plug

1. Install welch plug with pin punch slightly smaller than outside diameter of plug. Press in until plug is flattened slightly. DO NOT cave in the plug**.**

2. After plug is installed, seal outside edge of plug with fingernail polish or non-hardening sealant. See Figure 49.

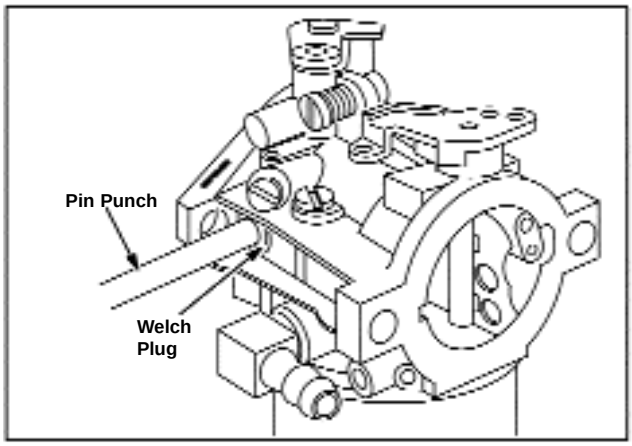


Figure 49 - Installing Welch Plug

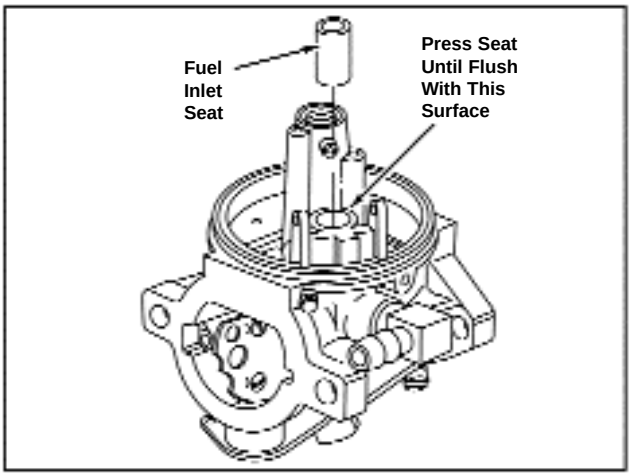


Figure 50 - Installing Fuel Inlet Seat

Install Fuel Inlet Seat

• Using a flat tipped object approximately 5/16” inch diameter, press fuel inlet seat into carburetor body until flush with fuel inlet boss. See Figure 50.

Install Choke Shaft

1. Install foam seal and return spring on choke shaft hooking small hook in notch on choke lever. See Figure 51 inset.

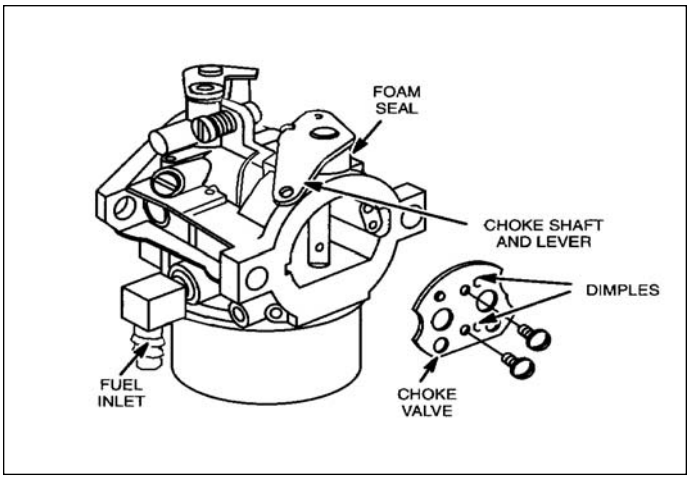


Figure 51 - Installing Metal Choke Shaft

2. Insert choke shaft assembly into carburetor body and engage large end of return spring on boss.

3. Place choke valve on shaft with single notch on edge towards fuel inlet. Two (2) half moon dimples will help to position valve on shaft.

4. Place a drop of Locktite® on screw threads and tighten.

Note: Lift slightly on choke shaft before snuging screws, to prevent choke spring interference with choke spring pin.

5. Check for free movement.

Install Throttle Shaft

1. Install plastic throttle shaft bushing in carburetor body.
2. Slide foam seal, spring and plastic seal on to throttle shaft.

3. Slide throttle shaft assembly with foam, seal, and spring into carburetor making sure idle stop on throttle lever is left of idle speed screw.

4. Engage pin end of throttle spring into carburetor body. Rotate throttle shaft clockwise until throttle lever stop is against idle speed screw.

5. Place throttle valve on throttle shaft with numbers facing into carburetor and to the right.

Note: If throttle valve is not correctly positioned, screw holes will not align with throttle shaft. Make sure idle stop screw is loosened completely and throttle valve is carefully centered before tightening screws.

6. Place a drop of Loctite® on screw threads and tighten. See Figure 52.

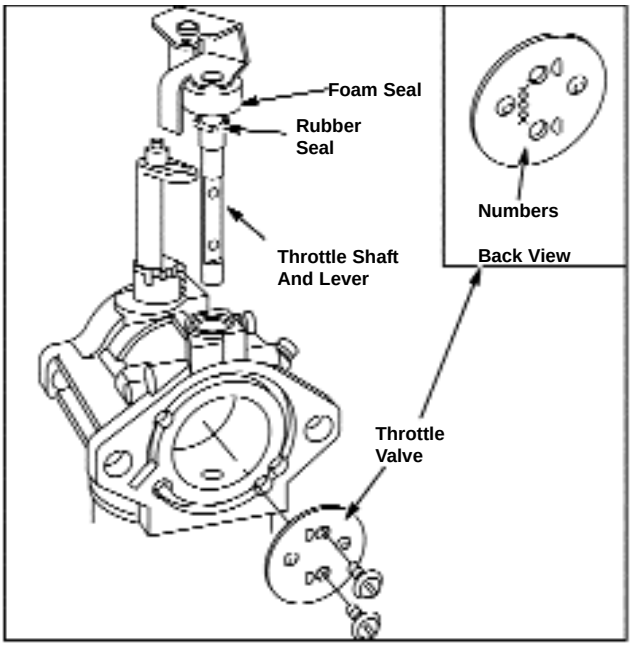


Figure 52 - Installing Throttle Shaft

Install Main Nozzle

1. Install main nozzle using until nozzle seats. See Figure 53.

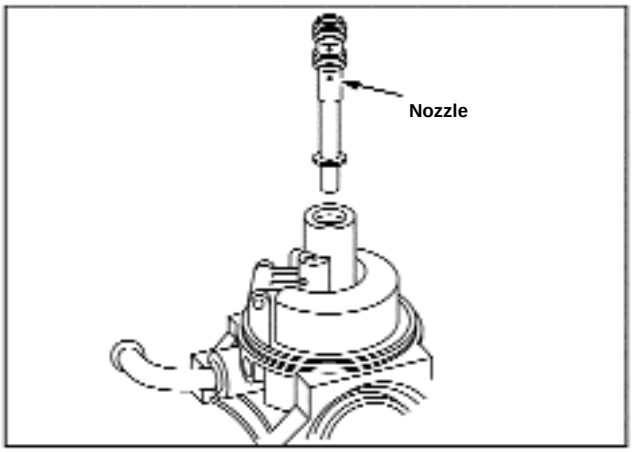


Figure 53 - Installing Jet Nozzle

2. After installing main nozzle, use compressed air to blow out any chips or debris that may have loosened while installing main nozzle.

High Altitude Compensation

The following table list the standard and high altitude jets for Briggs & Stratton/Walbro LMT carburetors for 13 H.P. Engine.

Table 4 Main Jets		
Standard and High Altitude Main Jets		
Engine Type	**Standard Jet**	**High Altitude Jet**
13 H.P.	N/A	N/A

Install Inlet Needle Valve and Float

1. Insert inlet needle valve in slot on float.

2. Place float and needle on carburetor and install float hinge pin centering hinge pin.

Note: Insert hinge pin only until moderate resistance is felt. Do not force float pin through float pin standoff.

3. Place bowl gasket on carburetor body.

4. Place bowl on carburetor and install bolt with gasket.

Install Idle Screw

Install idle mixture screw with return spring. Tighten only until valve just seats. Back off valve 1 1/2 turns.

Note: Do not install limiter cap until final adjustment has been completed.

Installation

1. Slide intake insulator block gasket on to engine studs.

2. Install insulator spacer and additional gasket on to engine carburetor mounting studs.

3. Slide carburetor and air intake elbow gasket on to carburetor mounting studs.

4. Install air intake elbow and throttle cable mounting bracket. Next, install two hex nuts, tighten to 100 inch/lbs. (11.3 Nm).

5. Snap throttle cable into throttle lever swivel.

6. Assemble on to choke cable, double shoulder spacer, spring, single shouldered spacer.

7. Insert choke cable into choke lever swivel, tighten swivel lock screw.

8. Pull choke knob on console to verify choke operation and adjustment. Readjust if necessary to achieve minimum 7/8 choke valve closing.

Note: See Cable Adjustment page 2-21 for cable adjustment procedure.

Carburetor Adjustment

Caution: When adjusting carburetor, always support rear of vehicle off of ground. Always support rear of vehicle on jack stands to support vehicle off of ground to prevent accident or injury.

Warning: While operating engine, keep hands, tools, and clothing away from moving parts. (Clutches, drive belt, etc.) Always, operate vehicle in well ventilated area.

1. Start and warm up engine (approximately 5 minutes) prior to adjustment.

2. Turn idle speed screw counterclockwise until throttle lever is completely closed.

3. Rotate idle speed screw clockwise **ONLY** until adjustment screw lightly contacts throttle lever.

Note: Never allow idle speed screw to hold throttle open. If throttle is held open, backfire and erratic starting will occur.

4. Holding accelerator pedal, allow engine to idle at approximately 1,000-1,100 RPM.

5. While maintaining engine RPM, slowly rotate idle mixture screw clockwise until engine begins to slow. See Figure 39.

6. Then, turn mixture screw opposite direction (counterclockwise) until engine just begins to slow.

7. Rotate screw back to midpoint.

8. Place idle mixture screw limiter cap onto idle mixture screw, with stopper tab pointed upward. See Figure 54.

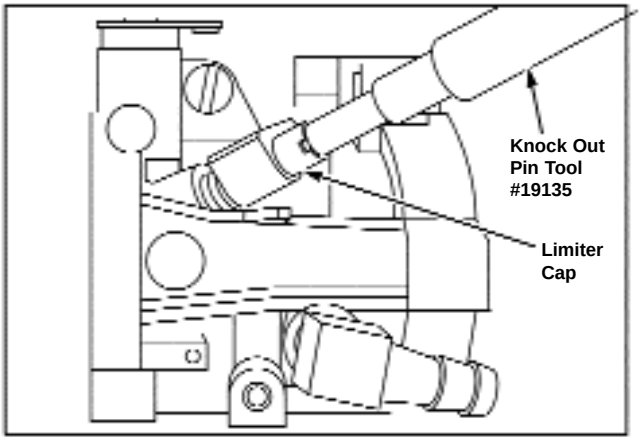


Figure 54 - Installing Limiter Cap

FUEL PUMP

Description

The fuel pump, mounted on the main frame at the right rear wheel creates a continuous supply of fuel from the fuel tank to the carburetor. The pump is operated by vacuum pulses from the engine.

Operation

Vacuum pulses from the crankcase of the engine are used to push and pull at an internal diaphragm. As this diaphragm is pushed and pulled, it in turn creates high and low pressure on the fuel side of the diaphragm.

As high and low pressure pulses occur on the fuel side of the pump diaphragm, fresh fuel is drawn into the pump by low pressure and pushed from the pump by high pressure.

An integral part of the operation of the fuel pump is the engine's breather system located in the valve cover. See Lubrication and Breather Systems for additional information.

Warning: Use care when working with fuel system. Clean up any spilled fuel immediately before continuing. Never service or repair fuel system near open spark or flame.

Fuel Pump Removal

1. Carefully, disconnect the single vacuum hose from top of engine and two fuel hoses from fuel pump. See Figure 55.

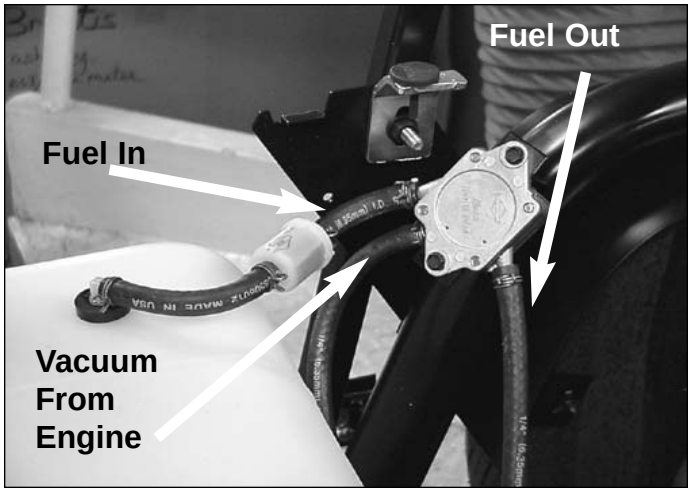


Figure 55 - Remove Fuel and Vacuum Line

2. Remove two screws holding fuel pump to frame, and remove fuel pump.

Fuel Pump Installation

1. Place fuel pump on main frame, recessed into mounting bracket. Install two mounting screws. See Figure 55.

2. Reconnect fuel tank line to input fuel pump fitting.

3. Reconnect carburetor supply fuel line to fuel pump output fitting.

4. Connect engine vacuum hose to center fitting of fuel pump.

Note: Always, replace any weak fuel hose clamps, or fuel hoses if leakage or cracks appear.

Warning: Use care when working with fuel system. Clean up any spilled fuel immediately before continuing. Never service or repair fuel system near open spark or flame.

INLINE FUEL FILTER SERVICE

Warning: Use care when working with fuel system. Clean up any spilled fuel immediately before continuing. Never service or repair fuel system near open spark or flame.

Inline fuel filter should be checked yearly or every 100 hours of operation.

Replace filter if dirt or water are present.

Note: Always, replace weak fuel hose clamps or fuel hoses exhibiting cracks or splits.

Always, install fuel filter with directional arrow pointing from fuel tank towards fuel pump. See Figure 56.

Figure 56 - Install Fuel Filter

For best results, always, use original Columbia ParCar/ Briggs & Stratton parts. Refer to your Columbia ParCar parts manual for part number information.

FUEL TANK

Inspect Fuel Tank

Warning: Use care when working with fuel system. Clean up any spilled fuel immediately before continuing. Never service or repair fuel system near open spark or flame.

Inspect fuel tank for cracks or leaks at seams, fuel tank, and fuel pick up pipe. If leaks are found, replace fuel tank. Always, keep fuel level minimum 1 1/2” inches below fuel tank filler opening.

Fuel Tank Removal

1. Disconnect fuel line at fuel filter.

2. Remove two mounting bolts securing fuel tank to main frame. Lift tank off the frame.

Fuel Tank Installation

1. Set fuel tank into main frame fuel tank area. Fuel tank tabs should be inside of main frame mounting tabs.

2. Install two mounting bolts, washers and lock nuts.

3. Reconnect fuel tank fuel line to fuel filter.

4. Operate vehicle, inspect for fuel leakage.

IGNITION SYSTEM

Warning: To prevent accidental starting, which could cause injury, the spark plug wire must be removed from spark plug and grounded, after removing boot.

Warning: DO NOT REMOVE SPARK PLUG WHEN CHECKING IGNITION. A fire or explosion may occur from ignition of the mixture exiting the spark plug hole.

Columbia ParCar/Briggs & Stratton OHV engines use MAGNETRON® ignition (a transistor [no moving parts], ignition armature), and flywheel magnets.

CHECK IGNITION

1. Connect spark plug wire to long terminal of Spark Tester, Tool #95970-96 and ground tester to engine with alligator clip, Figure 57.

2. Operate starter, and observe spark gap in tester. If spark jumps tester gap, ignition is good.

3. If no spark is observed, disconnect black engine wire from gray wire harness lead. Recheck:

   a. If spark is observed, check key switch or accelerator micro switch.

   b. If no spark is observed, replace armature coil.

Note: Flywheel must rotate at 350 RPM, minimum, on engines equipped with MAGNETRON® ignition.

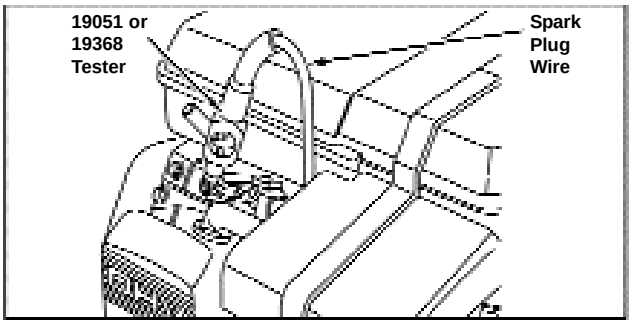


Figure 57 - Checking for Spark

Note: On all engines equipped with MAGNETRON®, spark will also be observed at the tester when there is a sheared flywheel key.

Check For Spark Miss

1. To determine if an engine miss is ignition related, use Spark Tester, Tool #95970-96, in series with spark plug lead and spark plug, Figure 58.

2. Start and run engine.

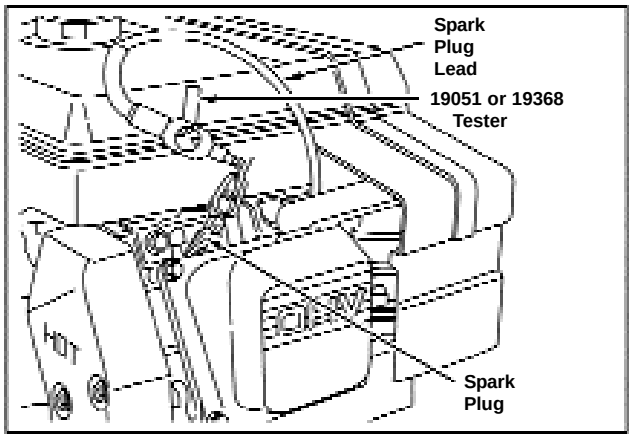


Figure 58 - Running Check

3. If spark jumps tester gap regularly, but miss continues, problem is spark plug, compression, or fuel system.

Spark Plug - All Model Series

Spark plugs recommended by Briggs & Stratton for OHV engines are:

Spark Plug Type	Champion	Autolite	NGK
Resistor Long Plug	RC12YC	3924	FR5 or BK-5RE

Note: In some areas, local law requires the use of a resistor spark plug to suppress ignition signals. If an engine was originally equipped with a resistor spark plug, be sure to use the same type of spark plug for replacement.

Spark Plug Maintenance

Set gap at .030" (76 mm) for all models, Figure 59. If electrodes are burned away, or porcelain is cracked or fouled, replace with a new plug. DO NOT USE ABRASIVE CLEANING MACHINES.

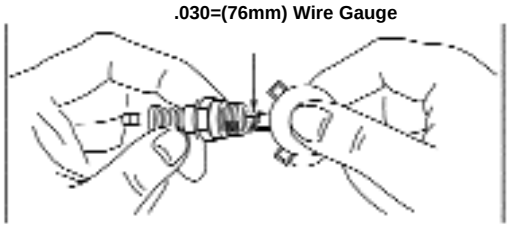


Figure 59 - Adjusting Spark Plug Gap

MAGNETRON® IGNITION

The best means of testing Magnetron® armatures is on the engine. However, before replacing armature, be sure the problem is not in the vehicle wiring, stop switch, or key switch.

Remove MAGNETRON® Armature

1. Remove blower housing.

The flywheel does not need to be removed to service MAGNETRON® ignition except to check keyways, flywheel key, and oil seals. If damaged, replace parts.

Note: Flywheel must be removed on 9 H.P. engine to remove armature.

2. Remove armature screws, disconnect stop wire, and lift off armature, Figure 61.

3. Remove rubber cap. With a screwdriver, remove threaded terminal from elbow, Figure 60.

4. Remove spark plug wire and rubber boot from elbow. Figure 4.

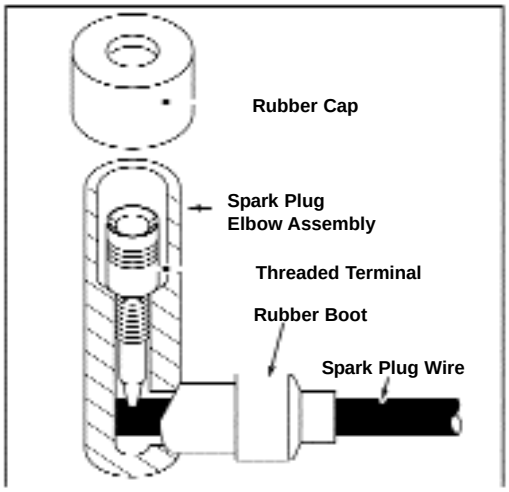


Figure 60 - Removing Spark Plug Elbow

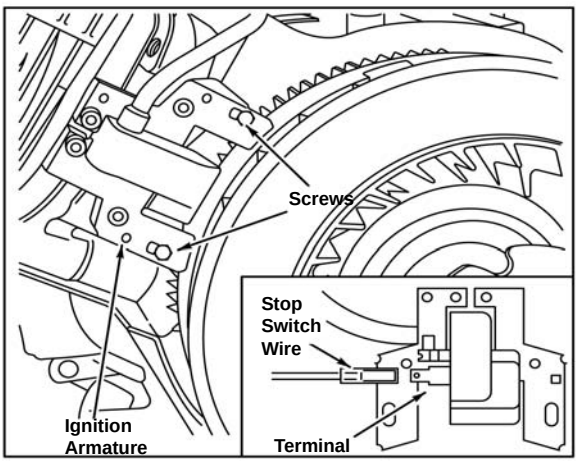


Figure 61 - Removing Ignition Armature, Typical

Remove Flywheel

1. Remove blower housing by removing four (4) screws securing housing to engine case.

2. Use flywheel holder (CPC part #95900-96) to hold flywheel from turning, Figure 62.

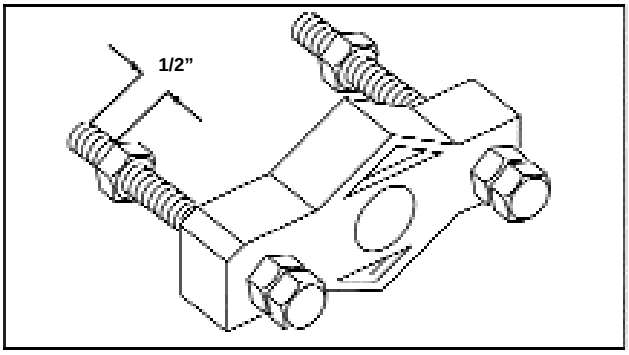


Figure 62 - New Style Flywheel Puller

3. Use socket and breaker bar to remove flywheel nut.

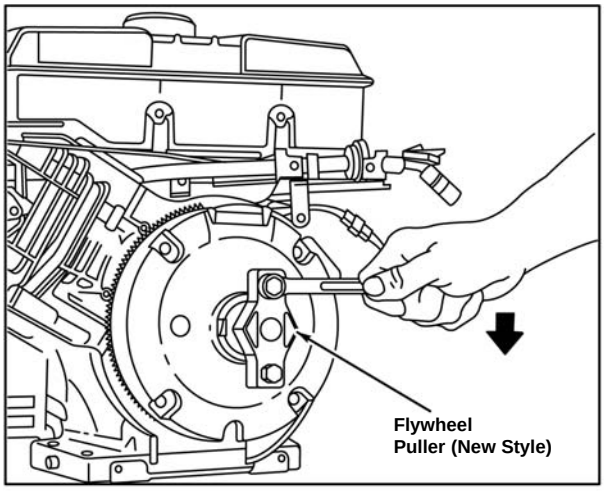


Figure 63 - Pulling Flywheel, Typical

4. Use flywheel nut to protect crankshaft threads by turning nut down flush with top of threads, Figure 63.

5. Turn screw retainer nuts up until 1/2" of threads are exposed, Figure 64. Then, install flywheel puller turning screws until nuts bottom.

6. Tighten puller nuts equally until flywheel loosens.

Inspect Flywheel Key, Keyways, Flywheel, and Crankshaft

Inspect flywheel key for partial or complete shearing. If sheared, replace, Figure 64. Flywheel should be inspected for cracks, burrs on taper or keyway, and distortion of keyway. Also, check taper of crankshaft for burrs, rust, or other damage. Check fan or flywheel for broken fins. If parts are damaged, replace with new parts.

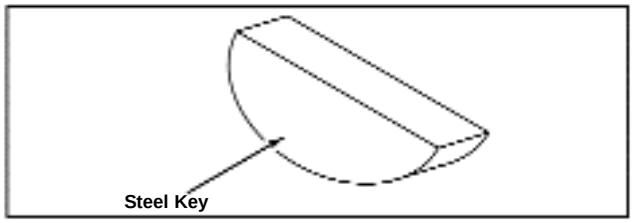


Figure 64 - Inspect Flywheel Key

Install Flywheel

Warning: Do not use impact wrenches to install flywheel.

Note: On 9 H.P. engines, MAGNETRON® armature must be installed before installing flywheel.

1. Before installing flywheel on 9 and 13 H.P. engines, inspect oil sensor wire routing and clamps, Figure 10. Inspect to be sure wire is connected, under clip and secured in lead wire clip.
2. Clean flywheel taper and crankshaft taper, removing all oil, dirt, or grease.

Note: On 9 and 13 H.P. engines, use only the BRIGGS & STRATTON STEEL KEY. DO NOT use substitutes. See Figure 64.

3. Install flywheel key in slot before installing flywheel.
4. Slide flywheel onto crankshaft

Note: The flywheels for 13 H.P. engines have two (2) key ways in the flywheel taper. The correct key way to use is the one to the left of the flywheel puller hole closest to the flywheel magnet.

5. Using fly wheel holder, torque fly wheel nut to 60 ft.lbs. (81.36 Nm.). See Figure 65.

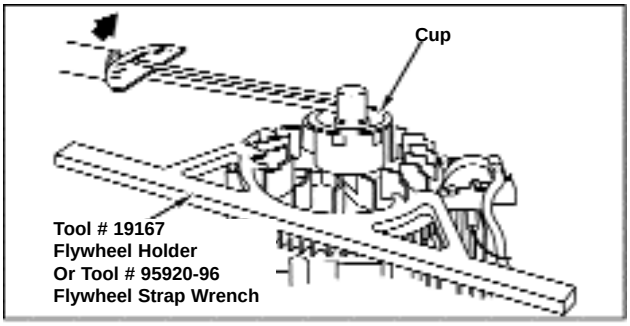


Figure 65 - Torquing Flywheel, Typical

Install Magnetron® Armature

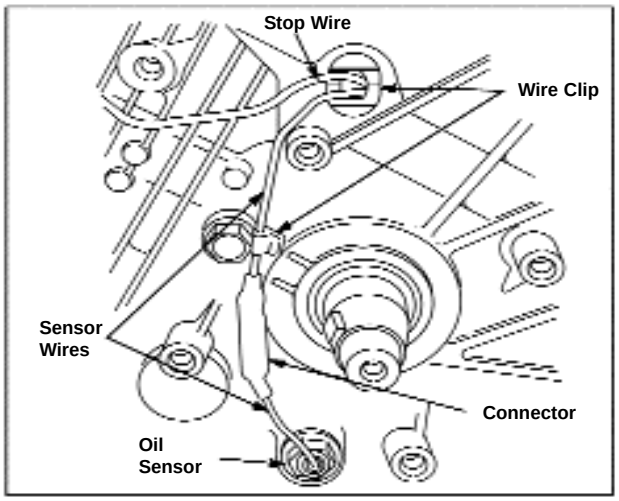


Figure 66 - Oil Sensor Wiring

1. Install stop switch wire on armature, Figure 66.
2. Place armature on cylinder with armature pilot in boss on cylinder, Figure 67.

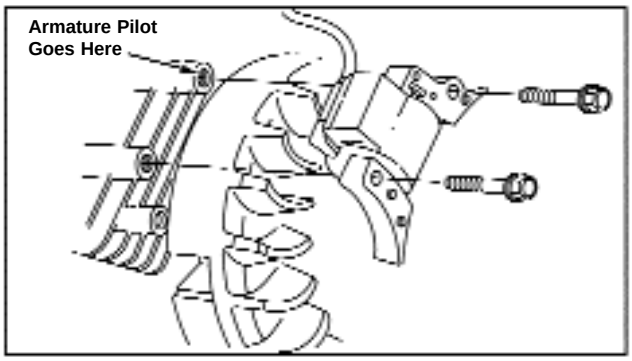


Figure 67 - Installing Armature

3. Install armature screws finger tight.

Adjust Armature Air Gap - 13 H.P. Engine

Note: Armature air gap on 9 horse power engines is not adjustable. Armature air gaps should be no less than .012 inches (0.31 mm.) and no greater than .020 inches (0.51 mm.) If armature air gap is incorrect, inspect crank shaft main bearings for damage or free play. See Figure 68 and 69.

1. Check that armature is correctly seated against engine.

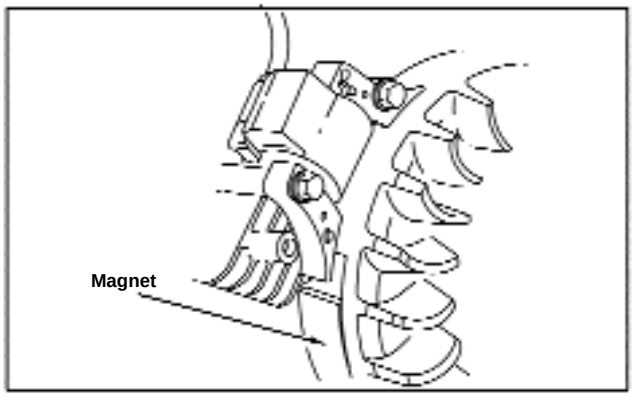


Figure 68 - Magnets Away from Armature

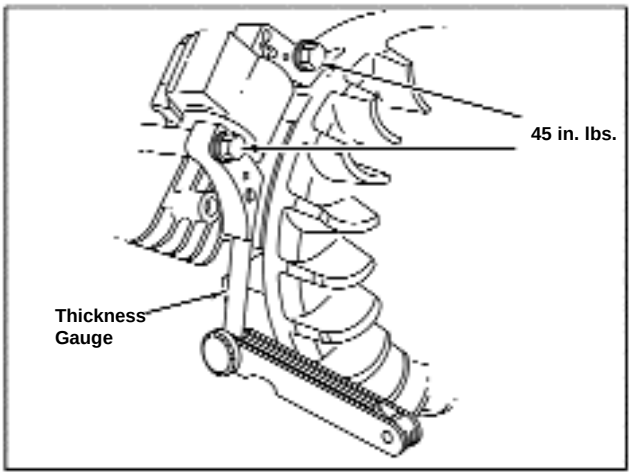


Figure 69 - Magnet Under Armature

2. Tighten both screws to 45 in. lbs.(52 kgcm/kpcm). See Figure 69.

Spark Plug Wire Routing

1. Route spark plug wire through notch in heat shield and notch in blower housing, Figure 70.

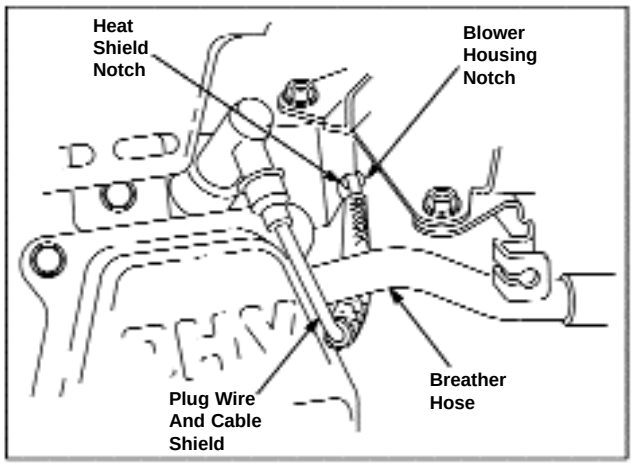


Figure 70 - Wire Routing, Typical

Install Spark Plug Elbow

1. Insert spark plug wire through rubber boot into elbow until wire stops, Figure 71.

2. Install threaded terminal with a screwdriver or until terminal pierces wire and bottoms, Figure 71.

3. Install rubber cap on elbow, and slide rubber boot onto elbow, Figure 71.

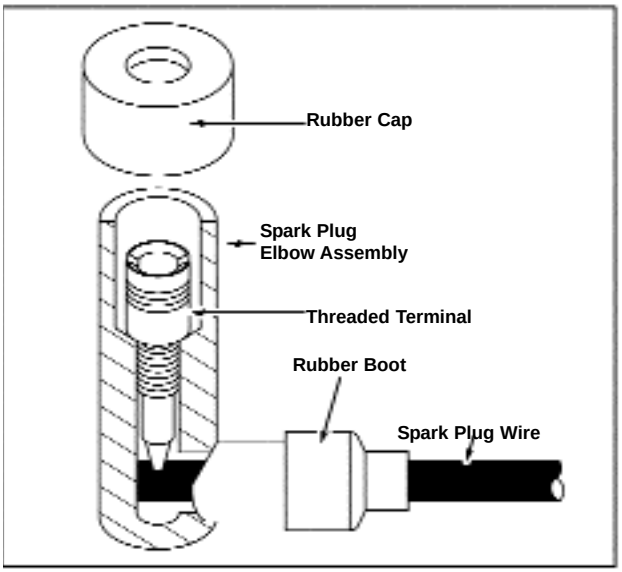


Figure 71 - Installing Spark Plug Elbow

Install MAGNETRON®Armature13 H.P Engine

1. Install stop switch wire on armature. See Figure 72.

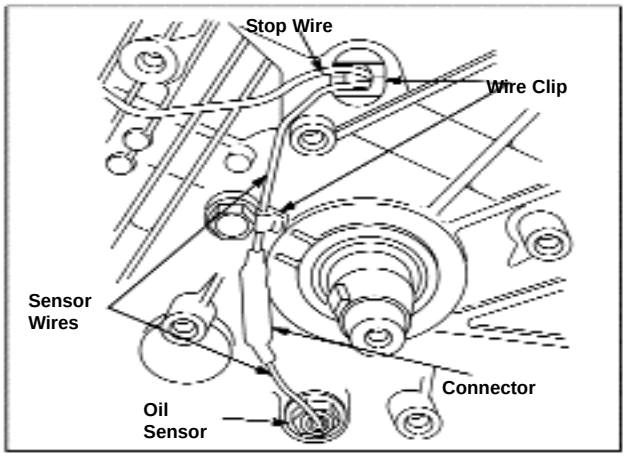


Figure 72 - Oil Sensor Wiring

2. Turn flywheel so magnet is away from armature. Install armature on engine.

3. Install armature and mounting screws. See Figure 73.

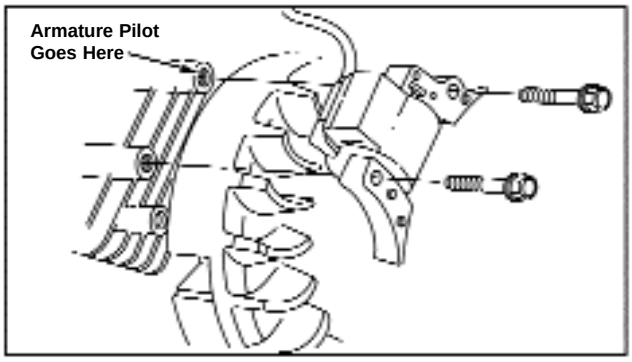


Figure 73 - Installing Armature

Note: Mounting holes in armature are slotted.

4. Push armature away from flywheel as far as possible and tighten one screw to hold armature in place.

Adjust Armature Air Gap - 13 H.P. Engine

1. Rotate flywheel until magnet is under armature laminations.

2. Place thickness gauge, magnet and armature laminations, Figure 74.

3. Correct air gap is minimum .008 inches (.020 mm.), maximum .012 inches (0.31 mm.).

4. Torque both mounting screws to 25 in. lbs. (29 kgcm/kpcm2.8 Nm). Rotate flywheel to remove thickness gauge.

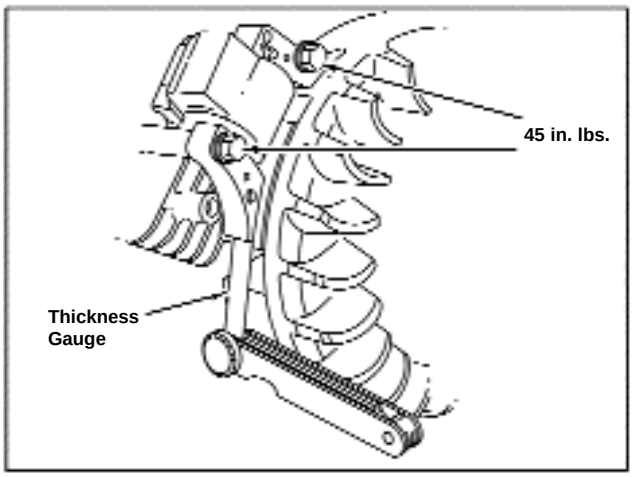


Figure 74 - Magnet Under Armature

Install Fan Housing

1. Place fan housing on engine and insert bolt through a small wire (from A-1 terminal) for engine ground. See Figure 75.

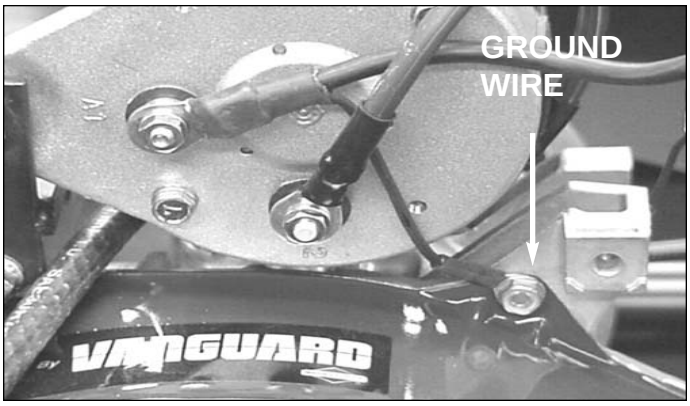


Figure 75 - Engine Ground Wire

2. Install oil guard bracket and module if applicable. See Figure 76.

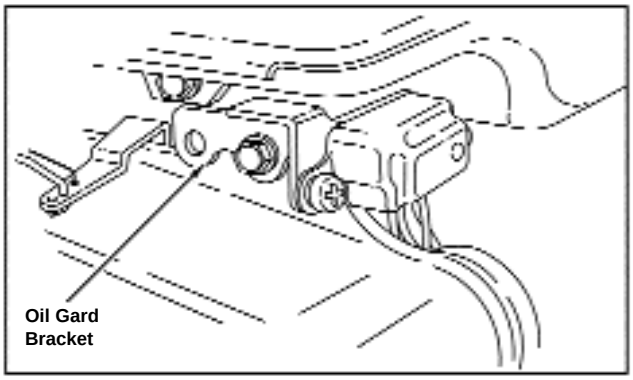


Figure 76 - Installing Oil Gard® Bracket, Typical

3. Install remaining fan housing screws.

Table 5 SPECIFICATION TABLE

Model Series	Armature Air Gap	Flywheel Puller Tool No.	Flywheel Holder Tool No.	Flywheel Nut Torque
185430	.012" - .020" (.30 - .51 mm)	95900-96	95920-96	60 ft. lbs. (81.3 Nm)
245430	.008" - .012" (.20 - .30 mm)	95900-96	95920-96	60 ft. lbs. (83.4 Nm)

ENGINE REMOVAL AND INSTALLATION

Removal

Use the following to remove 9 or 13 H P engines from all gas-powered vehicles.

Warning: Remove key from key switch and disconnect battery negative cable from battery before proceeding. Also, remove spark plug lead from spark plug to prevent accidental starting. Raise vehicle and safely support on jack stands.

1. Remove two bolts holding air cleaner assembly to rear fork support. Remove breather hose from air intake hose fitting. See Figure 77.

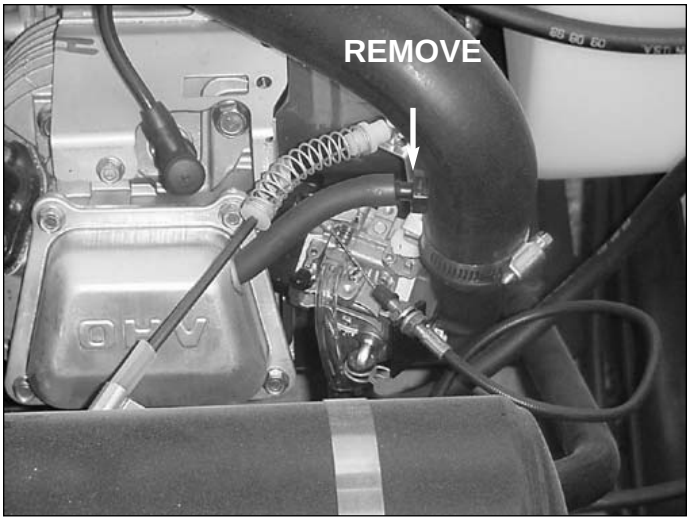


Figure 77 - Breather Hose Removal

2. Loosen screw clamp securing air cleaner hose then set air cleaner and hose assembly aside.

3. Disconnect choke cable from swivel at carburetor choke lever. See Figure 77.

4. Disconnect fuel supply hose from fuel pump, at carburetor inlet fitting. See Figure 78.

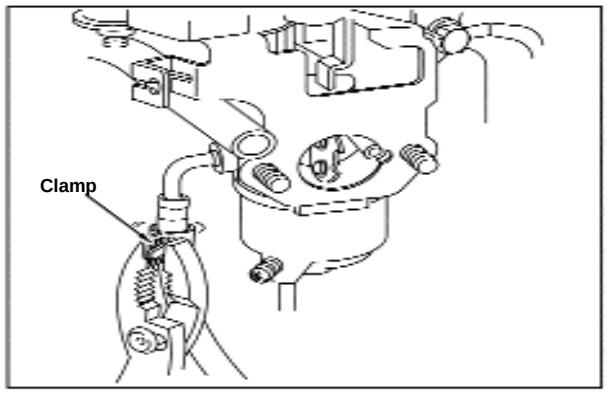


Figure 78 - Remove Fuel Line at Carburetor

Danger: Gasoline is extremely flammable and should be kept away from spark, open flame or possible source of ignition. Quickly clean up any spilled fuel to prevent accidental fire and or injury.

5. Remove throttle cable from carburetor and throttle cable bracket. See Figure 77.

6. Remove muffler and muffler cradle. See page 7-58.

7. Remove drive belt. See page 5-1.

8. Locate ground lead from starter/generator to fan housing and remove lead from fan housing. See Figure 79.

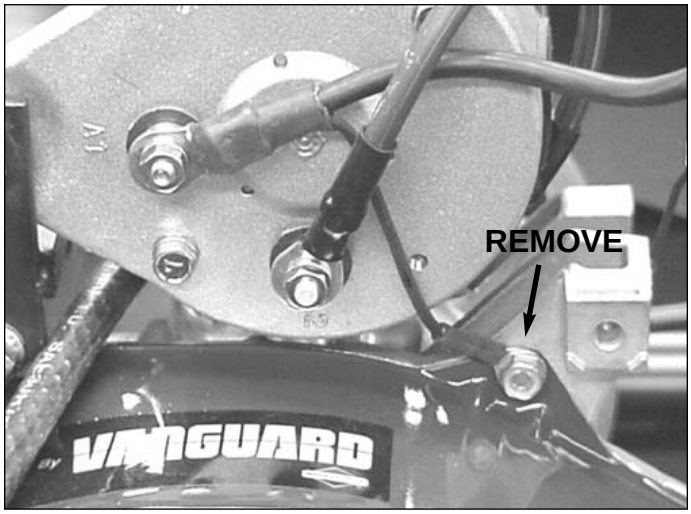


Figure 79 - Remove Engine Ground Lead

9. Locate gray wire from wire harness (under starter/generator) and disconnect from engine black wire.

10. If vehicle is equipped low oil warning light, disconnect blue wire harness lead (under starter/generator) from blue wire from engine.

11. Loosen two rear starter/generator mount bolts, and one front adjuster bracket bolt. Allow starter/generator to drop down and slide belt from pulley and drive clutch.

12. Remove four bolts securing engine to engine mount plate. See Figure 80. Remove engine.

Warning: Have an assistant help lift engine from vehicle, or use an appropriate hoist or lifting aid to prevent personal injury or accident.

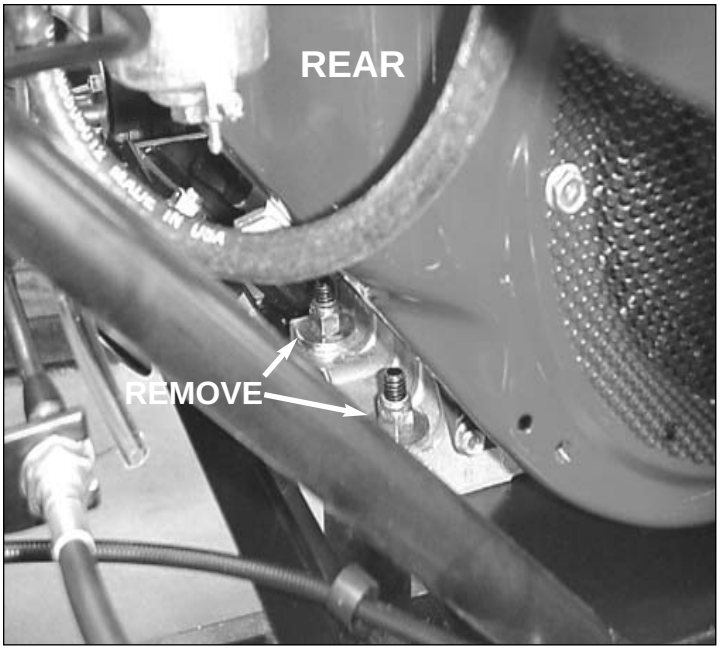


Figure 80 - Engine Mount Bolts

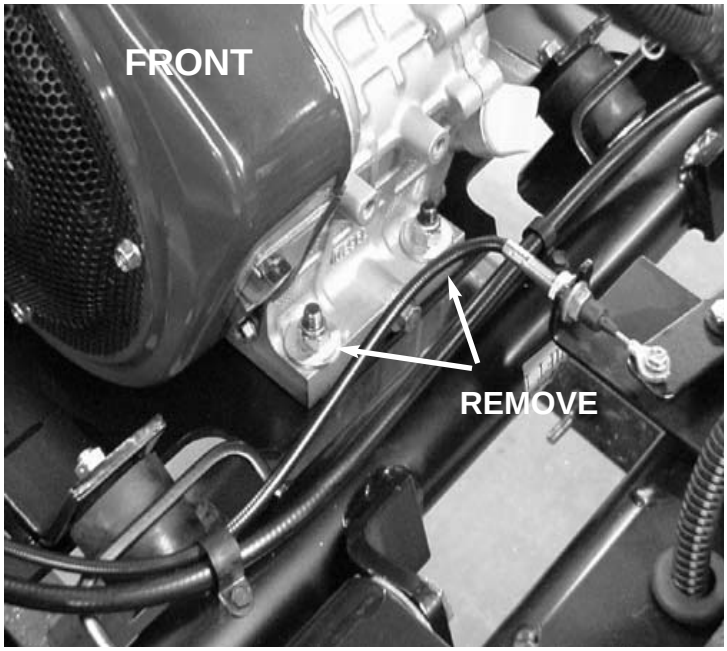


Figure 81 - Engine Mount Bolts

Installation

1. Lift engine into place on engine mount plate. Secure engine to mount plate with for bolts washers and nuts. Do not tighten hardware at this time.

Warning: Have an assistant help lift engine from vehicle, or use an appropriate hoist or lifting aid to prevent personal injury or accident.

2. Install starter/generator and starter belt and adjust starter belt tension. See starter/generator installation, page 8-13.

3. If vehicle is equipped low oil warning light, connect blue wire harness lead (under starter/generator) to blue wire from engine.

4. Locate gray wire from engine wire harness (under starter/generator) and connect to engine black wire.

5. Locate ground lead from starter/generator to fan housing and install lead to engine using fan-housing bolt. See Figure 79.

6. Install muffler and muffler cradle. See page 7-59.

7. Install throttle cable to throttle cable bracket and carburetor. For carburetor adjustment procedures, see page 7-19 for 9 H.P. Engines and 7-25 for 13 H.P. Engines.

8. Connect fuel hose from fuel pump to carburetor inlet fitting. See Figure 78.

Danger: Gasoline is extremely flammable and should be kept away from spark, open flame or possible source of ignition. Quickly clean up any spilled fuel to prevent accidental fire and or injury.

9. Install two bolts holding air cleaner assembly to rear fork support.

10. Position air cleaner hose on carburetor intake elbow and tighten clamp securing air cleaner hose. Note: use care to properly position hose clamp. See page 7-19, Carburetor Installation, Figure 33 for details.

11. Install engine breather hose from valve cover to air intake hose fitting.

12. Install single shouldered spacer, spring, and then double shouldered spacer onto choke cable. Install choke cable to choke lever on carburetor. See page 7-24, Installation.

Caution: Do not operate vehicle until engine alignment has been performed. Failure to perform this adjustment will cause excessive wear, vibration and poor performance.

Danger: Never operate engine with drive belt removed. Governor located in rear transaxle will not function, and engine damage will result. Maximum engine speed could be exceeded causing debris to be thrown from engine, resulting in serious injury or death.

Engine Alignment

At any time the engine, transaxle, or transmission is removed or repositioned, engine alignment must be checked and corrected. If engine realignment is not performed, vehicle could exhibit poor transmission performance, excessive vibration or excessive belt wear.

Warning: Remove key from key switch and disconnect battery negative cable from battery before proceeding.

1. With drive belt removed, place rear of Columbia ParCar alignment tool (PN 12345-96) into driven clutch mounted to rear transaxle.

Note: Engine alignment tool is adjustable for use on 1996 through early 1997 models (with shorter rear suspension fork), or mid 1997 through current (longer rear fork) vehicles. Refer to parts reference book for detailed V.I.N. information

2. Make certain tool is firmly aligned between the pulley halves of the secondary driven clutch before proceeding. Slowly drop front end of tool into drive clutch on engine. If engine position is correct, front end of tool will rest exactly on center shaft of drive clutch (between pulley halves). If tool does not align correctly with the drive clutch, slide or twist engine, as required, to correctly align engine to tool.

3. With alignment tool in place and engine aligned to transaxle, torque four engine mount bolts to 25 to 35 ft. lbs. (34 to 47 N.m.) in the crossing pattern.

4. Recheck engine alignment to transaxle. If engine moved while mount bolts or torqued, loosen mount bolts and return to step 2.

5. Remove alignment tool and install drive belt.

Danger: Never operate engine with drive belt removed. Governor (located in rear transaxle) will not function, and engine damage will result. Maximum engine speed could be exceeded causing debris to be thrown from engine, resulting in serious injury or death.

COMPRESSION
Compression Testing
(when test equipment is not available)

Briggs & Stratton does not publish compression pressures, as it is extremely difficult to obtain an accurate reading.

A simple and accurate indication of compression can be made as follows.

Caution: Always turn key off, and remove key. Connect spark plug wire to engine ground before continuing.

Spin flywheel counterclockwise (flywheel side) against compression stroke. A sharp rebound indicates satisfactory compression. Slight or no rebound indicates poor compression.

Loss of compression will usually be the result of the following:

1. Cylinder head gasket blown or leaking. (Also, check flywheel key.)

2. Valves sticking or not seating properly.

3. Piston rings not sealing, which would also cause engine to consume an excessive amount of oil.

Compression Testing
(Using CPC Tool Part #79010-00, Leak Down Tester)

1. Start and run engine for approximately 5 minutes to allow engine to reach operating temperature.

Note: If engine is cold or cannot be started, air flow may be higher and gauge readings lower because compression components are not at normal operating temperatures.

2. Remove spark plug from engine. Then remove air cleaner hose and carburetor and disconnect valve cover breather tube from air cleaner hose.

3. Rotate crankshaft counterclockwise until piston is at top dead center of compression stroke.

4. Assemble clamping tool from Leak Down Tester Kit on crankshaft. Torque screws to 150 in. lbs. (17.0 N.m.). Insert drive end of 1/2 inch drive breaker bar into square hole in clamp. See Figure 82.

Note: The crankshaft must be held with the piston at top dead center to eliminate any chance of rotation.

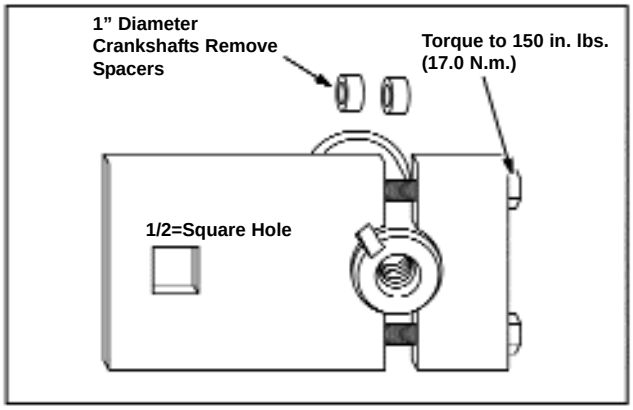


Figure 82 - Installing Clamping Tool

Caution: Injury may occur if the crankshaft is not positively locked from rotating. The air pressure can create a rotational force of up to 60 ft. lbs. (70 kg/cm, kp/cm81.4 Nm) if the crankshaft is not locked with the piston at top dead center.

5. Pull regulator lock nut out and turn adjustment knob counterclockwise as far as it will go, Figure 83.

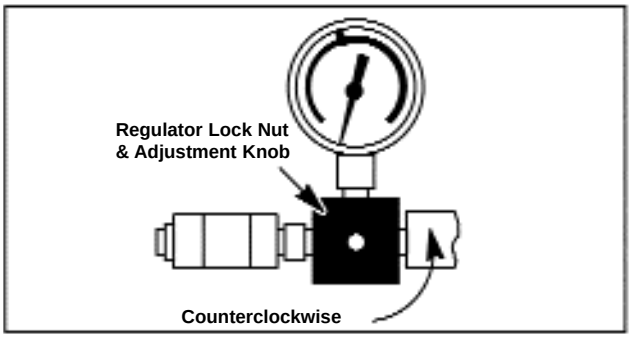


Figure 83 - Pre-Setting Regulator

6. Connect tester to the shop air source (minimum air pressure of 70 psi. (49.2 KG/cm2).

7. Install outlet hose into spark plug hole of cylinder being tested. Be sure O-Ring is seated to prevent air leak at spark plug hole. Connect other end to tester.

8. With breaker bar held securely, slowly turn regulator adjustment knob clockwise until tester's inlet gauge needle is on the set point. Push in regulator lock nut. Note position of outlet gauge needle, Figure 84.

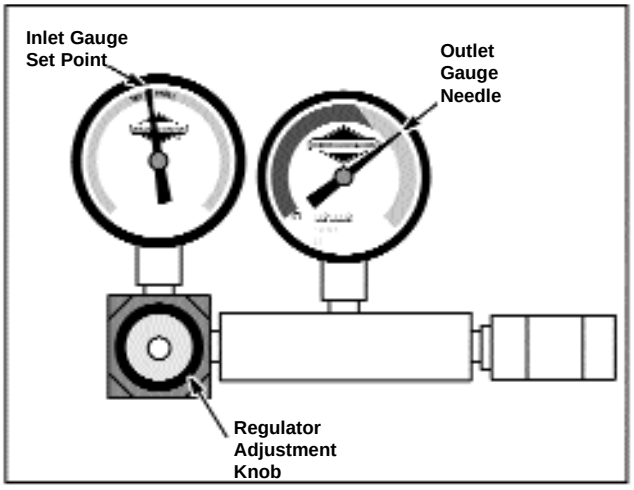


Figure 84 - Setting Tester

Note: Any air leaks at connections or fittings of tester will affect the accuracy of test.

9. Listen for air leaking from cylinder head gasket, carburetor, exhaust system and either crankcase breather or high oil fill dipstick tube.

Note: If a high flow of air is leaking from exhaust and carburetor, make sure that piston is at TDC on compression stroke.

a. Air flowing between cylinder and cylinder head indicates that cylinder head gasket is leaking.
b. Air flowing from carburetor indicates air is leaking past intake valve and seat.
c. Air flowing from exhaust system indicates air is leaking past exhaust valve and seat.
d. Air flowing from crankcase breather tube or high oil fill dipstick tube indicates air is leaking past piston rings.

Test	Result
Reading is Green. A small amount of air is leaking from head gasket.	Replace head gasket, then re-test.
Reading is Green, minimum air leakage.	Look for other problems that are not compression related.
Reading is Green/Red or Red, and all the air is leaking from one component.	Look for a possible problem with that component.
Reading is Red, and air is leaking from several components.	Check that piston is at TDC, on compression stroke. If reading does not change, look for problems beginning with component that appeared to leak the most air. Re-test after repair.

10. When test is complete, push regulator lock nut in and turn regulator lock nut counterclockwise as far as it will go to release pressure in combustion chamber.

11. Disconnect outlet hose from tester before removing from spark plug hole.

Cylinder Head

Prepare Cylinder Head for Removal

Before cylinder head can be removed, external parts such as air cleaner hose, fuel lines, oil fill tube and dipstick, blower housing, muffler head pipe, carburetor, throttle and choke cables, and starter/generator must be removed.

Remove Rocker Arm Cover

1. Remove four screws from valve cover.

2. Remove valve cover and breather valve assembly. See Figure 85.

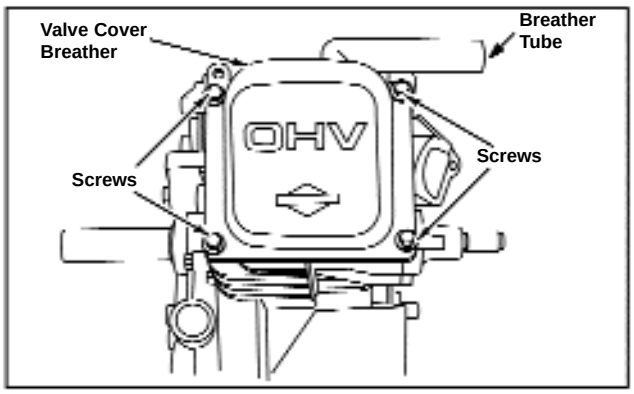


Figure 85 - Removing Valve Cover, Typical

Remove Cylinder Head

Remove cylinder head screws, cylinder head, push rods, and cylinder head gaskets, Figure 86.

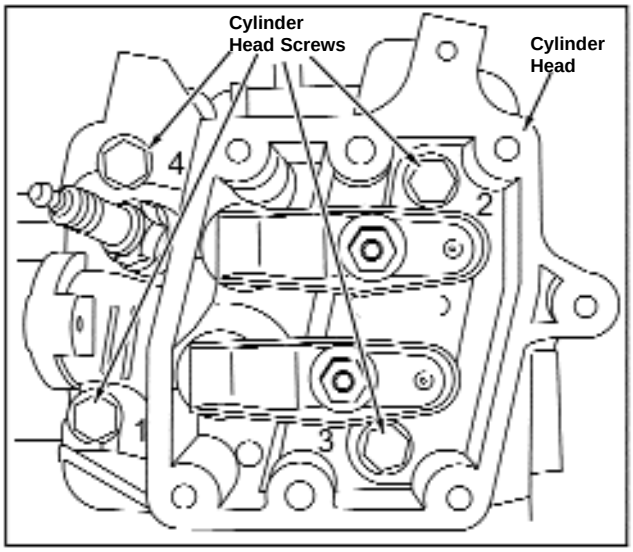


Figure 86 - Removing Cylinder Head, Typical

Disassemble Cylinder Head - 9 H.P. Engine

1. If valve seats will be reconditioned, loosen rocker arm screws and remove rocker arm nuts, and rocker arms, Figure 87.

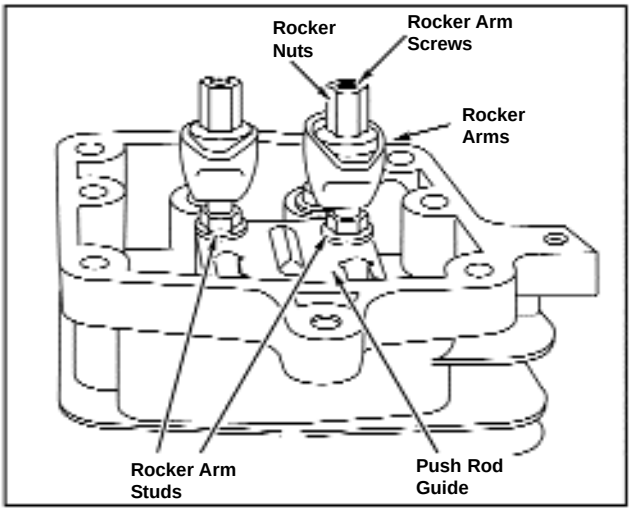


Figure 87 - Removing Rocker Nuts, Typical

2. Then remove rocker arm studs and push rod guide.

Disassemble Cylinder Head - 13 H.P. Engine

1. Remove two (2) hex. screws holding rocker arm shaft to cylinder head, Figure 88.

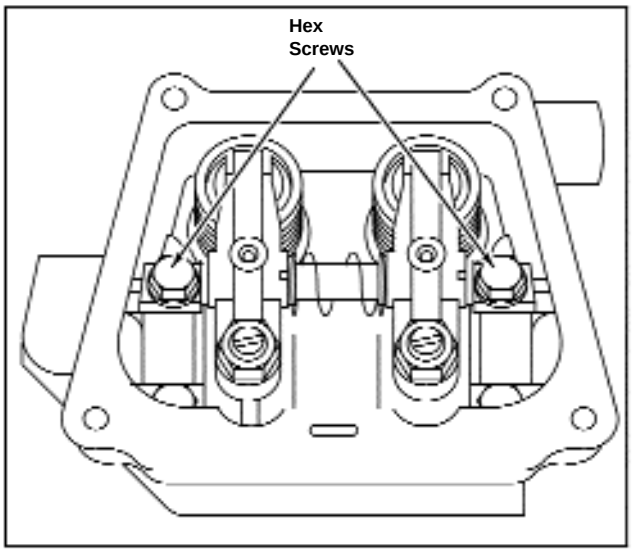


Figure 88 - Removing Rocker Arm Shaft

2. Disassemble rocker assembly by using external snap ring pliers to remove either snap ring, Figure 89.

3. Remove valves as described in “Remove Valves - 13 H.P. Engine.”

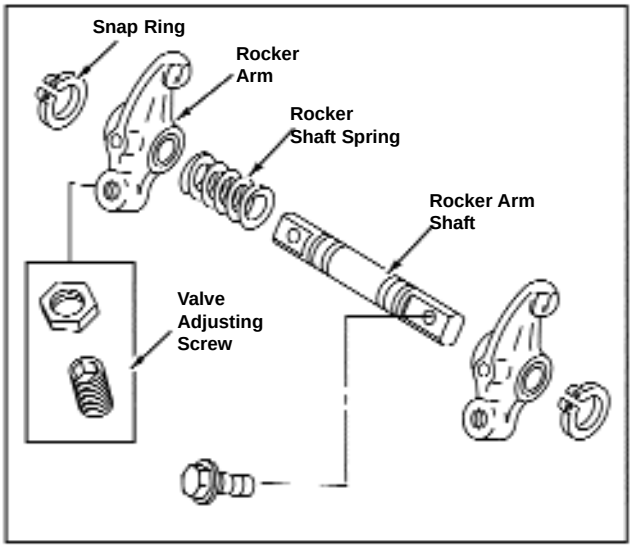


Figure 89 - Disassembling Rocker Arm Shaft

Remove Valves - 9 H.P. Engine

1. Place cylinder head on work surface.

2. With thumbs, press down on spring retainer and valve spring to compress valve spring, Figure 90.

3. With spring compressed, remove both halves of valve retainer.

4. Slowly relieve tension on spring and retainer.

5. Remove spring, valve and valve stem seal (intake valve only). Discard valve stem seal.

6. Repeat for other valve, Figure 90.

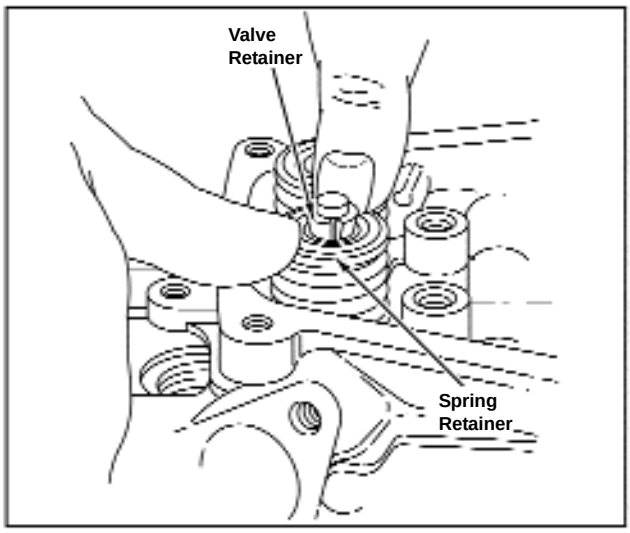


Figure 90 - Removing Valves

Remove Valves - 13 H.P. Engine

1. Place cylinder head on work surface.

2. Remove valve cap (when used) from valve stems, Figure 10. With thumbs, press down on valve spring retainer and spring to compress until large end of slot in retainer can line up with end of valve stem, Figure 91.

3. With thumbs, press down on valve spring retainer and spring to compress until large end of slot in retainer can line up with end of valve stem. See Figure 91.

4. Release pressure on retainer and spring.

5. Remove retainer, spring, and intake valve seal and washer (when used), if removing intake valve, Figure 91.

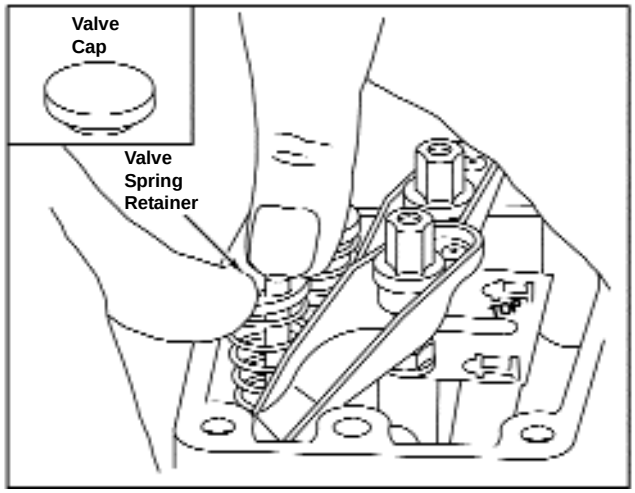


Figure 91 - Removing Valves

Valve Guide Service

Inspect Valve Guides - 9 and 13 H.P. Engines

1. Measure intake and exhaust valve guides using CPC Part #95990-96, Valve Guide Plug Gauge.

2. If flat end of gauge can enter guide for 1/4" (6.35 mm) or more, valve guide must be replaced.

3. If plug gauge is not available, refer to Table 6, page 7-40 for reject size.

Valve Service

Reface Valves and Seats

1. Valve faces may be resurfaced on a valve grinder.

2. Valve seats are cut using CPC Part #96000-96, Neway Valve Seat Cutter Kit, and CPC Part #96000-96, Valve Seat Cutter Kit, to 45° on exhaust and intake seats.

3. Valve and seat are lapped by using CPC Part #96020-96, Valve Lapping Tool, and CPC Part #96030-96, Valve Lapping Compound, to remove grinding marks and assure a good seal between valve face and seat.

4. Thoroughly clean lapping compound from valve seat and valve face.

5. Valve seat width should be as shown in Figure 92 and Table 7, page 7-40.

6. If seat is wider, a narrowing cutter should be used. If valve face is badly burned, the burned valve should be replaced.

7. Replace valve if margin is 1/64 inch (.39 mm) or less or damaged, Figure 92.

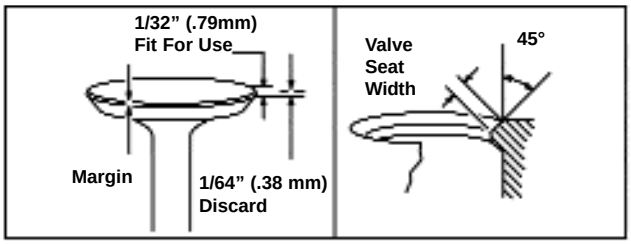


Figure 92 - Valve and Seat Dimensions

If seats are burned or damaged, replace cylinder head.

Assemble Cylinder Head

Install Push Rod Guide and Studs - 9 H.P. Engine

1. If push rod guide or rocker arm studs were removed, place rod guide in cylinder head.

2. Coat rocker arm stud threads that go in head with hardening sealant.

3. Install rocker arm studs, torquing studs to torque listed in Table 8, page 7-40 . See Figure 93.

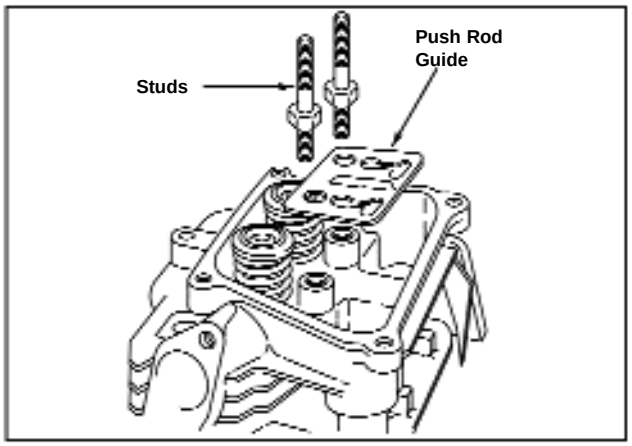


Figure 93 - Installing Push Rod Guide and Studs

Assemble Rocker Arm Shaft - 13 H.P. Engine

1. Place one (1) retainer ring on rocker shaft with square edges toward middle of shaft.

2. Oil rocker shaft and slide on one (1) rocker arm and rocker arm shaft spring.

3. Slide on second rocker arm, and install second retainer ring with square edges toward rocker arm.

Install Valves - 9 and 13 H.P. Engines

1. Valve stems and guides must be free of foreign material and burrs or valve sticking will occur and valve stem seals will be damaged.

2. Lightly coat valve stems with a High quality Valve Guide Lubricant, and install in valve guides.

3. Place valve stem seal gasket or washer on intake valve guide.

4. Oil inside diameter of valve stem seal with engine oil and install on valve stem. Press seal down over valve guide.

Note: Be sure Valve Guide Lubricant is not on valve seat or exposed end of valve stem.

Install Valve Springs and Retainers

1. Place cylinder head on work surface, and install valve spring over valve stem.

2. Place retainer on spring and with thumbs on retainer, press on retainer to compress spring, Figure 94.

3. Compress spring until valve stem extends through valve retainer and groove is above retainer.

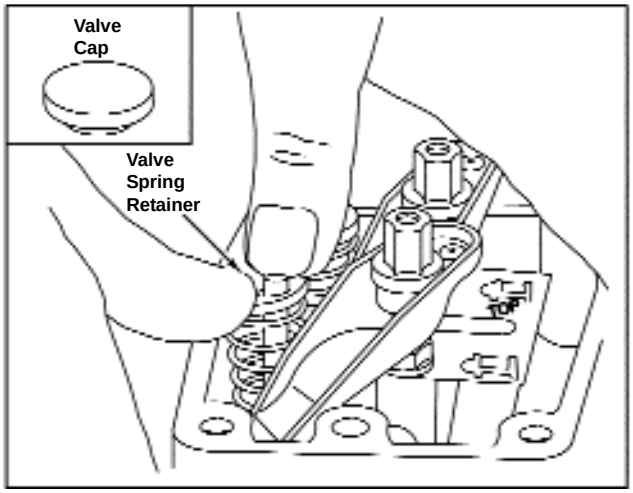


Figure 94 - Installing Rocker Balls and Screws, Typical

4. Place both halves of valve retainer in valve stem groove and slowly release tension on valve spring and valve spring retainer.

5. 13 H.P. engines, install valve cap over retainers.

Install Cylinder Head - 9 and 13 H.P. Engines

DO NOT USE SEALER OF ANY KIND ON GASKETS.

1. Coat threads of cylinder head screws with a high quality Valve Guide Lubricant.

2. Place new cylinder head gasket on cylinder pins and then install cylinder head and cylinder head screws.

3. Torque screws as listed in Table 9 Page 7-40 in sequence that cylinder head screws are numbered on cylinder head, or as shown in Figure 95.

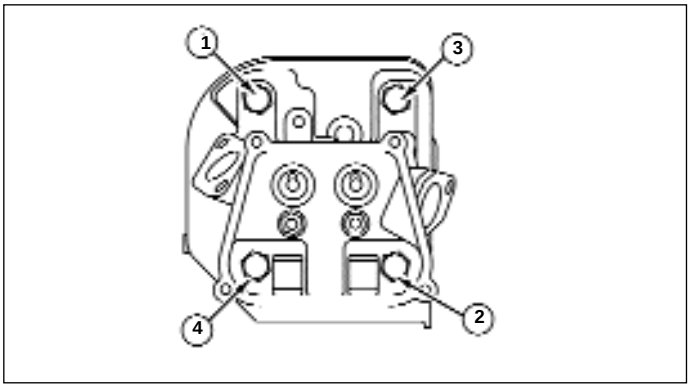


Figure 95 - Torque Pattern, Cylinder Heads

It is recommended that cylinder heads be torqued in three (3) steps:

1. 75 in. lbs. (86 Kgcm8.5 Nm)
2. 150 in lbs. (173 Kgcm16.9 Nm) e.g.
3. Refer to Table 4 for the final torque.

Note: Do not torque one screw down completely before the others, as it may cause a warped cylinder head.

Install Rocker Arms - 9 H.P. Engines

1. Install push rods through push rod guide making sure push rods are in valve tappets, Figure 96.

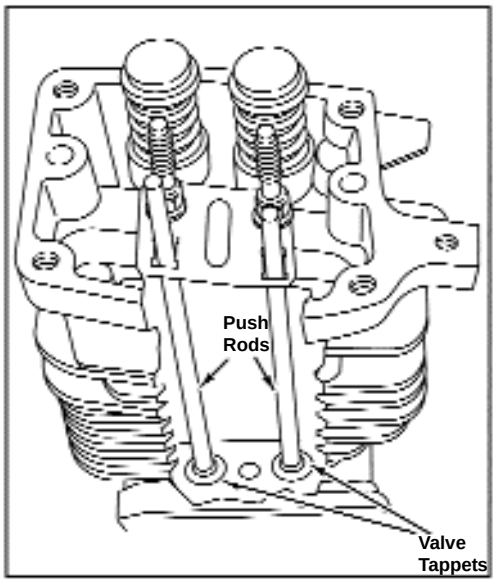


Figure 96 - Installing Push Rods

2. Remove all lubricant from end of valve stems.

3. Place rocker arms on studs and install rocker arm nut and screw while holding rocker arm against valve cap and push rod until rocker ball is finger tight, Figure 97.

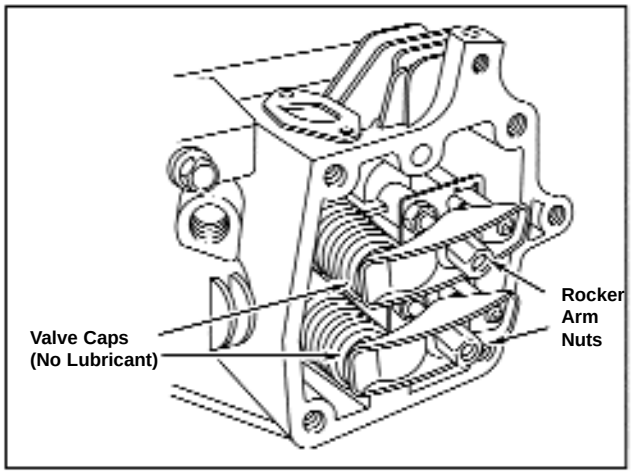


Figure 97 - Installing Rocker Balls and Screws, Typical

4. Rotate crankshaft at least two (2) revolutions to be sure push rods operate rocker arms.

Install Rocker Arm Shaft - 13 H.P. Engines

1. Install push rods making sure each rod is in its tappet.

2. Place rocker arm shaft assembly on cylinder head making sure that push rod sockets engage valve adjusting screws.

3. Install two (2) screws in rocker arm shaft and cylinder head. Torque screws to 85 in. lbs.(9.6 Nm), Figure 98.

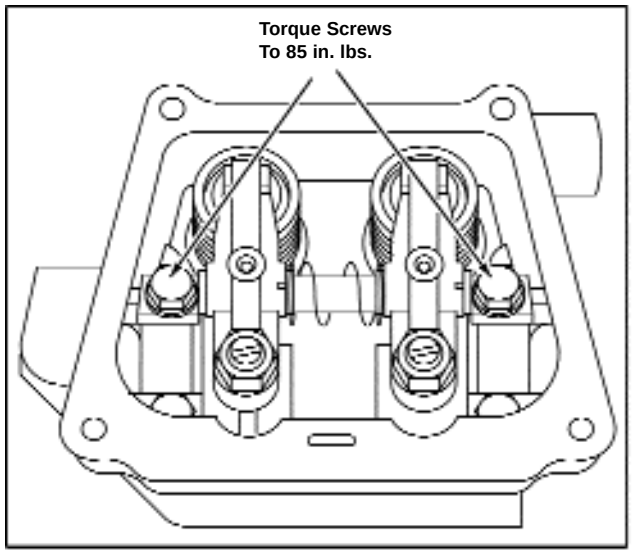


Figure 98 - Installing Rocker Arm Shaft

Adjust Valve Clearance - 9 and 13 H.P. Engines

Note: Check valve clearances while engine is cold.

1. Turn crankshaft until piston is at Top Dead Center (both valves closed) on compression stroke.

2. Insert a narrow screwdriver or small rod into spark plug hole against piston. Screwdriver is used to gauge piston movement.
3. Turn crankshaft clockwise (flywheel end), while watching screwdriver, past Top Dead Center until piston is 1/4" (6.35 mm) down.

4. Using feeler gauges, check valve clearance. Clearance should be as listed in Table 10 Page 7-40.

5. Adjust as required, Figure 99.

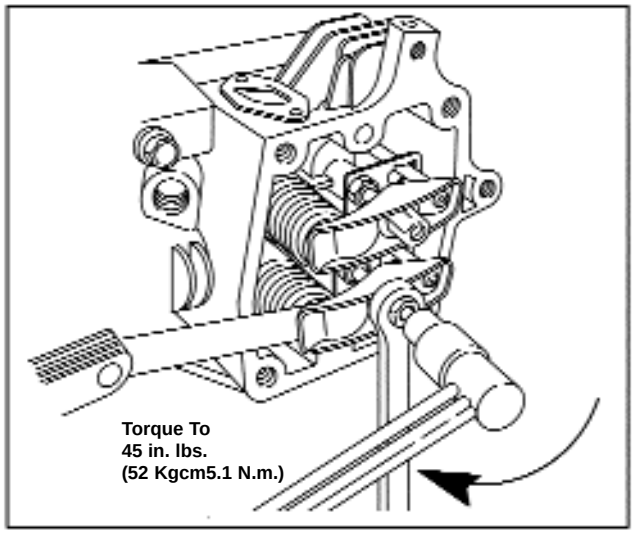


Figure 99 - Adjusting Valve Clearance

6. When valves are adjusted, hold rocker nut and torque rocker ball screw or nut to torque listed in Table 11 page 7-41.

7. Recheck clearance and readjust, if required.

Note: Correct positioning of crankshaft is required to correctly adjust valve clearance.

Install Valve Cover

Install valve cover with new gasket, Figure 100. Install four screws. Tighten screws to torques listed in Table 12, Page 7-41, in sequence shown in Figure 101.

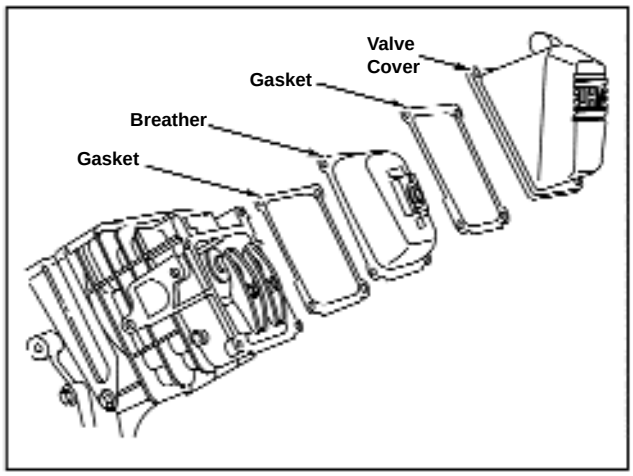


Figure 100 - Installing Valve Cover

Figure 101- Valve Cover Torque Sequence, Typical

Install carburetor, exhaust manifold, and others parts removed for cylinder head access.

Table 6 - Valve Guide Reject Dimension All Models
Intake and Exhaust
.240” (6.09 mm)

Table 7 - Valve Seat Width		
Model	**Intake Valve**	**Exhaust Valve**
9 & 13 H.P. Engines	1/32-3/64” (.79-1.19 mm)	1/32-3/64” (.79-1.19 mm)

Table 8 - Rocker Arm Stud Or Shaft Torque	
Model Series	**In.Lb. (N.m.)**
9 H.P. Engine	175 (19.8)
13 H.P. Engine	85 (9.5N.m.)

Table 9- Cylinder Head Bolt Torque	
Model	**Torque**
9 H.P. Engines	300 inch lbs. (33.9N.m.)
13 H.P. Engines	35 Ft. Lbs. (47.4 N.m.)

Table 10 - Valve Clearances		
Model	**Intake**	**Exhaust**
9 & 13 H.P. Engines	.002-.004” (.05-.10 mm)	.002-.004” (.05-.10 mm)

Table 11 - Rocker Ball Set Screw or Nut Torque	
Model Series	**In. Lbs. (Nm)**
9 H.P. Engines	35 (3.9)

Table 12 - Valve Cover Torque	
Model Series	**Torque**
9 & 13 H.P. Engines	45 inch lbs, (5.1N.m.)

BREATHERS

Briggs & Stratton engines utilizes a breather valve to control and maintain a partial vacuum in the crankcase.

The breather valve is a fiber disc or reed valve which closes on the piston's up stroke and opens on the piston's down stroke to keep a partial vacuum in the crankcase.

This partial vacuum prevents oil leakage past piston rings, valve guides, oil seals, governor lever shaft and gaskets.

Remove Breather (Valve Cover)

1. Breather valve is integral part of valve cover.
2. Remove four (4) valve cover screws.
3. Remove valve cover, and remove breather tube from air cleaner hose and carburetor air intake elbow. See Figure 102.

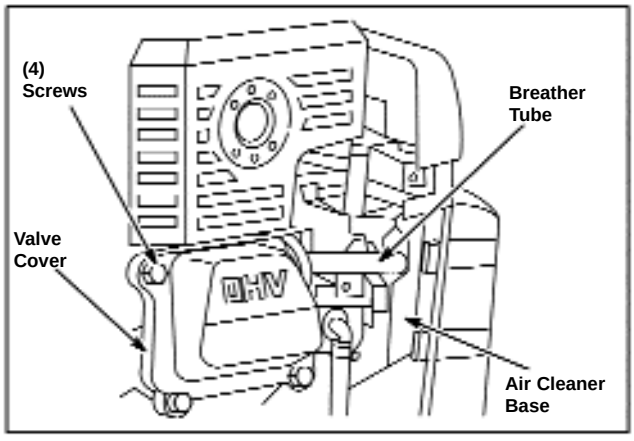


Figure 102 - Removing Breather

Check Breather (Valve Cover)

1. Breather valve is an integral part of the valve cover, and can be checked on or off the engine.
2. Blow air through breather tube. There should be no leakage.
3. Apply vacuum (suction) to breather tube. Air should flow freely.
4. If breather valve has restricted air flow or no resistance to air flow, replace valve cover.

Install Breather Hose and Valve Cover

1. Place new gasket and valve cover on cylinder head.
2. Install four (4) screws and torque to 35 in. lbs.(40 Kgcm (3.9 Nm) torque.
3. Oil end of breather tube and insert into valve cover. Connect opposite end of breather tube to fitting on air intake hose (9 H.P. Engine), or air intake elbow (13 H.P. Engine).

Inspect Breather Tube

Inspect breather tube for cracks, holes, and hardening. See Figure 103.

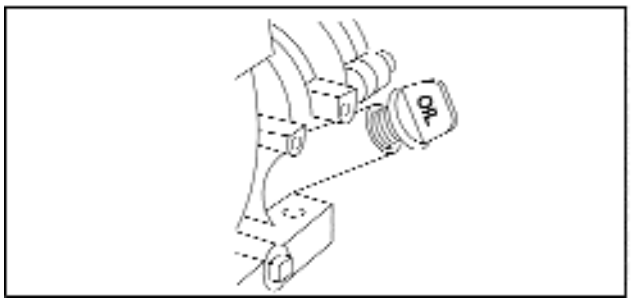


Figure 103- Checking Oil Level

Check, also, air intake hose for damage and proper sealing.

LUBRICATION SYSTEM

The Briggs & Stratton overhead valve, 9 H.P. and 13 H.P. engines, use an oil dipper lubrication system.

Engine Oil

Engine oil capacities are listed in Table 13, on page 7-44.

Note: **LONG DIPSTICK** - Always screw long dipstick in completely to check oil level.
SHORT DIPSTICK - Set short dipstick into opening, do not screw in to check oil level. See Figure 2.

Oil Dipper Lubrication

The dipper is an integral part of the connecting rod cap and as the crankshaft turns at the bottom of each stroke, the dipper splashes oil up onto the cylinder wall, crankshaft, connecting rod, piston and cam gear, Figure 3.

Oil Dipper Inspection

Inspect dipper for cracks, broken or missing pieces. Replace if damaged. See Figure 104.

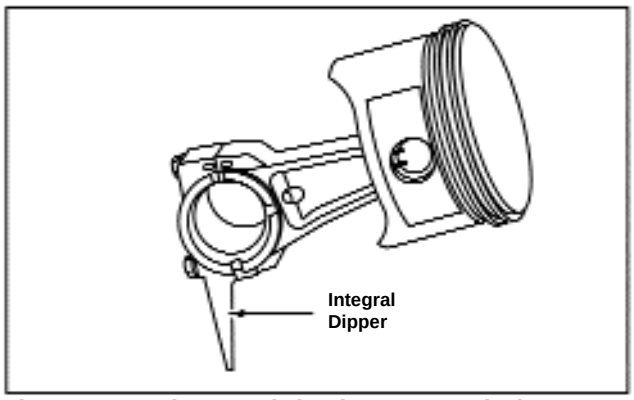


Figure 104 - Dipper Lubrication - Integral Dipper

OPTIONAL OIL GARD® SYSTEMS

Oil Guard® low oil shut off system is available on both 9 and 13 H.P. engines. The system will shut off engine, preventing damage from running with insufficient oil.

If engine is running low on oil, the Oil Gard® float switch will close and the engine will stop. Engine cannot be restarted until sufficient oil is added. Fill to FULL mark on dipstick.

Principles of Operation

The Oil Gard® system consists of:

- Oil Sensor (located inside crankcase)
- Module (located above fan housing on engine)
- Vehicle wiring

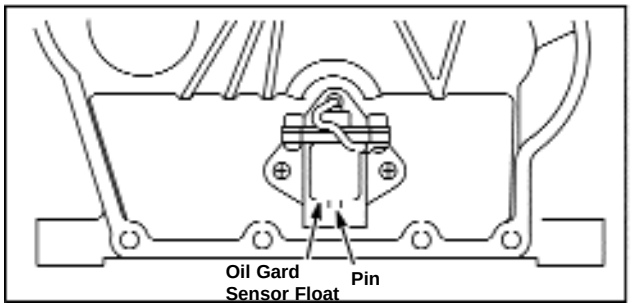


Figure 105 - Oil Gard® Operation

When oil level drops below the minimum recommended oil level, the oil sensor float pin makes contact with the bottom of the crankcase. This completes a circuit from the ignition coil through the module to the sensor and to ground stopping the engine, Figure 105

The chart below lists possible problems with the possible cause and cure.

Possible Problems with Possible Cause and Cure

PROBLEM	POSSIBLE CAUSE	CURE
No Spark	Low Oil in Crankcase Excessive Angle of Operation Defective Oil Gard® Switch	Refill With Oil Reduce Angle of Operation Replace Switch
No Spark - Correct Amount of Oil in Crankcase	Wiring Harness Grounded Stop Wire Grounded Defective Magnetron® Armature	Repair or Replace Wiring Harness Repair or Replace Wire Replace Armature
Spark Present - Engine Does Not Kill if Low on Oil	Defective Harness Oil Gard® Switch Wire Not Making Ground to Cylinder Defective Oil Gard® Switch	 Adjust Wire Replaces Switch
Intermittent Spark	Grounded Stop Wire or Harness Defective Oil Gard® Switch Oil Gard® Switch Wire Not Making Ground to Cylinder	Repair or Replace Wire or Harness Replace Switch Adjust Switch Wire
No Spark - Low on Oil	Wiring Harness Connections Reversed	Reverse Connections

TROUBLESHOOTING OIL GARD® System

Engine Starts, And Dies, or Will Not Start

1. Check engine oil level. If low, add oil to bring to full mark on dipstick. If engine starts and continues to run, problem corrected. If oil is between ADD and FULL, go to next step.

2. Disconnect Blue wire at #1, and gray wire at #4. See Figure 106. Start Engine.
   a. If engine starts and dies, replace Oil Gard® Module and retest.
   b. If engine starts and continues to run, reconnect wire at #1.
   c. Engine dies, check continuity between #1 and #2. If wire is good , replace OIL GARD® float.
   d. If engine starts, reconnect wire at #4. If engine dies, test key switch, accelerator micro switch and related circuit.

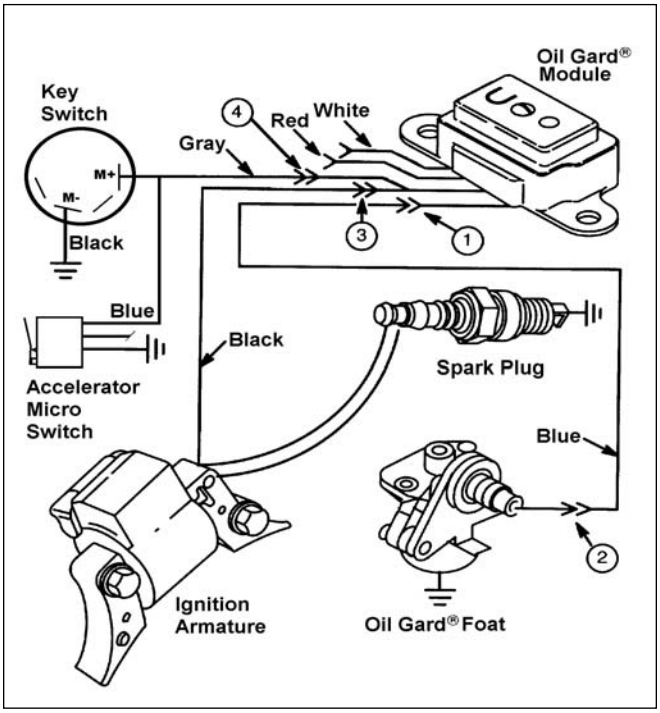


Figure 106 - Oil Guard Wiring

Disassemble OIL GARD® Low Oil Warning System

1. Refer to ignition section, page 7-27, for fan cover and flywheel removal. Remove flywheel.

2. See page 7-47 (crankshaft and cam gears) for crank case cover removal. Remove crank case cover.

3. Disconnect oil sensor blue wire and remove from retainer clips. See Figure 107

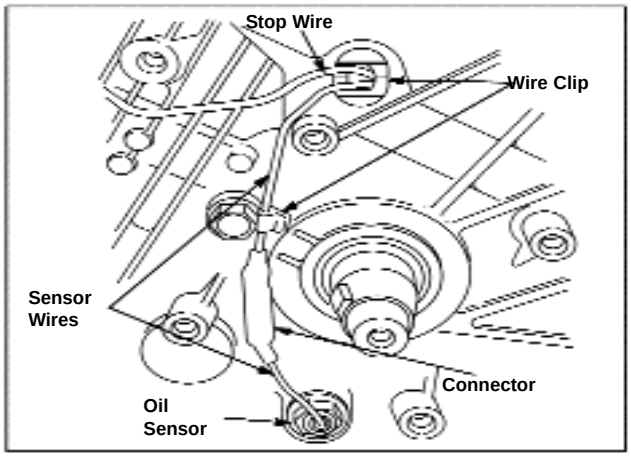


Figure 107 - Oil Sensor Wiring

4. Remove external nut from oil sensor. Remove oil sensor from crank case. See Figure 108.

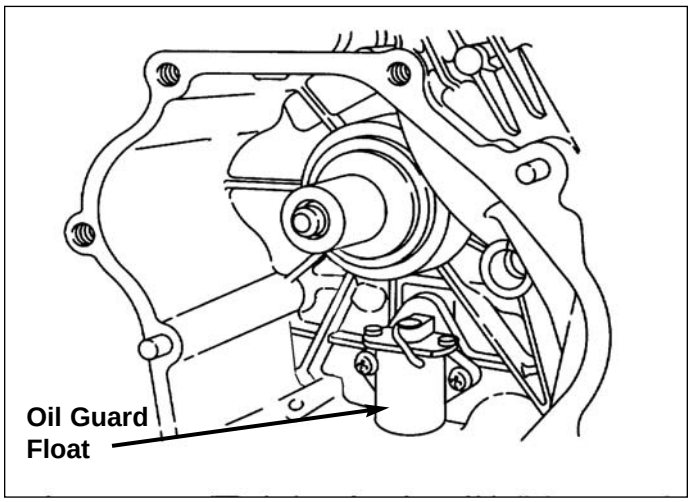


Figure 108 - Oil Guard Float

Inspect OIL GARD® Low Oil Warning System

1. Inspect float assembly for cracks in housing and float.

2. Check Oil Gard® switch operation by connecting a continuity tester to the wire terminal and ground clip.

3. In normal upright position, tester should show continuity.

4. Turn float assembly upside down.

5. Tester should indicate no continuity.

Assemble OIL GARD® Low Oil Warning System

1. Install Oil Guard® float assembly into crankcase, tighten oil sensor mounting nut.

2. Route blue oil sensor wires through guide clips. See Figure 107.

3. Install internal engine parts per Figure 148, page 7-58. Install crankcase cover as described on page 7-56.

4. Install fan and fan housing as described on pages 7-31.

Table 13 Approximate Crankcase Oil Capacity (Dry)	
Model	**Capacity**
9 H.P. and 13 H.P. Engines	41 oz. (1.2 liters)

PISTONS, RINGS, AND CONNECTING RODS

Note: Crankcase cover must be removed before piston and rod can be removed. See crankshaft and cam gears, page 7-47.

Remove Piston and Connecting Rod - ALL

On connecting rods, with dippers held by both connecting rod bolts. No washers are used.

1. Remove connecting rod cap. See Figure 109.

2. Remove any carbon or ridge at top of cylinder bore to prevent ring breakage.

3. Push piston and rod out through top of cylinder.

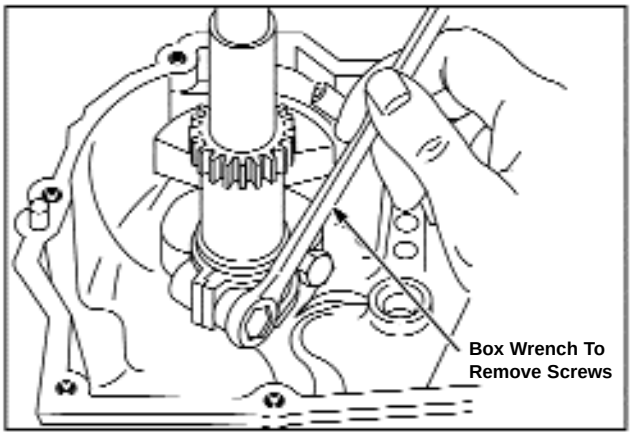


Figure 109 - Remove Piston and Connecting Rod, Typical

Remove Connecting Rod and Piston Pin

1. Remove piston pin lock with thin nose pliers, Figure 110.

2. Push out piston pin from opposite side.

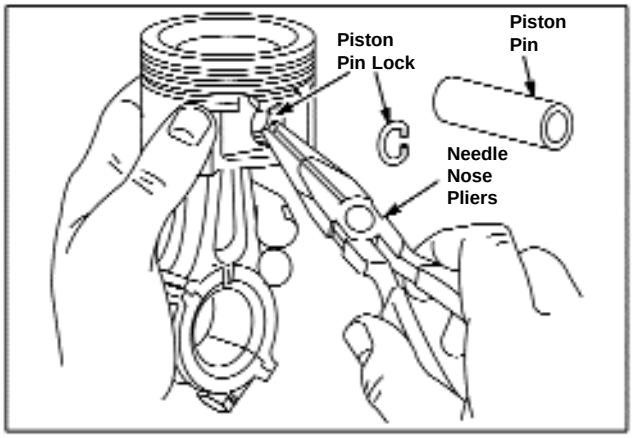


Figure 110 - Removing Rod, Typical

Remove Piston Rings - All

Remove piston rings using Tool #96050-96, Piston Ring Expander, Figure 111.

Note: Some oil control rings consist of two thin steel rails and a spring expander. These steel rails cannot be removed with Tool #96050-96, Piston Ring Expander.

1. Grasp one end of the steel rail and wind the rail from the oil ring groove into the next ring groove.

2. Repeat into the top ring groove and off the piston.

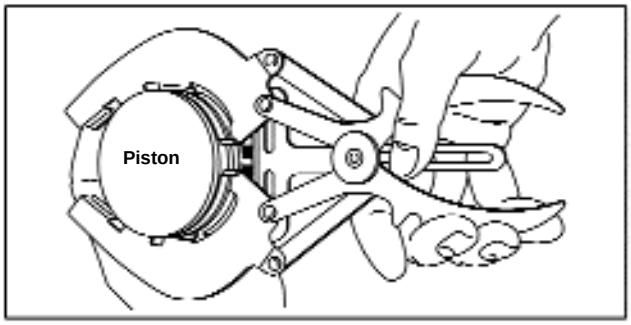


Figure 111 - Removing Rings, Typical

Inspect Piston Ring Groove Wear

1. Clean carbon from top ring groove.

2. Place a NEW ring in groove and measure space between ring and ring land. Refer to Table 14 for specifications. See Figure 112

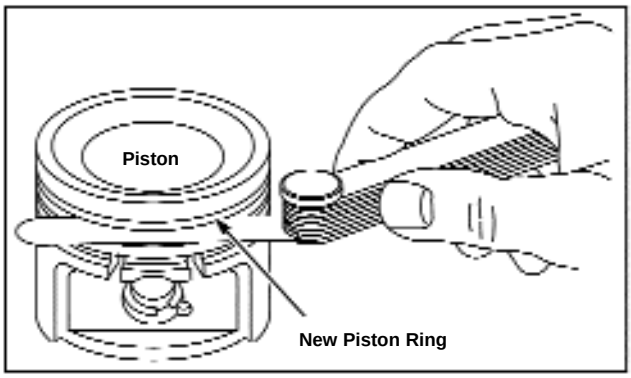


Figure 112 - Checking Ring Grooves

Inspect Piston Ring End Gap

1. Clean all carbon from the end of the rings, and from the cylinder bore.

2. Insert old rings one at a time one inch down into the cylinder. Push into place with piston to assure rings are correctly positioned in bore.

3. Check end gap with feeler gauge, Figure 113.

4. If ring gap is greater than shown in Table 15, the rings should be rejected.

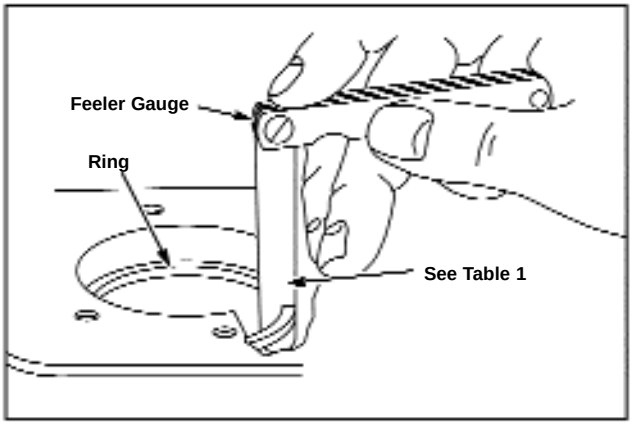


Figure 113 - Checking Ring Eng Gap

Inspect Connecting Rod

If the crankpin bearing is scored, the rod must be replaced. Reject sizes of crankpin bearing hole and piston pin bearing hole, Figure 114, are shown in Table 16, page 7-47.

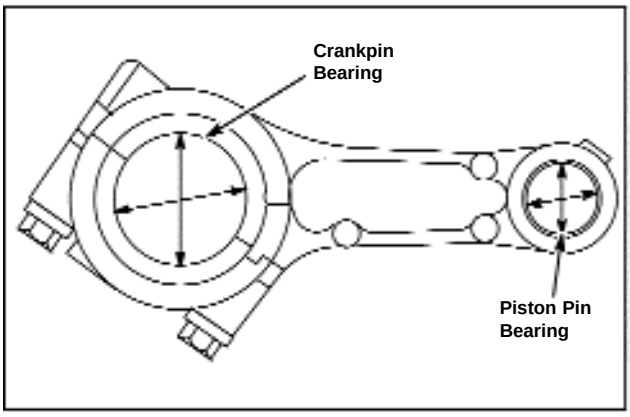


Figure 114 - Checking Rod Bearings

Note: .020" (.51 mm) undersized connecting rods are available when crankpin is scored or worn below reject. See page 7-48 (Inspect Crankshaft) for crankshaft grinding information for undersized connecting rods.

Inspect Piston Pin and Piston Pin Bore

If piston pin is worn .0005" (.013 mm) out of round or below reject size shown in Table 17, it should be replaced.

If piston pin bore, Figure 115, is worn above reject size, Table 17, replace piston.

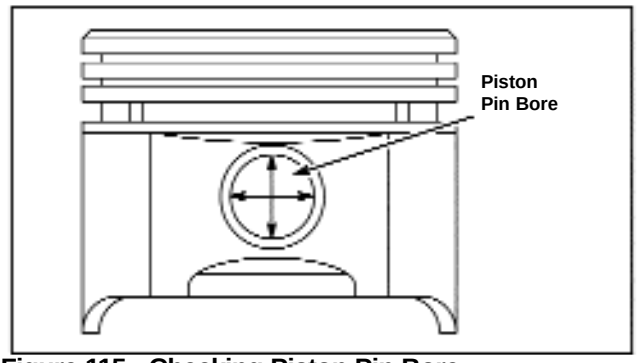


Figure 115 - Checking Piston Pin Bore

Assemble Piston and Connecting Rod

1. The piston pin is a slip fit in both piston and connecting rod.

2. Using thin nose pliers or screwdriver, place piston pin lock in groove on one side of piston.

3. Piston must be installed with notch or arrow toward flywheel side of cylinder. Dot on piston can face either direction.

4. Determine correct position of connecting rod relative to notch or arrow on piston. See Figure 116.

5. Insert piston pin from side opposite installed lock until pin stops against lock.

6. Place second piston pin lock in groove at other end of piston pin.

7. Be sure both locks are firmly set in grooves.

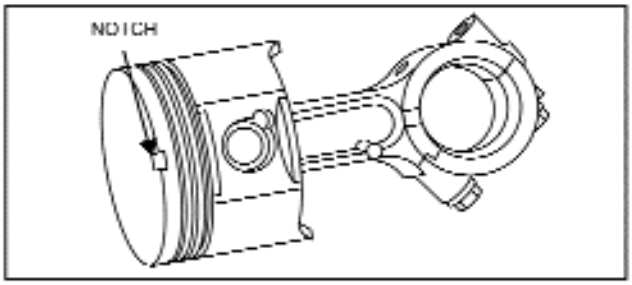


Figure 116 - Assemble Piston and Connecting Rod

Install Piston Rings To Piston

1. Oil piston rings and piston skirt.

2. Compress rings with Tool #96040-96, Ring Compressor, as shown, Figure 118.

3. Place piston and compressor upside down on bench and push piston down until head of piston is even with edge of compressor.

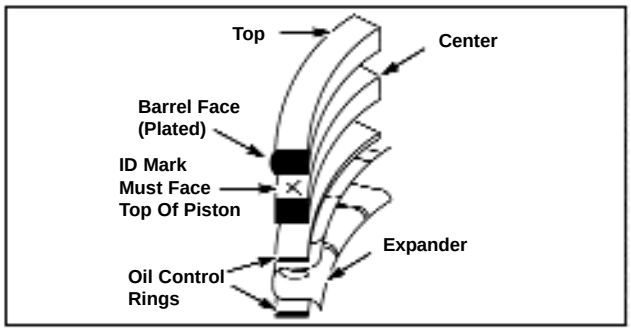


Figure 117 - Piston Ring Installation

4. Tighten compressor until piston cannot be turned in compressor.

5. Then loosen compressor until piston can be turned with slight resistance.

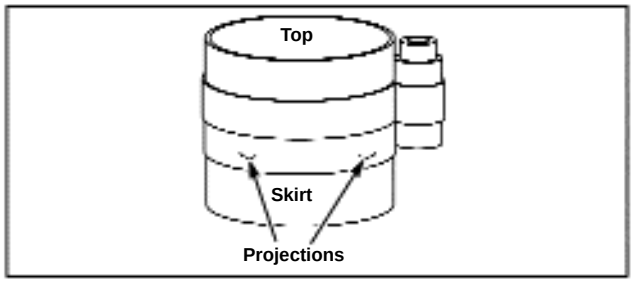


Figure 118 - Ring Compressor

DO NOT ATTEMPT TO INSTALL PISTON AND RING ASSEMBLY WITHOUT RING COMPRESSOR.

Install Connecting Rod and Piston

1. Thoroughly clean and then oil cylinder bore.

2. Rotate crankshaft until crankpin journal is at bottom of stroke.

Note: This permits complete entry of compressed rings, piston and rod assembly, when pushed into cylinder, Figure 119.

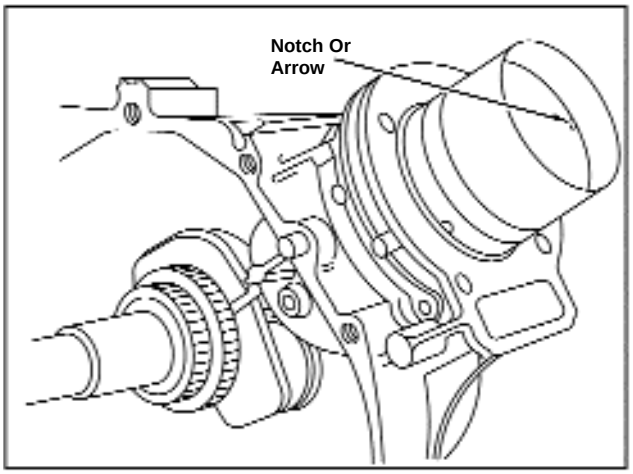


Figure 119 - Installing Piston Assembly

3. Install piston with notch or arrow toward flywheel side of engine, Figure 116, taking care not to damage crankpin journal or connecting rod journal, when installing.

4. Clean and oil crankshaft crankpin.

5. Pull connecting rod against crankpin and install rod cap with match marks aligned, Figure 120.

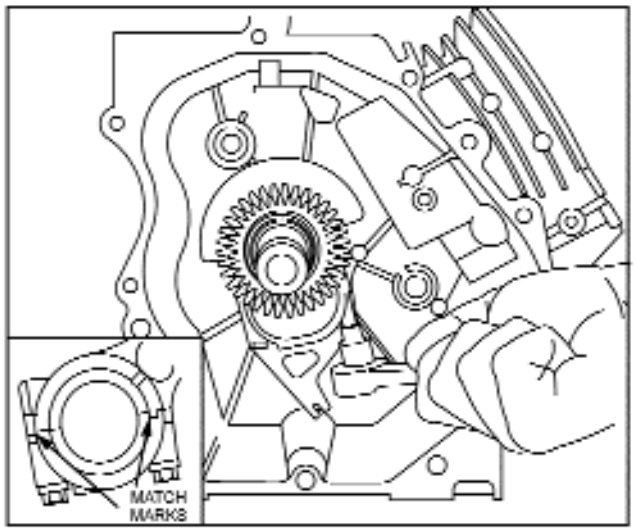


Figure 120 - Rod and Cap Alignment

6. Cap with dipper should snap on when assembled correctly. Install rod screws.

7. Torque connecting rods screws. Set Torque Wrench to specifications listed in Table 8 page 7-47.

Note: Failure to use a torque wrench can result in loose rods causing breakage, or deformed over tightened rods causing scoring.

8. Rotate crankshaft two (2) revolutions to make sure crankpin and rod are not binding during rotation.

9. Move connecting rod sideways to be sure rod slides from side to side.

SPECIFICATION TABLES

Table 14 - Piston Ring Groove Rejects

Model Series	Compression Rings	Oil Control Ring
9 & 13 H.P. Engines	.007” (18 mm)	.007” (18 mm)

Table 15 - Piston Ring End Gap Rejection Size

Model Series	Compression Rings	Oil Ring	Oil Rails
9 & 13 H.P. Engines	.030” (.76 mm)	–	.030” (.76 mm)

Table 16 - Connecting Rod Reject Sizes		
Model Series	**Crankpin Bearings**	**Piston Pin Bearing**
9 H.P. Engine	1.339” (34.01 mm)	.7102” (18.04 mm)
13 H.P. Engine	1.4984” (38.06 mm)	.8028” (20.39 mm)

Table 17- Piston Pin & Piston Pin Bore Reject Size		
Model Series	**Piston Pin**	**Piston Pin Bore**
9 H.P. Engine	.7072” (17.96 mm)	.7102” (18.04 mm)
13 H.P. Engine	.7996” (20.31 mm)	.8028” (20.39 mm)

Table 18 - Connecting Rod Screw Torque	
Model Series	**In. Lbs. (Nm)**
9 H.P. Engine	175 (19.8)
13 H.P. Engine	175 (19.8)

CRANKSHAFTS & CAM GEARS

Removal

Before removing crankshaft from engine, remove rust, paint, or burrs from power take off end of crankshaft. This will eliminate or reduce chances of damaging oil seal, crankcase cover bearing. For Engine Removal, see page 7-32

1. Remove drive belt, starter belt, and drive clutch.
2. Drain oil from crankcase.
3. Remove crankcase cover or sump.
4. If crankcase cover, tap lightly with soft hammer on alternate side near dowel pins, Figure 121.

Note: It is not necessary to remove dowel pins.

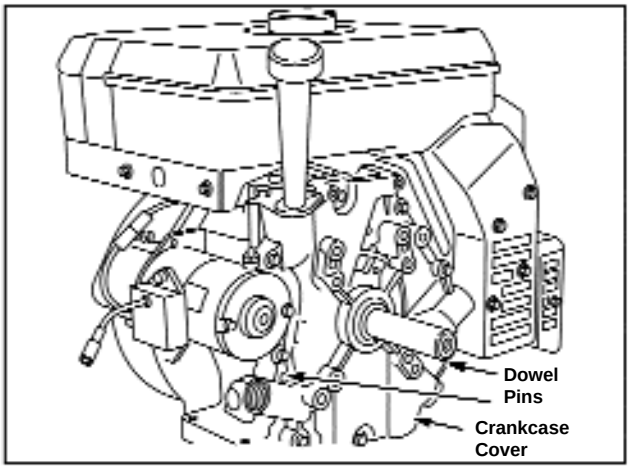


Figure 121 - Removing Crankcase Cover

5. Tip engine towards flywheel side of crankcase.
6. Support engine to prevent end of crankshaft from resting on workbench.
7. Rotate crankshaft until timing marks are aligned.
8. With cam gear in this position, the valve tappets will remain clear of cam lobes. Lift out cam gear. See Figure 122.

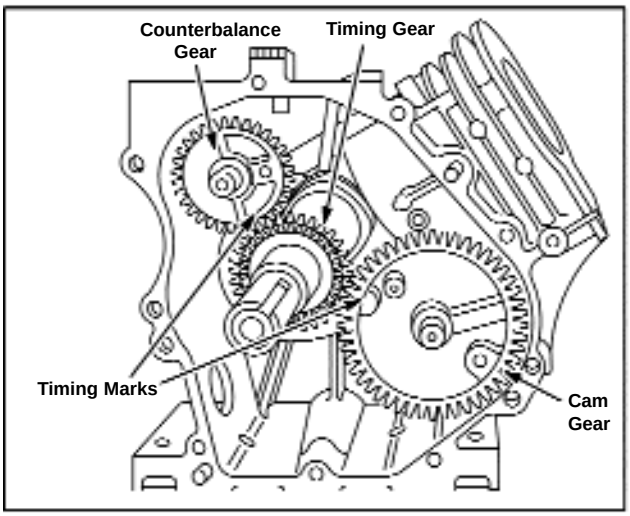


Figure 122 - Removing Cam Gear

9. Remove counterbalance shaft. See page 7-57.

Remove Crankshaft

1. Before crankshaft can be removed, it is necessary to remove flywheel, page 7-28, and connecting rod cap, page 7-44.
2. Rotate crankshaft to position piston at top dead center for ease of removal.
3. Remove crankshaft from crankcase.

Inspect Crankshaft

Table 19 shows reject sizes of various wear points of the crankshaft. Discard crankshaft if worn smaller than size shown. Keyways should be checked to be sure they are not worn or spread. Remove burrs from keyway edges to prevent scratching bearing. Figure123 shows various points to be checked on crankshaft.

Note: Do not straighten bent crankshaft.

Check timing gears for chipped or cracked teeth and keyway for wear. Replace timing gear, if damaged. If timing gear

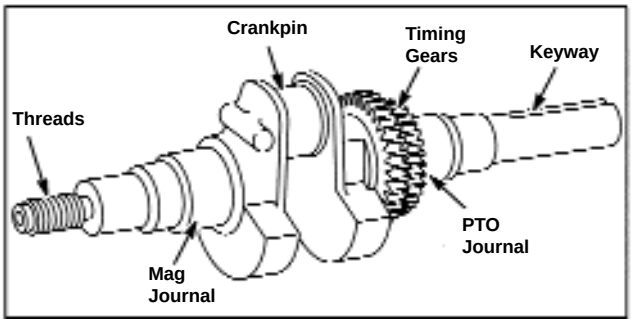


Figure 123 - Crankshaft Check Points, Typical

is chipped or cracked, also check cam gear for damage.

Note: .020" (.51 mm) undersize connecting rods may be obtained for use on reground crankpin journals. Complete instructions are included with undersize rod. (See Illustrated Parts List to find appropriate undersize connecting rod.)

For grinding dimensions of crankpin journal, see Table 20.

Check Cam Gear

Inspect gear teeth for wear and nicks, Figure 124. Cam gear, cam gear journals, and lobe rejection sizes are

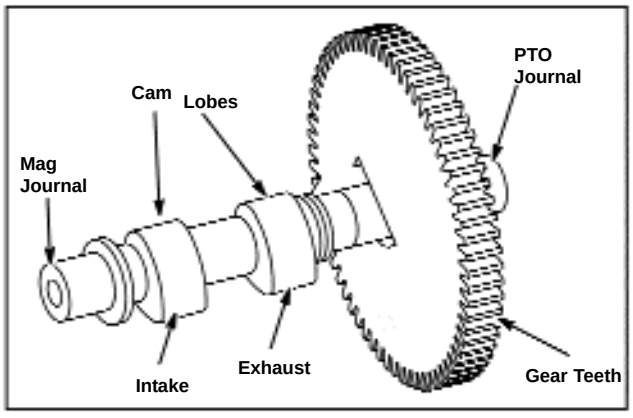


Figure 124 - Cam Gear Check Points, Typical

shown in Table 21. See Figure 124 for other areas to be checked for wear.

Polish Crankshaft Journals

Polish crankshaft with crocus 200 grit cloth until polish lines are uniform over entire journal, Figure 125. Direction of polish lines must be as shown in Figure 125. It is important that crankshaft journal be thoroughly cleaned. Wash journal with a solvent such as kerosene to remove emery residue.

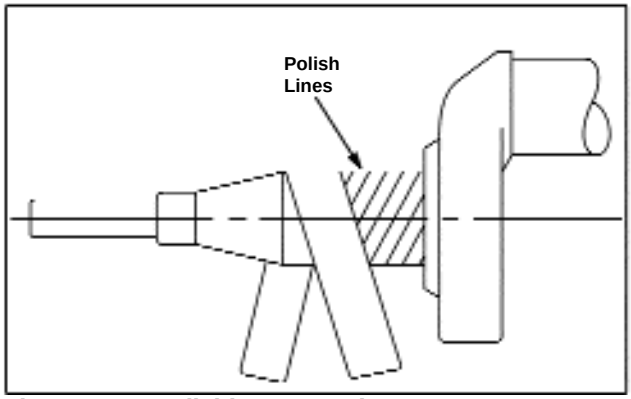


Figure 125 - Polishing Journal

Install Crankshaft

1. Install intake and exhaust valve tappets first.

2. Supporting both ends of crankshaft, install in cylinder.
3. Install connecting rod on crankshaft, page 7-46.

4. Install slip fit timing gear (if removed) with inner chamfer toward crankpin. This assures timing mark will be visible.

5. Install counterbalance shaft and gear, page 7-58.

Install Cam Gear

Install cam gear, making sure tappets clear cam lobes. Timing marks must align. See Figure 126.

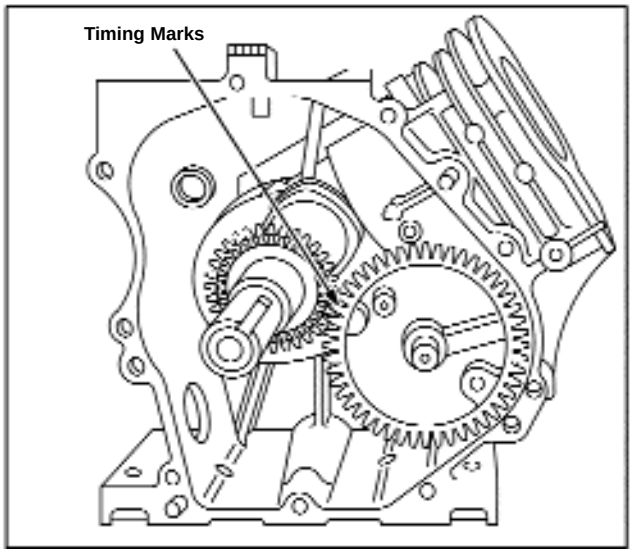


Figure 126 - Aligning Timing Marks, Typical

Install Crankcase Cover

1. Install dowel pins into engine crankcase. Align gasket on to dowel pins.

2. Install crankcase cover. DO NOT FORCE. Gently, seat on to crankcase gasket, taping with mallet at four (4) corners, only if necessary.

3. Install screws and torque in sequence shown: Figure 127, 9 H.P. Engines and Figure 128 13 H.P. Engines

4. See Table 23 for torque values.

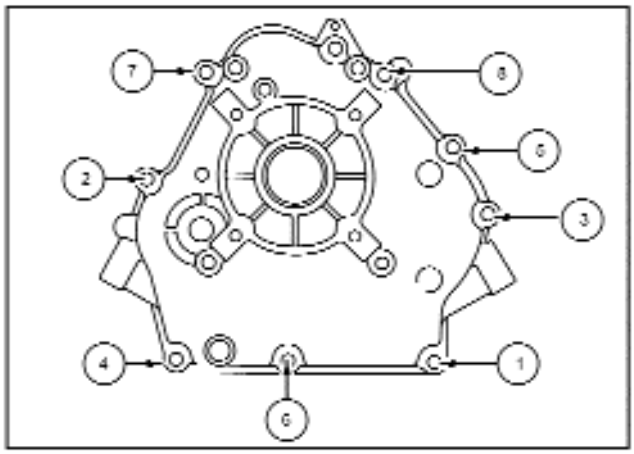


Figure 127 - 9 H.P. Engine, 175 in. lbs. (19.8 Nm)

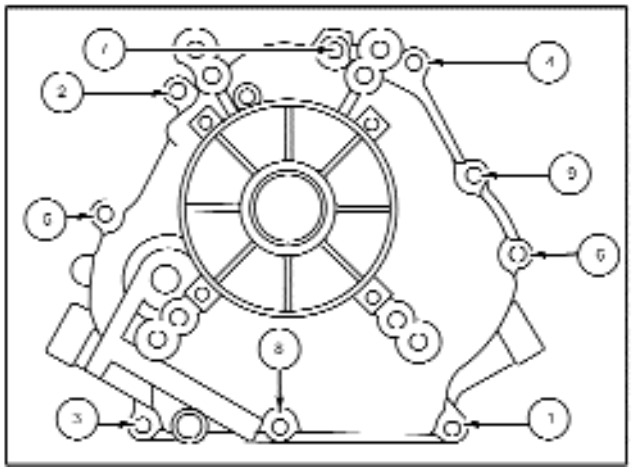


Figure 128 - 13 H.P. Engine, 175 in lbs. (19.8 Nm)

Adjust valve tappet clearances, and install valve cover. See page 7-39.

Check Crankshaft End Play

When crankcase cover or sump is installed with a standard gasket, end play should be as listed in Table 23.

Adjust Crankshaft End Play

If crankshaft end play is more than shown in Table 23, use thrust washers between PTO ball bearing and crankcase cover until correct end play is obtained. See Illustrated Parts List. For proper procedures and tools to remove ball bearings, see pages 7-52 through 7-56.

SPECIFICATION TABLES

Table 19 - Crankshaft Reject Sizes

Model Series	Mag. Journal	Crankpin Journal	PTO Journal	Eccentic
9 H.P. Engine	Ball	1.3368” (33.95 mm)	Ball	–
13 H.P. Engine	Ball	1.4953” (37.98 mm)	Ball	–

Table 20 - Crankshaft Grinding Dimensions for Undersize Connecting Rods

Model Series	.020” .51 mm Undersized Crankpin Size	Fillet Radius	Crank-shaft Throw
9 H.P. Engine	1.3187” 1.3183” (33.49 mm) (33.48 mm)	.090” .078” (1.98 mm) (2.29 mm)	1.1625” (29.58 mm)
13 H.P. Engine	1.5158” 1.5156” (38.502 mm) (38.497 mm)	.110” .087” (2.8 mm) (2.5 mm)	1.244” 1.236” (31.6 mm) (31.4 mm)

Table 21 - Cam Gear Reject Sizes

Model Series	Mag. Journal	PTO Journal	Cam Lobes
9 H.P. Engine	.5875” (14.93 mm)	.5875” (14.93 mm)	–
13 H.P. Engine	.5875” (14.92 mm)	.5875” (14.92 mm)	1.2657” (32.15 mm)

Table 22 - Crankcase Cover or Sump Torque	
Model Series	**In.Lb.**
9 & 13 H.P. Engines	175 (19.7)

Table 23 - Crankshaft End Play	
9 & 13 H.P. Engines	175 (19.7)

CYLINDERS AND BEARINGS

Cylinders

Columbia ParCar/Briggs & Stratton OHV engines use ball bearings to support the crankshaft.

Inspection, All Models

Always, inspect cylinder after engine has been disassembled. Visual inspection will show if there are any cracks, stripped bolt holes, broken fins or if cylinder wall is damaged.

Use a Telescoping Gauge and CPC# 96070-96, Dial Caliper, or inside micrometer to determine size of cylinder bore.

Measure at right angles, Figure 129.
Table 1 lists standard cylinder bore sizes.
If the cylinder bore is more than .003" (.08 mm) oversize, or .0015" (.04 mm) out of round, it must be resized.

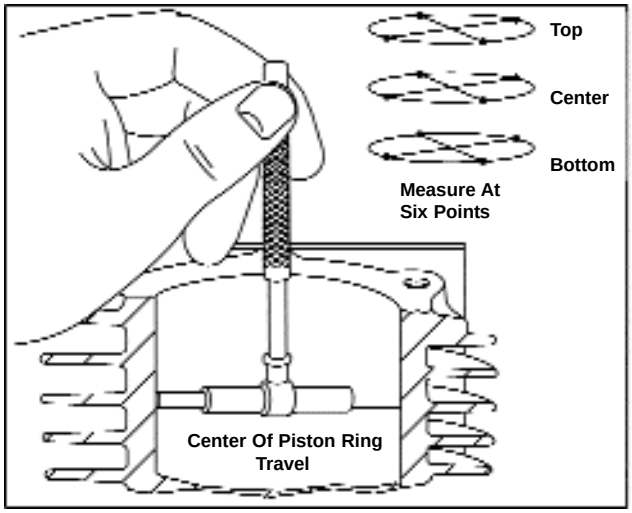


Figure 129 - Checking Cylinder Bore

Note: If cylinder bore is within specification and shows no sign of scoring or other damage, new piston rings may be installed providing cylinder bore is reconditioned using a rigid hone with finishing stones, to restore the proper cross hatch angle in the cylinder bore.

Proper cylinder cross hatch ensures proper lubrication and piston ring rotation. See Cylinder Finish, page 7-52.

Table 24 - Standard Bore Diameter		
Model Series	**Max. Inches**	**Min. Inches**
9 H.P.	3.1504” (80.02 mm)	3.1496” (80.00 mm)
13 H.P.	3.5047” (89.02 mm)	3.5039” (89.00 mm)

Resizing

ALWAYS RESIZE TO EXACTLY .010" OR .020", (.25 MM, OR.50 MM) OVER STANDARD SIZE AS SHOWN IN TABLE 24. IF THIS IS DONE ACCURATELY, THE STOCK OVERSIZE RINGS AND PISTONS WILL FIT PERFECTLY AND PROPER CLEARANCES WILL BE MAINTAINED.

Cylinders can be quickly resized with a good hone such as Briggs & Stratton Tool #19205 with 19303 and 19304 stones or Tool #19211, Hone Sets. Contact your Briggs & Stratton source of supply. Use stones and lubrication recommended by hone manufacturers to produce correct cylinder wall finish.

Note: An acceptable honing oil can be made by mixing 4 parts No. 30 weight oil with 1 part kerosene or use automatic transmission fluid.

Note: If a boring bar is used, a hone must be used after boring operation to produce proper cylinder wall finish.

Honing can be done with a portable variable speed 1/2" electric drill or carpenter's brace, but it is easier to use a drill press, Figure 130.

To Set Up For Honing

Fasten cylinder to a heavy iron bracket or use honing fixture. Some cylinders require shims. Use a level to align drill press spindle with cylinder bore.

Check cylinder bores at top and bottom for burrs. Remove burrs to prevent damage to hone.

Note: Remove ball bearing from cylinder before honing. If honing grit enters ball bearing, rapid wear of the bearing will result. Honing grit is virtually impossible to remove from a ball bearing. See procedure by model number, this section, for removing and installing ball bearing.

Note: Cylinders bores are 30° from the horizontal plane. Honing fixture must hold base of cylinder at 60° from horizontal plane for cylinder bore to be vertical.

Oil surface of drill press table liberally. Set plate and cylinder on drill press table. (Do not anchor to drill press table).

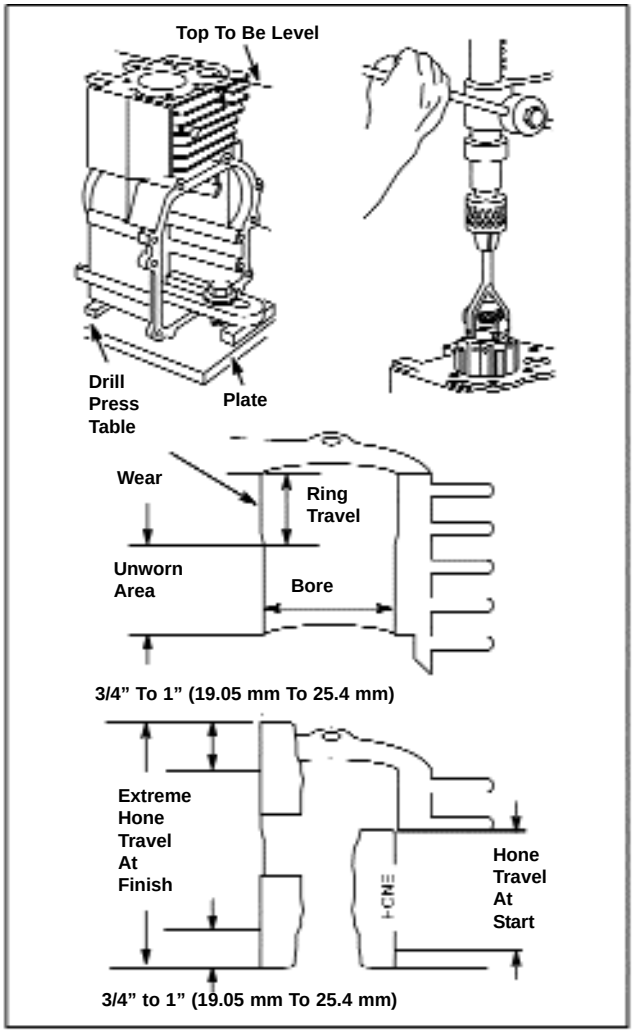


Figure 130 - Honing Set-up, Example

If using portable drill, set plate and cylinder on floor. Place hone drive shaft in chuck of drill or portable drill.

To Hone Cylinder

1. Select hone set and stone set. Place hone in middle of cylinder bore.

2. Tighten adjusting knob with finger or small screwdriver until stones fit snugly against cylinder wall. DO NOT FORCE.

3. Drill press or portable electric drill should operate hone at 300 to 700 RPM.

4. Connect drive shaft to hone. Be sure that cylinder and hone are centered and aligned with drive shaft and drill spindle.

5. Lubricate honing stones and cylinder bore with honing oil.

6. Start drill and as hone spins, move it up and down at lower end of cylinder. Figure 130.

The cylinder is not worn at the bottom but is round so it will guide the hone to straighten cylinder bore.

7. As the bottom of the cylinder increases diameter, gradually increase strokes until hone travels full length of bore.

Do not extend hone more than 3/4" to 1" (19.05 mm to 25.4) mm at either end of cylinder bore.

8. As cutting tension decreases, stop hone and tighten adjusting knob.

9. Check cylinder bore frequently with an accurate micrometer.

10. Hone about .0005" (.01 mm) larger to allow for shrinkage when cylinder cools.

On cast iron sleeve cylinders, change from rough stones to finishing stones when within .0015" (.04 mm) of desired size.

ALWAYS HONE .010" OR .020" (.25 MM OR .50 MM) ABOVE THE STANDARD DIMENSIONS GIVEN IN TABLE 24, PAGE 7-50.

Note: If a boring bar is used, a hone must be used after boring operation to produce proper cylinder wall finish.

Table 25 - Cylinder Hones

Bore Material	Bore Size	Stone Set#	Carrier Set#
Cast Iron	3-1/2” to 2-3/4” (47.63 mm to 69.85 mm)	19303 (60 grit)	19205

Cylinder Finish (Cross Hatch)

The finish on a resized or reconditioned cylinder should have a crosshatch appearance, Figure 131.

Proper stones, lubrication and drill speed along with rapid movement of hone within the cylinder during the last few strokes, will produce this finish. Crosshatching will allow proper lubrication and ring rotation.

Note: To produce the proper cross hatch finish use a drill speed of approximately 200 RPM and 40-60 strokes per minute.

Lubricate hone liberally to prevent build up on finishing stones.

Note: A carpenter's brace can also be used to produce proper crosshatch in cylinder bore.

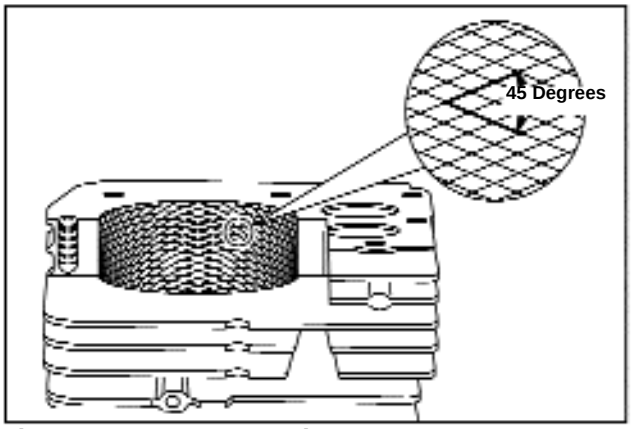


Figure 131 - Cross Hatch

Cylinder Cleaning

1. It is most important that the entire cylinder and crankcase be thoroughly cleaned after honing.

2. First, wash the cylinder and crankcase, carefully, in a solvent such as kerosene or commercial solvent.

3. Then, thoroughly wash cylinder and crankcase using a stiff brush with soap and hot water. Clean until all traces of honing grit are gone.

   Honing grit is highly abrasive and will cause rapid wear to all of the internal components of the engine unless it is completely removed.

BEARINGS

Check Cam Gear Bearings

Replace cylinder or crankcase cover if cam gear bearings are worn more than than shown in Table 26 . If specified plug gauge can be inserted in bearing 1/4" (6.35 mm) or more, replace cylinder or crankcase cover, Figure 132. If gauge is not available, and bearings are worn larger than dimensions shown in Table 26, replace cylinder or crankcase cover.

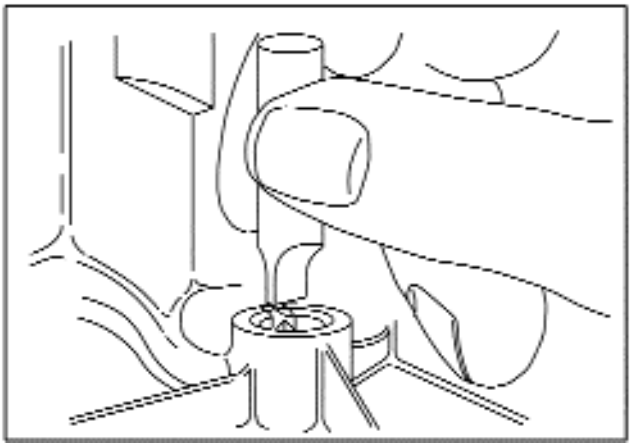


Figure 132 - Checking Cam Gear Bearing

Table 26 - Camshaft Bearing Reject Sizes

Engine	Inches Millimeters (mm)	Gauge #
9 H.P. & 13 H.P.	.593” (15.06 mm)	-

Check Ball Bearings

To check a ball bearing rotate bearing slowly by hand; if any roughness is felt, bearing should be replaced.

Remove Magneto Ball Bearing - 9 H.P. Engines

Bearing Removal Tool Components	
Tool/Part Description	**Tool/Part #**
Washer	95910-96
Puller Screw	95930-96
Driver	95940-96
Support	95951-96

1. Remove oil seal.

2. Assemble Part #9510-96, Washer, to Tool #95930-96, Puller Screw and insert through large end of Tool #95940-96, Driver.

3. Place open side of Tool #95951-96, Support against ball bearing.

4. Insert screw with driver through ball bearing and thread into support. Continue tightening screw until ball bearing is removed, Figure 133.

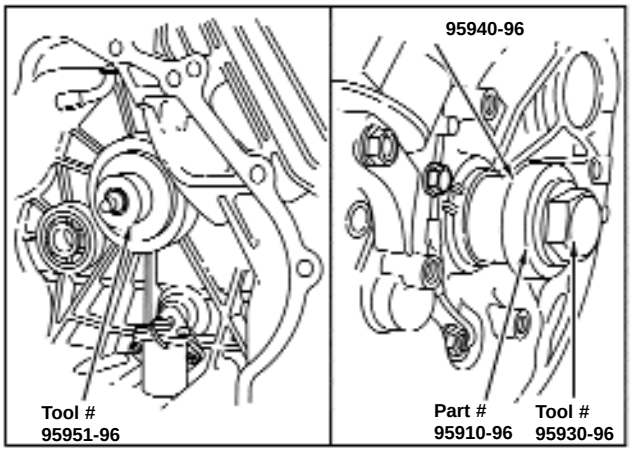


Figure 133 - Removing Bearing - Mag. Side

Install Magneto Ball Bearing - 9 H.P. Engines

Bearing Installation Tools Components	
Tool/Part Description	**Tool/Part #**
Washer	95910-96
Puller Screw	95930-96
Pilot	95950-96
Support	95951-96

1. Lubricate outside diameter of ball bearing before installing.
2. Place ball bearing on to Tool #95951-96, support.
3. Assemble Part #95910-96, Washer to Tool #95930-96, Puller Screw.
4. Insert small end of Tool #95950-96, Pilot into oil seal boss in cylinder.
5. Insert screw through pilot and thread into support. Tighten screw until ball bearing is seated, Figure 134.
6. Install new oil seal. Use large end of Tool #95940-96, Driver, and press in oil seal until flush with cylinder.

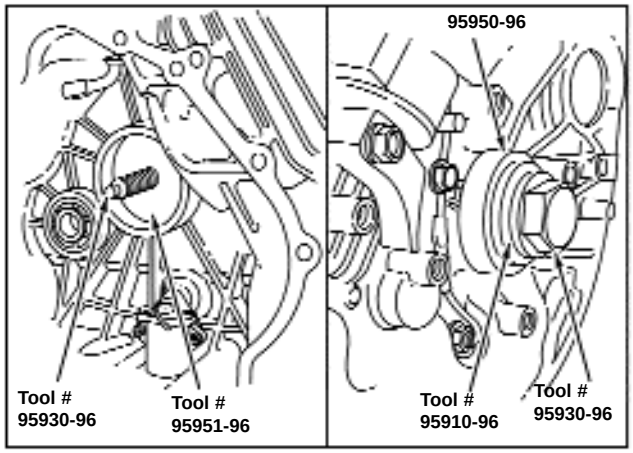


Figure 134- Installing Bearing - Mag. Side

Remove PTO Ball Bearing - 9 H.P. Engines

Bearing Removal Tools Components	
Tool/Part Description	**Tool/Part #**
Washer	95910-96 (2)
Puller Screw	95930-96
Driver	95940-96
Support	95951-96

1. Remove oil seal.
2. Assemble Part #95910-96, Washer to Tool #95930-96, Puller Screw and insert through large end of Tool #95940-96, Driver.
3. Then, assemble a second washer over puller screw up against bushing.
4. Place open side of Tool #95951-96 support against ball bearing.
5. Insert screw with bushing and washer through ball bearing and thread into support.
6. Continue tightening screw until ball bearing is removed, Figure 135.

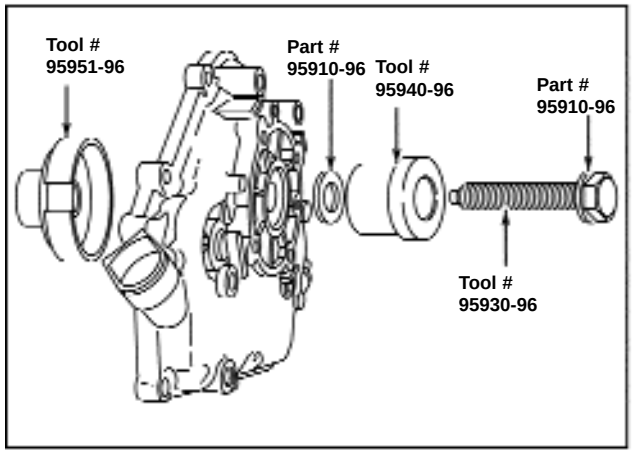


Figure 135 - Removing Bearing - PTO Side

Install PTO Ball Bearing - 9 H.P. Engines

Bearing Installation Tools Components	
Tool/Part Description	**Tool/Part #**
Washer	95910-96
Puller Screw	95930-96
Pilot	95950-96
Support	95951-96

1. Lubricate outside diameter of ball bearing before installing. Install shim(s) if used.
2. Place ball bearing on Tool #95951-96, Support.
3. Assemble Part #9591-96, Washer, to Tool #95930-96, Puller Screw.
4. Insert large end of Tool #95950-96 Pilot into oil seal boss in crankcase cover.
5. Insert screw through pilot and thread into support. Tighten screw until ball bearing is seated, Figure 136.

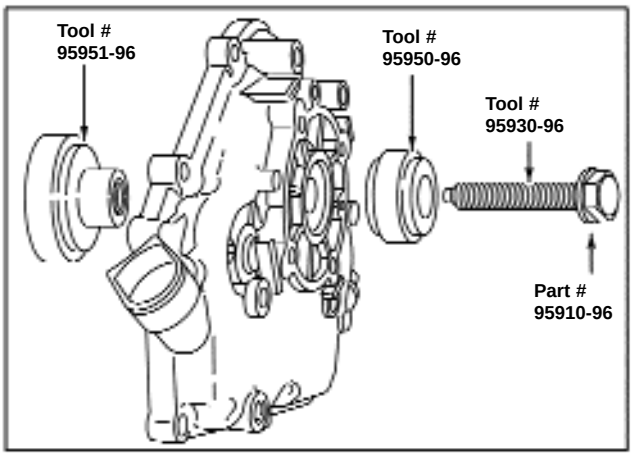


Figure 136 - Installing Bearing - PTO Side

6. Install new oil seal. Use large end of Tool #95940-96, Driver, and press in oil seal until flush with crankcase cover.

Remove Magneto Ball Bearing - 13 H.P. Engines

Bearing Installation Tools	
Tool/Part Description	**Tool/Part #**
Washer	9510-96
Puller Screw	95930-96
Pilot	95950-96
Support	95951-96

1. Remove oil seal.

2. Assemble Part #95910-96, Washer, to Tool #95930-96, Puller Screw and insert through large end of Tool #95940-96 Driver.

3. Place open side of Tool #95951-96, Support against ball bearing.

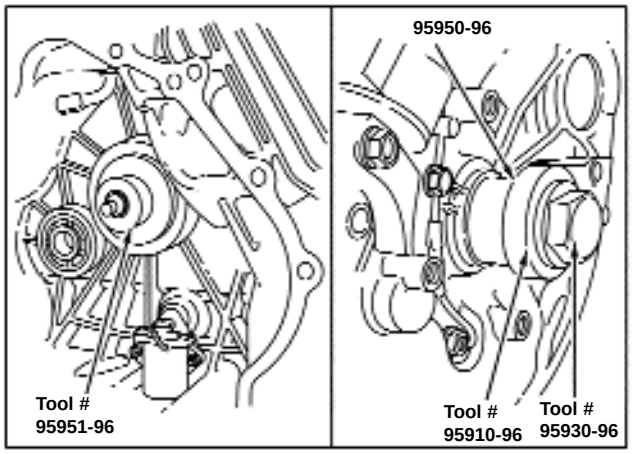


Figure 137 - Removing Bearing - Mag. Side

4. Insert screw with driver through ball bearing and thread into support. Continue tightening screw until ball bearing is removed, Figure 137.

Bearing Installation Tool Components	
Tool/Part Description	**Tool/Part #**
Washer	95910-96
Puller Screw	95930-96
Pilot	95950-96
Support	95951-96

Install Magneto Ball Bearing - 13 H.P. Engines

1. Lubricate outside diameter of ball bearing before installing.

2. Place ball bearing on to Tool #95951-96, Support.

3. Assemble Part #95910-96, Washer to Tool #95930-96, Puller Screw.

4. Insert small end of Tool #95950-96, Pilot into oil seal boss in cylinder.

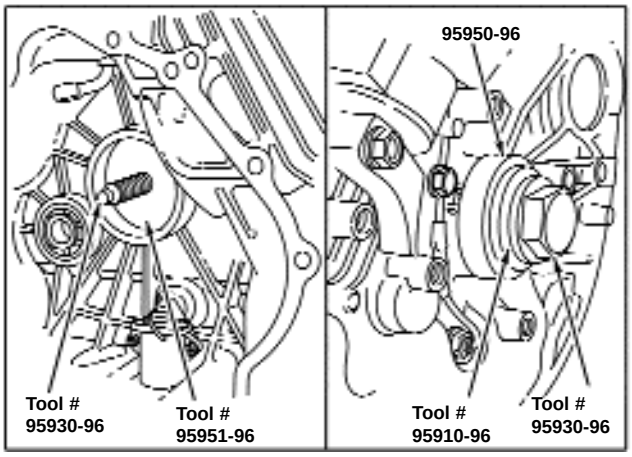


Figure 138 - Installing Bearing - Mag. Side

5. Insert screw through pilot and thread into support. Tighten screw until ball bearing is seated, Figure 138.

Bearing Removal Tool Components	
Tool/Part Description	**Tool/Part #**
Washer	95910-96 (2)
Puller Screw	95930-96
Driver	95940-96
Support	95951-96

Remove PTO Ball Bearing - 13 H.P. Engines

1. Remove oil seal.

2. Assemble Part #95910-96, Washer to Tool #95930-96, Puller Screw and insert through large end of Tool #95940-96, Driver.

3. Then, assemble a second washer over puller screw up against bushing.

4. Place open side of Tool #95951-96, Support against ball bearing with notch of support over two (2) ribs on crankcase cover, Figure 139.

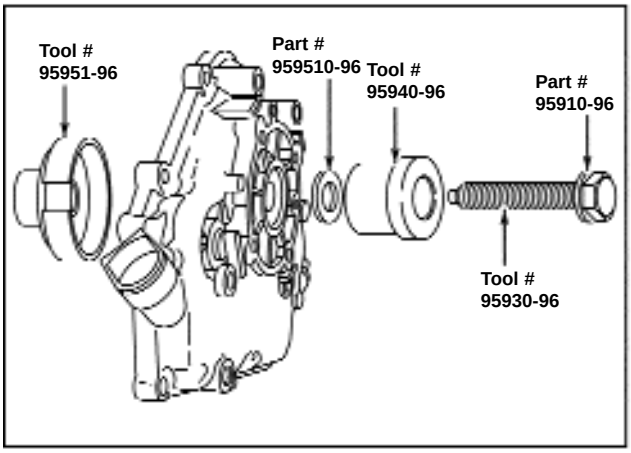


Figure 139 - Removing Bearing - PTO Side

5. Insert screw with bushing and washer through ball bearing and thread into support.

6. Continue tightening screw until ball bearing is removed, Figure 139.

Install PTO Ball Bearing - 13 H.P. Engines

Bearing Installation Tools Components	
Tool/Part Description	**Tool/Part #**
Washer	95910-96
Puller Screw	95930-96
Pilot	95950-96
Support	95951-96

1. Lubricate outside diameter of ball bearing before installing. Install shim(s) if used.

2. Place ball bearing on Tool #95951-96, support.

3. Assemble Part #95910-96 Washer, to Tool #95930-96, Puller Screw.

4. Insert large end of Tool #95950-96, Pilot into oil seal boss in crankcase cover.

5. Insert screw through pilot and thread into support. Tighten screw until ball bearing is seated, Figure 140.

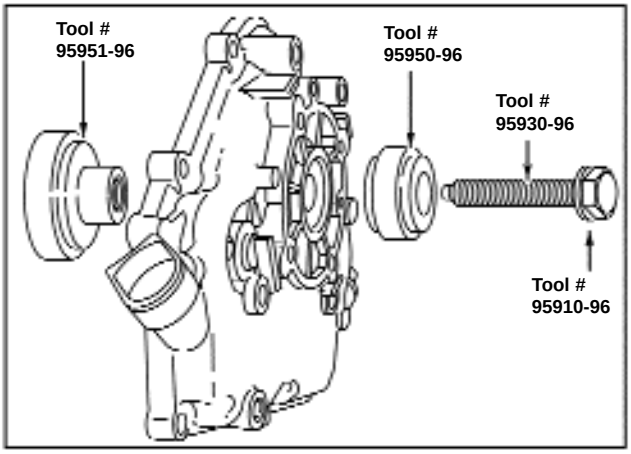


Figure 140 - Installing Bearing - PTO Side

6. Install new oil seal. Use large end of Tool #95940-96, Driver, and press in oil seal until flush with crankcase cover.

Remove Synchro-Balance® Ball Bearings

Bearing Removal Tools Components	
Tool/Part Description	**Tool/Part #**
Puller Nut	95952-96
Puller Stand Off	95953-96
Nut-Hex	From Tool 95900-96
Screw-Hex	From Tool 95900-96

1. Remove Hex Nut and Hex Screw (from Tool #95900-96, Flywheel Puller) from puller.

2. Place a flat washer with 1/4" hole, on screw assembly and insert through hole in Tool #95953-96 Puller Stand Off.

3. Thread screw into Tool #95952-96, Puller Nut. **Do not** have end of hex screw extend through puller nut.

4. Insert assembly into inside diameter of ball bearing until puller nut engages inner race.

5. Turn nut down unto Tool #95953-96, Puller Stand Off.

6. While holding puller screw from turning, turn nut until ball bearing is free, Figure 141.

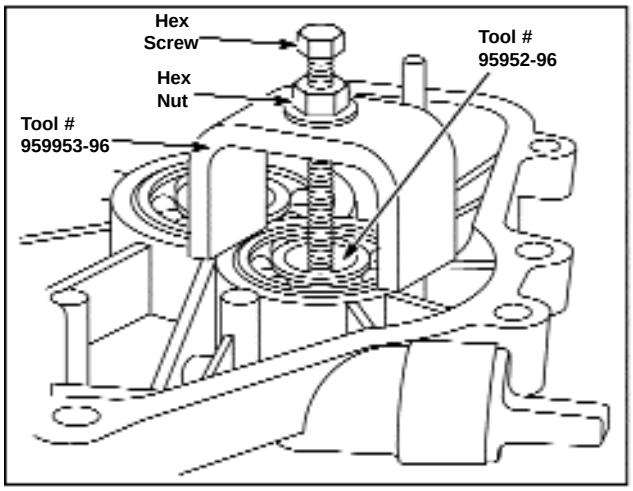


Figure 141 - Removing Ball Bearing

Install Synchro-Balance® Ball Bearings

Bearing Installation Tools Components	
Tool/Part Description	**Tool/Part #**
Driver	95940-96

1. Oil out side diameter of new ball bearing.

2. Using an arbor press and Tool #95940-96 Driver, press in ball bearing until it bottoms, Figure 142.

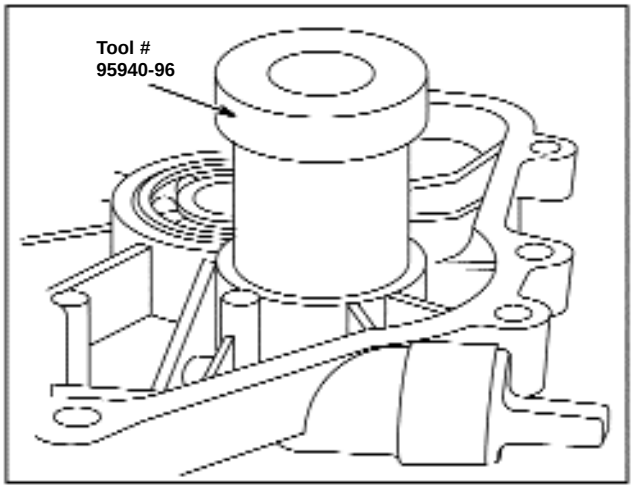


Figure 142- Install Ball Bearing

Oil Seals

Always, install new oil seals whenever engine is disassembled for major servicing or when replacing bearings.

Crankcase Cover

Installation

Protect oil seal when installing crankcase cover or sump. DO NOT FORCE COVER OR SUMP. Make sure mechanical governor gear and oil pump (when used) is engaged with cam gear.

1. For adjustment procedure for crankshaft end play, see page 7-49.

2. Torque crankcase cover screws in sequence shown in Figures 143 and 144.

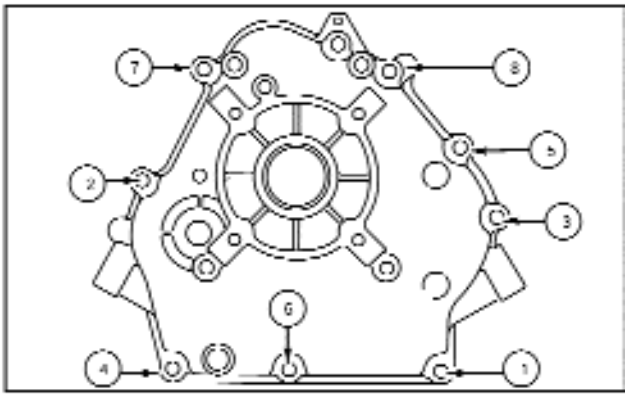


Figure 143 - Torque Sequence, 9 H.P. Engine (175 in. lbs.) (19.8 Nm)

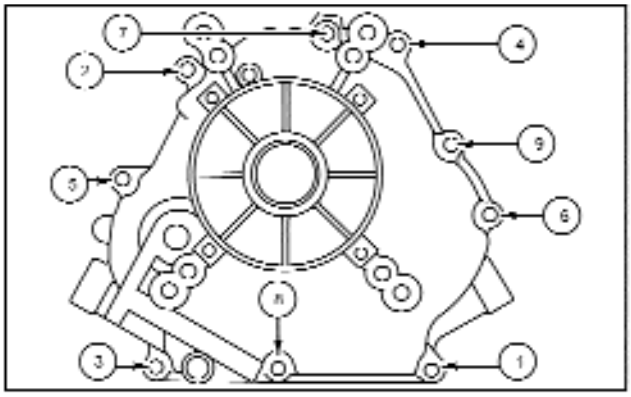


Figure 144 - 13 H.P. Engine (175 in. lbs.) (19.8 Nm)

Specification Tables

Table 27- Standard Bore

Model Series	Standard Bore Diameter	
	Magneto Bearing	PTO Bearing
9 H.P. Engine	3.1504” (80.02 mm)	3.1496” (80.00 mm)
13 H.P. Engine	3.5047” (89.02 mm)	3.5039” (89.00 mm)

Table 28 - Cylinder Bearing Reject Size Chart		
Model Series	Magneto Bearing	PTO Bearing
9 H.P. Engine	Ball	Ball
13 H.P. Engine	Ball	

Table 29 - Cam Gear Bearing Reject Size		
Model Series	Inches Millimeters	Gauge #
9 & 13 H.P. Engines	.593” (15.06 mm)	–

Table 30 - Crankcase Cover or Sump Torque	
Model Series	In.Lb. NM
9 & 13 H.P. Engines	175 (19.7)

SYNCHRO-BALANCE® SYSTEM

Description

The Columbia ParCar/Briggs & Stratton Engine uses a geared rotating counterweight that rotates in the opposite direction to the crankshaft counterweights, Figure 145.

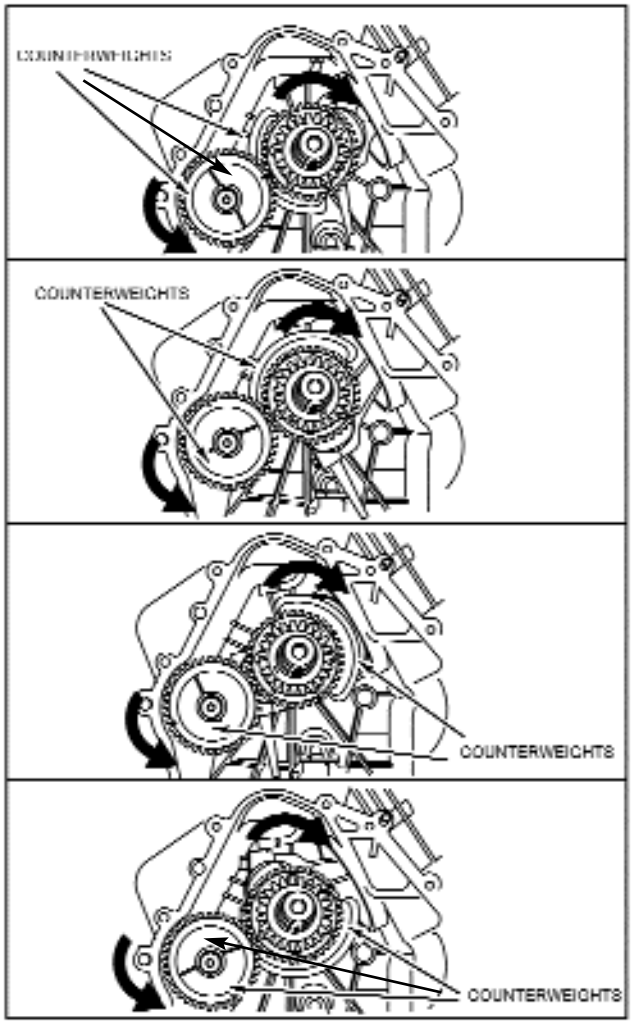


Figure 145 - Rotating Counterweight

Remove Rotating Counterweight Shaft

1. Remove crankcase cover, page 7-47.

2. Turn crankshaft to align timing marks on crankshaft gear and counterweight shaft gear, Figure 146. Remove shaft.

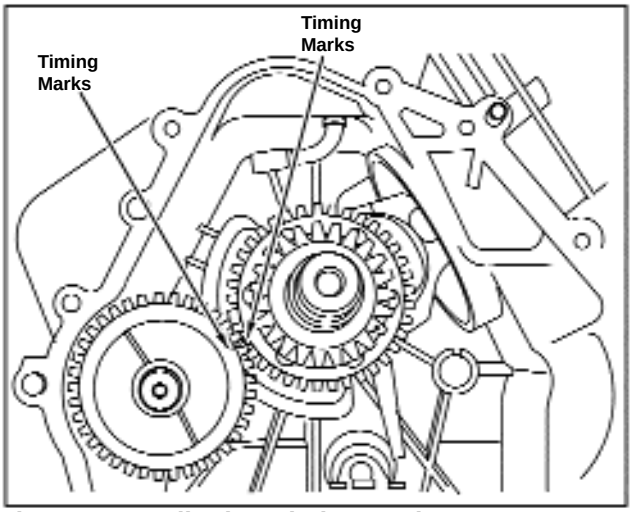


Figure 146 - Aligning Timing Marks

Inspect Counterweight Shaft

Inspect bearings and gear teeth for wear, scoring, or damage, Figure 147. Replace if damaged.

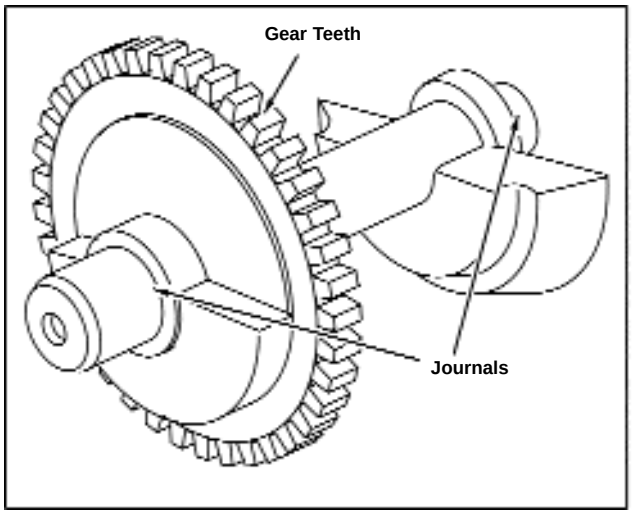


Figure 147 - Inspecting Counterweight Shaft

Install Rotating Counterweight Shaft

1. Turn crankshaft to align timing marks on cam gear and crankshaft gear, Figure 148.

2. Install counterweight shaft into crankcase, and align timing mark on gear with second timing mark on crankshaft gear, Figure 148.

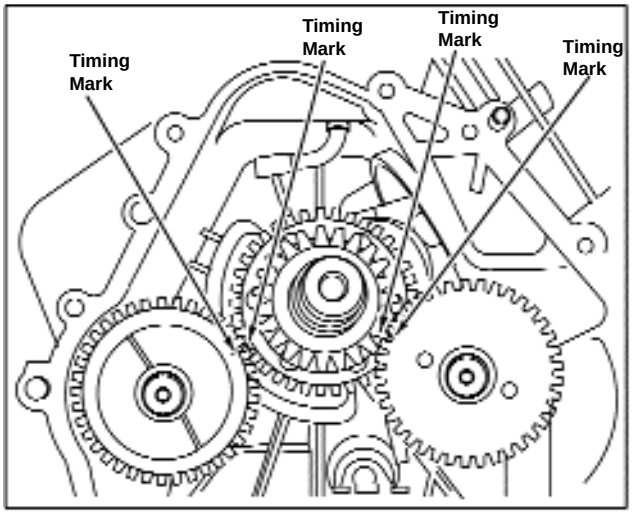


Figure 148 - Installing Counterweight Shaft

3. Install crankcase cover, page 7-56.

EXHAUST SYSTEM

Operation

Exhaust system is used to muffle engine exhaust noise and direct engine exhaust gases out under rear of vehicle. Exhaust system requires no routine maintenance, other than occasional inspection. Removal may be required for access to other vehicle components.

For best results, follow instructions and order of disassembly and reassembly closely.

Removal of Exhaust System

Caution: Always, remove key from switch and disconnect battery negative cable before performing any service.

Warning: Hot exhaust could cause severe burns. Always, allow engine and exhaust to cool completely before beginning service or repair.

1. Use pliers or a spring installation tool to remove two springs, connecting exhaust pipe to muffler inlet pipe.

Figure 149 - Remove Retaining Springs

2. Remove two worm gear clamps holding muffler to muffler support cradle. Lift muffler from engine compartment. See Figure 150.

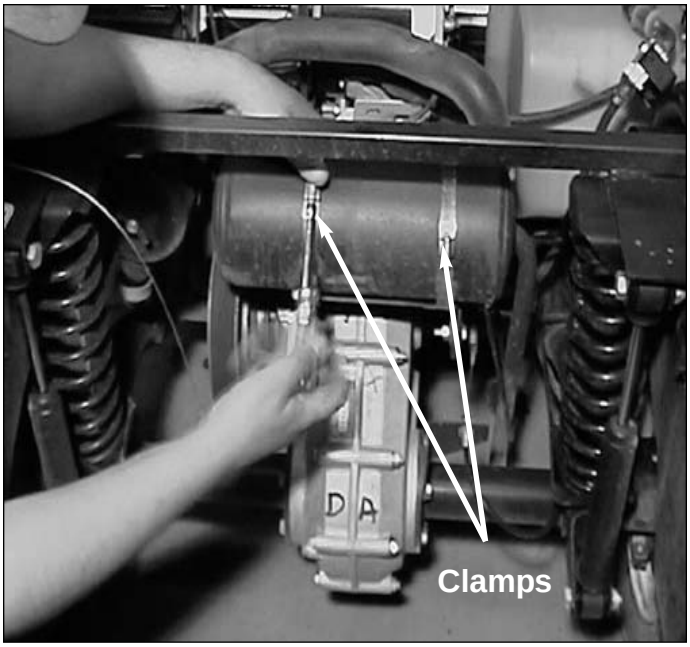


Figure 150 - Remove Worm Gear Clamps

3. Remove choke cable mounting bracket from tab at front of muffler cradle. See Figure 151.

Figure 151 - Remove Choke Cable From Muffler

4. Remove four bolts securing muffler cradle to left and right supports, and set aside. Upon installation, bolts must be inserted from inside.

5. Remove two nuts and washers from engine exhaust pipe. Remove engine exhaust pipe and gasket. See Figure 152.

Note: Do not leave engine exhaust port exposed longer than necessary. Cover with shop towel to prevent debris from entering engine if assembly is to be delayed.

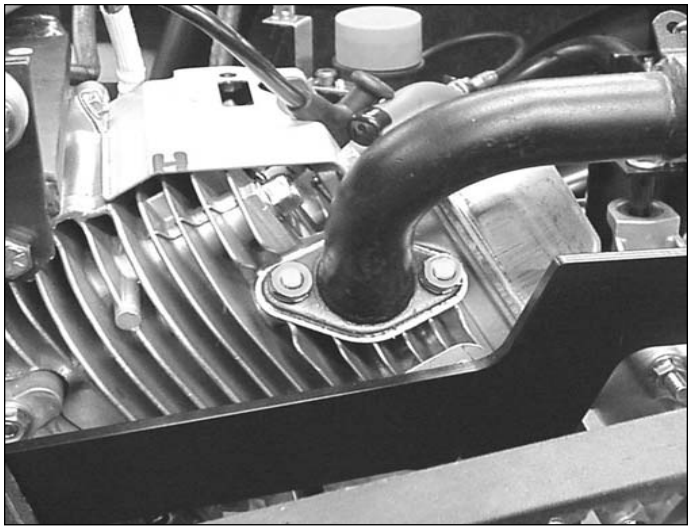


Figure 152 - Engine Exhaust Pipe

Installation of Exhaust System

1. Install engine exhaust pipe to engine using new exhaust gasket. Torque nuts evenly to 175 in. lbs. (19.6 N.m.). See Figure 152.

2. Install muffler support cradle loosely, insert bolts from inside pointing out. Do not tighten hardware at this time.

3. Clean engine exhaust pipe end thoroughly, apply a 3/16 wide bead of high temperature exhaust sealant around end of engine exhaust pipe. Allow to air dry for 15 minutes before muffler installation. See Figure 153.

Figure 153 - Apply Sealant

4. Clean thoroughly inlet pipe opening of muffler. Set muffler into muffler cradle, inserting engine exhaust pipe into muffler inlet pipe opening.

5. Connect two springs securing engine exhaust pipe to muffler inlet pipe. See Figure 149.

6. Install two worm gear clamps around muffler.

Note: Position screw ends of clamps at approximately 10 O'clock position, as shown in Figure 150.

7. Lift muffler and cradle to align horizontally with engine exhaust pipe. While holding muffler cradle in place, tighten four muffler cradle mounting bolts to 18 ft. lbs.(24.4 N.m.).

   Note: For best results, do not start engine for 12 hours after installation of exhaust sealant. This allows sealant to cure completely before use.

Caution: Always follow the order of assembly above, or exhaust system breakage or damage could result.

CHAPTER 8

ELECTRICAL SYSTEMS & COMPONENTS — PAGE

CHAPTER 8

ELECTRICAL SYSTEMS & COMPONENTS (Continued) PAGE

CHAPTER 8

ELECTRICAL SYSTEMS & COMPONENTS (Continued) PAGE

GAS VEHICLE ELECTRICAL SYSTEM & COMPONENTS

Operation

The electrical system used on gas powered vehicles, consists of five separate circuits. These circuits are:

1. Control circuit, starting circuit.
2. Motor circuit, starter.
3. Reverse buzzer circuit.
4. Engine ignition & ignition ground circuit.
5. Generator/voltage regulator circuit.

Each are illustrated in the wiring schematic. See Figure 1.

Caution: The electrical system used on gas vehicles has been designed for harsh environments. This system uses dedicated ground paths, as opposed to chassis grounds. If electrical accessories are added, using a chassis ground, care must be taken to properly ground the chassis to support added accessories. Failure to upgrade chassis grounds, or use dedicated ground paths, will result in electrical short and damage to vehicle.

Micro Switches

The gas vehicle electrical system uses several micro switches to perform specific duties. These switches may occasionally require adjustment. Micro switches are used to complete or to disconnect electrical circuits. Use the following guide for adjustment of specific switches.

Accelerator Micro Switch

Warning: Always, raise vehicle rear wheels and safely support on jack stands before performing the following adjustments. Failure to follow this warning could cause accident and injury.

The accelerator micro switch is used to start and stop engine. As accelerator is depressed, accelerator micro switch completes the starter/generator control circuit, energizing the starting solenoid. To adjust accelerator micro switch:

1. Connect a digital volt/ohm meter (VOM) red positive lead to the battery B+ terminal and black negative lead to starting solenoid small terminal (with dark blue wire). Select DC voltage scale adequate to read 12 DC volts.

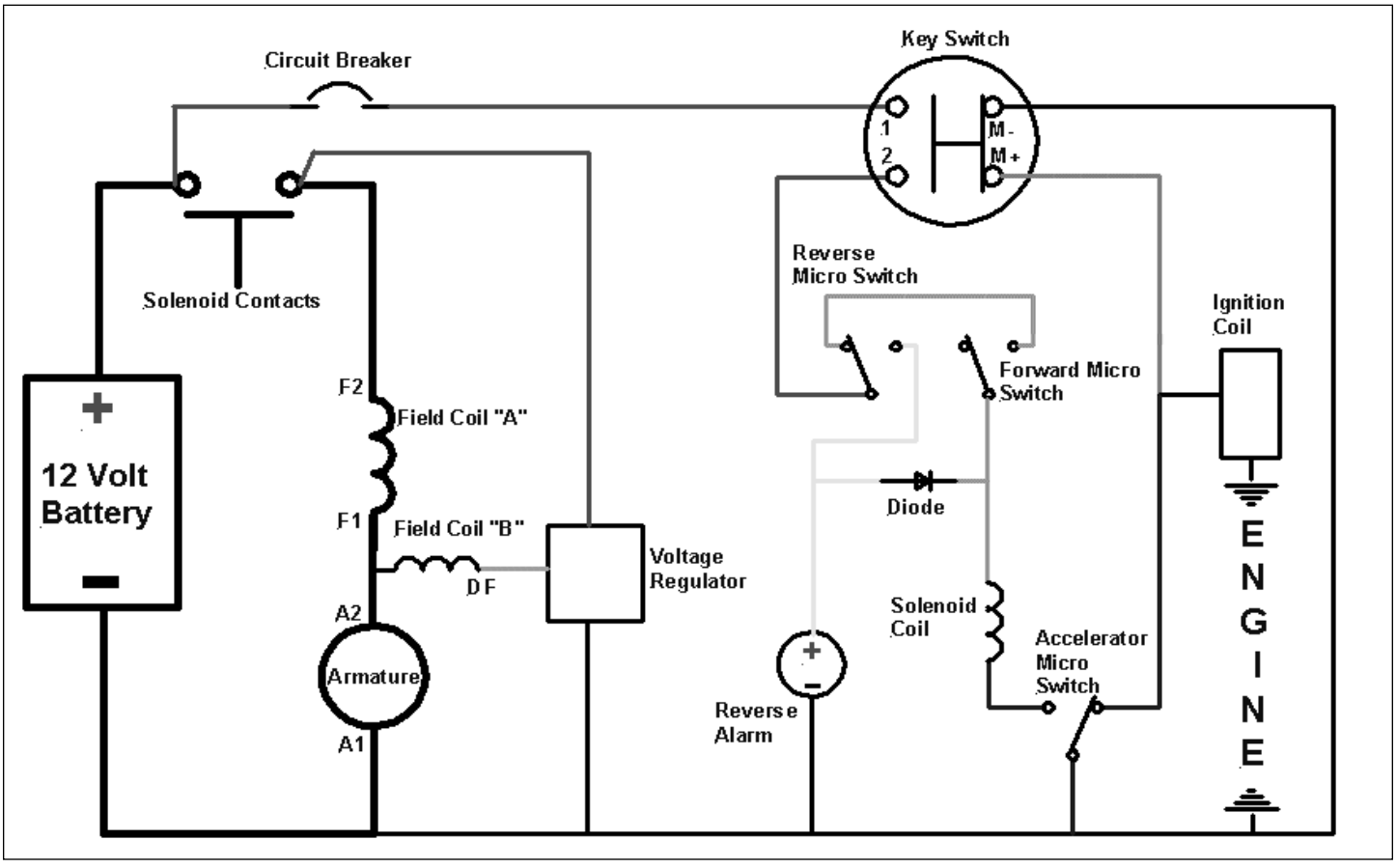


Figure 1 - Gas Vehicle Schematic

2. Set park brake. As accelerator is depressed (and accelerator micro switch is released), battery voltage will be observed. This indicates the switch has activated the starting circuit.

Note: The switch should not activate starting circuit until park brake is released.

If switch activates before park brake is released, switch must be adjusted. See also Throttle Cable Adjustment, Chapter 2, for synchronizing micro switch and throttle opening adjustments.

3. If micro switch requires adjustment, loosen two screws mounting accelerator micro switch to micro switch bracket. With screws loosened, micro switch will move and rotate for adjustment. If greater range of adjustment is required, accelerator linkage rod length can be adjusted. See Figure 2.

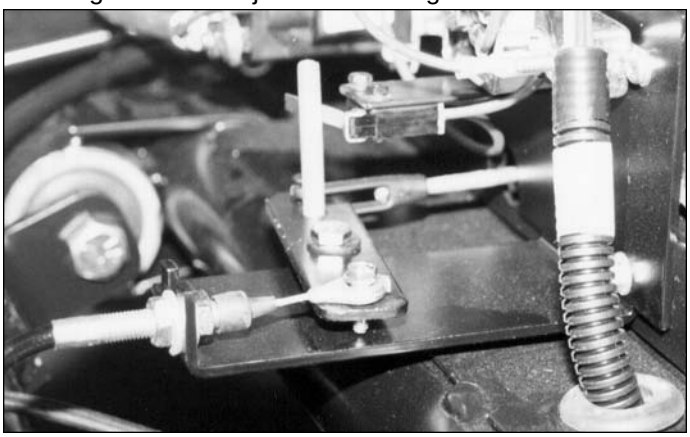


Figure 2 - Accelerator Micro Switch

Caution: Excessive tightening of micro switch screws could cause switch failure. Use care to not over tighten screws.

Console Shifter Micro Switch Adjustment

Warning: Always, raise vehicle's rear wheels and safely support on jack stands before performing following adjustments. Failure to follow this warning could cause accident and injury.

The console mounted shift assembly uses two micro switches as a safety, to prevent accidental starting of engine while shifting forward & reverse lever. One of these micro switches is also used to energize the reverse warning alarm. Incorrect adjustment of either micro switch could cause damage to switch or intermittent starting problems with vehicle. To adjust console shift assembly micro switches:

1. Connect a digital volt /ohm (VOM) meter red positive lead to starting solenoid, small terminal with orange wire.

Connect black negative lead to battery negative (B-) terminal. Select DC voltage scale adequate to read 12 DC volts. Turn key switch to on position.

2. While observing VOM, slowly operate shift lever to reverse and back to forward position. Each micro switch should energize the circuit shortly before shift lever comes to rest at end of shifting lever travel.

3. If in either direction the micro switch does not energize the circuit, or if the circuit is energized as the shift lever comes to rest, micro switch adjustment will be required. See Chapter 2 for Front Body Removal before continuing.

4. Locate forward or reverse micro switch to be adjusted. See Figure 3. Loosen micro switch mount screws and move switch so that shift lever will completely depress switch. Tighten screws. Recheck that circuit is energized shortly before shift lever comes to rest at end of shifting lever travel.

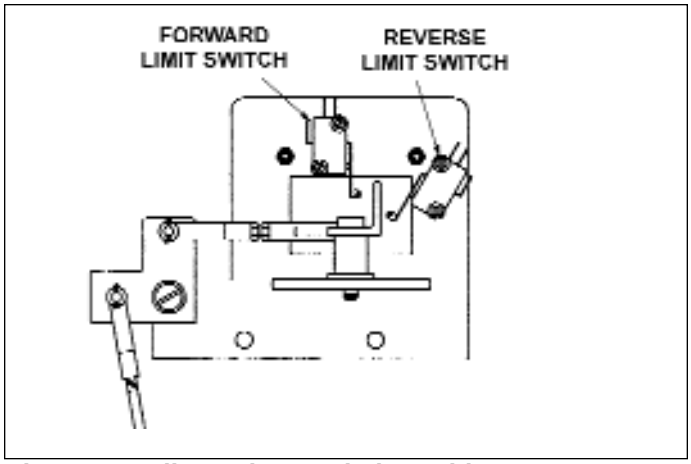


Figure 3 - Adjust Micro Switch Position

5. If after adjustment switch still does not energize circuit or if voltage is less than battery voltage by 10% or more, replace defective micro switch.

Gas Vehicle Key Switch

Equipment needed for test: Battery powered continuity tester or ohmmeter set at 1 K ohms or higher.

With key switch wires disconnected:

1. Switch in OFF position. There should be continuity between M-1 and M-2 terminals.

2. Switch in OFF position. There should NOT be continuity between #1 and #2 terminals.

3. Switch in ON position. There should NOT be continuity between M-1 and M-2 terminals.

4. Switch in ON position. There should be continuity between #1 and #2 terminals. See Figure 4.

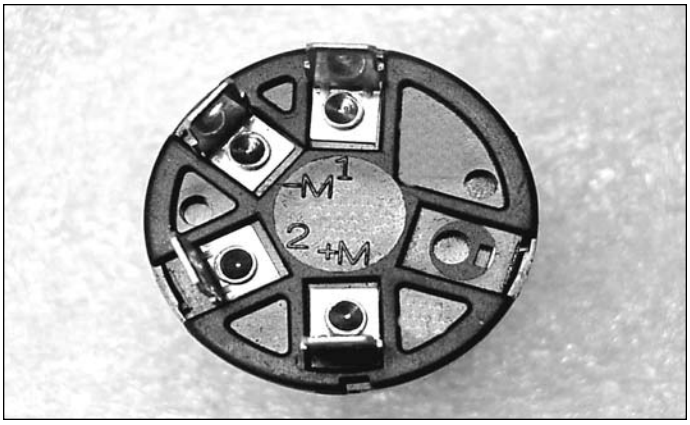


Figure 4- Key Switch Contacts

Electrical System Testing

The electrical system used in Columbia ParCar gas vehicles is designed to be simple and reliable. All circuits of the electrical system can be tested with a digital volt/ohm meter.

The testing process includes voltage tests designed to dynamically test all components in place on the vehicle. It will not be necessary to remove components from the vehicle for testing.

Warning: Always, raise vehicle and safely support on jack stands before servicing electrical system. If engine is to be operated, use care to keep all clothing, hands, tools and other objects away from moving parts.

Caution: Always, check that vehicle battery is fully charged and tested before vehicle electrical system is checked. See Gas Vehicle battery, page 8-14 for details regarding battery testing and charging.

Trouble Shooting Guide

Vehicle "Clicks", But Starter Does Not Spin Engine		
Test	**Results**	
	Good	**Bad**
Voltmeter red positive lead to starter solenoid, small terminal with orange wire. Voltmeter black negative lead to starter solenoid, small terminal with dark blue wire. Key switch on, select forward or reverse and depress accelerator.	If 10 DC volts or greater is observed, continue to next step.	If less than 10 DC volts, refer to **Vehicle will not click or spin engine to start.**
Voltmeter red positive lead to starter solenoid, large terminal with battery positive cable. Voltmeter black negative lead to battery negative (B-) terminal. Key switch on, select forward or reverse and depress accelerator.	If 10 DC volts or greater, continue to next test.	If less than 10 DC volts, charge or test battery, check battery cable connections for corrosion or loose connections.
Voltmeter red positive lead to starter solenoid, large terminal opposite battery positive cable. Voltmeter black negative lead to battery negative (B-) terminal. Key switch on, select forward or reverse and depress accelerator.	If 10 DC volts or greater, continue to next test.	If less than 10 DC volts, replace starting solenoid.
Voltmeter red positive lead to starter/generator F-2 terminal. Voltmeter black negative lead to battery negative (B-) terminal. Key switch on, select forward or reverse and depress accelerator.	If greater than 10 DC volts, proceed to next test.	If less than 10 DC volts, check cable from starting solenoid to F-2 terminal for damage or loose connections.
Voltmeter red positive lead to starter/generator F-2 terminal. Voltmeter black negative lead to starter/generator A-1 terminal. Key switch on, select forward or reverse and depress accelerator.	If greater than 10 DC volts, proceed to next test.	If less than 10 DC volts, check cable from battery (B-) terminal for corrosion or incorrect wiring connections. See wire diagram, Figure 1.
Voltmeter red positive lead to starter/generator F-1 terminal. Voltmeter black negative lead to starter/generator A-1 terminal. Key switch on, select forward or reverse and depress accelerator.	If greater than 10 DC volts, proceed to next test.	If less than 10 DC volts, starter/generator field coil is damaged or shorted. See page 8-9 for details regarding repair of starter/generator.
Voltmeter red positive lead to starter/generator A-2 terminal. Voltmeter black negative lead to starter/generator A-1 terminal. Key switch on, select forward or reverse and depress accelerator.	If greater than 10 DC volts, brushes or armature repair will be required. See page 8-9 for details regarding repair of starter/generator.	If less than 10 DC volts, check cable connecting F-1 terminal to A-2 for damage or loose connections. Check also that battery negative cable is correctly connected to the starter/generator A-1 terminal before proceeding.

Vehicle Will Not Click or Spin Engine To Start (Forward or Reverse)

Test	Results	
	Good	**Bad**
Voltmeter red positive lead to starter solenoid, small terminal with orange wire and black negative lead to starter solenoid, small terminal with dark blue wire. Key switch on, select forward or reverse and depress accelerator.	If less than 10 DC volts, proceed to next step.	If 10 DC volts or greater is observed, refer to vehicle "clicks", but starter does not spin engine, step #2 & 3.
Voltmeter red positive lead to battery positive terminal and black negative lead to starter solenoid, small terminal with dark blue wire. Depress accelerator.	If 10 DC volts or greater is observed, continue to next step.	If less than 10 DC volts, check accelerator micro switch wire connections and test micro switch. Replace accelerator micro switch if necessary.
Voltmeter red positive lead to circuit breaker, double tab terminal and black negative lead to battery negative (B-) terminal.	If greater than 10 DC volts, continue to next test.	If less than 10 DC volts, move red positive lead to circuit breaker threaded terminal. If still less than 10 DC volts, check battery cable and connections for damage or corrosion.

Remove front body for access to key switch and micro switches on console shifter assembly. See Chapter 2 for Front Body Removal.

Note: Verify wiring of micro switches is identical to wiring diagram before proceeding. See Figure 4. If switches are not wired correctly, reconnect wiring to match wire diagram before proceeding. If not corrected, further testing will be inconclusive and offer misleading results.

Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the red wire. Black negative lead to black auxiliary wire from the wire harness. Key switch on, select forward or reverse.	If 10 DC volts or greater, continue to next test.	If less than 10 DC volts, check key switch wires and key switch. Replace key switch if necessary.
Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the orange wire and black negative lead to black auxiliary wire from the wire harness. Key switch on, select forward.	You should observe greater than 10 DC volts in forward and no volts when switched to reverse. If so, proceed to next test.	If greater than 10 DC volts is observed in forward and reverse, disconnect orange wire and recheck orange wire with red positive lead. If now there is voltage at the orange wire, replace diode in wire harness. If less than 10 DC volts were originally observed, replace the micro switch.
Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the yellow wire and black negative lead to auxiliary black wire from the wire harness. Key switch on, select reverse.	If greater than 10 DC volts, continue to next test.	If less than 10 DC volts, replace micro switch.
Note: The two orange wires on the forward micro switch can be installed to the micro switch in reverse order without problem. So long as one is connected to the common terminal and the other to the N.O. (normally open), the vehicle will operate correctly.		
Voltmeter red positive lead to forward micro switch (on the console shifter), to one tab with the orange wire and black negative lead to auxiliary black wire from the wire harness. Key switch on, select forward, then reverse. Next, Voltmeter red positive lead to forward micro switch (on the console shifter), opposite tab with the orange wire and black negative lead to auxiliary black wire from the wire harness. Key switch on, select forward, then reverse.	In forward position, both orange wire connections should have greater than 10 volts, and both should have no voltage in reverse.	If voltage is observed on either orange wire terminal in the reverse position, check wire harness diode and wiring to reverse micro switch.

Vehicle Operates In Forward Only, Not in Reverse		
Test	**Results**	
	Good	**Bad**
Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the red wire. Black negative lead to black auxiliary wire from the wire harness. Key switch on, select forward or reverse.	If 10 DC volts or greater, continue to next test.	If less than 10 DC volts, check key switch wires and key switch. Replace key switch if necessary.
Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the orange wire and black negative lead to black auxiliary wire from the wire harness. Key switch on, select forward.	You should observe greater than 10 DC volts in forward and no volts when switched to reverse. If so, proceed to next test.	If greater than 10 DC volts are observed in forward and reverse, disconnect orange wire and recheck orange wire with red positive lead. If now there is voltage at the orange wire, replace diode in wire harness. See Diode Testing page 8-7. If less than 10 DC volts were originally observed, replace the micro switch.
Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the yellow wire and black negative lead to auxiliary black wire from the wire harness. Key switch on, select reverse.	If greater than 10 DC volts, good.	If less than 10 DC volts, replace micro switch.

Vehicle Operates In Reverse Only, Not In Forward		
Test	**Results**	
	Good	**Bad**
Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the red wire. Black negative lead to black auxiliary wire from the wire harness. Key switch on, select forward or reverse.	If 10 DC volts or greater, continue to next test.	If less than 10 DC volts, check key switch wires and key switch. Replace key switch if necessary.
Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the orange wire and black negative lead to black auxiliary wire from the wire harness. Key switch on, select forward.	You should observe greater than 10 DC volts in forward and no volts when switched to reverse. If so, proceed to next test.	If greater than 10 DC volts is observed in forward and reverse, disconnect orange wire and recheck orange wire with red positive lead. If now there is voltage at the orange wire, replace diode in wire harness. If less than 10 DC volts were originally observed, replace the micro switch.
Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the yellow wire and black negative lead to auxiliary black wire from the wire harness.	If greater than 10 DC volts, continue to next test.	If less than 10 DC volts, replace micro switch.
Note: The two orange wires on the forward micro switch can be installed to the micro switch in reverse order without problem. So long as one is connected to the common terminal and the other to the N.O. (normally open), the vehicle will operate correctly.		
Key switch on, select reverse.Voltmeter red positive lead to forward micro switch (on the console shifter), to one tab with the orange wire and black negative lead to auxiliary black wire from the wire harness. Key switch on, select forward, then reverse. Next, Voltmeter red positive lead to forward micro switch (on the console shifter), opposite tab with the orange wire and black negative lead to auxiliary black wire from the wire harness. Key switch on, select forward, then reverse.	In forward position, both orange wire connections should have greater than 10 volts, and both should have no voltage in reverse.	If voltage is observed on either orange wire terminal in the reverse position, check wire harness diode and wiring to reverse micro switch.

Reverse Alarm Operates In Forward And Reverse		
Test	**Results**	
	Good	**Bad**
Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the red wire. Black negative lead to black auxiliary wire from the wire harness. Key switch on, select forward or reverse.	If 10 DC volts or greater, continue to next test.	If less than 10 DC volts, check key switch wires and key switch. Replace key switch if necessary.
Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the orange wire and black negative lead to black auxiliary wire from the wire harness. Key switch on, select forward.	You should observe greater than 10 DC volts in forward and no volts when switched to reverse. If so, proceed to next test.	If greater than 10 DC volts is observed in forward and reverse, disconnect orange wire and recheck orange wire with red positive lead. If now there is voltage at the orange wire, replace diode in wire harness. If less than 10 DC volts were originally observed, replace the micro switch.
Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the yellow wire and black negative lead to auxiliary black wire from the wire harness. Key switch on, select reverse.	If greater than 10 DC volts, continue to next test.	If less than 10 DC volts, replace micro switch.
Test wire harness diode, see Diode Testing.		

Reverse Alarm Will Not Operate		
Test	**Results**	
	Good	**Bad**
Voltmeter red positive lead to reverse alarm positive terminal (red paint mark) and black negative lead to negative reverse alarm terminal. Key switch on, select reverse.	If no voltage, continue to next test.	If 10 volts or greater, replace reverse warning alarm.
Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the red wire. Black negative lead to black auxiliary wire from the wire harness. Key switch on, select forward or reverse.	If 10 DC volts or greater, continue to next test.	If less than 10 DC volts, check key switch wires and key switch. Replace key switch if necessary.
Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the orange wire and black negative lead to black auxiliary wire from the wire harness. Key switch on, select forward.	You should observe greater than 10 DC volts in forward and no volts when switched to reverse. If so, proceed to next test.	If greater than 10 DC volts is observed in forward and reverse, disconnect orange wire and recheck orange wire with red positive lead. If now there is voltage at the orange wire, replace diode in wire harness. If less than 10 DC volts were originally observed, replace the micro switch.
Voltmeter red positive lead to reverse micro switch (on the console shifter), to the tab with the yellow wire and black negative lead to auxiliary black wire from the wire harness. Key switch on, select reverse.	If greater than 10 DC volts, continue to next test.	If less than 10 DC volts, replace micro switch.
Test wire harness diode, see Diode Testing, page 8-7.		

Engine Kill Circuit

Engine spins but will not spark.

1. See page 7-27 for ignition testing. If testing indicates the problem originates in vehicle engine kill circuit, proceed to next step.

2. In testing above (step 1) gray wire harness lead under starter/generator was disconnected. Reconnect gray wire at this time. Locate gray wire harness lead connected to dark blue lead from accelerator micro switch, and disconnect it from accelerator micro switch. Depress accelerator and check for spark. If ignition sparks, replace accelerator micro switch. If no spark is observed, continue to next step.

Remove front body for access to key switch and micro switches on console shifter assembly. See Chapter 2 for Front Body Removal.

3. Disconnect gray lead wire from key switch and recheck for spark. If ignition spark returns, replace key switch.

Diode Testing

Diode must be disconnected for testing. Disconnect yellow positive wire from reverse warning alarm. Disconnect yellow wire from reverse micro switch. Pull back wire harness conduit to determine which orange wire is connected to diode.

Test for continuity between orange wire and one end of yellow wire. Reverse test leads and recheck for continuity. Continuity should be observed only in one of the two tests. If no continuity is observed or if continuity is found with both tests, diode is failed and must be replaced.

Voltage Regulator

A "solid-state" voltage regulator is used to control the generator output. It is a sealed unit and not adjustable.

If trouble is experienced with the battery or charging system, it is first necessary to determine if the generator or the voltage-regulator is faulty.

Charging Circuit Test

Make the following test to determine if the regulator is functioning correctly. Battery must be in good condition and fully charged. Engine must be warmed up so that regulator is at normal operating temperature.

Caution: Be sure jack stands fully engage fork or frame tubes and that stands are set squarely on a level floor surface before lowering vehicle onto stands. Check that vehicle is secure and will not slip from stands before operating vehicle. For additional recommendations, see Chapter 2, Lifting Instructions.

1. Attach a voltmeter across battery terminals.

2. With the regulator in place and the regulator at operating temperature, run the engine at approximately 2800 RPM (governed speed in forward direction) and read the voltmeter.

3. If voltmeter reads within specified voltages 13.9 to 14.2 volts (measured at the battery terminals), at approximately 75°,air temperature surrounding the vehicle, it indicates that the voltage regulator is functioning properly.

Note: Some vehicles with additional electrical accessories, may charge from 14.5-14.9 volts, if a diode has been installed on the voltage regulator black wire circuit. This custom modification can compensate for heavy electrical loads and prevent battery discharge. If used, the diode band (or stripe) must always be closest to the ground. If reversed, the regulator will not function.

4. If voltmeter reading is above upper limit, generator charging rate is too high and will overcharge the battery causing possible internal battery damage. Check voltage regulator wiring, or replace defective voltage regulator.

5. If voltmeter reading is below the lower limit, charging rate is too low and may result in a discharged battery. See Starter/Generator & Voltage Regulator Testing.

Testing Starter/Generator & Voltage Regulator in Vehicle

Make the following test to determine if the starter/generator and voltage regulator are functioning correctly. Battery must be in good condition and fully charged.

Caution: Be sure jack stands fully engage fork or frame tubes and that stands are set squarely on a level floor surface before lowering vehicle onto stands. Check that vehicle is secure and will not slip from stand before operating vehicle. For additional recommendations, see Chapter 2, Lifting Instructions.

1. Disconnect the green (GN) wire located on starter-generator DF terminal.

2. Using a jumper wire, ground the DF terminal.

Caution: Do not ground regulator DF terminal (green wire) with the regulator wire attached. Remove generator field wire from terminal and ground the DF terminal of generator with jumper when making output tests.

3. Connect a voltmeter across the battery terminals and run engine at approximately 2000-RPM. The voltmeter should show an increase in voltage.

Caution: Only operate the engine long enough to determine the starter/generator output increases over battery voltage. Continuing to operate the engine will cause excessive high voltage and cause damage to battery and electrical components.

If no increase in voltage is seen, remove starter/generator and make tests as described in Starter-Generator Section. See page 8-9.

If voltage rises during this test, but voltmeter reading was below the lower limit in Charging Circuit Test, then regulator is defective and must be replaced.

Caution: Do not ground regulator DF terminal (green wire) with the regulator wire attached. Remove generator field wire from terminal and ground the DF terminal of generator with jumper when making output tests.

Voltage Regulator Removal

1. Raise the vehicle body.

Warning: (ParCar with angle bag rack) To secure body upright and avoid possible personal injury through accidental closing of body, remove body hold-up rod from clip and insert into slot in body frame.

Warning: Disconnect battery cables (negative cable first) to prevent accidental start up of vehicle and possible personal injury.

2. Disconnect voltage regulator wires.

3. Remove the mounting screw and remove the voltage regulator.

Voltage Regulator Installation

1. Install and tighten the mounting fastener to secure voltage regulator.

Note: Check to ensure that all 4 ground wires are installed to the regulator mount bolt before tightening.

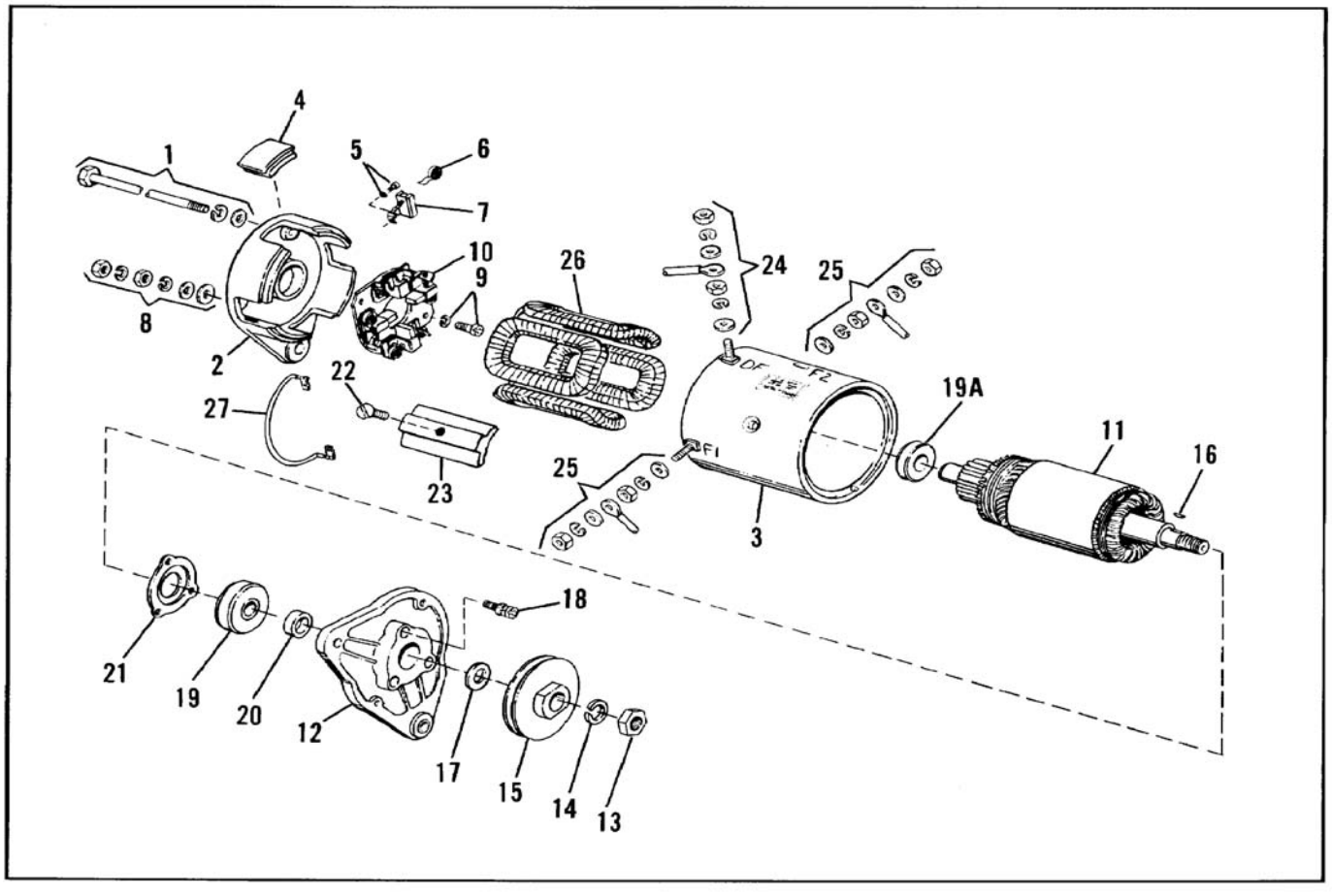


Figure 5 - Starter/Generator

2. Reconnect the voltage regulator wires as follows:

   RED WIRE (R) to generator side of solenoid.
   GREEN WIRE (GN) to green wire from engine wire harness (to starter-generator).
   BLACK WIRE (BK) to regulator mount bolt (with three other black ground leads).

3. Connect battery cables.

4. Recheck voltage regulator wires. See applicable wiring diagram. Re-test voltage regulator as described above

Starter-Generator

If the starter-generator is found to be faulty, this section will outline the disassembly, testing, repair and reassembly process.

Removal

1. Golf vehicles, raise the body. Utilitrucks, lift seat and remove deck plate.

⚠ Warning: Disconnect battery cables (negative cable first) to prevent accidental start up of vehicle and possible personal injury.

⚠ Warning: (ParCar G4S models) To secure body upright and avoid possible personal injury through accidental closing of body, remove rear body support rod from clip and insert into slot in body frame.

2. Disconnect all wires and cables from starter-generator. Do not allow terminal studs to turn. Make sure wires are marked for correct reassembly.

3. Remove front mounting bolt from adjuster bracket.

4. Remove two (2) mounting bolts from rear mount bracket.

5. Lift starter-generator out of vehicle.

Disassembly

1. Remove rubber brush covers (4) (or strap type brush cover on early starter-generator PN 30083-95), screws and lockwashers (5), brush springs (6) and brushes (7). See Figure 5.

2. Remove through bolts and washers (1). Pull commutator end cover (2) free of starter frame (3). See Figure 5.

Note: If it is not necessary to remove brushes, they can be held off of commutator with brush springs. See Figure 6.

3. Brush Holder (10) is to be removed, remove terminal nuts, washers and lockwashers (8), brush holder screws and lockwashers (9). Then, remove brush holder (10). See Figure 5.

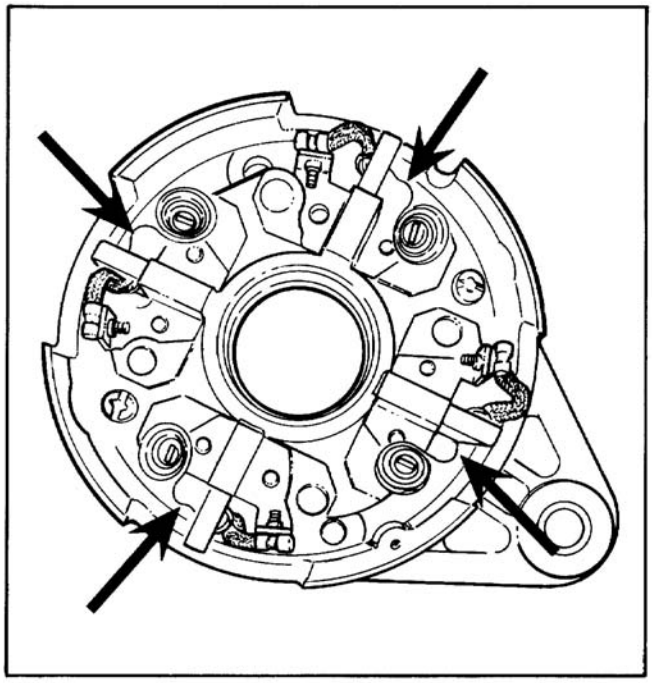


Figure 6 - Holding Brushes Off Commutator

4. To separate armature (11) from drive end cover (12), remove nut (13), lockwasher (14), pulley (15), shaft key (16), washer (17), bearing retainer screws (18) and spacer (20).

5. To separate commutator bearing (19) or drive end bearing (19A) and spacers (20) from armature (11), use claw puller tool and wedge attachment tool. See Figure 7.

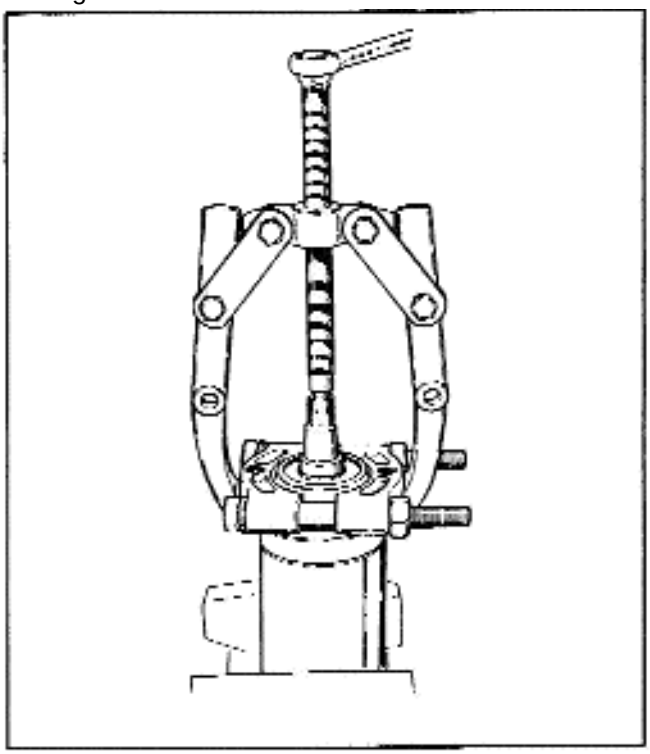


Figure 7 - Removing Armature Bearings

Caution: Use care while removing bearing from shaft so as not to damage retainer plate.

6. Remove bearing retainer (21).

Note: Do not remove pole shoes unless electrical test indicates it is necessary.

7. Remove pole shoe screws (22), pole (23), DF terminal hardware (24) F1 and F2 terminal hardware (251 and remove field coil (26).

Inspecting Brushes

1. Visually inspect brushes. Replace brushes, which are cracked or severely chipped.

2. Check brush length. Figure 8. If any brush is worn to its minimum length when measured at its shortest point, new brushes are needed. Replace brushes in sets of four only.

Minimum brush length
Starter-Generator Part # 30083-95……3/8 in. (9.534 mm)
Starter-Generator Part # 30083-98 .... 5/8 in. (15.875mm)

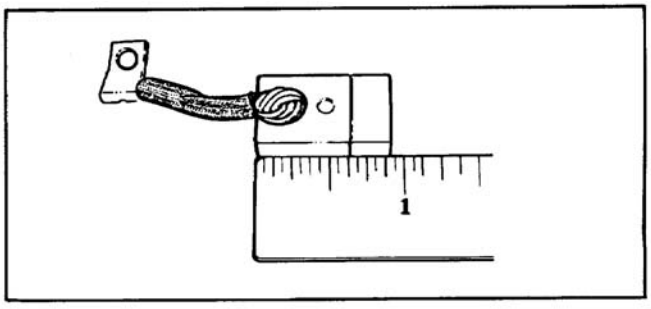


Figure 8 - Measure Brush Length

Brush Springs

1. Inspect springs. Reject springs, which are discolored from heat (straw or blue in color).

2. Test brush spring tension. Use a scale. Figure 9, to test spring tension. Reject springs that apply a force less than specified.

Starter-Generator Part # 30083-95……15 oz. 420 grams
Starter-Generator Part # 30083-98 ……....28 ± 4 oz. (680.4 grams).

Caution: When checking brush spring tension, do not pull springs beyond the point they would normally be if there were new brushes installed. Exerting excessive force, or pulling brush springs beyond normal resting point will damage springs.

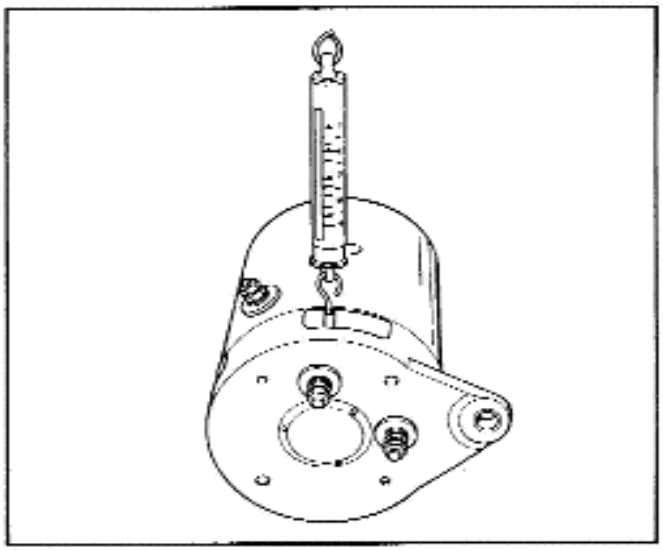


Figure 9 - Test Brush Spring Tension

Armature Inspection

Obvious defects can be seen by examining the armature. If an armature has frayed or charred insulation, broken wires or thrown solder, it is obvious, without further testing, that it should be replaced. Faults seen during the visual inspection can aid in diagnosing the original cause of failure.

Visually, check armature for:
1. Burned, charred or cracked insulation.
2. Thrown solder.
3. Worn, burned or glazed commutator.
4. Loose commutator bars.
5. Bruised armature core laminations.
6. Worn armature bearing or shaft.
7. Dirty or oily commutator.

Armature Testing

Note: Before testing, wipe armature with clean rag and blow carbon dust and metal particles from between commutator bars and windings.

Caution: Do not submerge armature in solvent.

A completely GROUNDED or SHORTED armature will prevent a starter-generator motor from operating. However, an armature may have an open or high resistance winding and still operate at a lower efficiency than normal.

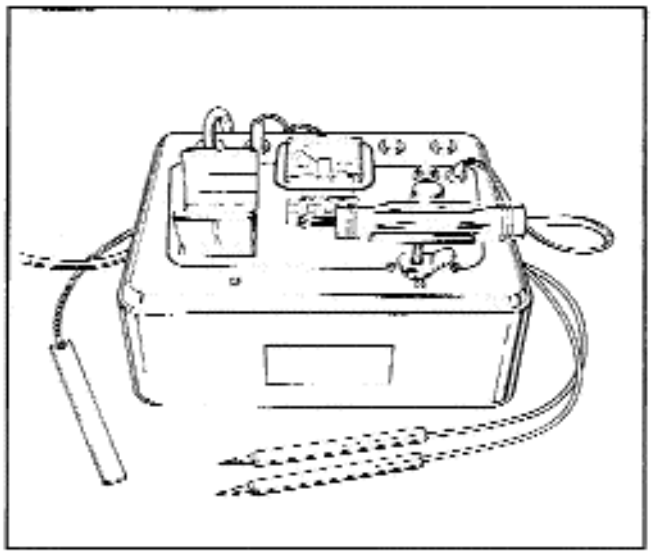


Figure 10 - Armature Tester

Armature Ground Test

1. Plug in tester.

2. Place armature in growler.

3. Turn on taster.

4. Touch one test probe to commutator and other to armature core. Test lamp should be OFF, indicating no continuity. If the test lamp is on, the armature is grounded and must be replaced. See Figure 11.

Note: The armature ground test can also be performed in the same manner with a continuity tester or ohmmeter.

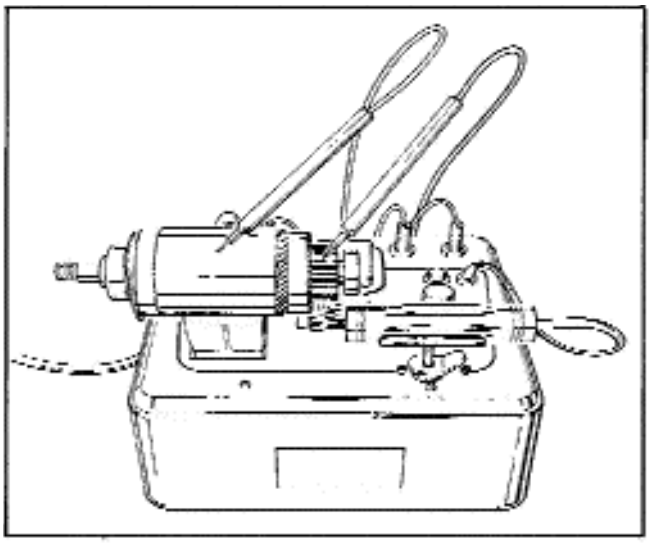


Figure 11 - Armature Ground Test

Armature Short Test

1. With armature in same position as previous test, turn tester on.

2. Using steel blade provided with tester, or hack saw blade, hold blade parallel with and touching armature core. See Figure 12.

3. Slowly, rotate armature one complete revolution in growler. If the armature is shorted the blade will vibrate on the armature core. Shorted armatures must be replaced.

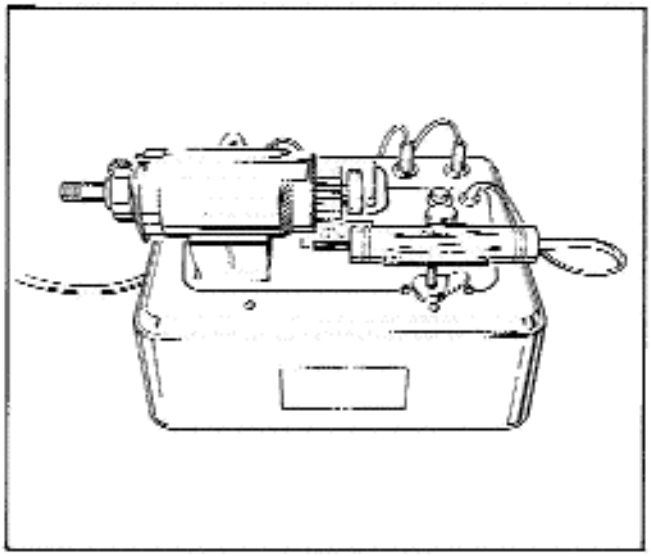


Figure 12 - Armature Short Test

Armature Coil Balance Test

The armature coil balance test is designed to determine whether all the coils are of equal efficiency. This is essential for maximum motor generator performance and also to prevent rapid commutator burning. A wide variance in coil efficiency will reduce the performance of the starter-generator motor and overheat the entire assembly.

1. With armature in same position as previous tests, turn tester on.

2. Turn sensitivity control clockwise to stop.

3. Place contact handle in cradle and position cradle so contacts of handle touch a pair of commutator bars. See Figure 13.

4. Position contact handles to obtain highest reading on meter. Set cradle to hold contact handle in this position.

5. Slowly rotate armature one complete revolution pausing to note reading on meter of each pair of commutator bars. The highest reading of each pair of commutator bars should be even within one division of the lowest reading. If reading for a particular pair of bars is noticeably lower, an open or poor connection exists in the winding.

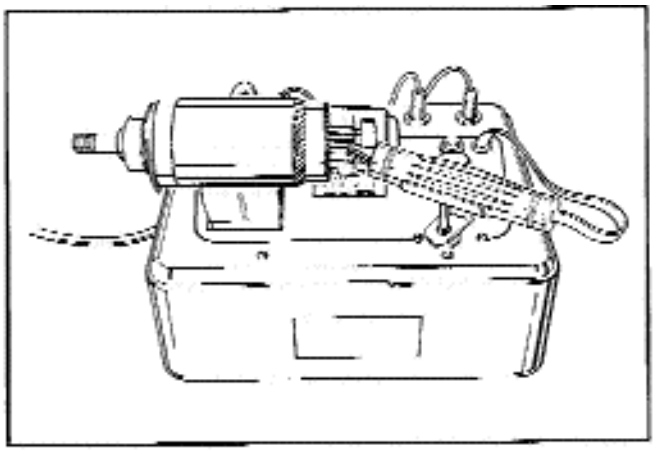


Figure 13 - Armature Coil Balance Test

Refinishing Commutator

To refinish commutator, mount armature in lathe and diamond turn commutator. Limit depth of cut to .005 in. (1.27 mm) or less and repeats cut as often as required. Do not reduce commutator diameter to less than specified.

Commutator Minimum Diameter
Starter-Generator Part # 30083-95……1.65 in. (42 mm)
Starter-Generator Part # 30083-98……1.535 in. (39 mm)

After commutator is turned, the mica insulation between segments must be undercut .031 (1.32) in. (.8 mm). See Figure 15. Undercutting should be done with special undercutting equipment. If one is not available, satisfactory undercutting can be carefully done with a piece of hacksaw blade. Carefully trim blade thickness until offset teeth are the same width as slots in commutator. Slots must be square bottomed for best results. Finish cut commutator after undercutting, and check for excessive commutator runout. Runout should not exceed .01 in. (.25mm).

Field Coil Inspection

If the insulation on the field coils appears blackened or charred, the serviceability of the coils is questionable.

Burned or scorched coil insulation indicates the motor has overheated due to overloads, grounded or shorted coil windings.

Check for loose pole shoes. Check all terminals. Repair or replace as needed.

Grounded Field Test

1. Attach continuity tester or ohmmeter between F1 terminal and motor frame. Continuity tester should not light, ohmmeter should read infinity. See Figure 14.

2. Grounded fields should be replaced.

3. Check continuity between F1 and F2 terminals and continuity between F1 and DF.

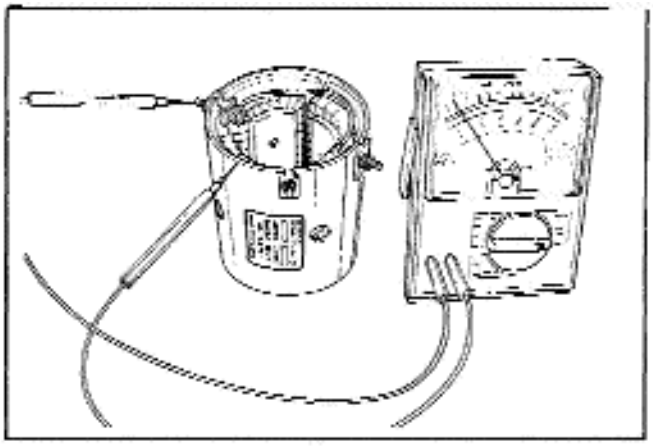


Figure 14 - Grounded Field Test

Open Field Test

1. Set ohmmeter to RX1 scale or equivalent.

2. Connect ohmmeter to F1 and DF terminals.

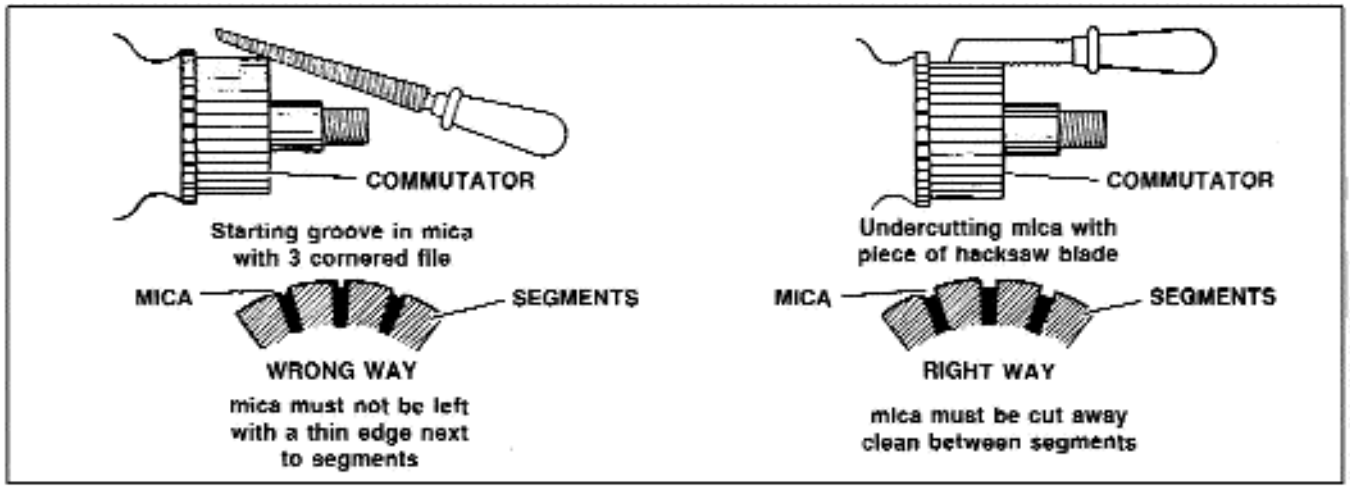


Figure 15 - Recessing the Mica Separators

3. Resistance should read 4.5 to 5.5 ohms.

4. Connect ohmmeter to DF terminal and housing (ohms reading).

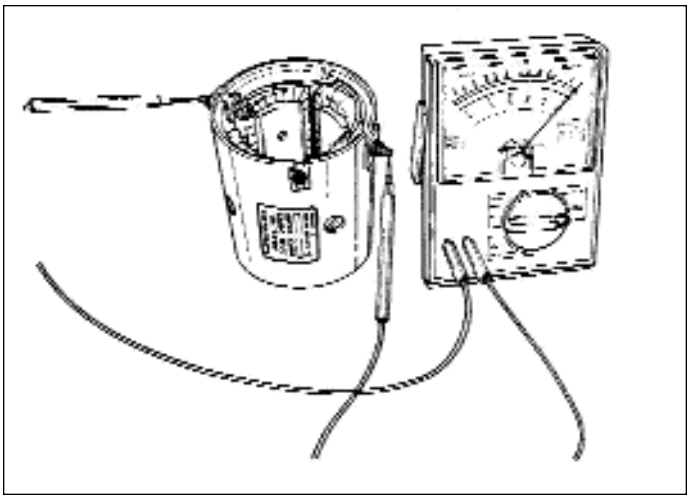


Figure 16 - Open Field Test

Assembly

Note: Refer to Figure 5, page 8-8.

1. If removed, install field coil assembly (26) into frame (3) and secure using pole shoes (23) and pole screws (22). Tighten pole shoe screws to 9 ft.lbs. (1.2 kgm) torque. See Figure 16.

Caution: Route field terminal wires so that they will not contact armature.

2. Connect internal field coil wires are follows:
   Starter-Generator Part # 30083-95

   Single RED wire to DF terminal.
   RED wire & metal strap to F1.
   Metal strap to F2 terminal.

   Starter-Generator Part # 30083-98
   Single RED wire to DF terminal.
   RED wire & metal strap to F1.
   Metal strap to F2 terminal.

3. Figure 5 shows correct stacking of wire mounting bolt hardware (24), (25).

Caution: Use caution while pressing bearing on shaft so as not to damage bearing retainer (21).

4. Install bearing retainer (21) on drive end of shaft, press bearing (19) on to shaft, pressing bearing (19A} on commutator end of shaft.

5. Install brush springs (6), brushes (7), screw and lockwasher (5) to brush holder (10) and hasten brush holder (10) to commutator end cover (2) with screws and washers (9).

6. Install armature (11) into drive end cover (12) and tighten bearing retainer screws (18).

7. Slide frame (3) over armature (11) and locate pins used for aligning. These locating pins in body should align with holes in end covers.

Note: Hold brushes off commutator by lifting brush springs and putting brushes back until the springs rest on the side of the brushes. See Figure 6, page 8-9.

8. Install commutator end cover, aligning cover hole with body pin and install through bolts and washers (1), terminal nuts, washers and lockwashers (8). Install brush covers (4).

9. Install spacer (20), washer (17), shaft key (16), pulley (15), lockwasher (14) and nut (13). Tighten pulley nut (13) to 26-33 ft.-lbs. (3.59-4.56 kgm) torque.

Installation

1. Golf vehicles, raise the body. Utilitrucks, lift seat and remove deck plate.

Warning: (ParCar G4S models) To secure body upright and avoid possible personal injury through accidental closing of body, remove rear body support rod from clip and insert into slot in body frame.

2. Set starter-generator on to engine of vehicle.

3. Install two (2) mounting bolts through rear mount bracket. Finger tighten only at this time.

4. Install front mounting bolt through adjuster bracket. Finger tighten only at this time.

5. Slide belt onto pulleys.

6. Reconnect all wires and cables to starter-generator.

7. Using a pry bar resting on the block at front top of engine, lift starter-generator until 90 to 110 Lb. of tension is measured at the started belt.

8. While holding tension on belt, tighten front adjuster bolt to 35 ft. lb. (47.4 N.m.) and the rear bolts (2) to 35 ft. lb. (47.4 N.m.).

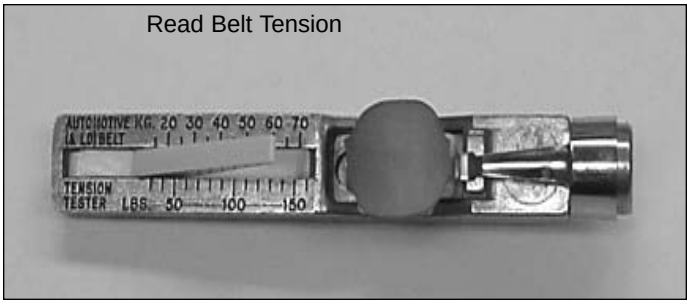


Figure 17 - "Kricket" Belt Tension Test Tool, CPC Part Number 89559-94

Warning: Reconnect battery cables (negative cable last) to prevent accidental start up of vehicle and possible personal injury.

9. Lower the vehicle body.

Battery, Gasoline Vehicle

Water cannot be added to this battery. The "maintenance free" battery is completely sealed except for a small vent in each side. The gases produced in the battery will escape through these vents.

Danger: Batteries produce explosive hydrogen gas at all times, especially when being charged. To avoid personal injury, keep cigarettes, open flame, and do not work around charging batteries with tools that could cause a short circuit resulting in a spark. Always shield eyes when working near charging batteries.

Ventilate area when charging battery. Raise body or seats over batteries while charging vehicle to allow hydrogen gas to escape freely. Ventilation fans should be located at the highest point in the room, and must be capable of changing the total volume of air in the room five (5) times per hour. Consult a local HVAC engineer.

The battery is designed to withstand some of the damaging affects of overcharging, but overcharging can still severely damage the battery.

Danger: The vents require keeping the battery in an upright position to prevent electrolyte leakage. Tipping the battery beyond a 45° angle in any direction can allow a small amount of electrolyte to leak out the vent hole. DO NOT exceed this 45° angle when carrying or installing the battery because of its dangerous chemicals which could cause severe personal injury when accidentally coming in contact with skin, eyes or clothing.

Danger: Batteries contain sulfuric acid, which is highly corrosive and can cause chemical burns. Avoid contact with skin, eyes or clothing. Always wear approved eye protection when working around batteries.

Antidote

External - Flush with water.
Internal - Drink large quantities of milk or water, followed by Milk of Magnesia, vegetable oil or beaten eggs. Call doctor immediately.
Eyes - Flush with water, get immediate medical attention.

Visual Inspection and Maintenance

Check for obvious damage such as cracked or broken case or cover that could permit loss of electrolyte. If obvious physical damage is noted, replace battery.

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.

To determine whether battery needs charging, see Load Testing, Page 8-15.

Removal

Warning: Disconnect the battery cables (negative cable first) to prevent accidental start up of vehicle and possible personal injury.

a. Raise the vehicle body.

Warning: (ParCar with angle bag rack) To secure body upright and avoid possible personal injury through accidental closing of body, remove body hold-up rod from clip and insert into slot in body frame.

b. Remove two (2) nuts and washers, and hold down bracket.

Warning: When lifting out battery DO NOT tip beyond the 45° angle in any direction to avoid electrolyte leakage.

c. Lift out battery.

d. Install battery in reverse order.

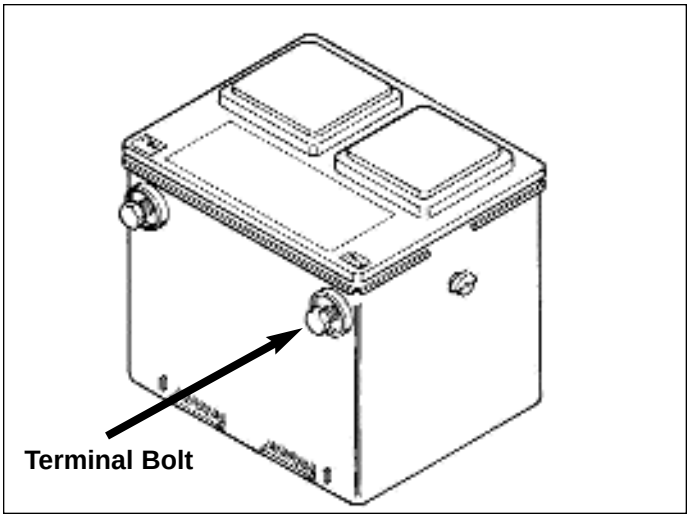


Figure 18 - Battery Removal

Charging

Warning: The gases produced by a storage battery on charge are highly explosive. To prevent possible personal injury, charge batteries in a well-ventilated area, keep fire and flame away from charging batteries and do not work around charging batteries with tools that could cause a short circuit resulting in a spark. Always, shield eyes when working near charging batteries.

Ventilate area when charging battery. Raise body or seats over batteries while charging vehicle to allow hydrogen gas to escape freely. Ventilation fans should be located at the highest point in the room, and must be capable of changing the total volume of air in the room five (5) times per hour. Consult a local HVAC engineer.

Battery In Vehicle

Start charger only after connections have been made.

a. Attach positive charger cable (+) to positive (+) terminal on battery.
b. Attach negative charger cable (-) to negative (-) terminal on battery.
c. Follow Table 1 for desired charging rate.

Battery Out of Vehicle

Start charger only after connections have been made.

a. Thread a 3/8-16 bolt into each terminal, hand tight, Figure 18.
b. Attach positive charger cable (+) to bolt in positive (-) terminal on battery.
c. Attach negative charger cable (-) to bolt in negative (-) terminal on battery.
d. See Table 1 for desired charging rate

Table 1 - Charging Rates, 12 Volt Battery	
Slow Charge Rate	**Fast Charge Rate**
5 Amps for 10 hours or 10 Amps for 5 hours	**20 Amps for 2 1/2 hours or 30 Amps for 1 1/2 hours**

Caution: If battery case feels hot (approximately 125° or more), and/or emits gases and/or fluid boiling from vent, stop charging procedure at once. Allow battery to cool and resume charging battery at a lower amp charge per hour. Failure to stop charging procedure could result in personal injury and/or damage to the battery

Load Testing

Note: Battery must be fully charged before load test.

Start load tester only after connections have been made.

a. Connect load tester to battery and remove sur face charge (excess voltage) by running a 300-amp load across terminals for 15 seconds.
b. Load battery to 130 amps.
c. Read voltage after 15 seconds of load and then remove load.
d. Minimum voltage, see Table 2, will determine if fully charged battery is good. If voltage is below minimum, replace battery.

Storage

a. Battery can remain in vehicle.
b. Fully charge battery.
c. Clean battery top and connections.
d. Fully charged battery 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.

A battery in low state of charge (low specific gravity readings) will freeze at low temperatures.

Check battery every 4 to 6 weeks in warmer climates, 8 to 10 weeks, or 12 to 16 weeks if stored below 40° F. Recharge as necessary to bring the battery to 75-100% specific gravity to prevent battery from freezing. As ice forms in a freezing battery, the electrolyte expands and can crack the base, 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 75% specific gravity. If specific gravity is 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 filamentous 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.

while in a partially discharged condition. This type of service requires a deep cycle battery - a battery that is durable enough to withstand repeated complete cycling. For this reason, electric vehicle batteries are constructed with heavier plates and cells with a greater capacity for electrolyte.

Caution: Only batteries designed for electric golf care service should be used.

Table 2 - Minimum Voltage (12 Volt Batteries)

If Temp Is:	70° F (20° C) & Above	60° F (16° C)	50° F (10° C)	40° F (4° C)	30° F (-1° C)	20° F (-7° C)	10° F (-12° C)	0° F (-18° C)
Then the Minimum Voltage Needed Is:	9.6	9.5	9.4	9.3	9.1	8.9	8.7	8.5

State of Charge	Freezing		Risk of Sulfation
	F°	C°	
100%	-70°	-57°	Low
75%	-39°	-38°	Low
50%	-16°	-26°	Low
25%	-2°	-19°	Moderate
Discharged	+17°	-8	High

ELECTRIC VEHICLE ELECTRICAL SYSTEMS AND COMPONENTS

Warning: For XP and XP Plus models, always turn key switch to OFF, remove key, block tires and disconnect the battery negative (-) cable on before performing any vehicle service to avoid accidental start-up of vehicle and possible injuries.

For Power Master (PM) models, always block tires, disconnect the battery positive (+) cable, turn key to reverse position until buzzer is silent.

Electric Vehicle Battery

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

Receive- Charging vehicle batteries.
Store- Vehicle standing idle.
Deliver-Driving vehicle.

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

Automotive batteries are designed to furnish high current draws for short duration, and are kept in a near fully charged state by the charging system. Electric vehicle batteries must be able to furnish currents up to 50 amperes for long durations, and also be able to supply that current

Warning: Batteries contain sulfuric acid, which is highly corrosive and can cause chemical burns. Avoid contact with skin, eyes or clothing. Always, wear approved eye protection when working around batteries.

Antidote

External- Flush with water.

Internal- Drink large quantities of milk or water, followed by Milk of Magnesia, vegetable oil or beaten eggs. CALL DOCTOR IMMEDIATELY.

Eyes- Flush with water, get immediate medical attention.

Inspection and Maintenance

Batteries should be carefully inspected weekly, 6 hours of operating time, or every 10 rounds of play. This procedure should also be followed before any tests are performed on the batteries.

a. Battery must be clean and dry. Dirt and electrolyte on top of battery causes battery to self discharge. Clean battery top with baking soda (sodium bicarbonate) and water solution (5 teaspoons baking soda per quart water). Do not allow solution to enter cap vent holes.

b. Inspect battery posts, clamps and cables for breakage, loose connections and corrosion. Clean battery posts and clamps.

c. 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.

d. 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.

e. Check electrolyte level. Sufficient distilled water would be added to cover plates before charging, then after charging, remaining distilled water can be added to bring electrolyte to correct level.

f. Inspect battery case for cracks or leaks.

Charging

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.

Caution: Overcharging is harmful. Batteries should be charged just long enough to bring them up to full charge and no more. The state of charge can be tested accurately with a Hydrometer. See Testing Battery.

Warning: The gases produced by a storage battery on charge are highly explosive. To prevent possible personal injury, charge batteries in a well-ventilated area, keep fire and flame away from battery charging area, and do not work around charging battery with tools that could cause a short circuit resulting in a spark. Always, shield eyes and face when working near batteries.

Charging Procedure

a. Check electrolyte level in all cells and add distilled water as necessary to cover tops of plates. Do not overfill, as electrolyte expands during charging.

b. Be sure charger is turned OFF, and insert charger plug into car's receptacle.

c. 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.

d. Whenever a manual charger is used, refer to Table 3 for battery condition (state of charge) testing.

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

e. After charging, check electrolyte level and add water as necessary to triangle or split ring of each cell. See Figure 19.

Table 3

State of Charge	Specific Gravity (80º F
100%	1.250-1.270
75%	1.220-1.240
50%	1.190-1.210
25%	1.160-1.180

Specific Gravity Taken from at Least 2 Cells of Each Battery

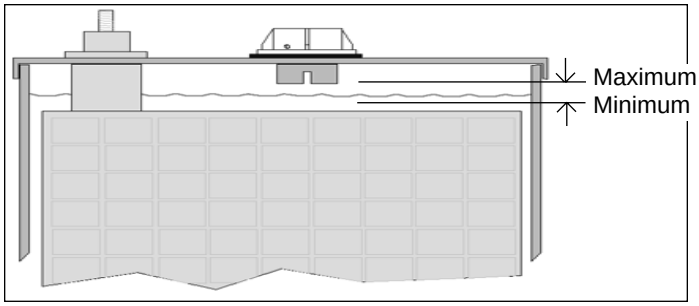


Figure 19 - Battery Electrolyte Level

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

Conditions Which Affect Charging

a. If car is used only occasionally, a refresher charge should be given prior to using the car. Use specific gravity reading to determine if charge is required. Charger will determine length of charge required.

Table 4

Comparison of Power Available From Fully Charged Batteries at Various Ambient Temperatures
80º F - 100%
32º F - 65%
0º F - 40%

b. Fleet cars should be rotated so that all cars are used equally.

c. Battery efficiency is affected by temperature. See Table 4.

If the temperature of the outside air and/or batteries is below 60º F, battery capacity is reduced. Batteries will require more frequent and longer charge periods in early spring, fall and winter. It will help to put batteries on charge while they are still warm from use.

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

e. If batteries are unusually hot at the end of normal charge with heavy deposits of moisture around the filler caps and/or water use is high, this may indicate one or more defective cells or that the batteries are nearing the end of their useful life. See Testing Battery.

f. If the batteries do not respond to normal charging, one or more cells may be defective and all should be checked. See Testing Battery. Batteries found defective must be replaced. All batteries in a car should be matched according to age, capacity and brand.

The charger can be used to determine the overall condition of the battery bank after charging. Compare the finish charge rate with the specific gravity readings of the batteries. See Table 5.

Testing Battery

Testing with a Charger

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

Test: Connect charger to car, and turn on. Charger ammeter needle should jump to 15 amps or more and then taper into the 1-3 amp area within 15 minutes, indicating good fully charged batteries.

Battery banks failing this test should be tested with hydrometer and/or load tester. See Specific Gravity Test.

Specific Gravity Test

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

a. State of Charge - The amount of electrical power stored in the battery.

b. Condition - The ability of battery to store and deliver power.

Note: 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.

Using the Hydrometer

a. Squeeze rubber bulb and insert nozzle in cell, release bulb, slowly drawing electrolyte up into barrel.

b Adjust electrolyte level in barrel so float rides free of bottom but is not striking top of barrel.

c. 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.

d. Record the reading.

e. Return electrolyte to cell from which it was removed.

f. 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 your readings as follows:

Above 80º F- Add .004 to the specific gravity readings for each 10º above 80º F.

Below 80º F- Subtract .004 from the specific gravity readings for each 10º below 80º F.

Table 5

Finish Charge Rate	Specific Gravity at 80ºF	Possible Condition
1-3 amps	All cells above 1.250 and even	Good
8-10 amps	All cells above 1.250 and even	Batteries nearing end of useful life
Above 4 amps	All cells below 1.250 and even	Batteries need additional charge
Above 10 amps	All cells above 1.250 and even	Batteries bad - (see TESTING BATTERIES)
Above 4 amps	Cell readings vary more than .050	See SPECIFIC GRAVITY TEST

Interpretation of Hydrometer Readings

State of charge: Check specific gravity of each cell. Refer to Tables 6 and 7.

Table 6

Specific Gravity Reading at 80ºF	State of Charge
1.250-1.270	100%
1.220-1.240	75%
1.190-1.210	50%
1.160-1.180	25%

Condition: If the difference between the highest and lowest cell is .050 (50 points) or more, the battery is nearing the end of its useful life and should be replaced.

Note: If the highest cell reads less than 1.200, the test for condition is questionable. Recharge battery, and perform test again.

Discharge (Load) Test

The discharge, or load test, is the recommended method of determining battery condition because it simulates golf car 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.

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

Preparation for Discharge Test

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

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

b. Discharge (Load) Test must be performed within 18 hours of charging.

c. Vehicle must not be used, even for short runs, prior to Discharge (Load) Test.

d. Electrolyte level must be correct in all cells.

Discharge (Load) Test Procedure

Caution: Discharge Load Test must be performed in well ventilated area.

a. Connect tester leads to battery bank.

b. Check and record electrolyte temperature of center cell of each battery.

c. Turn tester on.

d. After 20-30 minutes, with tester on, check and record individual battery voltages to the nearest .1 (1/10) volt.

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

e. Allow tester to shut off automatically, and record time elapsed from start of discharge.

Note: Tester shutoff should occur at a battery voltage of 31.5v +/- .2v. Check tester shutoff voltage periodically. This setting must be accurate for a valid test.

Interpretation of Discharge Test Results

a. Compare individual battery voltages recorded in Step 'd' of Discharge (Load) Test Procedure and discard any battery that is .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.

b. If all battery voltages are within .2 volts of each other, compare discharge time from Step 'd' of Discharge (Load) Test Procedure with minimum times in Table 8.

Table 7

	Specific Gravity Reading Each Cell at 80º F			
Battery	**1**	**2**	**3**	**Required Action**
1	1.100	1.100	1.100	Charge and recheck
2	1.260	1.180	1.250	Bad cell (2) replace battery
3	1.250	1.260	1.250	Good
4	1.190	1.170	1.120	Charge and recheck (suspect cell #3)

Note: Even if individual battery voltages are satisfactory, but the discharge time fails to meet minimums in Table 8, the entire battery bank should be replaced.

Table 8

Electrolyte Temperature (Step 3)	Minimum Discharge Time To 3.1v (Step 6)
40 to 49º	40 Minutes
50 to 59	45
60 to 64	50
65 to 69	54
70 to 74	57
75 to 79	60
80 to 84	62
85 to 89	64
90 to 99	66
100 to 109	68
110 to 119	70
120 to 129	72
130 to 150	74

Storing Batteries

a. Batteries can remain in vehicle.

b. Fully charge batteries.

c. Clean tops and connections.

d. 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 80º F, will discharge faster and require recharge every few weeks. Batteries stored at or below 0º F may not require recharge for periods up to four (4) months. When recharging, bring batteries to 1.250-1.270 specific gravity to prevent freezing. See Table 9.

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.

Key Switch

Equipment needed for test: Battery powered continuity tester or ohmmeter set at XI or equivalent.

1. Switch in OFF position. Check continuity between all terminals. There should be no continuity.

2. Switch in FORWARD position. Check continuity between indicated terminals.

3. Switch in REVERSE position. Check continuity between indicated terminals.

Table 9

State of Charge	Specific Gravity	Fº - Freezing Point - Cº		Risk of Sulfation
100%	1.260	-70º	-57º	Low
75%	1.230	-39º	-38º	Low
50%	1.200	-16º	-26º	Low
25%	1.170	- 2º	-19º	Moderate
Discharged	1.110	+17º	- 8º	High

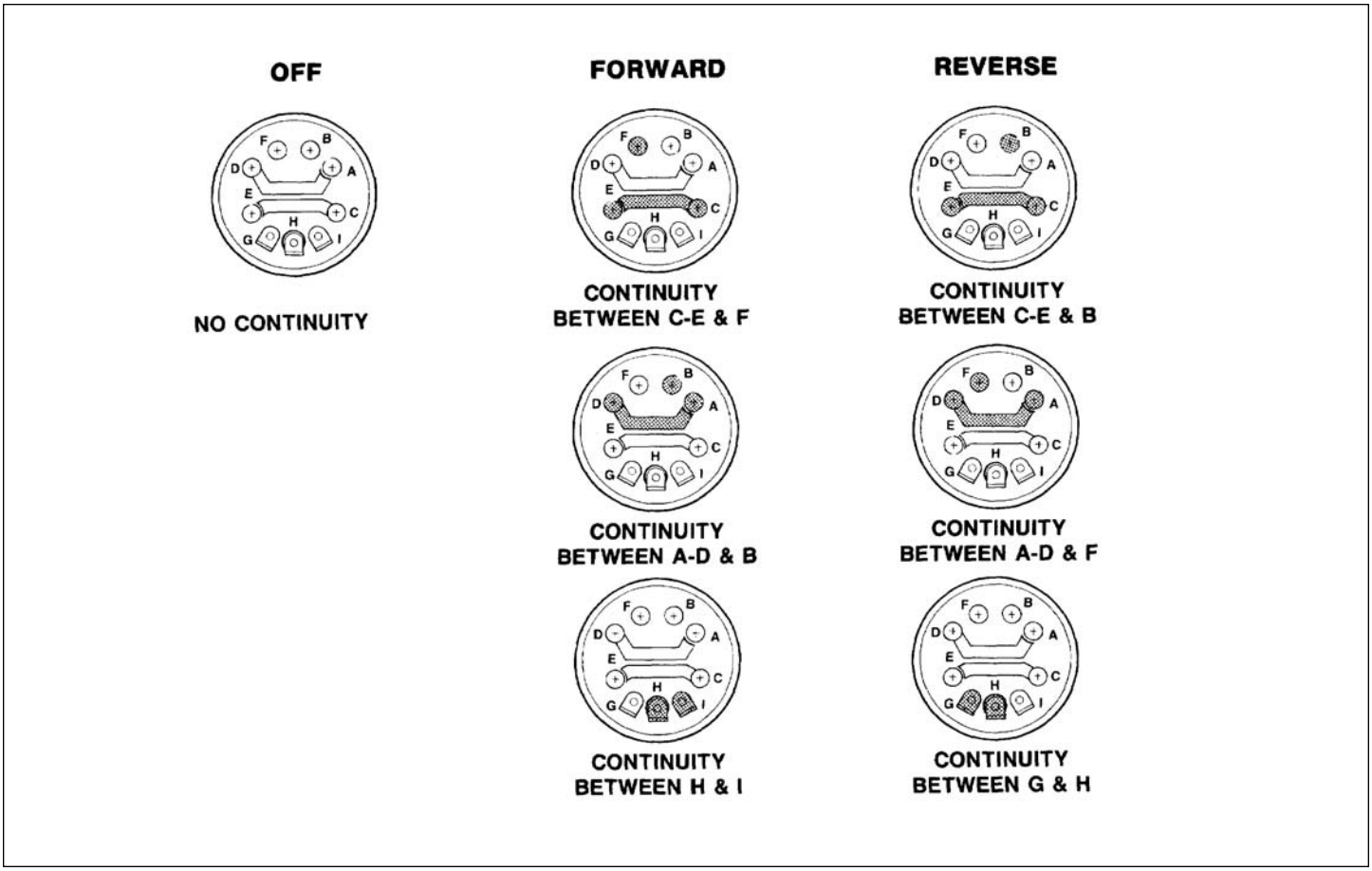


Figure 20 - Key switch Test (Electric Vehicles)

Solenoid

This solenoid is an electro-magnetic switch which energizes when current is applied to the small control circuit terminals. When energized, the solenoid core moves up due to magnetism created by the coil and internal contacts create a connection between two large terminals, allowing current to pass through the solenoid. When control circuit voltage is removed from the small terminals, the magnetic field collapses and a spring returns the core to its rest position. A single contact solenoid in the normal position has an open circuit between the large terminals, preventing current from passing through it. A double contact solenoid in the normal position has an open circuit at top and normally closed circuit at bottom. This allows current to pass through its lower contacts without being energized.

Note: Solenoids are mounted in vertical position, gravitational pull aids internal spring in returning to normal position.

Testing information can be found in Trouble Shooting sections. Refer to the correct speed control system used on your vehicle.

Motor Resistor

Impedes current flow, which reduces voltage to circuit. Two types of resistors will be found on speed control systems. These resistors can be visually inspected and require no special test procedures.

a. Low wattage light duty resistors are used on XP Plus and Power Master control circuits.

b. Heavy high current resistor coils are used on XP speed control motor circuits.

Speed Switch (Pot Box)

This type of speed switch assembly is used with XP plus and Power Master systems, to signal the speed control module regarding accelerator pedal position.

The speed switch assembly consists of two separate circuits. First is the accelerated micro switch. This switch activates the vehicles electrical system as the accelerator is depressed. As the accelerated is released, this switch disables the vehicles electrical system, for safety and to conserve energy.

The second circuit is a variable resistor, commonly referred to as a "pot" or potentiometer. The potentiometer is a variable resistor used to signal the speed control module regarding accelerated pedal position.

Testing

Testing can be performed on or off of vehicle. To determine if speed switch is functioning correctly, follow precisely testing instructions in the order as they appear. As discussed before, the speed switch assembly uses two separate circuits. Test each circuit to ensure that both components are in proper working order.

Micro Switch Test

1. Using a digital volt/ohm meter (VOM), set to test continuity, probe to the first and third terminals on micro switch.

2. With micro switch lever depressed, no continuity should be observed.

3. With micro switch lever released, continuity should be observed.

4. If results of your test are erratic or inconsistent with the above, the micro switch must be replaced.

Pot Switch Test

1. Using a digital volt/ohm meter (set to test continuity) probe to the terminals at ends of black and white lead wires.

2. With speed switch lever released, 0 to 50 ohms will be observed.

3. With speed switch lever depressed completely, 4500 to 5500 ohms will be observed.

4. As speed switch lever is depressed, resistance should rise smoothly from 0 to 50 ohms, to a maximum of 4500 to 5500 ohms.

5. If resistance value observed is incorrect, refer to Pot Switch Adjustment, page 8-23.

Caution: If resistance readings are erratic and inconsistent, the pot switch must be replaced.

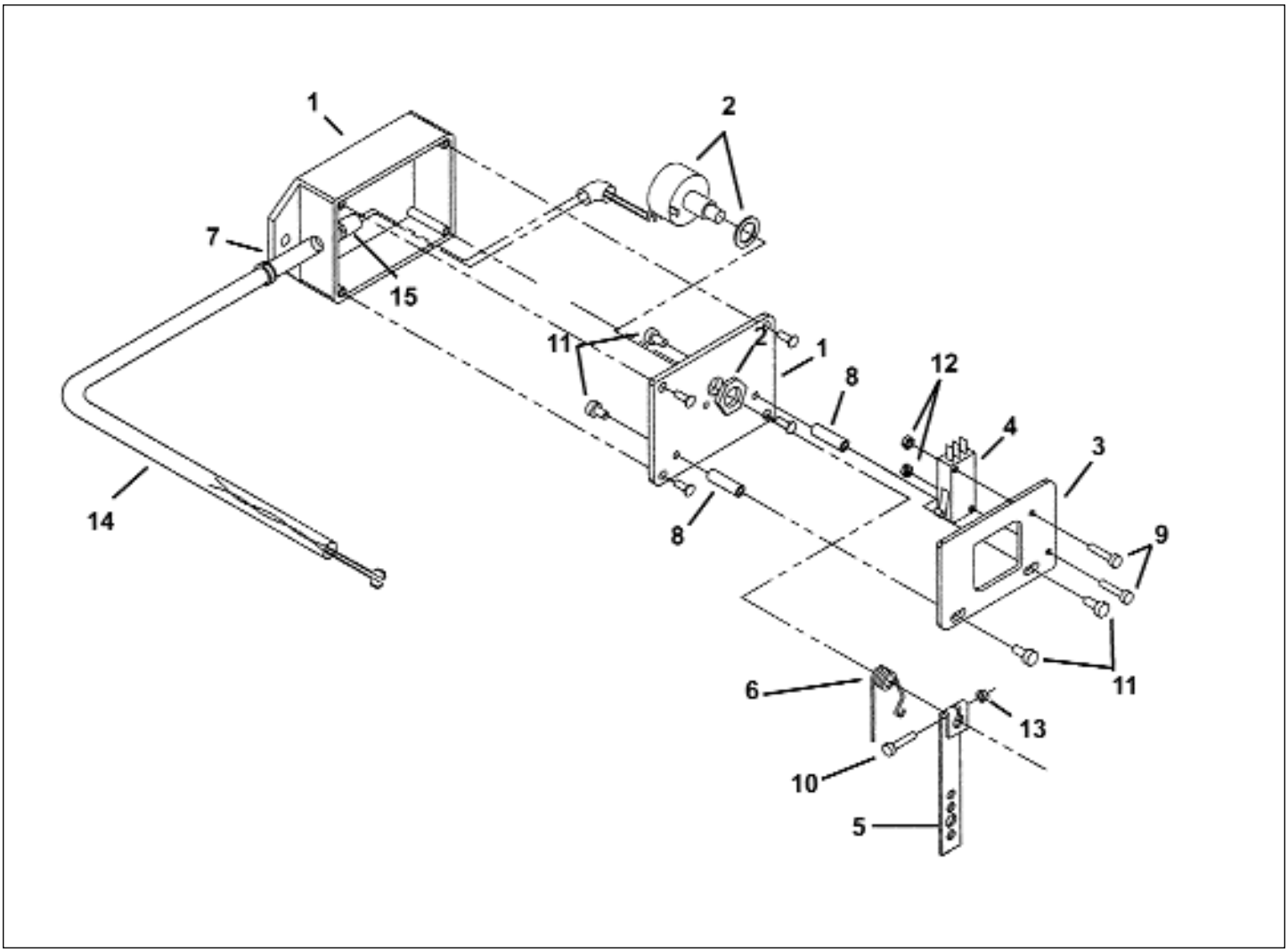


Figure 21 - Speed Switch Assembly

Removal

1. Remove red and black wires from micro switch mounted to speed switch.

2. Remove white and black leads from speed control module #2 and # 3 tab terminals.

3. Remove wire ties securing speed switch lead wires to frame.

4. Remove cotter pin and accelerator clevis from speed switch lever. Note which position clevis pin was removed from. You will need to reinstall to original position.

5. Remove screws securing speed switch to frame. Remove speed switch from vehicle.

Disassembly

Note: Refer to Figure 21, page 8-22.

1. Remove two screws (Figure 21, #11) holding micro switch plate to support spacers.

2. Loosen lock screw clamping speed switch lever to pot switch. Remove speed switch lever and return spring.

3. Remove four screws, and remove pot box cover.

4. Remove micro switch plate support spacers from cover.

5. Remove nut holding pot switch into cover, and remove pot switch. See Figure 21#2)

Caution: If pot switch is to be removed, solder connections must be cut or solder must be melted with soldering iron for wire removal. Care must be taken to prevent internal pot switch damage caused by excessive heat when de-soldering and soldering.

6. Lead wires and grommet can now be removed from box.

Assembly

1. Insert lead wires into box with grommet. Check that wire length in box is sufficient for connecting pot switch.

2. Connect black wire to center tab and white wire to left tabs of pot switch. Solder pot witch wires to pot switch tabs. See Figure 22.

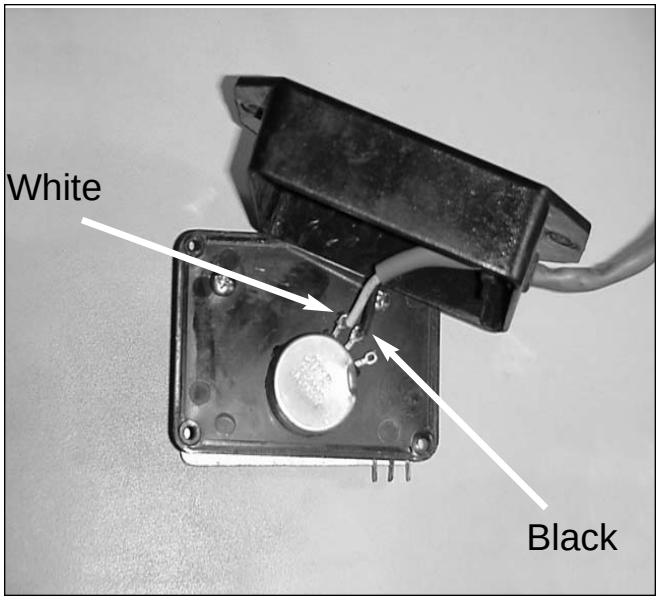


Figure 22 - Pot Switch Wires

Caution: Care must be taken to prevent internal pot switch damage caused by excessive heat when soldering.

3. Install lock washer onto pot switch, insert pot switch into box cover aligning tab on pot switch to engage into hole in cover. Install nut to outside of box.

4. Install spacers (2) to outside of pot box cover.

5. Install cover with pot switch to box.

6. Install return spring and speed switch lever to pot switch. See Figure 21. Do not torque clamp screw until adjustment has been completed.

7. Install micro switch plate to spacers on switch assembly cover.

8. Refer to Pot Switch Adjustment for final internal adjustment recommendations before use.

Warning: Any time that a pot switch is disassembled, it must be adjusted before put into use. Failure to perform this adjustment could cause accident or injury.

Pot Switch Adjustment

To adjust pot switch:

1. Loosen screw clamping speed switch lever to pot switch.

2. With volt/ohm meter, connect black and white lead wires (wires must be disconnected from speed control module for this test).

3. With speed switch lever released, rotate pot switch (using a straight screwdriver) until correct reading of 0 to 50 ohms is observer.

4. Torque speed switch lever clamp screw and rotate speed switch lever to full speed position. Check for 4500 to 5500 ohms. Adjust pot switch as required only if necessary to achieve correct ohm resistance value.

Caution: If resistance results are inconsistent or erratic, the pot switch must be replaced.

Installation

1. Set speed switch into place on frame mount, and install speed switch mount screws. Do not torque screws at this time.

2. Connect accelerator linkage using clevis pin, washer and new cotter pin.

Caution: As linkage is connected, check that accelerator rod moves freely without interference with frame or other components. Tension from interference will damage switch over time and cause pot switch failure.

3. Adjust accelerated switch position (if mount holes are slotted) and torque mounting screws.

4. Route wires along frame to speed control module. Connect white lead wire to # 2 tab terminal and black lead wire to # 3 tab terminal on speed control module. See Figure 22.

5. Tie speed switch wires along frame with wire ties, to prevent wires from dragging under vehicle and damaging wires.

6. Connect red and black wires from wire harness to speed switch assembly micro switch, 1st and 3rd terminals. DO NOT USE CENTER TERMINAL.

Speed Switch Assembly Adjustment

Slowly depress accelerator, and check that:

1. As accelerator is depressed, speed switch lever does not contact micro switch plate support spacers.

2. As accelerator is released, speed switch lever must contact micro switch lever shortly before accelerator pedal reaches stop position. Also, check at speed switch lever does not contact micro switch support spacer.

If adjustment is required, remove clevis pin from speed switch lever and rotate clevis to lengthen or shorten accelerator rod as required.

Caution: All years and models of vehicles will not be the same, regarding the clevis pin position in speed switch arm. If clevis pin is inserted into incorrect speed switch lever hole, the following will occur:

* Vehicle will not operate at full speed or poor hill climbing performance will be observed. Move clevis pin down one hole on speed switch lever.

* Speed switch lever will contact micro switch plate support spacers, and rod adjustment will not correct the problem. Move clevis pin up one hole on speed switch lever.

Always, use new cotter pin when reassembling.

Traction Motor

Maintenance

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

Since the operating environment: of Golf or Industrial/Commercial equipment varies widely, the following recommendations are suggested for periodic maintenance inspection.

Table 10 - Periodic Maintenance

Usage	Inspection Interval
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.

Severe Service would include:

1. **Dusty or sandy** locations such as cement plant, lumber or flour mills, coal dust or stone-crushing areas.

2. **High Temperature Areas** such as steel mills, foundries, etc.

3. **Sudden Temperature changes** such as continuous in-door-outdoor movement, as in refrigeration plants, etc.

External Motor Inspection

Routine motor inspection should include the following:

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 quality "Anti-seize" compound.

3. Check for any sign of oil leaks from final drive axle, which might cause oil to enter traction motor.

4. Make visual inspection of brush and commutation area. Brush inspection cover should be removed for viewing.

Internal Motor Inspection

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

Brush and commutator inspection can be accomplished by removing the brush inspection cover from the commutator end of the motor. The brushes and commutator should be inspected for even wear and good communication.

Good communication 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

Caution: Always remove key from key switch and disconnect battery leads before servicing, to prevent accidental operation and possible injury.

1. Disconnect batteries from control circuit.

2. Mark motor cables (if not already marked), with motor terminal identification. Remove cables from traction motor.

3. Remove three (3) bolts securing motor to rear axle/differential housing, while carefully supporting motor to prevent it from falling.

4. Lift motor from vehicle.

Disassembly

1. Remove motor head cover (1) & two screws (2). See Figure 23.

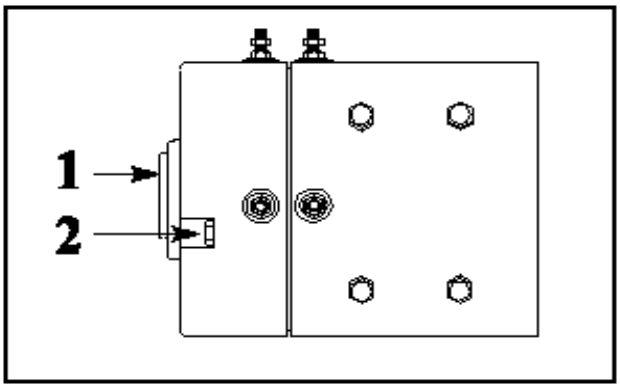


Figure 23 - Motor Disassembly

2. Pull on motor head to remove armature from frame. A light tap may be required to loosen motor head from frame.

3. Place puller around the motor head and use the center of the shaft to locate puller.

4. Pull motor head assembly off of armature assembly maintaining equal pressure on all sides of head. See Figure 24.

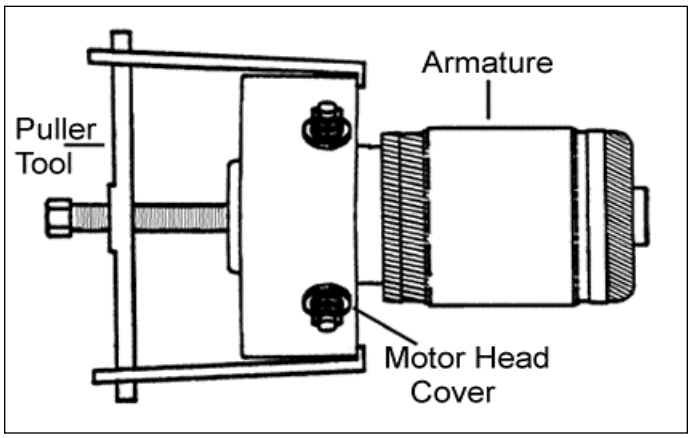


Figure 24 - Remove Armature

5. Brushes can now be removed.

6. Remove terminal nuts, washers and insulators. Remove (4) brush plate screws, remove brush plate assembly and terminal assemblies. See Figure 25.

7. Remove bearing retainer and screws. Remove bearing from motor head end cover.

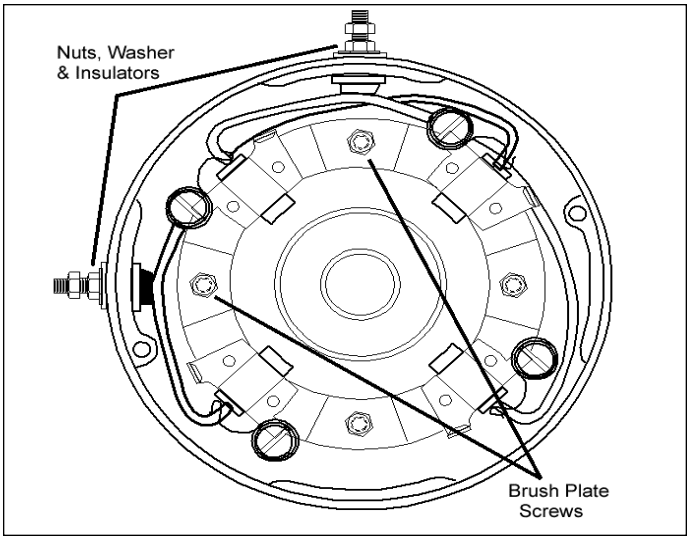


Figure 25 - Brush Removal

Armature Inspection

Support the armature at both bearing journals, check run-out of commutator with a dial gage. Total indicated run-out should not exceed .003 inch or .001 inch bar to bar. If the readings fall outside this limit, commutator must be turned and re-undercut. After the commutator has been undercut, 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. Clean commutator with dry compressed air and recheck commutator runout. See Figure 26.

Armature Testing

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

Check armature for grounded circuits by placing one test lead of a Dielectric Breakdown Tester on the commutator and the other lead at the armature shaft. If the test light comes on, the armature is grounded. See Figure 27.

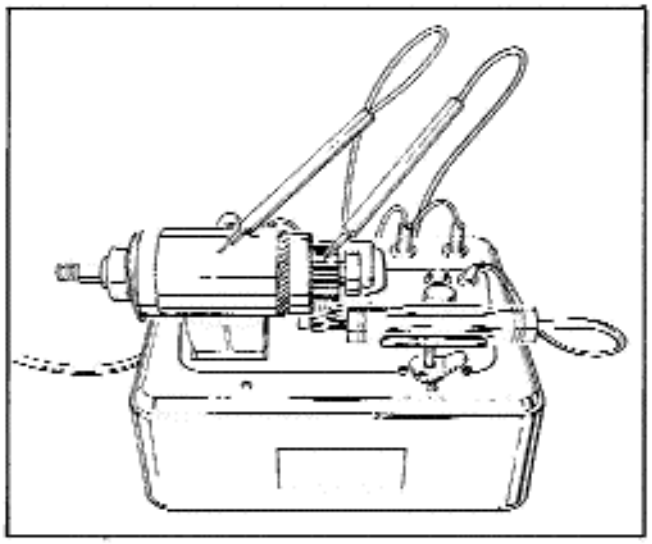


Figure 27 - Shorted Armature Test

For short circuit connection, the armature is tested, on a growler using a hacksaw plate to locate any shorted windings. See Figure 28.

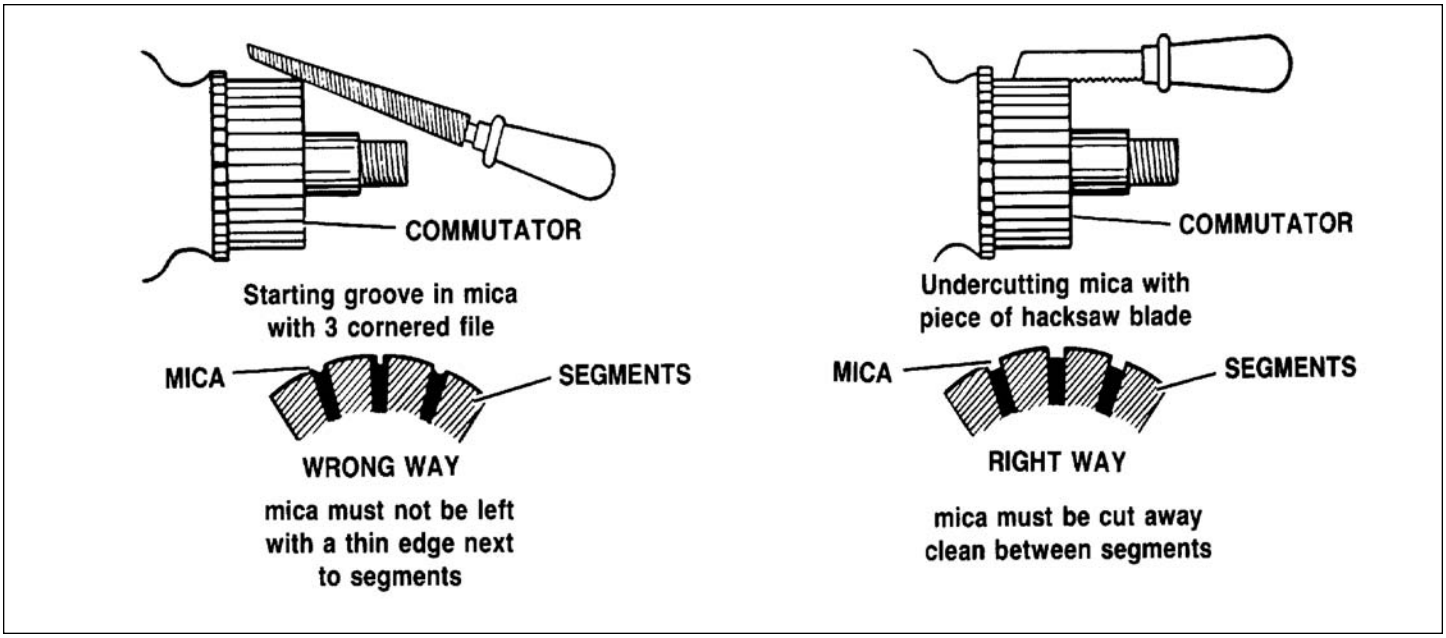


Figure 26 - Armature Undercutting

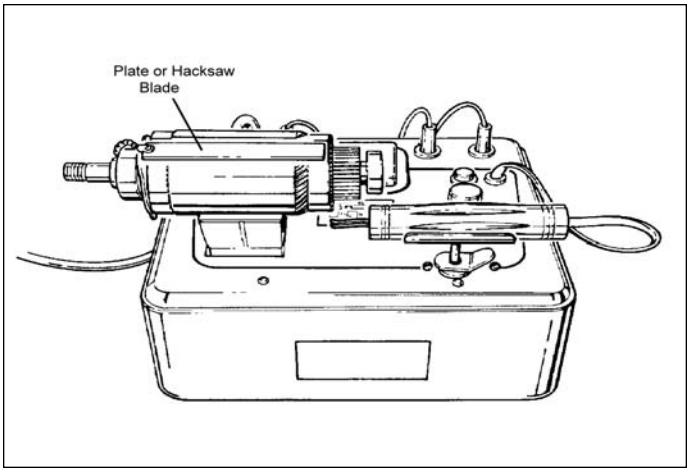


Figure 28 - Growler Test of Armature

Table 11 - Commutator Diameter Specifications	
XP Motor Part # 69200-89A	
Maximum Diameter New	2.92 inches (74 mm)
Minimum Diameter for re-slotting	2.80 inches (71 mm)
Replacement Diameter	2.75 inches (70 mm)

P.M. Motor Part # 69300-97	
Maximum Diameter New	2.92 inches (74 mm)
Minimum Diameter for re-slotting	2.80 inches (71 mm)
Replacement Diameter	2.75 inches (70 mm)

Brushes

Brushes should be inspected for uneven wear and signs of overheating such as discolored brush leads and brush springs. Check the brush holders for physical damage and make sure they are not loose on the end head or the brush holder plate.

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

Table 12 - Brush Specifications	
XP Motor Part # 69200-89A	
New Brush Length	1.30 inches (35 mm)
Minimum Brush Length	0.62 inches (16 mm)
P.M. Motor Part # 69300-97	
New Brush Length	1.30 inches (35 mm)
Minimum Brush Length	0.62 inches (16 mm)

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. After the installation of new brushes, the motor should be operated at 12 volt, no load and brushes seated to the commutator with a dressing stone. Stone dust must be blown out with dry compressed air.

Bearings

After the motor has been disassembled, it is recommended that new bearings are installed. Bearings may have been damaged during removal. Although the bearings may appear and feel good, the bearing races could be lightly damaged and failure will occur within a relatively short period of service.

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.

Preferred method of checking brushes for proper tension. See Figure 29.

1. Place paper strip between brush face and commutator.

2. Hook Spring Scale as shown on sketch below.

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

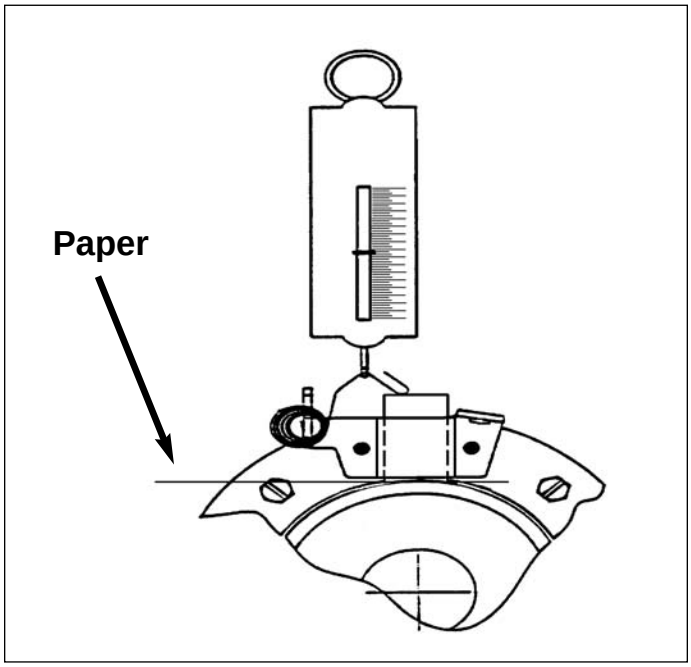


Figure 29 - Brush Spring Pull Test

Table 13		
Motor #	**Spring Tension**	
XP Motor Part# # 69200-89A	New	65 Oz. (1820 Grams)
	Worn (Minimum)	40 Oz. (1120 Grams)
Power Master Motor Part # 69300-97	New	65 Oz. (1820 Grams)
	Worn (Minimum)	40 Oz. (1120 Grams)

Frame & Field Coil

Note. Do not remove the field coils from the motor frame unless it is absolutely necessary. Removal and re-installation could shorten field coil life.

There should be no continuity between the frame of the motor, and field coil. Field coil resistance should be:

Table 14-Field Coil Resistance at 75º F. (23º C)	
XP Motor Part # 69200-89A	.013 Ohms (± 10%)
Power Master Motor Part # 69300-97	2.20 Ohms (± 10%)

If removal is required:

1. Remove two pole shoe bolts from each pole shoe (laminated steel bar).

2. Carefully pry each pole shoe from the coils, using care to prevent nicking or scratching the insulation on field coils.

3. Remove the field coil terminal nuts, washers and insulators.

4. Carefully, begin lifting the field coils from the frame, starting at one terminal stud and working around to the opposite. Remove the coil from the frame.

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

In this case it is recommended to clean the complete frame and field in a cleaning solution of Safety-Kleen 105 washing solvent or an equivalent product. After cleaning, the frame and field must be oven-cured for one hour at 300F (148C). It is recommended to add a coat of WS-200 PT George varnish for proper Insulation protection. This is a class H water-soluble varnish. A similar air-dry varnish may also be used providing it has a class H thermal specification.

Assemble field coil terminals as shown in Figure 30. Motor terminals should be torqued to 140 in./lbs. (15.5 N.m.). Pole shoe screws should be torqued to 250 - 300 in./lbs. (28 to 33.5 N.m.).

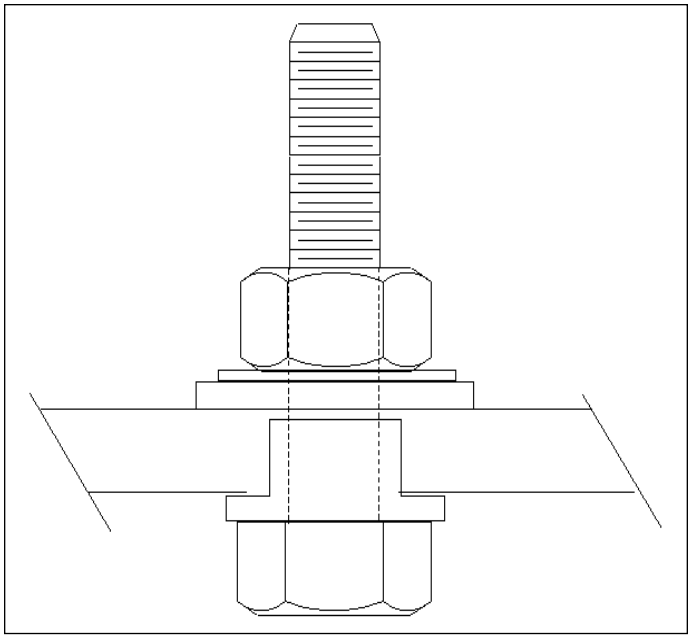


Figure 30 - Terminal Assembly and Torque

Assembly

1. Install brush holder into motor end housing (if removed).

2. Always, use a new bearing when servicing a motor. Press bearing into motor end housing, press only against the outer race.

3. Add snap ring to retain bearing.

4. Install brush holder into motor end cover as shown in Figure 25. Install insulators and brush leads into cover, see Figure 31. Motor terminals should be torqued to 140 in./lbs. (15.5 N.m.).

5. Install brushes partially into holders, wedging the brush spring against the sides of each brush. This will hold the brush up within each holder, to prevent interference and damage to brushes and armature during assembly.

6. Press motor end housing and bearing onto armature, pressing only against inner race. See Figure 31.

7. Install brush springs then partially insert each brush into its 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.

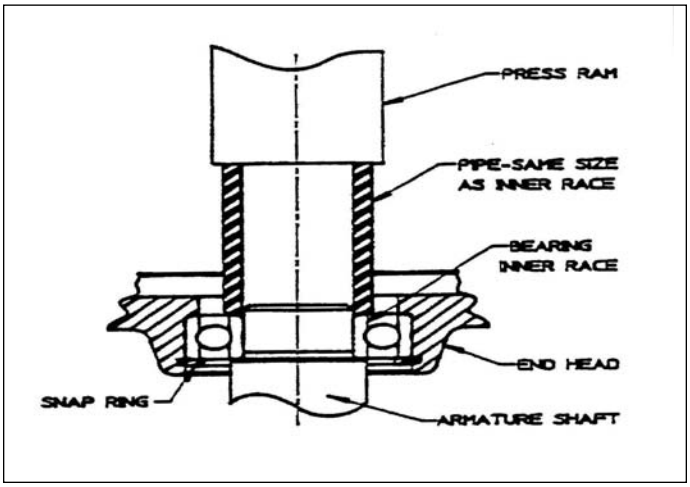


Figure 31 - Press Bearing and End Cover on to Armature

8. Check that end cover and bearing rotates freely, without noise or irregular interference. Press brushes inward against armature commutator and check that brushes ride smoothly on the commutator.

9. If the field coils have been removed from the motor frame:

   a. Insert new field coil into motor frame, re-using original frame insulators. Insert terminal studs and stud insulators through terminal openings in motor frame.

   b. Insert each pole shoe, using care not to nick or damage the insulation on field coil windings. Hand tighten two bolts into each pole shoe to hold it in place. Once all four pole shoes are in place, torque to 250 to 300 inch Ib. (28 to 33.6 N.m.).

   c. Coat the interior of the frame and field coils with WS-200 PT George varnish for proper insulation protection. This is a class H water-soluble varnish. A similar air-dry varnish may also be used providing it has a "class H" thermal specification.

   d. After completely dried, test with an ohmmeter to make certain there is no continuity between frame and field coil

Install motor head cover and armature assembly into field coil and frame assembly, aligning armature terminals to field coil terminals. See Figure 23.

Install two (2) bolts securing motor head cover to frame. Make certain motor head cover is completely seated to the frame before tightening. Torque to 156 inch Ib. (17.5 N.m).

Insert rubber bumper into the open end of the armature, and paint the open end of the armature and rear axle input shaft liberally with anti-seize compound.

Place motor into vehicle and onto input shaft. Rotate to align bolt holes in motor, to axle as shown in Figure 32. Install three (3) bolts securing motor to rear axle/differential housing, while carefully supporting motor to prevent it from falling. Torque 3 bolts to 100 inch lb.

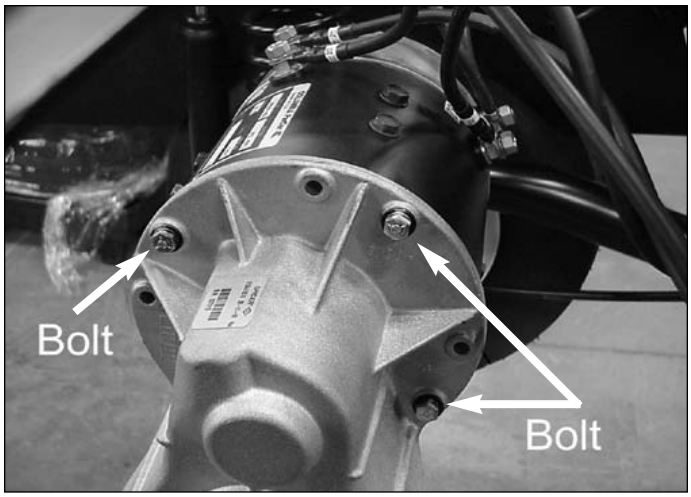


Figure 32 - Motor Installation

Inspect electrical system cables for terminal identification (A-1, A-2, etc.). Install cables to traction motor, double checking wire diagram to motor cable installation to ensure connections are correct. See wire diagrams for XP, XP Plus, and Power Master Systems.

Torque cable terminal nuts to 100 in./lbs. (11.2 N.m.), while holding the bottom nut using a thin open-end wrench. See Figure 33. Motor should not be tested without a load. Always, place the vehicle onto the ground, or onto a dynamometer to test operation.

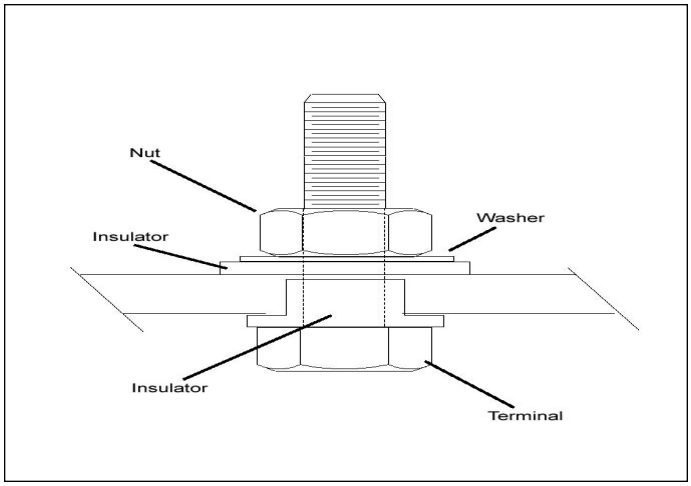


Figure 33 - Torque Motor Terminals

Caution: Do not run motor without load at full motor voltage.

XP Speed Control System (Soft Start System)

This system uses solenoids and resistors to control current flow to traction motor and vehicle direction. They are two basic circuits involved.

a. Solenoid circuit includes key switch speed control module, solenoids and light gauge wiring.

b. Motor circuit includes solenoid heavy duty contacts, large resistor coils, traction motor, heavy gauge motor and battery cables and batteries.

In the system, two 36 volt, 6 terminal solenoids control forward and reverse direction and two 36 volt, 4 terminal solenoids control speed by switching resistance in and out of the circuit.

XP System, Solid State Speed Control Adjustment

When properly adjusted, the speed control will provide all four speeds, and allow the parking brake to be fully applied without activating the first speed. The parking brake should release before activating first speed.

Check Speed Control Adjustment

Warning: Be sure jack stands fully engage fork or frame tubes and that stands are set squarely on a level floor surface before lowering vehicle onto stands. Check that vehicle is secure and will not slip from stands before operating vehicle. For additional recommendations, see Chapter 2, Lifting Instructions.

a. Set parking brake.

b. Slowly depress accelerator pedal until brake releases. At this point, motor should not be running. Continue to depress pedal slowly through first, second, third and fourth speeds. If brake does not release before first speed engages, or if fourth speed is not engaged before the pedal bottoms against the floorboard, the speed control requires adjustment.

Adjust Speed Control

Warning: Be sure jack stands fully engage fork or frame tubes and that stands are set squarely on a level floor surface before lowering vehicle onto stands. Check that vehicle is secure and will not slip from stands before operating vehicle. For additional recommendations, see Chapter 2, Lifting Instructions.

a. Speed control module is located behind the battery tray. The speed has an adjustable linkage rod from the accelerator.

b. Remove cotter pin and clevis pin. Rotate clevis to shorten or lengthen accelerator rod as required.

c. Replace pins. See Figure 34.

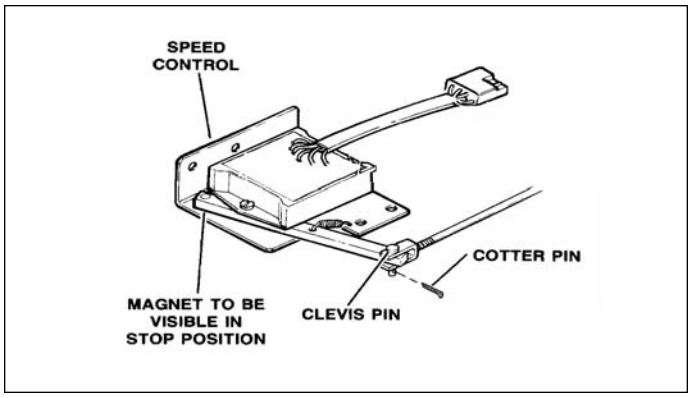


Figure 34 - Speed Control Adjustment

Electrical Operation And Circuits

Caution: Do not touch resistors after operating vehicle. Normal operation causes resistors to heat and possibly touching resistors after operating vehicle will cause severe burns.

Charging

Key Switch position	Off
Speed Switch Arm position	At rest
Solenoid C1	Not energized - open
Solenoid C2	Not energized - open
Solenoid F	Not energized; circuit connection between bottom terminals; top terminals open
Solenoid R	Not energized; circuit connection between bottom terminals; top terminals open
Voltage to Motor A1-A2	None
Resistor R1	No current flow (cold)
Resistor R2	No current flow (cold)

First Speed

Key Switch position	Forward
Speed Switch position	First speed
Solenoid C1	Not energized
Solenoid C2	Not energized
Solenoid F	Energized; circuit connection between large top terminals; large bottom terminals open
Solenoid R	Not energized; circuit connection between large bottom terminals; large top terminals open
Voltage to Motor A1-A2	Approximately 26.5 Volts
Resistor R1	In circuit (hot)
Resistor R2	In circuit (hot)

Second Speed

Key Switch position..... Forward
Speed Switch Arm position.....Second speed
Solenoid C1..... Energized; circuit connection between large bottom terminals
Solenoid C2..... Not energized
Solenoid F..... Energized; circuit connection between large top terminals; large bottom terminals open
Solenoid R..... Not energized; circuit connection between large bottom terminals; large top terminals open
Voltage to Motor A1-A2..... Approximately 29 Volts
Resistor R1..... Out of circuit (cold)
Resistor R2..... In circuit (hot)

Third Speed

Key Switch position..... Forward
Speed Switch Arm position.....Third speed

Solenoid C1..... Not energized
Solenoid C2..... Energized; circuit connection between large bottom terminals
Solenoid F..... Energized; circuit connection between large top terminals; bottom terminals open
Solenoid R.....Not energized; circuit connection between large bottom terminals; Large top terminals open
Voltage to Motor A1-A2.....Approximately 31.5 Volts
Resistor R1.....In circuit (hot)
Resistor R2.....In circuit (cold)

Fourth Speed

Key Switch position..... Forward
Speed Switch position.....Fourth speed
Solenoid C1..... Energized
Solenoid C2..... Energized
Solenoid F..... Energized; circuit connection between large top terminals; large bottom terminals open
Solenoid R.....Not energized; circuit connection between large bottom terminals, large top terminals open
Voltage to Motor A1-A2.....Approximately 34 Volts
Resistor R1.....Out of circuit (cold)
Resistor R2.....Out of circuit (cold)

Reverse

Key Switch position..... Reverse
Speed Switch Arm position.....Same as forward speeds
Solenoid C1..... Same as forward speeds
Solenoid C2..... Same as forward speeds
Solenoid F..... Not energized; circuit connection between large bottom terminals; large top terminals open
Solenoid R.....Energized; circuit connection between large top terminals; large bottom terminals open
Voltage to Motor A1-A2.....Same as forward speeds
Resistor R1.....Same as forward speeds
Resistor R2.....Same as forward speeds

Trouble Shooting Guide - XP Speed Control System

Note: Always follow trouble shooting guide in exact order as listed below. Performing tests out of sequence will cause inaccurate results and lost time in diagnosing electrical system problems.

Vehicle Does Not Operate, Forward or Reverse.		
Test	**Passed**	**Failed**
Voltmeter positive red lead to battery B+ terminal, Voltmeter negative black lead to battery B- terminal.	36 volts = Good	Less than 36 volts, charge and or replace batteries
1. Key switch in forward. Voltmeter positive red lead to green wire at forward solenoid, Voltmeter negative black lead to battery negative (B-) terminal. 2. Key switch in reverse, Voltmeter positive red lead to blue wire at reverse solenoid, Voltmeter negative black lead to battery negative (B-) terminal.	36 volts = Good	Less than 36 volts, check key switch and wire harness.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to green wire at forward solenoid, Voltmeter negative black lead to white wire at forward solenoid.	36 volts = Good	Less than 36 volts, speed control module defective.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to blue wire at reverse solenoid, Voltmeter negative black lead to white wire at reverse solenoid.	No voltage = Good	36 volts = speed control module defective.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to reverse solenoid, #1 terminal. Voltmeter negative black lead to battery negative terminal.	36 volts = Good	Less than 36 volts, replace defective forward solenoid.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to reverse solenoid, #4 terminal. Voltmeter negative black lead to battery negative terminal.	36 volts = Good	Less than 36 volts, check traction motor field coil and motor cables.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to A-2 terminal at traction motor, Voltmeter negative black lead to A-1 terminal at traction motor.	36 volts = Good	If motor does not operate, check resistors. If good, check motor brushes and armature. See page 8-27.

1. Key switch in forward. Voltmeter positive red lead to green wire at forward solenoid, Voltmeter negative black lead to battery negative terminal. 2. Key switch in reverse. Voltmeter positive red lead to blue wire at reverse solenoid, Voltmeter negative black lead to battery negative terminal.	36 volts = Good	Less than 36 volts, check key switch and wire harness.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to green wire at forward solenoid, Voltmeter negative black lead to white wire at forward solenoid.	36 volts = Good	Less than 36 volts, speed control module defective.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to blue wire at reverse solenoid, Voltmeter negative black lead to white wire at reverse solenoid.	No voltage = Good	36 volts = speed control module defective
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to forward solenoid, #2 terminal. Voltmeter negative black lead to battery negative terminal.	36 volts = Good	Less than 36 volts, poor battery cable connection or excessive corrosion.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to reverse solenoid, #1 terminal. Voltmeter negative black lead to battery negative terminal.	36 volts = Good	Less than 36 volts, replace defective forward solenoid.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to reverse solenoid, #4 terminal. Voltmeter negative black lead to battery negative terminal.	36 volts = Good	Less than 36 bolts, check traction motor field coil and motor cables.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to reverse solenoid, #3 terminal. Voltmeter negative black lead to battery negative terminal.	36 volts = Good	Less than 36 volts, replace reverse solenoid.

Vehicle Does Not Operate In Reverse, Operates Correctly In Forward		
Test	**Passed**	**Failed**
1. Key switch in forward. Voltmeter positive red lead to green wire at forward solenoid, Voltmeter negative black lead to battery negative terminal. 2. Key switch in reverse. Voltmeter positive red lead to blue wire at reverse solenoid, Voltmeter negative black lead to battery negative terminal.	36 volts = Good	Less than 36 volts, check key switch and wire harness.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to blue wire at reverse solenoid, Voltmeter negative black lead to white wire at reverse solenoid.	36 volts = Good	Less than 36 volts, speed control module defective.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to green wire at forward solenoid, Voltmeter negative black lead to white wire at forward solenoid.	No voltage = Good	36 volts = speed control module defective.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to reverse solenoid, #1 terminal. Voltmeter negative black lead to battery negative terminal.	36 volts = Good	Less than 36 volts, poor battery cable connection or excessive corrosion.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to reverse solenoid, #2 terminal. Voltmeter negative black lead to battery negative terminal.	36 volts = Good	Less than 36 volts, replace defective reverse solenoid.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to forward solenoid, #3 terminal. Voltmeter negative black lead to battery negative terminal.	36 volts = Good	Less than 36 volts, check traction motor field coil and motor cables.
Key switch in forward, depress accelerator pedal.Voltmeter positive red lead to reverse solenoid, #4 terminal. Voltmeter negative black lead to battery negative terminal.	36 volts = Good	Less than 36 volts, replace forward solenoid.

No First And Second Speed, Operates Correctly In Third And Fourth.		
Test	**Passed**	**Failed**
Visual inspection of R-2 resistor for cracks or breakage.	No cracks or breakage = Good	Cracked or broken, replace R-2 resistor.
Key switch in forward, depress accelerator pedal through first speed position. Voltmeter positive red lead to green wire at forward solenoid, Voltmeter negative black lead to white wire at forward solenoid.	36 volts = Good, continue to next test.	
Key switch in forward, depress accelerator pedal through second speed position. Voltmeter positive red lead to gray wire at C-1 solenoid, Voltmeter negative black lead to orange wire at C-1 solenoid.	36 volts = replace C-1 solenoid.	Less than 36 volts, replace speed control module.

No First And Third Speed, Operates Correctly In Second And Fourth		
Test	**Passed**	**Failed**
Visual inspection of R-1 resistor for cracks or breakage.	No cracks or breakage = Good	Cracked or broken, replace R-1 resistor.
Key switch in forward, depress accelerator pedal to first speed position. Voltmeter positive red lead to green wire at forward solenoid, Voltmeter negative black lead to white wire at forward solenoid.	36 volts = Good, continue to next test.	Less than 36 volts, replace speed control module.
Key switch in forward, depress accelerator pedal through third speed position. Voltmeter positive red lead to brown wire at C-2 solenoid, Voltmeter negative black lead to orange wire at C-2 solenoid.	36 volts = replace C-2 solenoid.	Less than 36 volts, replace speed control module.

No Second And Fourth Speed, Operates Correctly In First And Third		
Test	**Passed**	**Failed**
Key switch in forward, depress accelerator pedal through second speed position. Voltmeter positive red lead to gray wire at C-1 solenoid, Voltmeter negative black lead to orange wire at C-1 solenoid.	36 volts = replace C-1 solenoid.	Less than 36 volts, replace speed control module.

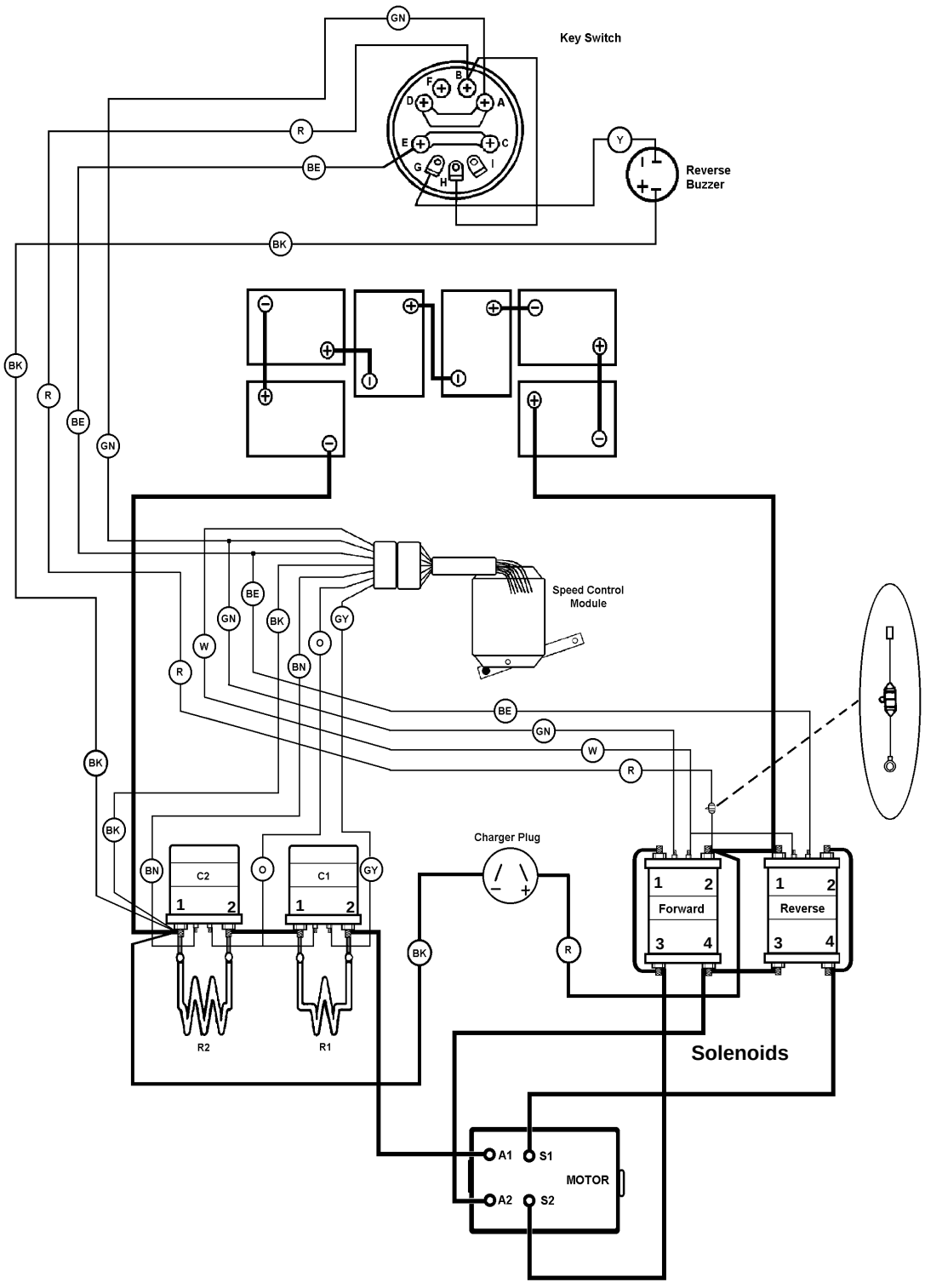
No Third And Fourth Speed, Operates Correctly In First And Second		
Test	**Passed**	**Failed**
Key switch in forward, depress accelerator pedal through third speed position. Voltmeter positive red lead to brown wire at C-2 solenoid, Voltmeter negative black lead to orange wire at C-2 solenoid.	36 volts = replace C-2 solenoid.	Less than 36 volts, replace speed control module.

No Fourth Speed, Operates Correctly In First, Second, And Third		
Test	**Passed**	**Failed**
Disconnect speed switch linkage, operate speed switch by hand.	If vehicle operates correctly, adjust speed switch linkage.	If vehicle does not operate to fourth speed, continue to next test.
1. Key switch in forward, depress accelerator pedal to fourth speed position. Voltmeter positive red lead to gray wire at C-1 solenoid, Voltmeter negative black lead to orange wire at C-1 solenoid. 2. Key switch in forward, depress accelerator pedal to fourth speed position. Voltmeter positive red lead to brown wire at C-2 solenoid, Voltmeter negative black lead to orange wire at C-2 solenoid.	36 volts = Good	If 36 volts is not observed at both solenoids, replace speed control module.

Vehicle Continues To Operate, Accelerator Released (Forward and Reverse)		
Test	**Passed**	**Failed**
Switch key to off position.	If vehicle continues to operate, continue to next test.	If vehicle stops, adjust accelerator rod.
Key switch in forward, **do not** depress accelerator pedal. Voltmeter positive red lead to green wire at forward solenoid, Voltmeter negative black lead to white wire at forward solenoid.	No voltage = Good	36 volts = speed control module defective.

Vehicle Continues To Operate, Key Switch And Off Position		
Test	**Passed**	**Failed**
Key switch in off position.		* If vehicle operates in forward position, replace defective forward solenoid. * If vehicle operates in reverse position, replace defective reverse solenoid.

XP Speed Control Wire Diagram



XP Plus System (Curtis System)

Operation

The XP Plus speed control system offers infinitely variable speed control, in forward and in reverse. This is a highly efficient speed control system in that the pulse modulating controller does not waste battery energy. For reduced speeds, the controller turns on and off the motor circuit at an extremely high rate of speed. For increased speed, the controller increases the duration at which the motor circuit is completed, then decreases the connection duration for lower vehicle speed. The result is a smooth and gradual increase and decrease in speed, appropriate to accelerator position. This system also uses a potentiometer (pot box) for accelerator speed control. Two six (6) terminal solenoids are used for directional control, one four (4) terminal solenoid is used as a main contactor.

Speed Control Switch (Pot Box)

For details regarding speed control (pot box) adjustment or repair, refer to page 8-23. This section contains information regarding testing and failure diagnosis.

Warning: Raise vehicle per lifting instructions, Chapter 2. Support safely on jack stands before preceding. Failure to do so, could cause accident and/or injury.

Electrical Operation and Circuits

Charging

Keep switch position……..... Off
Accelerator/speed switch position… Up/At rest
Solenoid F…… Not energized connection between bottom terminals; top terminals open
Solenoid R…… Not energized connection between bottom terminals; top terminals open
Solenoid M…….. Not energized; top terminals open
Controller #1 tab terminal……... Not energized

Forward Operation

Key switch position forward.....accelerator pedal depressed
Solenoid F…… Energized connection between large top terminals; large bottom terminals open
Solenoid R…… Not energized; contact between large bottom terminals; large top terminals open
Solenoid M……Energized; contact between large top terminals
Controller #1 tab terminal…….…. Energized

Reverse Operation

Key switch position reverse .....accelerator pedal depressed
Solenoid F…… Not energized; contact between large bottom terminals; large top terminals open
Solenoid R……Energized connection between large top terminals; large bottom terminals open
Solenoid M……Energized; contact between large top terminals
Controller #1 tab terminal…….…. Energized

Trouble Shooting Guide - XP Plus Speed Control System

Note: Always follow trouble shooting guide in exact order as listed below. Performing tests out of sequence will cause inaccurate results and lost time in diagnosing electrical system problems.

Vehicle Does Not Operate, Forward or Reverse.		
Test	**Passed**	**Failed**
Voltmeter positive red lead to battery B+ terminal, Voltmeter negative black lead to battery B- terminal.	Full battery voltage = Good	Less than full battery voltage, charge and or replace batteries.
1. Key switch in forward. Voltmeter positive red lead to red wire at forward solenoid small terminal, Voltmeter negative black lead to battery negative (B-) terminal. 2. Key switch in reverse, Voltmeter positive red lead to yellow wire at reverse solenoid small terminal, Voltmeter negative black lead to battery negative (B-) terminal.	Full battery voltage = Good	Less than full battery voltage, check key switch and wire harness.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to red wire at forward solenoid small terminal, Voltmeter negative black lead to gray wire at forward solenoid small terminal.	Full battery voltage = Good	Less than full battery voltage, accelerator micro switch or micro switch circuit defective.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to yellow wire at reverse solenoid small terminal, Voltmeter negative black lead to gray wire at reverse solenoid small terminal.	No voltage = Good	Full battery voltage, diodes between forward and reverse solenoid defective.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to white wire at main solenoid, Voltmeter negative black lead to gray wire at main solenoid.	Full battery voltage = Good	Less than full battery voltage, diodes between forward and reverse solenoids defective, or accelerator micro switch defective.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to white wire at #1 tab terminal of speed control module, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than full battery voltage, diodes between forward and reverse solenoids, or accelerator micro switch defective.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to yellow wire at reverse solenoid small terminal, Voltmeter negative black lead gray wire at reverse solenoid small terminal.	Full battery voltage = Good	Less than full battery voltage, accelerator micro switch or micro switch circuit defective.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to red wire at forward solenoid small terminal, Voltmeter negative black lead to gray wire at forward solenoid small terminal.	No voltage = Good	Full battery voltage, diodes between forward and reverse solenoids are defective.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to white wire at main solenoid, Voltmeter negative black lead to gray wire at main solenoid.	Full battery voltage = Good	Less than full battery voltage, diodes between forward and reverse solenoids defective, or accelerator micro switch defective.
Key switch in forward, **do not** depress accelerator pedal. Voltmeter positive red lead to main solenoid #2 terminal, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than full battery voltage, low batteries, poor or corroded connections.
Key switch in forward, **do not** depress accelerator pedal. Voltmeter positive red lead to main solenoid #1 terminal, Voltmeter negative black lead to controller B- terminal.	1 to 5 volts less than full battery voltage = Good	No voltage, defective resistor. If full battery voltage, replace welded main solenoid.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to main solenoid #1 terminal, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	No increase or voltage drops, replace defective main solenoid.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to traction motor A-1 terminal, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than full battery voltage, check for loose or poor connections from main solenoid #1 terminal, to controller B+ and to motor A-1.

Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to controller M- terminal.	As accelerator is depressed, battery voltage should rise to within 1 to 2 volts of battery voltage.	Refer to **speed switch testing** below before continuing. If speed switch testing concludes speed switch is good, then controller has failed.
Key switch in forward, depress accelerator pedal.Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #1 terminal at forward solenoid.	Full battery voltage = Good	If low or no voltage, check cables and cable connections from controller M- to forward solenoid #1 terminal.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #2 terminal at forward solenoid.	Full battery voltage = Good	If low or no voltage, replace defective forward solenoid.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to traction motor S-2 terminal.	Full battery voltage = Good	If low or no voltage, check cables and cable connections from forward solenoid #2 terminal, to forward #3 and to motor S-2.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to traction motor S-1 terminal.	Full battery voltage = Good	Defective field coil in traction motor. See Traction Motor, page 8-24 for repair procedures.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #3 terminal of reverse solenoid.	Full battery voltage = Good	If low or no voltage, check cables and cable connections from motor S-2 terminal, to reverse solenoid #3 terminal.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #4 terminal of reverse solenoid.	Full battery voltage = Good	Less than full battery voltage, replace defective reverse solenoid.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to traction motor A-2 terminal.	Full battery voltage = Good	If low or no voltage, check cables and cable connections from reverse solenoid #4 terminal, to forward #3 and to motor A-2.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to A-1 terminal at traction motor, Voltmeter negative black lead to A-2 terminal at traction motor.	Full battery voltage = Good	If motor does not operate, check motor brushes and armature. See Traction Motor, page 8-24..

Speed Switch (Pot Box) Testing		
Test	**Passed**	**Failed**
Remove white and black lead wires from controller #2 and #3 1/4" tab terminals. Switch volt/ohm meter to ohms scale. Capable of measuring 0 to 100 ohms. Connect volt/ohm meter leads to white and black wires from controller. **Do not depress accelerator. Leave key in off position.**	0 to 50 ohms resistance = Good	Greater than 50 ohms, refer to Pot Switch Adjustment, page 8-23. If adjustment does not correct, replace pot switch or speed switch assembly. See page 8-23.
Leave ohm meter leads connected to white and black leads (removed from controller #2 and #3 tab terminals). Switch ohm meter to a scale capable of measuring up to 6,000 ohms (K ohms). Slowly depress accelerator and monitor change.	Ohms of resistance should rise gradually to a maximum of 4,500 to 5,500 ohms.	* If rise in resistance is erratic or skips as pedal is depressed, replace pot switch or speed switch assembly. * If maximum resistance is less than or greater than 4,500 to 5,500 ohms, adjust pot switch to correct. Refer to page 8-23.

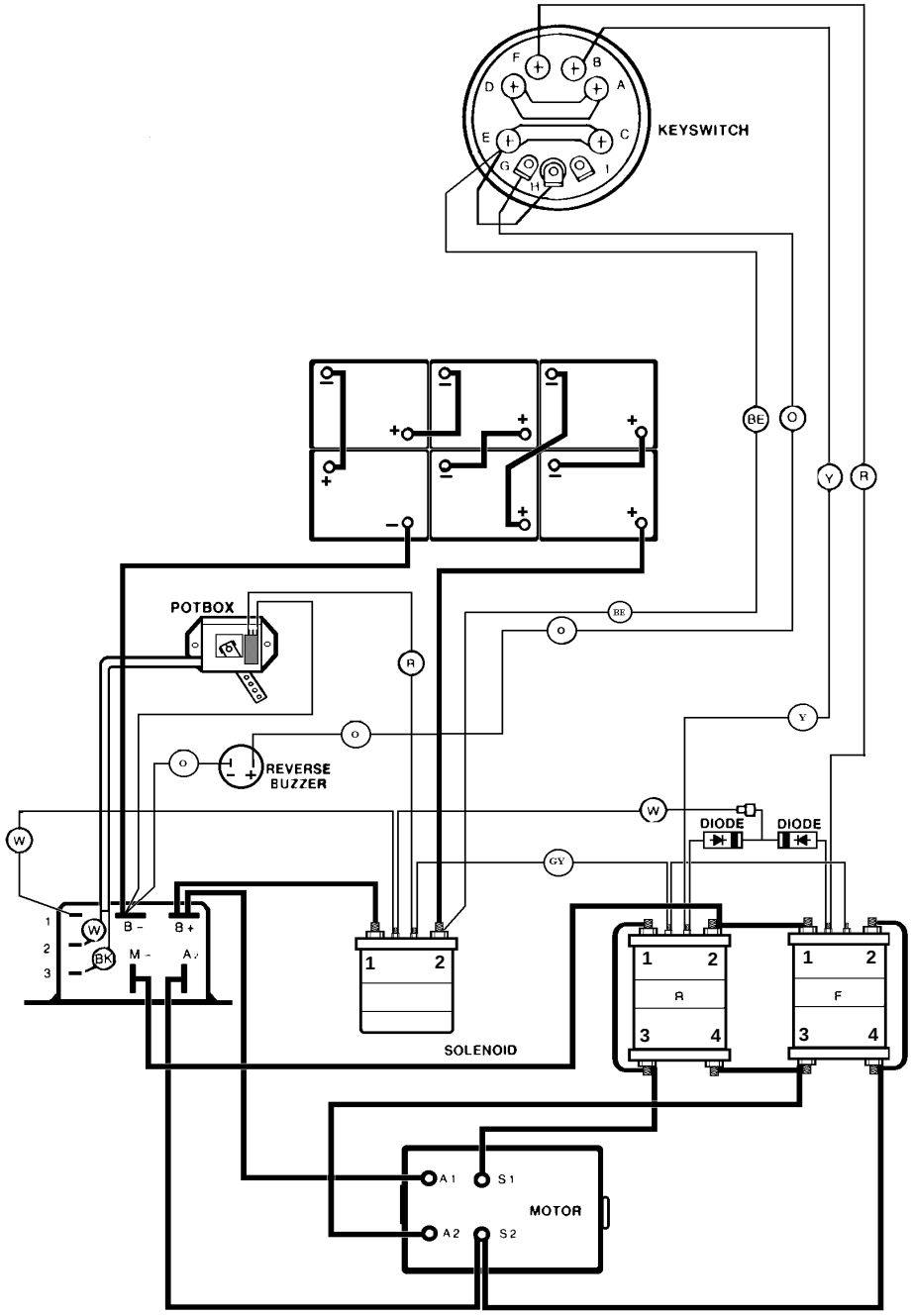
Note: Always follow trouble shooting guide in exact order as listed below. Performing tests out of sequence will cause inaccurate results and lost time in diagnosing electrical system problems.

Vehicle Does Not Operate In Forward, Operates Correctly in Reverse		
Test	**Passed**	**Failed**
Voltmeter positive red lead to battery B+ terminal, Voltmeter negative black lead to battery B- terminal.	Full battery voltage = Good	Less than full battery voltage, charge and or replace batteries.
1. Key switch in forward. Voltmeter positive red lead to red wire at forward solenoid small terminal, Voltmeter negative black lead to battery negative (B-) terminal. 2. Key switch in reverse. Voltmeter positive red lead to yellow wire at reverse solenoid small terminal, Voltmeter negative black lead to battery negative (B-) terminal.	Full battery voltage = Good	Less than full battery voltage, check key switch and wire harness.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to red wire at forward solenoid small terminal, Voltmeter negative black lead to gray wire at forward solenoid small terminal.	Full battery voltage = Good	Less than full battery voltage, accelerator micro switch or micro switch circuit defective.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to yellow wire at reverse solenoid small terminal, Voltmeter negative black lead to gray wire at reverse solenoid small terminal.	No voltage = Good	Full battery voltage, diodes between forward and reverse solenoid defective.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to white wire at main solenoid, Voltmeter negative black lead to gray wire at main solenoid.	Full battery voltage = Good	Less than full battery voltage, diodes between forward and reverse solenoids defective or accelerator micro switch defective.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to white wire at #1 tab terminal of speed control module, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than full battery voltage, diodes between forward and reverse solenoids, or accelerator micro switch defective.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal. Voltmeter negative black lead to #1 terminal at forward solenoid.	Full battery voltage = Good	If low or no voltage, check cables and cable connections from controller M- to forward solenoid #1 terminal.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #2 terminal at forward solenoid.	Full battery voltage = Good	If low or no voltage, replace defective forward solenoid.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #3 terminal of reverse solenoid.	Full battery voltage = Good	If low or no voltage, check cables and cable connections from motor S-2 terminal, to reverse solenoid #3 terminal.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #4 terminal of reverse solenoid.	Full battery voltage = Good	Less than full battery voltage, replace defective reverse solenoid.

Note: Always follow trouble shooting guide in exact order as listed below. Performing tests out of sequence will cause inaccurate results and lost time in diagnosing electrical system problems.

Vehicle Does Not Operate In Reverse, Operates Correctly In Forward		
Test	**Passed**	**Failed**
Voltmeter positive red lead to battery B+ terminal, Voltmeter negative black lead to battery B- terminal.	Full battery voltage = Good	Less than full battery voltage, charge and or replace batteries.
1. Key switch in forward. Voltmeter positive red lead to red wire at forward solenoid small terminal, Voltmeter negative black lead to battery negative (B-) terminal. 2. Key switch in reverse. Voltmeter positive red lead to yellow wire at reverse solenoid small terminal, Voltmeter negative black lead to battery negative (B-) terminal.	Full battery voltage = Good	Less than full battery voltage, check key switch and wire harness.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to yellow wire at reverse solenoid small terminal, Voltmeter negative black lead to gray wire at forward solenoid small terminal.	Full battery voltage = Good	Less than full battery voltage, accelerator micro switch or micro switch circuit defective.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to red wire at forward solenoid small terminal, Voltmeter negative black lead to gray wire at forward solenoid small terminal.	No voltage = Good	Full battery voltage, diodes between forward and reverse solenoid defective.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to white wire at main solenoid, Voltmeter negative black lead to gray wire at main solenoid.	Full battery voltage = Good	Less than full battery voltage, diodes between forward and reverse solenoids defective or accelerator micro switch defective.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to white wire at #1 tab terminal of speed control module, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than full battery voltage, diodes between forward and reverse solenoids, or accelerator micro switch defective.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal. Voltmeter negative black lead to #2 terminal at reverse solenoid.	Full battery voltage = Good	If low or no voltage, check cables and cable connections from controller M- to forward solenoid #2 terminal.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #1 terminal at reverse solenoid.	Full battery voltage = Good	If low or no voltage, replace defective forward solenoid.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to traction motor S-1 terminal.	Full battery voltage = Good	If low or no voltage, check cables and cable connections from reverse solenoid #1 terminal, to reverse #3 and to motor S-1.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #4 terminal of forward solenoid.	Full battery voltage = Good	If low or no voltage, check cables and cable connections from motor S-2 terminal, to forward solenoid #4 terminal.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #3 terminal of reverse solenoid.	Full battery voltage = Good	Less than full battery voltage, replace defective forward solenoid.

XP Plus Speed Control Wire Diagram



Power Master System

Operation

The Power Master System is used to offer controlled speed reduction characteristics not normally found on electric vehicles. This is often referred to as "Regen-Breaking". In order to control this function, the traction motors armature and field coils are controlled separately. For this reason, this system is occasionally referred to as a" separately excited" system.

Normally, when traction motors operate, battery current runs through the armature and field coils (in series) as one complete circuit. With the Power Master System, the field coil and armature circuits are separate systems, and controlled as separate (parallel) circuits. Vehicles using this Power Master System will decelerate (rather than free wheel) as the accelerator pedal is released. As these vehicles descend steep grades, the Power Master System will prevent the vehicle speed from increasing beyond the normally rated top speed. One additional feature is referred to as the "anti-rollaway" function. Once a vehicle with this system comes to a stop, this function prevents the vehicle from accidentally rolling away undetected. Should for any reason the vehicle begin to roll, the Power Master System will engage preventing the vehicle from exceeding one to two miles per hour and the reverse warning alarm will sound. This function is active with the key on or off.

These functions are produced by separately energizing the field coil, causing the drive motor to function as a generator. When in this mode, the generator (motor) causes resistance through the rear axle, preventing vehicle speed from increasing or causing the vehicle to slow. While in this "generator" mode, new energy is produced by the generator (motor) which is directed to the batteries and drive motor, resulting in increased resistance. One example of this variable resistance is modern exercise equipment. As this equipment is operated, resistance or a resisting forced is observe. As the force against the equipment increases, the resisting force produced by the equipment, increases proportionally. As force against the equipment decreases, the equipment's resisting force also decreases proportionally. The Power Master System operates in a very similar manner. The steeper the incline the vehicle descends, the greater the resisting force applied to the drive train and a lesser incline produces a lesser rolling resistance.

The Columbia ParCar Power Master System, is a unique and patented system. Cables from the armature circuit of the traction motor are connected to a sensor module. Residual magnetism in the drive motor causes electricity to be produced whenever the motor's armature (and rear wheels) begins to rotate. This electricity is recognized by the sensor module, which in turn energizes the field coil in the traction motor. The motor now acts as a generator. Should vehicle speed increase, descending a steeper grade, the generator (motor) turns faster and produces more voltage. This increased voltage, also directed into the field coil, causes greater resistance to slow the vehicle. Should vehicle speed decrease, descending a lesser grade, the generator (motor) turns slower and produces less voltage. This decreased voltage, also directed into the field coil, causes less resistance to slow the vehicle.

Warning: The Power Master System is not designed to replace the use of brakes on electric vehicles. This system is designed to aid existing brake systems and to prevent electric vehicles from freewheeling to unsafe speeds during down hill descents. If for any reason the Power Master System becomes disabled or is found to be malfunctioning, the vehicle brakes must be used to stop vehicle. Failure to use vehicle brakes could cause accident or injury. Any vehicles found to be malfunctioning must be removed from service until it can be properly repaired by a qualified technician.

Warning: Since residual magnetism is utilized in the system function, it is important to remember that residual magnetism decays during long extended storage periods. If the vehicle has been stored for a period of 30 days or more, operate the vehicle for at least 5 minutes before testing the "Anti-rollaway and other regenerative properties.

Caution: During the first two years of production (1997 & 1998), 3 versions of the Power Master System were used. They are referred to as versions A, B, and version C. Always, verify exactly which version you are working on when referencing the wire diagrams in this chapter. Never attempt to alter a sensor or electronics module in order to use it on a vehicle with a different version of wiring.

Electrical System Testing

Warning: Before testing electrical system, always raise rear of vehicle and safely support it on jack stands. Block front wheels for additional safety. Never perform electrical tests with vehicle on ground. Accident and or injury could result.

Note: Always follow trouble shooting guide in exact order as listed below. Performing tests out of sequence will cause inaccurate results and lost time in diagnosing electrical system problems.

Note: Whenever testing the Power Master System function or operation, refer to the "Operation" section above to verify correct system function. These vehicles use two separate electrical systems. The Power Master System only controls the field coil of the traction motor and aids in the energizing of the solenoids. The controller, solenoids and speed switch, control only the traction motor's armature circuit.

Always, begin testing by first determining if the field coil (Power Master System), or armature (speed and directional control) circuit is at fault.

Begin by testing at the traction motor to determine the best way to proceed. With rear wheels raised:

1. Using a volt/ohm meter (VOM), connect red positive lead of VOM to S-1 and black negative lead to S-2 terminals on traction motor. Key switch to forward and depress accelerator pedal. If there is an audible "click" at the solenoids and from 7 to 24 DC volts is observed, proceed to step #2. If no audible click is observed, or if no DC voltage is present, refer to Power Master Testing below.

2. Using a volt/ohm meter (VOM), connect red positive lead of VOM to A-1 and black negative lead to A-2 terminals on traction motor. Key switch to forward and depress accelerator pedal. If there is an audible "click" at the solenoids and a rise of DC volts (up to 1 to 3 volts less than full battery voltage) is observed, the system is operating correctly and the traction motor should be removed and inspected. See traction motor. If no audible click is observed, test Power Master system as described below. If no D.C. voltage is observed at traction motor ‘A-1’ and ‘A-2’ terminals, see speed and directional circuit testing, page 8-45. If tests 1 and 2, above, test good refer to Traction Motor Section, Page 8-24

Power Master System Testing

Note: Always follow trouble shooting guide in exact order as listed below. Performing tests out of sequence will cause inaccurate results and lost time in diagnosing electrical system problems.

Field coil does not energize (7 to 24 DC volts) or no audible “click” energizing solenoids; follow the steps below:

1. Check tow switch position. Must be in up "run" position.

2. Using a digital volt/ohm meter (VOM), check battery condition. Connect red positive lead of VOM to B+ and black negative lead to B-. If less than 36 volts, charge batteries and retest. If 36 volts or greater, continue to next test.

3. Check 15 AMP fuse. If fuse is blown:
   * Check vehicle wiring for shorts or chafing and exposed wires.
   * Check motor terminal connections at ‘S-1’ and ‘S-2’ field coil terminals.
   * Check motor field coil for short. See traction motor, page 8-24.

4. Check accelerator micro switch.
   * Continuity between "C" and "NC" terminals with switch lever released.
   * Continuity between "C" and "NO" terminals with switch lever depressed.

5. Disconnect the wire harness from the Power Master electronics module. Connect voltmeter negative lead to battery negative (B-) terminal and positive lead to wire harness pin from the yellow wire. Turn key switch to forward and depress accelerator pedal. Test for battery voltage. See Figure 35. If battery voltage is observed, continue to next test. If battery no voltage is observed, check tow switch resistor fuse, tow switch and yellow wire connections at tow switch and main solenoid. If battery voltage is observed, reconnect harness to Power Master electronics module and continue to next test.

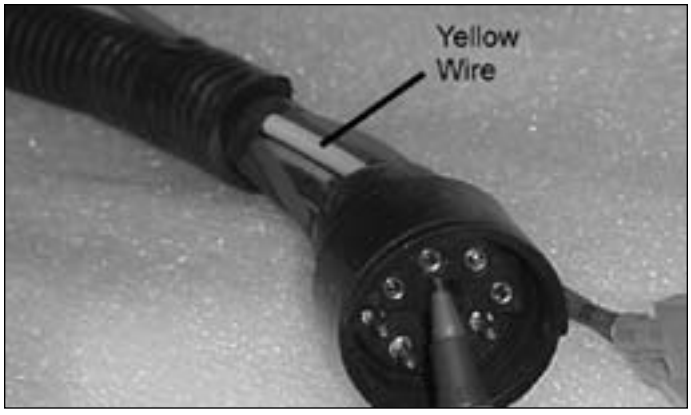


Figure 35 - Test Voltage At Harness Plug

6. Check that Power Master System is properly energizing solenoids. Key switch to forward and depress accelerator pedal. Voltmeter black negative lead on forward solenoid, terminal, red voltmeter lead to battery B+ terminal. If battery powered is not observed, check the accelerator micro switch. If no fault is found with the accelerator micro switch or wires connecting to it, replace Power Master electronics control module. If in the above test, battery voltage is observed but Power Master system is not functioning, then continue to next test.

7. Connect voltmeter red positive lead to S-1 terminal and negative lead to S-2 terminal at traction motor. Turn key switch to forward and depress accelerator pedal. If operating voltage (7 to 24 DC volts) is observed, continue to test #7. If operating voltage is not observed, continue to next test.

8. Disconnect two large 10 gage red wire leads Power Master electronics and sensor modules. Connect the voltmeter negative lead to red wire from Power Master sensor module and positive lead to red wire from Power Master electronics module. Turn key switch to forward and depress accelerator pedal. If operating voltage (7 to 24 DC volts) is observed, replace wire harness leads connecting Power Master sensor and electronics modules to traction motor S-1 and S-2 terminals. If operating voltage is not observed, replace Power Master electronics or sensor module as required. Retest to confirm repair is complete.

Speed And Directional Circuit Testing

If Armature Circuit (A-1 to A-2) Does Not Energize, Follow Recommended Test Below in Exact Order as Presented.

Vehicle Does Not Operate, Forward or Reverse.		
Test	**Passed**	**Failed**
Voltmeter positive red lead to battery B+ terminal, Voltmeter negative black lead to battery B- terminal	Full battery voltage = Good	Less than full battery voltage, charge and or replace batteries.
1. Key switch in forward. Voltmeter positive red lead to red wire at forward solenoid, Voltmeter negative black lead to battery negative (B-) terminal. 2. Key switch in reverse. Voltmeter positive red lead to yellow wire at reverse solenoid, Voltmeter negative black lead to battery negative (B-) terminal.	Full battery voltage = Good	Less than full battery voltage, check key switch and wire harness.
Key switch in forward, depress accelerator pedal completely. Voltmeter positive red lead to red wire at forward solenoid (terminal'B'), Voltmeter negative black lead to gray wire at forward solenoid (terminal 'A').	Full battery voltage = Good	Less than full battery voltage: Accelerator micro switch or micro switch circuit defective. Or Power Master System failure. See Power Master System testing page 8-43.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to yellow wire at reverse solenoid (terminal 'A'), Voltmeter negative black lead to gray wire at reverse solenoid (terminal 'B').	No voltage = Good	Full battery voltage, diodes between forward & reverse solenoid defective.
Key switch in forward, depress accelerator pedal completely. Voltmeter positive red lead to white wire at main solenoid (terminal 'A'), Voltmeter negative black lead to gray wire at main solenoid (terminal 'B').	Full battery voltage = Good	Less than full battery voltage, diodes between forward & reverse solenoids defective, or accelerator micro switch defective.
Key switch in forward, depress accelerator pedal completely. Voltmeter positive red lead to white wire at #1 tab terminal of speed control module, Voltmeter negative black lead to controller B- terminal. **Note:** Lift white wire connector but do not remove from #1 tab terminal for testing.	Full battery voltage = Good	Less than full battery voltage, diodes between forward & reverse solenoids.
Key switch in reverse, depress accelerator pedal completely. Voltmeter positive red lead to yellow wire at reverse solenoid (terminal 'B'), Voltmeter negative black lead to gray wire at reverse solenoid (terminal 'A').	Full battery voltage = Good	Less than full battery voltage, accelerator micro switch, micro switch circuit defective, or Power Master system failure. See Power Master System Testing, page 8-43.

Key switch in reverse, depress accelerator pedal completely. Voltmeter positive red lead to red wire at forward solenoid (terminal 'B'), Voltmeter negative black lead to gray wire at forward solenoid (terminal 'A').	No voltage = Good	Full battery voltage, diodes between forward & reverse solenoids defective.
Key switch in reverse, depress accelerator pedal completely. Voltmeter positive red lead to white wire at main solenoid (terminal 'A'), Voltmeter negative black lead to gray wire at main solenoid (terminal 'B').	Full battery voltage = Good	Less than full battery voltage, diodes between forward & reverse solenoids defective, or accelerator micro switch defective.
Key switch in forward, **do not** depress accelerator pedal. Voltmeter positive red lead to main solenoid #1 terminal, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than full battery voltage, low batteries, poor or corroded connections.
Key switch in forward, **do not** depress accelerator pedal. Voltmeter positive red lead to main solenoid #2 terminal, Voltmeter negative black lead to controller B- terminal.	1 to 5 volts less than full battery voltage = Good	No voltage, defective resistor. If full battery voltage, replace welded main solenoid.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to main solenoid #2 terminal, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	No increase or voltage drops, replace defective main solenoid.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to #3 terminal reverse solenoid, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than full battery voltage, low batteries, poor connections from main solenoid to reverse #3.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to #4 terminal reverse solenoid, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than full battery voltage, replace defective reverse solenoid.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to traction motor A-1 terminal, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than full battery voltage poor connections from #4 terminal forward solenoid traction motor A-1.
Key switch in forward, depress accelerator pedal completely. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to controller M- terminal.	As accelerator is depressed, voltage should rise to within 1 to 2 volts of full battery voltage.	No voltage, or less than within 2 volts of battery voltage, See page 8-38 for Speed Switch Testing. If speed switch is good, controller is defective.
Key switch in forward, depress accelerator pedal completely. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #2 terminal forward solenoid.	Within 1 to 2 Volts of full battery voltage = Good	Less than full battery voltage, check connections from controller M-, to sensor module, to reverse and forward solenoids.
Key switch in forward, depress accelerator pedal completely. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #1 terminal forward solenoid.	Within 1 to 2 volts of full battery voltage = Good	Less than full battery voltage, replace defective forward solenoid.
Key switch in forward, depress accelerator pedal completely. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to traction motor A-2 terminal.	Within 1 to 2 volts of full battery voltage = Good	Less than full battery voltage, check connections from forward solenoid #1 to forward #3, and to motor A-2.
Key switch in forward, depress accelerator pedal completely. Voltmeter positive red lead to A-1 terminal at traction motor, Voltmeter negative black lead to A-2 terminal at traction motor.	Within 1 to 2 volts of full battery voltage and motor operates = Good	Within 1 to 2 volts of full battery voltage and motor does not operate, check traction motor. See Traction Motor, page 8-24.

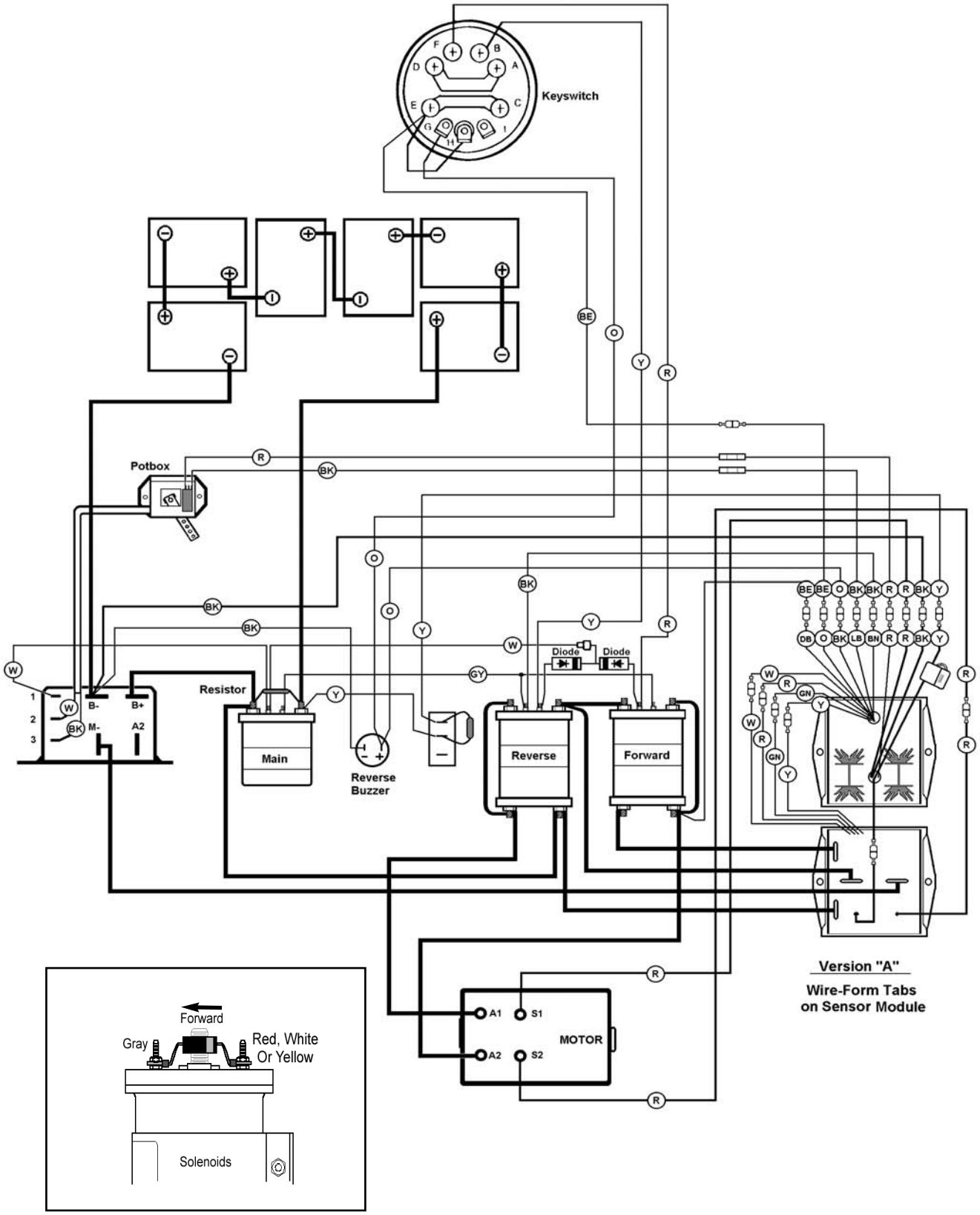
Vehicle Does Not Operate In Forward, Operates Correctly In Reverse.		
Test	**Passed**	**Failed**
Voltmeter positive red lead to battery B+ terminal, Voltmeter negative black lead to battery B- terminal	Full battery voltage = Good	Less than full battery voltage, charge and or replace batteries.
1. Key switch in forward. Voltmeter positive red lead to red wire at forward solenoid (terminal 'B'), Voltmeter negative black lead to battery negative (B-) terminal. 2. Key switch in reverse. Voltmeter positive red lead to yellow wire at reverse solenoid (terminal 'A'), Voltmeter negative black lead to battery negative (B-) terminal.	Full battery voltage = Good	Less than full battery voltage, check key switch and wire harness.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to red wire at forward solenoid (terminal 'B'), Voltmeter negative black lead to gray wire at forward solenoid (terminal 'A').	Full battery voltage = Good	Less than full battery voltage: Accelerator micro switch or micro switch circuit defective. Or Power Master System failure. See Power Master System Testing page 8-43.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to yellow wire at reverse solenoid (terminal 'A'), Voltmeter negative black lead to gray wire at reverse solenoid (terminal 'B').	No voltage = Good	Full battery voltage, diodes between forward & reverse solenoid defective.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to white wire at main solenoid (terminal 'A'), Voltmeter negative black lead to gray wire at main solenoid (terminal 'B').	Full battery voltage = Good	Less than full battery voltage, diodes between forward & reverse solenoids defective.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to white wire at #1 tab terminal of speed control module, Voltmeter negative black lead to controller B- terminal. **Note:** Lift white wire connector, but do not remove from #1 tab terminal for testing.	Full battery voltage = Good	Less than full battery voltage, diodes between forward & reverse solenoids.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to #3 terminal reverse solenoid, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than full battery voltage, low batteries, poor connections from main solenoid to reverse #3.
Key switch in forward, depress accelerator pedal Voltmeter positive red lead to #4 terminal reverse solenoid, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than full battery voltage, replace defective reverse solenoid.
Key switch in forward, depress accelerator pedal. Voltmeter positive red lead to traction motor A-1 terminal, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than full battery voltage poor connections from #4 terminal forward solenoid traction motor A-1.
Key switch in forward, depress accelerator pedal completely. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to controller M- terminal.	As accelerator is depressed, voltage should rise to within 1 to 2 volts of full battery voltage = Good	No voltage, or less than within 2 volts of battery voltage, See page 8-38 for Speed Switch Testing. If speed switch is good, controller is defective.

Key switch in forward, depress accelerator pedal completely. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #2 terminal forward solenoid.	Within 1 to 2 volts of full battery voltage = Good	Less than full battery voltage, check connections from controller M-, to sensor module, to reverse and forward solenoids.
Key switch in forward, depress accelerator pedal completely. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #1 terminal forward solenoid.	Within 1 to 2 volts of full battery voltage = Good	Less than full battery voltage, replace defective forward solenoid.
Key switch in forward, depress accelerator pedal completely. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to traction motor A-2 terminal.	Within 1 to 2 volts of full battery voltage = Good	Less than full battery voltage, check connections from forward solenoid #1 to forward #3, and to motor A-2.

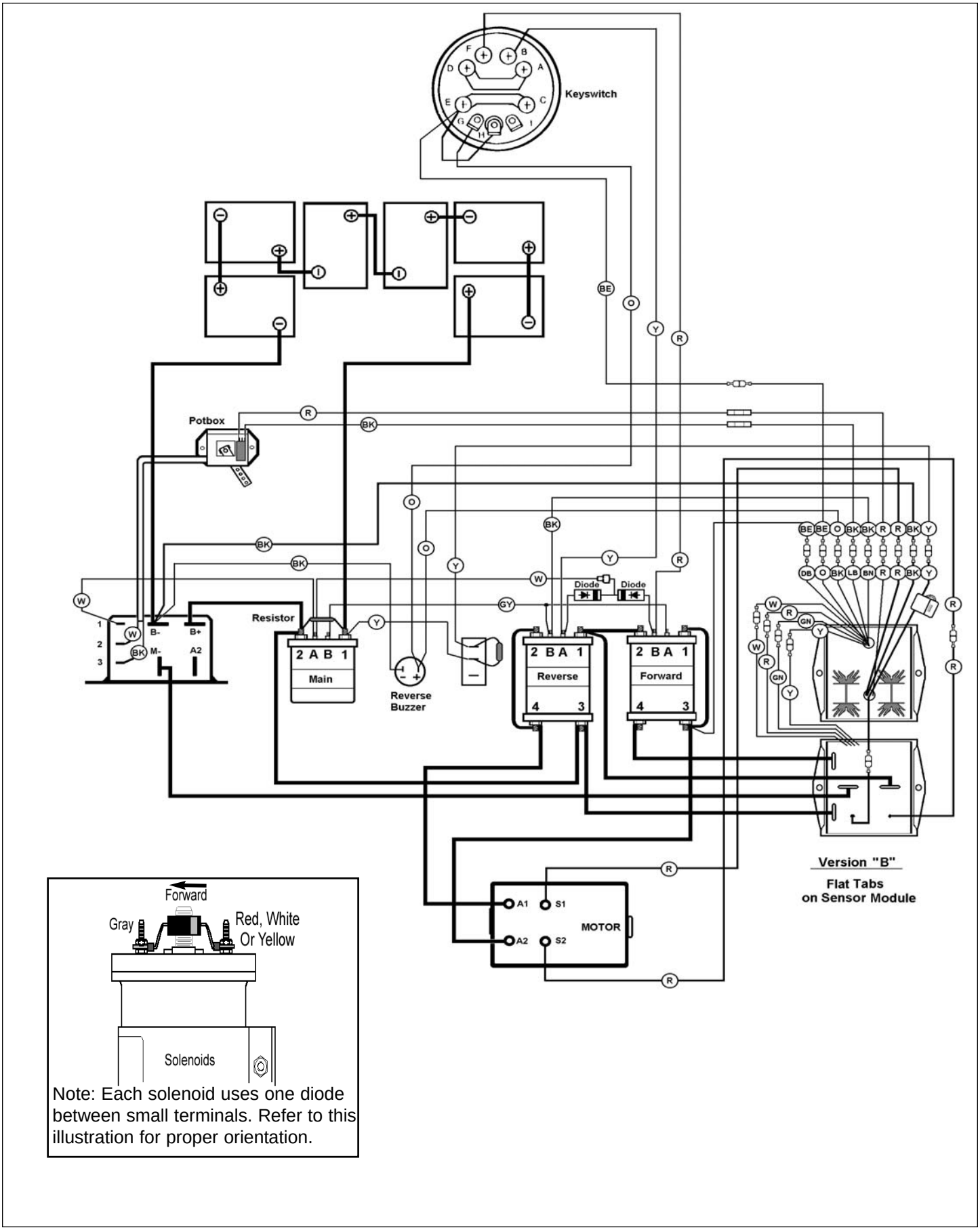
Vehicle Does Not Operate In Reverse, Operates Correctly In Forward.		
Test	**Passed**	**Failed**
Voltmeter positive red lead to battery B+ terminal, Voltmeter negative black lead to battery B- terminal	Full battery voltage = Good	Less than full battery voltage, charge and or replace batteries.
1. Key switch in forward. Voltmeter positive red lead to red wire at forward solenoid (terminal 'B'), Voltmeter negative black lead to battery negative (B-) terminal. 2. Key switch in reverse. Voltmeter positive red lead to yellow wire at reverse solenoid (terminal 'A'), Voltmeter negative black lead to battery negative (B-) terminal.	Full battery voltage = Good	Less than full battery voltage, check key switch and wire harness.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to yellow wire at reverse solenoid (terminal 'A'), Voltmeter negative black lead to gray wire at reverse solenoid (terminal 'B').	Full battery voltage = Good	Less than full battery voltage: Accelerator micro switch or micro switch circuit defective. Or Power Master System failure. See Power Master System Testing page 8-43.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to red wire at forward solenoid (terminal 'B'), Voltmeter negative black lead to gray wire at forward solenoid (terminal 'A').	No voltage = Good	Full battery voltage, diodes between forward & reverse solenoid defective.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to white wire at main solenoid (terminal 'A'), Voltmeter negative black lead to gray wire at main solenoid (terminal 'B').	Full battery voltage = Good	Less than full battery voltage, diodes between forward & reverse solenoids defective.

Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to white wire at #1 tab terminal of speed control module, Voltmeter negative black lead to controller B- terminal. **Note:** Lift white wire connector, but do not remove from #1 tab terminal for testing.	Full battery voltage = Good	Less than full battery voltage, diodes between forward & reverse solenoids.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to #3 terminal reverse solenoid, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than full battery voltage, low batteries, poor connection from main solenoid to reverse #3.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to #4 terminal forward solenoid, Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than battery voltage, check connections from reverse solenoid #3 terminal to sensor module and to forward #4 terminal.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to red wire at forward solenoid #3 terminal. Voltmeter negative black lead to controller B- terminal.	Full battery voltage = Good	Less than full battery voltage, replace defective forward solenoid.
Key switch in reverse, depress accelerator pedal. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to traction motor A-2 terminal.	Full battery voltage = Good	Less than full battery voltage, check connections from forward solenoid #1 to forward #3, and to motor A-2.
Key switch in reverse, depress accelerator pedal completely. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to controller M- terminal.	As accelerator is depressed, voltage should rise to within 1 to 2 volts of full battery voltage = Good	No voltage, or less than within 2 volts of battery voltage, see page 8-38 for Speed Switch Testing. If speed switch is good, controller is defective.
Key switch in reverse, depress accelerator pedal completely. Voltmeter positive red lead to controller B+ terminal. Voltmeter negative black lead to #1 terminal reverse solenoid.	Within 1 to 2 volts of full battery voltage = Good	Less than full battery voltage, check connections from controller M-, to sensor module to reverse solenoid.
Key switch in reverse, depress accelerator pedal completely. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to #2 terminal reverse solenoid.	Within 1 to 2 volts of full battery voltage = Good	Less than full battery voltage, replace defective forward solenoid.
Key switch in reverse, depress accelerator pedal completely. Voltmeter positive red lead to controller B+ terminal, Voltmeter negative black lead to traction motor A-1 terminal.	Within 1 to 2 volts of full battery voltage = Good	Less than full battery voltage, check connections from reverse solenoid #2 to forward #4 and to motor A-1.

Power Master System Wiring Diagram, Version A



Power Master System Wiring Diagram, Version B



Power Master System Wiring Diagram, Version C