# JOHN DEERE

## WORLDWIDE COMMERCIAL & CONSUMER EQUIPMENT DIVISION

**Lawn Tractors**
**LTR155, LTR166 and LTR180**

ITM1768 FEBRUARY 2002

# TECHNICAL MANUAL

JOHN DEERE

Litho in U.S.A.

North American Version
Litho in U.S.A.

This technical manual is written for an experienced technician and contains sections that are specifically for this product. It is a part of a total product support program.

The manual is organized so that all the information on a particular system is kept together. The order of grouping is as follows:

- Table of Contents
- General Diagnostic Information
- Specifications
- Electrical Wiring Harness Legend
- Component Location
- System Schematic
- Wiring Harness
- Troubleshooting Chart
- Theory of Operation
- Diagnostics
- Tests & Adjustments
- Repair

*Note: Depending on the particular section or system being covered, not all of the above groups may be used.*

Each section will be identified with a symbol rather than a number. The groups and pages within a section will be consecutively numbered.

We appreciate your input on this manual. To help, there are postage paid post cards included at the back. If you find any errors or want to comment on the layout of the manual please fill out one of the cards and mail it back to us.

All information, illustrations and specifications in this manual are based on the latest information available at the time of publication. The right is reserved to make changes at any time without notice.



**Safety**

**Specifications and Information**

**Kohler Engine**

**Briggs & Stratton Engine**

**Kawasaki Engine**

**Electrical**

**Power Train (Hydrostatic)**

**Steering**

**Attachments**

**Miscellaneous** M

# SAFETY

## RECOGNIZE SAFETY INFORMATION

This is the safety-alert symbol. When you see this symbol on your machine or in this manual, be alert to the potential for personal injury.

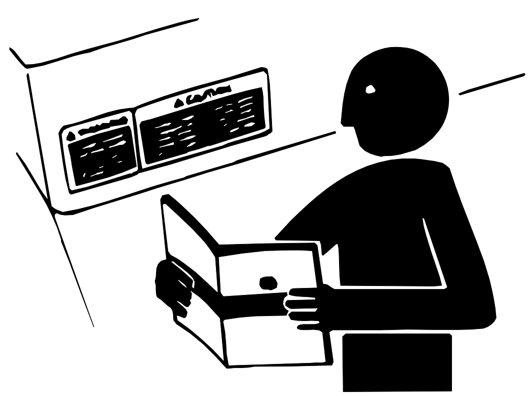
Follow recommended precautions and safe servicing practices.

### UNDERSTAND SIGNAL WORDS

A signal word—DANGER, WARNING, or CAUTION—is used with the safety-alert symbol. DANGER identifies the most serious hazards.

- DANGER identifies the most serious hazards. Danger or Warning safety signs are located near specific hazards.
- CAUTION safety signs are used where general precautions should be used. CAUTION also calls attention to safety messages in this manual.

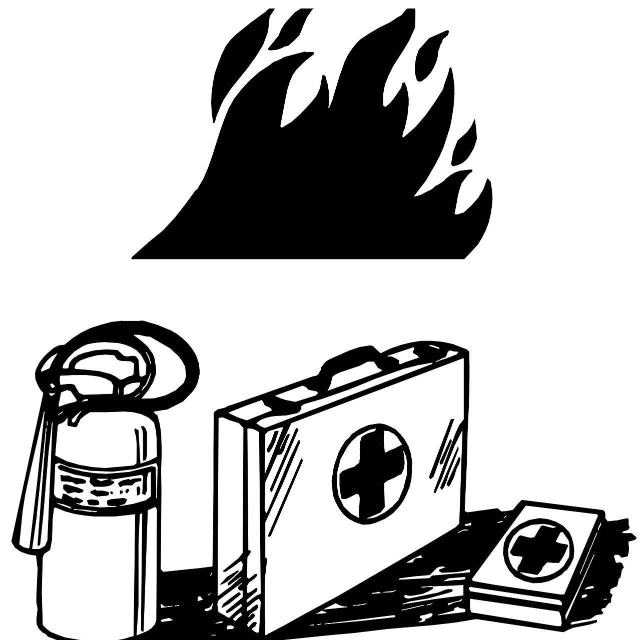
## REPLACE SAFETY SIGNS



Replace missing or damaged safety signs. See the machine operator’s manual for correct safety sign placement.

## HANDLE FLUIDS SAFELY-AVOID FIRES

### BE PREPARED FOR EMERGENCIES



When you work around fuel, do not smoke or work near heaters or other fire hazards.

Store flammable fluids away from fire hazards. Do not incinerate or puncture pressurized containers.

Make sure machine is clean of trash, grease, and debris.

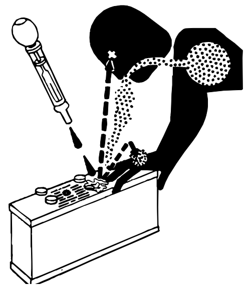
Do not store oily rags; they can ignite and burn spontaneously.

Be prepared if a fire starts.

Keep a first aid kit and fire extinguisher handy.

Keep emergency numbers for doctors, ambulance service, hospital, and fire department near your telephone.

## USE CARE IN HANDLING AND SERVICING BATTERIES



### PREVENT BATTERY EXPLOSIONS

- Keep sparks, lighted matches, and open flame away from the top of battery. Battery gas can explode.
- Never check battery charge by placing a metal object across the posts. Use a volt-meter or hydrometer.
- Do not charge a frozen battery; it may explode. Warm battery to 16°C (60°F).

### PREVENT ACID BURNS

- Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, eat holes in clothing, and cause blindness if splashed into eyes.

- **Avoid acid burns by:**

1. Filling batteries in a well-ventilated area.
2. Wearing eye protection and rubber gloves.
3. Avoiding breathing fumes when electrolyte is added.
4. Avoiding spilling or dripping electrolyte.
5. Use proper jump start procedure.

- **If you spill acid on yourself:**

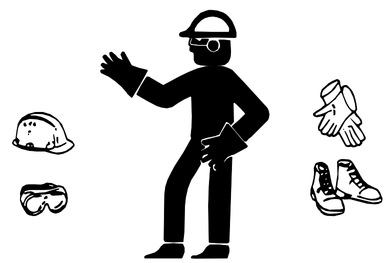
1. Flush your skin with water.
2. Apply baking soda or lime to help neutralize the acid.
3. Flush your eyes with water for 10_15 minutes.
4. Get medical attention immediately.

- **If acid is swallowed:**

1. Drink large amounts of water or milk.
2. Then drink milk of magnesia, beaten eggs, or vegetable oil.
3. Get medical attention immediately.

## USE SAFE SERVICE PROCEDURES

### WEAR PROTECTIVE CLOTHING

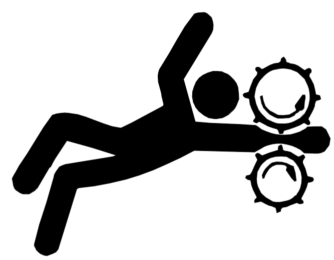


Wear close fitting clothing and safety equipment appropriate to the job.

Prolonged exposure to loud noise can cause impairment or loss of hearing. Wear a suitable hearing protective device such as earmuffs or earplugs to protect against objectionable or uncomfortable loud noises.

Operating equipment safely requires the full attention of the operator. Do not wear radio or music headphones while operating machine.

### SERVICE MACHINES SAFELY



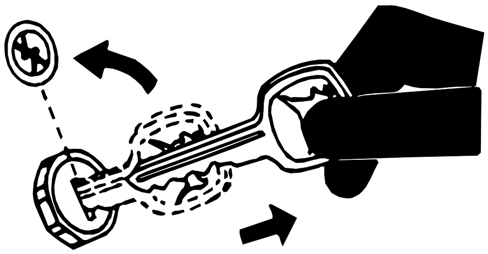
Tie long hair behind your head. Do not wear a necktie, scarf, loose clothing, or necklace when you work near machine tools or moving parts. If these items were to get caught, severe injury could result.

Remove rings and other jewelry to prevent electrical shorts and entanglement in moving parts.

### USE PROPER TOOLS

Use tools appropriate to the work. Makeshift tools and procedures can create safety hazards. Use power tools only to loosen threaded parts and fasteners. For loosening and tightening hardware, use the correct size tools. **DO NOT** use U.S. measurement tools on metric fasteners. Avoid bodily injury caused by slipping wrenches. Use only service parts meeting John Deere specifications.

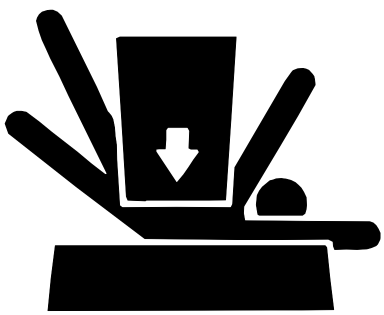
## PARK MACHINE SAFELY



**Before working on the machine:**

1. Lower all equipment to the ground.
2. Stop the engine and remove the key.
3. Disconnect the battery ground strap.
4. Hang a "DO NOT OPERATE" tag in operator station.

## SUPPORT MACHINE PROPERLY AND USE PROPER LIFTING EQUIPMENT



If you must work on a lifted machine or attachment, securely support the machine or attachment.
Do not support the machine on cinder blocks, hollow tiles, or props that may crumble under continuous load. Do not work under a machine that is supported solely by a jack. Follow recommended procedures in this manual. Lifting heavy components incorrectly can cause severe injury or machine damage. Follow recommended procedure for removal and installation of components in the manual.

## WORK IN CLEAN AREA

**Before starting a job:**

1. Clean work area and machine.
2. Make sure you have all necessary tools to do your job.
3. Have the right parts on hand.
4. Read all instructions thoroughly; do not attempt shortcuts.

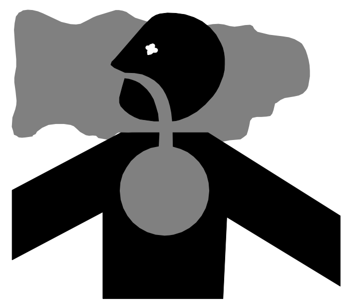
## USING HIGH PRESSURE WASHERS

Directing pressurized water at electronic/electrical components or connectors, bearings, hydraulic seals, fuel injection pumps or other sensitive parts and components may cause product malfunctions. Reduce pressure and spray at a 45 to 90 degree angle.

## ILLUMINATE WORK AREA SAFELY

Illuminate your work area adequately but safely. Use a portable safety light for working inside or under the machine. Make sure the bulb is enclosed by a wire cage. The hot filament of an accidentally broken bulb can ignite spilled fuel or oil.

## WORK IN VENTILATED AREA



Engine exhaust fumes can cause sickness or death. If it is necessary to run an engine in an enclosed area, remove the exhaust fumes from the area with an exhaust pipe extension.
If you do not have an exhaust pipe extension, open the doors and get outside air into the area.

## WARNING: CALIFORNIA PROPOSITION 65

WARNING
Gasoline engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

## REMOVE PAINT BEFORE WELDING OR HEATING

Avoid potentially toxic fumes and dust. Hazardous fumes can be generated when paint is heated by welding, soldering, or using a torch. Do all work outside or in a well ventilated area. Dispose of paint and solvent properly. Remove paint before welding or heating: If you sand or grind paint, avoid breathing the dust. Wear an approved respirator. If you use solvent or paint stripper, remove stripper with soap and water before welding. Remove solvent or paint stripper containers and other flammable material from area. Allow fumes to disperse at least 15 minutes before welding or heating.

## AVOID HARMFUL ASBESTOS DUST

Avoid breathing dust that may be generated when handling components containing asbestos fibers. Inhaled asbestos fibers may cause lung cancer.

Components in products that may contain asbestos fibers are brake pads, brake band and lining assemblies, clutch plates, and some gaskets. The asbestos used in these components is usually found in a resin or sealed in some way. Normal handling is not hazardous as long as airborne dust containing asbestos is not generated.

Avoid creating dust. Never use compressed air for cleaning. Avoid brushing or grinding material containing asbestos. When servicing, wear an approved respirator. A special vacuum cleaner is recommended to clean asbestos. If not available, apply a mist of oil or water on the material containing asbestos. Keep bystanders away from the area.

## SERVICE TIRES SAFELY

Explosive separation of a tire and rim parts can cause serious injury or death.

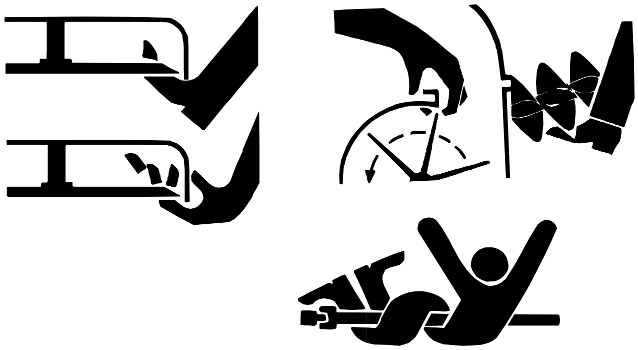
Do not attempt to mount a tire unless you have the proper equipment and experience to perform the job.

Always maintain the correct tire pressure. Do not inflate the tires above the recommended pressure. Never weld or heat a wheel and tire assembly. The heat can cause an increase in air pressure resulting in a tire explosion. Welding can structurally weaken or deform the wheel.

When inflating tires, use a clip-on chuck and extension hose long enough to allow you to stand to one side and NOT in front of or over the tire assembly. Use a safety cage if available.

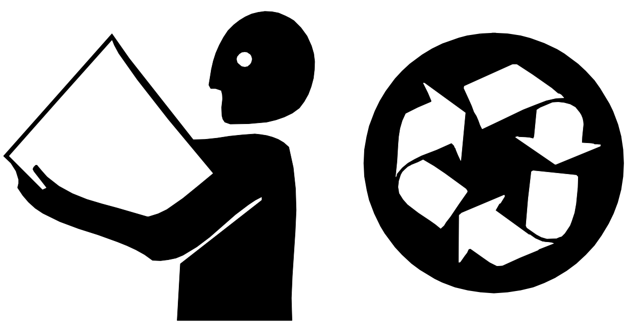
Check wheels for low pressure, cuts, bubbles, damaged rims or missing lug bolts and nuts.

## AVOID INJURY FROM ROTATING BLADES, AUGERS AND PTO SHAFTS



Keep hands and feet away while machine is running. Shut off power to service, lubricate or remove mower blades, augers or PTO shafts.

## HANDLE CHEMICAL PRODUCTS SAFELY



Direct exposure to hazardous chemicals can cause serious injury. Potentially hazardous chemicals used with John Deere equipment include such items as lubricants, coolants, paints, and adhesives.

A Material Safety Data Sheet (MSDS) provides specific details on chemical products: physical and health hazards, safety procedures, and emergency response techniques. Check the MSDS before you start any job using a hazardous chemical. That way you will know exactly what the risks are and how to do the job safely. Then follow procedures and recommended equipment.

## DISPOSE OF WASTE PROPERLY

Improperly disposing of waste can threaten the environment and ecology. Potentially harmful waste used with John Deere equipment include such items as oil, fuel, coolant, brake fluid, filters, and batteries. Use leakproof containers when draining fluids. Do not use food or beverage containers that may mislead someone into drinking from them. Do not pour waste onto the ground, down a drain, or into any water source. Inquire on the proper way to recycle or dispose of waste from your local environmental or recycling center, or from your John Deere dealer.

## LIVE WITH SAFETY


Before returning machine to customer, make sure machine is functioning properly, especially the safety systems. Install all guards and shields.

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# GENERAL VEHICLE SPECIFICATIONS

## KOHLER ENGINE—LTR155

| | |
|---|---|
| Make | Kohler |
| Model / Model Number | Command 15 QT / CV15S-41562 |
| Power | 11.2 kW (15.0 hp) |
| Displacement | 426 $cm^3$ (26.0 cu-in.) |
| Cylinders | 1 |
| Stroke/Cycle | 4 |
| Valves | Overhead Valves |
| Lubrication | Pressurized Gerotor Pump 0 – 413 kPa (0 – 60 psi) |
| Oil Filter | Single Element, Full Flow, Spin-On Filter |
| Crankcase Capacity (With Filter) | 1.8 L (1.9 U.S. qt; 60 U.S. oz) |
| Without Filter | 1.4 L (1.5 U.S. qt; 48 U.S. oz) |
| Cooling System | Air Cooled |
| Air Cleaner | Paper with outer foam element |
| Muffler | Horizontal discharge below frame |

## BRIGGS & STRATTON ENGINE—LTR166

| | |
|---|---|
| Make | Briggs & Stratton |
| Series | Vanguard V-Twin |
| Type | 916928 Gasoline |
| Model | 303777 |
| Horsepower | 11.94 kW (16.0 hp) |
| Displacement | 480 $cm^3$ (29.3 cu. in.) |
| Cylinders | 2 |
| Stroke/Cycle | 4 |
| Valves | Overhead Valves |
| Lubrication | Pressurized 0 – 344 kPa (10 – 50 psi) |
| Oil Filter | Full Flow Filter (w/o By-Pass Valve) |
| Crankcase Capacity (With Filter) | 1.5 L (1.6 U.S. qt; 52 U.S. oz) |
| Without Filter | 1.4 L (1.5 U.S. qt; 48 U.S. oz) |
| Cooling System | Air Cooled |
| Air Cleaner | Paper with outer foam element |
| Muffler | Horizontal discharge below frame |

## KAWASAKI ENGINE—LTR180

| | |
|---|---|
| Make | Kawasaki |
| Model | FH500V-AS32 V-Twin |
| Horsepower | 12.7 kW (17.0 hp) |
| Displacement | 494 $cm^3$ (30.0 cu. in.) |
| Cylinders | 2 |
| Stroke/Cycle | 4 |
| Valves | Overhead Valves |
| Lubrication | Pressurized |
| Oil Filter | Single Element, Full Flow, Spin-On Filter |
| Crankcase Capacity (With Filter) | 1.7 L (1.8 U.S. qt; 58 U.S. oz) |
| Without Filter | 1.5 L (1.6 U.S. qt; 52 U.S. oz) |
| Cooling System | Air Cooled |
| Air Cleaner | Paper with outer foam element |
| Muffler | Horizontal discharge below frame |

## FUEL SYSTEM

| | |
|---|---|
| Aspiration | Natural |
| Fuel Tank Location | Rear |
| Fuel Tank Capacity | 6.0 L (1.6 U.S. gal) |
| Fuel Type (minimum octane) | Unleaded Gasoline, 87 Octane |
| Fuel Delivery | Float-Type Side Draft CArburetor |
| Fuel Filter | Replaceable In-Line |

## ELECTRICAL

| | |
|---|---|
| Ignition | Electronic Capacitor Discharge Ignition (CDI) |
| Type of Starter | Bendix |
| Charging System | Flywheel Alternator |
| Voltage | 12 |
| BCI group | U-1 |
| CCA rating (Amps At -18°C (0°F) | 160 |
| Reserve capacity (Minutes At 25 Amps) | 20 |
| Specific gravity (Minimum) | 1.225 points |
| Electrolyte required fill (Approximate) | 1.9 L (2.0 qt) |
| Load test (Minimum) | 255 amp for 15 seconds |

## HYDROSTATIC TRANSAXLE

| | |
|---|---|
| Drive Train | Belt Drive Transaxle with foot-controlled variable speed drive |
| Model | Tuff Torq® K46 Transaxle |
| Travel Speed-Forward | 0 – 8.0 km/h (0 – 5.0 mph) |
| Travel Speed-Reverse | 0 – 4.7 km/h (0 – 2.9 mph) |
| Brake type | Single, Internal Wet Disc Brake |

## PTO DRIVE

| | |
|---|---|
| Type | V-Belt |
| Clutch Type | Mechanical |
| Control | Lever on Dash |

## STEERING

| | |
|---|---|
| Type | Sector and Pinion |
| Turning Radius | 38.1 cm (15 in.) |

## IMPLEMENT LIFT

| | |
|---|---|
| Lift System | Manual |
| Lift Lever Location | Left Side |

## TIRES

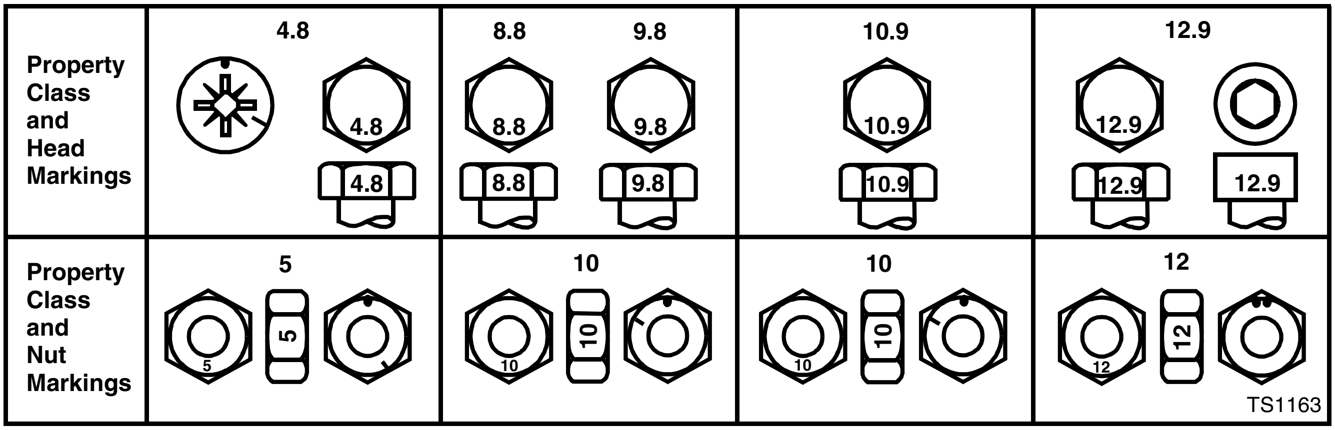
| | |
|---|---|
| Size-Front | 15x6.00-6 |
| Size-Rear | 20x10.00-8 |
| Pressure-Front (with mower) | 83 kPa (12 psi) |
| Pressure-Rear (with mower) | 55 kPa (8 psi) |

## DIMENSIONS

| | |
|---|---|
| Wheelbase | 120 cm (47.2 in.) |
| Overall Length | 197.7 cm (77.8 in.) |
| With Grass Collector | 241.5 cm (95.1 in.) |
| Overall Width (without mower) | 92 cm (36.2 in.) |
| Overall Height | 103 cm (40.6 in.) |
| Net Weight (Approx.) | 273 kg (602 lb) |

# TORQUE SPECIFICATIONS

## METRIC FASTENER TORQUE VALUES




| | Class 4.8 | | | | Class 8.8 or 9.8 | | | | Class 10.9 | | | | Class 12.9 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lubricated[a] | | Dry[a] | | Lubricated[a] | | Dry[a] | | Lubricated[a] | | Dry[a] | | Lubricated[a] | | Dry[a] | |
| SIZE | N•m | lb-ft | N•m | lb-ft | N•m | lb-ft | N•m | lb-ft | N•m | lb-ft | N•m | lb-ft | N•m | lb-ft | N•m | lb-ft |
| M6 | 4.8 | 3.5 | 6 | 4.5 | 9 | 6.5 | 11 | 8.5 | 13 | 9.5 | 17 | 12 | 15 | 11.5 | 19 | 14.5 |
| M8 | 12 | 8.5 | 15 | 11 | 22 | 16 | 28 | 20 | 32 | 24 | 40 | 30 | 37 | 28 | 47 | 35 |
| M10 | 23 | 17 | 29 | 21 | 43 | 32 | 55 | 40 | 63 | 47 | 80 | 60 | 75 | 55 | 95 | 70 |
| M12 | 40 | 29 | 50 | 37 | 75 | 55 | 95 | 70 | 110 | 80 | 140 | 105 | 130 | 95 | 165 | 120 |
| M14 | 63 | 47 | 80 | 60 | 120 | 88 | 150 | 110 | 175 | 130 | 225 | 165 | 205 | 150 | 260 | 109 |
| M16 | 100 | 73 | 125 | 92 | 190 | 140 | 240 | 175 | 275 | 200 | 350 | 225 | 320 | 240 | 400 | 300 |
| M18 | 135 | 100 | 175 | 125 | 260 | 195 | 330 | 250 | 375 | 275 | 475 | 350 | 440 | 325 | 560 | 410 |
| M20 | 190 | 140 | 240 | 180 | 375 | 275 | 475 | 350 | 530 | 400 | 675 | 500 | 625 | 460 | 800 | 580 |
| M22 | 260 | 190 | 330 | 250 | 510 | 375 | 650 | 475 | 725 | 540 | 925 | 675 | 850 | 625 | 1075 | 800 |
| M24 | 330 | 250 | 425 | 310 | 650 | 475 | 825 | 600 | 925 | 675 | 1150 | 850 | 1075 | 800 | 1350 | 1000 |
| M27 | 490 | 360 | 625 | 450 | 950 | 700 | 1200 | 875 | 1350 | 1000 | 1700 | 1250 | 1600 | 1150 | 2000 | 1500 |
| M30 | 675 | 490 | 850 | 625 | 1300 | 950 | 1650 | 1200 | 1850 | 1350 | 2300 | 1700 | 2150 | 1600 | 2700 | 2000 |
| M33 | 900 | 675 | 1150 | 850 | 1750 | 1300 | 2200 | 1650 | 2500 | 1850 | 3150 | 2350 | 2900 | 2150 | 3700 | 2750 |
| M36 | 1150 | 850 | 1450 | 1075 | 2250 | 1650 | 2850 | 2100 | 3200 | 2350 | 4050 | 3000 | 3750 | 2750 | 4750 | 3500 |

DO NOT use these hand torque values if a different torque value or tightening procedure is given for a specific application. Torque values listed are for general use only and include a ± 10% variance factor. Check tightness of fasteners periodically. DO NOT use air powered wrenches.

Shear bolts are designed to fail under predetermined loads. Always replace shear bolts with identical grade.

Fasteners should be replaced with the same class. Make sure fastener threads are clean and that you properly start thread engagement. This will prevent them from failing when tightening.

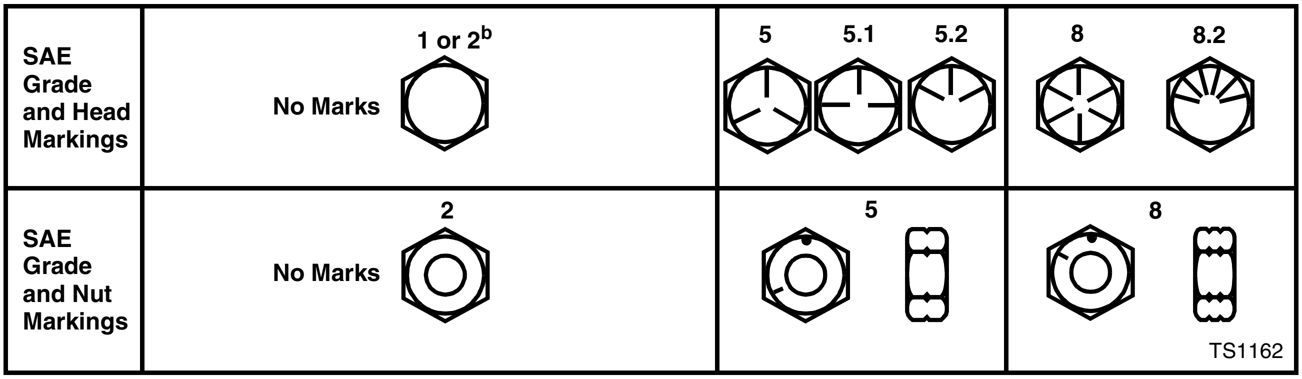
When bolt and nut combination fasteners are used, torque values should be applied to the **NUT** instead of the bolt head.

Tighten toothed or serrated-type lock nuts to the full torque value.

[a] *"Lubricated" means coated with a lubricant such as engine oil, or fasteners with phosphate and oil coatings. "Dry" means plain or zinc plated (yellow dichromate - Specification JDS117) without any lubrication.*

Reference: JDS—G200.

# INCH FASTENER TORQUE VALUES




| | Grade 1 | | | | Grade 2[b] | | | | Grade 5, 5.1 or 5.2 | | | | Grade 8 or 8.2 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lubricated[a] | | Dry[a] | | Lubricated[a] | | Dry[a] | | Lubricated[a] | | Dry[a] | | Lubricated[a] | | Dry[a] | |
| SIZE | N•m | lb-ft | N•m | lb-ft | N•m | lb-ft | N•m | lb-ft | N•m | lb-ft | N•m | lb-ft | N•m | lb-ft | N•m | lb-ft |
| 1/4 | 3.7 | 2.8 | 4.7 | 3.5 | 6 | 4.5 | 7.5 | 5.5 | 9.5 | 7 | 12 | 9 | 13.5 | 10 | 17 | 12.5 |
| 5/16 | 7.7 | 5.5 | 10 | 7 | 12 | 9 | 15 | 11 | 20 | 15 | 25 | 18 | 28 | 21 | 35 | 26 |
| 3/8 | 14 | 10 | 17 | 13 | 22 | 16 | 27 | 20 | 35 | 26 | 44 | 33 | 50 | 36 | 63 | 46 |
| 7/16 | 22 | 16 | 28 | 20 | 35 | 26 | 44 | 32 | 55 | 41 | 70 | 52 | 80 | 58 | 100 | 75 |
| 1/2 | 33 | 25 | 42 | 31 | 53 | 39 | 67 | 50 | 85 | 63 | 110 | 80 | 120 | 90 | 150 | 115 |
| 9/16 | 48 | 36 | 60 | 45 | 75 | 56 | 95 | 70 | 125 | 90 | 155 | 115 | 175 | 130 | 225 | 160 |
| 5/8 | 67 | 50 | 85 | 62 | 105 | 78 | 135 | 100 | 170 | 125 | 215 | 160 | 215 | 160 | 300 | 225 |
| 3/4 | 120 | 87 | 150 | 110 | 190 | 140 | 240 | 175 | 300 | 225 | 375 | 280 | 425 | 310 | 550 | 400 |
| 7/8 | 190 | 140 | 240 | 175 | 190 | 140 | 240 | 175 | 490 | 360 | 625 | 450 | 700 | 500 | 875 | 650 |
| 1 | 290 | 210 | 360 | 270 | 290 | 210 | 360 | 270 | 725 | 540 | 925 | 675 | 1050 | 750 | 1300 | 975 |
| 1-1/8 | 470 | 300 | 510 | 375 | 470 | 300 | 510 | 375 | 900 | 675 | 1150 | 850 | 1450 | 1075 | 1850 | 1350 |
| 1-1/4 | 570 | 425 | 725 | 530 | 570 | 425 | 725 | 530 | 1300 | 950 | 1650 | 1200 | 2050 | 1500 | 2600 | 1950 |
| 1-3/8 | 750 | 550 | 950 | 700 | 750 | 550 | 950 | 700 | 1700 | 1250 | 2150 | 1550 | 2700 | 2000 | 3400 | 2550 |
| 1-1/2 | 1000 | 725 | 1250 | 925 | 990 | 725 | 1250 | 930 | 2250 | 1650 | 2850 | 2100 | 3600 | 2650 | 4550 | 3350 |

DO NOT use these hand torque values if a different torque value or tightening procedure is given for a specific application. Torque values listed are for general use only and include a ± 10% variance factor. Check tightness of fasteners periodically. DO NOT use air powered wrenches.

Shear bolts are designed to fail under predetermined loads. Always replace shear bolts with identical grade.

Fasteners should be replaced with the same grade. Make sure fastener threads are clean and that you properly start thread engagement. This will prevent them from failing when tightening.

When bolt and nut combination fasteners are used, torque values should be applied to the **NUT** instead of the bolt head.

Tighten toothed or serrated-type lock nuts to the full torque value.

[a] *"Lubricated" means coated with a lubricant such as engine oil, or fasteners with phosphate and oil coatings. "Dry" means plain or zinc plated (yellow dichromate - Specification JDS117) without any lubrication.*

[b] *"Grade 2" applies for hex cap screws (not hex bolts) up to 152 mm (6-in.) long. "Grade 1" applies for hex cap screws over 152 mm (6-in.) long, and for all other types of bolts and screws of any length.*

Reference: JDS—G200.

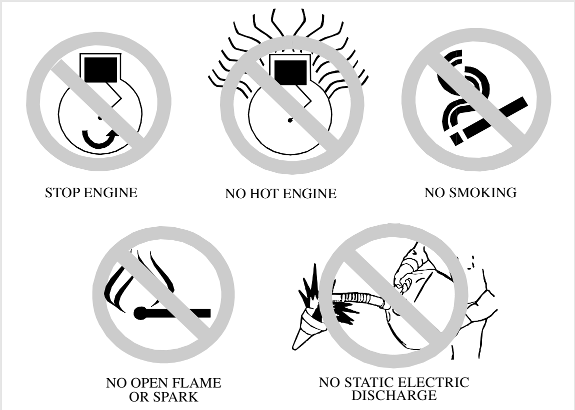
## FUEL AND OIL SPECIFICATIONS

**CAUTION**

**Gasoline is HIGHLY FLAMMABLE, handle it with care.**

**DO NOT refuel machine while:**

- **indoors, always fill gas tank outdoors;**
- **machine is near an open flame or sparks;**
- **engine is running, STOP engine;**
- **engine is hot, allow it to cool sufficiently first;**
- **smoking.**




**Help prevent fires:**

- **fill gas tank to bottom of filler neck only;**
- **be sure fill cap is tight after fueling;**
- **clean up any gas spills IMMEDIATELY;**
- **keep machine clean and in good repair–free of excess grease, oil, debris, and faulty or damaged parts;**
- **any storage of machines with gas left in tank should be in an area that is well ventilated to prevent possible igniting of fumes by an open flame or spark, this includes any appliance with a pilot light.**

**To prevent fire or explosion caused by STATIC ELECTRIC DISCHARGE during fueling:**

- **ONLY use a clean, approved POLYETHYLENE PLASTIC fuel container and funnel WITHOUT any metal screen or filter.**

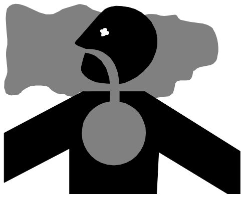
## GASOLINE

**To avoid engine damage:**

- DO NOT mix oil with gasoline;
- **ONLY use clean, fresh unleaded gasoline with an octane rating (anti-knock index) of 87 or higher**;
- fill gas tank at the end of each day's operation to help prevent condensation from forming inside a partially filled tank;
- keep up with specified service intervals.

Use of alternative oxygenated, gasohol blended, unleaded gasoline is acceptable as long as:

- the ethyl or grain alcohol blends DO NOT exceed 10% by volume or
- methyl tertiary butyl ether (MTBE) blends DO NOT exceed 15% by volume.



**IMPORTANT: DO NOT use METHANOL gasoline because METHANOL is harmful to the environment and to your health.**

**WARNING**

<u>California Proposition 65 Warning:</u> **Gasoline engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.**

## GASOLINE STORAGE— NORTH AMERICA

**IMPORTANT: Keep all dirt, scale, water or other foreign material out of gasoline.**

Keep gasoline stored in a safe, protected area. Storage of gasoline in a clean, properly marked **("UNLEADED GASOLINE") POLYETHYLENE PLASTIC container WITHOUT** any metal screen or filter is recommended. **DO NOT** use de-icers to attempt to remove water from gasoline or depend on fuel filters to remove water from gasoline. Use a water separator installed in the storage tank outlet. **BE SURE** to properly discard unstable or contaminated gasoline. When storing unit or gasoline, it is recommended that you add **John Deere Gasoline Conditioner and Stabilizer (TY15977)** or an equivalent to the gasoline. **BE SURE** to follow directions on container and to properly discard empty container.

## ENGINE OIL

Use the appropriate oil viscosity based on the expected air temperature range during the period between recommended oil changes. Operating outside of these recommended oil air temperature ranges may cause premature engine failure.

The following John Deere oil is **PREFERRED**:

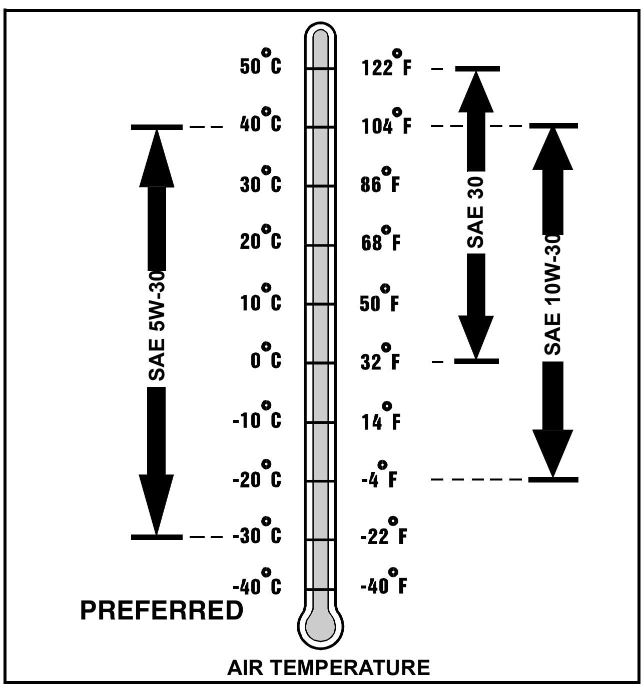
- **TORQ-GARD SUPREME®—SAE 5W-30.**
- **UNI–GARD™—SAE 5W-30.**

The following John Deere oils are **also recommended**, based on their specified temperature range:

- **TURF–GARD®—SAE 10W-30;**
- **PLUS–4®—SAE 10W-30;**
- **TORQ–GARD SUPREME®—SAE 30.**

Other oils may be used if above John Deere oils are not available, provided they meet one of the following specifications:

- SAE 5W-30—API Service Classification SG or higher;
- SAE 10W-30—API Service Classification SG or higher;
- SAE 30—API Service Classification SC or higher.
- **UNI–GARD™—SAE 30.**




**John Deere Dealers:** You may want to cross-reference the following publications to recommend the proper oil for your customers:

- Module DX,ENOIL2 in JDS–G135;
- Section 530, Lubricants & Hydraulics, of the John Deere Merchandise Sales Guide;
- Lubrication Sales Manual PI7032.

## ENGINE BREAK–IN OIL

**IMPORTANT: ONLY use a quality break-in oil in rebuilt or remanufactured engines for the <u>first 5 hours (maximum) of operation</u>. DO NOT use oils with heavier viscosity weights than SAE 5W-30 or oils meeting specifications API SG or SH (North America); or oils meeting CCMC Specification G5 (Europe). These oils will not allow rebuilt or remanufactured engines to break-in properly.**

The following John Deere oil is **PREFERRED**:

- **BREAK–IN ENGINE OIL**.

**John Deere BREAK–IN ENGINE OIL** is formulated with special additives for aluminum and cast iron type engines to allow the power cylinder components (pistons, rings, and liners as well) to “wear-in” while protecting other engine components, valve train and gears, from abnormal wear. Engine rebuild instructions should be followed closely to determine if special requirements are necessary.

**John Deere BREAK–IN ENGINE OIL** is also recommended for non-John Deere engines, both aluminum and cast iron types.

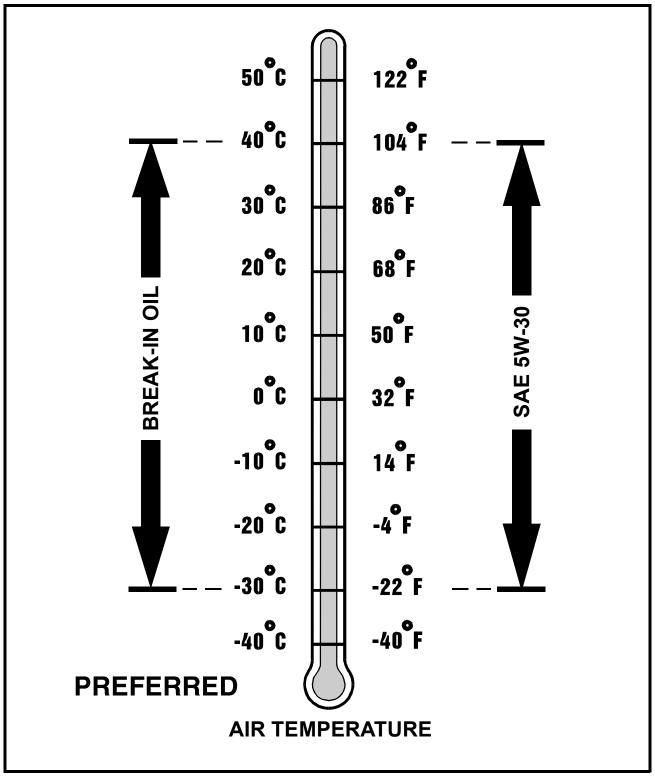
The following John Deere oil is **also recommended** as a break-in engine oil:

- **TORQ–GARD SUPREME®—SAE 5W-30.**

If the above recommended John Deere oils are not available, use a break-in engine oil meeting the following specification during the first 5 hours (maximum) of operation:

- SAE 5W-30—API Service Classification SE or higher.
- SAE 5W-30—CCMC Specification G4 or higher.

**IMPORTANT: After the break-in period, use the John Deere oil that is recommended for this engine.**




**John Deere Dealers:** You may want to cross-reference the following publications to recommend the proper oil for your customers:

- Module DX,ENOIL4 in JDS–G135;
- Section 530, Lubricants & Hydraulics, of the John Deere Merchandise Sales Guide;
- Lubrication Sales Manual PI7032.

# LUBRICANT SPECIFICATIONS

## ANTI-CORROSION GREASE

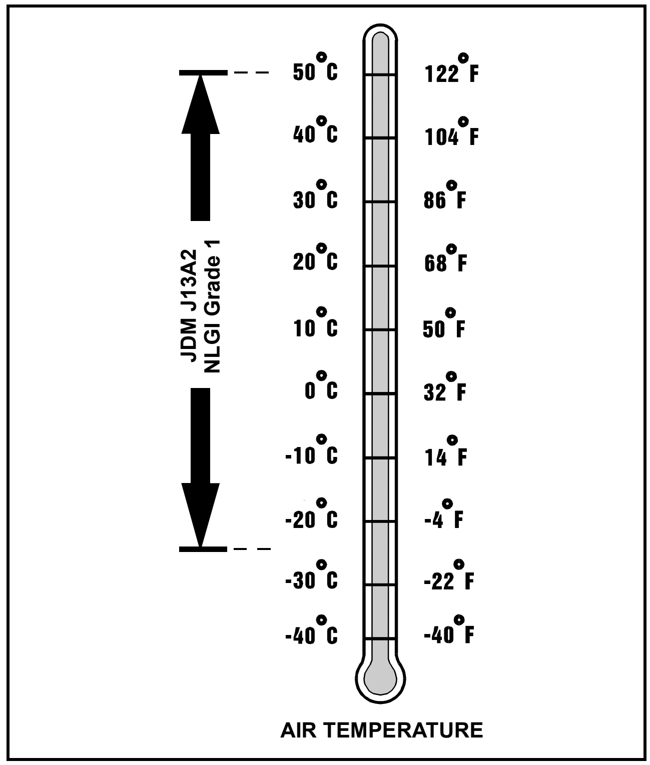
This anti-corrosion grease is formulated to provide the best protection against absorbing moisture, which is one of the major causes of corrosion. This grease is also superior in its resistance to separation and migration.

The following anti-corrosion grease is **PREFERRED**:

- **DuBois MPG-2® Multi-Purpose Polymer Grease—M79292.**

Other greases may be used if they meet or exceed the following specifications:

- John Deere Standard JDM J13A2, NLGI Grade 1.




**John Deere Dealers:** You may want to cross-reference the following publications to recommend the proper grease for your customers:

- Module DX,GREA1 in JDS–G135;
- Section 530, Lubricants & Hydraulics, of the John Deere Merchandise Sales Guide;
- Lubrication Sales Manual PI7032.

## ALTERNATIVE LUBRICANTS

Conditions in certain geographical areas outside the United States and Canada may require different lubricant recommendations than the ones printed in this technical manual or the operator's manual. Consult with your John Deere Dealer, or Sales Branch, to obtain the alternative lubricant recommendations.

**IMPORTANT: Use of alternative lubricants could cause reduced life of the component.**

If alternative lubricants are to be used, it is recommended that the factory fill be thoroughly removed before switching to any alternative lubricant.

## SYNTHETIC LUBRICANTS

Synthetic lubricants may be used in John Deere equipment if they meet the applicable performance requirements (industry classification and/or military specification) as shown in this manual.

The recommended air temperature limits and service or lubricant change intervals should be maintained as shown in the operator's manual.

Avoid mixing different brands, grades, or types of oil. Oil manufacturers blend additives in their oils to meet certain specifications and performance requirements. Mixing different oils can interfere with the proper functioning of these additives and degrade lubricant performance.

## LUBRICANT STORAGE

All machines operate at top efficiency only when clean lubricants are used. Use clean storage containers to handle all lubricants. Store them in an area protected from dust, moisture, and other contamination. Store drums on their sides. Make sure all containers are properly marked as to their contents. Dispose of all old, used containers and their contents properly.

## MIXING OF LUBRICANTS

In general, avoid mixing different brands or types of lubricants. Manufacturers blend additives in their lubricants to meet certain specifications and performance requirements. Mixing different lubricants can interfere with the proper functioning of these additives and lubricant properties which will downgrade their intended specified performance.

## CHASSIS GREASE

Use the following grease based on the air temperature range. Operating outside of the recommended grease air temperature range may cause premature failures.

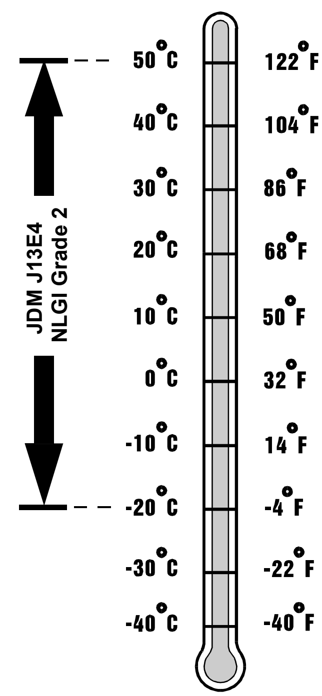
**IMPORTANT: ONLY use a quality grease in this application. DO NOT mix any other greases in this application. DO NOT use any BIO–GREASE in this application.**

The following John Deere grease is **PREFERRED**:

- **NON-CLAY HIGH-TEMPERATURE EP GREASE®—JDM J13E4, NLGI Grade 2.**
- **GREASE–GARD™—JDM J13E4, NLGI Grade 2**.

Other greases may be used if above preferred John Deere grease is not available, provided they meet the following specification:

- John Deere Standard JDM J13E4, NLGI Grade 2.




AIR TEMPERATURE

**John Deere Dealers:** You may want to cross-reference the following publications to recommend the proper grease for your customers:

- Module DX,GREA1 in JDS–G135;
- Section 530, Lubricants & Hydraulics, of the John Deere Merchandise Sales Guide;
- Lubrication Sales Manual P17032.

# HYDROSTATIC TRANSMISSION OIL

**IMPORTANT: ONLY use a quality SAE 10W-30 SYNTHETIC engine oil in this transmission. Mixing of two viscosity grade oils is NOT RECOMMENDED. DO NOT use BIO–HY–GARD® in this transmission.**

The following John Deere transmission and hydraulic oil is **PREFERRED**:

- **10W-30 SYNTHETIC OIL**.

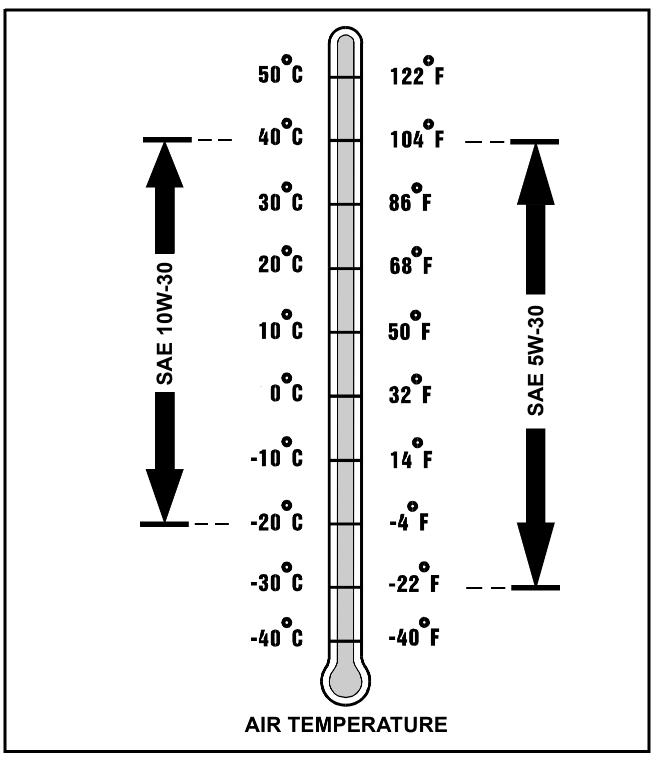
The following John Deere oil is **also recommended** if above preferred oil is not available:

- **John Deere Low Viscosity HY-GARD™ J20D.**

Other oils may be used if above recommended John Deere oils are not available. Use only oils that meet one of the following specifications:

- John Deere Standard JDM J20D;
- John Deere Standard JDM J20C.
- CCMC Specifications G4 or higher.

Use the appropriate oil viscosity based on these air temperature ranges. Operating outside of these recommended oil air temperature ranges may cause premature hydrostatic transmission failure.




**John Deere Dealers:** You may want to cross-reference the following publications to recommend the proper oil for your customers:

- Module DX,ENOIL2 in JDS–G135;
- Section 530, Lubricants & Hydraulics, of the John Deere Merchandise Sales Guide;
- Lubrication Sales Manual PI7032.

Use only oils that meet the following specifications:

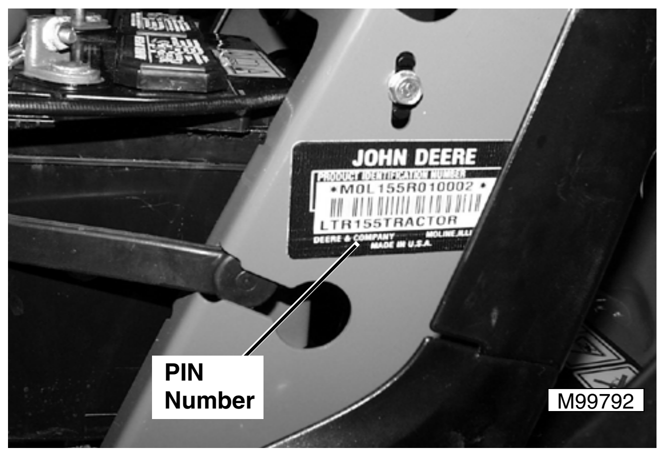
- API Service Classifications SG or higher.

# PRODUCT IDENTIFICATION LOCATIONS

When ordering parts or submitting a warranty claim, it is IMPORTANT that you include the product identification number and the component product identification numbers.

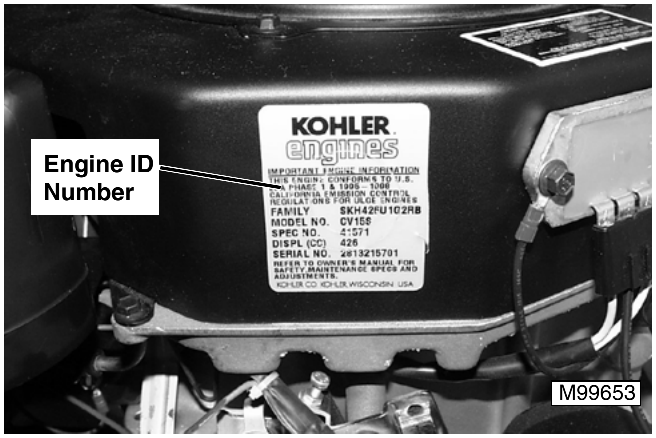
# PRODUCT IDENTIFICATION NUMBER (PIN)

**(S/N –030000)**



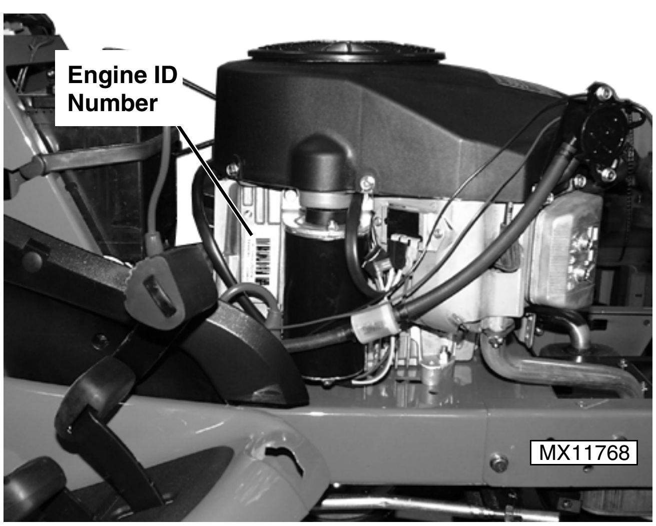

**(S/N 030001–)**

## ENGINE IDENTIFICATION NUMBER—KOHLER

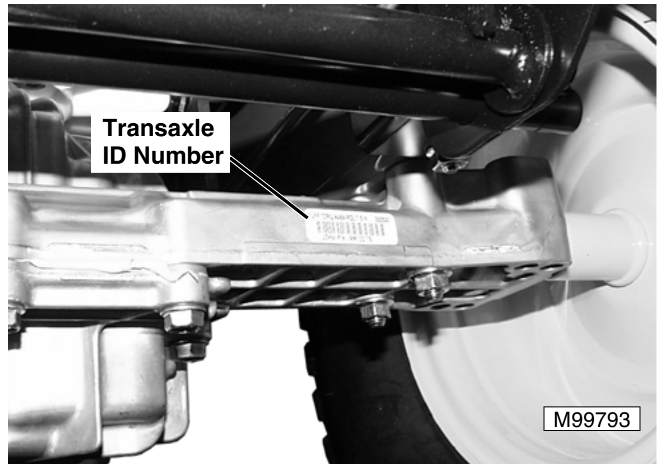



## ENGINE IDENTIFICATION NUMBER—BRIGGS & STRATTON


## ENGINE IDENTIFICATION NUMBER—KAWASAKI




## HYDROSTATIC TRANSAXLE IDENTIFICATION NUMBER



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# SPECIFICATIONS

## GENERAL SPECIFICATIONS

| | |
|---|---|
| Make | Kohler |
| Model | Command 15 QT / CV15S-41562 |
| Power | 11.2 kW (15.0 hp) |
| Displacement | 426 $cm^3$ (26.0 cu-in.) |
| Cylinders | 1 |
| Stroke/Cycle | 4 |
| Valves | Overhead Valves |
| Bore | 90 mm (3.60 in.) |
| Stroke (All) | 67 mm (2.64 in.) |
| Compression Ratio | 2:1 Cranking—8.5:1 Running |
| Compression Release | Automatic/Centrifugal |
| Crankshaft Type | Vertical (counterbalanced) |
| Lubrication | Pressurized Gerotor Pump 0 – 413 kPa (0 – 60 psi) |
| Oil Filter | Single Element, Full Flow, Spin-On Filter |
| Crankcase Capacity (With Filter) | 1.8 L (1.9 U.S. qt; 60 U.S. oz) |
| Without Filter | 1.4 L (1.5 U.S. qt; 48 U.S. oz) |
| Cooling System | Air Cooled |
| Air Cleaner | Paper with outer foam element |
| Muffler | Horizontal discharge below frame |
| Maximum Angle of Operation (With Full Crankcase): | |
| Continuous (All Directions) | 20° |
| Intermittent (All Directions) | 35° |
| Fuel Filter | Replaceable (In-Line Type) |
| Fuel Shut-Off Solenoid (Optional) | Replaceable (Below Carburetor Float Bowl) |
| Weight | 39.54 kg (87 lbs) |

## TESTS & ADJUSTMENTS SPECIFICATIONS

**Engine:**

| | |
|---|---|
| Slow Idle | 1700 ± 100 rpm |
| Fast Idle (Domestic) | 3350 ± 50 rpm |
| Valve Adjustment | None (hydraulic lifters) |
| Oil Pressure (Minimum at 1250 rpm) | 124 kPa (18 psi) |
| Crankcase Vacuum (Minimum At Operating Temp.) | 102 mm (4 in.) Water Movement |
| Automatic Compression Release Minimum Lift (Engine Cold) | 0.25 mm (0.01 in.) |
| Carburetor Slow Idle Mixture Screw Initial Setting | Lightly Seat, Then 1 Turn Out |

# REPAIR SPECIFICATIONS

**Cylinder Head:**

- Cylinder Head Flatness (Maximum Warpage) . . . . . 0.076 mm (0.003 in.)

**Push Rod:**

- Maximum Bend . . . . . 0.76 mm (0.030 in.)

**Valves and Valve Lifters:**

- Hydraulic Lifter Clearance . . . . . 0.0124 – 0.0501 mm (0.0005 – 0.0020 in.)
- Intake Valve-to-Guide Clearance . . . . . 0.038 – 0.076 mm (0.0015 – 0.0030 in.)
- Intake Valve Stem OD . . . . . 6.982 – 7.000 mm (0.2749 – 0.2756 in.)
- Exhaust Valve Stem OD . . . . . 6.970 – 6.988 mm (0.2744 – 0.2751 in.)
- Exhaust Valve-to-Guide Clearance . . . . . 0.050 – 0.088 mm (0.0020 – 0.0035 in.)
- Intake Valve Guide ID:
  - New . . . . . 7.038 – 7.058 mm (0.2771 – 0.2779 in.)
  - Maximum . . . . . 7.134 mm (0.2809 in.)
- Exhaust Valve Guide ID:
  - New . . . . . 7.038 – 7.058 mm (0.2771 – 0.2779 in.)
  - Maximum . . . . . 7.159 mm (0.2819 in.)
- Valve Guide Reamer:
  - Standard . . . . . 7.048 mm (0.2775 in.)
  - Oversize (0.25 mm) . . . . . 7.298 mm (0.2873 in.)
- Intake Valve Lift (Minimum—Engine Cold) . . . . . 8.96 mm (0.353 in.)
- Exhaust Valve Lift (Minimum—Engine Cold) . . . . . 9.14 mm (0.360 in.)
- Valve Face Angle . . . . . 45°
- Valve Seat Angle . . . . . 44.5°

**Rocker Arms:**

- Rocker Arm ID
  - New . . . . . 15.837 – 16.127 mm (0.63 – 0.64 in.)
  - Wear Limit . . . . . 15.727 mm (0.619 in.)

**Rocker Shaft:**

- Rocker Shaft OD
  - New . . . . . 15.837 – 16.127 mm (0.63 – 0.64 in.)
  - Wear Limit . . . . . 15.727 mm (0.619 in.)

**Crankshaft:**

- End Play . . . . . 0.0575 – 0.4925 mm (0.0023 – 0.0194 in.)
- Crankshaft Bore ID (Crankcase Half):
  - New . . . . . 44.965 – 45.003 mm (1.7703 – 1.7718 in.)
  - Maximum . . . . . 45.016 mm (1.7723 in.)
  - Clearance (New) . . . . . 0.03 – 0.09 mm (0.0012 – 0.0035 in.)
- Crankshaft Bore (Oil Pan Half):
  - New . . . . . 44.965 – 45.003 mm (1.7703 – 1.7718 in.)
  - Maximum . . . . . 45.016 mm (1.7723 in.)
  - Clearance (New) . . . . . 0.03 – 0.09 mm (0.0012 – 0.0035 in.)
- Main Bearing Journal OD (Flywheel End):
  - New . . . . . 44.913 – 44.935 mm (1.7682 – 1.7691 in.)
  - Minimum . . . . . 44.84 mm (1.765 in.)
  - Maximum Taper . . . . . 0.022 mm (0.0009 in.)
  - Maximum Out-of-Round . . . . . 0.025 mm (0.0010 in.)

- Main Bearing Journal OD (Oil Pan End):
  - New . . . . . . 41.915 – 41.935 mm (1.6502 – 1.6510 in.)
  - Minimum . . . . . . 41.86 mm (1.648 in.)
  - Maximum Taper . . . . . . 0.020 mm (0.0008 in.)
  - Maximum Out-of-Round . . . . . . 0.025 mm (0.0010 in.)
- Connecting Rod Journal OD:
  - New . . . . . . 38.958 – 38.970 mm (1.5338 – 1.5343 in.)
  - Minimum . . . . . . 38.94 mm (1.5328 in.)
  - Maximum Taper . . . . . . 0.012 mm (0.0005 in.)
  - Maximum Out-of-Round . . . . . . 0.025 mm (0.0010 in.)
- Crankshaft Total Indicated Runout (TIR):
  - PTO End (In Engine) . . . . . . 0.15 mm (0.0059 in.)
  - Entire Crankshaft (In Bench V-Blocks) . . . . . . 0.10 mm (0.0039 in.)

**Camshaft:**

- End Play (with shims) . . . . . . 0.076 – 0.127 mm (0.003 – 0.005 in.)
- Clearance . . . . . . 0.025 – 0.063 mm (0.0010 – 0.0025 in.)
- Bore ID:
  - New . . . . . . 20.000 – 20.025 mm (0.7874 – 0.7884 in.)
  - Maximum . . . . . . 20.038 mm (0.7889 in.)
- Bearing OD:
  - New . . . . . . 19.962 – 19.975 mm (0.7859 – 0.7864 in.)
  - Minimum . . . . . . 19.959 mm (0.7858 in.)

**Balance Shaft:**

- End Play . . . . . . 0.0575 – 0.3625 mm (0.0023 – 0.0143 in.)
- Clearance . . . . . . 0.025 – 0.063 mm (0.0009 – 0.0025 in.)
- Bore ID:
  - New . . . . . . 20.000 – 20.025 mm (0.7874 – 0.7884 in.)
  - Maximum . . . . . . 20.038 mm (0.7889 in.)
- Balance Shaft Bearing OD:
  - New . . . . . . 19.962 – 19.975 mm (0.7859 – 7864 in.)
  - Minimum . . . . . . 19.959 mm (0.7858 in.)

**Cylinder Bore, Piston and Rings:**

- Cylinder Bore ID:
  - New . . . . . . 90.000 – 90.025 mm (3.5433 – 3.5443 in.)
  - Maximum . . . . . . 90.63 mm (3.5681 in.)
- Maximum Out-of-Round . . . . . . 0.12 mm (0.0047 in.)
- Maximum Taper . . . . . . 0.05 mm (0.0020 in.)
- Piston-To-Pin Clearance . . . . . . 0.006 – 0.017 mm (0.0002 – 0.0007 in.)
- Piston Pin Bore ID:
  - New . . . . . . 19.006 – 19.012 mm (0.7483 – 0.7485 in.)
  - Maximum . . . . . . 19.025 mm (0.7490 in.)
- Piston Pin OD:
  - New . . . . . . 18.995 – 19.000 mm (0.7478 – 0.7480 in.)
  - Minimum . . . . . . 18.994 mm (0.74779 in.)
- Top Compression Ring-To-Groove Side Clearance . . . . . . 0.060 – 0.105 mm (0.0023 – 0.0041 in.)
- Middle Compression Ring-To-Groove Side Clearance . . . . . . 0.040 – 0.085 mm (0.0015 – 0.0002 in.)
- Oil Control Ring-To-Groove Side Clearance . . . . . . 0.176 – 0.026 mm (0.0069 – 0.0010 in.)
- Top and Center Compression Ring End Gap
  - New Bore . . . . . . 0.27 – 0.51 mm (0.010 – 0.020 in.)
  - Used Bore (Maximum) . . . . . . 0.77 mm (0.030 in.)
- Piston Thrust Face OD:
  - New: . . . . . . 89.951 – 89.969 mm (3.5413 – 3.5420 in.)
  - Minimum . . . . . . 89.824 mm (3.5363 in.)

Piston Thrust Face-To-Cylinder Bore Clearance
New . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 0.031 – 0.043 mm (0.0012 – 0.0016 in.)

**Connecting Rod:**

Crankshaft (Big End) Clearance
New . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 0.030 – 0.055 mm (0.0012 – 0.0022 in.)
Maximum . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 0.07 mm (0.0025 in.)
Side . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 0.18 – 0.41 mm (0.007 – 0.016 in.)
Piston Pin Clearance. . . . . . . . . . . . . . . . . . . . . 0.015 – 0.028 mm (0.0006 – 0.0011 in.)
Piston Pin End ID:
New . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19.015 – 19.023 mm (0.7486 – 0.7489 in.)
Maximum . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 19.036 mm (0.7495 in.)

**Governor:**

Crankcase Control Arm Bore ID:
New . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6.025 – 6.050 mm (0.2372 – 0.2382 in.)
Maximum . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 6.063 mm (0.2387 in.)
Control Arm OD:
New . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5.975 – 6.000 mm (0.2352 – 0.2362 in.)
Minimum . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5.962 mm (0.2347 in.)
Crankcase Bore-To-Control Arm Clearance . . . 0.025 – 0.075 mm (0.0010 – 0.0030 in.)
Gear Shaft OD:
New . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5.990 – 6.000 mm (0.2358 – 0.2362 in.)
Minimum . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 5.977 mm (0.2353 in.)
Gear Shaft-To- Gear Bore Clearance . . . . . . . . 0.015 – 0.140 mm (0.0006 – 0.0055 in.)

# TORQUE SPECIFICATIONS (Alphabetical)

*NOTE: Use appropriate torque wrench which will read within the inch pound range given, or convert inch pounds to foot pounds as follows: Inch-pounds ÷ 12 = Foot-pounds*

| | |
|---|---|
| Air Cleaner Base Nut | 9.9 N•m (88 lb-in.) |
| Cylinder Head Cap Screw | |
| Initial | 20 N•m (177 lb-in.) |
| Final | 41 N•m (30 lb-ft) |
| Connecting Rod Cap Screws: | |
| 8 mm Straight Shank Bolt | 22.7 N•m (200 lb-in.) |
| Step Down Shank Bolt | 14.7 N•m (130 lb-in.) |
| 6 mm Straight Shank Bolt | 11.3 N•m (100 lb-in.) |
| Engine Mounting Cap Screws | 32 N•m (24 lb-ft) |
| Fan Cap Screw | 9.9 N•m (88 lb-in.) |
| Flywheel Cap Screw | 68 N•m (50 lb-ft) |
| Fuel Pump/Cover Screw: | |
| New Installation (Thread Forming) | 9.0 N•m (80 lb-in.) |
| Replacement | 7.3 N•m (65 lb-in.) |
| Fuel Bowl Nut | 4.0 N•m (35 lb-in.) |
| Governor Control Panel Screw | 9.9 N•m (88 lb-in.) |
| Ignition Module Screw | |
| New Installation (Thread Forming) | 6.2 N•m (55 lb-in.) |
| Replacement | 4.0 N•m (35 lb-in.) |
| Muffler Nut | 24.4 N•m (216 lb-in.) |
| Oil Filter | 7.35 N•m (65 lb-in.) |
| Oil Filter Drain Plug | 8.15 N•m (72.5 lb-in.) |
| Oil Pan Cap Screw | 24.4 N•m (216 lb-in.) |
| Oil Pump Cover Screw | |
| New Installation (Thread Forming) | 6.2 N•m (55 lb-in.) |
| Replacement | 4.0 N•m (35 lb-in.) |
| Rocker Arm Pivot Cap Screw | 14 N•m (124 lb-in.) |
| Spark Plug | 40.7 N•m (30 lb-ft) |
| Starting Motor Mounting Cap Screws | 24.0 N•m (216 lb-in.) |
| Stator Cap Screw | 4.0 N•m (35 lb-in.) |
| Throttle Plate Cap Screw | 10.7 N•m (95 lb-in.) |
| Valve Cover Cap Screw | |
| New Installation (Thread Forming) | 10.7 N•m (95 lb-in.) |
| Replacement | 7.3 N•m (65 lb-in.) |

# SPECIAL OR REQUIRED TOOLS

| Tool | Purpose |
|---|---|
| JDG705 Reaming Tool | Valve guide |
| 6.4 mm (0.25 in.) Drill Bit | Throttle and choke adjustment |
| Dial Indicator | Automatic compression relief test, Valve inspection |
| JTO5719 Photo Tachometer | Slow idle adjustment |
| JT035029 Cylinder Leak Tester | Cylinder leak test |
| JTO5697 U-Tube Manometer Test Kit; or, JT03503 Crankcase Vacuum Test Kit | Crankcase vacuum check |
| JT07262 Oil Pressure Test Adapter w/ O-ring (required ONLY on engines without test ports)<br>JT05847 Connector<br>JT03017 Hose Assembly<br>JT03262 Coupler<br>JT07034 Gauge, 0 – 700 kPa (0 – 100 psi) | Oil pressure test |
| Lapping Tool | Valve lapping |

# OTHER MATERIALS

| Number | Name | Use |
|---|---|---|
| M79292 | MPG-2® Multipurpose Grease | Apply to engine crankshaft |
| | SCOTCH-BRITE® Abrasive Sheets/Pads | Clean cylinder head |
| | Valve Guide Cleaner | Clean valve guides |
| | Stanisol (or Kerosene) | Finish ream valve guides |
| | Lithium Base Grease | Pack oil seals |
| | Mineral Spirits | Clean armature |
| | Valve Lap Compound | Lap valves |
| T43512 / TY9473 / 242 | Thread Lock and Sealer (Medium Strength) | Apply to threads of throttle and choke plate screws |
| TY15130 / 395 | LOCTITE® Form-in-Place Gasket | Rocker arm cover mating surfaces |

MPG-2® is a registered trademark of DuBois USA.
LOCTITE® is a registered trademark of the Loctite Corp.
SCOTCH-BRITE® is a register trademark of the 3M Co.

# TROUBLESHOOTING

| Problem or Symptom / Check or Solution | Engine cranks but will not start or starts hard | Engine will not stay running or runs rough | Engine stalls frequently | Engine backfires | Engine surges, uneven or uncontrolled rpm | Engine misses | Low power under load | Engine has no spark | Engine will not crank | Exhaust black, engine floods or burns rich | Exhaust smoke blue or high oil consumption | Engine has low oil pressure | Fuel in oil | Engine overheats | Excessive engine noise or vibration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Spark plug fouled or incorrect gap. Incorrect spark plug. | ● | ● | ● | | ● | ● | ● | ● | | ● | | | ● | ● | |
| Defective ignition components. | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● | | |
| Starter worn. Cranking rpm too slow, cables corroded, battery weak. Engine overloaded. | ● | ● | ● | | | | ● | | ● | | | ● | | ● | ● |
| Fuel tank outlet restricted, shut-off valve not fully open, fuel filter or line restricted. Fuel stale, contains water, or wrong type. | ● | ● | ● | | ● | ● | ● | | | ● | ● | | | | |
| Air filter element plugged or oil soaked. | ● | ● | ● | | ● | ● | ● | | | ● | | | ● | | |
| Choke, throttle, or governor linkage worn / out of adjustment. Carburetor set too rich. | ● | ● | ● | ● | ● | ● | ● | | ● | ● | | | ● | ● | |
| Carburetor worn, contaminated with debris or varnish. Passages plugged. Wrong jets or adjusted too lean. | ● | ● | ● | ● | ● | ● | ● | | | | | | ● | | |
| Carburetor, intake manifold, or cylinder head gaskets leaking. | ● | ● | ● | ● | ● | ● | ● | | | | | | | ● | ● |
| Low compression: worn piston, rings, cylinder, valves. Warped head. | ● | ● | ● | | ● | ● | ● | | | | ● | ● | ● | ● | ● |
| Valve clearance incorrect. Burned or warped valves and seats. Defective springs. | ● | ● | ● | ● | ● | ● | ● | | | | | | | ● | ● |
| Engine oil viscosity or level incorrect. Engine oil filter restricted. Oil pump worn or passages obstructed. | ● | ● | | | | | ● | | ● | | | ● | | ● | ● |
| Engine gaskets or seals leaking. | ● | ● | ● | ● | ● | ● | ● | | | | ● | ● | ● | ● | ● |
| Crankcase breather restricted, reed valve damaged, clearance incorrect, or drain hole plugged. | ● | ● | ● | | ● | | ● | | ● | | ● | ● | | ● | |
| Valve guides or seals worn or leaking. Valve stems worn. | ● | ● | ● | ● | ● | ● | ● | | | | ● | | | ● | ● |
| Worn, stuck, or broken piston rings. Cylinder bore worn. Check compression and vacuum. | ● | ● | ● | ● | ● | ● | ● | | | | ● | ● | ● | ● | ● |
| Connecting rod or crankshaft bearings worn. Internal wear limits out of specification. | ● | ● | ● | | ● | | ● | | | | | ● | | ● | ● |
| Engine mounting hardware loose or broken. | | | | | ● | | ● | | | | | | | | ● |

## TROUBLESHOOTING (Continued)

| Check or Solution / Problem or Symptom | Fuel overflows carburetor | Engine stops when hot | Engine races or runs one | Engine clatters | Engine won't run | White smoke on start-up | Engine runs slow & clicks | Engine runs on after | Engine won't shut off |
|---|---|---|---|---|---|---|---|---|---|
| Dirt in carburetor. Float sticking Clean carb, replace filter, check float | ● | | | | | | | | |
| Vapor lock. Check temperature of fuel system. Clear vent in top of fuel cap | | ● | | | ● | | | | |
| Fuel shutoff valve closed | | | | | ● | | | | |
| Move governor shaft with engine running, check for resistance | | | ● | | | | | | |
| Lifter is collapsed | | | | ● | ● | | | | |
| Lifter is stuck in bore | | | | ● | ● | | | | |
| Water in fuel bowl of carburetor | | | | | ● | ● | | | |
| Engine RPM too low; automatic compression release still on Adjust low idle speed | | | | ● | | | ● | | |
| Inspect ignition switch and ground | | | | | | | | ● | ● |
| Inspect engine ground cable | | | | | | | | ● | ● |
| Adjust idle speed to specs. Move throttle to idle before shutdown | | | | | | | | ● | |
| Inspect piston, valves, cylinder head & exhaust for high carbon build-up | | | | | | | | ● | |

# ENGINE TROUBLESHOOTING

## Engine Hard To Start or Will Not Start

Remove spark plug and check spark by cranking engine while having the plug grounded against engine block. Install spare plug to simulate actual cranking conditions.

**CAUTION:**
**To avoid electric shock, DO NOT hold plug. Make sure to hold plug cap.**

NO → Are sparks produced when spark plug is replaced?

- YES → • Faulty spark plug. — Replace
- NO → Are sparks produced between high tension lead and engine block with plug cap removed?
  - YES → • Faulty contact of plug cap terminal to lead. — Correct
  - NO → Are sparks produced between high tension lead and engine block when ignition module is replaced?
    - YES → • Faulty ignition module. — Replace
    - NO →
      - • Faulty ignition coil. — Replace
      - • Faulty high tension lead. — Replace
      - • Incorrect ignition coil air gap. — Correct

YES → Is compression sufficient?

- YES → Crank engine several times, then remove spark plug and observe electrodes. Are they wet?
  - NO →
    - • No fuel in the tank. — Add
    - • Closed shutoff valve. — Open
    - • Clogged fuel filter. — Replace
    - • Closed fuel shutoff solenoid. — Check or replace
    - • Plugged air vent hole in tank cap. — Clean
    - • Plugged fuel line — Clean
    - • Faulty fuel pump. — Replace
    - • Low crankcase vacuum. — Correct
  - YES →
    - • Excessive use of choke. — Open choke
    - • Clogged air cleaner. — Clean
    - • Fuel level too high in float bowl. — Adjust
- NO →
  - • Worn piston/piston rings. — Replace
  - • Stuck piston rings. — Clean or replace
  - • Worn cylinder bore. — Bore or replace
  - • Faulty contact of valve seat. — Lap or grind
  - • Misadjusted valves. — Adjust
  - • Warped cylinder head. — Repair or replace
  - • Broken valve spring. — Replace
  - • Stuck valve. — Clean or grind
  - • Leaking head gasket. — Replace

Check carburetor. →

- • Check for plugged fuel passage.
- • Check for plugged air passage.
- • Check float level.
- • Check carburetor setting.
- • Stale fuel.

## Engine Malfunctions at Low Speed

Remove spark plug and check spark by cranking engine while having the plug grounded against engine block. Install spare plug to simulate actual cranking conditions.

**CAUTION: To avoid electric shock, DO NOT hold plug. Make sure to hold plug cap.**

WEAK →

- Faulty plug insulation. — Replace
- Fouled electrodes. — Clean
- Faulty high tension lead. — Replace
- Incorrect ignition coil air gap. — Correct
- Faulty ignition coil. — Replace

STRONG ↓

Is unusual smoke emitted out of muffler?

YES →

- Plugged air filter. — Clean
- Deposits in exhaust port. — Clean
- Misadjusted carburetor. — Adjust
- Misadjusted float. — Adjust
- Overfilled crankcase. — Correct
- Worn piston/piston rings. — Repair
- Worn cylinder bore. — Replace

NO ↓

Gradually open throttle valve by hand. Does engine speed drop or does engine stall at a certain position?

YES →

- Passages in carburetor plugged. — Clean
- Plugged fuel filter. — Correct
- Plugged vent. — Correct
- Stale fuel. — Fresh fuel

NO ↓

Is air drawn through carburetor flange?

YES →

- Loose flange nuts. — Tighten
- Damaged gasket. — Replace
- Warped flange. — Replace

NO ↓

Is valve clearance normal?

NO →

- Misadjusted valve. — Adjust
- Worn camshaft lobes, pushrods. — Replace

YES ↓

Is alignment of timing gear marks correct?

NO →

- Incorrect valve timing. — Correct

## Engine Runs Erratically

| | | |
|---|---|---|
| Problem in fuel system (lack of fuel). | • Dust or water in fuel line or fuel filter. | Clean |
| | • Air or vapor lock in fuel line. | Remove |
| | • Plugged air vent in fuel tank cap. | Clean |
| | • Plugged air/fuel passages in carburetor. | Clean |
| | • Too little opening of carburetor pilot air-screw. | Correct |
| | • Stale fuel. | Fresh fuel |
| Problem in governor system. | • Incorrect governor linkage adjustment. | Correct |
| | • Faulty governor spring. | Replace |
| | • Governor gear assembly malfunction. | Check |
| Engine knocks. | • Stale fuel. | Fresh fuel |
| | • Excessive carbon deposit in engine. | Clean |
| | • Excessive engine load. | Adjust |
| | • Engine overheating. | See **Has Low Power** |

## Oil Consumption Is Excessive

Is compression sufficient?

**YES**

| | |
|---|---|
| • Plugged oil ring groove. | Clean |
| • High oil level. | Adjust |
| • Worn valve stems and valve guides. | Replace |
| • Oil leakage along governor shaft. | Replace |
| • Oil seals leaking. | Replace |
| • Head gasket leaking. | Replace |
| • Drain plug leaking. | Retighten or replace |
| • Breather valve clogged. | Clean |
| • Drain-back hole in tappet chamber plugged. | Clean |
| • Incorrect oil viscosity. | Change |

**NO**

| | |
|---|---|
| • Worn piston/piston rings. | Replace |
| • Stuck piston rings. | Clean or replace |
| • Worn cylinder bore. | Bore or replace |
| • Faulty contact of valve seat. | Lap or grind |
| • Misadjusted valves. | Adjust |
| • Warped cylinder head. | Repair or replace |
| • Broken valve spring. | Replace |
| • Stuck valve. | Clean or grind |
| • Leaking head gasket. | Replace |

## Engine Has Low Power

**Is engine overheated?** — YES →

- Excessive engine load. — Adjust load
- Carburetor not properly adjusted (too lean). — Adjust
- Dirty or clogged air intake screen, shroud and engine fins. — Clean
- Carbon deposit in combustion chamber. — Clean
- Incorrect oil level. — Adjust

NO ↓

**Is lubricating condition normal?** — NO →

- Too much or too little oil in crankcase. — Correct
- Excessively contaminated lubricating oil/filter. — Change
- Faulty oil pump. — Replace

YES ↓

**Is black or blue smoke emitted out of muffler?** — YES →

- Air cleaner clogged. — Clean
- Carbon deposit in exhaust port and muffler. — Clean
- Carburetor not properly adjusted. — Adjust
- Too much oil in crankcase. — Correct
- Stale fuel. — Fresh fuel

NO ↓

**Is compression sufficient?** — NO →

- Worn piston/piston rings. — Replace
- Stuck piston rings. — Clean or replace
- Worn cylinder bore. — Bore or replace
- Faulty contact of valve seat. — Lap or grind
- Misadjusted valves. — Adjust
- Warped cylinder head. — Repair or replace
- Broken valve spring. — Replace
- Stuck valve. — Clean or grind
- Leaking head gasket. — Replace

## Fuel Consumption Is Excessive

**Is compression sufficient?** — YES →

- Carburetor float or pilot air screw not properly adjusted. — Adjust
- Air cleaner clogged. — Clean
- Fast idle speed excessive (too high). — Adjust
- Choke valve not fully open. — Adjust
- Leak in fuel system. — Correct

NO →

- See *Engine Has Low Power—Is compression sufficient? - NO,* above.

## STARTER MOTOR TROUBLESHOOTING GUIDE

1. Disconnect spark plug cap, and ground the cap terminal.
2. Turn key switch to "START" position and check condition.

**⚠ CAUTION**

**Engine may be cranked in this test. DO NOT touch any rotating parts of engine and equipment during test.**

**IMPORTANT: If starter does not stop when key switch is in off position, disconnect negative (–) lead from battery as soon as possible.**

### Starter Does Not Rotate

| Check | Answer | Cause | Remedy |
|---|---|---|---|
| Click sound from solenoid (switch)? | NO | • Faulty battery. | Charge or replace |
| | | • Faulty leads or connection. | Repair or replace |
| | | • Melted fuse. | Replace |
| | | • Faulty key switch. | Repair or replace |
| | | • Faulty solenoid (switch). | Replace |
| | YES | • Weak battery. | Charge or replace |
| | | • Faulty leads or connection. (Solenoid to motor) | Repair or replace |
| | | • Faulty solenoid (switch). (Main terminal in solenoid) | Replace |
| | | • Faulty starter motor. | Repair or replace |

### Starter Rotates Slowly

| Check | Answer | Cause | Remedy |
|---|---|---|---|
| Is battery charged? | NO | • Weak battery. | Charge or replace |
| | YES | • Faulty leads or connection. (Solenoid to motor) | Repair or replace |
| | | • Faulty solenoid (switch). (Main terminal in solenoid) | Replace |
| | | • Faulty starter motor. | Repair or replace |
| | | • Faulty engine. | Repair or replace |

### Starter Rotates But Can Not Crank Engine

| Check | Answer | Cause | Remedy |
|---|---|---|---|
| Does pinion mesh with ring gear? | NO | • Worn pinion or ring gear. | Replace |
| | | • Incorrect starter alignment. | Correct |
| | YES | • Faulty bendix. | Replace |

### Starter Does Not Stop With Key Switch In RUN or OFF Position

| Check | Answer | Cause | Remedy |
|---|---|---|---|
| Can stop starter with key switch in RUN or OFF position. | NO | • Faulty key switch. | Repair or replace |
| | | • Faulty solenoid (switch). | Replace |
| | YES | • Faulty pinion or ring gear | Repair or replace |
| | | • Incorrect starter alignment. | Correct |
| | | • Faulty pinion return mechanism. | Repair or replace |

# TESTS AND ADJUSTMENTS

## THROTTLE CABLE ADJUSTMENT

**Reason:**

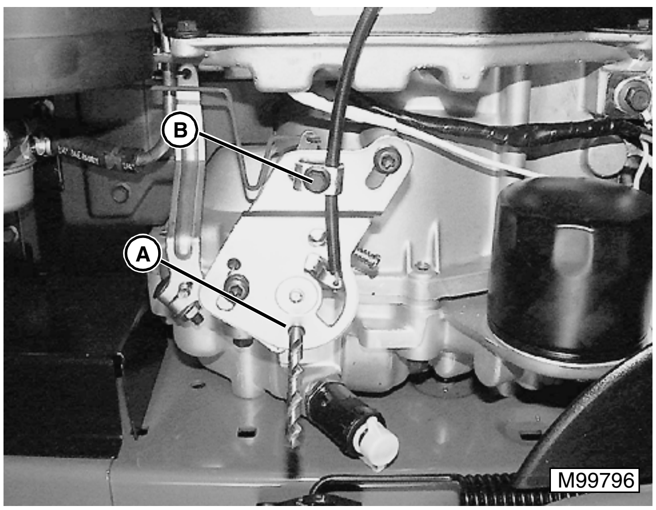
To make sure the throttle cable moves the throttle and choke control lever through its full range of movement.

**Equipment:**

- 6.4 mm (0.25 in.) Drill Bit

**Procedure:**

1. Move throttle lever to FAST idle position.




2. Align hole in throttle control lever with hole (A) in throttle control plate. Put a **6.4 mm (0.25 in.)** drill bit through holes to keep the throttle control lever from moving. Be sure drill bit is perpendicular to the throttle control plate.
3. Loosen cap screw (B) and pull throttle cable housing tight. Tighten cap screw.
4. Remove drill bit.
5. Move throttle lever to the full choke position. Make sure throttle lever is held up against throttle plate. Choke should be fully closed.
6. Move throttle lever through full range to be sure linkage is not binding.

## CHOKE ADJUSTMENT

**Reason:**

To make sure the choke plate is fully closed when the throttle lever is in the full choke position. Correct adjustment also makes sure choke is completely open in the fast idle position.

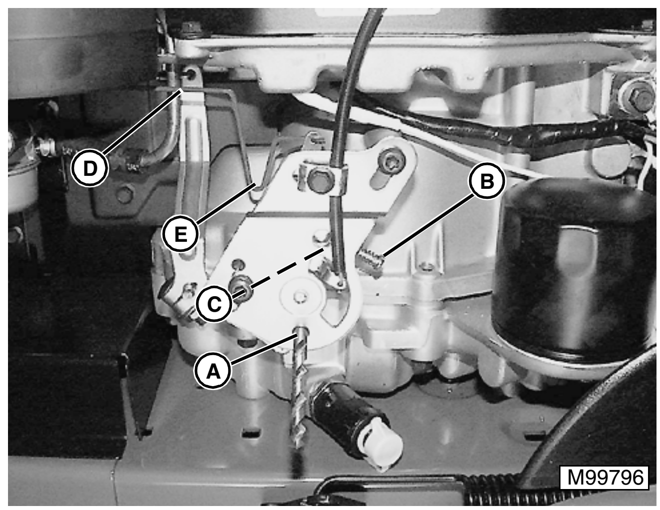
**Equipment:**

- 6.4 mm (0.25 in.) Drill Bit

**Procedure:**

*NOTE: Adjust throttle cable before adjusting choke.*

1. Move throttle lever to CHOKE position then back to FAST idle position.




2. Align hole in throttle control lever with hole in throttle control plate. Put a **6.4 mm (0.25 in.)** drill bit (A) through holes to keep the throttle control lever from moving. Be sure drill bit is perpendicular to the throttle control plate.
3. Turn screw (B) counterclockwise until screw does not contact the choke control lever (C).
4. Turn screw clockwise until screw just touches the choke control lever.
5. Remove drill bit.
6. Move throttle lever to full choke position.
7. Try to move choke rod (D) forward (choke rod should not move). If the choke rod moves forward, the choke plate is not fully closed. Carefully bend the choke rod at Vee bend (E) until the choke plate is fully closed.
8. Move throttle lever to be sure choke linkage is not binding.

## GOVERNOR ADJUSTMENT

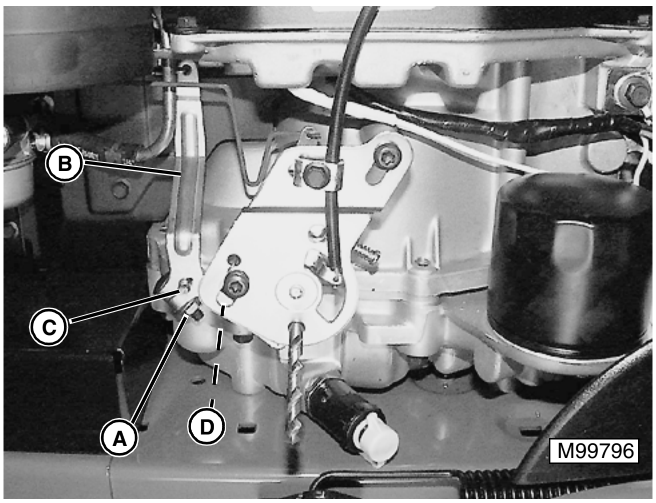
**Reason:**

To make sure the governor shaft contacts the fly-weight plunger when the engine is stopped.

*NOTE: Adjust throttle cable before adjusting governor linkage.*

**Procedure:**

1. Move throttle lever to FAST idle position.




2. Loosen nut (A).
3. Hold top of governor arm (B) toward carburetor. Turn governor shaft (C) counter-clockwise until it stops. Hold governor shaft and tighten nut.
4. Move throttle lever through full range to be sure linkage is not binding.
5. Governor spring (D) should be installed in the hole closest to governor shaft. If governor is not responding properly, replace spring and readjust fast idle speed. If spring did not correct the problem, repair governor.

## FAST IDLE SPEED ADJUSTMENT

**Reason:**

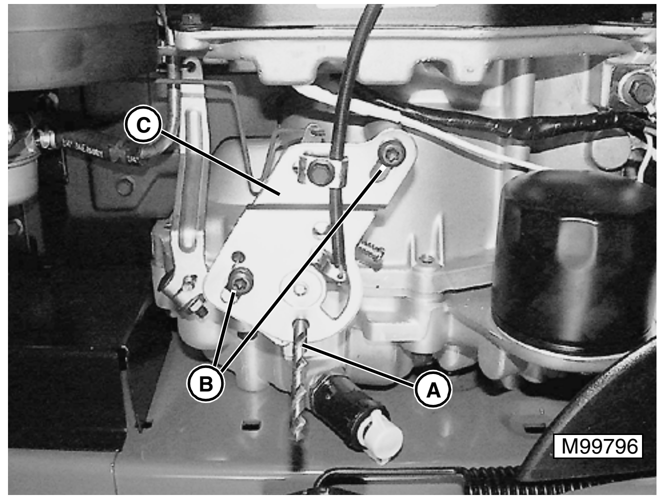
To set engine fast idle rpm.

**Equipment:**

• JTO5719 Photo Tachometer

**Procedure:**

1. Move transaxle shift lever to NEUTRAL position. Engage park brake.




2. Put reflective tape on blower housing screen.
3. Start and run engine at MEDIUM idle for five minutes.

**⚠ CAUTION**

**Engine will be HOT. Be careful not to burn skin.**

4. Move throttle lever to FAST idle position.
5. Align holes of throttle lever and throttle control plate with **6.4 mm (0.25 in.)** drill bit (A). This keeps the throttle control lever from moving during adjustment. Be sure drill bit is perpendicular to the throttle control plate.
6. Use a photo tachometer to check engine rpm at the blower housing screen.

**Specifications:**

**Fast idle speed setting . . . . . . . . . . . 3350 ± 50 rpm**
**Control panel screw torque. . . . . 9.9 N•m (88 lb-in.)**

**Results:**

• If fast idle speed does not meet the specifications, loosen cap screws (B)
• Move throttle control plate (C) upward to increase rpm or downward to decrease rpm
• Hold the throttle control plate and tighten cap screws

## SLOW IDLE SPEED ADJUSTMENT

**Reason:**

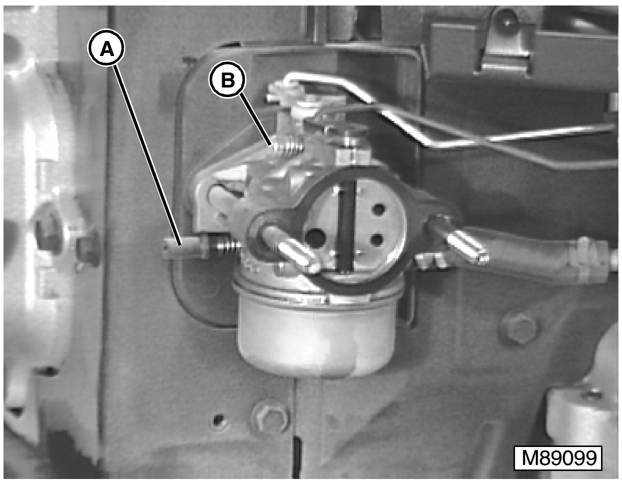
To set engine slow idle mixture and rpm.

**Equipment:**

- JTO5719 Photo Tachometer

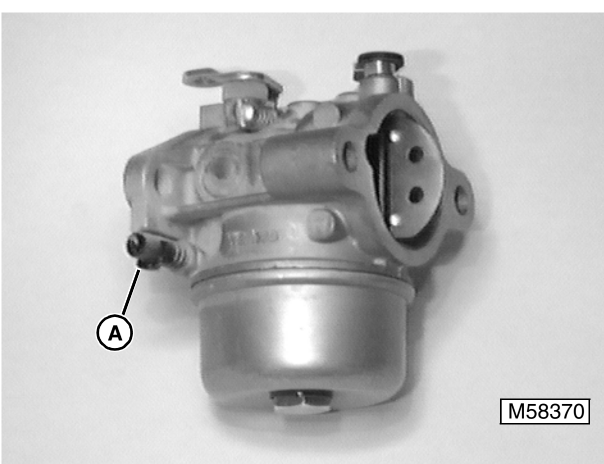
**Procedure:**

1. Move transaxle to NEUTRAL. Engage park brake.




**IMPORTANT: Forcing the idle mixture screw tight will damage the needle and seat. Air cleaner removed for photo, DO NOT remove for tests.**

2. Put reflective tape on blower housing screen.




3. No preliminary adjustment is required for black limiter slow idle mixture screw (A), this is pre-set by manufacturer.
4. Start and run engine at MEDIUM idle for 5 minutes.
5. Move throttle lever to SLOW idle position.
6. Use a photo tachometer to check engine rpm at the blower housing screen.
7. Turn SLOW idle stop screw (B) in either direction until specified SLOW idle speed is reached.
8. Turn slow idle mixture screw (A) in either direction until a maximum slow idle speed is reached. It may be necessary to adjust SLOW idle stop screw (B) again.

**Specification:**

**SLOW idle stop screw setting. . . . . 1700 ± 100 rpm**

*NOTE: For high altitude operation above 4000 feet, use high altitude carburetor kit, to prevent over rich fuel mixture and black exhaust smoke.*

## CYLINDER LEAK TEST

**Reason:**

To check pressure capacity of piston rings and cylinder bore for efficient engine operation.

**Equipment:**

- JTO35029 Cylinder Leak Tester

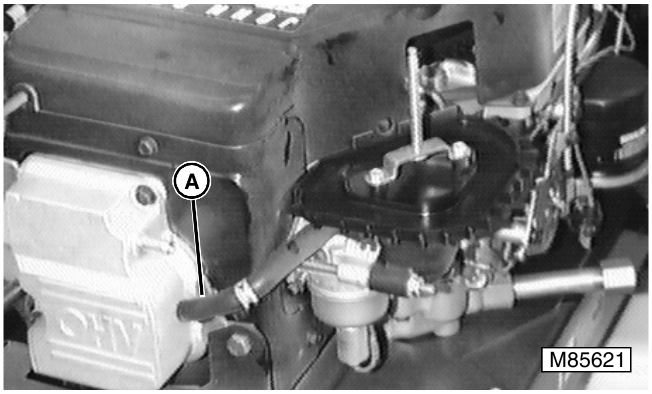
**Procedure:**

1. Remove hood.
2. Warm engine to operating temperature.

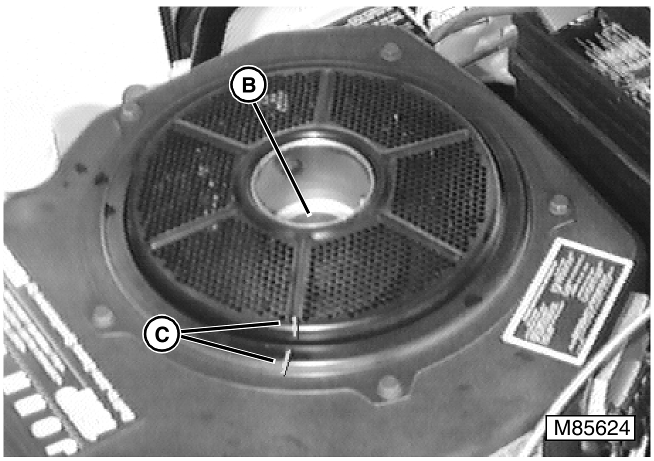
**CAUTION**

**Engine will be HOT. Do not touch with bare skin, especially the exhaust pipe or muffler while making test.**

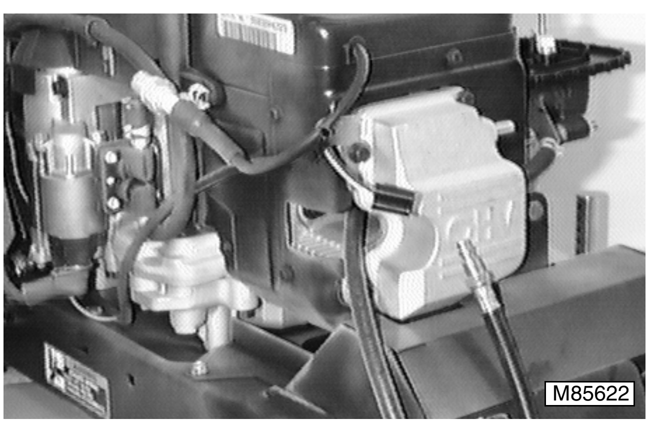
3. Move transaxle shift lever to NEUTRAL. Engage park brake.
4. Pry off the flywheel screen and use a breaker bar on the flywheel nut to hold the flywheel in position when performing the test.



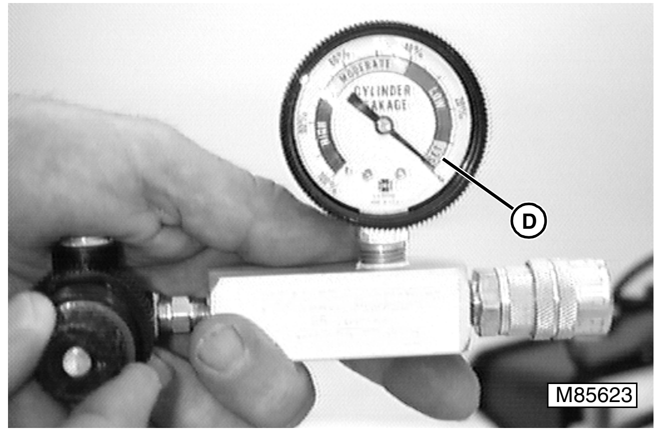

5. Disconnect crankcase breather hose (A) from valve cover breather port and remove air cleaner element from engine so you can listen for air leaks.



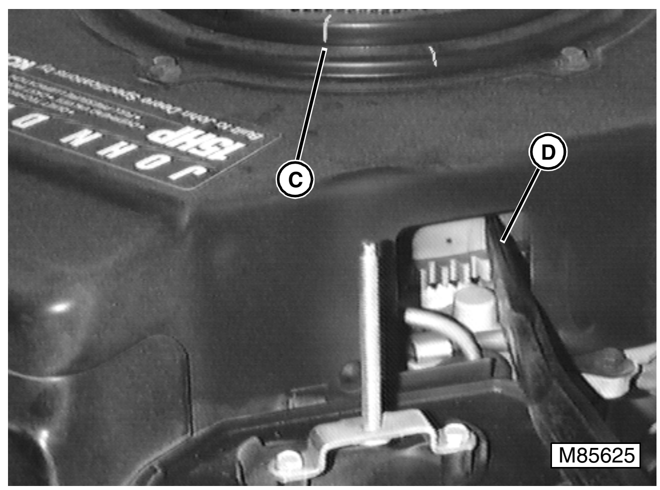

6. Use flywheel mounting cap screw (B) to turn flywheel and find approximate top dead center (TDC) of the compression stroke.
7. Remove spark plug and put a wooden dowel on top of piston to find actual TDC of the compression stroke. Then mark flywheel screen rib and shroud as shown (C) between front and left shroud cap screws.




8. Ground ignition high tension lead using JDM-74A-5 Ignition Test Plug to protect ignition system and install test kit adapter hose into spark plug hole.

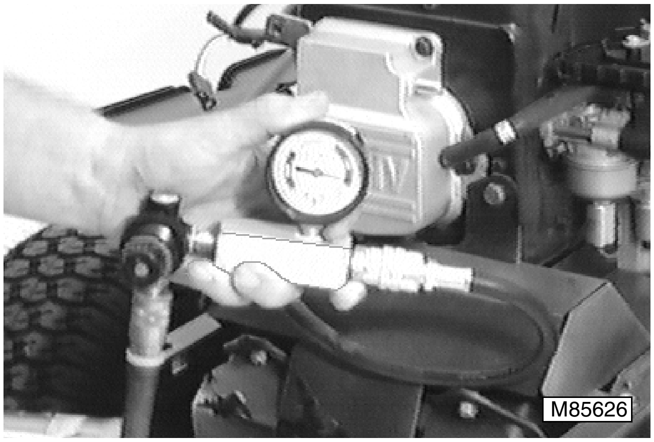



9. First turn regulator knob on tester OFF (fully counterclockwise) then attach appropriate air source to coupler below black regulator valve.
10. Gradually turn regulator knob clockwise until needle aligns with “zero” of the yellow “SET” scale (D).




11. Turn flywheel clockwise until screen TDC mark (C) is between shroud TDC mark and front cap screw.

**IMPORTANT: Have a helper put a wide blade pry bar (D) between two flywheel teeth (D) and up against engine block post and firmly wedge the pry bar against edge of shroud opening. This must be done properly to prevent piston and crankshaft from turning in a clockwise direction when compressed air is applied.**




*NOTE: A slight air leak from the breather port is normal as air escapes from the crankcase through the oil drainback hole in the head and breather valve.*

12. Connect adapter hose to tester. Watch and record gauge reading while listening for excessive air leaks at carburetor intake, crankcase breather port, and exhaust outlet. Pressure should hold steady or reduce only slightly and only a faint air leak should be heard at the breather port.
13. Remove test equipment and install spark plug. Tighten spark plug to **40 N•m (30 lb-ft)**.
14. Install hood.

**Results:**

Leakage should not exceed 25%, if so, listening at the carburetor (intake valve), oil filler (piston rings) or muffler (exhaust valve) for escaping air will provide clues as to where to investigate for problems.

**Air Leaks—Carburetor:**
**slight . . . "low-to-moderate" wear to intake valve**
**excessive . . . . . . intake valve bad, fix or replace**

**Air Leaks—Crankcase Breather:**
**slight (normal) . . . . . . . . . . . . . . . . . . . . . . . . . ok**
**excessive . . . . . . . . . . rings or cylinder wall bad,**
**. . . . . . . . . . . . . . replace rings and hone cylinder,**
**. . . . . . . . . . . . . . . . . . . . . . . . . or use short block**

**Air Leaks—Exhaust Outlet:**
**slight . . "low-to-moderate" wear to exhaust valve**
**excessive . . . . . exhaust valve bad, fix or replace**

**Gauge Color Codes—**
**Green (low) . . . . . . . . . . . . . . . compression good**
**Yellow (moderate). . . . . . compression borderline**
**Red (high) . . . . . . . . . . . . . . . . . .compression bad**

# AUTOMATIC COMPRESSION RELEASE (ACR) CHECK

**Reason:**

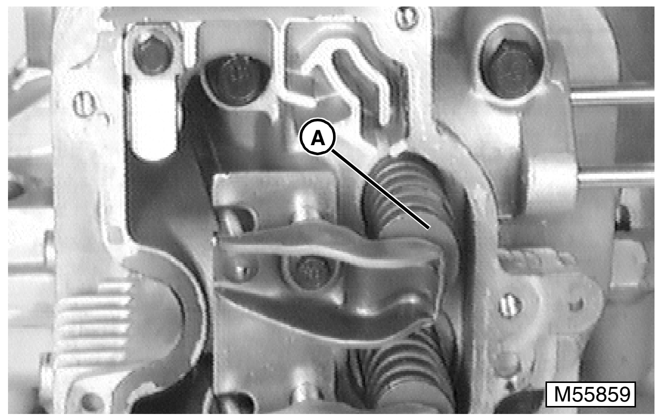
To determine if the automatic compression release is opening the exhaust valve.

**Equipment:**

• Dial Indicator

**Procedure:**

1. Remove valve cover and spark plug. Rotate crankshaft slowly to observe ACR operation.




2. The exhaust valve (A) must open (depress) briefly just after the intake valve closes.
3. Use a dial indicator to measure exhaust valve ACR movement.
4. Install rocker cover, see Remove and Install Cylinder Head in the Engine Repair group.

**Specification:**

**Exhaust valve ACR movement**
**Minimum . . . . . . . . . . . . . . . . . . 0.25 mm (0.01 in.)**

**Results:**

• If the exhaust valve does not open or depress properly, the automatic compression release tab is faulty and camshaft assembly must be replaced

# CRANKCASE VACUUM TEST

**Reason:**

To measure the amount of crankcase vacuum, to ensure the crankcase is not pressurized. A pressurized crankcase will force oil to leak past the seals.

**Equipment:**

- JTO5697 U-Tube Manometer Test Kit; or,
- JT03503 Crankcase Vacuum Test Kit

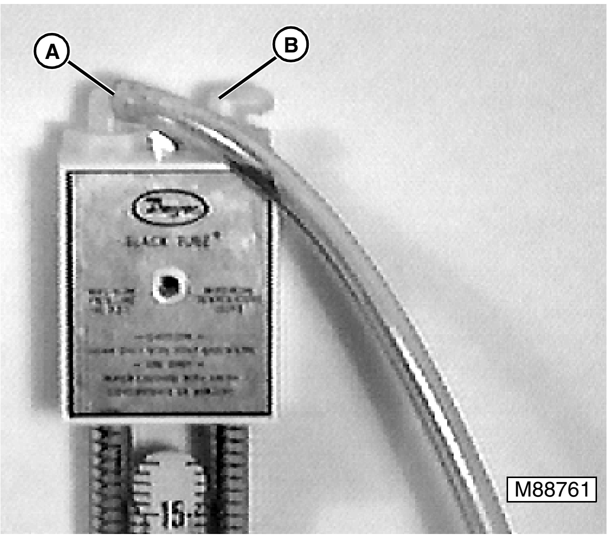
**Procedure 1:**

**IMPORTANT: Test must be run with the engine at normal operating temperature, if not, test will be inaccurate. DO NOT use more than 3 ft. of manometer tubing. If a longer hose is used the readings will be inaccurate.**

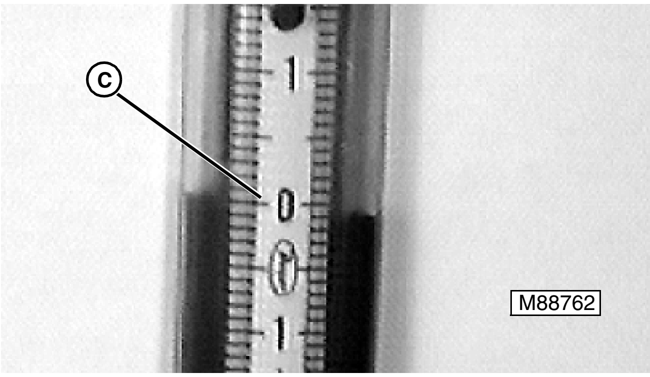
1. Park machine on level surface.
2. Raise engine hood and remove dipstick. Check dipstick/oil fill cap and o-ring for cracks or damage, replace as necessary.
3. Install appropriate size rubber plug in dipstick tube.
4. Insert barbed fitting in rubber plug so that clear line to fitting (A) can be connected at a later step.

**IMPORTANT: DO NOT make connection between U-Tube Manometer clear line and engine crankcase BEFORE engine is running or fluid in manometer could be drawn into crankcase.**

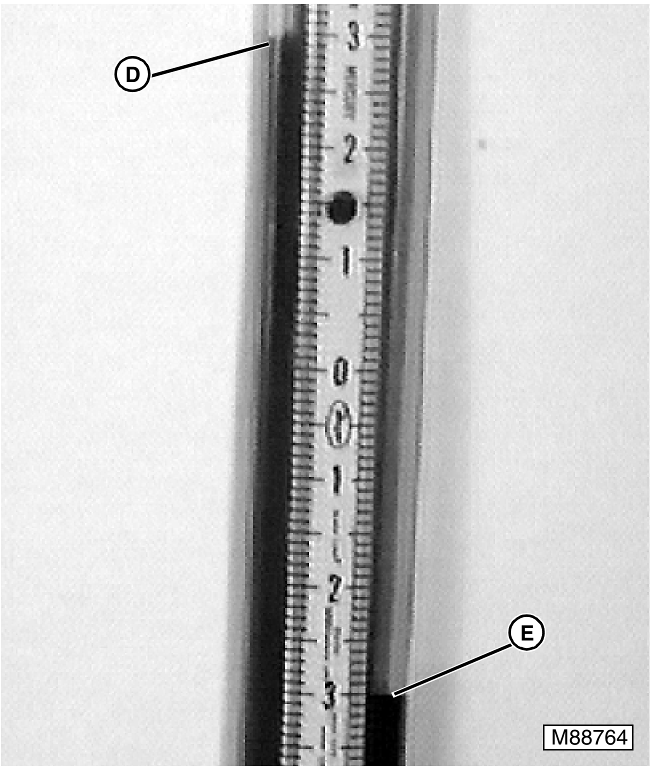
5. Attach manometer magnets to a solid metal surface.




6. Open top valves (A) and (B) one turn.




7. Zero out the manometer by sliding the ruled scale up or down so “0” (C) is located where water level on both sides is even.
8. Hold finger over rubber plug hole to keep oil from spraying out. Start engine, move the throttle lever to fast idle (3350 rpm) and allow engine to reach operating temperature.
9. Quickly attach clear line from manometer to rubber plug in dipstick opening.




Example: 3 + 3 = 6 in. of vacuum

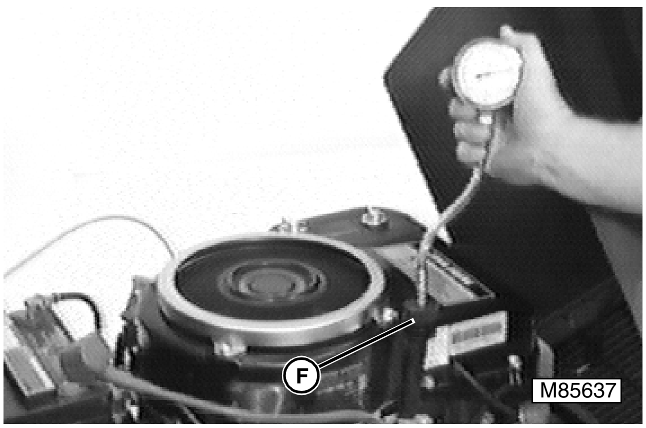
10. Record vacuum reading. Gauge should show a **minimum vacuum of 10.2 cm (4 in.) of water movement**. The reading is obtained by adding (D) and (E) water movement from “0” position.

**IMPORTANT: Repeat test at least three times for accuracy. To repeat test, remove the manometer tube from top of manometer at “D”.
DO NOT remove manometer tube from engine. Perform step #7 then reattach manometer tube to side “D”. Continue with step #10.**

11. Remove line from manometer before stopping engine. Then remove dipstick hose connection and install dipstick.

**Procedure 2:**

1. Park machine on level surface.
2. Raise engine hood and remove dipstick. Check dipstick/oil fill cap and o-ring for cracks or damage, replace as necessary.
3. Install appropriate size rubber plug in dipstick tube.
4. Insert barbed fitting in rubber plug (F) so that clear line to fitting can be connected at a later step.




**IMPORTANT: DO NOT make connection between test gauge and rubber plug BEFORE engine is running at FAST idle or gauge damage may result.**

**After test reading is made, DO disconnect test gauge WHILE engine is running at FAST idle to prevent damage to gauge.**

5. Hold finger over rubber plug hole to keep oil from spraying out. Start engine, move the throttle lever to fast idle (3350 rpm) and allow engine to reach operating temperature.
6. Connect gauge, clear line, and barbed fitting to rubber plug.
7. Record crankcase vacuum reading. Gauge should show a **minimum vacuum of 10.2 cm (4 in.) of water movement**.
8. Disconnect barbed fitting, clear line, and gauge from rubber plug while engine is running at FAST idle. Hold finger over rubber plug hole to keep oil from spraying out.
9. Move throttle to SLOW idle and turn engine OFF.
10. Remove rubber plug and install dipstick.

**Specification:**

**Minimum crankcase**
**Vacuum at 3350 rpm . . . . . . . . 10.2 cm (4 in. water)**

**Results:**

If crankcase vacuum does not meet specification, check the following:

*NOTE: A new engine may have low vacuum readings due to the fact that the rings are not seated.*

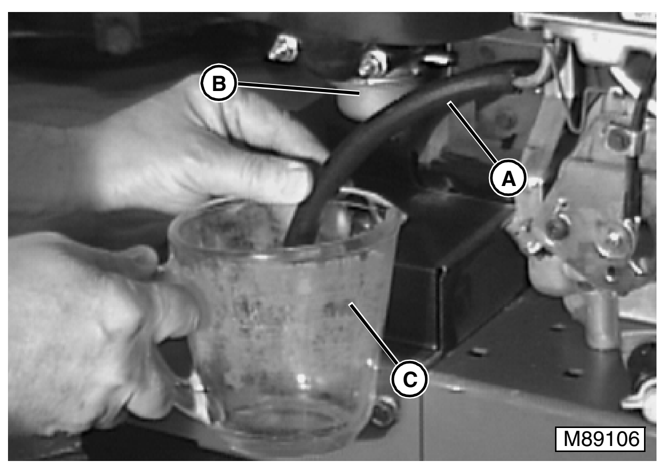
- Breather reed valve clearance and condition
- Seals and gaskets for leakage
- Rocker arm cover O-ring for leakage
- Rings, piston, and cylinder bore for wear or damage

## FUEL FLOW TEST

**Equipment:**

- Proper Fuel Container

**Procedure:**




1. Clamp fuel line (A) or turn off fuel shut-off valve, if equipped, to prevent fuel flow.

**IMPORTANT: Ensure that the fuel container is clean if fuel is to be returned to the tank after test.**

2. Disconnect fuel line from carburetor (B) and place

in container.
3. Release clamp on fuel line or turn on fuel shut-off valve, if equipped.
4. Crank engine, fuel should flow freely into container (C).
5. Clamp line or close fuel shut-off valve to install fuel line (A) on carburetor.
6. Pour captured fuel into tank.

**Results:**

If fuel flow is slow, check the following:

- Replace fuel filter
- Check fuel lines, fuel pump, shut-off valve (if equipped), fuel tank outlet, and fuel tank cap for restrictions

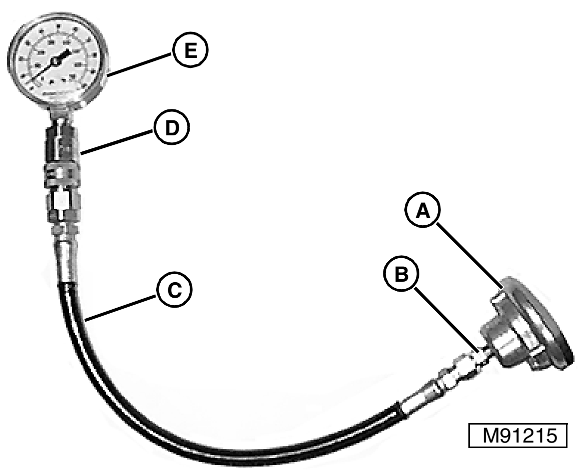
## OIL PRESSURE TEST

**Reason:**

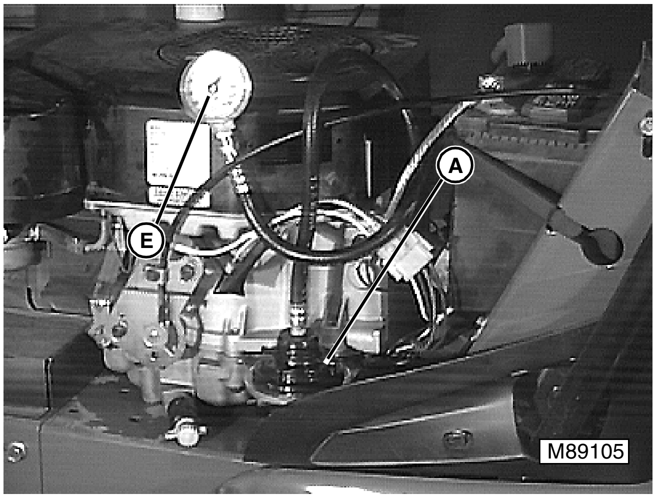
To verify that the engine has enough oil pressure to lubricate the internal engine components.

**Equipment:**

- JT07262 Oil Pressure Test Adapter w/ O-ring (A) (required ONLY on engines without test ports)
- JT05847 Connector (B)
- JT03017 Hose Assembly (C)
- JT03262 Coupler (D)
- JT07034 Gauge, 0 – 700 kPa (0 – 100 psi) (E)




**Procedure:**




*NOTE: The connector, hose assembly, coupler, and gauge are found in other SERVICEGARD™ test kits. The connector pipe thread (NPT) also matches the oil pressure switch port on early Kohler engines.*

**Test Procedure At Oil Filter Base:**

1. Perform test procedure with engine level.
2. Stop engine.
3. Disconnect spark plug wire and allow engine to cool.
4. Drain engine oil from oil filter.
5. Remove oil filter and wipe filter base clean.
6. Install pre-assembled adapter (A), connector, hose assembly, coupler, and gauge (E) on to oil filter base. ONLY hand-tighten adapter to oil filter base.
7. Check crankcase oil level and adjust to full mark.
8. Monitor oil pressure during cranking, if oil pressure is **below 28 kPa (4 psi)—STOP engine immediately** and correct cause before continuing.
9. Connect spark plug wire.
10. Warm-up engine by running at MEDIUM idle for five minutes.

**⚠ CAUTION**

**Engine components are HOT. DO NOT touch with bare skin. Wear protective eye glasses and clothing.**

11. Record oil pressure readings at SLOW and FAST idle.
12. Stop engine and allow to cool.
13. Remove adapter, connector, hose assembly, coupler, and gauge.
14. Install new oil filter.

15. Run engine for 30 seconds and stop engine.
16. Check crankcase oil level and adjust to full mark.

**Results:**

- If oil pressure readings are not within **69 kPa (10.0 psi) – 517 kPa (75.0 psi**) at FAST idle, inspect and/ or replace the following:

–Oil pump assembly. (See “OIL PUMP REMOVAL AND INSTALLATION” on page 47.)

–Oil suction screen.

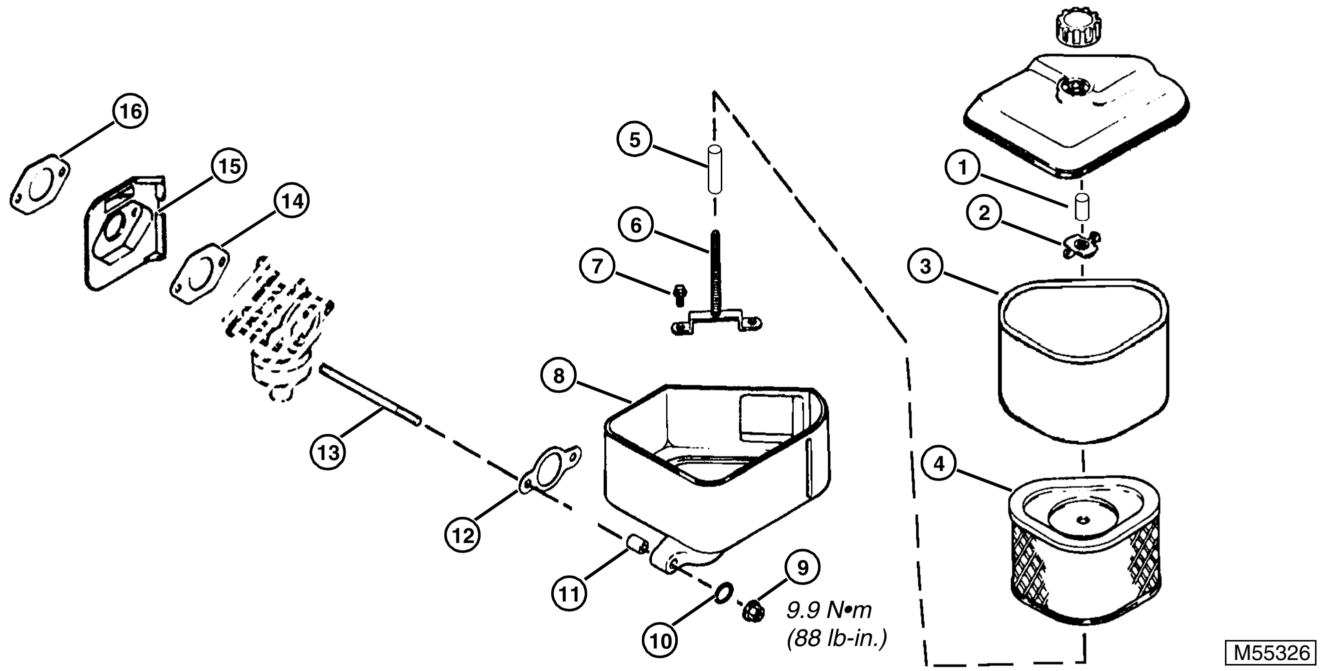
–Oil passages

–Bearing wear

–Oil Seals

# FUEL AND AIR REPAIR

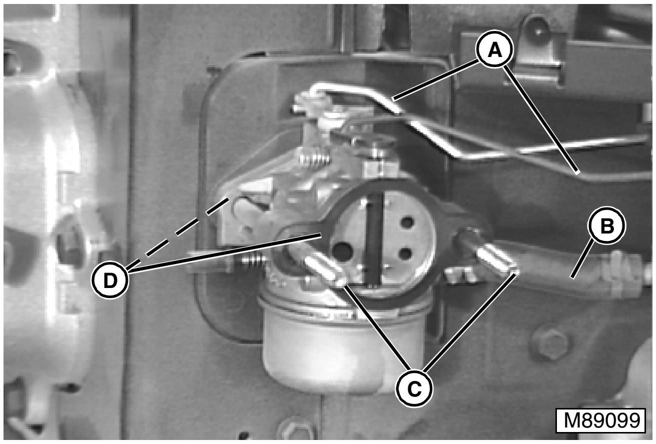
## AIR INTAKE SYSTEM COMPONENTS




| | | | |
|---|---|---|---|
| 1. Rubber Seal | 5. Rubber Seal | 9. Nut | 13. Stud |
| 2. Wing Nut | 6. Stud | 10. Washer[a] | 14. Gasket |
| 3. Foam Element | 7. Retaining Screw | 11. Sleeve | 15. Shield |
| 4. Paper Element | 8. Housing | 12. Gasket | 16. Gasket |

a. Used on stud without electrical eyelet of grounding lead

## CARBURETOR REMOVAL AND INSTALLATION




**⚠ CAUTION**

**Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment; including equipment that utilizes pilot lights. Wipe-up any spills IMMEDIATELY.**

**Procedure:**

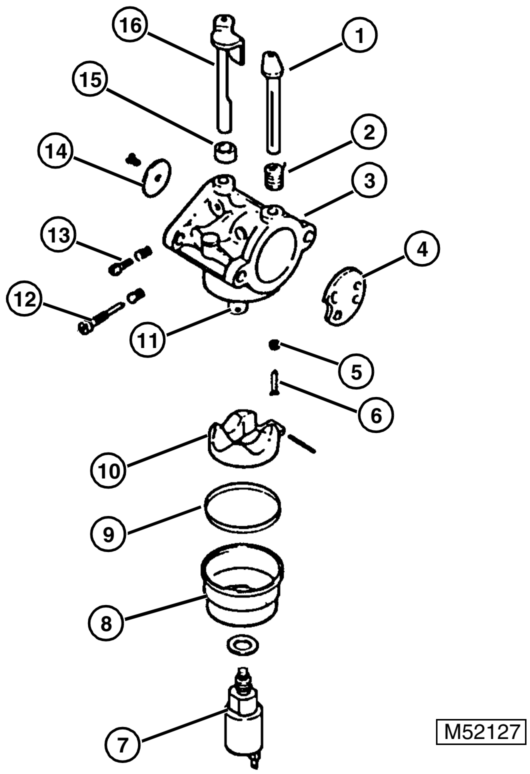
1. Turn ignition switch OFF and disconnect battery negative (–) ground cable.
2. Pinch fuel line (B) to block fuel flow or turn fuel shut-off valve (if equipped) to OFF position, then disconnect fuel line (B) and solenoid wire (if optional fuel shut-off solenoid is installed).
3. Remove air filter assembly (not shown) and carburetor, DO NOT damage threads of studs (C).

4. Disconnect linkage rods (A) from carburetor levers.
5. Remove and discard gaskets (D), install new ones.
6. Connect linkage rods (A) and install carburetor, studs (C), and air filter assembly.
7. Connect solenoid wire (if installed), and fuel line (B)—open fuel line or turn fuel shut-off valve (if installed) to ON position.
8. Adjust carburetor, see Test and Adjustments earlier in this section.

**Specification:**

**Air Filter Assembly Nuts . . . . . . . 9.9 N•m (88 lb-in.)**

## CARBURETOR INSPECTION




| | |
|---|---|
| 1. Choke Shaft | 9. Seal |
| 2. Choke Spring | 10. Float |
| 3. Body | 11. Main Jet |
| 4. Choke Plate | 12. Fuel Screw |
| 5. Inlet Seal | 13. Idle Screw |
| 6. Needle | 14. Throttle Plate |
| 7. Fuel Solenoid (Opt.) | 15. Seal |
| 8. Float Bowl | 16. Throttle Shaft |

**Procedure:**

**CAUTION**

**Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment; including equipment that utilizes pilot lights. Wipe-up any spills IMMEDIATELY.**

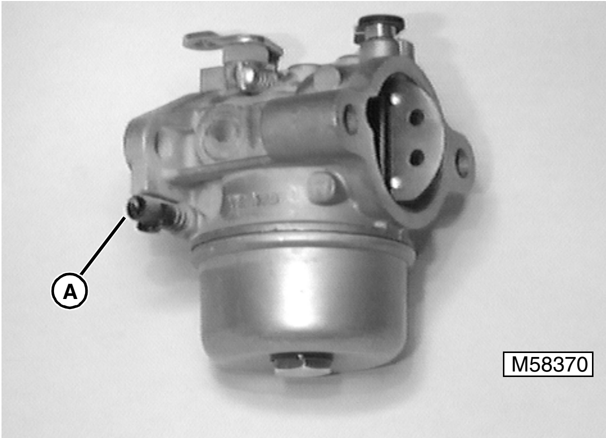
1. Disassemble bowl, float, inlet needle, low idle mixture screw and spring.

**IMPORTANT: Further disassembly of carburetor is not required for general cleaning. Further disassembly will require replacing parts with new parts. DO NOT soak carburetor in carburetor cleaner when fiber, rubber or foam gaskets are still installed. Cleaner may damage these components.**

2. Clean carburetor using pressurized carburetor cleaner and compressed air. Clean out all passages.
3. DO NOT remove idle port welch plug unless absolutely necessary. To remove, pierce with sharp tool. Clean chamber. Install new plug using a flat tool about the same size as plug. Flatten plug but do not force below the surface of the cavity.
4. If inlet seat was leaking or damaged it can be replaced by pulling it out with a drill bit or screw. Always replace with new parts. Press in new seat until it bottoms in bore.
5. If throttle and choke plates were removed, use a high strength thread lock and sealer on the small retaining screws. Install screws slightly loose. Apply pressure on shafts to center plates in bore, then tighten screws.

*NOTE: High altitude jet is available.*

6. Main jet can be pressed out. Replace with new jet. Press new jet in until flush with surface.
7. Low idle mixture screw has a precision taper. If screw is grooved, bent or broken, this may indicate seat damage and carburetor may need to be replaced.
8. On standard carburetors, to set preliminary adjustment for idle mixture screw—**turn clockwise until LIGHTLY seated and back-out (counterclockwise) one full turn**.




New Emissions Carburetor

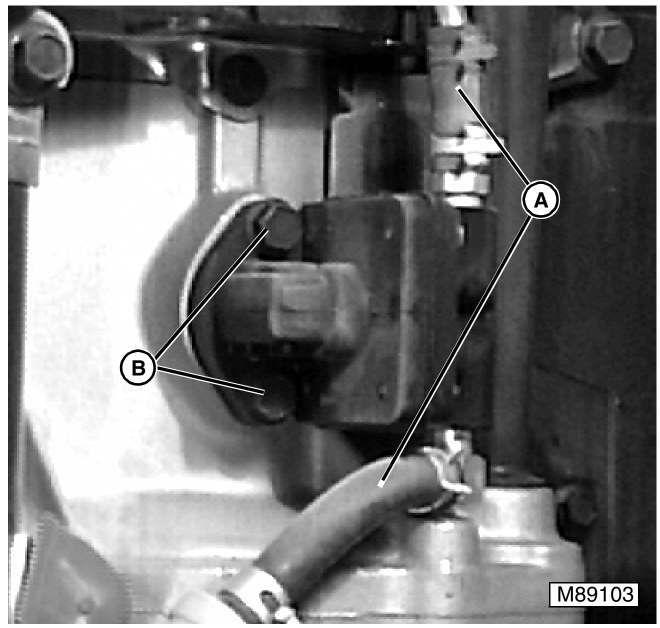
9. On new emissions carburetors, no preliminary adjustment is required for idle mixture screw (A), this is pre-set by manufacturer—**only turn screw (limited to maximum 1/4 turn in either direction) until specified slow idle speed is obtained.**
10. Perform Slow Idle Speed Adjustment. See “SLOW IDLE SPEED ADJUSTMENT” on page 18.

# ENGINE REPAIR

## FUEL PUMP REMOVAL AND INSTALLATION

**Procedure:**

1. Close fuel shut-off (if equipped), or pinch fuel line shut.




2. Disconnect fuel lines (A).
3. Remove bolts (B) from fuel pump.
4. Install components in reverse order of removal.

**Specifications:**

| | |
|---|---|
| **New installation (Thread forming)** | **9.0 N•m (80 lb-in.)** |
| **Replacement** | **7.3 N•m (65 lb-in.)** |

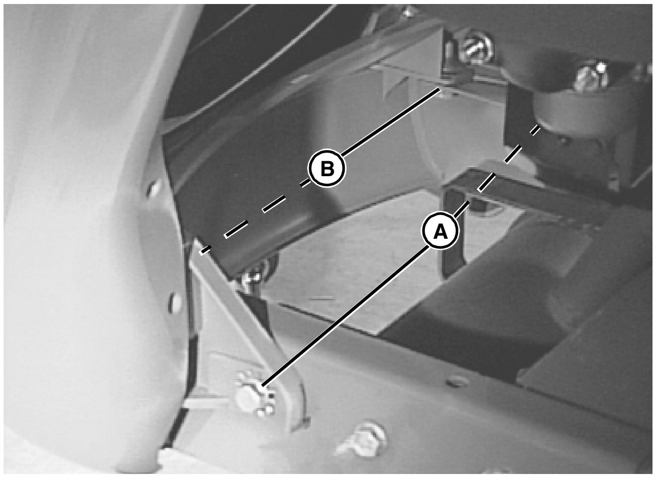
## ENGINE REMOVAL AND INSTALLATION

**Conditions:**

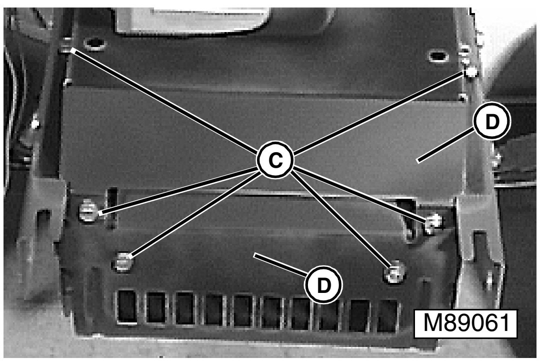
- Machine parked on level surface
- Park brake engaged
- PTO disengaged
- Mower deck removed

**Procedure:**

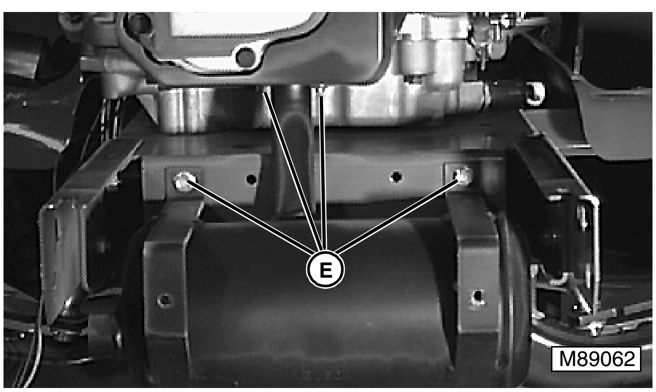
1. Raise hood, disconnect battery, headlight connector, and spark plug lead.




2. Remove two bolts (A) securing the hood to the left and right frame side rails. Loosen the two bolts (B) securing the hood to the upper side of the left and right side rails. Remove hood.



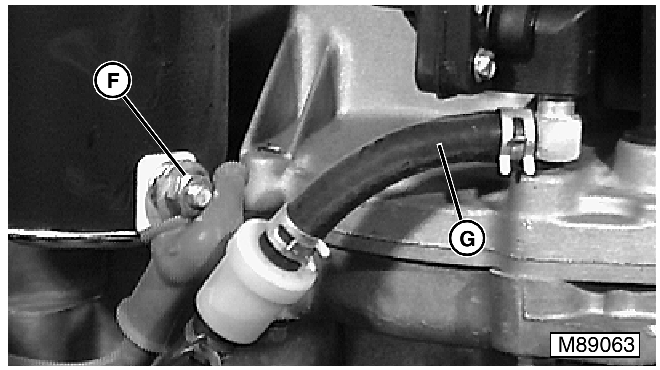

3. Remove six bolts (C) and remove heat shields (D).



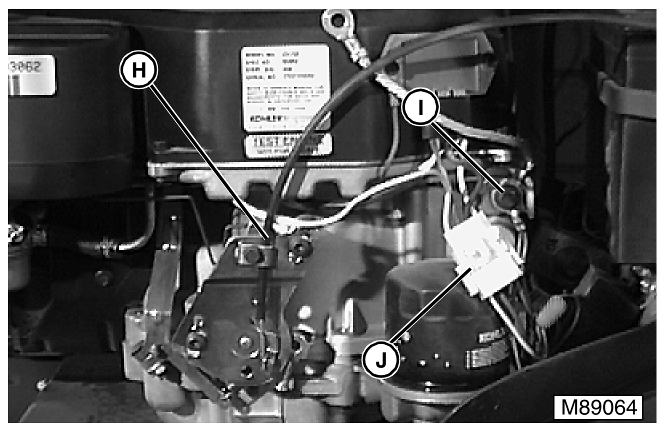

4. Remove muffler, four bolts (E).

## ⚠ CAUTION

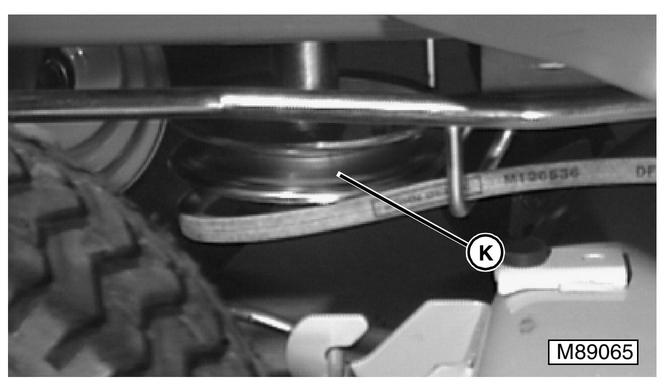
**Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment; including equipment that utilizes pilot lights. Wipe-up any spills IMMEDIATELY.**




5. Disconnect starter lead (F) and fuel line (G).



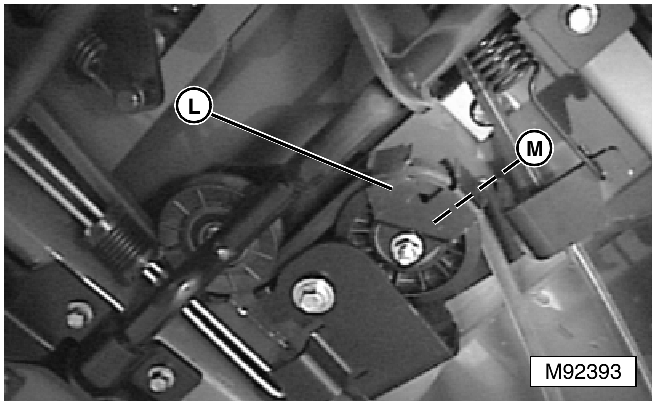

6. Disconnect throttle cable (H) engine ground wires (I) and engine connector (J).



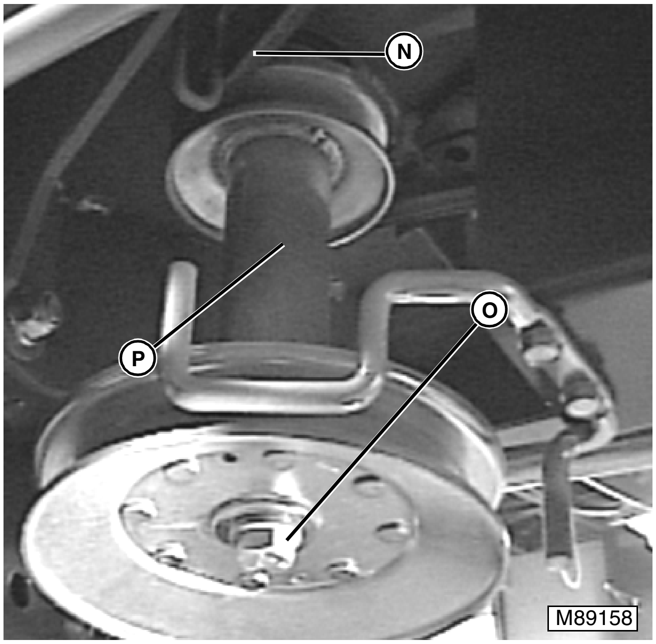
7. Remove mower drive belt (K).

NOTE: *It is not necessary to completely remove drive belt to remove engine.*

.



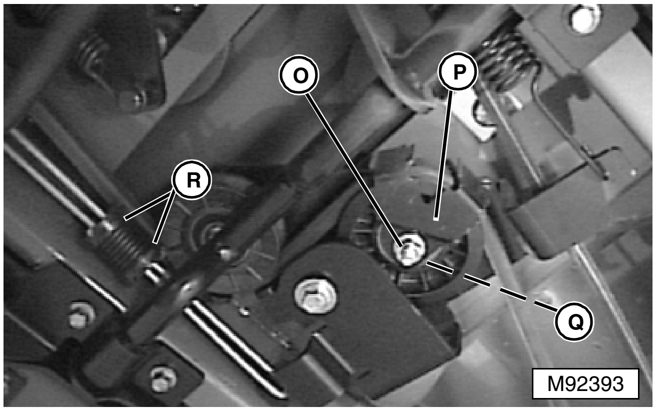

8. Remove belt guide nut and belt guide (L).
9. Loosen idler nut (M) and slide idler forward until belt can be removed from double sheave.



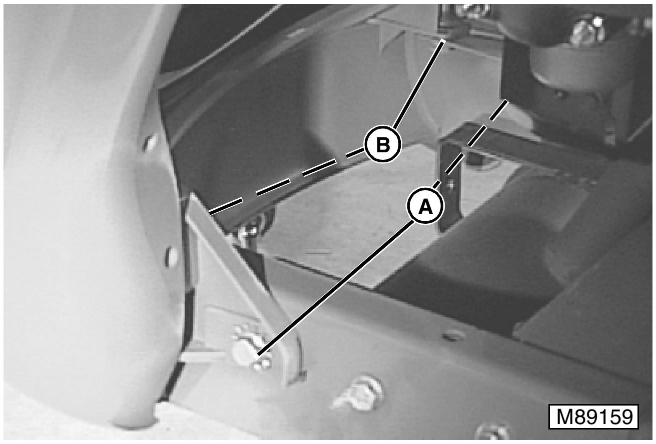

10. Remove engine drive belt (N) from double sheave.
11. Remove sheave nut (O) and double sheave (P).
12. Remove four (4) engine mounting bolts and remove engine.

**Installation:**

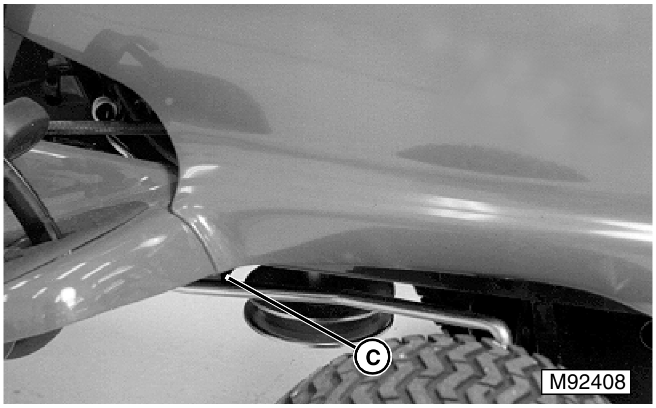
1. Install engine and tighten four (4) engine mounting bolts to **32 N•m (24 lb-ft)**.
2. Install double sheave and drive belt. Tighten to **75 N•m (55 lb-ft)**.




3. Slide belt idler (O) rearward until distance between plastic caps of compression spring (R) is **32.5 mm (1.28 in.)**.
4. Tighten idler nut (Q) to **26 N•m (230 lb-in.)**.
5. Install belt guide (P).
6. Inspect muffler flange for flatness. Install muffler, new gasket, and shield. Tighten muffler bolts to **24.4 N•m (216 lb-in.)**.
7. Connect and adjust throttle cable.
8. Connect fuel line and adjust carburetor.
9. Make all electrical wiring connections, including spark plug lead and battery.




10. Slide hood into position and install bolts (A). Lightly tighten fasteners so that the hood can be moved forward or backward for alignment.

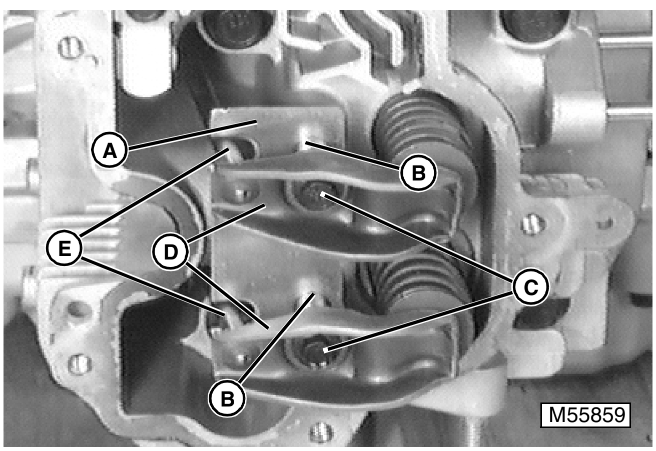



11. Lower hood into the locked position and align hood as shown (C), tighten bolts (B), then raise hood and tighten bolts (A).

## ROCKER ARMS REMOVAL AND INSTALLATION

**Procedure:**

1. Remove valve cover.




**IMPORTANT: Mark push rods for assembly in original locations.**

2. Remove cap screws (C) and pivot ball spacers (B).
3. Remove rocker arms (D).
4. Remove push rods (E).
5. Remove splash plate (A).
6. Inspect and replace components as necessary.
7. Install components in reverse order of removal.

**Specifications:**

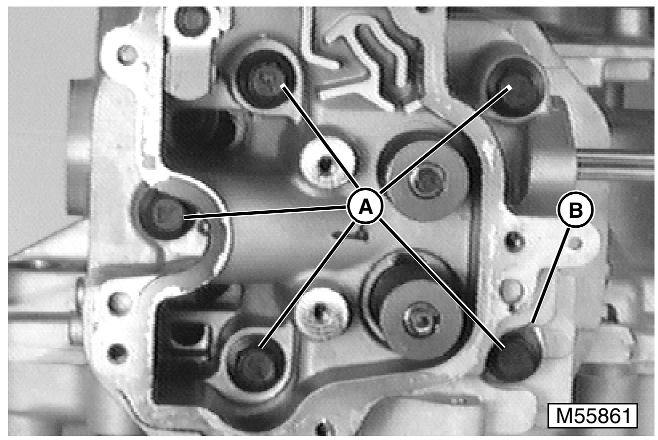
**Rocker Arm Pivot Cap Screws . . 14 N•m (124 lb-in.)**
**Push Rod Bend (maximum) . . . 0.76 mm (0.030 in.)**

## CYLINDER HEAD REMOVAL AND INSTALLATION

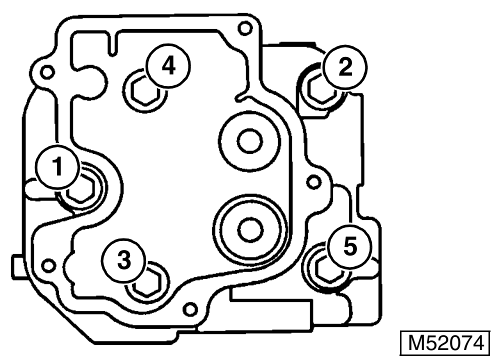
**Procedure:**

**IMPORTANT: Engine must be cold before removing cap screws to avoid warping aluminum cylinder head.**

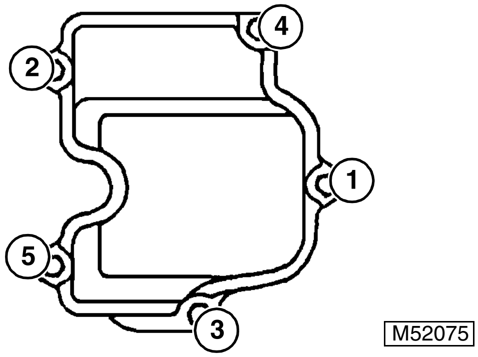
*NOTE: Cylinder head can be serviced without removing engine from tractor.*




1. Remove cap screws (A), spacer (B) and cylinder head. Discard gasket and clean head and block.
2. Install new gasket with cylinder head, cap screws and spacer. Following tube instructions, apply an approved room temperature vulcanizing (RTV) silicone sealant to bottom surface of bolt heads.




3. Tighten cylinder head cap screws in **7 N•m (62 lb-in.)** increments in sequence illustrated, to **41 N•m (30 lb-ft)**.
4. Install push rods and rocker arms.



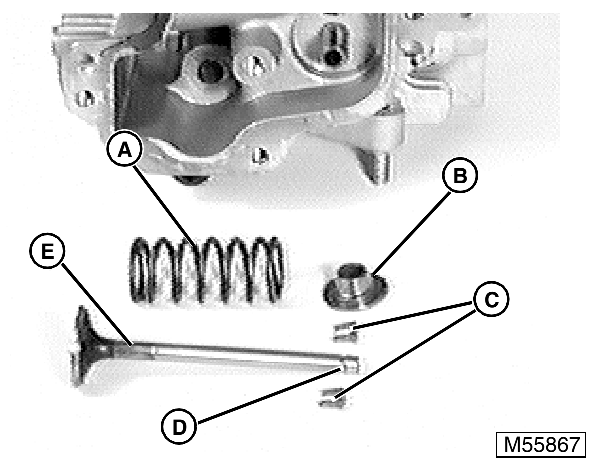

5. Clean valve cover and install using RTV silicone sealant between mating surfaces. Tighten valve cover cap screws, in sequence illustrated.

**Specifications:**

**Cylinder Head Cap Screws . . . . . . . 41 N•m (30 lb-ft)**
**Rocker Arm Pivot Cap Screws . . 14 N•m (124 lb-in.)**
**Valve Cover Cap Screws . . . . . . . 7.3 N•m (65 lb-in.)**

## VALVES AND SPRINGS REMOVAL AND INSTALLATION

**Procedure:**



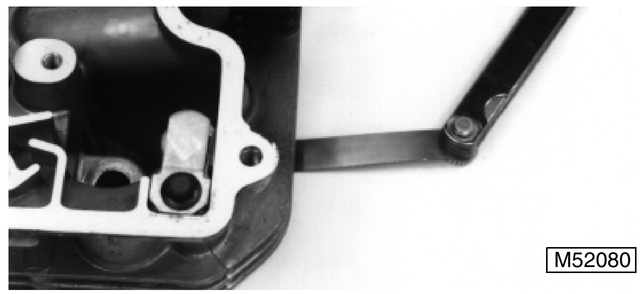

**IMPORTANT: Make sure keepers are seated in valve stem groove (D).**

1. Compress intake and exhaust springs using an appropriate size spring compressor.
2. Remove keepers (C), spring caps (B), springs (A), and valves (E).
3. Install valve components.
4. Compress spring and install keepers in grooves (D).
5. Install rocker arm assembly and cylinder head in reverse order.

## CYLINDER HEAD INSPECTION

**Procedure:**

1. Remove carbon deposits and clean gasket surface with SCOTCH-BRITE® abrasive or equivalent.
2. Inspect head for cracks or damage. Make sure oil drain port is open.




3. Put head on a **flat** surface plate. Check for distortion at several points with a feeler gauge. Replace head if distorted beyond specification.

**Specification:**

**Cylinder Head Warpage (max.) 0.076 mm (0.003 in.)**

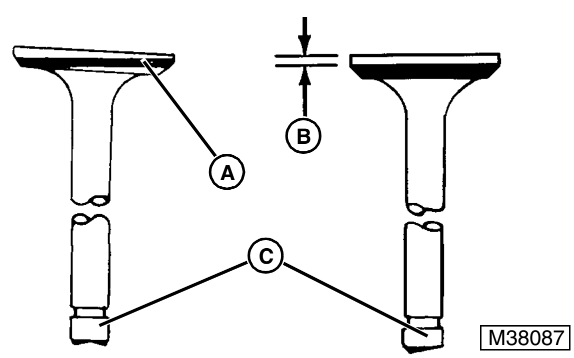
## VALVES INSPECTION

**Special or Required Tools:**

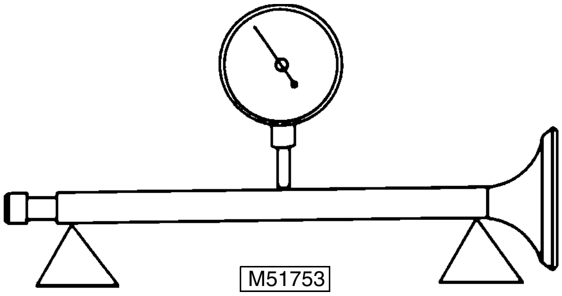
• Dial Indicator

**Procedure:**

1. Remove carbon from valve head, face, and stem.
2. Check valve for cracks or damage.




3. Replace warped valves (A) or valves with less than serviceable margin (B). Valve stem ends (C) should be square, not worn uneven as shown.




4. Inspect valve stems for bends using V-blocks and dial indicator. Turn valve slowly and read variation. Replace if variation is greater than specification.

**Specification:**

**Valve Stem Bend (maximum)**

**. . . . . . . . . . . . . . . . . . . . . . . . . . 0.076 mm (0.003 in.)**

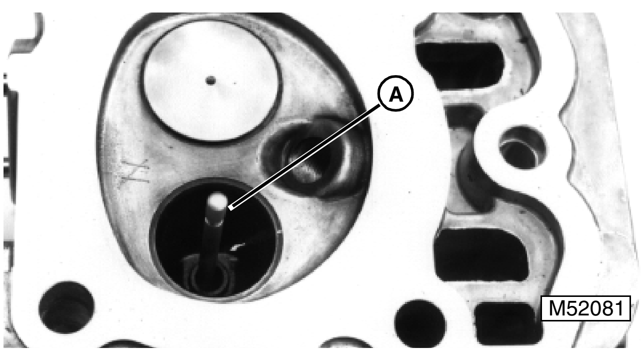
## VALVE GUIDES INSPECTION

**Special or Required Tools:**

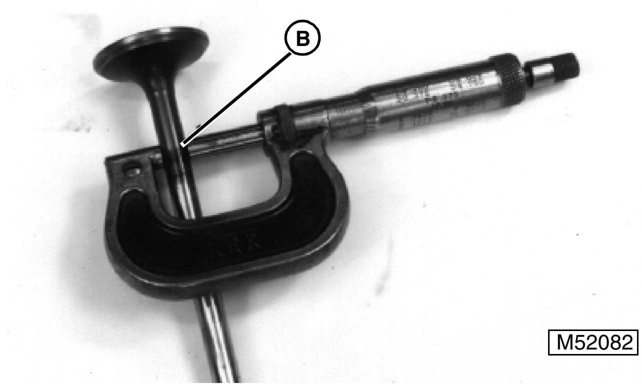
• JDG705 Reaming Tool

**Procedure:**

1. Clean inside of valve guide. Standard valve guide reamer can be used.




2. Measure inside diameter of guide with gauge (A).



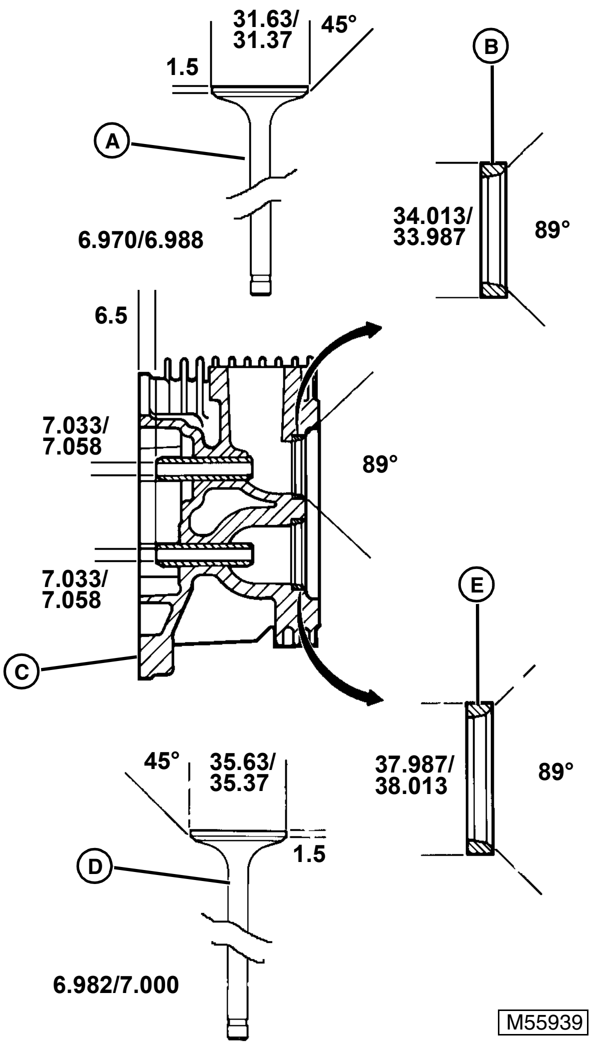

3. Measure outside diameter of valve stem (B).
4. An oversize valve is available. Replace valve if stem-to-guide clearance is too great.

**IMPORTANT: If guide is reamed oversized, an oversize valve must be installed.**

5. Use oversize reaming tool (JDG705) to ream guide, if necessary.
6. Replace cylinder head if inside diameter of guide is greater than oversize specification.

# VALVE SEATS RECONDITION

**Procedure:**




A. Exhaust Valve

B. Exhaust Insert

C. Cylinder Head

D. Intake Valve

E. Intake Insert

1. Inspect valve seats.
2. Replace cylinder head if seats are warped or distorted beyond reconditioning.
3. Reface pitted or worn seats as shown in drawing.
4. Lap valves after refacing
5. Check seat for good contact using Prussian Blue Compound.

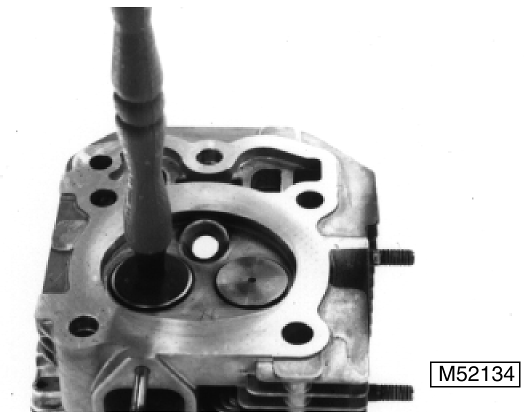
# VALVES LAP

**Special or Required Tools:**

- Lapping Tool

**Procedure:**

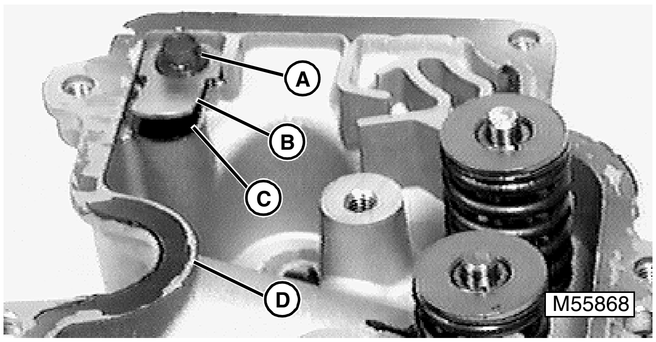
**IMPORTANT: Valves and seats should be lapped if they do not make good contact.**




1. Apply light coat of lapping compound to valve face, then turn valve in seat using vacuum cup tool.
2. Check valve every 8 strokes until a uniform ring appears around surface of valve face.
3. Wash parts in solvent to remove lapping compound.
4. Check position of lap mark on face–lap mark must be on or near center of valve face.

# BREATHER INSPECTION

**Procedure:**

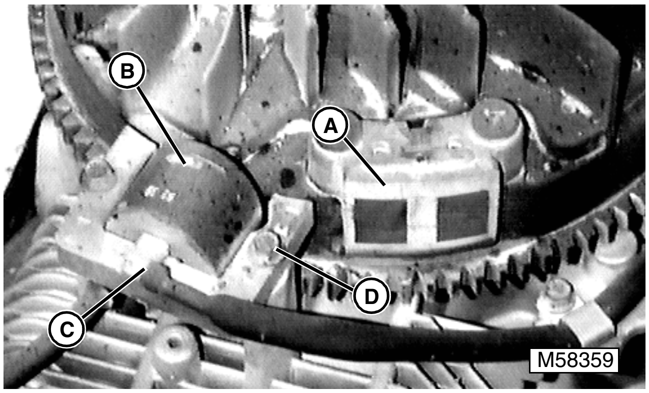



1. Remove cap screw (A), plate (B), and reed (C).
2. Check that breather opening is clear.
3. Replace reed if it does not lie flat on casting.
4. Clean mating surface of any sealant residue (D).

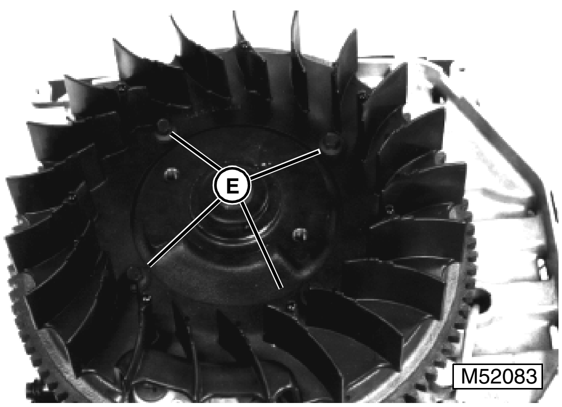
# FLYWHEEL REMOVAL AND INSTALLATION

**Removal:**

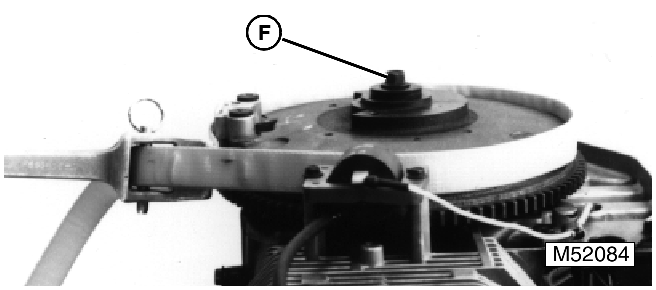
1. Remove blower housing sheet metal.



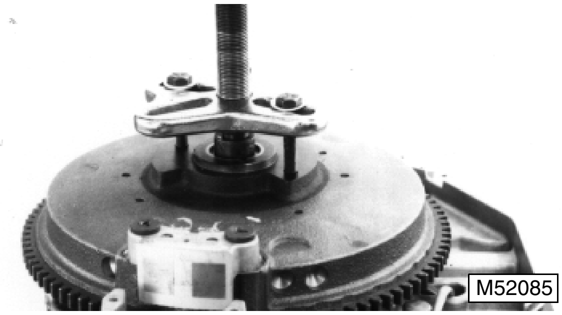

1. Turn flywheel magnet (A) away from ignition module (B).
2. Disconnect wire (C) from terminal.
3. Remove cap screws (D) and ignition module.




4. Remove four fan cap screws and washers (B) and fan.




5. Hold flywheel with strap wrench. Remove cap screw (F).




6. Remove flywheel using a puller.

*NOTE: Flywheel and magnets are not serviceable.*

7. Inspect flywheel for cracks, chips, and broken teeth. Replace as necessary.
8. Inspect for sheared or partially sheared key, replace as necessary.

**IMPORTANT: Check that crankshaft end and flywheel hub are clean and free of lubricant, and flywheel key is installed properly in keyway. Improperly installed flywheel can cause machine damage and serious personal injury.**

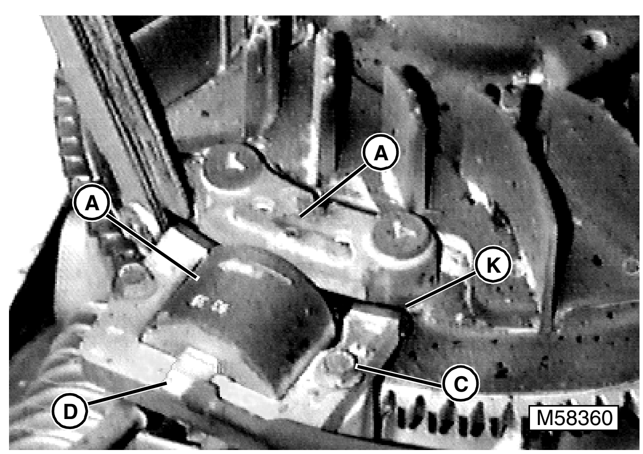
**Installation:**

1. Install flywheel and key on crankshaft. Install flywheel.
2. Hold flywheel with strap wrench. Install cap screw and tighten to specification.

**Specification:**

**Flywheel Cap Screw. . . . . . . . . . . . 68 N•m (50 lb-ft.)**

3. Rotate magnet away from module mount. Install module loosely.



4. Align flywheel magnet (A) with mounting posts for ignition module.
5. Place **0.2 – 0.3 mm (0.008 – 0.012 in.)** feeler gauge blade (K) or shim stock across magnet face.

**IMPORTANT: Ensure flywheel magnet (B) is centered on ignition module (A) so all three poles of the ignition module are properly gapped from the flywheel magnet.**

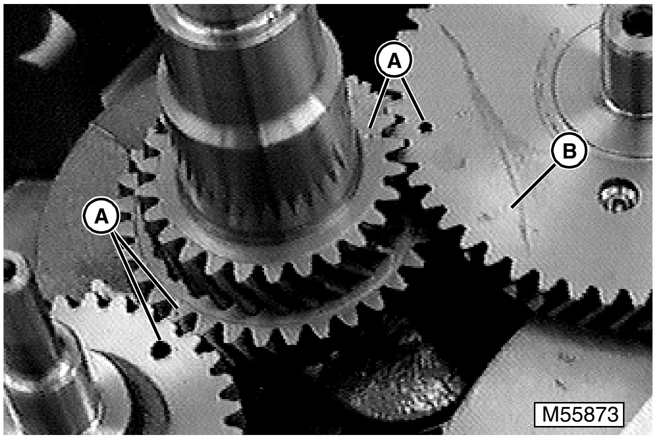
6. Slide ignition module (A) against feeler gauge so all three poles mate with the feeler gauge blade (K).
7. Tighten the ignition module capscrews to **5.1 N•m (45 lb-in.)**.
8. Remove feeler gauge and connect wire (D) to terminal.

**Specifications:**

**Ignition module air gap**
**. . . . . . . . . . . . . . . 0.2 – 0.3 mm (0.008 – 0.012 in.)**
**Module cap screws . . . . . . . . . . . 5.1 N•m (45 lb-in.)**

## CAMSHAFT REMOVAL AND INSTALLATION

**Procedure:**



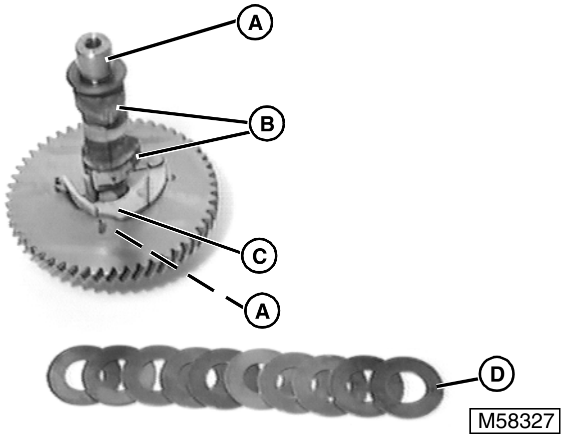

1. Rotate crankshaft to align two sets of marks (A).
2. Remove camshaft (B).
3. Inspect camshaft closely, replace as necessary.
4. Coat entire camshaft with engine oil.
5. Install camshaft with four timing marks (A) aligned.
6. Check camshaft end play.
7. If not within specification, use appropriate shims from Camshaft Shim Kit (D), shown in photo M58327.
8. Align flat surface of balancer shaft with bore flat of oil pump inner rotor gear as you install oil pan.
9. Install push rods, rocker arm assembly, and valve cover, see those procedures earlier in this section.

**Specification:**

**Camshaft**
**End Play . . . . . 0.076 – 0.127 mm (0.003 – 0.005 in.)**

## CAMSHAFT INSPECTION

**Procedure:**

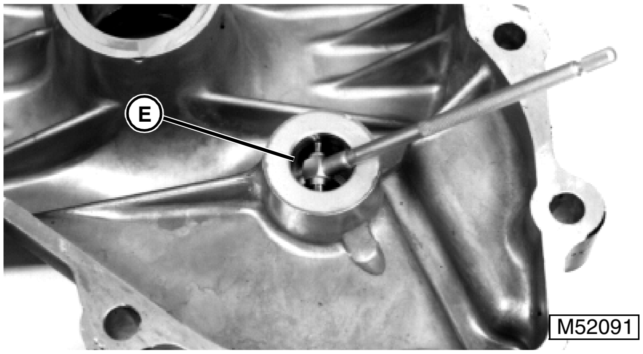



1. Inspect steel gear camshaft for worn or broken teeth.
2. Measure journals (A) at both ends. Replace camshaft if measurements do not meet specifications.

**Camshaft Journal Specifications:**

**OD (New). 19.962 – 19.975 mm (0.7859 – 0.78.64 in.)**
**OD (Max. Wear Limit) . . . . . . 19.959 mm (0.7858 in.)**

3. Inspect lobes (B). Replace camshaft if lobes show excessive wear.
4. Inspect ACR mechanism (C). Replace spring if necessary and check that weight moves freely.

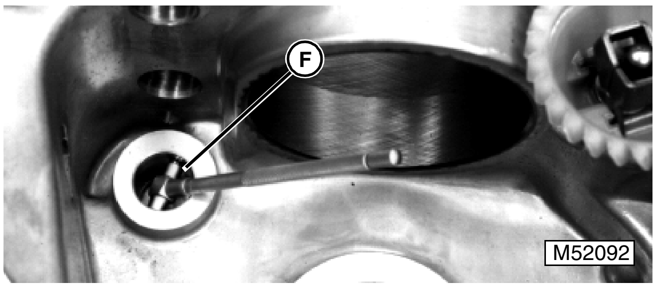



5. Measure camshaft bore (E) in oil pan.

6. Subtract journal OD. from bore ID. to determine clearance with camshaft journal. Replace if not within specifications.

**Camshaft Bearing Bore Specifications:**

**Oil Pan Camshaft Bore**
**(New): . . . 20.000 – 20.025 mm (0.7874 – 0.7844 in.)**
**(Max. Wear Limit) . . . . . . . . . 20.038 mm (0.7889 in.)**
**Camshaft to Bore**
**Clearance . . 0.025 – 0.063 mm (0.0010 – 0.0025 in.)**




7. Measure camshaft bore (F) in crankcase.
8. Subtract journal OD. from bore ID. to determine clearance with camshaft journal. Replace if not within specification.

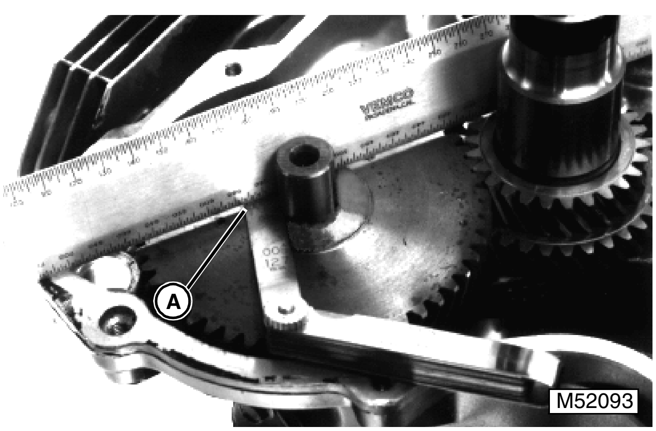
**Camshaft Bearing Bore Specifications:**

**Crankcase Camshaft Bore**
**(New) . . . . 20.000 – 20.025 mm (0.7874 – 0.7844 in.)**
**(Max. Wear Limit) . . . . . . . . . 20.038 mm (0.7889 in.)**
**Camshaft to Bore**
**Clearance . . 0.025 – 0.063 mm (0.0010 – 0.0025 in.)**

## CAMSHAFT END PLAY MEASUREMENT

**Procedure:**

1. Check that camshaft is seated in crankcase bore.




2. Measure play (A) between camshaft and straight edge (spanning crankcase) using flat feeler gauge.
3. Use shims from Shim Kit (D) as necessary until end play is within specification.

**Camshaft End Play Specification:**

**Maximum (with shims)**
**. . . . . . . . . . . . . 0.076 – 0.127 mm (0.003 – 0.005 in.)**

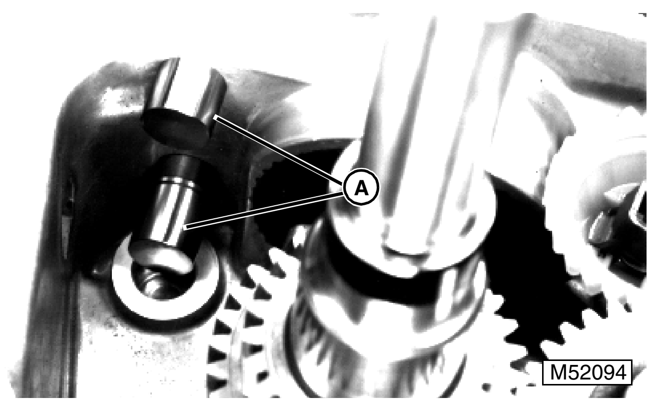
**Shim Thickness Range:**
**White . . . . . . 0.692 – 0.730 mm (0.0273 – 0.0288 in.)**
**Blue . . . . . . . 0.743 – 0.781 mm (0.0293 – 0.0308 in.)**
**Red . . . . . . . 0.794 – 0.832 mm (0.0313 – 0.0328 in.)**
**Yellow . . . . . 0.845 – 0.883 mm (0.0333 – 0.0348 in.)**
**Green. . . . . . 0.895 – 0.994 mm (0.0352 – 0.0368 in.)**
**Gray. . . . . . . 0.946 – 0.984 mm (0.0373 – 0.0388 in.)**
**Black . . . . . . 0.997 – 1.035 mm (0.0393 – 0.0408 in.)**

## HYDRAULIC VALVE LIFTERS REMOVAL/INSTALLATION

**Procedure:**

1. Remove camshaft.

**IMPORTANT: Used lifters are mated to their camshaft lobes. Mark them for installation in the correct bore.**

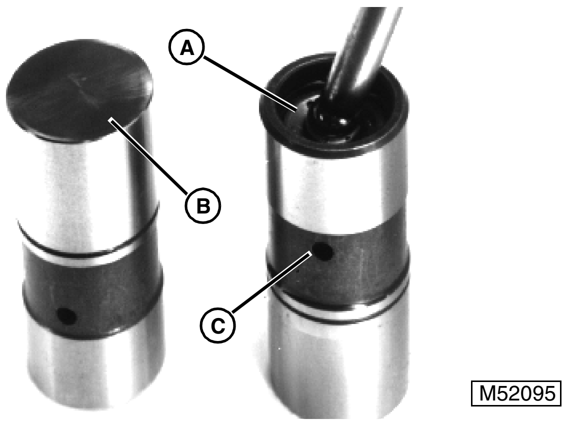



2. Remove lifters (A).
3. Inspect lifters for wear, replace as necessary.
4. Coat lifters with engine oil and install in correct bore.
5. Install camshaft.

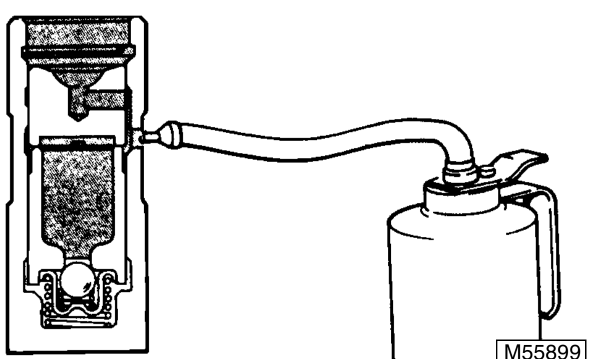
# HYDRAULIC VALVE LIFTERS INSPECTION

**Procedure:**

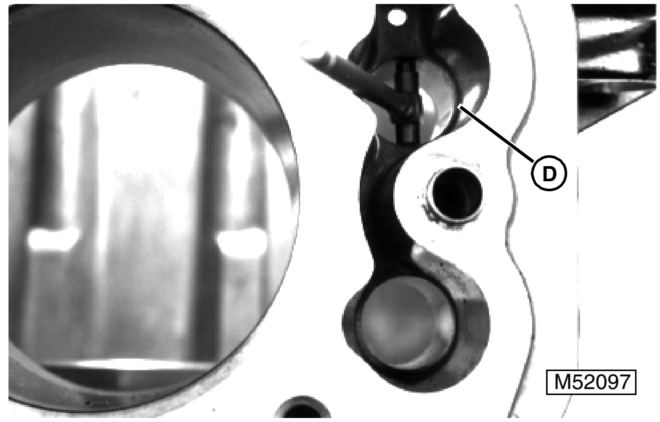
**IMPORTANT: Damaged or worn lifters usually indicate a damaged camshaft. Check camshaft before replacing lifters.**




1. Inspect lifter face (B) for wear. Face should be flat and smooth.
2. Use push rod to depress plunger (A). Plunger should offer resistance but move smoothly.
3. Check that oil hole (C) is clear to inner piston.
4. Measure outside diameter of lifter.
5. Replace lifters that are worn or damaged.




*NOTE: When installing new lifters, make sure lifters are full of oil. Submerse lifters in oil and use old push rod to pump lifter several times to purge air and fill with oil, or force oil into lifter with oil can (shown above), until lifter feels solid. Reassemble engine and allow 10 minutes for lifters to bleed down. Crank engine over by hand and check for compression. If no compression exists or engine cannot be turned, lifters have not bled down, and may have trapped air inside. Wait 10 minutes more to allow lifters to bleed down.*



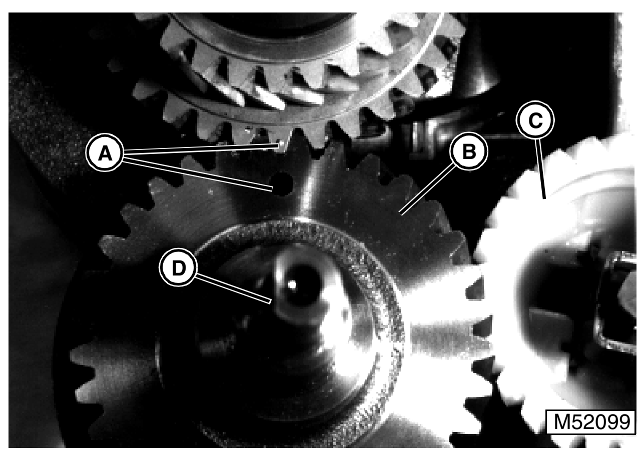

6. Measure inside diameter of crankcase lifter bore (D).
7. Subtract lifter OD from bore ID to determine if clearance is not within specification. Replace components as necessary.

**Specification:**

**Valve Lifter to Bore Clearance (maximum)**
**. . . . . . . 0.0124 – 0.0501 mm (0.0005 – 0.0020 in.)**

# BALANCER SHAFT REMOVAL AND INSTALLATION

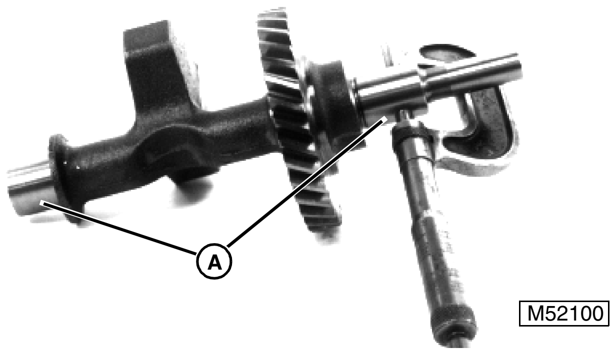
**Procedure:**




1. Align marks (A) on balancer shaft and crankshaft.
2. Remove balancer shaft (B).
3. Inspect balancer shaft, replace as necessary.
4. Align marks (A) and install balancer shaft (B) so it also aligns with governor gear (C).
5. Remember, when installing oil pan, be sure to align flat (D) of balancer shaft with bore flat of oil pump inner rotor gear.

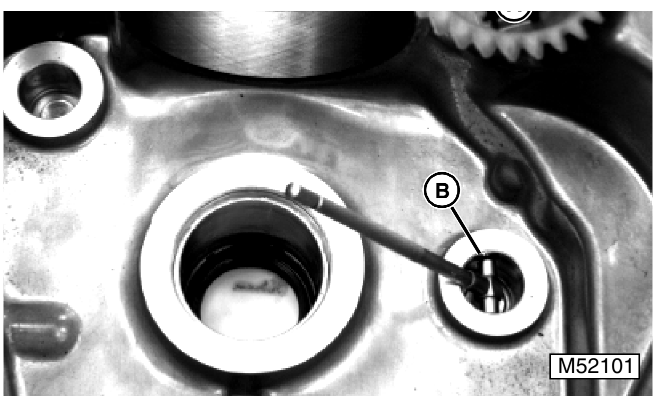
# BALANCER SHAFT INSPECTION

**Procedure:**




1. Inspect shaft for cracks and broken teeth. Replace shaft if cracked or damaged.
2. Measure journals (A). Replace if not within specification.

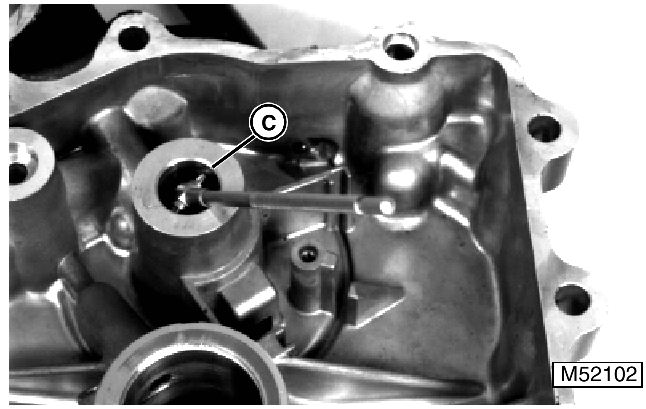
**Balancer Shaft Journal OD Specifications**
**New . . . . . 19.962 – 19.975 mm (0.7859 – 0.7864 in.)**
**Minimum . . . . . . . . . . . . . . . . 19.959 mm (0.7858 in.)**




3. Measure balancer shaft bore (B) in crankcase.
4. Subtract journal OD from bore ID to determine clearance with balancer shaft journal. Replace crankcase if measurements are not within specifications.

**Balancer Shaft Crankcase Bore Specifications:**
**ID (New). . 20.000 – 20.025 mm (0.7874 – 0.7884 in.)**
**Wear Limit. . . . . . . . . . . . . . . 20.038 mm (0.7889 in.)**

**Balancer Shaft to Crankcase Bore Clearance . . . . . . . . . . . . . . . 0.025 – 0.063 mm (0.0009 – 0.0025 in.)**



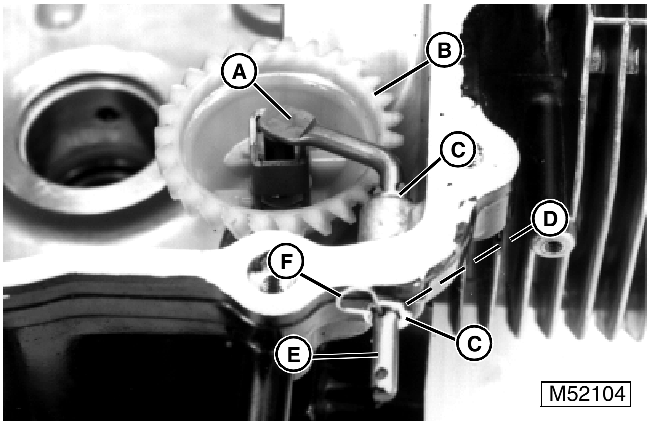

5. Measure balancer shaft bore (C) in oil pan.
6. Determine clearance with balancer shaft journal. Replace oil pan if measurements not within specifications.

**Balancer Shaft Oil Pan Bore Specifications:**
**ID (New). . 20.000 – 20.025 mm (0.7874 – 0.7884 in.)**
**Maximum. . . . . . . . . . . . . . . . 20.038 mm (0.7889 in.)**

**Balancer Shaft to Crankcase Bore Clearance . . . . . . . . . . . . . . . 0.025 – 0.063 mm (0.0009 – 0.0025 in.)**

# GOVERNOR REMOVAL AND INSTALLATION

**Procedure:**




1. Remove governor lever (not shown) from end of control arm (E).
2. Remove spring clip (F), washers (C), and governor control arm (A) from inside of crankcase.
3. Remove and discard seal (D).

*NOTE: Check governor shaft/gear assembly, if plastic gear, flyweight assembly, flyweight cap, and/or shaft are damaged, the complete assembly must be replaced.*

4. Inspect governor shaft/gear assembly (B), replace as necessary (see Replace Governor Shaft/Gear Assembly, later in this group).
5. Install governor shaft/gear assembly.
6. Install new seal (D) using suitable driver.
7. Install control arm, washers, and clip.
8. Install lever (not shown).

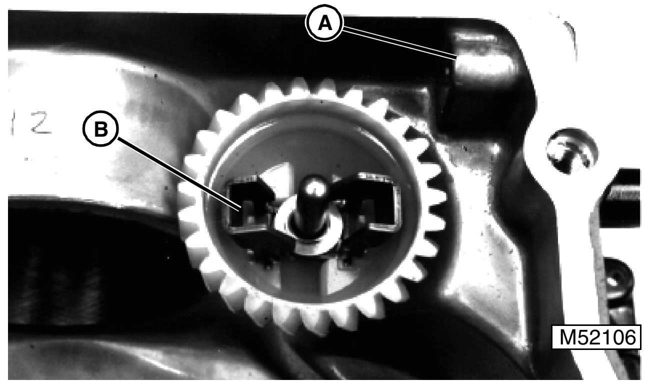
# GOVERNOR INSPECTION

**Procedure:**


1. Measure outside diameter of control arm shaft. Replace if not within specification.

**Governor Control Arm Specifications**

**OD (New) . . . 5.975 – 6.000 mm (0.2352 – 0.2362 in.)**
**Wear Limit . . . . . . . . . . . . . . . . 5.962 mm (0.2347 in.)**




2. Measure inside diameter of crankcase bore (A).

**Governor Control Arm Crankcase Bore Specs**

**ID (New) . . . . 6.025 – 6.050 mm (0.2372 – 0.2382 in.)**
**Maximum . . . . . . . . . . . . . . . . . 6.063 mm (0.2387 in.)**

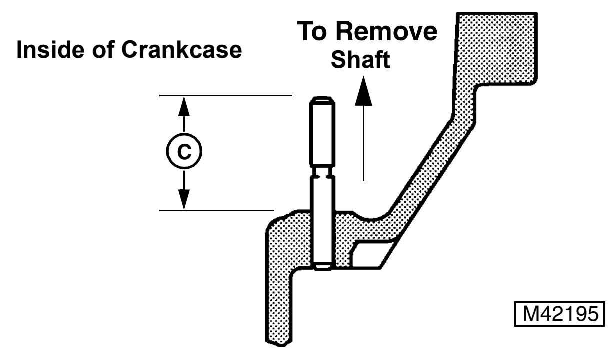
3. Determine governor control arm shaft-to-bore clearance. Replace governor shaft/gear assembly as necessary.

**Governor Control Arm-to-Crankcase Bore Spec**

**Clearance . . 0.025 – 0.075 mm (0.0010 – 0.0030 in.)**

4. Inspect flyweights (B) for proper operation and free movement. Replace governor shaft/gear assembly as necessary.

**IMPORTANT: DO NOT remove governor shaft with vise-grips or pliers, damage to case may result.**




5. With a small punch, CAREFULLY drive governor shaft toward inside of crankcase to remove it.
6. From inside of crankcase, install new governor shaft/gear assembly by pressing or lightly tapping shaft into crankcase bore to specified height (C).

**Governor Gear Shaft Specifications:**

**Height (C) . . 32.639 – 32.842 mm (1.285 – 1.293 in.)**
**Diameter (New). . . . . . . . . . . . . . . . . . . . . . . . . . . . . .**
**. . . . . . . . . 5.990 – 6.000 mm (0.2358 – 0.2362 in.)**
**Diameter (Minimum). . . . . . . . 5.977 mm (0.2353 in.)**

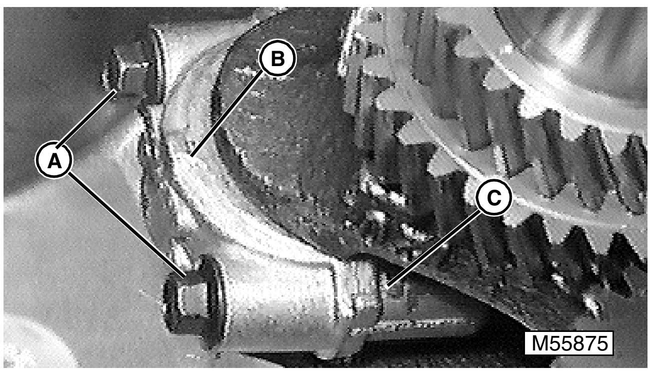
# PISTON ASSEMBLY REMOVAL

**Procedure:**

1. Remove balance shaft, and camshaft.

**IMPORTANT: Remove carbon ridge, if present, from cylinder before removing piston.**

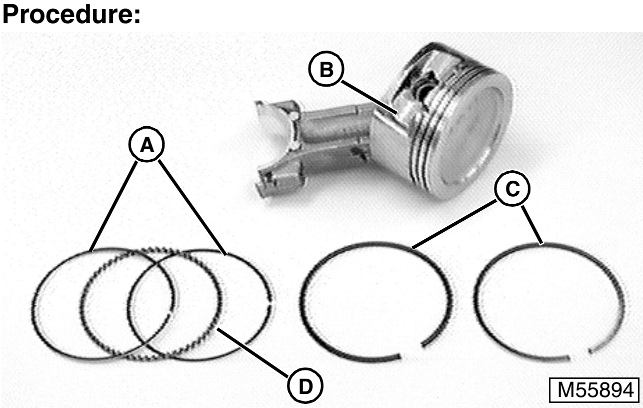
2. Remove carbon ridge, if present at top of cylinder, using a ridge reamer.



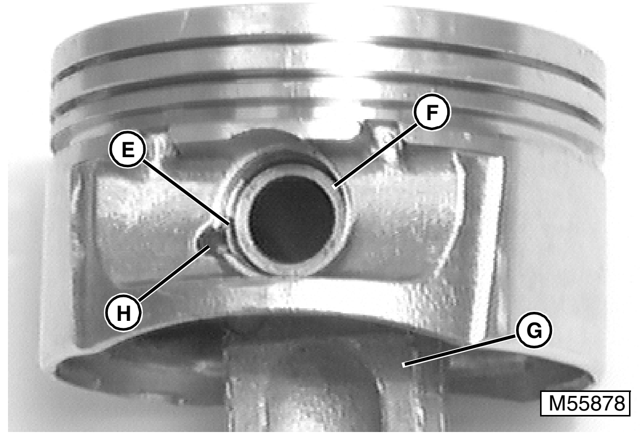

3. Remove cap screws (A) to remove cap (B) from connecting rod (C).
4. Remove piston assembly through top of cylinder.
5. Inspect piston assembly, see following two topics.

# PISTON ASSEMBLY DISASSEMBLE

**Procedure:**




1. Remove compression rings (C) from piston (B) using ring expander.
2. Remove rails (A).
3. Remove spacer (D).

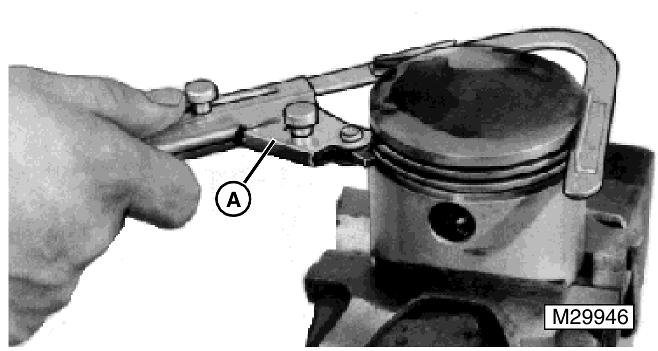



4. Remove retaining rings (E) by prying at indent (H).
5. Use wooden dowel to remove pin (F) from piston and connecting rod (G).
6. Inspect parts.

# PISTON INSPECTION

**Procedure:**

1. Carefully remove piston rings.




**IMPORTANT: Do not use caustic cleaners or wire brush to clean aluminum piston. Piston damage can result.**

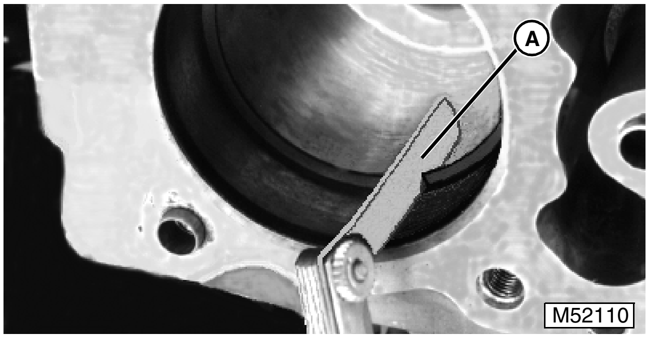
2. Clean piston. Inspect for scoring or fractures.
3. Clean carbon from grooves using ring groove tool (A).

## PISTON RING END GAP MEASUREMENT

**Procedure:**

**IMPORTANT: If new rings are to be installed, deglaze cylinder so rings will seat properly. (See Deglaze Cylinder Bore, later in this section.)**

1. Use a clean or new piston to push piston compression ring squarely into bore, to a point where it normally runs.



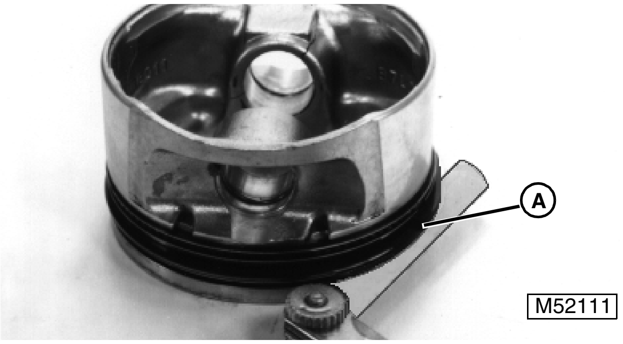

2. Measure end gap (A).
3. Remove ring and file ends squarely until gap meets specification. Rings with too large a gap must be replaced. If one piston ring needs replaced, all must be replaced as a set.

**Specifications:**

**Piston Ring End Gap (New Bore):**
**. . . . . . . . . . . . . 0.27 – 0.51 mm (0.010 – 0.020 in.)**
**Piston Ring End Gap (Used Bore) (Max):**
**. . . . . . . . . . . . . . . . . . . . . . . . 0.77 mm (0.030 in.)**

## PISTON RING SIDE CLEARANCE MEASUREMENT

**Procedure:**




1. Measure piston ring side clearance (A) as shown at several points around piston.
2. Replace piston if measurements exceed clearance specifications.

**Specifications:**

**Piston Ring-To-Groove Side Clearance**

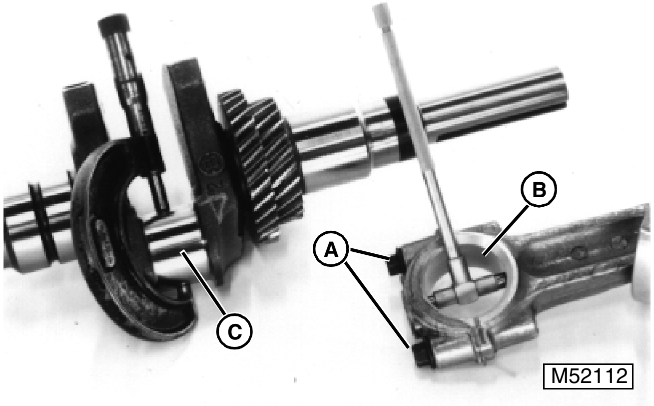
**Top Compression Ring**
**. . . . . . . . . 0.060 – 0.105 mm (0.0023 – 0.0041 in.)**

**Middle Compression Ring**
**. . . . . . . . . 0.040 – 0.085 mm (0.0015 – 0.0033 in.)**

**Oil Control Ring**
**. . . . . . . . . 0.176 – 0.026 mm (0.0069 – 0.0010 in.)**

## PISTON ASSEMBLY MEASUREMENT

**Procedure:**




*NOTE: Connecting rod is available 0.25 mm (0.010 in.) undersize.*

1. Tighten cap screws (A) to specification.
2. Measure inside diameter of connecting rod (B).
3. Measure outside diameter of crankshaft journal (C).
4. Determine connecting rod-to-crankshaft clearance.

Replace parts that are not within specifications.

**Crankshaft Specifications:**

**Connecting Rod Journal OD**
**New . . . 38.958 – 38.970 mm (1.5338 – 1.5343 in.)**
**Wear Limit. . . . . . . . . . . . . . 38.94 mm (1.5328 in.)**
**Taper (maximum) . . . . . . . . 0.012 mm (0.0005 in.)**
**Out-Of-Round (max). . . . . . 0.025 mm (0.0010 in.)**

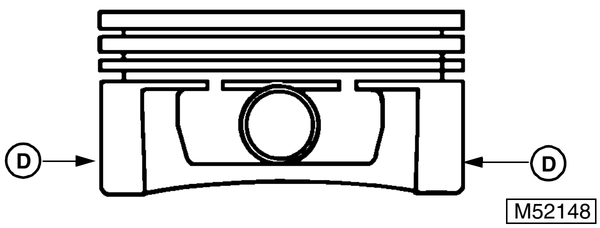
**Crankshaft-to-Connecting Rod Clearance**
**New . . . . . 0.030 – 0.055 mm (0.0012 – 0.0022 in.)**
**Maximum. . . . . . . . . . . . . . . . 0.07 mm (0.0025 in.)**

**Connecting Rod Specifications:**

**Piston Pin End ID**
**New . . . 19.015 – 19.023 mm (0.7486 – 0.7489 in.)**
**Maximum. . . . . . . . . . . . . . 19.036 mm (0.7495 in.)**

**Piston Pin OD.**
**New . . . . 18.995 – 19.00 mm (0.7478 – 0.7480 in.)**
**Minimum . . . . . . . . . . . . . 18.994 mm (0.74779 in.)**

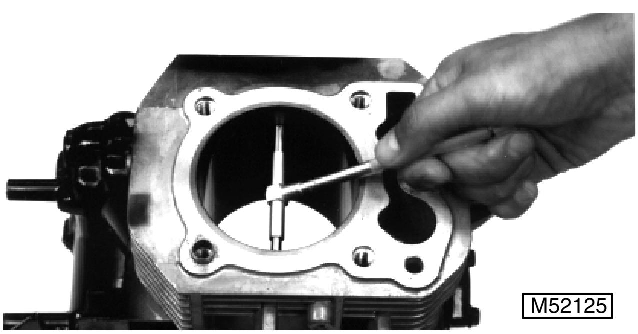
**Connecting Rod Cap Screws Torque:**
**8 mm Straight Shank . . . . . . 22.6 N•m (200 lb-in.)**
**Step Down Shank. . . . . . . . . 14.6 N•m (130 lb-in.)**
**6 mm Straight Shank . . . . . . 11.3 N•m (100 lb-in.)**




5. Measure diameter of piston at a point (D), **6 mm (0.25 in.)** from skirt bottom and perpendicular to piston pin.

**Specifications:**

**Piston Thrust Face OD**
**New . . . 89.951 – 89.969 mm (3.5413 – 3.5420 in.)**
**Minimum . . . . . . . . . . . . . . 89.824 mm (3.5363 in.)**




6. Measure cylinder bore.
7. Replace piston and/or rebore cylinder block if not within specifications.

**Piston Specifications:**

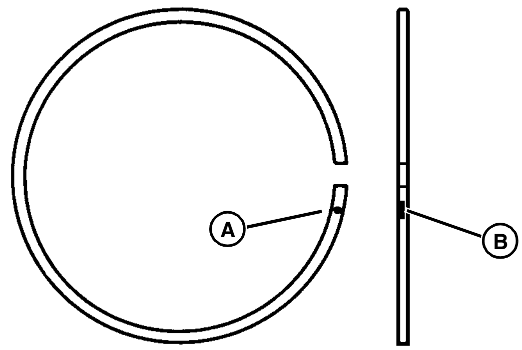
**Thrust Face to Cylinder Bore Clearance**
**New . . . . . 0.031 – 0.043 mm (0.0012 – 0.0016 in.)**

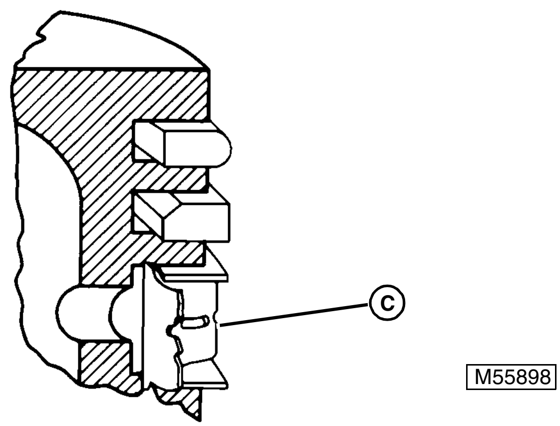
**Piston Pin Bore ID**
**New . . . 19.006 – 19.012 mm (0.7483 – 0.7485 in.)**
**Maximum. . . . . . . . . . . . . . 19.025 mm (0.7490 in.)**

# PISTON ASSEMBLY

**Procedure:**

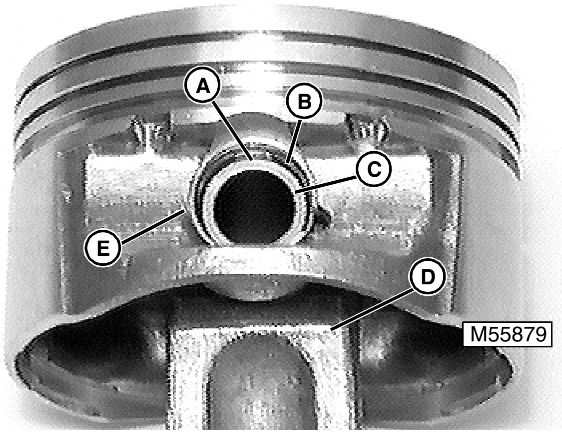
**IMPORTANT: Side of ring marked TOP faces top of piston with Dykem stripe to left of end gap. Top compression ring has a blue Dykem stripe. Bottom compression ring has a pink Dykem stripe.**




1. Install rings as shown on piston using ring expander.
- Compression ring gaps should be staggered 120°
- Note shape of compression rings and install as shown
- Compression rings should be installed with “Pip” mark (A) up and Dykem strip (B) to left of ring gap
- Install oil ring spacer (C) first. Make sure that its ends do not overlap
- Stagger end gasp of oil rails 180° apart
- Rings should turn freely in grooves

*NOTE: Install piston pin before retaining ring to prevent possible scoring of bore.*




**IMPORTANT: Retaining rings (B) should be installed with end gap (A) pointing up.**

2. Install one piston pin retaining ring (B) in groove of piston bore (E).
3. Install pin (C) through piston bore (E) and connecting rod (D). Pin should install easily with thumb pressure.
4. Install remaining retaining ring (B) in opposite side.

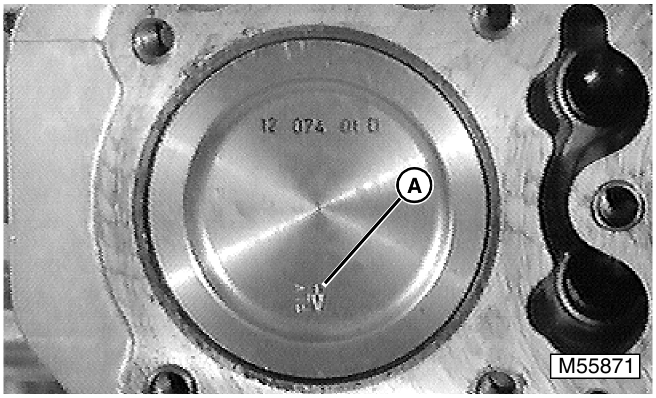
## PISTON INSTALLATION

**Special or Required Tools:**

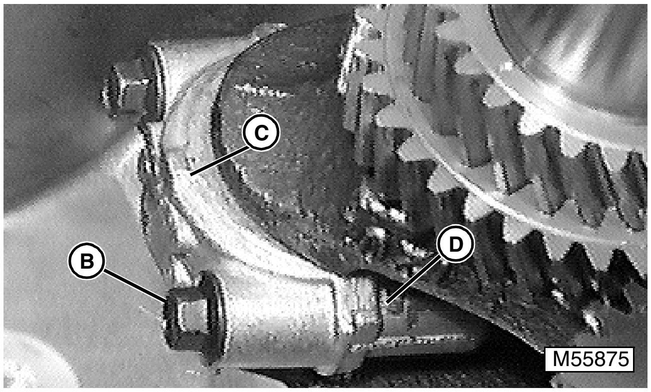
• Piston Ring Compression Tool

**Procedure:**

1. Install piston rings so piston ring end gaps are staggered 120° apart.
2. Coat cylinder, piston skirt, rod, and cap bearing surfaces with oil.
3. Compress rings with ring compressor tool.




4. Install piston with FLY mark (A) toward flywheel side of crankcase. Use wooden dowel to push piston into bore.




5. Fasten connecting rod (D) and cap (C) to crankshaft.
6. Tighten cap screws (B) to specification.
7. Check connecting rod to crankshaft side clearance. Replace if not within specification.
8. Install balance shaft, camshaft, oil pan, and cylinder head. See appropriate procedures in this section.

**Connecting Rod Specifications:**

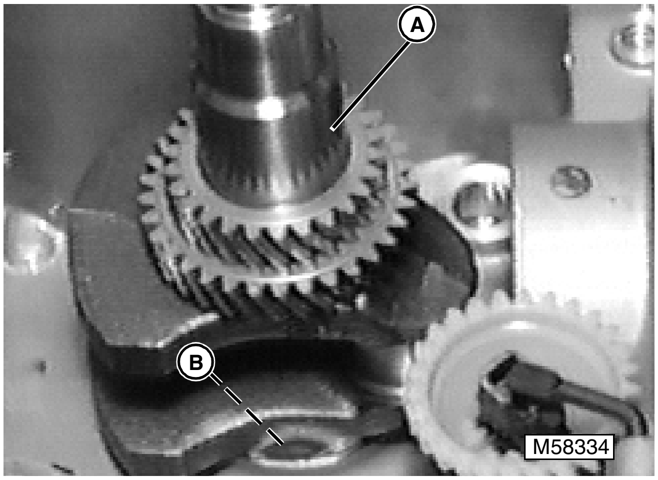
**Cap Screw Torque:**
**8 mm Straight Shank . . . . . . 22.6 N•m (200 lb-in.)**
**Step Down Shank. . . . . . . . . 14.6 N•m (130 lb-in.)**
**6 mm Straight Shank . . . . . . 11.3 N•m (100 lb-in.)**

**Side Clearance . . 0.18 – 0.41 mm (0.007 – 0.016 in.)**

## CRANKSHAFT REMOVAL AND INSTALLATION

**Procedure:**

1. Remove camshaft and balancer assemblies.

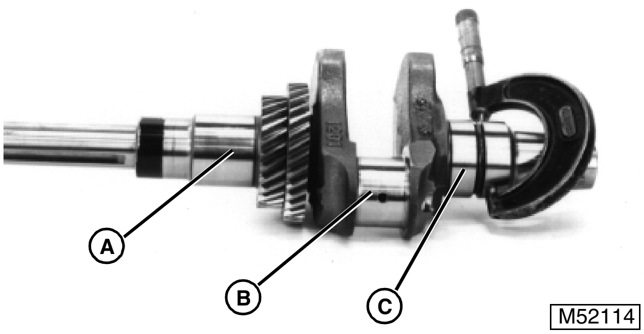


2. Remove and inspect crankshaft (A).
3. Install new seals (B) in crankcase and oil pan.
4. Install crankshaft carefully, DO NOT damage seals.

## CRANKSHAFT AND MAIN BEARING INSPECTION

**Procedure:**

1. Inspect for cracks or chipped teeth.




2. Check crankshaft alignment, see next heading.
3. Measure journals (A), (B), and (C).

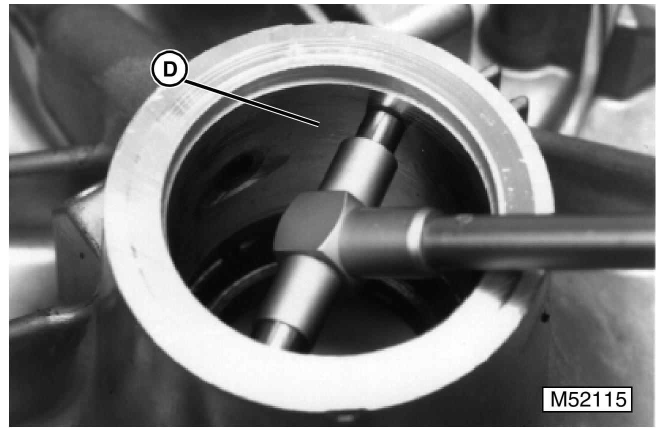
Replace crankshaft if bent, damaged, or not within specifications.

**Crankshaft Bearing Journal Specifications:**

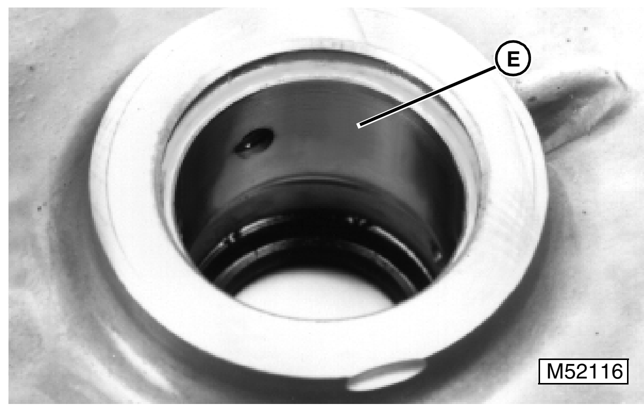
**Oil Pan End Main Journal OD:**
**New . . . 41.915 – 41.935 mm (1.6502 – 1.6510 in.)**
**Minimum . . . . . . . . . . . . . . . . 41.86 mm (1.648 in.)**
**Taper (maximum) . . . . . . . . 0.020 mm (0.0008 in.)**
**Out-of-Round (maximum) . 0.025 mm (0.0010 in.)**

**Flywheel End Main Journal OD:**
**New . . . 44.913 – 44.935 mm (1.7682 – 1.7691 in.)**
**Minimum . . . . . . . . . . . . . . . . 44.84 mm (1.765 in.)**
**Taper (maximum) . . . . . . . . 0.022 mm (0.0009 in.)**
**Out-of-Round (maximum) . 0.025 mm (0.0010 in.)**

**Connecting Rod Journal OD:**
**New . . . 38.958 – 38.970 mm (1.5338 – 1.5343 in.)**
**Minimum . . . . . . . . . . . . . . . 38.94 mm (1.5328 in.)**
**Taper (maximum) . . . . . . . . 0.012 mm (0.0005 in.)**
**Out-of-Round (maximum) . 0.025 mm (0.0010 in.)**




4. Measure inside diameter of crankshaft main bearing bore (D) in oil pan.




5. Measure inside diameter of crankshaft main bearing bore (E) in crankcase.
6. Subtract journal OD from bore ID to determine if clearance is within specifications. Replace parts if not within specifications.

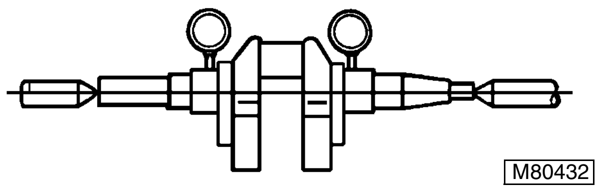
**Crankshaft Sleeve Bearing Bore Specifications:**

**Oil Pan & Crankcase Main Bearing Bore ID**
**. . . . . . . 44.965 – 45.003 mm (1.7703 – 1.7718 in.)**

**Main Bearing Bore-to-Crankshaft Clearance**
**. . . . . . . . . . . 0.03 – 0.09 mm (0.0012 – 0.0035 in.)**

## CRANKSHAFT ALIGNMENT

**Procedure:**




In alignment jig:

- Rotate crankshaft slowly. Dial indicators (A) measure maximum Total Indicated Runout (TIR).

In engine:

- Rotate crankshaft slowly. Measure TIR at oil pan end of crankshaft using dial indicator.

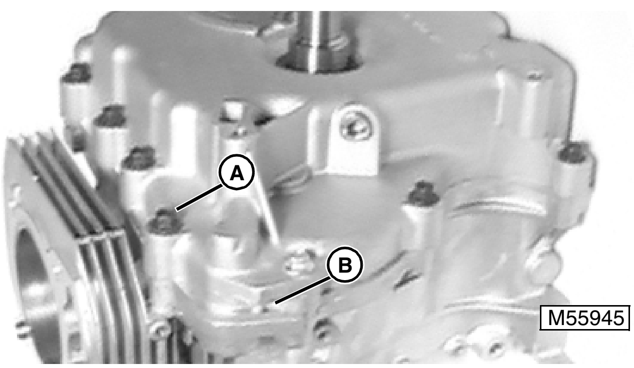
Replace crankshaft if not within specification.

**Specifications:**

**Crankshaft Maximum TIR**
**In Alignment Jig . . . . . . . . . . 0.10 mm (0.0039 in.)**
**In Engine . . . . . . . . . . . . . . . . 0.15 mm (0.0059 in.)**

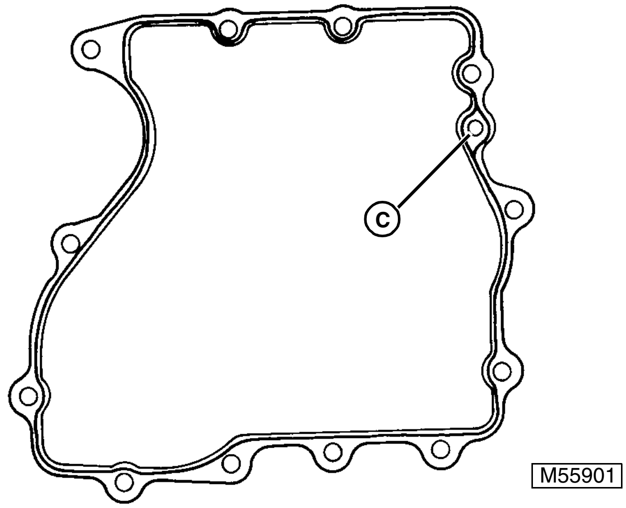
## OIL PAN REMOVAL AND INSTALLATION

**Procedure:**




*NOTE: Do not pry on gasket surface when removing oil pan from crankcase.*

1. Remove cap screws (A).
2. Pry oil pan from crankcase using flat blade screwdriver on splitting tabs (B).
3. Clean mating surfaces of crankcase and oil pan.
4. Replace crankshaft seals, see Remove And Install Oil Pan Seal and Remove And Install Crankcase Seal.

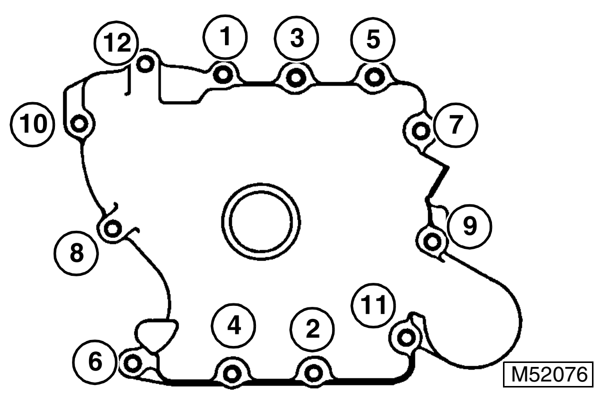



**IMPORTANT: DO NOT get sealant in oil passage (C). Apply just enough to seal both sides of oil passage when case halves are fastened together.**

5. Apply 1.6 mm (1/16 in.) bead of RTV silicone sealant to oil pan flange. DO NOT block oil passage (C).
6. Apply grease to inside lip of crankshaft main bearing seal.
7. Install oil pan over crankshaft carefully to avoid damaging main bearing seal.

**IMPORTANT: Be sure to align flats of balancer shaft and oil pump inner rotor when installing oil pan.**

8. Install oil pan onto crankcase.



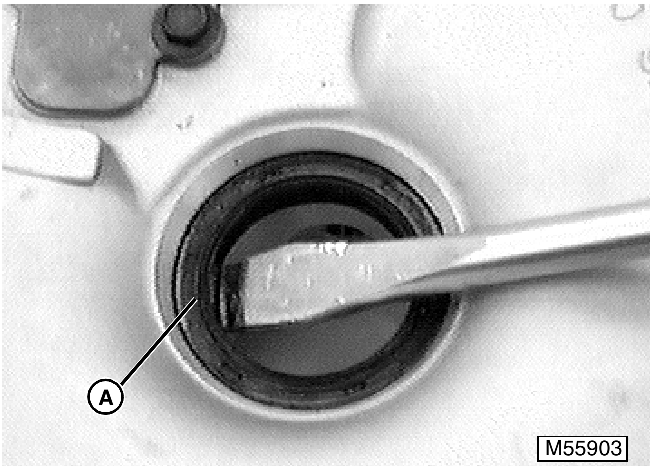

9. In sequence shown, tighten oil pan cap screws to specification.

**Specification:**

**Oil Pan Cap Screws . . . . . . . . . . . 24 N•m (216 lb-in.)**

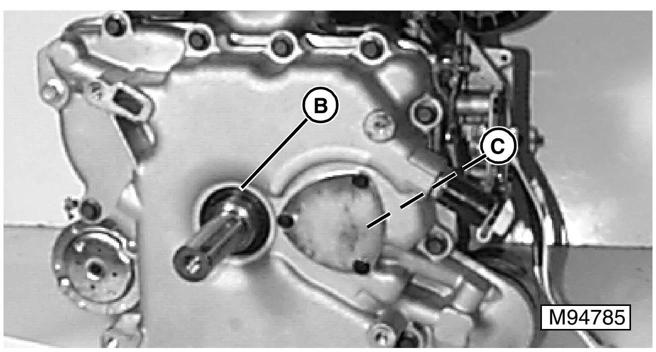
# OIL PAN SEAL REMOVAL AND INSTALLATION

**Procedure:**




**IMPORTANT: DO NOT damage pan bore when removing seal.**

1. Remove and discard seal (A).
2. When replacing crankshaft seals, apply a thin film of LOCTITE® or equivalent to the OD of seal.




3. Using a suitable driver and disc (B), install new oil seal to specification.

**Specification:**

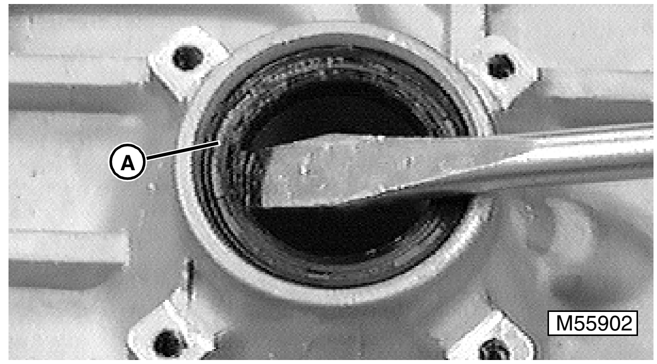
**Oil Pan Seal Depth**
**. . . . . . . . . . . . . . . . 2.49 – 2.98 mm (0.098 – 0.117 in.)**
**or until its top surface is flush with machined bore opening.**

4. Apply grease to inside lip of seal to aid installation.

**IMPORTANT: Be sure to align flats (C) of balancer shaft and oil pump inner rotor when installing oil pan. Prepare and install oil pan, see Remove And Install Oil Pan — Steps 3 – 9.**

# CRANKCASE OIL SEAL REMOVAL AND INSTALLATION

**Procedure:**




**IMPORTANT: DO NOT damage crankcase bore when removing seal.**

1. Remove and discard crankcase oil seal (A).
2. When replacing crankshaft seals, apply a thin film of LOCTITE® 598 or equivalent to the OD of seal.
3. Using a suitable driver and disc, install new oil seal to specification.

**Specification:**

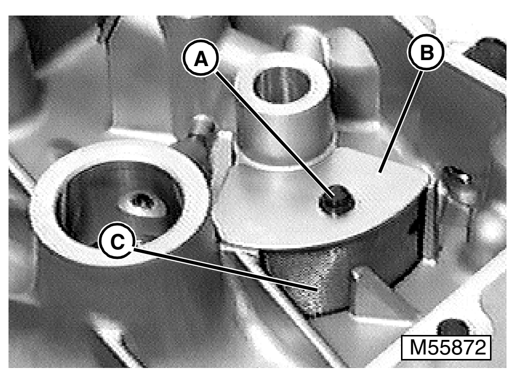
**Crankcase Seal Depth . . . . . . . . . 4.0 mm (0.157 in.)**
**or until its top surface is flush with machined bore opening.**

**IMPORTANT: Coat inside seal lip with grease to aid installation. Install crankshaft carefully to avoid damaging seal.**

4. Carefully install crankshaft seal.

# OIL PICKUP INSPECTION

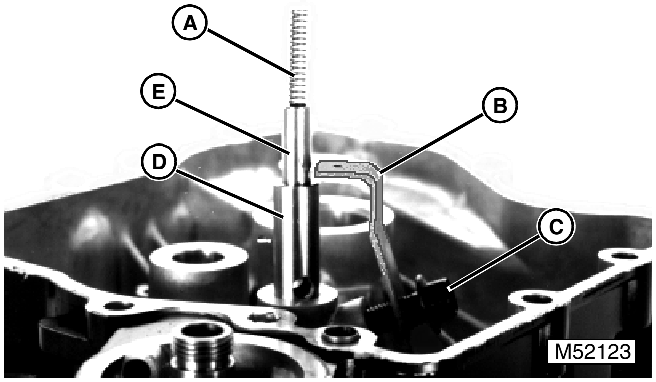
**Procedure:**



1. Remove cap screw (A) and plate (B) to remove pickup screen (C).
2. Clean screen with approved solvent. Replace if damaged.
3. Install screen, plate, and cap screw.
4. Install oil pan.

## OIL PUMP RELIEF VALVE INSPECTION

**Procedure:**




1. Loosen cap screw (C) and retainer (B) to gain access to individual components.
2. Remove and measure spring (A), replace if not to specification.

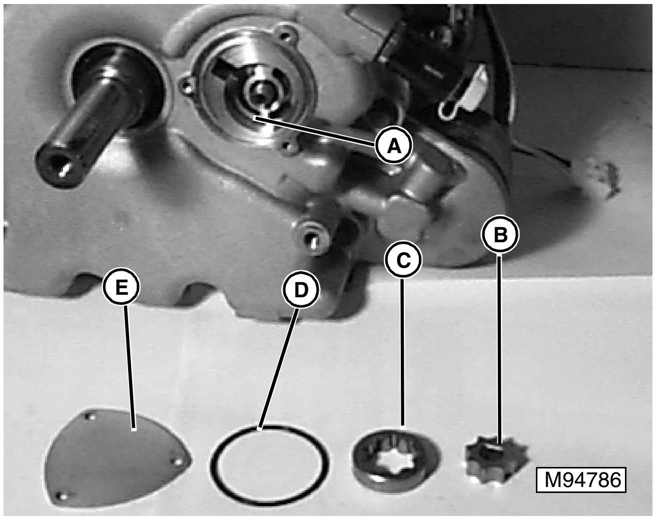
**Specifications:**

**Relief Valve Spring Free Length**
**. . . . . . . . . . . . . . . . . . . . . . 25.1968 mm (0.992 in.)**

3. Inspect spring, piston (E), and body (D). Replace parts that are damaged or worn.
4. Install components with retainer and cap screw.
5. Install oil pan.

## OIL PUMP REMOVAL AND INSTALLATION

**Procedure:**



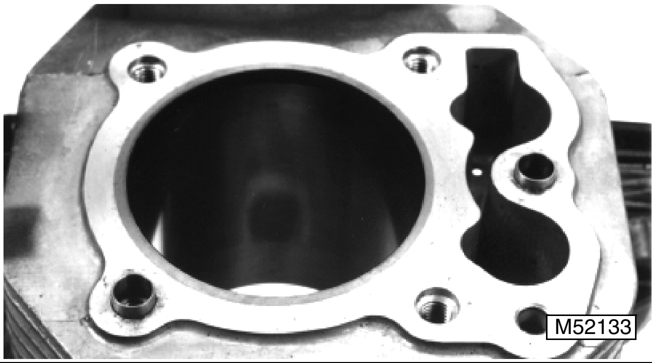

1. Remove cover (E), O-ring (D), pump outer rotor (C), and pump inner rotor (B).
2. Inspect rotor, pump, and inside surface of cavity (A) for scoring, discoloration, and wear.
3. Replace parts as necessary.
4. Lubricate parts (A, B, and C) with engine oil. Install in cavity.
5. Install O-ring and cover. Tighten cap screws to specification.

**Oil Pump Cover Cap Screw Torque Specifications:**

**New Oil Pan (Thread Forming) . . 6.2 N•m (55 lb-in.)**
**Used Oil Pan (Threads Cut). . . . . 4.0 N•m (35 lb-in.)**
**Oil Pump Cover-to-Rotor Clearance:. . . . . . . . . . . . . . . 0.076 mm (0.003 in.)**

## CYLINDER BLOCK REMOVAL/ INSTALLATION

**Procedure:**

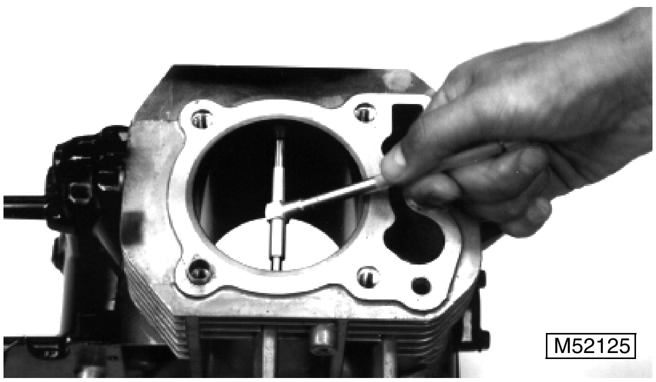


All components must be removed from block before inspection or machine work can be performed.

## CYLINDER BLOCK INSPECTION

**Procedure:**

1. Clean and check block for cracks.
2. Cracks not visible to the eye may be detected by coating the suspected area with mixture of 25 percent kerosene and 75 percent light engine oil.
3. Wipe area dry and immediately apply coating of zinc oxide dissolved in wood alcohol. If crack is present, coating becomes discolored at the defective area.
4. Replace block if any cracks are found.




5. Measure cylinder bore inside diameter at six places; two measurements 90° apart at top, middle, and bottom of ring travel.
6. Measure piston outside diameter perpendicular to piston pin bore.

*NOTE: Pistons and rings are available 0.25 and 0.50 mm (0.010 and 0.020 in.) oversize.*

Replace block or bore cylinder to accept larger piston if clearance exceeds specification.

**Specifications:**

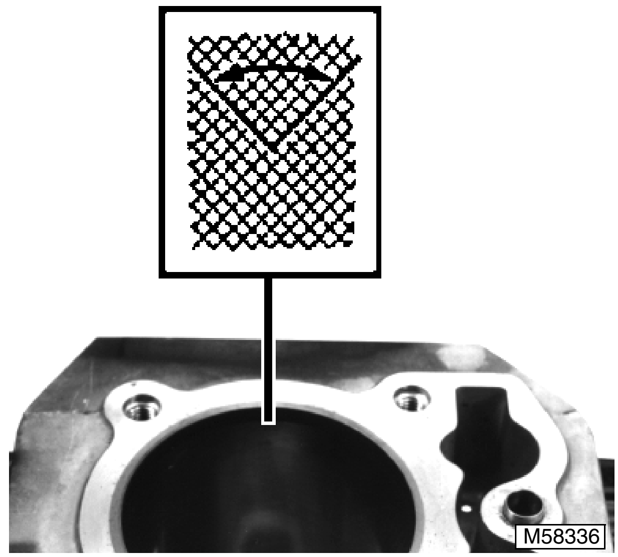
**Cylinder Bore:**
**New . . . 90.000 – 90.025 mm (3.5433 – 3.5443 in.)**
**Maximum. . . . . . . . . . . . . . 90.063 mm (3.5681 in.)**
**Out-of-Round (maximum) . . . . 0.12 mm (0.0047 in.)**
**Taper (maximum) . . . . . . . . . . . 0.05 mm (0.0020 in.)**
**Piston-to-Cylinder Clearance**
**. . . . . . . . . 0.031 – 0.043 mm (0.0012 – 0.0016 in.)**

## CYLINDER BORE DEGLAZING

**Procedure:**

**IMPORTANT: Remove crankshaft and internal engine components when deglazing cylinder. Abrasives can cause engine damage.**

1. Use the appropriate size flex-hone to deglaze cylinder bore.




2. Deglaze cylinder bore using flex-hone to obtain **23 – 33**° crosshatch pattern.
3. Clean abrasive residue from cylinder using warm soapy water until clean white rags show no discoloration.
4. Dry cylinder and apply engine oil.

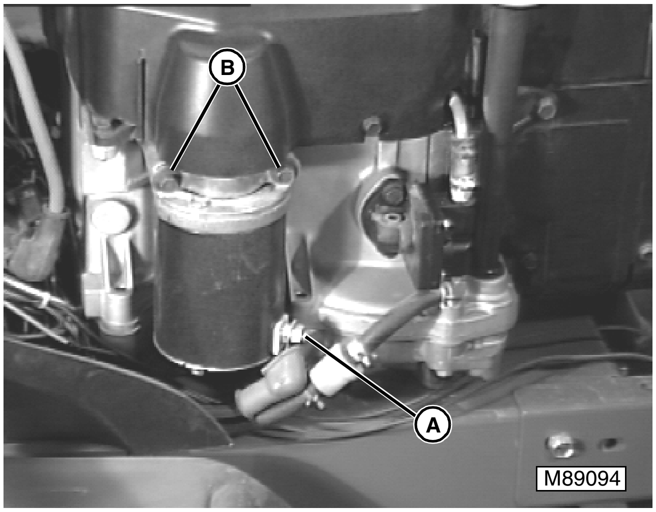
**Specification:**

**Deglaze Crosshatch Pattern . . . . . . . . . . . . . 23 – 33°**

## STARTING MOTOR REMOVAL AND INSTALLATION

**Procedure:**

1. Park machine on level surface.
2. Turn key switch to OFF position.
3. Move Forward/Reverse pedals to NEUTRAL position.
4. Engage park brake.
5. Raise hood.
6. Disconnect battery negative terminal (–).



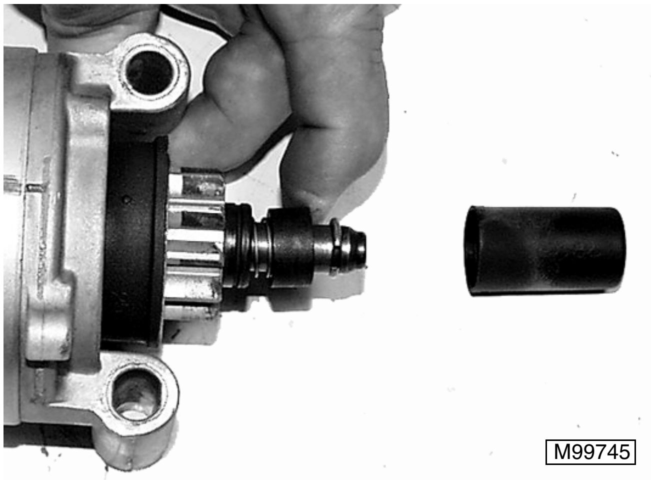

7. Disconnect battery terminal (A) from starting motor.
8. Remove the two capscrews (B) securing the starting motor to the engine.

**Installation:**

9. Position starting motor on engine and install starting motor retaining capscrews. Tighten capscrews to **24 N·m (18 lb-ft)**.
10. Connect battery cable to starting motor and reconnect battery negative cable.

## STARTING MOTOR DRIVE REPLACEMENT

*NOTE: Check for available service parts before disassembling motor.*




1. Remove starting motor. Remove dust cover.
2. Compress retainer and remove stop clip.
3. Disassemble bendix drive.
4. Replace with new bendix drive kit.

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# SPECIFICATIONS

## GENERAL SPECIFICATIONS

| | |
|---|---|
| Make | Briggs & Stratton |
| Series | Vanguard V-Twin |
| Type | Gasoline |
| Model | 303777 |
| Horsepower | 11.94 kW (16.0 hp) |
| Displacement | 480 $cm^3$ (29.3 cu. in.) |
| Cylinders | 2 |
| Stroke/Cycle | 4 |
| Valves | Overhead Valves |
| Bore | 68 mm (2.68 in.) |
| Stroke | 66 mm (2.60 in.) |
| Lubrication | Pressurized 0 – 344 kPa (10 – 50 psi) |
| Oil Filter | Full Flow Filter (w/o By-Pass Valve) |
| Crankcase Capacity (With Filter) | 1.5 L (1.6 U.S. qt; 52 U.S. oz) |
| Without Filter | 1.4 L (1.5 U.S. qt; 48 U.S. oz) |
| Cooling System | Air Cooled |
| Air Cleaner | Paper with outer foam element |
| Muffler | Horizontal discharge below frame |
| Aspiration | Natural |
| Fuel Filter | Replaceable, In-Line |

## TESTS & ADJUSTMENTS SPECIFICATIONS

| | |
|---|---|
| Valve Clearance | 0.10 – 0.16 mm (0.004 – 0.006 in.) |
| Valve Guide Depth | 0.7 mm (0.281 in.) |
| Slow Idle | 1750 ± 100 rpm |
| Fast Idle | 3350 ± 50 rpm |
| Oil Pump Operating Pressure | 10 – 50 psi |

## REPAIR SPECIFICATIONS

| | |
|---|---|
| Spark Plug Gap | 1.015 mm (0.040 in.) |

**Valves:**

| | |
|---|---|
| Valve Guide Standard Dimension | 6.01 – 6.02 mm (0.236 – 0.237 in.) |
| Wear Limit | 6.05 mm (0.238 in.) |
| Valve Stem Standard Dimension | |
| Intake | 5.94 – 5.96 mm (0.234 – 0.235 in.) |
| Exhaust | 5.94 – 5.95 mm (0.234 – 0.235 in.) |
| Valve stem Wear Limit | |
| Intake | 5.92mm (0.233 in.) |
| Exhaust | 5.91mm (2.328 in.) |
| Valve Seat Width | 1.2 – 1.6 mm (0.047 – 0.062 in.) |
| Valve Margin (Min) | 0.4 mm (0.016 in.) |
| Valve Face Angle | 45° |
| Valve Seat Narrowing Angle | 30° |

**Cylinder Bore, Pistons and Rings:**

| | |
|---|---|
| Cylinder Bore Standard Dimension | 68 – 68.025 mm (2.677 – 2.678 in.) |

| | |
|---|---|
| Wear Limit | 68.065 mm (2.6795 in.) |
| Piston Pin Standard Dimension | 17.07 – 17.08 mm (0.672 – 0.673 in.) |
| Wear Limit | 17.06 mm (0.672 in.) |
| Piston Pin Bore Standard Dimension | 17.09 – 17.1 mm (0.673 – 0.674 in.) |
| Wear Limit | 17.12 mm (0.674 in.) |
| Ring End Gap Standard Dimension | 0.20 – 0.40 mm (0.008 – 0.016 in.) |
| Wear Limit | 0.76 mm (0.030 in.) |
| Compression Ring Groove Wear Limit (New Ring Installed) | 0.10 mm (0.004 in.) |
| Oil Ring Groove Clearance Wear Limit (New Ring Installed) | 0.20 mm (0.008 in.) |

**Connecting Rod and Crankshaft:**

| | |
|---|---|
| Connecting Rod Crankpin Standard Dimension | 37.06 – 37.08 mm (1.459 – 1.460 in.) |
| Wear Limit | 37.12 mm (1.461 in.) |
| Connecting Rod Piston Pin Bearing Std. Dimension | 17.09 – 17.1 mm (0.672 – 0.673 in.) |
| Wear Limit | 17.12 mm (0.674 in.) |
| Crankshaft PTO Journal Standard Dimension | 34.96 – 34.97 mm (1.376 – 1.377 in.) |
| Wear Limit | 34.92 mm (1.375 in.) |
| Crankshaft Magneto Journal Standard Dimension | 29.98 – 30.00 mm (1.180 – 1.181 in.) |
| Wear Limit | 29.94 mm (1.179 in.) |
| Magneto Bearing Standard Dimension | 30.10 – 30.12 mm (1.185 – 1.186 in.) |
| Wear Limit | 30.08 mm (1.184 in.) |
| PTO Bearing Standard Dimension | 35.04 – 35.05 mm (1.379 – 1.380 in.) |
| Wear Limit | 35.07 mm (1.381 in.) |
| Crankshaft Crankpin Journal Standard Dimension | 37.0 – 37.02 mm (1.456 – 1.457 in.) |
| Wear Limit | 36.95 mm (1.455 in.) |
| Crankshaft End Play | 0.08 – 0.40 mm (0.003 – 0.015 in.) |
| Cam Gear PTO Journal Standard Dimension | 19.94 – 19.96 mm (0.785 – 0.786 in.) |
| Wear Limit | 19.92 mm (0.784 in.) |
| Cam Gear Magneto Journal Standard Dimension | 15.95 – 15.97 mm (0.628 – 0.629 in.) |
| Wear Limit | 15.93 mm (0.627 in.) |
| Cam Lobe Standard Dimension | 30.33 – 30.53 mm (1.194 – 1.202 in.) |
| Wear Limit | 30.25 mm (1.191 in.) |
| Cam Bearing (Magneto Side) Standard Dimension | 16.0 – 16.025 mm (0.630 – 0.631 in.) |
| Wear Limit | 16.08 mm (0.633 in.) |
| Cam Bearing (PTO Side) Standard Dimension | 20.0 – 20.02 mm (0.787 – 0.788 in.) |
| Wear Limit | 20.04 mm (0.789 in.) |

## TORQUE SPECIFICATIONS (Alphabetical)

| | |
|---|---|
| Alternator to Cylinder Block | 2.2 Nm (20 lb in.) |
| Air Cleaner Base to Carburetor | 7 N•m (65 lb-in.) |
| Connecting Rod Cap Screws | 13 N•m (115 lb-in.) |
| Crankcase Cover | 17 N•m (150 lb-in.) |
| Cylinder Head Bolts | 25 N•m (220 lb-in.) |
| Cylinder Shield | 7 N•m (65 lb-in.) |
| Exhaust Manifold | 17 N•m (150 lb-in.) |
| Flywheel Nut | 175 N•m (129 lb-ft) |
| Fuel Shutoff Solenoid | 5 N•m (45 lb-in.) |
| Oil Breather Mounting Bolt | 3 N•m (30 lb-in.) |
| Oil Filter Adaptor Mounting Bolts | 7 N•m (65 lb-in.) |
| Oil Pump Mounting Screws | 7 N•m (65 lb-in.) |
| Rocker Arm Adjustment Lock Nut | 7 N•m (65 lb-in.) |
| Rocker Arm Studs | 11 N•m (100 lb-in.) |
| Spark Plug | 20 N•m (180 lb-in.) |
| Valve Cover Nuts | 3 N•m (25 lb-in.) |

# TROUBLESHOOTING

| Problem or Symptom / Check or Solution | Engine will not crank | Engine cranks but will not start | Engine starts hard | Engine won't shutoff | Loss of power | Low compression | Excessive engine noise/vibration | Low oil pressure | Engine running on one cylinder | Engine overheats | Fuel mixture too rich |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Battery has low or no charge/ cables loose or dirty | ● | ● | ● | | | | | | | | |
| Fusible link (F1) open | ● | | | | | | | | | | |
| Starter motor/solenoid defective | ● | | | | | | | | | | |
| Improper switch position (See Electrical Section) | ● | ● | | | | | | | | | |
| Engine seized | ● | | | | | | | | | | |
| Fuel shutoff solenoid defective | | ● | | ● | | | | | | | |
| Fuel filter/lines clogged | | ● | ● | | ● | | | | | | |
| Fuel pump defective | | ● | ● | | ● | | | | | | |
| Ignition coil air gap not adjusted properly | | ● | ● | | ● | | | | ● | | |
| Carburetor not adjusted properly, dirty | | ● | ● | ● | ● | | | | | ● | ● |
| Air cleaner dirty | | ● | ● | | ● | | | | | | ● |
| Old/contaminated fuel | | ● | ● | | ● | | | | | | |
| Spark plugs loose/dirty | | ● | ● | | ● | ● | | | ● | | |
| Magneto kill circuit grounded/ shorted (See Electrical Section) | | ● | | | | | | | ● | | |
| Valve tappets need adjustment | | ● | ● | | ● | ● | | | ● | | |
| Lack of compression, check valves, pistons and rings | | ● | ● | | ● | | | | ● | | |
| Magneto kill circuit open (See Electrical Section) | | | | ● | | | | | | | |
| Mower deck binding or dragging | | | | | ● | | ● | | | ● | |
| Grass build-up under deck | | | | | ● | | ● | | | ● | |

| Check or Solution / Problem or Symptom | Engine will not crank | Engine cranks but will not start | Engine starts hard | Engine won't shutoff | Loss of power | Low compression | Excessive engine noise/vibration | Low oil pressure | Engine running on one cylinder | Engine overheats | Fuel mixture too rich |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No lubrication in gear box or hydro/transaxle | | | | | ● | | ● | | | ● | |
| Excessive drive belt tension | | | | | | | | | | ● | |
| Deck spindles seized | | | | | ● | | ● | | | ● | |
| Loose cylinder head bolts | | | | | | ● | | | ● | | |
| Defective head gasket | | | | | | ● | | | ● | | |
| Burned valves, valve seats, and/or loose valve seats | | ● | ● | | ● | ● | | | ● | | |
| Warped cylinder head | | | ● | | ● | ● | | | ● | | |
| Worn bore and/or rings | | | ● | | ● | ● | ● | | ● | | |
| Broken connecting rod | | | ● | | ● | ● | ● | | ● | | |
| Cutter blade or other rotating part bent or out of balance | | | | | | | ● | | | | |
| Mounting bolts loose | | | | | | | ● | | | | |
| Camshaft worn | | ● | ● | | ● | ● | | | ● | | |
| Internal bearings worn or excessive tolerance | | | | | | | | ● | | | |
| Oil galleries/filter clogged | | | | | | | | ● | | | |
| Oil pump defective | | | | | | | | ● | | | |
| Low oil level or wrong viscosity | | | | | | | | ● | | ● | |
| Exhaust system restricted | | | ● | | ● | | | | | ● | |
| Air/fuel mixture excessively lean | | | | | | | | | | ● | |
| Cylinder cooling fins/blower housing filled with grass clippings | | | | | | | | | | ● | |
| Overchoking | | | | | | | | | | | ● |
| Float needle stuck open | | | | | | | | | | | ● |

# ENGINE TROUBLESHOOTING

## Engine Will Not Crank

*NOTE: To test specific electrical components, see Electrical Section and refer to either Diagnostics or Tests & Adjustments for further guidance.*

**⚠ CAUTION**

**BE AWARE! The engine may start to rotate at any time. Keep hands away from all moving parts when testing.**

Check battery voltage. Is battery voltage 12.4 volts or higher?

- **NO** → Charge battery and perform a no-load test. Is battery voltage 12.4 volts or higher?
  - **NO** → • Battery defective
  - **YES** → (continue below)
- **YES** → Does starter solenoid click when ignition switch is turned to START position?
  - **NO** →
    - • Fusible link open
    - • Starter solenoid defective
    - • Defective switches or wiring

    See Electrical Troubleshooting
  - **YES** →
    - • Engine seized
    - • Starter solenoid defective
    - • Starter pinion gear sticking or damaged
    - • Starter motor defective

    Repair or replace

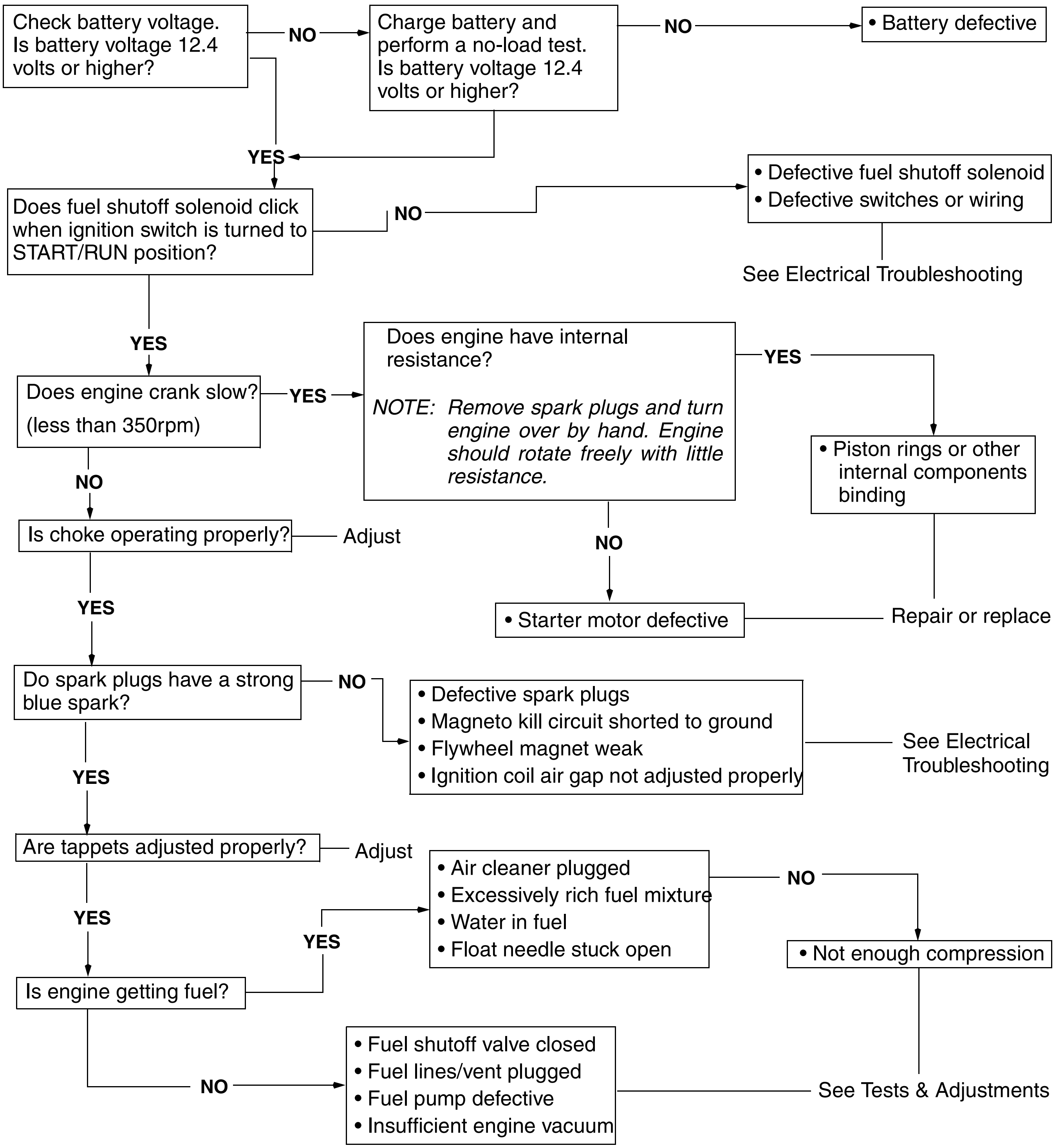
## Engine Cranks But Will Not Start

**CAUTION**

**DO NOT rotate engine with starter if the spark plugs are removed. Gasoline spray from the open cylinders may be ignited by ignition spark and cause an explosion or fire.**

**IMPORTANT: Perform a visual inspection first to determine if battery cables are tight and not corroded and if the battery is of sufficient size to turn the engine over at minimum cranking speed of 350 rpm.**

*NOTE: To test specific electrical components, see Electrical Section and refer to either Diagnostics or Tests & Adjustments for further guidance.*



## Engine Runs Erratically/Loss Of Power

**IMPORTANT: Before proceeding, inspect the mower deck and belts for binding in the spindle assemblies or belts that are too tight/loose. A loose belt like a loose blade can cause a backlash effect that will counteract engine cranking effort. Excessive drive belt tension may cause premature bearing wear or result in bearing seizure. Grass clippings that build up near the cutting blades can cause excessive resistance and heat build-up that causes problems with the engine's ability to turn the blades at a constant speed. Low lubricant levels in the spindles will build-up heat causing excessive resistance for the engine to deal with.**

**There is a diode in-line in the magneto kill wire coming from each ignition module. This diode prevents feedback from one module to the other. Without these diodes, one magneto could fire the coil for the other magneto. If a diode fails in one of the magneto kill wires, that coil, could be fired by the other module. The result may be similar to that of an erratic running engine.**
**A two cylinder engine may run adequately on one cylinder as long as the power required for the application does not exceed the power produced by the one cylinder.**

*NOTE: To test specific electrical components, see Electrical Section and refer to either Diagnostics or Tests & Adjustments for further guidance.*

Perform a Cylinder Balance Test to determine if the problem is with one cylinder or both cylinders. Does the problem exist in just one cylinder?

**YES** →

- Defective spark plug

*NOTE: A fouled spark plug may indicate that the carburetor is out of adjustment.*

- Faulty ignition wire/ignition system
- Defective head gasket
- Intake manifold leak
- Valves/valve adjustment
- Piston rings
- Piston
- Cylinder bore
- Faulty diode in Magneto kill circuit
- Camshaft

See Tests & Adjustments

**NO** →

- Carburetion
- Crankcase vacuum
- Ignition Timing
- Governor operation
- Camshaft

See Tests & Adjustments

# TESTS AND ADJUSTMENTS

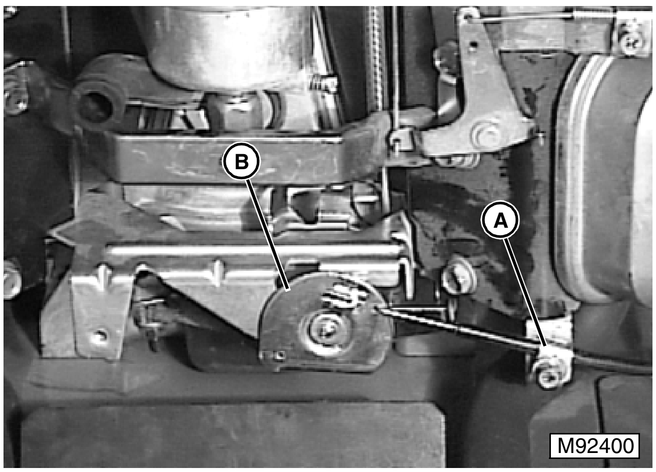
## THROTTLE CABLE ADJUSTMENT

**Reason:**

To make sure the throttle cable moves the throttle through its full range of movement.

**Procedure:**

1. Remove air cleaner assembly, and base.
2. Install nuts on carburetor studs.
3. Move throttle lever to FAST idle position.




4. Loosen throttle cable clamp (A).
5. Move throttle cable until governor control swivel (B) is at end of travel.
6. Tighten throttle cable clamp.

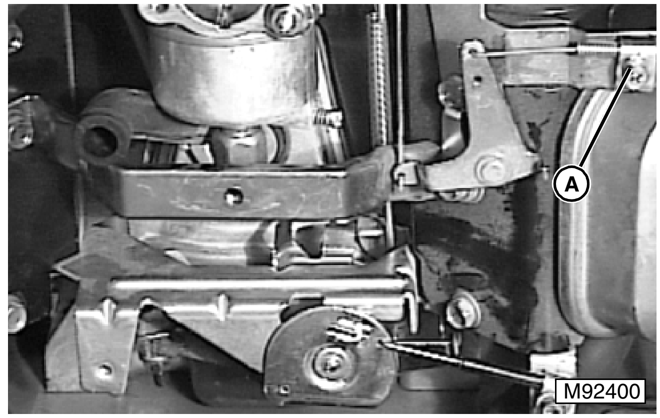
## CHOKE CABLE ADJUSTMENT

**Reason:**

To make sure the choke cable moves the choke through its full range of movement.

**Procedure:**

1. Move choke lever to full choke position.




2. Loosen choke cable clamp (A).
3. Move choke cable until choke is completely closed.
4. Tighten choke cable clamp.

## FUEL SHUTOFF SOLENOID TEST

**Reason:**

To test proper operation of fuel shutoff solenoid.

**Required Tools:**

- Jumper wire

**Procedure:**

1. Remove air cleaner assembly, and base.
2. Install nuts on carburetor studs.
3. Listen for an audible click when ignition switch is turned from OFF to ON.
4. If solenoid does not click, problem could be in equipment wiring.
5. Disconnect wire from solenoid.
6. Momentarily place a jumper wire from solenoid wire to battery positive terminal.
7. If solenoid now clicks, the solenoid is working properly.

*NOTE: If battery voltage drops below 9 volts when cranking engine or while engine is running, the solenoid will not function.*

**Results:**

- Solenoid is operating properly if a click is heard when ignition switched from off to on

# COMPRESSION TEST

**Reason:**

To determine the performance difference between cylinders.

**Required Tools:**

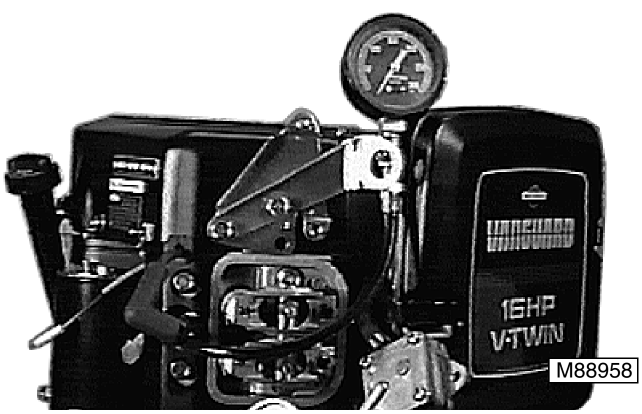
- JDM59 Compression Gauge

*NOTE: Briggs & Stratton does not publish any compression pressures, as it is extremely difficult to obtain an accurate reading without special equipment. Briggs & Stratton recommends to calculate the difference in compression readings between the two cylinders. Two methods are given in the following; one without a cylinder leak tester and one with a cylinder leak tester.*

## WITHOUT CYLINDER LEAK TESTER

**IMPORTANT: The battery must be fully charged for this test.**
**Check and adjust the valves to ensure the valves have not been adjusted too tight. If either valve is off its seat the leak test will be invalid.**

1. The engine should be run for at least 5 minutes to bring the engine to operating temperature.
2. Remove spark plugs and ground the magnetos by attaching a jumper wire from the magneto kill circuit connector to the engine to prevent a spark that could ignite anything combustible.




3. Insert a compression gauge into either cylinder.
4. Turn engine over with the starter until the highest pressure reading is obtained and record reading.
5. Repeat steps 3 & 4 with the next cylinder and record reading.
6. Use the following example and insert the recorded readings to determine the percent of leakage between cylinders.

**Example:**

| | |
|---|---|
| cyl #1 | cyl #2 |
| 75 psi | 55 psi |

*Formula:*

$55 \div 75 = 0.7333 \times 100 = 73.333$, $100 - 73.333 =$ <u>26.7%</u>

**Highest Reading**
**Lowest Reading**

**Results:**

- A difference of more than 25% indicates a loss of compression in the cylinder with the lowest reading.

## WITH CYLINDER LEAK TESTER

**Required Tools:**

- JTO3502 Cylinder Leak Tester
- Breaker Bar & 30 mm Socket

*NOTE: If the directions that come with the tester being used are different than the following, use the directions that came with the tester.*

**IMPORTANT: Check and adjust the valves to ensure the valves have not been adjusted too tight. If either valve is off its seat the leak test will be invalid.**

1. The engine should be run for at least 5 minutes to bring the engine to operating temperature.

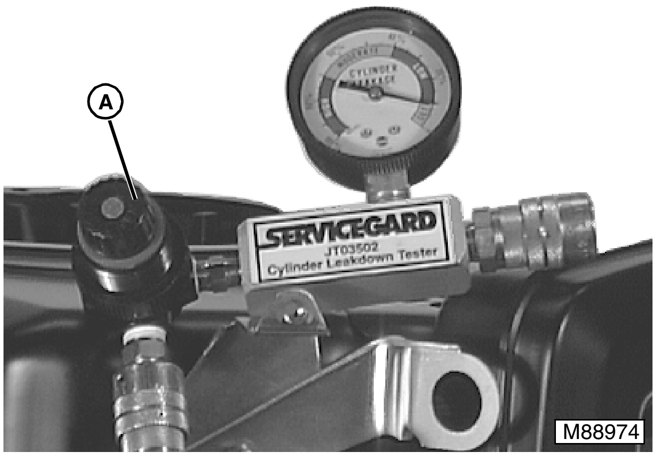
**⚠ CAUTION**

**With spark plugs removed, the magnetos must be grounded to the engine to prevent a spark that could ignite anything combustible.**

2. Remove spark plugs and ground the magnetos by attaching a jumper wire from the magneto kill circuit connector to the engine to prevent a spark that could ignite anything combustible.

**IMPORTANT: The piston must be positioned at Top Dead Center (TDC) to ensure that the intake valves are away from the compression relief balls. If not, the intake valve will be open and the leak test will be invalid.**

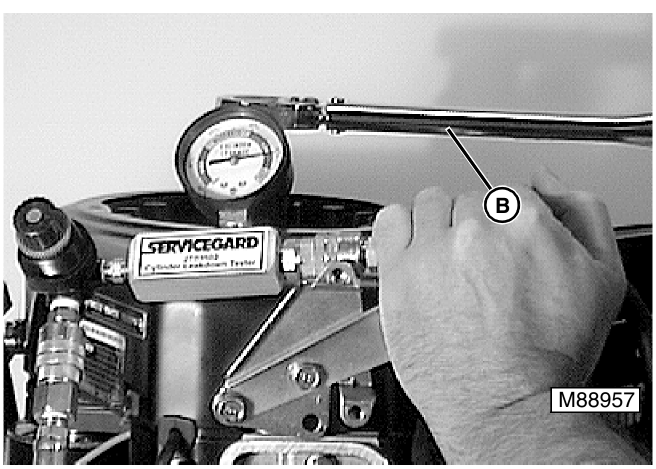
3. Remove valve covers.
4. Remove the rotating screen.
5. Turn crankshaft until piston is at TDC on the compression stroke (both valves closed).
6. Screw the adaptor into the spark plug hole but do not attach it to the tester at this time.




7. Pull back the locking ring and rotate the regulator knob (A) fully counterclockwise. Connect an air line to the tester.

**IMPORTANT: The air supply must have enough supply pressure to calibrate the tester (Usually 85 – 95 psi).**

8. Pull back the locking ring and rotate the regulator knob clockwise until the gauge needle rests in the SET range of the gauge. Push the locking ring towards the tester to lock it.




9. Connect the adaptor hose to the tester and record the needle position while holding the flywheel in position with a breaker bar (B).

*NOTE: A small amount of air escaping from the crankcase breather is normal.*

**Results:**

- Excessive air escaping from the crankcase breather indicates worn piston rings or cylinder wall
- Air escaping from the carburetor indicates a worn intake valve or seat
- Air escaping from the exhaust pipe indicates a worn exhaust valve or seat
- Gauge reading in the Green (low) area indicates good compression. Under 25% is considered normal.
- Gauge reading in the Yellow (Moderate) area indicates borderline compression. The engine is still usable but an overhaul or replacement should be considered
- Gauge reading in the Red (High) area indicates excessive compression loss and engine reconditioning or replacement is necessary

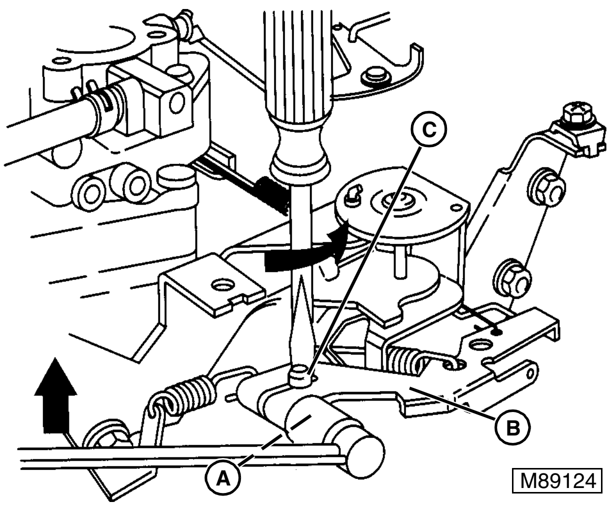
## GOVERNOR ADJUSTMENT

> **⚠ CAUTION**
>
> **Before starting or running engine, static adjustment of the governor must be made. Failure to make static adjustments first, could result in engine overspeeding, and may result in engine or equipment damage causing personal injury and/or property damage.**

**STATIC ADJUSTMENT (Engine OFF)**

*NOTE: All linkage must be installed to make adjustment.*

**Procedure:**




1. Remove:
 • Hood
 • Top muffler shield
 • Air cleaner assembly
2. Loosen governor lever bolt and nut (A).
3. Push on governor lever (B) until throttle is wide open.

**IMPORTANT: Do not bend governor link or distort governor lever.**

4. Hold lever in this position and rotate governor shaft (C) counterclockwise as far as it will go. Hold lever and shaft in position and torque governor lever bolt and nut to **8 N•m (70 lb-in.)**.

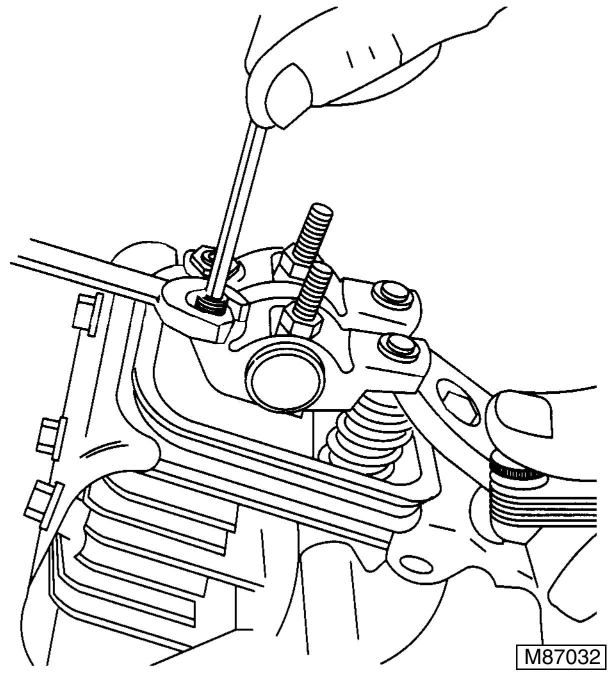
**Specification:**

**Lock Nut . . . . . . . . . . . . . . . . . . . . . . 8 N•m (70 lb-in.)**

## VALVE CLEARANCE ADJUSTMENT

*NOTE: Correct position of crankshaft is necessary to eliminate interference by the compression release mechanism on the cam gear when adjusting valve clearance.*

1. Remove valve cover.
2. Turn crankshaft until piston is at top dead center, (TDC) on the compression stroke (both valves closed).
3. Insert a screwdriver through the spark plug opening until it touches the top of the piston.
4. Continue to turn the crankshaft clockwise until the piston has moved down **6.35 mm (0.25 in.)**.




5. Check valve clearance with a feeler gauge between valve stem and rocker arm. Valve clearance should be **0.10 – 0.16 mm (0.004 – 0.006 in.)**.
6. If not, adjust as necessary using a 13 mm open end wrench and a 5 mm hex wrench. Tighten lock nut to **7 N•m (60 lb-in.)**.
7. Recheck clearance and make adjustments if necessary.
8. Install valve cover.

**Specifications:**

**Lock Nut . . . . . . . . . . . . . . . . . . . . . . 7 N•m (60 lb-in.)**
**Valve Clearance . 0.10 – 0.16 mm (0.004 – 0.006 in.)**

# CYLINDER BALANCE TEST

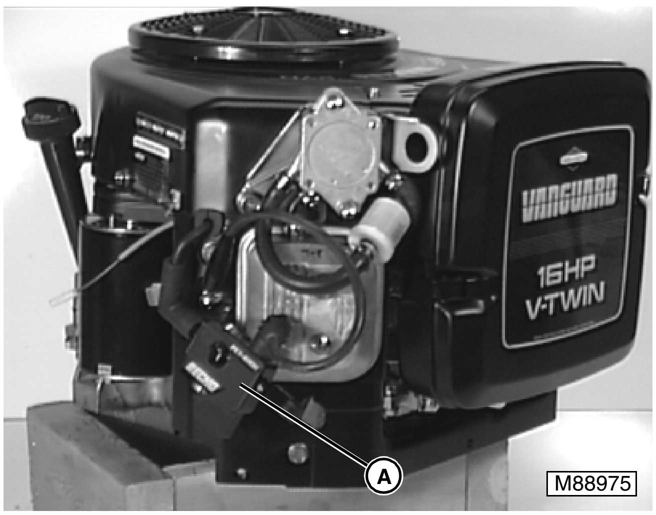
**Reason:**

If engine is hard starting, runs rough, misses or lacks power, perform a cylinder balance test to determine if both cylinders are operating to their full potential.

**Equipment:**

- D053515T Spark Tester
- JT07270 Engine Tachometer
- Screw driver with insulated handle

**Procedure:**




1. Disconnect spark plug high tension lead.
2. Connect spark tester (A) to spark plug and high tension lead.
3. Start engine and note spark at tester. Shut engine off.
4. Repeat steps 1 – 3 for second cylinder.
5. Connect engine tachometer.
6. Start engine and run at top no-load speed. Note rpm on tachometer.

.


7. Ground out one cylinder with screw driver. Note rpm on tachometer.
8. Remove screw driver and allow engine to recover.
9. Ground second cylinder with screw driver. Note rpm on tachometer.

**Results:**

- If the difference between the two cylinders is less than 75 rpm, the cylinders should be considered equal
- If the difference between the two cylinders is greater than 75 rpm, this indicates that the cylinder with the lower rpm loss is weakest, and should be considered as the possible problem

# ENGINE OIL PRESSURE TEST

**Reason:**

To verify that the engine has enough oil pressure to lubricate the internal engine components.

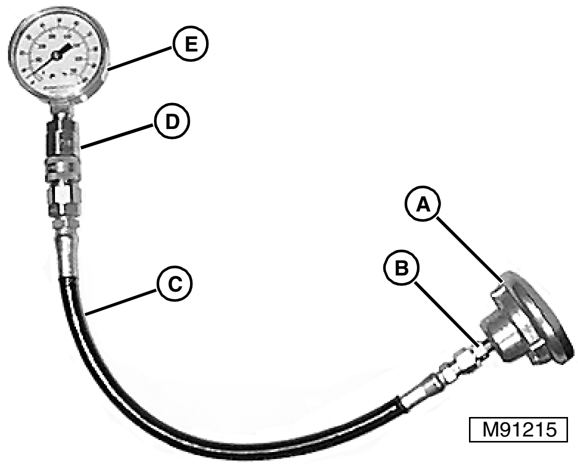
**Equipment:**

- JT07262 Oil Pressure Test Adapter w/ O-ring (A) (required ONLY on engines without test ports)
- JT05847 Connector (B)
- JT03017 Hose Assembly (C)
- JT03262 Coupler (D)
- JT07034 Gauge, 0 – 700 kPa (0 – 100 psi) (E)

*NOTE: The connector, hose assembly, coupler, and gauge are found in other SERVICEGARD™ test kits. The connector pipe thread (NPT) also matches the oil pressure switch port on early Kohler engines.*

**Test Procedure At Oil Filter Base:**

1. Perform test procedure with engine level.
2. Stop engine.
3. Disconnect spark plug wire and allow engine to cool.
4. Drain engine oil from oil filter.
5. Remove oil filter and wipe filter base clean.
6. Install pre-assembled adapter, connector, hose assembly, coupler, and gauge on to oil filter base. ONLY hand-tighten adapter to oil filter base.
7. Check crankcase oil level and adjust to full mark.




8. Monitor oil pressure during cranking, if oil pressure is **below 28 kPa (4 psi)—STOP the engine immediately** and correct the cause before continuing.
9. Connect spark plug wire.
10. Warm-up engine by running at MEDIUM idle for five minutes.

**CAUTION**

**Engine components are HOT. DO NOT touch with bare skin. Wear protective eye glasses and clothing.**

11. Record oil pressure readings at SLOW and FAST idle.
12. Stop engine and allow to cool.
13. Remove adapter, connector, hose assembly, coupler, and gauge.
14. Install new oil filter.
15. Run engine for 30 seconds and stop engine.
16. Check crankcase oil level and adjust to full mark.

**Results:**

- If oil pressure readings are not within **69 kPa (10.0 psi) – 517 kPa (75.0 psi**) at FAST idle, inspect and/or replace the following:

–Oil pump assembly. (See OIL PUMP DISASSEMBLY AND INSPECTION.)

–Oil suction screen.

–Oil passages

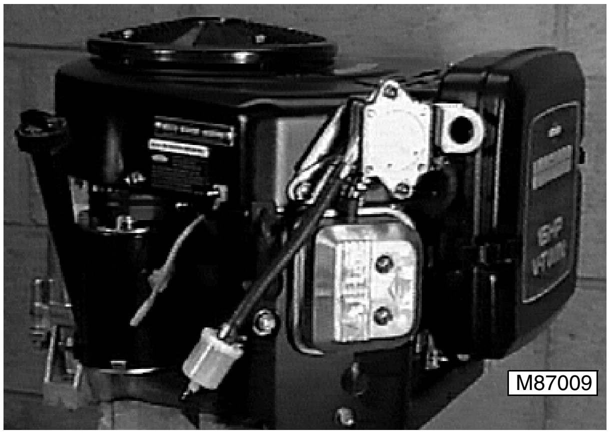
–Bearing wear

–Oil Seals

# FUEL AND AIR REPAIR

## UPPER BLOWER HOUSING REMOVAL AND INSTALLATION

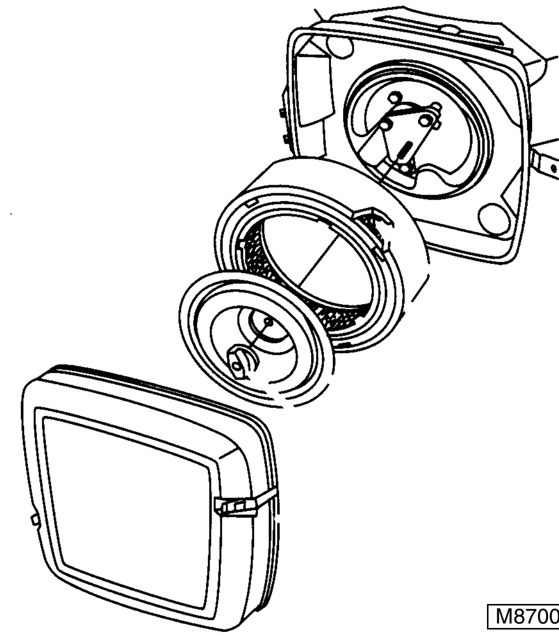
**Procedure:**




1. Remove rotating screen.
2. Remove fuel pump and bracket.
3. Disconnect upper bolt on dipstick tube.
4. Remove top carburetor access plate.
5. Remove upper blower housing.
6. Install in reverse order of removal.

# AIR CLEANER SERVICE

**Procedure:**



M87006

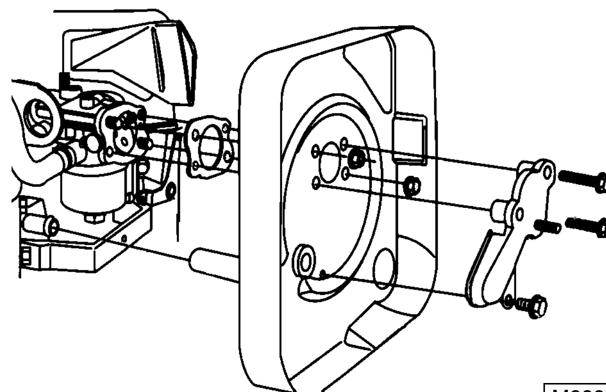
**IMPORTANT: DO NOT use petroleum solvents, such as kerosene, to clean paper cartridge. They may cause cartridge to deteriorate. DO NOT oil paper cartridge. DO NOT use pressurized air to clean or dry paper cartridge.**

1. To service pre-cleaner round dual element, remove cover assembly.
2. Slide foam pre-cleaner off cartridge.
3. Wash it in liquid detergent and water.
4. Squeeze it dry in a clean cloth.
5. Saturate it in engine oil. Wrap it in clean absorbent cloth and squeeze to remove excess oil.
6. Remove cartridge and clean by tapping gently on a flat surface. If very dirty, replace.
7. Reinstall cartridge, cover plate, knob and pre-cleaner.
8. Reinstall air cleaner cover.

# CARBURETOR REMOVAL AND INSTALLATION

**Removal:**

1. Remove carburetor access plate.
2. Remove air cleaner.

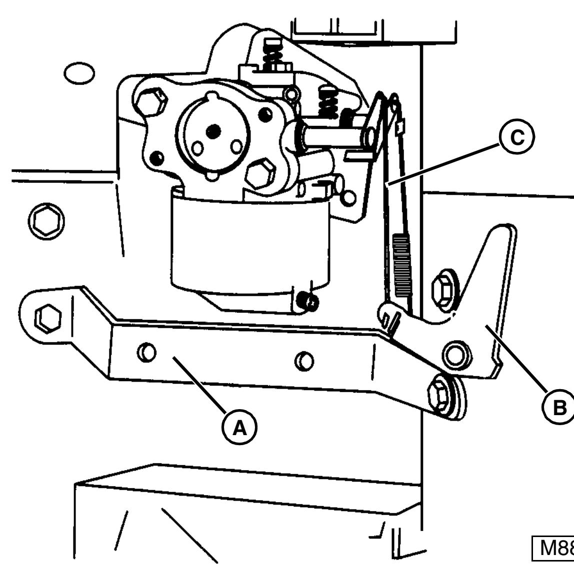


M88900

3. Remove air cleaner housing, air cleaner tube and breather tube.
4. Remove upper blower housing.

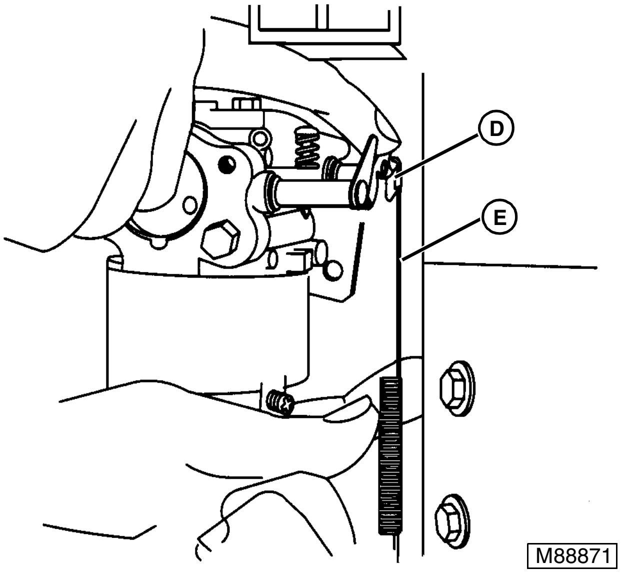
*NOTE: The engine is equipped with fuel shutoff solenoid. The blower housing should be removed so that the solenoid wire can be properly routed during reassembly. Disconnect fuel shutoff solenoid wire from equipment switch wire.*

5. Remove air cleaner base and breather tube.




M88870

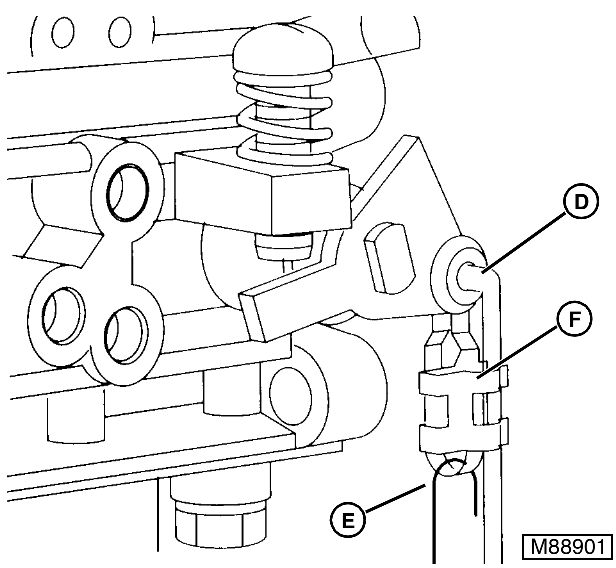
6. Remove two screws, air cleaner bracket (A), and choke control bracket (B).
7. Disconnect choke link (C) from carburetor.
8. Remove fuel line clamp and fuel line from carburetor.



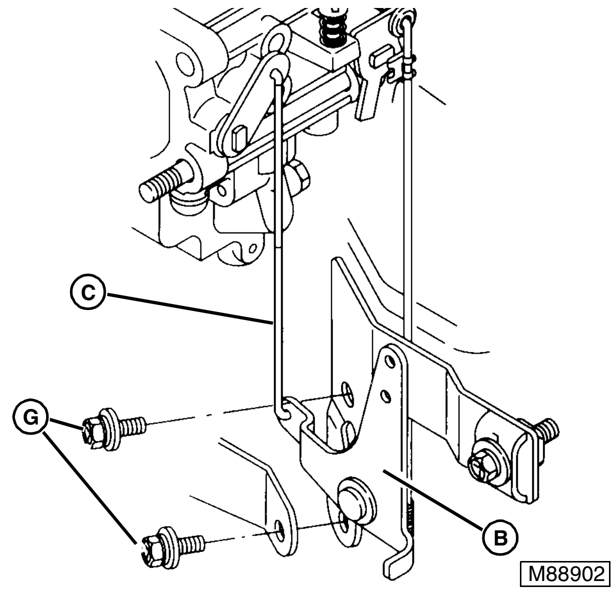

9. Disconnect governor link (D) and spring (E).
10. Remove carburetor, gaskets and spacer.

**Installation:**

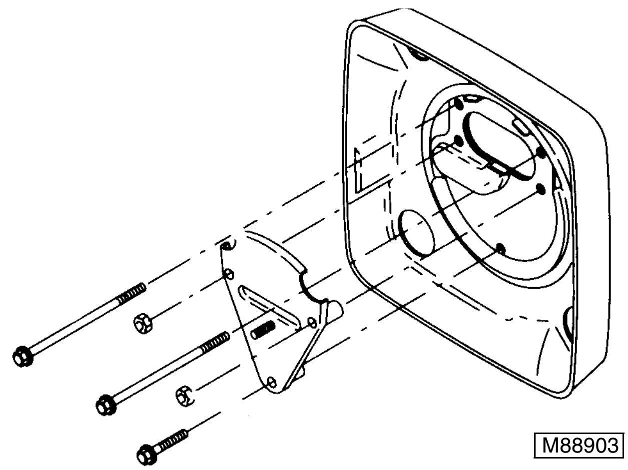
1. Install spacer, gaskets and carburetor. Tighten to **7 N•m (65 lb-in.)**.




2. Connect governor link (D) to throttle lever and snap retainer over link. Then install governor link spring (E) in loop on retainer (F).



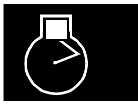

3. Connect choke link (C) to choke lever, install choke control bracket (B) and tighten to screws (G) **7 N•m (65 lb-in.)**.
4. Install blower housing and rotating screen. Install fuel pump and bracket and connect fuel line to carburetor. Rotate fuel line clamp so that it will not interfere with carburetor cover. DO NOT install carburetor cover at this time.




5. Install new air cleaner mounting gasket with adhesive side toward air cleaner base. Guide breather tube onto nipple on breather and install air cleaner base on carburetor mounting studs.

**IMPORTANT: Be sure breather tube is not kinked and that it is installed onto nipple as far as possible.**

6. Install carburetor shield.
7. Install nuts and screws finger tight.



**Specifications:**

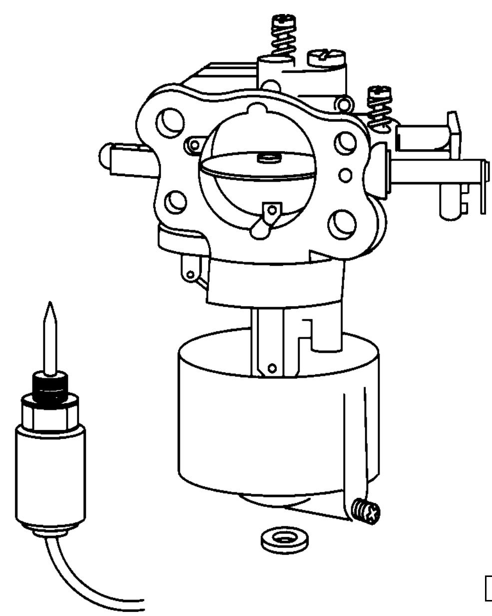
**Air Cleaner Bracket . . . . . . . . . . . . . 7 N•m (65 lb-in.)**
**Carburetor Screws . . . . . . . . . . . . . . 7 N•m (65 lb-in.)**
**Choke Control Bracket . . . . . . . . . . 7 N•m (65 lb-in.)**

*NOTE: Make sure air inlet tube is installed correctly in air cleaner base.*

> **⚠ CAUTION**
>
> **Static governor adjustment must be made whenever carburetor or manifold has been removed from engine. Failure to make static adjustments first could result in engine overspeeding and may result in engine or equipment damage causing personal injury or property damage.**

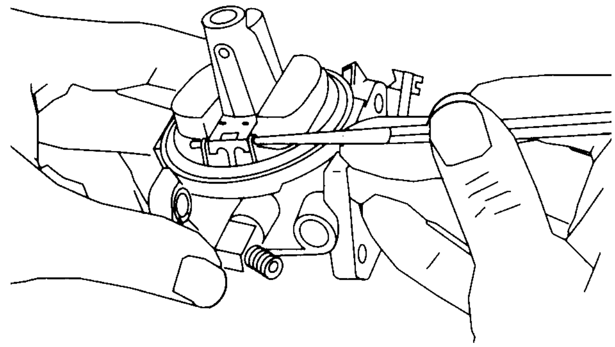
## CARBURETOR DISASSEMBLY

**Procedure:**



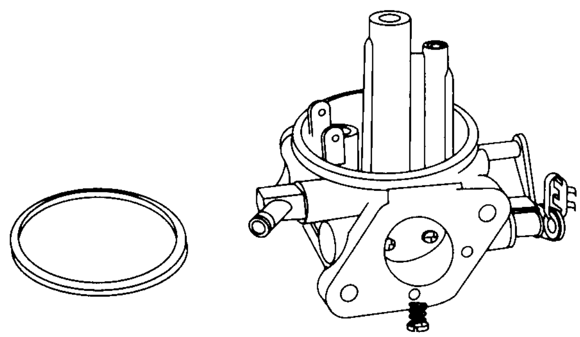
M88897

1. Observe position of bowl drain screw to aid in reassembly.
2. Remove fuel shutoff solenoid and washer and bowl.



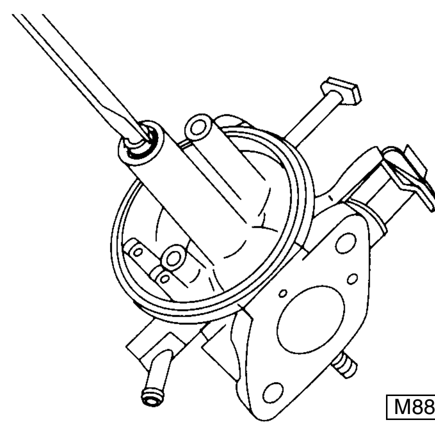
M88873

3. With a small punch, drive the float hinge pin out of float hinge. Remove float and fuel inlet valve assembly.



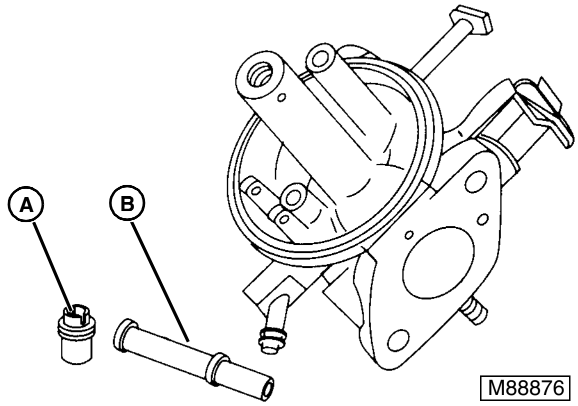
M88874

4. Remove carburetor bowl gasket.

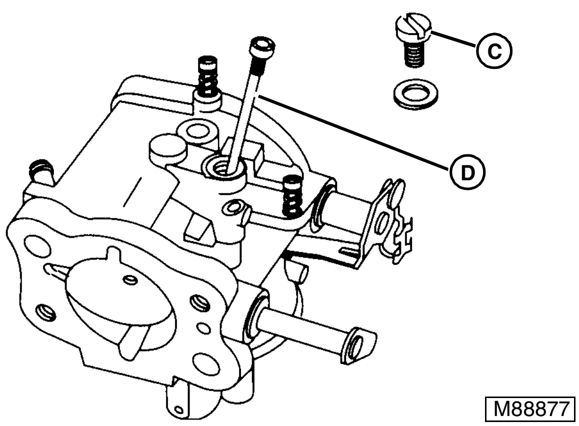


M88875

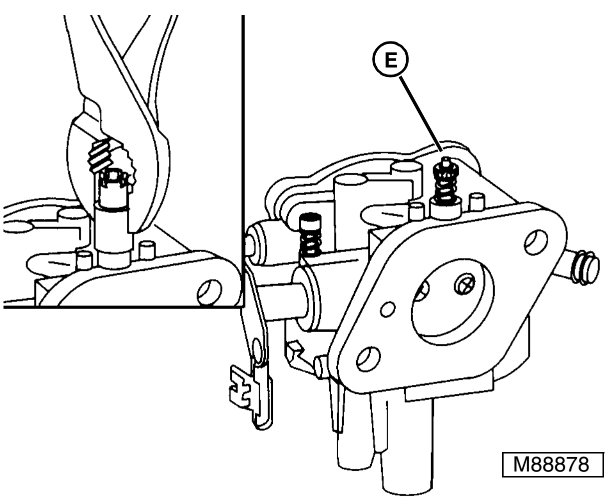
5. Remove fixed main jet (A) using a small blade screwdriver.




6. When the fixed main jet (A) has been removed, the high speed nozzle (B) can be removed. Reach into carburetor throat with a flat blade screw driver and push the high speed nozzle up through fixed main jet tube.

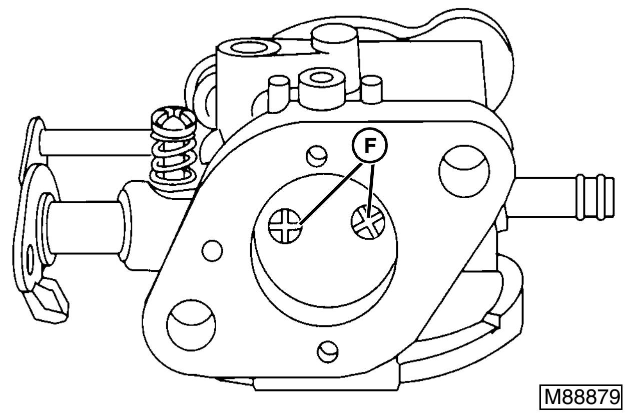



7. Remove idle jet plug (C) and idle jet (D).

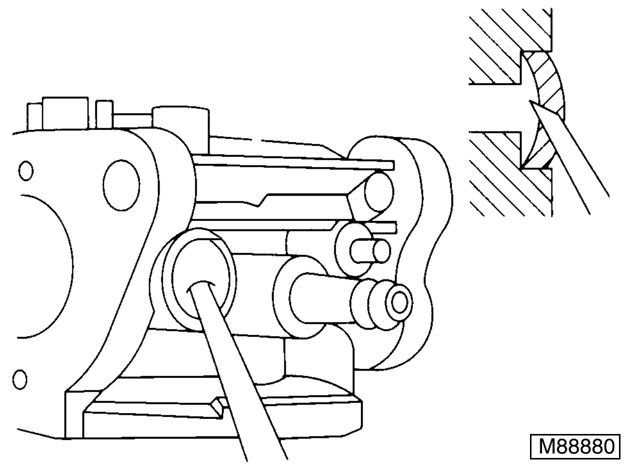



8. The idle mixture valve is equipped with a adjustment limiter cap. Use pliers to remove the cap.

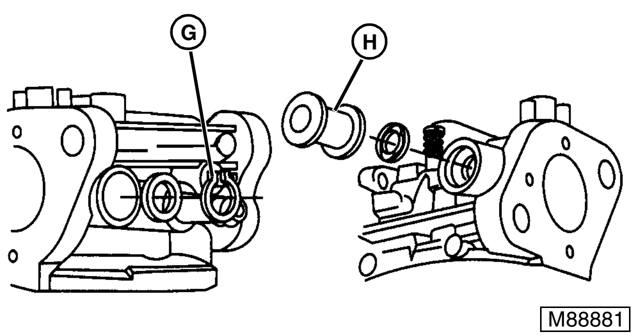
9. Remove the idle mixture valve (E).




10. Remove two screws (F) holding throttle valve to throttle shaft and remove throttle valve.

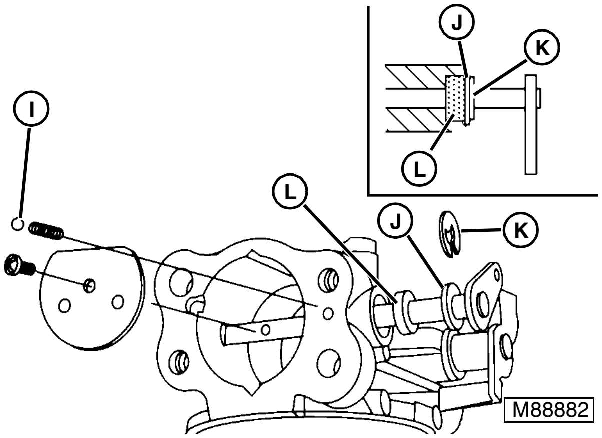



11. To remove throttle shaft it is necessary to first remove welch plug from side of carburetor. Use a punch to puncture and remove the plug.



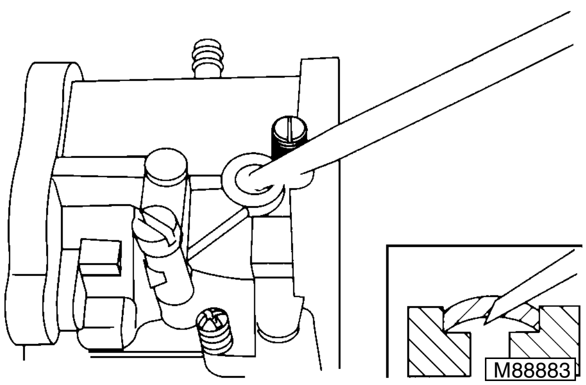

12. Remove external snap ring (G) and throttle shaft washer.
13. Remove throttle shaft, throttle shaft collar (H) and throttle shaft seal.

*NOTE: Lip of seal goes out.*




*NOTE: The choke shaft has a ball (I) and spring that keeps tension on the choke shaft. Use care when removing choke shaft.*

14. Remove choke valve screw and choke valve. Remove E- ring (K), then remove choke shaft, washer (J) and felt seal (L).



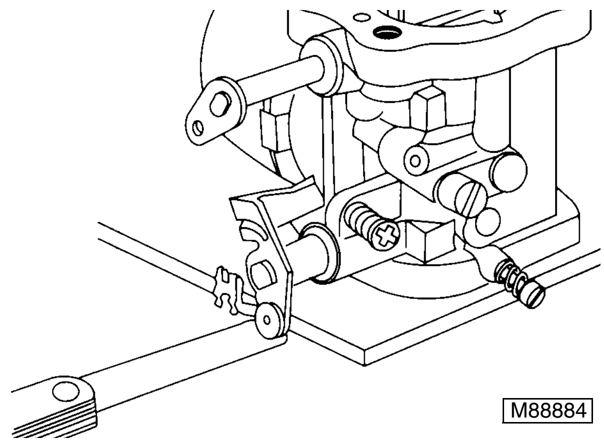

15. Remove small welch plug from top of carburetor body.

# CARBURETOR INSPECTION

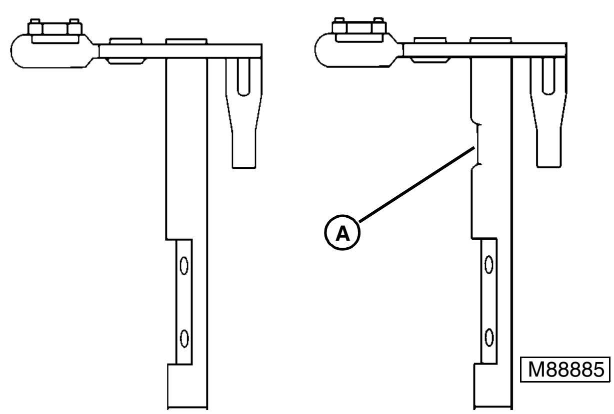
**IMPORTANT: A clean fuel system is necessary in order to maintain proper operation of the engine. Gummy or dirty fuel tanks and carburetors should be cleaned in a carburetor cleaner such as Bendix Carburetor cleaner or equivalent. DO NOT soak rubber, neoprene or plastic parts in cleaner.**

**Procedure:**

1. Check all moving parts for wear, nicks and burrs. Replace, if worn or damaged.
2. Check float for leaks or damage. Replace, if damaged or leaking.
3. Check all mating surfaces for nicks, burrs, foreign material, or cracks. Replace all damaged parts.




4. Inspect throttle and choke shaft and bushings for wear. Wear between throttle shaft and bushing should not exceed **0.25 mm (0.010 in.)**.
5. Check wear by placing carburetor on a flat surface. Measure the distance between the throttle lever and flat surface with a feeler gauge while pushing shaft down. Measure the distance again while pulling the shaft up.




6. If the difference between the two measurements is

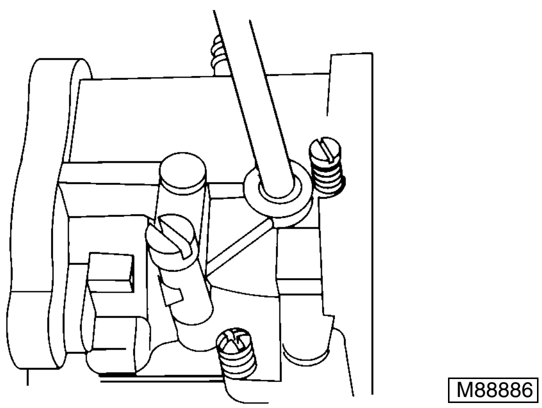
greater than **0.25 mm (0.010 in.)**, this indicates that the throttle shaft and/or bushings are worn.

7. Wear on the throttle shaft can be checked by comparing the worn (A) and unworn portions of the shaft.
8. Choke shaft and bushings are checked in the same manner.
9. Throttle and choke shaft are replaceable. If throttle or choke shaft bushings are worn, replace carburetor.

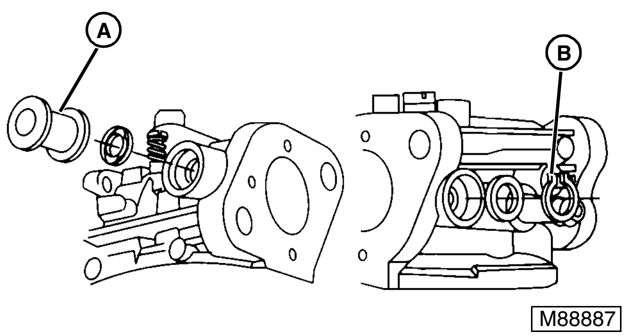
# CARBURETOR ASSEMBLY

**IMPORTANT: When assembling the carburetor, use new seals and gaskets.**

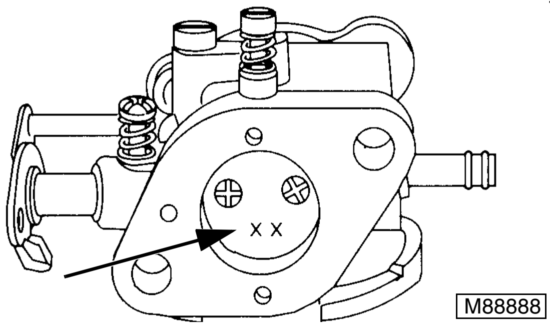
**Procedure:**



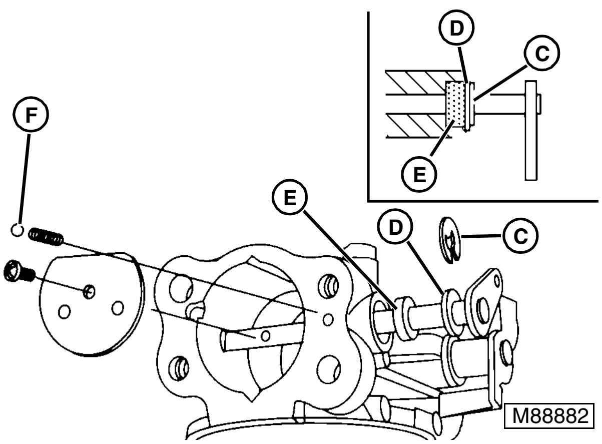

1. Install new secondary idle port welch plug. Use a round punch and tap in plug until it is flat. Use a sealant such as **Permatex® #2** or nail polish on outside diameter of plug to prevent air leaks.



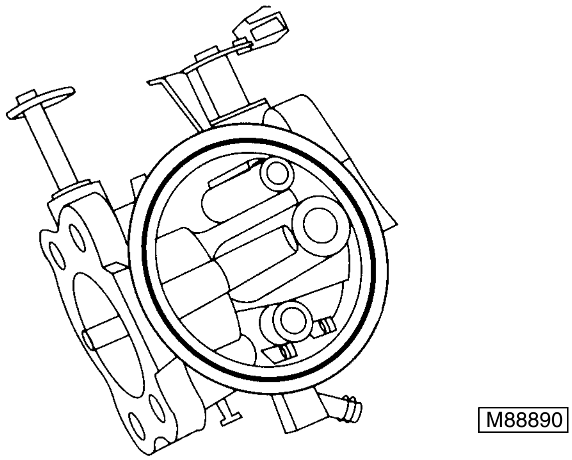

2. Install throttle shaft seal with sealing lip out. Slide collar (A) over throttle shaft and insert throttle shaft through carburetor body. Place washer over end of throttle shaft and install new snap ring (B).



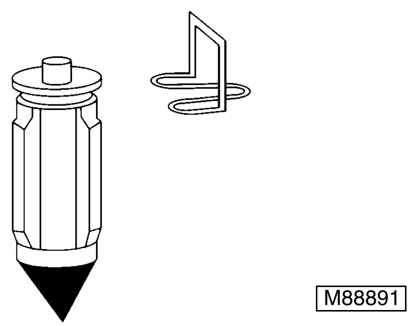

3. Install throttle valve on shaft with numbers down. With throttle valve in closed position, tighten screws securely.
4. Install new welch plug in side of carburetor body. Use a round punch and tap in plug until it is flat. Use a sealant on outside diameter of plug to prevent air leaks.



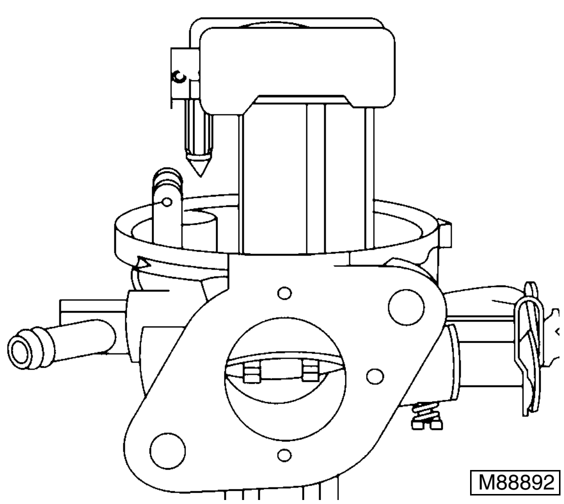

5. Install new E-ring (C), washer (D) and felt seal (E) onto choke shaft.
6. Insert spring and check ball (F) in to spring pocket. Push choke shaft into hole until ball engages groove in choke shaft.
7. Place choke valve onto flat on choke shaft, with flat edge of choke valve up and dimples down.
8. With choke valve in closed position, install and tighten screw securely.



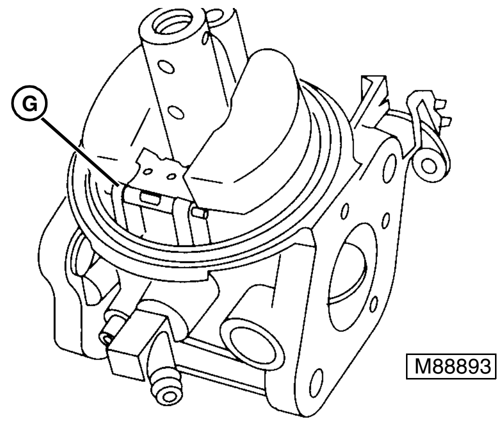

9. Install carburetor bowl gasket in carburetor body groove. Make sure gasket does not twist or kink.



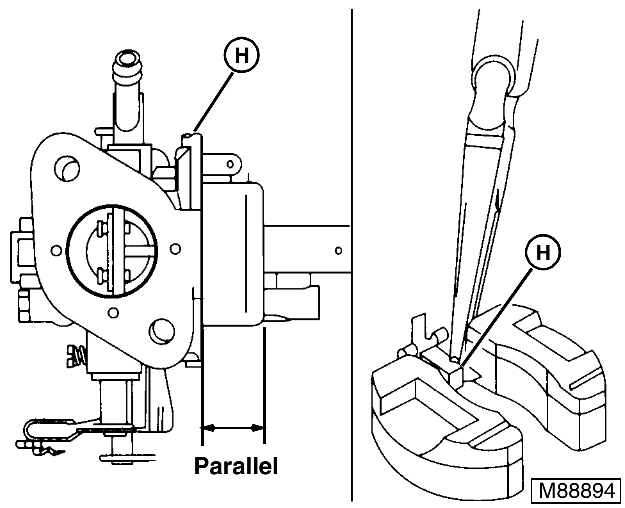

10. Install fuel inlet valve retainer in fuel inlet valve groove.



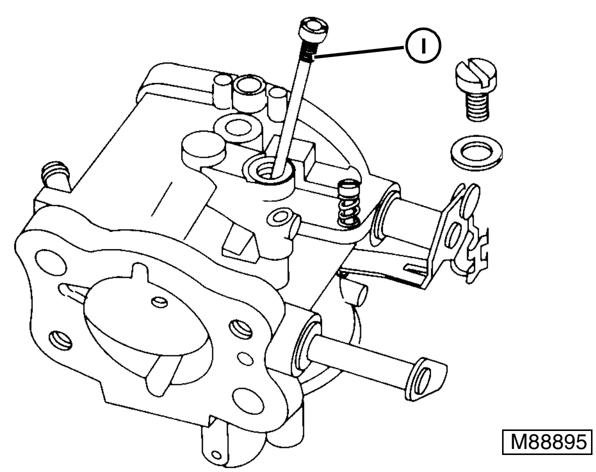

11. Slide fuel inlet valve assembly onto float tang and place assembly in carburetor.



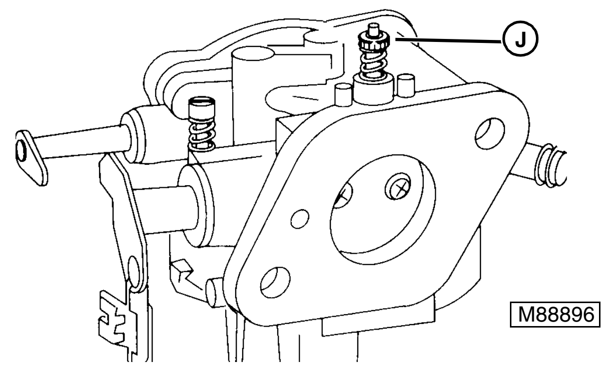

12. Install float hinge pin (G) into place.




13. Hold carburetor in vertical position, with float hinge up. The float should be parallel with carburetor bowl mounting surface. If not, bend tang (H). DO NOT press on float to adjust.

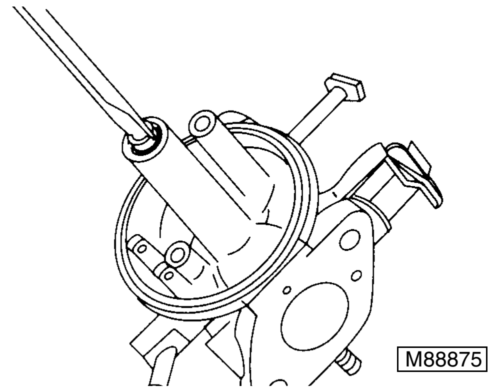



14. Install idle jet (I), plug and gasket. Tighten plug securely.

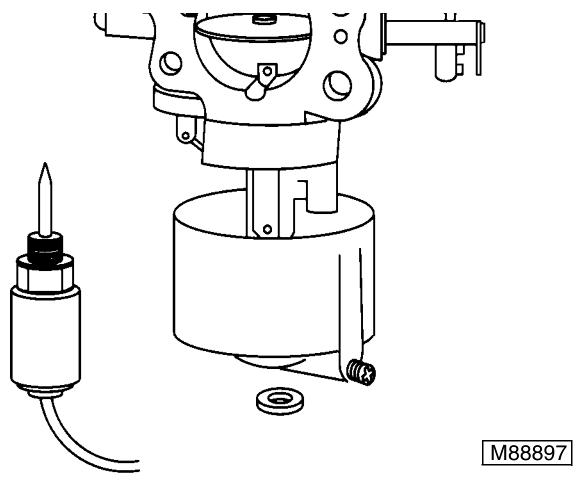



15. Install idle mixture valve (J) and adjustment limiter cap.

*NOTE: Special high altitude jets may be required in certain areas.*




16. Install high speed nozzle and fixed main jet.




17. Install bowl, washer and screw or fuel shutoff solenoid and washer. Position bowl drain.

**Specification:**

**Solenoid Torque . . . . . . . . . . . . . . . . 5 N•m (45 lb-in.)**

# ENGINE REPAIR

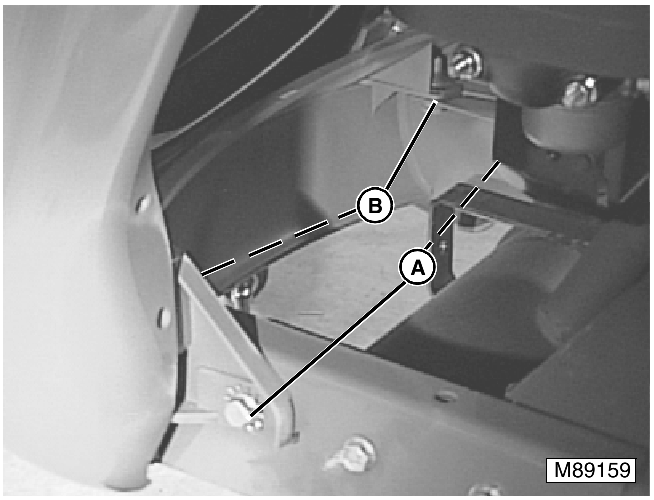
## ENGINE REMOVAL AND INSTALLATION

**Conditions:**

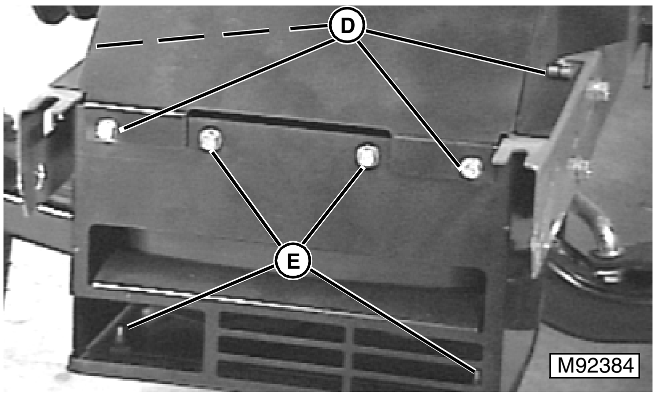
- Machine parked on level surface
- Park brake engaged
- PTO disengaged
- Mower deck removed

**Procedure:**

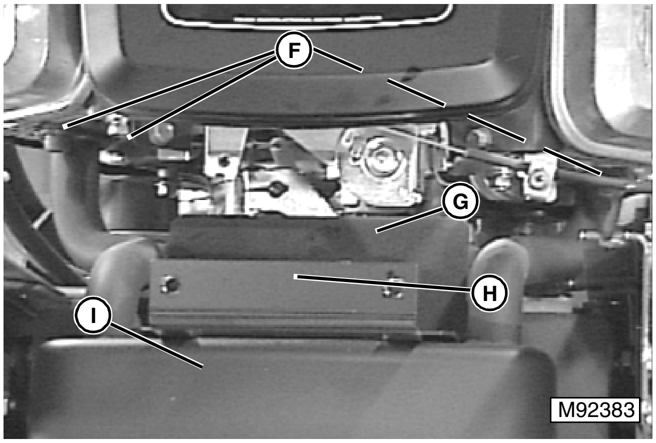
1. Turn all switches OFF, raise hood, disconnect battery, headlight connector, and spark plug lead.




2. Remove two bolts (A) securing the hood to the left and right frame side rails. Loosen the two bolts (B) securing the hood to the upper side of the left and right side rails. Remove hood.

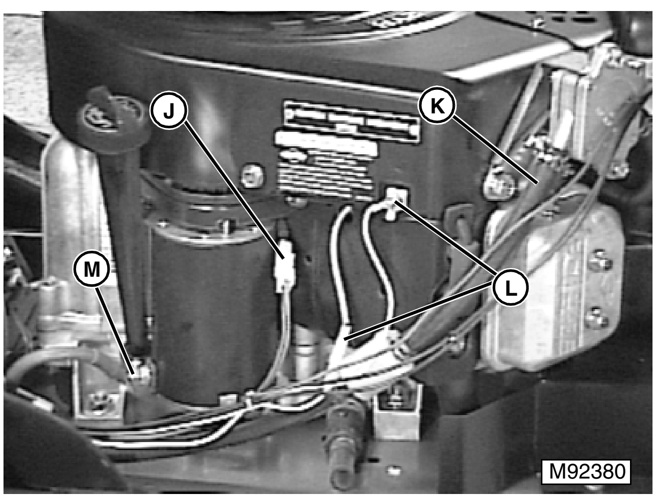



3. Remove four (4) upper shield bolts (D), four (4) lower shield bolts (E) and remove both shields.

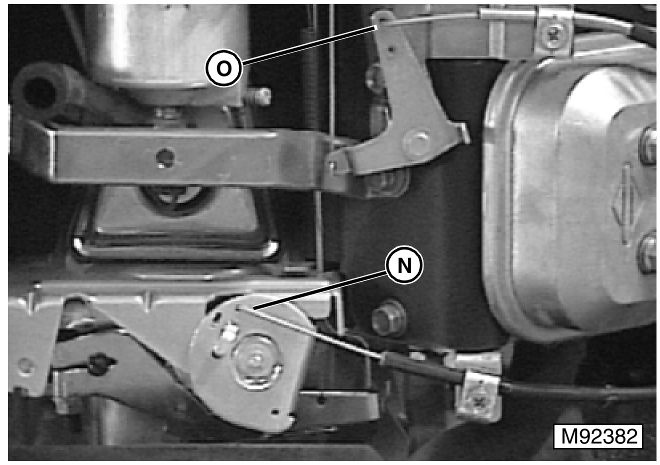



4. Remove inner shield (G), bracket (H) from frame, four (4) muffler bolts (F) and muffler (I).

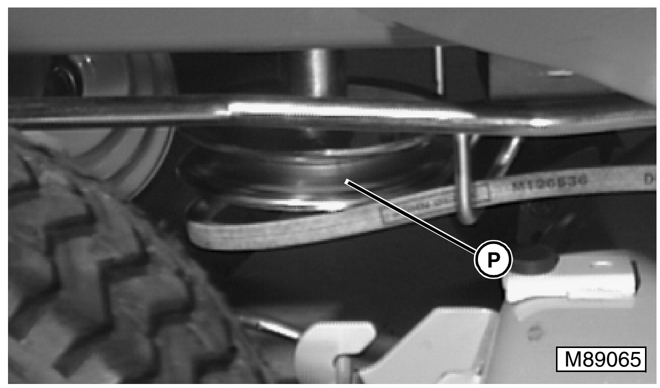
> **⚠ CAUTION**
>
> **Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment; including equipment that utilizes pilot lights. Wipe-up any spills IMMEDIATELY.**




5. Disconnect engine connector (J), fuel line (K), engine connections (L) and starter cable (M).

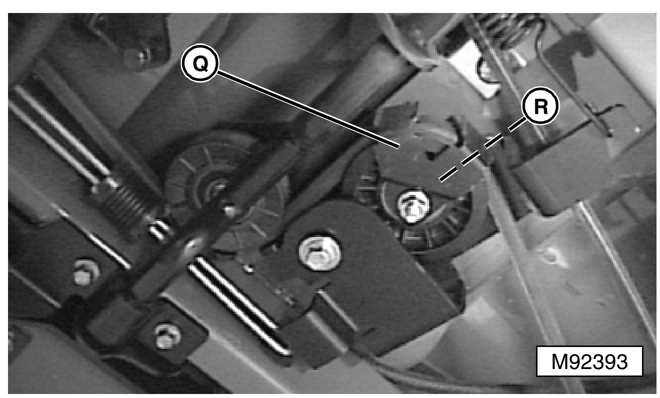



6. Disconnect choke cable (O) and throttle cable (N).

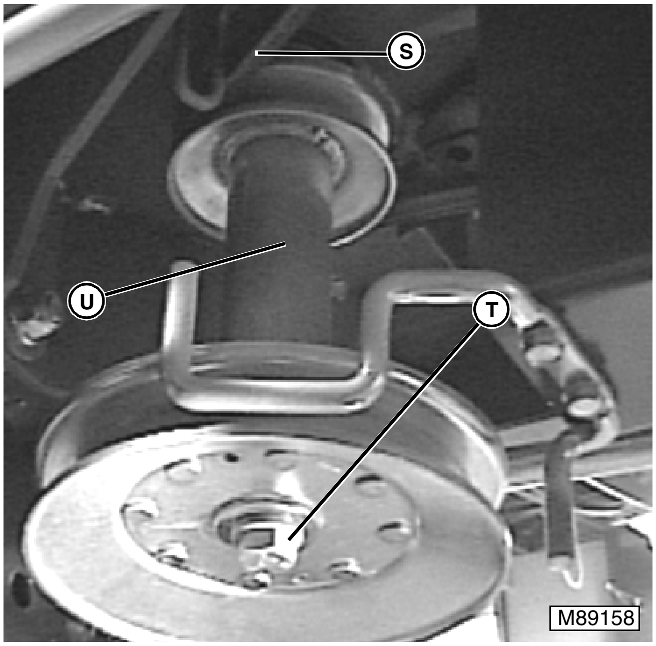



7. Remove mower drive belt (P).

*NOTE: It is not necessary to completely remove drive belt to remove engine.*



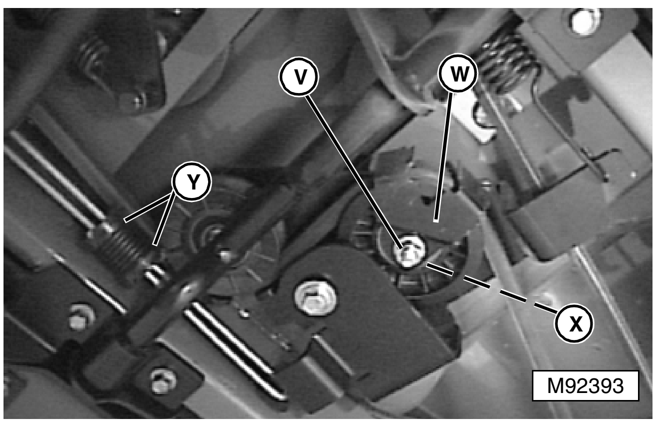

8. Remove belt guide nut and belt guide (Q).
9. Loosen idler nut (R) and slide idler forward until belt can be removed from double sheave.



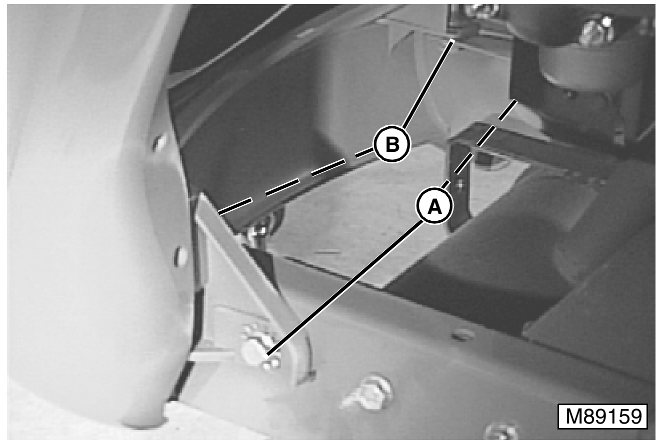

10. Remove engine drive belt (S) from double sheave.
11. Remove sheave nut (T) and double sheave (U).
12. Remove four engine mounting bolts and remove engine.

**Installation:**

1. Install engine and tighten four (4) engine mounting bolts to **32 N•m (24 lb-ft)**.
2. Install double sheave and sheave nut. Tighten nut to **75 N•m (55 lb-ft)**.
3. Install drive belt.




4. Slide belt idler (V) rearward until distance between plastic caps of compression spring (Y) is **32.5 mm (1.28 in.)**.
5. Tighten idler nut (X) to **26 N•m (19 lb-ft)**.
6. Install belt guide (W).
7. Inspect muffler flange for flatness. Install muffler, new gasket, and shield. Tighten muffler bolts to **24.4 N•m (18 lb-ft)**.
8. Connect and adjust throttle cable and choke cable.
9. Connect fuel line and adjust carburetor
10. Make all electrical wiring connections, including spark plug lead and battery (negative cable last).




11. Slide hood into position and install bolts (A). Lightly tighten fasteners so that the hood can be aligned.


12. Lower hood into the locked position and align hood as shown (C). Tighten bolts (B), then raise hood and tighten bolts (A).

**Specifications:**

| | |
|---|---|
| **Compression Spring** | **32.5 mm (1.28 in.)** |
| **Engine Mounting Bolts** | **32 N•m (24 lb-ft)** |
| **Muffler Mounting Bolts** | **24.4 N•m (18 lb-ft)** |
| **Idler Nut.** | **26 N•m (19 lb-ft)** |
| **Double Sheave Bolt** | **75 N•m (55 lb-ft)** |

## CYLINDER AIR GUIDES REMOVAL AND INSTALLATION

**Removal:**

1. Remove upper blower housing.
2. Remove air filter assembly.
3. Disconnect carburetor linkage.
4. Remove carburetor.
5. Remove intake manifold.
6. Remove front and side cylinder air guides.

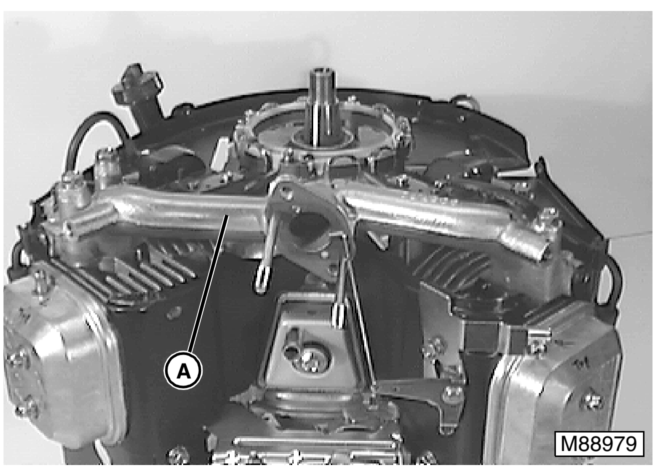
**Installation:**

1. Install right, front and side cylinder air guides.
2. Install carburetor.
3. Install carburetor linkage.
4. Install air filter assembly.
5. Install upper blower housing.

## INTAKE MANIFOLD REMOVAL AND INSTALLATION

**Procedure:**

1. Remove upper blower housing.
2. Remove air filter assembly.
3. Remove cylinder air guides.
4. Disconnect carburetor linkage.
5. Remove carburetor.




6. Remove intake manifold (A).
7. Clean all surfaces of old gasket material.

*NOTE: Replace used intake manifold and carburetor gaskets with new gaskets.*

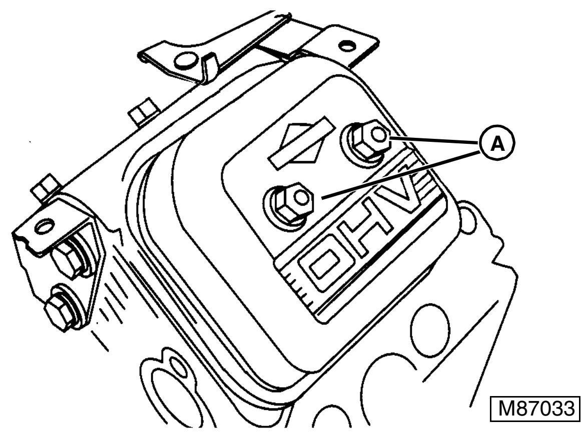
8. Install intake manifold.
9. Install carburetor.
10. Connect carburetor linkage.
11. Install cylinder air guides.
12. Install air filter assembly.
13. Install upper blower housing.

## CYLINDER HEAD REMOVAL AND INSTALLATION

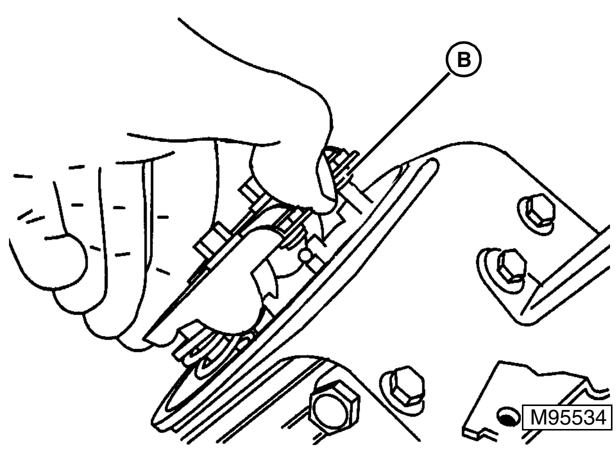
**IMPORTANT: Mark all parts when disassembling cylinder heads to prevent interchanging.**

**Procedure:**

1. Disconnect spark plug leads. Remove spark plugs.
2. Remove air cleaner assembly, support, choke bracket, carburetor and blower housing.
3. Remove intake manifold, valley cover, exhaust manifold, governor control bracket and linkage.
4. Remove cylinder air guides.



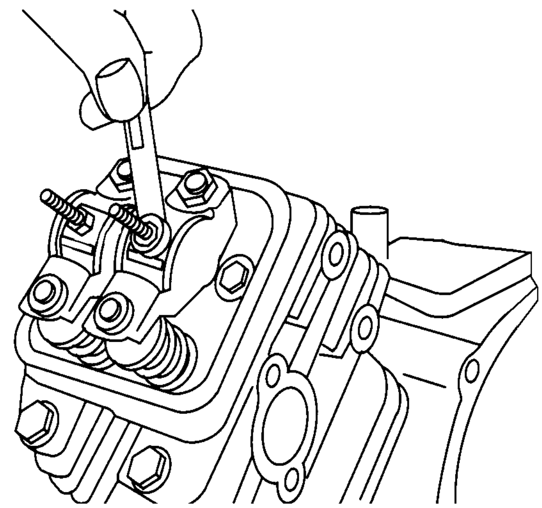

5. Remove nuts (A) and valve cover.

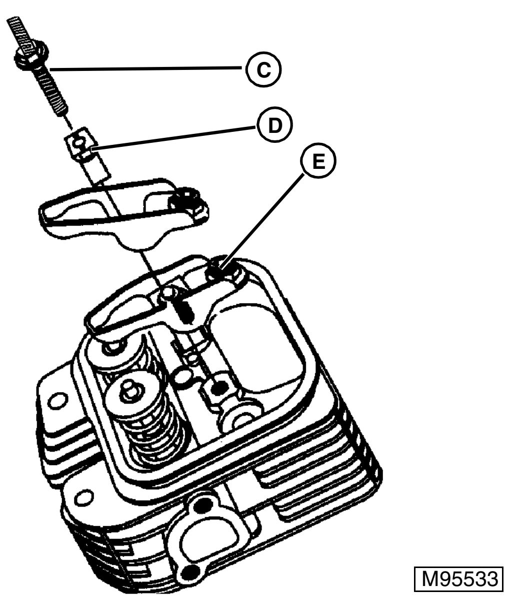



*NOTE: To release spring pressure from rocker arms,* *rock the arm against spring pressure and allow push rod (B) to drop out of the rocker arm socket. Push rod will move out of position, releasing valve spring pressure.*

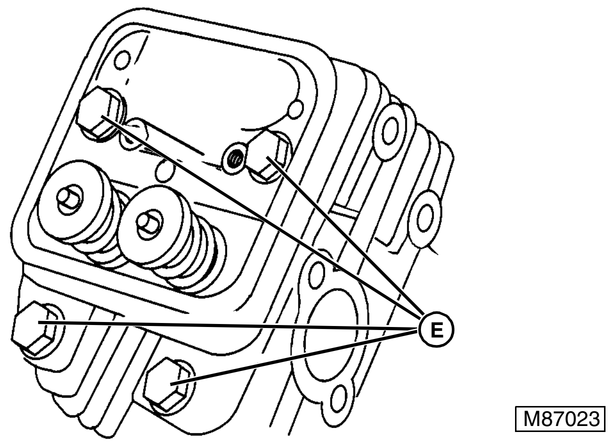
6. Release valve spring pressure.

**IMPORTANT: Exhaust valve push rods are aluminum. Intake valve push rods are steel. Mark push rods to prevent interchange during assembly.**

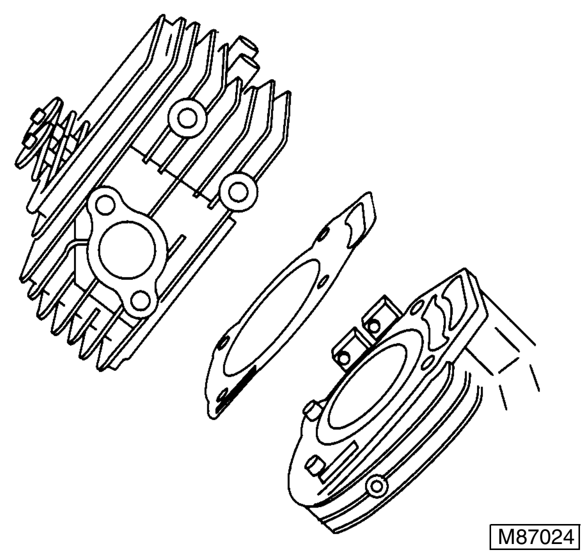





7. Remove rocker studs (C), supports (D) and rocker arms (E).
8. Lift out push rods.

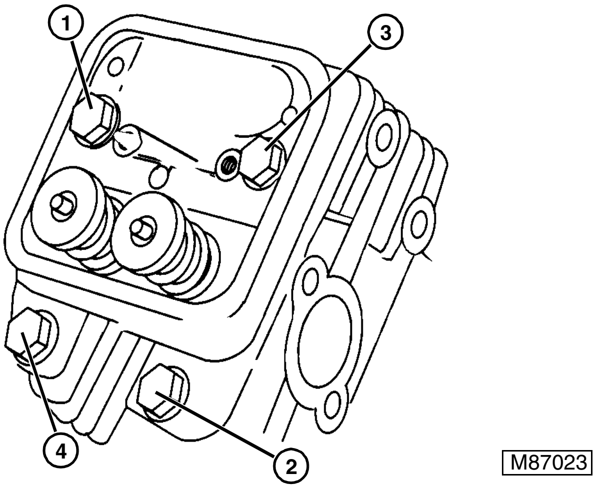



9. Remove cylinder head bolts (E).




10. Remove cylinder head and gasket.
11. Place new gaskets and cylinder head on cylinder. Align head with cylinder head alignment sleeves located in the cylinder.
12. Apply approved lubricant to bolts threads and install four cylinder heads bolts and two sealing washers.

**IMPORTANT: Do not use sealer of any kind on gaskets.**




13. Tighten four bolts down evenly by hand. Use a torque wrench to tighten the cylinder head bolts in sequence shown.

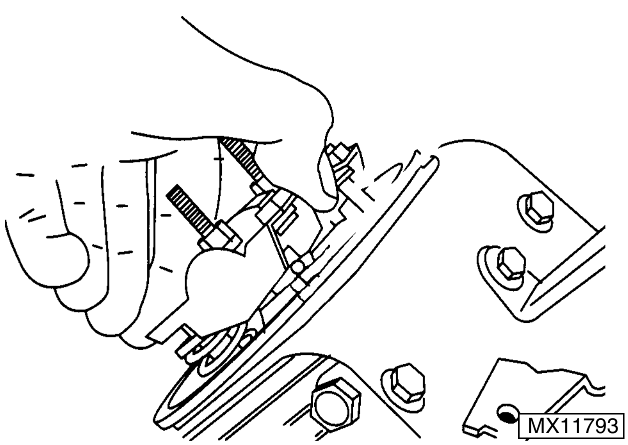
**IMPORTANT: Do not tighten one bolt down completely before all the bolts have been hand tightened evenly. Uneven tightening may cause a warped cylinder head.**

**Torque Specification:**

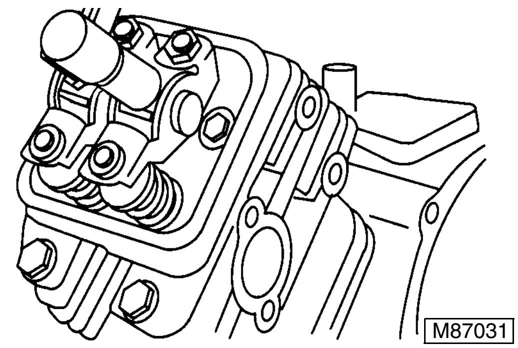
**Cylinder Head Bolts . . . . . . . . . . . 25 N•m (220 lb-in.)**

14. Insert push rods into recess in tappets.

**IMPORTANT: Exhaust valve push rods are aluminum. Intake valve push rods are steel. Do not interchange push rods during assembly.**



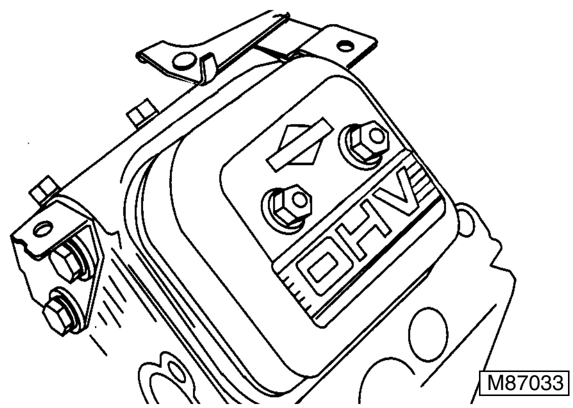

15. Compress valve spring with rocker arm and insert push rod into rocker arm socket. Be sure push rods remain seated in recess in tappets.




16. Lubricate rocker arm supports with clean engine oil.
17. Assemble rocker arms, supports and rocker studs. Install on cylinder head.
18. Tighten bolts to **11 N•m (100 lb-in.)**.
19. Adjust valves. See “VALVES INSTALLATION” on page 31.

**Torque Specification:**

**Studs . . . . . . . . . . . . . . . . . . . . . . . 11 N•m (100 lb-in.)**




20. Install gasket and valve cover. Place seal washers and nuts on studs.
21. Install intake and exhaust manifold, governor control bracket, cylinder air guides, valley cover, blower housing and air cleaner assembly.
22. Install spark plugs.Tighten to **20 N•m (180 lb-in.)**.
23. Install spark plug leads.

# CYLINDER HEAD INSPECTION AND REPAIR

**Procedure:**

1. Remove combustion chamber deposits from combustion chamber and around valves using a soft, hand wire brush or scraper. With piston at TDC remove combustion chamber deposits from top of piston.

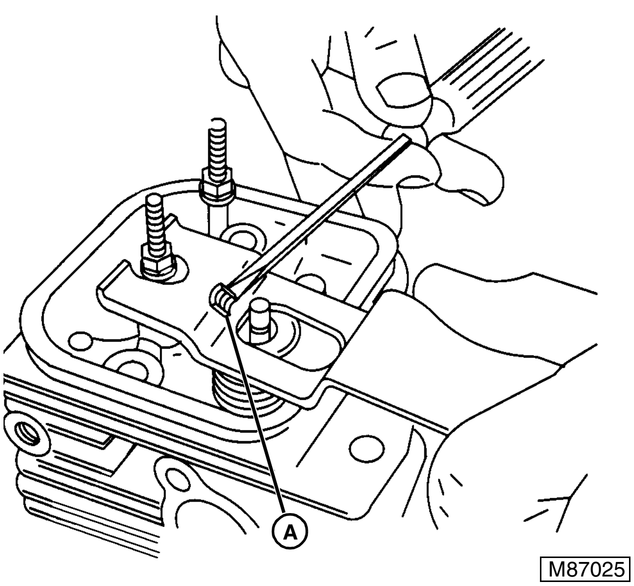
**IMPORTANT: Use care to prevent combustion chamber deposits from entering push rod or oil return cavity in cylinder. Take care not to damage cylinder, top of piston, cylinder head and cylinder head gasket surfaces. Remove only the combustion chamber deposits. It is not necessary to remove the discoloration marks on the piston, valves and cylinder head. These marks are normal and will not affect engine operation.**

2. Inspect cylinder head for broken fins or cracks. Repeat procedure for other cylinder head and cylinder.

# VALVES REMOVAL

**Procedure:**

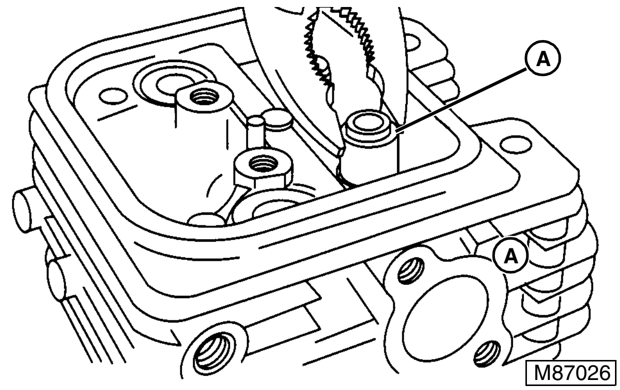
1. Remove the valves, place cylinder on workbench with support to hold valves in place.




2. Reinstall rocker studs into cylinder head. Do not tighten. Slip end of valve spring compressor under stud of valve spring. Press down on tool handle to compress valve spring and remove split retainers (A).
3. Release pressure and remove retaining washer and spring.
4. Remove rocker studs.
5. Repeat procedure on other cylinder head.

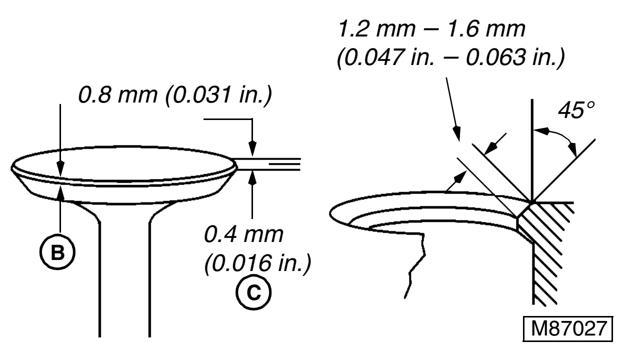
# VALVES INSPECTION AND REPAIR

**Procedure:**




1. To remove valve stem seals (A), grasp seal with pliers and pull up on seal while turning.

**IMPORTANT: Always replace valve stem seals whenever valves are removed for servicing.**

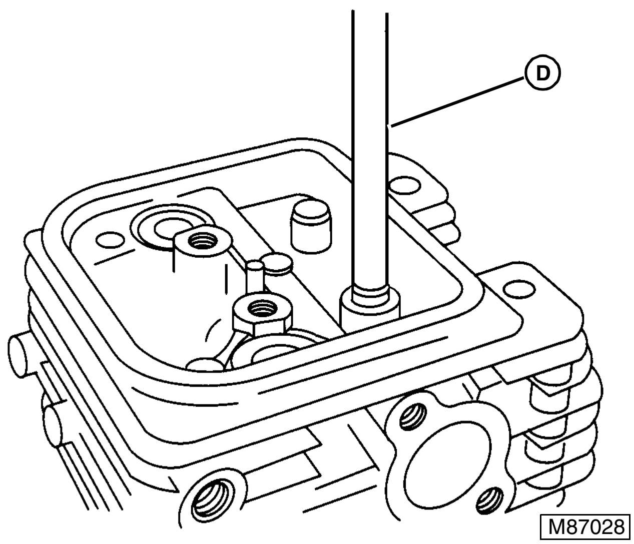



2. Faces on valves may be resurfaced with a valve grinder to 45°. Valve seats can be reconditioned using valve seat cutter. Valves and seats should then be lapped with valve lapping tool and valve lapping compound. Remove grinding marks and assure a good seal between valve and seat. Thoroughly clean lapping compound from valve seat and valve face.
3. Valve seat width should meet specification.

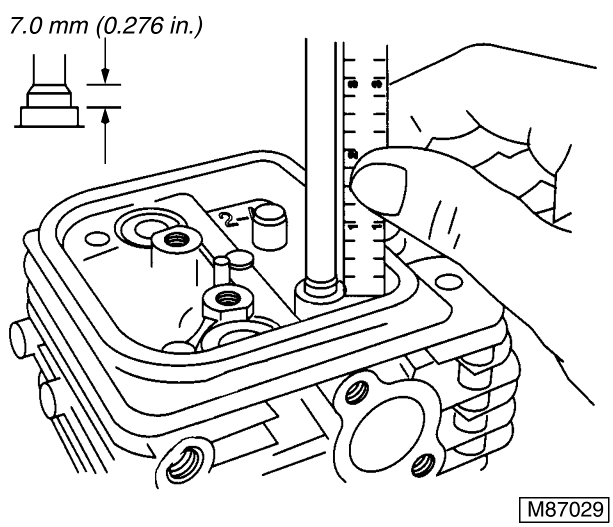
**Specification:**

**Valve Seat Width . . 1.2 – 1.6 mm (0.047 – 0.063 in.)**

4. If seat is wider than specification, it may be narrowed using valve seat cutter. Use 30° side of cutter to narrow the seats. If the valve is badly burned, it should be replaced. Replace valve if margin (B) is below specification (C) or is badly burned or damaged. Valve seats are not replaceable. If valve seats are badly burned or damaged, replace cylinder head.
5. Inspect valve springs. Replace if broken or worn.
6. Inspect valve guides by inserting plug gauge into valve guide. If plug gauge inserts **6.4 mm (0.252 in.)** or more, the guide must be replaced. If plug gauge is not available, the rejection dimension for both intake and exhaust valve guides is **6.05 mm (0.238 in.)**.



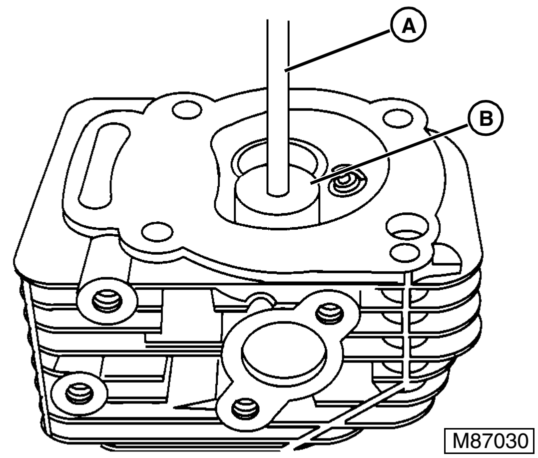

7. To remove valve guides, use bushing driver (D). Support cylinder head and press out valve guide.




8. To install new valve guides, place new valve guide on bushing driver. Valve guide can be installed either way. Press in valve guide to dimension **7.0 mm (0.281 in.)**.

## VALVES REAM

**Procedure:**



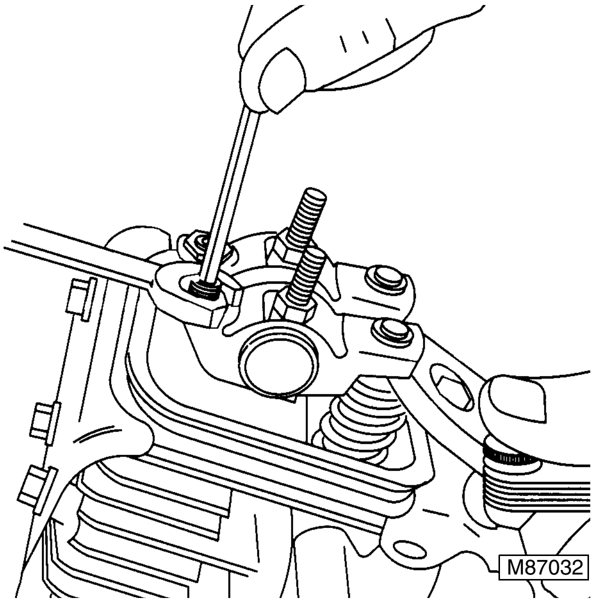

1. To ream valve guides, use finish reamer (A) and reamer pilot guide (B) to finish ream valve guide. Use oil, Stanisol or kerosene to lubricate reamer. Ream through entire guide. Keep turning reamer clockwise when removing reamer. Flush out all chips.
2. Install new seals over valve guides. Press down on seal until it bottoms. Valve stems must be free of foreign material and burrs or sticking will occur and valve stem seals will be damaged. Be sure valve guides are free of foreign materials and burrs. Lightly coat valve stems with valve guide lubricant and insert valves into valve guides.

**IMPORTANT: Insure valve guide lubricant is not on valve face, seat or end of valve stem.**

## VALVES INSTALLATION

**Procedure:**

1. Install springs and valve spring retainers over valve stems. Temporarily install rocker studs in cylinder head. With valve spring compressor, compress spring and install split retainers. Repeat procedure for other valves. Remove rocker studs.




*NOTE: Correct position of the crankshaft is necessary to eliminate interference by the compression release mechanism on the cam gear when adjusting valve clearance.*

2. Turn crankshaft until piston in cylinder you are checking is at TDC on the compression stroke (both valves closed). Using a screwdriver or similar object inserted through spark plug hole and touching the top of the piston, continue turning crankshaft clockwise until piston has moved **6.35 mm (0.250 in.)** past top dead center.
3. Check valve clearance with feeler gauge between valve stem and rocker arm. Valve clearance specifications are the same for both the intake and exhausts.
4. Tighten lock nut to **7 N•m (60 lb-in.)**.
5. Recheck clearance. Readjust if required.
6. Rotate crankshaft several turns to check for proper operation.

**Specifications:**

**Valve Clearance . 0.10 – 0.16 mm (0.004 – 0.006 in.)**
**Lock Nut Torque . . . . . . . . . . . . . . . . 7 N•m (60 lb-in.)**

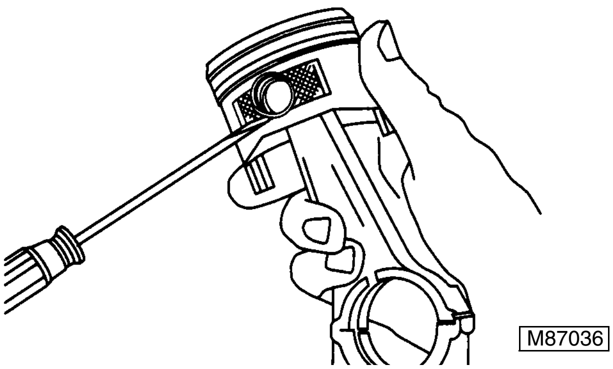
## PISTON, RINGS AND ROD REMOVAL AND INSTALLATION

**Procedure:**

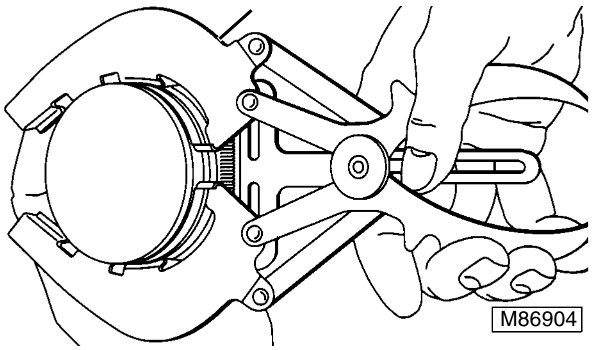
1. Remove air filter and bracket, upper blower housing, flywheel, alternator, carburetor and governor linkage.
2. Remove starter, cylinder heads and crankcase cover.

*NOTE: Remove any carbon or ridge at the top of the cylinder bore. This will prevent breaking the rings when removing the piston and connecting rod from the engine.*

3. Remove the connecting rod cap. Then push the piston and connecting rod out through the top of the cylinder.




4. To remove connecting rod from piston, remove piston pin locks with screwdriver. Piston pin is a push fit in piston and rod. Deposits may build up on piston pin and require the piston pin to be pressed out.

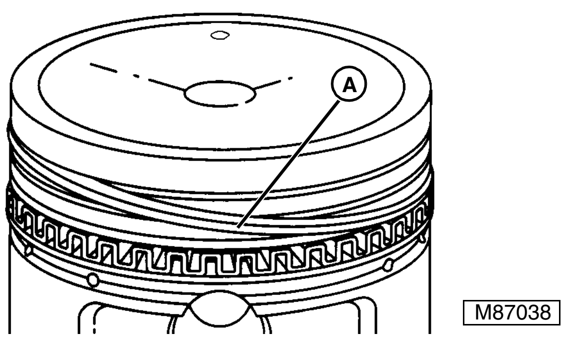



**IMPORTANT: Remove top and center compression rings using ring expander. New piston rings must be installed whenever the engine is disassembled for major servicing or overhaul, providing that cylinder bores are within specifications.**

*NOTE: Measure cylinder bores before checking pistons and rings. If cylinder bores require resizing it will not be necessary to check pistons and rings since a new oversized piston assembly will be used.*

5. If cylinder bore is more than **0.08 mm (.003 in.)** oversize, or **0.04 mm (.0016 in.)** out of round, it must be resized.

**IMPORTANT: When servicing pistons, rings, piston pins or rods, each rod, piston, piston pin and ring set must be kept as a set for the cylinder that it was removed from. Mark each set before removing from the engine.**

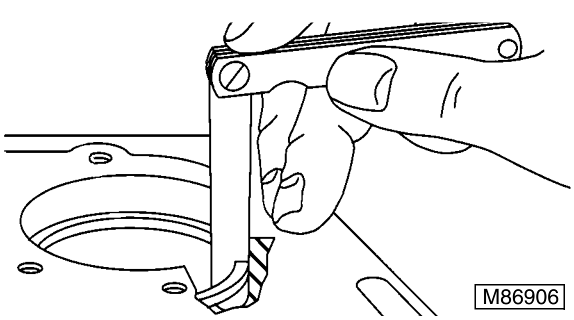



*NOTE: Oil control ring (A) is shown being spiraled into compression ring groove.*

6. Spiral top oil control ring from oil ring groove into center compression ring groove. Repeat into top compression ring groove, and then off piston. Repeat for bottom oil control ring.

*NOTE: If the cylinder is to be resized, there is no reason to check the piston, since a new oversized piston assembly will be used. If however, the cylinder is not to be resized and the piston shows no signs of wear or scoring, the piston rings must be replaced.*

7. Insert old rings one at a time approximately **25.4 mm (1.0 in.)** down into a cylinder bore.




8. Check end gap with feeler gauge. If ring gap is greater than **0.76 mm (0.030 in.)** for compression and oil ring, the ring groove is worn and should be replaced.

A worn ring will usually show scratches caused by abrasives and/or have a shiny appearance. Never reuse worn piston rings.

**⚠ CAUTION**

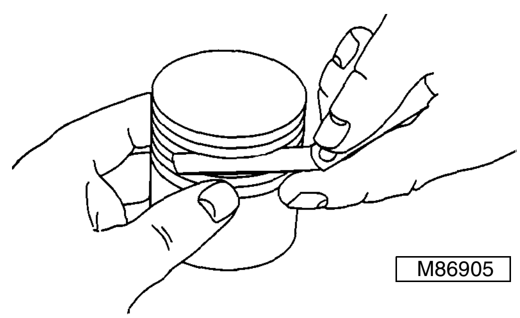
**The top and bottom edges of the ring may be extremely sharp. Never reuse worn piston rings.**

*NOTE: Before installing new piston rings, the cylinder bore should be reconditioned using a rigid hone with finishing stones. This will restore the proper cross hatch angle in the cylinder bores. The correct cylinder cross hatch ensures proper lubrication and piston ring rotation.*

## PISTON INSPECTION

**Procedure:**

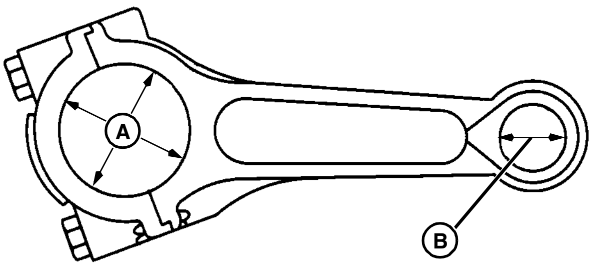
1. Clean carbon from top two ring grooves.
2. Place a new ring in each piston groove.




3. If a **0.10 mm (0.004 in.)** or larger feeler gauge can be inserted in the compression ring grooves, or a **0.20 mm (0.008 in.)** or larger feeler gauge can be inserted in the oil ring grooves, the compression and ring grooves are worn and the piston should be replaced.
4. To check ring end gap, first clean all carbon from the end of the rings.

# CONNECTING ROD INSPECTION

**Procedure:**

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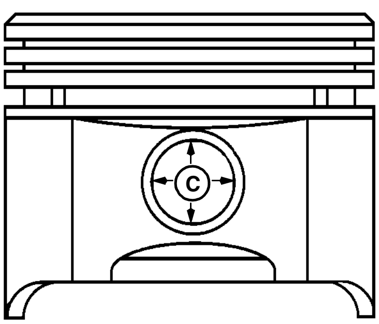
1. If the crankpin bearing in the connecting rod is scored, the rod must be replaced. Reject size of crankpin bearing (A) and piston pin bearing (B) is as follows:

**Specifications:**

**Crankpin bearing . . . . . . . . . . 37.12 mm (1.4614 in.)**
**Piston pin bearing . . . . . . . . . 17.10 mm (0.6732 in.)**

2. Replace connecting rod if either bore is worn.



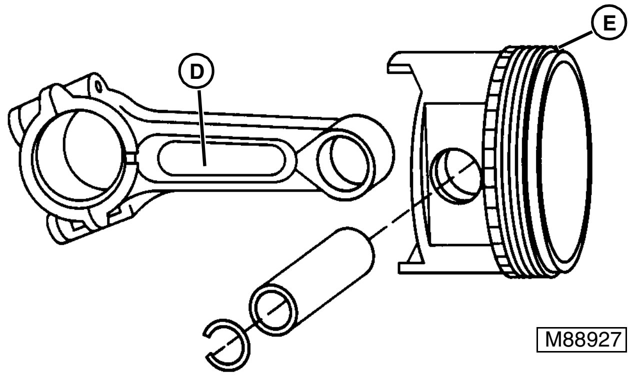

M88926

3. Reject sizes for piston pin and piston pin bore (C) are as follows:

**Specifications:**

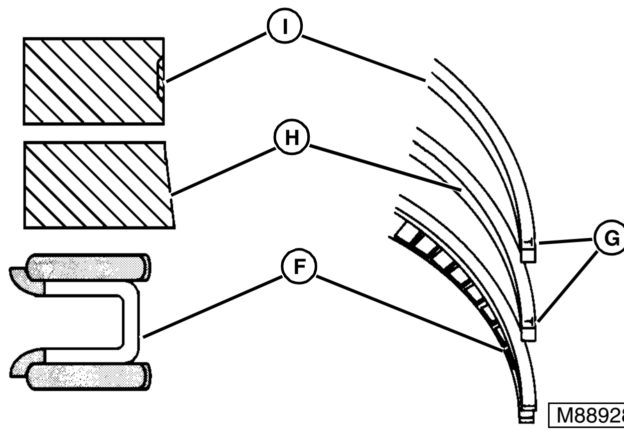
**Piston pin . . . . . . . . . . . . . . . . 17.06 mm (0.6717 in.)**
**Piston pin bore. . . . . . . . . . . . 17.10 mm (0.6732 in.)**

If piston pin is worn **0.01 mm (0.005 in.)** out of round or below reject size, it must be replaced.



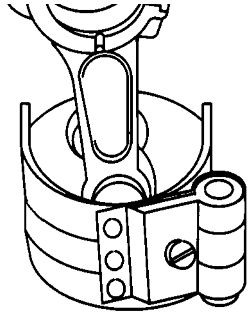

M88927

4. The piston pin is a slip fit in both piston and connecting rod. Use a thin nose pliers or screwdriver and install a piston pin snap ring lock in groove on one side of piston.Refer to above drawing to determine correct location of rod (“Out 1” Cylinder number one, or “Out 2” Cylinder number two) (D) in relation to notch or circle (E) on piston. Insert piston pin from opposite side of piston until pin stops against piston pin lock. Then install other piston pin snap ring lock. Be sure both locks are seated in grooves.

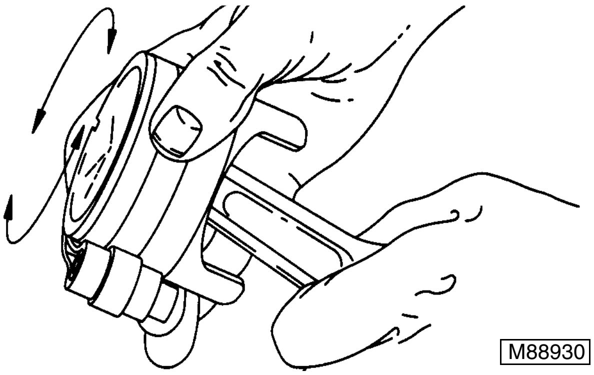



M88928

5. The correct piston ring positions are shown above. The oil ring is installed with the expander (F) between the two oil control rings. The top and second compression rings are installed with “ID” mark (G) toward top of piston.
6. Install expander first. Spiral bottom oil control ring into top ring groove, then into second ring groove and into position below expander. Repeat procedure for top oil control ring.
7. Using ring expander, install center compression ring (taper face) (H) then, top compression ring (barrel face) (I) as shown above.

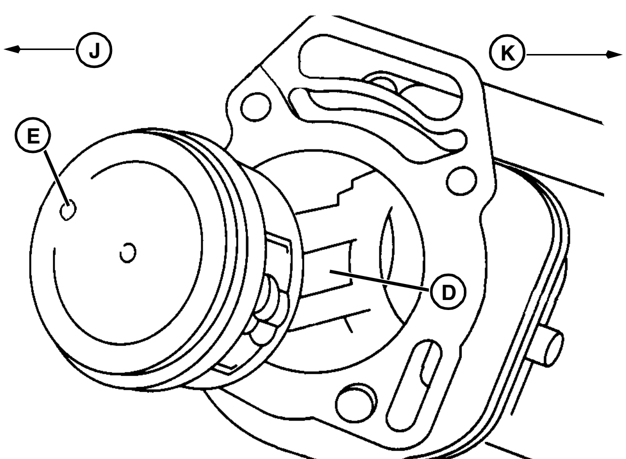


M88929



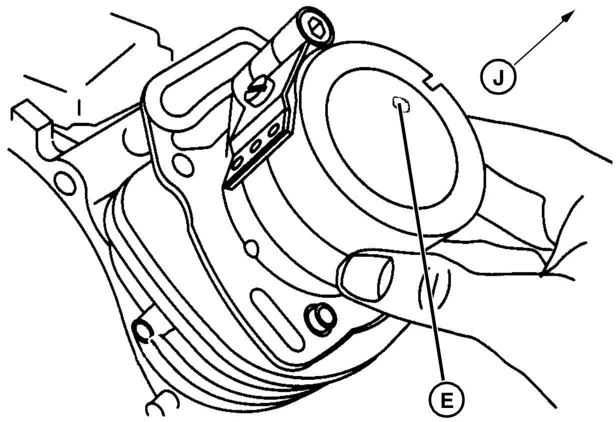
M88930

8. Apply oil to piston rings, piston skirt and compress rings with ring compressor tool. Place piston and ring compressor upside down on bench and push down until head of piston and edge of ring compressor are even. Tighten ring compressor until rings are fully compressed. Then loosen ring compressor very slightly so that compressor can be rotated on piston skirt while holding connecting rod.



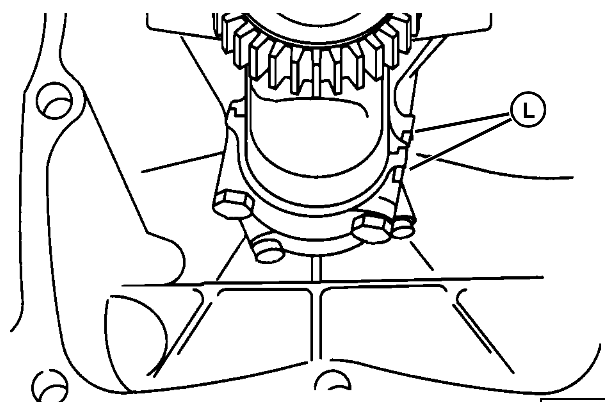

M88931

*NOTE: The pistons have offset piston pin bores. When the Circle (E) on piston is facing toward the flywheel side (J) of engine, the words "OUT-1" on the side of the connecting rod for cylinder No. 1 and "OUT-2" (D) on the side of the connecting rod for cylinder No. 2 should face toward the PTO side (K) of the crankcase.*




M88932

9. Thoroughly clean and then oil cylinder bore. Rotate crankshaft until crankpin journal is at bottom of stroke. This permits complete entry of compressed rings, piston and rod assembly, when pushed into cylinder. If other piston and rod assembly was removed, repeat procedure for that cylinder.




M88933

10. Clean and oil crankshaft crankpin.
11. Pull connecting rod against crankpin.
12. Install rod cap with match marks (L) aligned.
13. Install connecting rod screws and tighten to specification.

*NOTE: Failure to use a torque wrench can result in loose connecting rods causing breakage, or tight connecting rods causing scoring.*

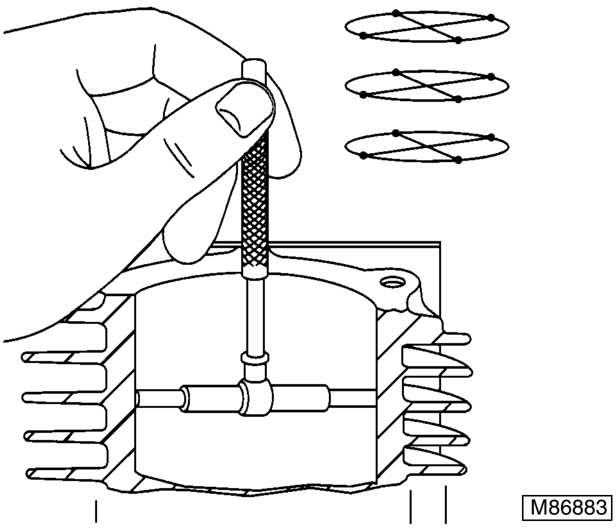
**Specification:**

**Connecting Rod Screws . . . . . . . 13 N•m (115 lb-in.)**

14. Rotate crankshaft two (2) revolutions to check for binding. Rod should also be free to slide sideways on crankpin.

# CYLINDER BORE INSPECTION

**Procedure:**




1. Always inspect cylinder after engine has been disassembled. Visual inspection will show if there are any cracks, stripped bolt holes, broken fins or if the cylinder walls are damaged. Use a telescoping gauge, and dial caliper, or an inside micrometer to determine the size of the cylinder bore. Measure at right angles.

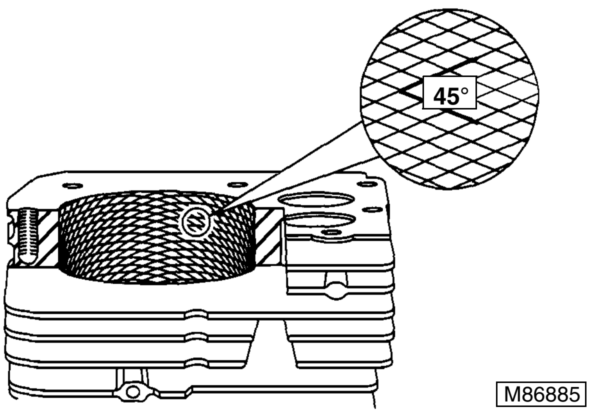
**Specifications:**

**Standard bore size (min.) . . . . 68.00 mm (2.677 in.)**
**Standard bore size (max.) . . . 68.025 mm (2.678 in.)**

2. If the cylinder bore is more than **0.08 mm (0.003 in.)** oversize, or **0.04 mm (0.0015 in.)** out of round, it must be resized, or replaced. See “RESIZING CYLINDER BORE” on page 36.
3. If cylinder bores are within specification and show no signs of scoring or other damage, new pistons rings may be installed providing the cylinder bores are reconditioned using a rigid hone with finishing stones. This will restore the proper cross hatch angle in the cylinder bores. The proper cylinder cross hatch ensures proper lubrication and piston ring rotation.

# CYLINDER BORE HONING

**Procedure:**




1. The cross hatch cylinder finish should be applied after cylinder bore has been resized to within **0.04 mm (0.0016 in.)** of the desired size or when reconditioning a cylinder bore. The finishing stones will produce the correct cross hatch necessary for proper lubrication and piston ring rotation. The correct hatch angle is approximately **45°**.
2. It is recommended that the cylinder bores be reconditioned to restore the cross hatch when new piston rings are to be installed in a cylinder that is within specification. Be careful not to hone oversize or it will be necessary to resize the cylinder.

*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.*

# CYLINDER BORE CLEANING

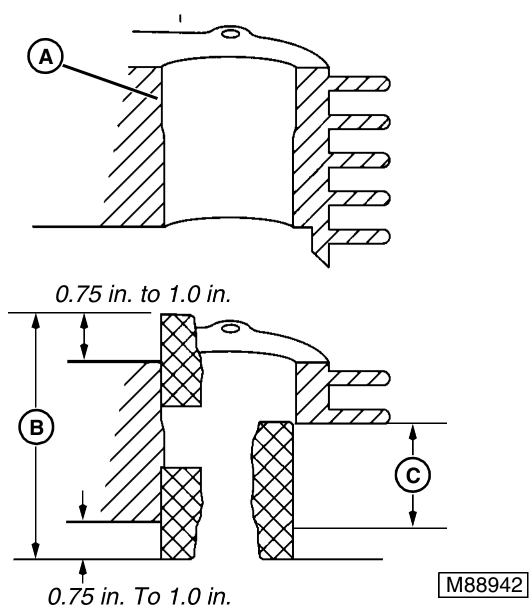
**IMPORTANT: Ensure that the entire cylinder and crankcase are thoroughly cleaned after honing. First wash the cylinder and crankcase carefully in a solvent such as kerosene or commercial solvent. Then thoroughly wash cylinder and crankcase using a stiff brush with soap and hot water, Rinse thoroughly with hot running water. Repeat washing and rinsing 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.**

**Procedure:**

1. When cylinder and crankcase have been thoroughly cleaned, use a clean white rag or napkin and wipe the cylinder bore. If honing grit is present it will appear as a gray residue on rag. If any honing grit is evident, re-wash and rinse entire cylinder and crankcase and check again. When there is no trace of honing grit on rag, the cylinder is properly cleaned. Then oil cylinder bore to prevent rusting.

# RESIZING CYLINDER BORE

**Procedure:**




A. Wear Area

B. Extreme Hone Travel at Finish

C. Hone Travel at Start

1. If the cylinder bore is not within specifications, it will have to be resized using a boring bar or hone. Always resize to exactly **0.25 mm (0.010 in.), 0.51 mm (0.020 in.), or 0.76 mm (0.030 in.)** over standard size.

**Specifications:**

**Standard Bore Size (min.) . . . . 68.00 mm (2.677 in.)**
**Standard Bore Size (max.). . . 68.025 mm (2.678 in.)**

2. If this is done accurately, the service oversize rings and pistons will fit perfectly and proper clearances will be maintained.

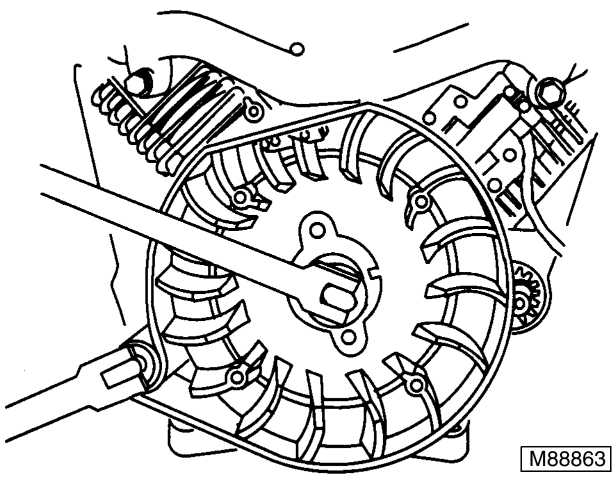
**IMPORTANT: If a boring bar is used, a hone must be used after the boring operation to produce the proper cylinder cross hatch. See “CYLINDER BORE HONING” on page 35.**

3. If a hone is used to resize the cylinder bore, place hone in middle of cylinder bore. Tighten adjusting knob with finger until stones fit snugly against cylinder wall. DO NOT FORCE.
4. Connect drive shaft to hone. Be sure that cylinder and hone are centered and aligned with drive shaft and drill spindle. Lubricate hone as recommended by hone manufacturer.
5. The recommended drill speed is **300 to 700 rpm** maximum and **40 – 60** strokes per minute.
6. Because cylinder bores normally wear only in the area of ring travel, the cylinder bore will be round above and below ring travel.
7. Start drill and, as hone spins, move it up and down at the bottom of the cylinder bore.
8. Gradually increase the length of the strokes until hone travels full length of cylinder bore. Do not travel more than **19.05 mm (0.75 in.) to 25.4 mm (1.0 in.)** above cylinder bore.
9. Lubricate hone frequently to prevent build up on stones.
10. As cutting tension decreases, stop hone and tighten adjusting knob following hone manufacturer’s recommendations.
11. Check cylinder bore size frequently.
12. Check cylinder bores at top and bottom for burrs. Remove burrs. Cylinder head and crankcase cover surfaces must be free of burrs and gasket material.
13. After cylinder bore has been brought to proper resizing dimension, a cross hatch must be applied to bore. See “CYLINDER BORE HONING” on page 35.

# FLYWHEEL REMOVAL AND INSTALLATION

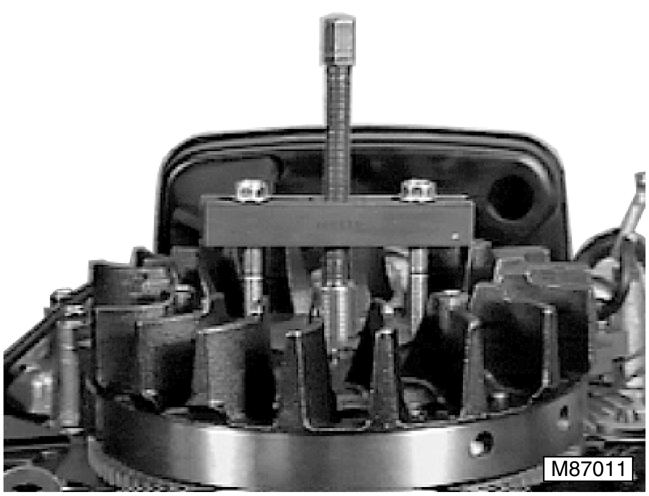
**Procedure:**

1. Remove rotating screen.
2. Remove blower housing.



M88863

3. Place flywheel strap wrench around outer rim of flywheel. Insert 1/2 in. breaker bar into drive end of strap wrench and wind clockwise to remove slack in strap. While holding breaker bar, loosen flywheel nut using 30 mm socket and wrench.

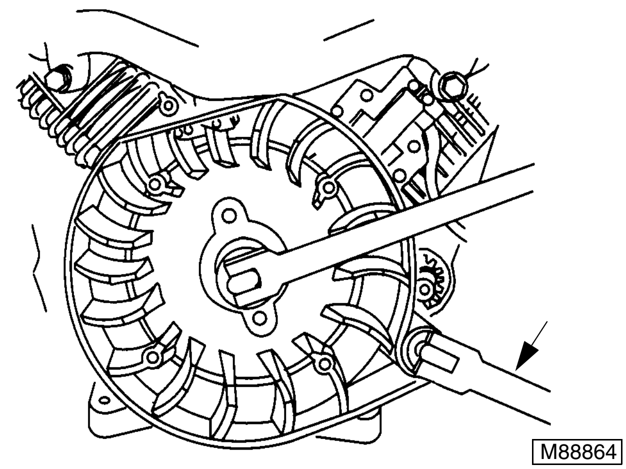


M87011

4. Install flywheel puller turning puller screws into flywheel puller holes evenly. Tighten puller screws equally until flywheel loosens.

**IMPORTANT: Protect crankcase threads during flywheel removal.**

5. Remove flywheel.
6. Flywheel should be inspected for cracks, broken flywheel fins, burrs on taper or keyway and distortion of keyway. Also check taper of crankshaft for burrs, rust or other damage. Replace crankshaft, if damaged.
7. Before installing flywheel, clean taper and crankshaft taper removing all oil, dirt or grease.
8. Install flywheel.
9. Install flywheel nut.



M88864

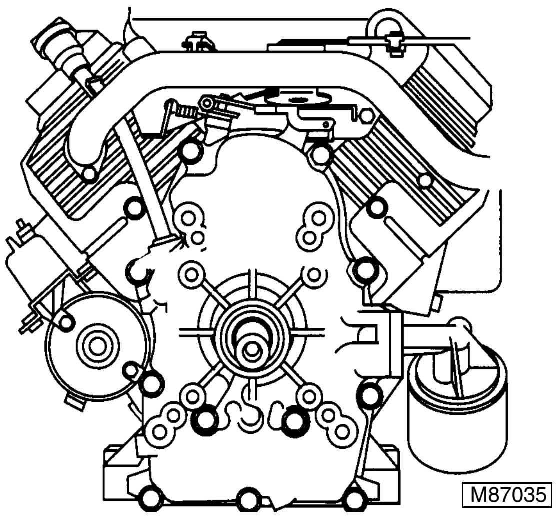
10. Place flywheel strap wrench around outer rim of flywheel. Insert 1/2 in. breaker bar into drive end of strap wrench and wind counterclockwise to remove slack in strap. While holding strap, tighten flywheel nut to **175 N•m (129 lb-ft)**.

**Specification:**

**Flywheel Nut . . . . . . . . . . . . . . . . . 175 N•m (129 lb-ft)**

# CRANKSHAFT AND CAM GEAR REMOVAL AND INSTALLATION

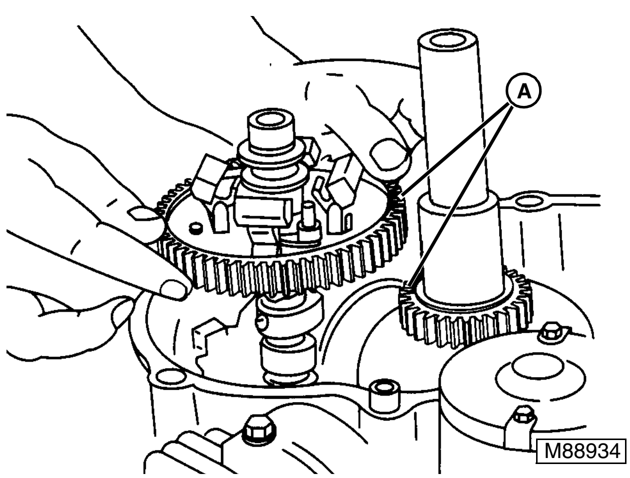
**Procedure:**




*NOTE: Before crankcase cover is removed, it is recommended that any rust, paint or burrs be removed from power take off end of crankshaft. This will eliminate or reduce chances of damaging the crankcase cover bearing.*

1. Remove governor lever and disconnect governor link and springs. Remove governor control bracket. Remove oil fill tube and dipstick assembly.
2. Remove exhaust manifold, intake manifold and cylinder heads.
3. Remove crankcase cover. If crankcase cover sticks, tap lightly with soft hammer on alternate sides near dowel pins.

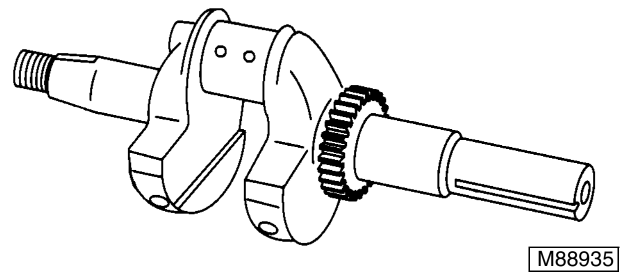
**IMPORTANT: DO NOT remove dowel pins.**




4. Tip engine over onto flywheel side of crankcase.
5. Support engine to prevent end of crankshaft from resting on workbench.
6. Rotate crankshaft until timing marks (A) are aligned. With cam gear in this position, the valve tappets will remain clear of cam lobes.

**IMPORTANT: If engine is rotated from this position, tappets will fall out. Tappets must not be mixed.**

7. Lift out cam gear and governor assembly.




8. Mark the connecting rods and caps to prevent interchanging when reassembling.
9. Remove piston and connecting rod assemblies.
10. Remove crankshaft from crankcase.

**IMPORTANT: The various wear points on the crankshaft must be measured.**

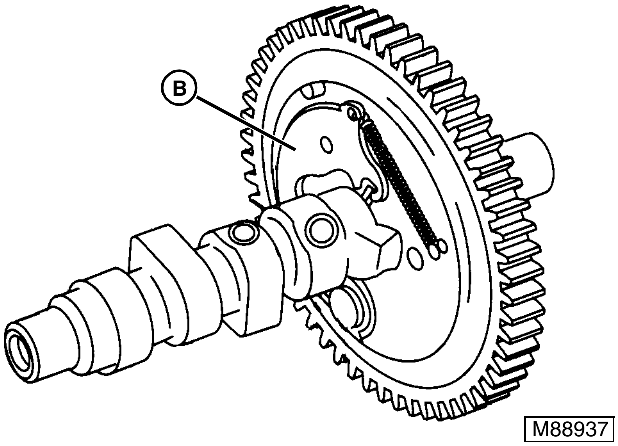
**Specifications:**

**PTO journal . . . . . . . . . . . . . . . . 34.92 mm (1.375 in.)**

**MAG. journal . . . . . . . . . . . . . . . 29.94 mm (1.179 in.)**

**Crankshaft crankpin . . . . . . . . 36.95 mm (1.455 In.)**

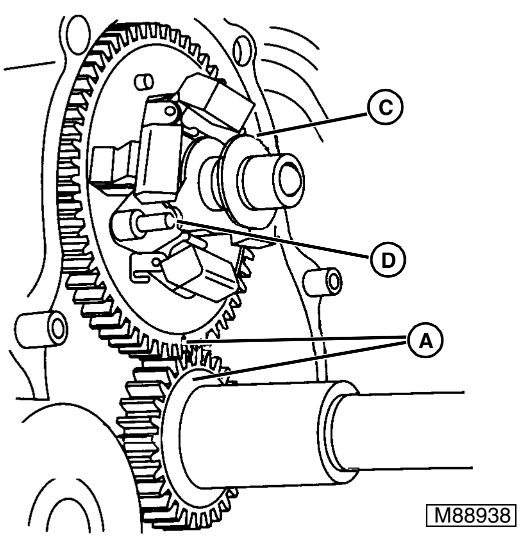
11. Replace crankshaft if worn or if journals are scored. Keyways should be checked to be sure they are not worn or spread. Remove burrs from keyway edges to prevent damaging the bearing or oil seal. Check oil galleries for blockage or obstructions.



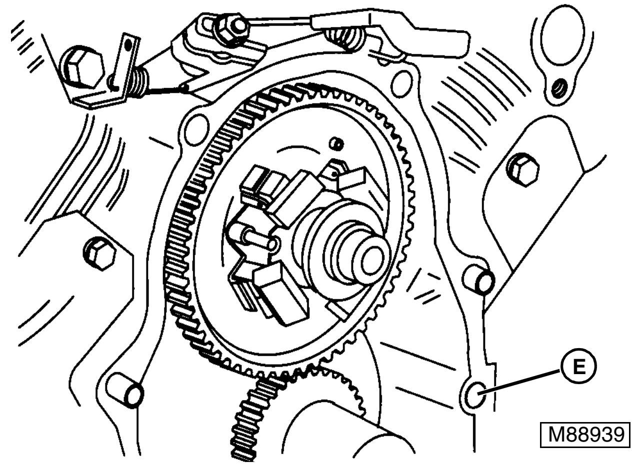

12. Check timing gear teeth for chipped or cracked teeth. Replace if needed.
13. The compression release balls must be clean and free to move when the centrifugal weight (B) is rotated counterclockwise. When the centrifugal weight is released, the balls should move up into the locked position.
14. Inspect cam gear teeth, lobes and journals for wear and nicks. Cam gear journal and lobe reject sizes are as follows:

**Specifications (Minimum):**

| | |
|---|---|
| **PTO journal** | **19.92 mm (0.7845 in.)** |
| **MAG. journal** | **15.93 mm (0.6273 in.)** |
| **Cam lobes** | **30.25 mm (1.191 in.)** |

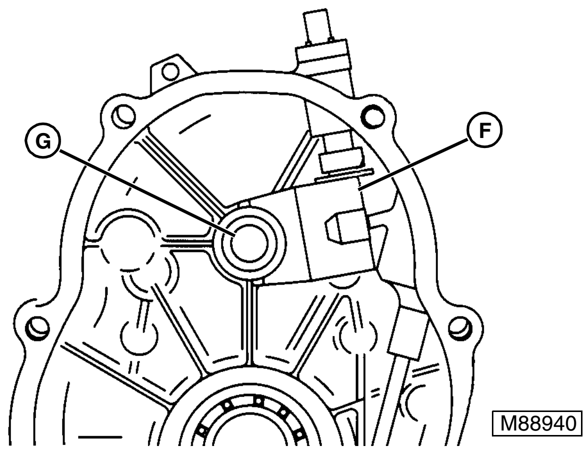



15. Governor slider (C) must move freely on PTO journal of cam gear. Flywheel must pivot freely. Make sure flyweight spring is not stretched. Governor weights must move freely on hinge pins. Make sure hinge pins are not loose.
16. Assemble governor slider onto PTO journal on cam gear making sure that slot on slider fits over locating pin (D) on cam gear. Be sure the weights are in the proper location so that they will be able to move freely without binding. Tip engine to position crankshaft horizontally.

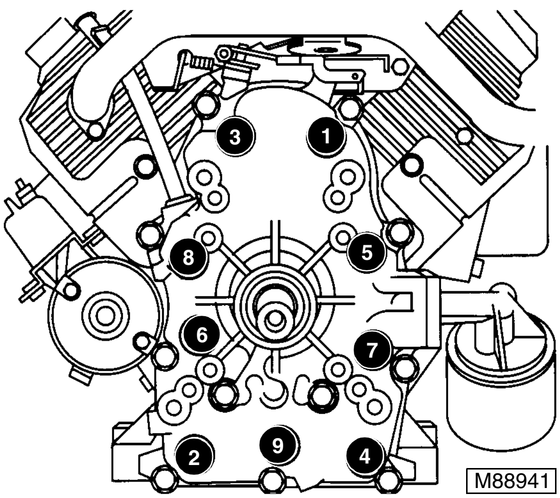



17. Place new crankcase cover gasket on crankcase.

*NOTE: Be sure O-ring (E) is installed in crankcase.*



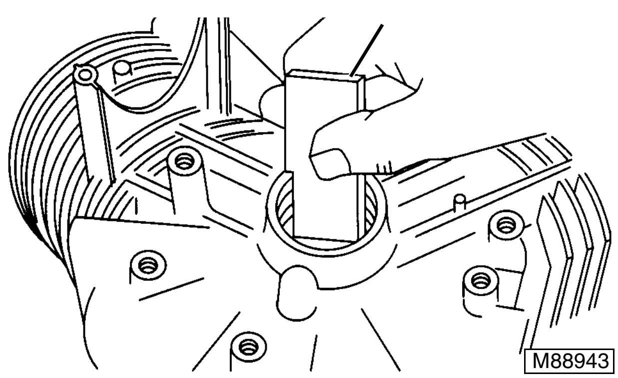

18. Rotate governor shaft (F) against boss (G).
19. Take care to protect the oil seal while assembling crankcase cover. No force should be used.




20. Tighten cover bolts to **17 N•m (150 lb-in.)** in the above sequence.
21. Install cylinder heads.
22. Install flywheel.
23. Install intake manifold and carburetor assembly.
24. Install governor lever and governor springs.
25. Install oil fill tube and dipstick assembly. Perform static governor adjustment.
26. Install engine shrouding.
27. Install air filter assembly.

# MAGNETO BEARING INSPECTION

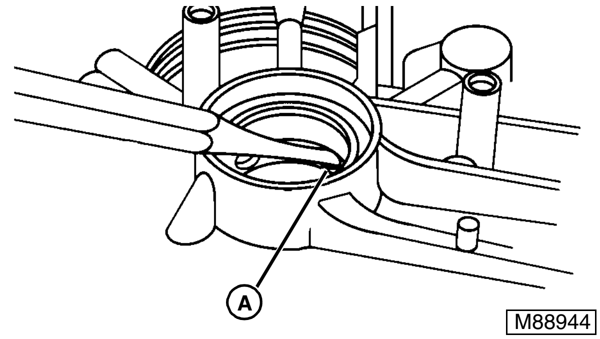
**Procedure:**



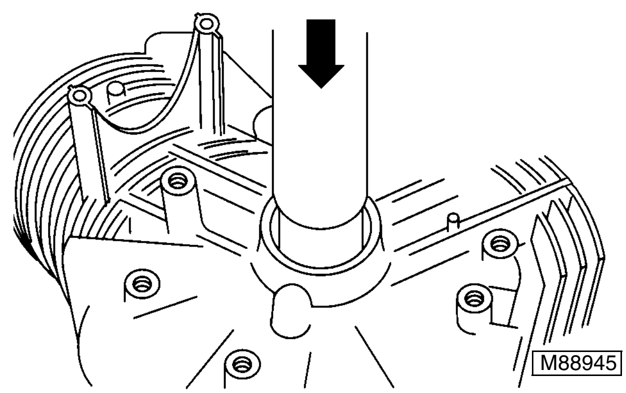

1. When checking the main magneto bearing, it should be replaced if scored or if not within specification.

**Specification:**

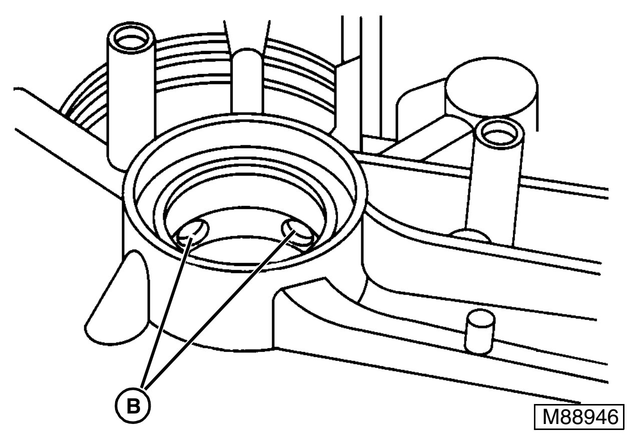
**Magneto Bearing Reject Size 30.08 mm (1.1843 in.)**



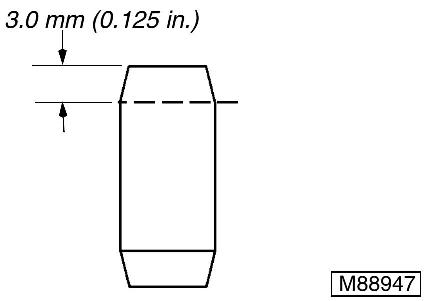

2. To remove the magneto bearing, first remove oil seal. The magneto bearing has a roll pin (A) installed in the oil gallery to prevent the bearing from turning. Use a **4.8 mm (3/16 in.)** punch to drive roll pin into oil gallery.



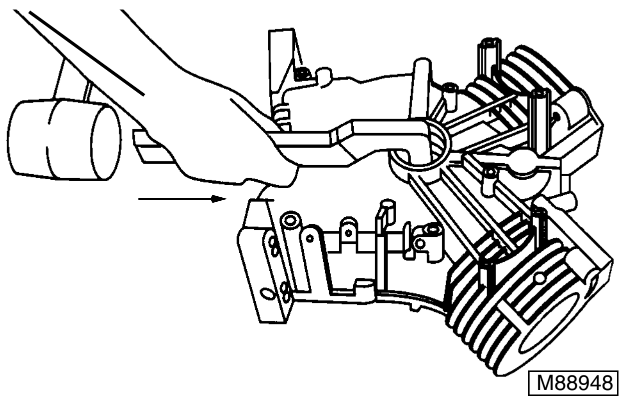

3. To install magneto bearing, place cylinder on a suitable cylinder support. Position new bushing against counterbore bearing in crankcase and carefully align oil holes in bushing with oil gallery holes in bearing. Press in new bushing with a suitable bushing driver tool.



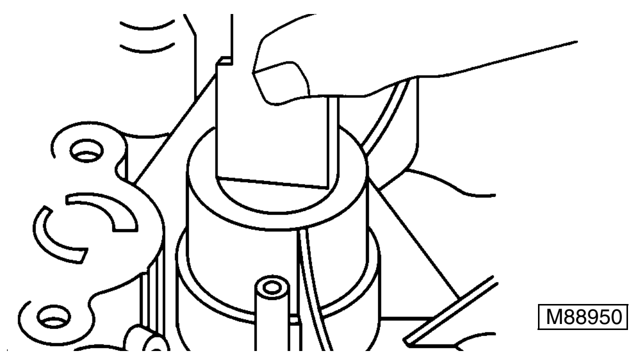

*NOTE: Be sure oil holes (B) in bushing are aligned with oil gallery holes in cylinder block.*




4. Before installing the new roll pin, grind off the taper, approximately **3.0 mm (0.125 in.)** from one end of new roll pin. Quench pin in water periodically to prevent loss of temper. Remove all burrs and clean thoroughly.




5. Place tapered end of new roll pin in oil hole in bearing. Use roll pin driver, to install new roll pin. Drive in new roll pin until tool bottoms. Install new oil seal. Use a suitable cylinder support and press in new oil seal until it is flush with cylinder.




**IMPORTANT: The crankcase cover must be replaced if PTO bearing is scored or if dimensions exceed reject size.**

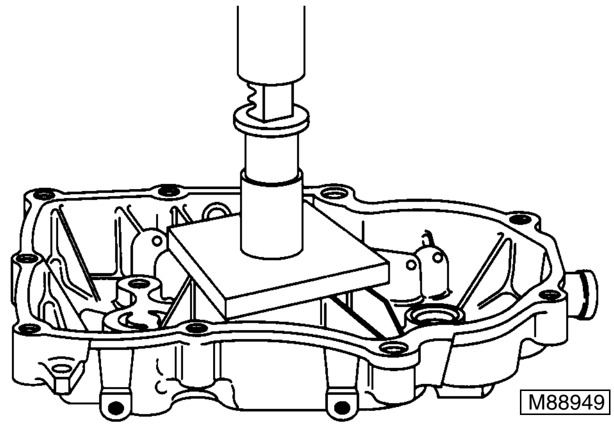
**Specification:**

**PTO Main Bearing Reject Size 35.07 mm (1.381 in.)**

## PTO BEARING REMOVAL AND INSTALLATION

**Procedure:**

1. Remove oil pump.
2. Remove oil seal.
3. Support crankcase cover on arbor press and using bushing driver. Press out bearing toward inside of the cover.




4. Lubricate outside surface of bearing and place on inside of cover. Using an arbor press and flat steel plate, press in bearing until flush with surface of cover.
5. Install new oil seal using a cylinder support. Press in seal until it is flush with mounting surface.
6. When installing new PTO oil seal, properly support cylinder. Press in seal until it is **1.5 mm (0.059 in.)** below mounting surface.
7. The crankcase cover must be replaced if the cam gear bearing dimensions exceed reject size.

**Specifications:**

**Cam Bearing Gear Bearing Reject Size**

**Magneto Bearing . . . . . . . . . . . 16.08 mm (0.633 in.)**

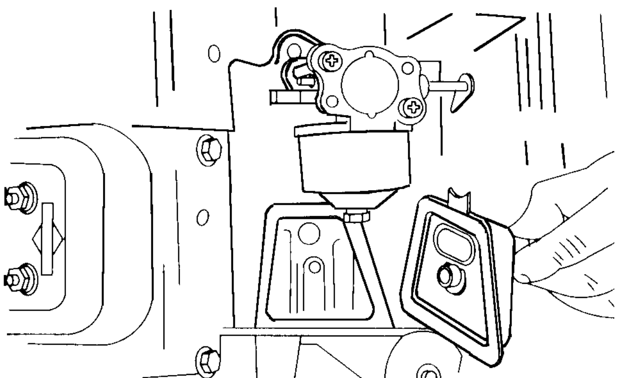
**PTO Bearing . . . . . . . . . . . . . . . 20.04 mm (0.789 in.)**

*NOTE: Always install new oil seals whenever engine is disassembled for major servicing or when repairing bearings. Always use the correct seal protector to prevent damaging oil seal.*

# BREATHER VALVE SERVICE

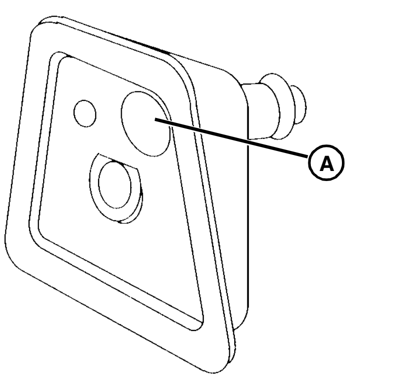
**IMPORTANT: A leak at the seal between the tube and crankcase cover, or at the seal at the upper end of the dipstick, can result in a loss of crankcase vacuum and a discharge of oil or smoke through the muffler.**

*NOTE: The engine utilizes a breather valve to control and maintain a vacuum in the crankcase. The breather valve closes on the up stroke of the piston and opens on the down stroke of the piston to maintain a vacuum in the crankcase. This vacuum prevents oil leakage past piston rings, valve guides, oil seals, governor shaft and gaskets.*



M88913

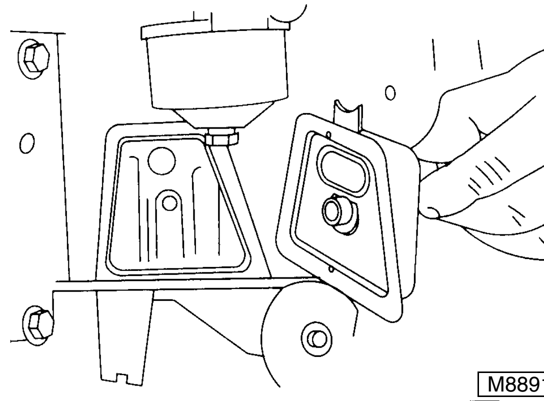
1. Before breather valve assembly can be removed for inspection, the air cleaner assembly and support bracket must be removed.




M88914

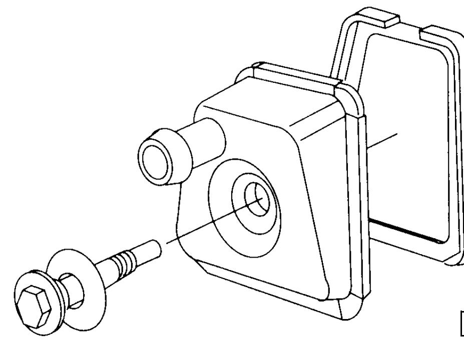
2. Check to see that reed valve (A) is not deformed. The reed valve is spring loaded and must make a complete seal around the vent hole in breather body.

**IMPORTANT: Do not use force on reed valve.**



M88915

*NOTE: When installing breather, make sure breather gasket is located properly.*

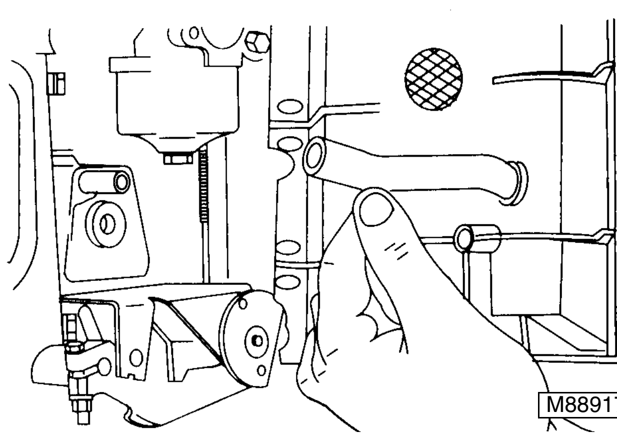


M88916

3. Place breather on gasket. Slip large O-ring onto mounting screw and install screw and tighten to specification.

**Specification:**

**Mounting Screw . . . . . . . . . . . . . . . . 3 N•m (30 lb-in.)**

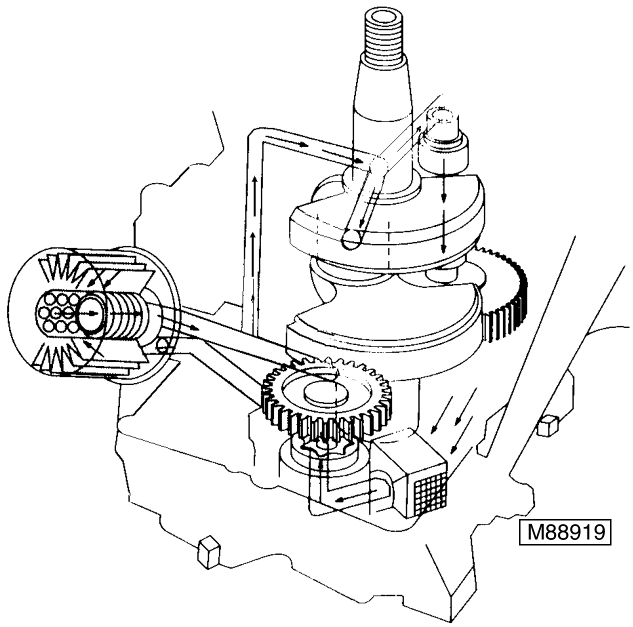


M88917

*NOTE: The breather is vented through the air cleaner to prevent dirt from entering the crankcase.*

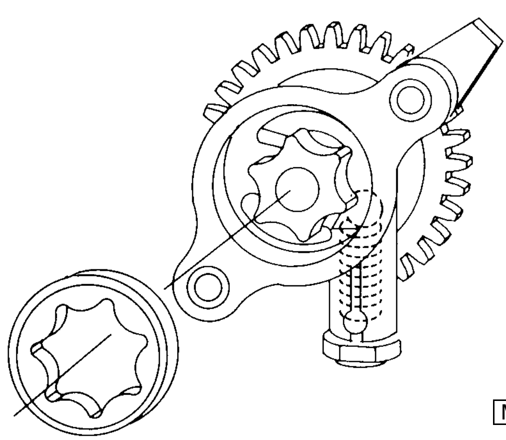
4. Check breather tube for cracks, holes or hardening. Replace if damaged.

# OIL PUMP REMOVAL AND INSTALLATION



M88919

This engine is equipped with a full pressure lubrication system with an oil filter.



M88918

The gear driven oil pump supplies lubrication to all bearing journals.

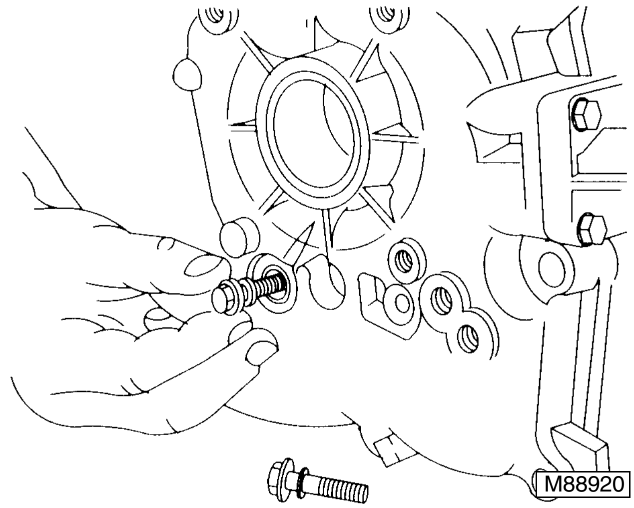
**Specification:**

**Oil pressure . . . . . . . . . . . . . . . . . . . . . . . 10 – 50 psi**

*NOTE: Engine oil pressure will vary with oil viscosity, ambient air temperature differences, operating temperatures and engine load.*

**Procedure:**

1. Remove oil fill dipstick assembly.
2. Remove crankcase cover.

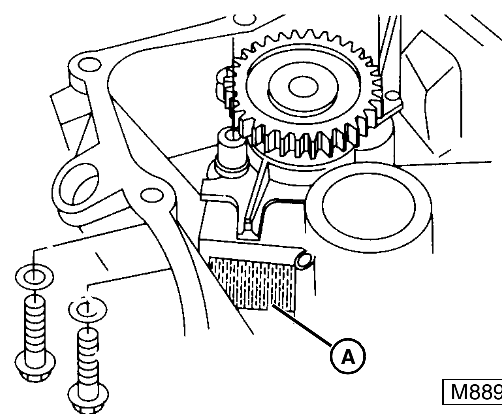


M88920

*NOTE: The oil pump is attached to the inside of the crankcase cover.*

3. Remove two screws attaching oil pump assembly to crankcase cover.

*NOTE: The outer rotor of pump can be removed for inspection and cleaning. With pump removed, oil pick-up screen may be removed for cleaning.*




M88921

4. Slip oil pick-up screen (A) into slots in crankcase cover.
5. Install oil pump and tighten mounting screws to specification.

*NOTE: Boss on oil pump body holds pick-up screen in proper position. Be sure to install new "O" rings on pump mounting screws.*

**Specification:**

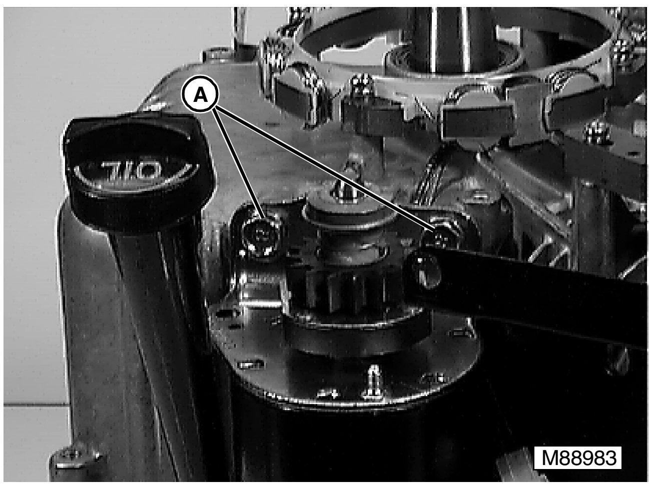
**Mounting Screws . . . . . . . . . . . . . . . 7 N•m (65 lb-in.)**

# STARTING MOTOR REMOVAL AND INSTALLATION

**Procedure:**

1. Disconnect negative (–) battery cable.
2. Disconnect wires from the starting motor cable lug.

*NOTE: Upper blower housing, flywheel, plate (below and surrounding stator), and starting motor gear cover plate removed for clarity and/or ease of starting motor removal.*




3. Remove starting motor bolts (A).
4. Install starting motor mounting bolts and tighten to specification.

**Specification:**

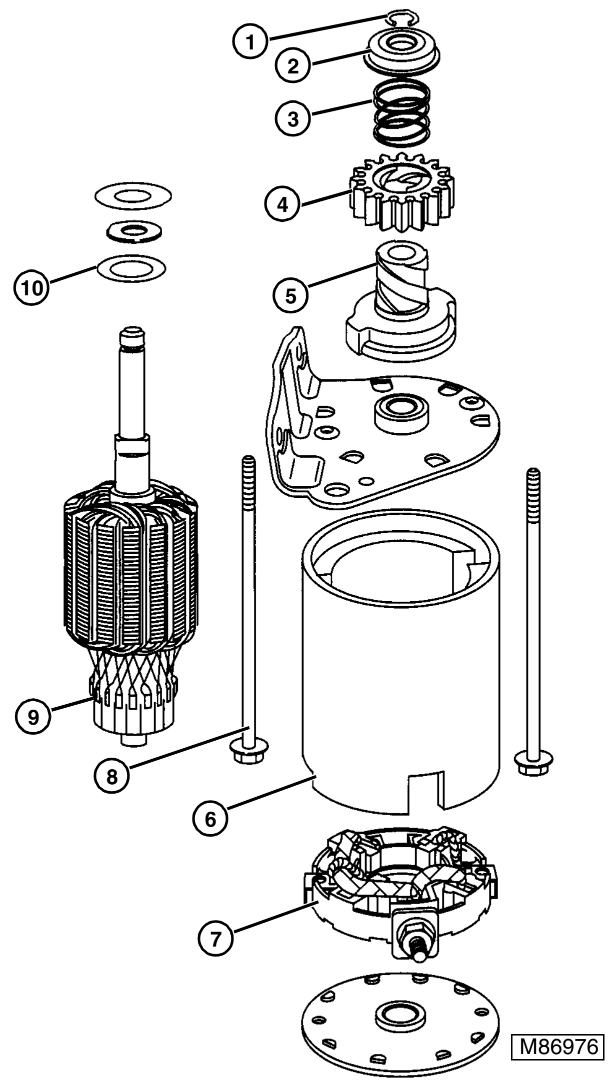
**Mounting Bolts . . . . . . . . . . . . . 15.8 N•m (140 lb-in.)**

5. Install starting motor pinion gear cover plate, plate (below and surrounding stator), flywheel and upper blower housing (if removed).

# STARTING MOTOR DISASSEMBLY

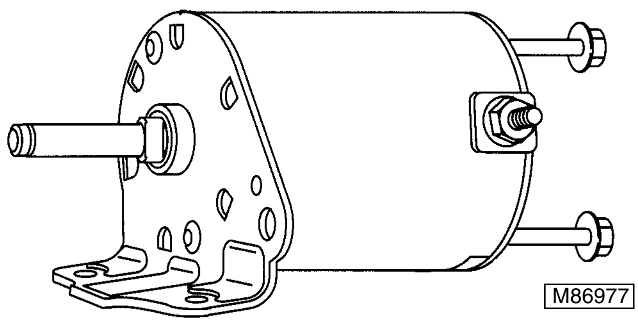
**CAUTION**

**DO NOT clamp motor housing in a vise or strike with a steel hammer. Starter motors contain two powerful magnets that can be broken or cracked if the motor housing is deformed or damaged.**

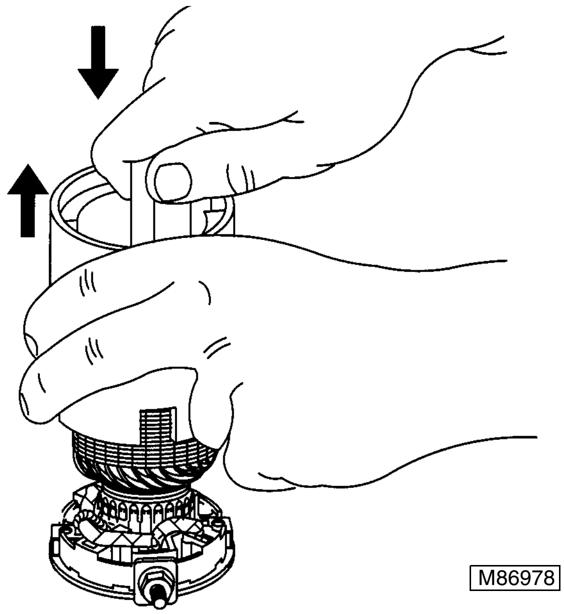



1. C-Ring
2. Retainer
3. Spring
4. Pinion Gear
5. Helix (Clutch)
6. Body
7. Brush Holder
8. Thru Bolt
9. Armature
10. Wave Washer

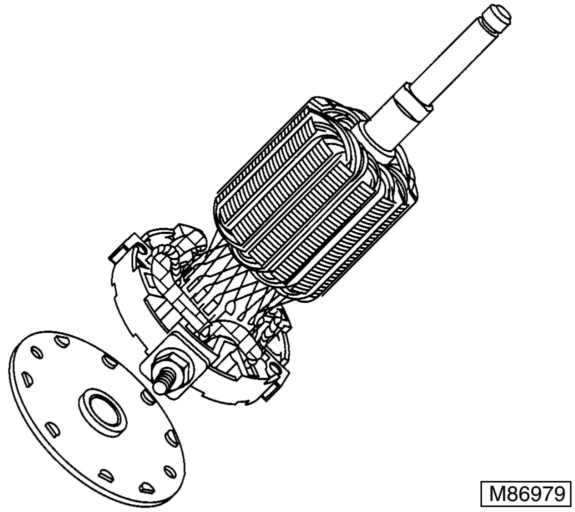
11. Refer to Pinion Gear Replacement to remove pinion gear assembly. (See “STARTING MOTOR PINION GEAR REPLACEMENT” on page 48.)



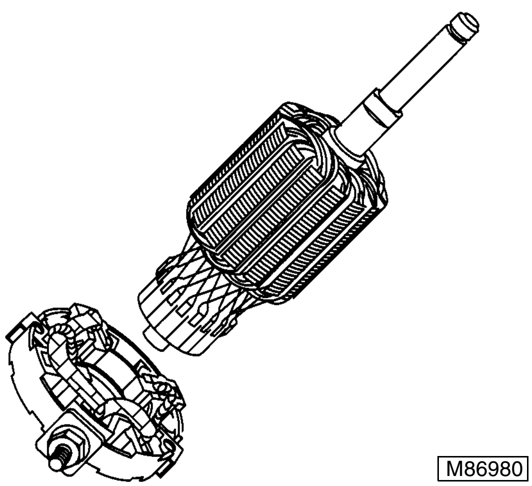

12. Remove bolts and inspect bushing for wear. If worn, replace drive head end assembly.




13. Hold the armature and bearing end cap against a work surface while sliding housing off the armature. (This allows the armature to remain in the bearing end cap and brush holder for inspection of brush contact to armature.)



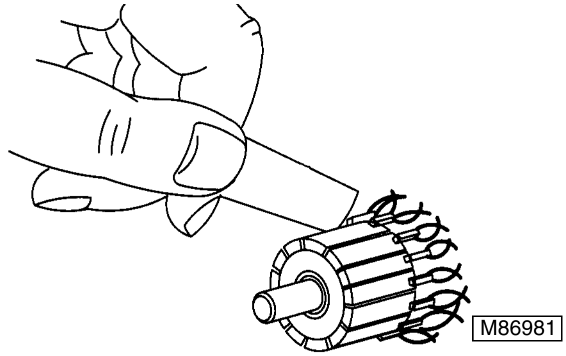

14. While holding brush holder and armature, remove bearing end cap from armature.




15. Remove brush holder from armature commutator.

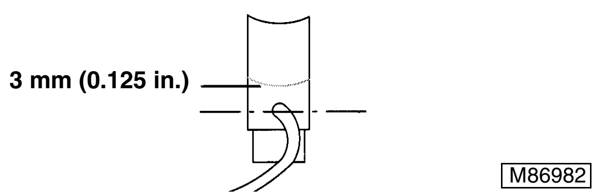
## ⚠ CAUTION

**DO NOT use emery cloth to clean the commutator. The particles from the cloth will become embedded in the commutator and cause rapid brush wear.**




*NOTE: The bearing housing and armature should not be soaked in a cleaning solution. Fine sandpaper, such as crocus cloth, can be used to clean the armature. The commutator may also be machined with the use of a diamond cutting tool to no less than **31.24 mm (1.23 in.)** outside diameter.*

16. Slots between the commutator bars should be cleaned as shown using a broken piece of hacksaw blade.
17. If it is suspected that the armature field coil, magnets or motor housing is defective, a new part should be tried in the motor. If proper testing equipment is available, check the suspected armature or field coil to determine if it is defective (opens or grounds).



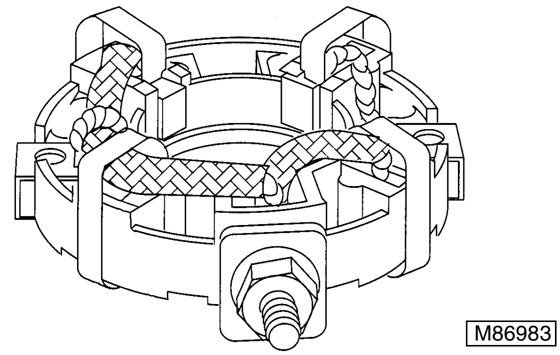

18. The brushes should be checked for proper seating, weak brush springs, dirt, oil or corrosion.
19. If brushes are worn to specification shown, replace brushes.

**Specification (Minimum):**

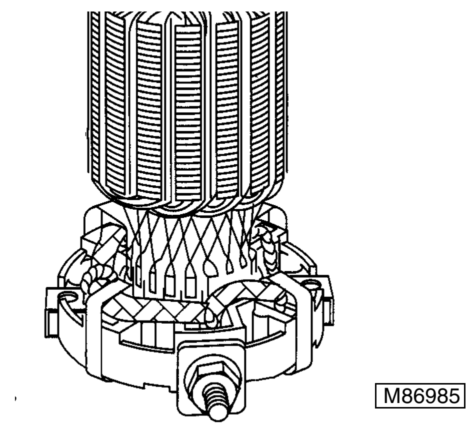
**Brush Length . . . . . . . . . . . . . . . . . . 3 mm (0.125 in.)**

When all parts have been thoroughly cleaned, lightly lubricate the bearings with #20 oil.

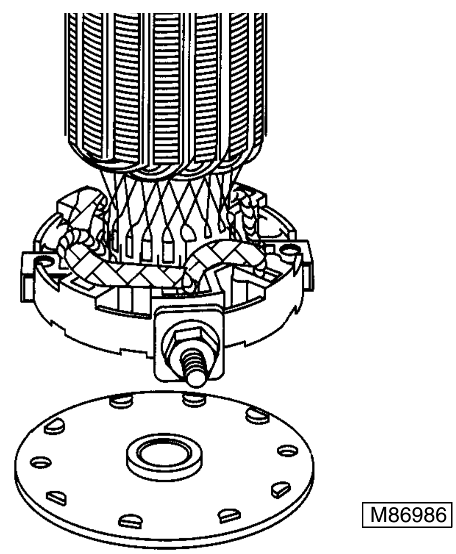
## STARTING MOTOR ASSEMBLY



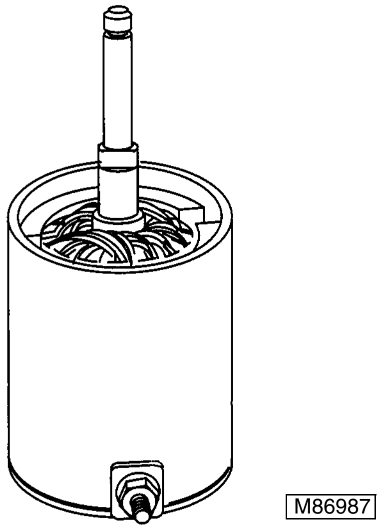

1. Place brushes in their slots and hold brushes with retainers.



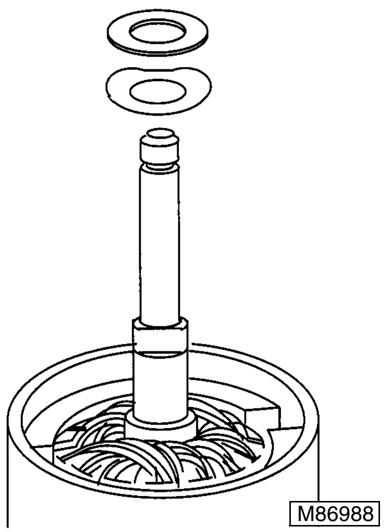

2. Place armature commutator in brush holder and remove brush retainers.



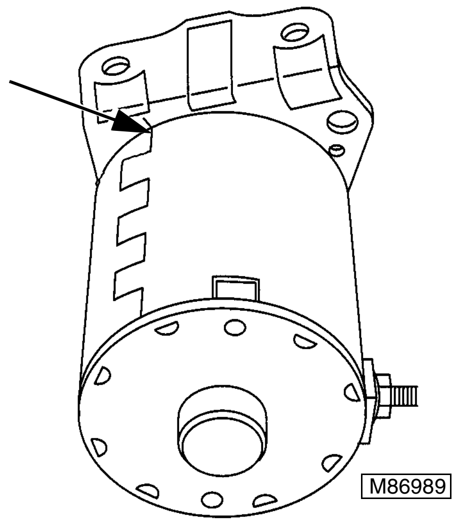

3. Install bearing end plate on armature commutator journal making sure plate indexes with brush holder.



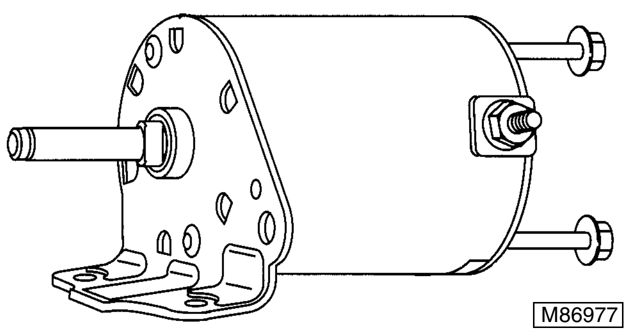

4. Slide motor housing over armature with the notch toward brush holder.




5. Place wave washer on armature shaft with concave side up. Then place flat washer on armature.




6. Place drive end cap on starting motor housing making sure that mark on cap lines up with housing seam.




7. Install thru bolts in starting motor hand tight, use starting motor clutch to check for binding of armature shaft and correct if it binds, Then tighten to specification.
8. Install starting motor drive.
9. Install starting motor and tighten bolts to the following:

**Torque Specifications:**

**Thru Bolts . . . . . . . . . . . . . . . . . . . 5.7 N•m (50 lb-in.)**
**Mounting Bolts . . . . . . . . . . . . . 15.8 N•m (140 lb-in.)**

## STARTING MOTOR PINION GEAR REPLACEMENT

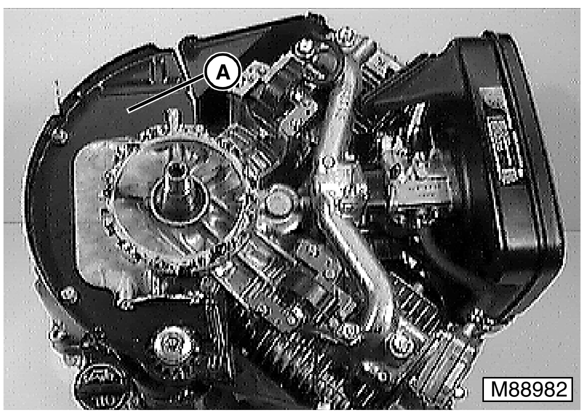
*NOTE: If only the pinion gear is to be replaced, the starting motor does not have to be removed from the engine.*

**Required Tools:**

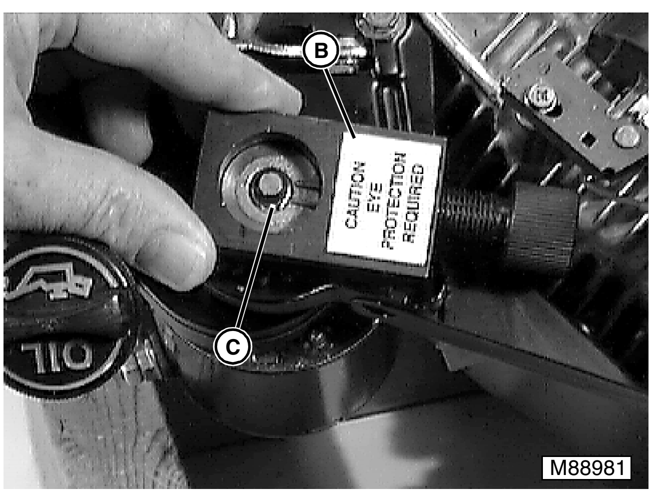
- JDG1087 C-Ring Remover
- JDG1086 C-Ring Installer

**Procedure:**

1. Disconnect negative (–) battery cable.
2. Remove upper blower housing and flywheel.



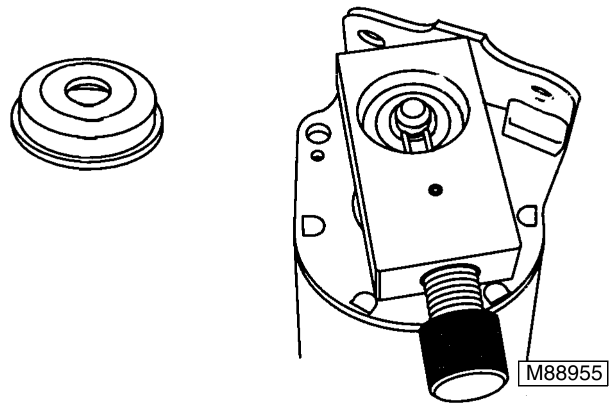

The plate (A) surrounding and below the stator does not have to be removed.

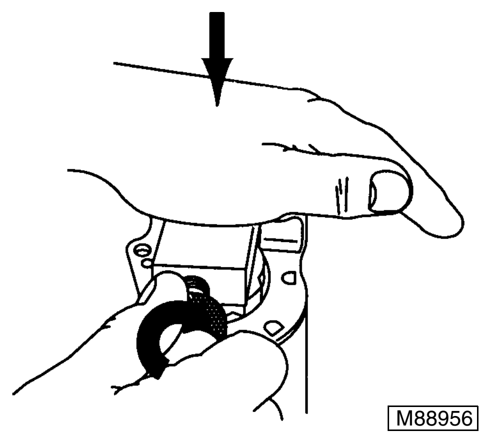



3. Position C-ring (C) using screw driver tip so C-ring removal tool (B) can be aligned properly.

**⚠ CAUTION**

**To prevent eye injury, always wear eye protection when removing C-ring.**

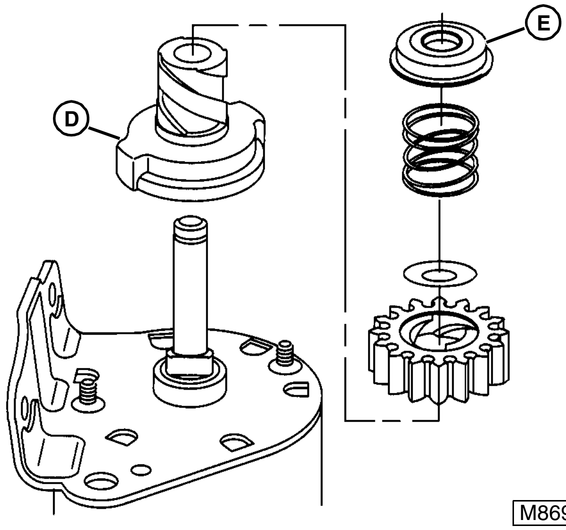



4. Install C-ring removal tool over retainer, and compress spring.

**IMPORTANT: The C-ring is not reusable once removed.**

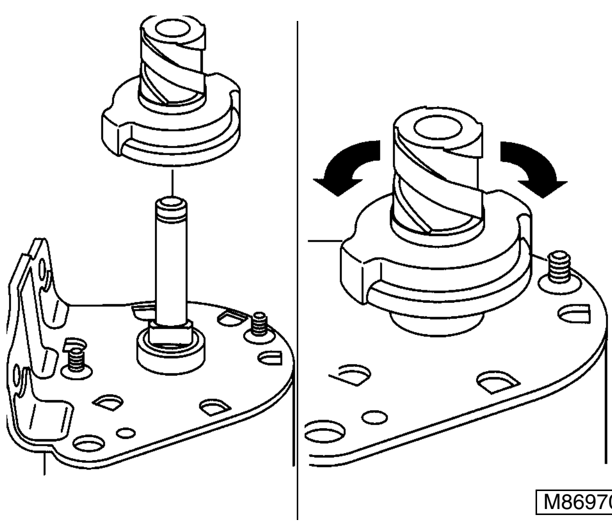
5. Screw in handle until drive pins on tool forces the C-ring from starting motor shaft.




M86969A

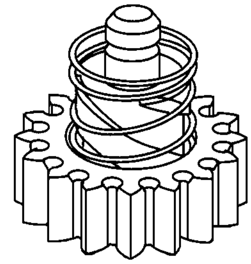
6. Remove retainer (E), spring, flat washer, wave washer, gear and starting motor clutch (D).
7. Before installing starting motor clutch, apply a lithium based lubricant sparingly around base of helix.

*NOTE: Do not use mineral spirit based lubricants to lubricate helix.*



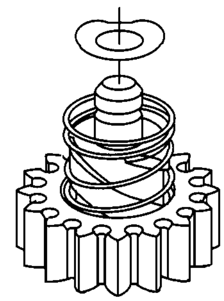
M86970

8. Place starting motor clutch on starting motor shaft, rotate clutch until it drops into place.



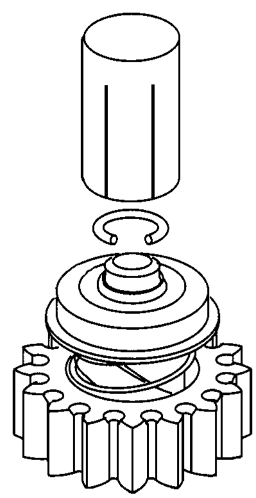
M88984

9. Install pinion gear with beveled side of teeth up, then install return spring making sure spring is in recess of starting motor gear.



M88985

10. Place wave washer with concave side up on starting motor clutch spline.



M88986

11. Place retainer and new C-ring on starting motor shaft.
12. Align one of the slots on the C-ring installer with open end of C-ring.
13. Use a hammer to drive snap ring down until it engages groove in starting motor shaft. Then make sure retainer is all the way up against the snap ring.
14. Install flywheel, upper blower housing and reconnect negative (–) battery cable.

## NOTES:

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# SPECIFICATIONS

## GENERAL SPECIFICATIONS

| | |
|---|---|
| Make | Kawasaki |
| Model Number | FH500V-AS32 |
| Power | 12.7 kW (17 hp) |
| Bore and Stroke | 68 mm (2.68 in.) |
| Displacement | 494 $cm^3$ (30.0 cu in.) |
| Cylinders | 2 (V-Twin) |
| Stroke Cycle | 4 |
| Valves | Overhead |
| Lubrication | Fully Pressurized |
| Oil Capacity w/o Oil Filter | 1.5 L (1.6 qt) |
| Oil Capacity w/ Oil Filter | 1.7 L (1.8 qt) |
| Oil Filter | Single Element, Full Flow, Spin-On |
| Cooling System | Air |
| Muffler | Horizontal Discharge Below Frame |
| Spark Plug Gap | 1.0 mm (0.040 in.) |
| Spark Plug Torque | 15 N•m (132 lb-in.) |
| Battery Reserve @ 25 amp | 90 minutes |
| Battery CCA @ -18° C (0° F) | 500 amp |

## TEST AND ADJUSTMENT SPECIFICATIONS

| | |
|---|---|
| Slow Idle | 1550 ± 75 rpm |
| Fast Idle | 3350 ± 50 rpm |
| Ignition Coil Air Gap | 0.25 – 0.40 mm (0.010 – 0.016 in.) |
| Ignition Timing @ 3000 rpm | 20° BTDC |
| Oil Pressure | 240 – 310 kPa (35 – 45 psi) |
| Oil Pressure Switch (open to close) | 98 kPa (14.2 psi) |
| Crankcase Vacuum | 1.3 – 25.4 cm (0.5 – 10.0 in.) |
| Cylinder Compression (Minimum) | 390 kPa (57 psi) |
| Cylinder Valve Clearance (Cold) | 0.05 – 0.1 mm (0.002 – 0.004 in.) |
| Fuel Pump Pressure (Slow Idle) | 2.45 kPa (0.36 psi) |
| Fuel Pump Flow Volume (Minimum) | 800 mL/min (0.8 qt/min) |
| Fuel Pump Push Rod Bend (Maximum) | 0.05 mm (0.002 in.) |

## REPAIR SPECIFICATIONS

| | |
|---|---|
| Cylinder Head: | |
| Cylinder Head Distortion (Maximum) | 0.05 mm (0.002 in.) |
| Valve Guides ID | 6.08 mm (0.239 in.) |
| Valve Seat Width | 0.6 – 0.9 mm (0.024 – 0.035 in.) |
| Valve Spring Free Length | 26.7 mm (1.05 in.) |
| Intake and Exhaust Valves: | |
| Valve Clearance (Cold) | 0.05 – 0.10 mm (0.002 – 0.004 in.) |
| Valve Stem OD (Intake) | 5.95 mm (0.234 in.) |
| Valve Stem OD (Exhaust) | 5.93 mm (0.233 in.) |
| Valve Stem Bend (Maximum) | 0.03 mm (0.001 in.) |
| Valve Guide ID | 6.08 mm (0.239 in.) |
| Valve Seating Surface (Standard) | 0.60 – 0.90 mm (0.024 – 0.035 in.) |
| Valve Seat and Face Angle | 45° |

| | |
|---|---|
| Valve Margin (Minimum) | 0.35 mm (0.014 in.) |
| Valve Seat Narrowing Angle | 30° |
| Piston Assembly: | |
| Piston Ring Side Clearance (Top Ring) | 0.15 mm (0.006 in.) |
| Piston Ring Side Clearance (Second Ring) | 0.12 mm (0.005 in.) |
| Piston Ring Side Clearance (Oil Ring) | Not Measured |
| Piston Ring Thickness (Top and Second) | 1.40 mm (0.055 in.) |
| Piston Ring End Gap Maximum (Top Ring) | 0.70 mm (0.028 in.) |
| Piston Ring End Gap Maximum (Second Ring) | 0.78 mm (0.031 in.) |
| Piston Ring End Gap Maximum (Oil Ring) | 1.05 mm (0.041 in.) |
| Piston Pin OD (Minimum) | 15.96 mm (0.628 in.) |
| Piston Pin Bore OD (Maximum) | 16.08 mm (0.633 in.) |
| Piston OD (Standard Minimum) | 67.79 mm (2.669 in.) |
| Piston OD (Oversize 0.50 mm (0.020 in.) | 68.29 mm (2.689 in.) |
| Piston-to-Cylinder Bore Clearance | 0.015 – 0.150 mm (0.001 – 0.006 in.) |
| Cylinder Bore ID (Standard) | 67.98 – 68.00 mm (2.676 – 2.677 in.) |
| Cylinder Bore ID (Wear Limit) | 68.10 mm (2.681 in.) |
| Cylinder Bore ID (Oversize 0.50 mm (0.020 in.)) | 68.48 – 68.50 mm (2.696 – 2.697 in.) |
| Cylinder Bore ID (Oversize 0.50 mm (0.020 in.) Wear Limit) | 68.60 mm (2.701 in.) |
| Connecting Rod: | |
| Crankshaft Bearing ID (Maximum) | 35.055 mm (1.380 in.) |
| Piston Pin Bearing ID (Maximum) | 16.05 mm (0.632 in.) |
| Crankshaft: | |
| Crankpin Width (Maximum) | 39.50 mm (1.380 in.) |
| Crankpin OD (Minimum) | 34.94 mm (1.376 in.) |
| Journal Diameter (PTO Side) (Minimum) | 34.90 mm (1.374 in.) |
| Journal Diameter (Flywheel Side) (Minimum) | 34.93 mm (1.375 in.) |
| Crankcase Cover PTO Shaft ID (Maximum) | 35.15 mm (1.384 in.) |
| Crankcase Crankshaft Journal Bearing ID (Maximum) | 35.15 mm (1.384 in.) |
| Camshaft: | |
| Lobe Height (Intake and Exhaust) (Minimum) | 29.131 mm (1.147 in.) |
| Journal Diameter (PTO and Flywheel) (Minimum) | 15.985 mm (0.629 in.) |
| Bearing ID (Crankcase and Cover) (Maximum) | 16.136 mm (0.635 in.) |
| Oil Pump: | |
| Rotor Shaft OD (Minimum) | 10.923 mm (0.430 in.) |
| Rotor Shaft Bearing ID (Maximum) | 11.072 mm (0.436 in.) |
| Outer Rotor OD (Minimum) | 40.47 mm (1.593 in.) |
| Outer Rotor Bearing ID (Maximum) | 40.80 mm (1.606 in.) |
| Outer Rotor Thickness (Minimum) | 9.83 mm (0.387 in.) |
| Inner and Outer Rotor Clearance (Maximum) | 0.2 mm (0.008 in.) |
| Pump Housing Depth (Maximum) | 10.23 mm (0.403 in.) |
| Spring Free Length (Minimum) | 19.5 mm (0.768 in.) |
| Oil Pressure Sensor Continuity (On) | 98 kPa (14.2 psi) |
| Oil Filter Bypass Valve Opening Pressure | 78.5 – 117.5 mm (11.4 – 17.1 psi) |
| Governor: | |
| Governor Mounting Shaft Height | 32.2 – 32.8 mm (1.267 – 1.291 in.) |
| Starting Motor: | |
| Maximum Amperage (No Load) | 50 amps @ 6000 rpm |
| Brush Length (Minimum) | 6.4 mm (0.25 in.) |

# TORQUE SPECIFICATIONS

| | |
|---|---|
| Breather Cover Cap Screws | 6.9 N•m (61 lb-in.) |
| Carburetor Mounting Stud Nut | 6.9 N•m (61 lb-in.) |
| Connecting Rod Cap Screw | 5.9 N•m (52 lb-in.) |
| Cooling Shroud Mounting Cap Screws | 6.9 N•m (61 lb-in.) |
| Cylinder Head Cap Screws: | |
| Initial Torque | 13 N•m (115 lb-in.) |
| Final Torque | 25 N•m (221 lb-in.) |
| Crankcase Cover Mounting Cap Screws | 25 N•m (221 lb-in.) |
| Engine Mounting Cap Screws | 34 N•m (25 lb-ft) |
| Exhaust Pipe Nuts | 6.9 N•m (61 lb-in.) |
| Fan Housing Cap Screws | 6.9 N•m (61 lb-in.) |
| Flywheel Cap Screw | 56 N•m (41 lb-ft) |
| Fuel Pump Mounting Cap Screws | 16 N•m (142 lb-in.) |
| Fuel Solenoid to Carburetor | 6.9 N•m (61 lb-in.) |
| Governor Arm Clamp Nuts | 7.8 N•m (69 lb-in.) |
| Governor Lever Nut | 7.8 N•m (69 lb-in.) |
| Ignition Coil Cap Screws | 7.8 N•m (69 lb-in.) |
| Intake Manifold Cap Screws: | |
| Initial Torque | 3 N•m (27 lb-in.) |
| Final Torque | 6.9 N•m (61 lb-in.) |
| Oil Plug (Metal) | 20 N•m (174 lb-in.) |
| Oil Pressure Switch | 9.8 N•m (87 lb-in.) |
| Oil Pump Cover Cap Screws | 6.9 N•m (61 lb-in.) |
| Rocker Arm Cap Screws | 27 N•m (20 lb-ft) |
| Rocker Cover Cap Screws | 6.9 N•m (61 lb-in.) |
| Spark Plug Torque | 15 N•m (133 lb-in.) |
| Starting Motor Mounting Cap Screws | 17 N•m (150 lb-in.) |
| Stator Coil Cap Screws | 3.9 N•m (35 lb-in.) |

# SPECIAL OR REQUIRED TOOLS

| Tool | Purpose |
|---|---|
| D-05351ST Spark Tester | Check condition of ignition system |
| D20020WI Reaming Tool (7.05 mm) | Clean or size valve guide |
| JDG705 Reaming Tool (7.25 mm) | Clean or size oversize valve guide |
| JDG356 Pressure Gauge | Check fuel pump performance |
| JDM59 Compression Gauge | Check engine cylinder compression |
| JDM70 Valve Spring Compressor | Remove and install valve springs |
| 6 mm (15/64 in.) Drill Bit | Throttle and choke adjustment |
| Dial Indicator | Automatic compression relief test, Valve inspection, Crankshaft end play |
| JTO7270 Digital Pulse Tachometer, or JTO5719 Photo Tachometer | Slow and fast idle adjustment |
| JTO5712 Current Gun | Check starting motor performance |
| JDM74A5 Spark Plug Ground | Protect engine and prevent accidental starting during engine tests |
| JT035029 Cylinder Leak Tester | Cylinder leak test |
| JTO5697 U-Tube Manometer Test Kit; or, JT03503 Crankcase Vacuum Test Kit | Crankcase vacuum check |

| Tool | Purpose |
|---|---|
| JT07262 Oil Pressure Test Adapter w/ O-ring (required ONLY on engines without test ports)<br>JT05487 Connector<br>JT03017 Hose Assembly<br>JT03262 Coupler<br>JT07034 Gauge, 0 – 700 kPa (0 – 100 psi) | Oil pressure test |
| Lapping Tool | Valve lapping |

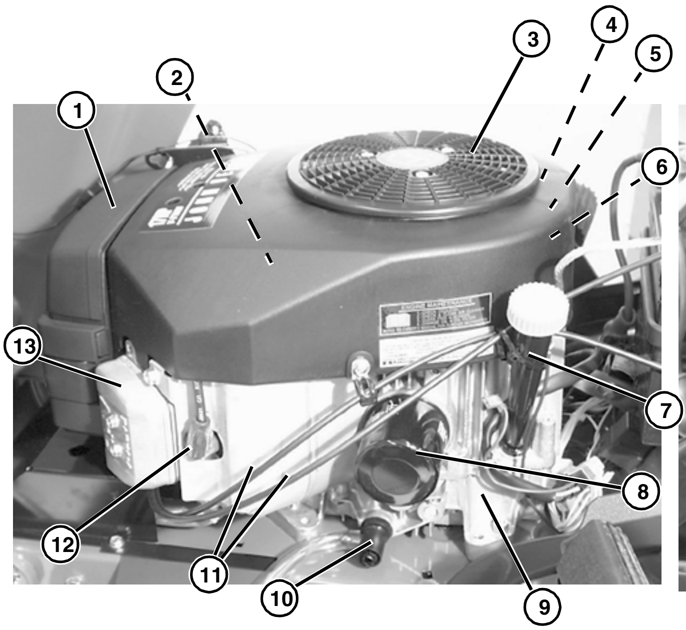
# OTHER MATERIALS

| Number | Name | Use |
|---|---|---|
| M79292 | MPG-2® Multipurpose Grease | Apply to engine crankshaft |
| | SCOTCH-BRITE® Abrasive Sheets/Pads | Clean cylinder head |
| | Valve Guide Cleaner | Clean valve guides |
| | Stanisol (or Kerosene) | Finish ream valve guides |
| | Lithium base Grease | Pack oil seals |
| | Mineral Spirits | Clean armature |
| | Valve Lap Compound | Lap valves |
| TY16135 | Form-In-Place Gasket | Rocker arm cover mating surfaces |
| TY9370 LOCTITE® No. 242 | Thread Lock and Sealer (Medium Strength) | Apply to threads of throttle and choke plate screws. |

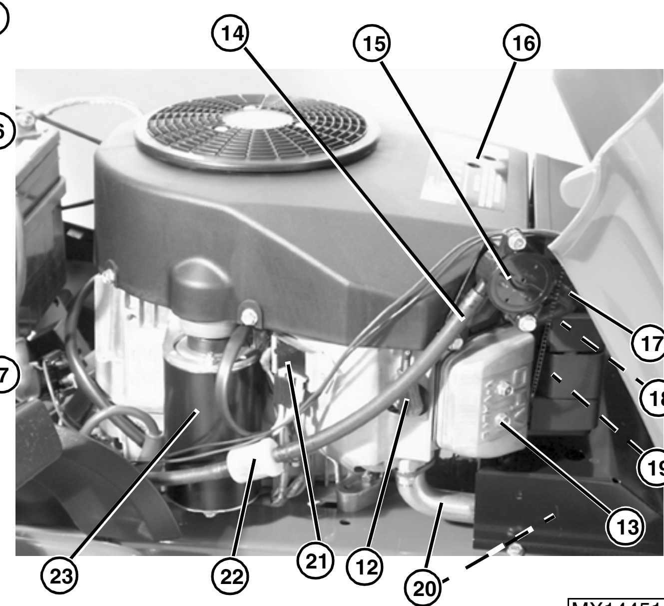
MPG-2® is a registered trademark of DuBois USA
LOCTITE® is a registered trademark of the Loctite Corp.
SCOTCH-BRITE® is a registered trademark of the 3M Co.

# COMPONENT LOCATION

## ENGINE EXTERIOR



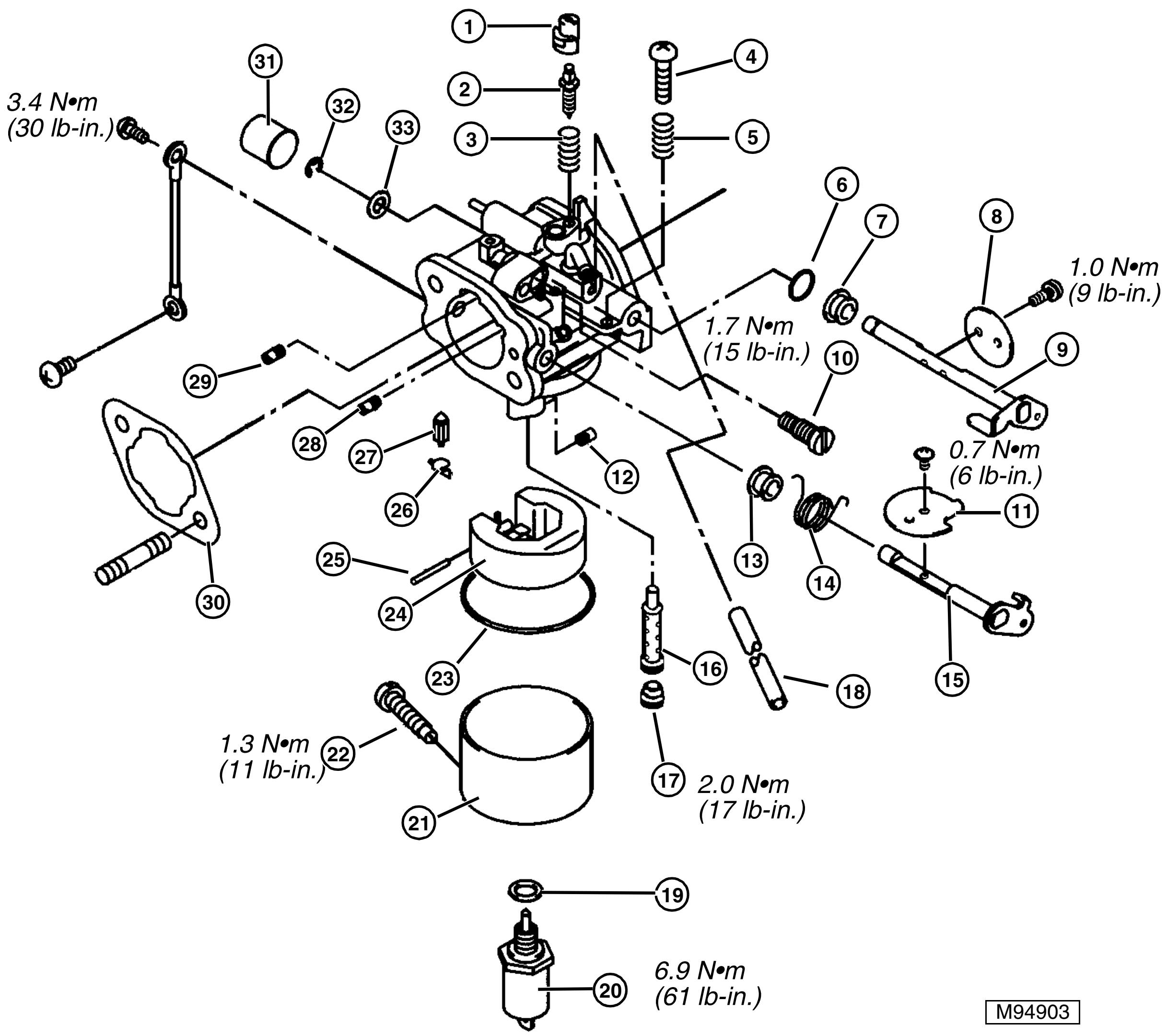

MX14452




MX14451

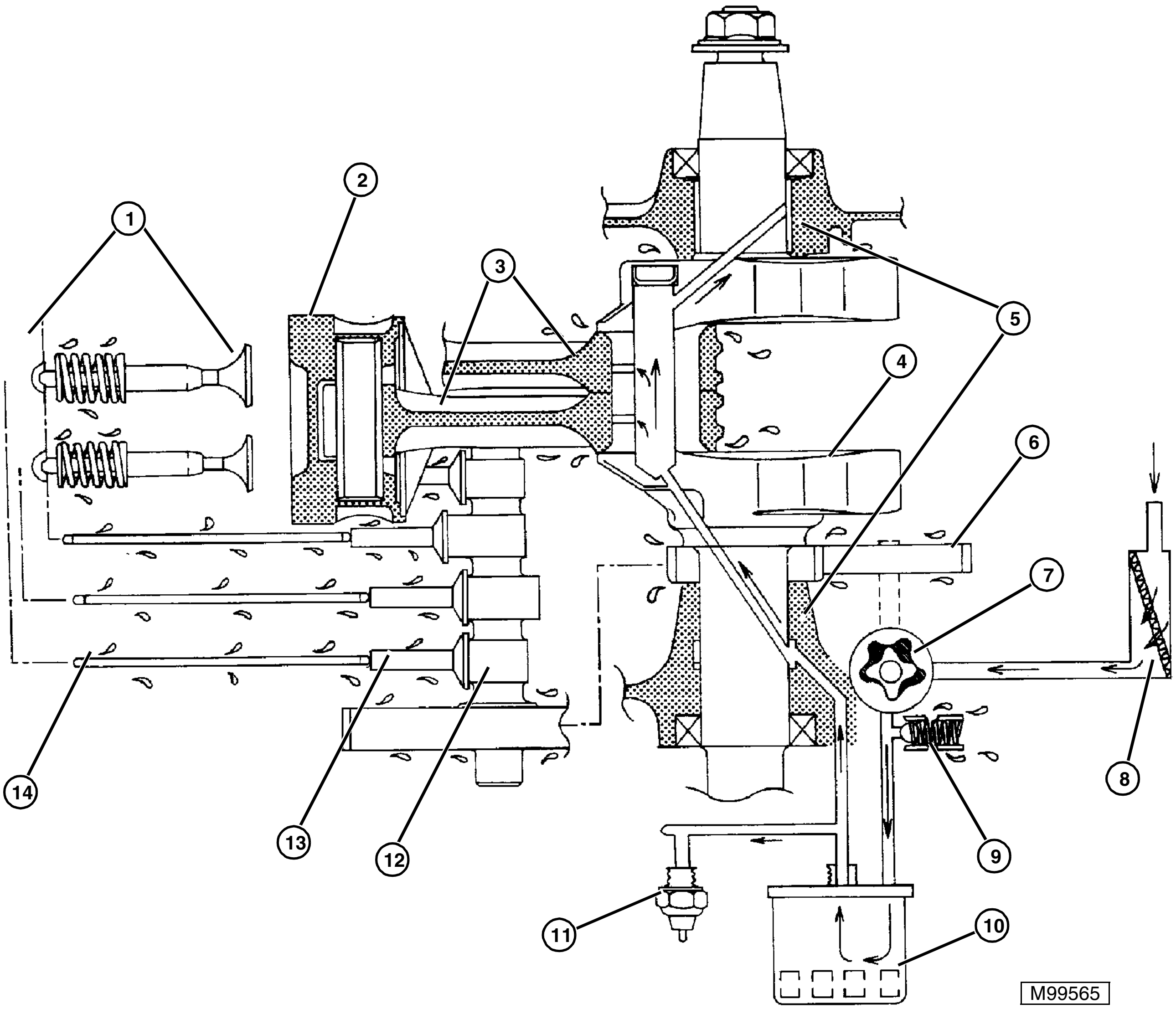
1. Air Cleaner Cover
2. Ignition Module
3. Screen
4. Blower Fan
5. Flywheel
6. Stator
7. Dipstick
8. OIl Filter
9. Crankcase
10. Drain Plug
11. Throttle and Choke Cables
12. Spark Plug
13. Rocker Arm Cover
14. Vacuum Hose
15. Fuel Pump
16. Blower Housing
17. Carburetor Inlet Hose
18. Carburetor
19. Fuel Shutoff
20. Exhaust Pipe and Muffler
21. Voltage Regulator/Rectifier
22. Fuel Filter
23. Starting Motor

# CARBURETOR COMPONENTS




1. Limiter
2. Pilot Air Screw
3. Spring
4. Low Idle Screw
5. Spring
6. Seal
7. Ring
8. Throttle Valve
9. Throttle Shaft
10. Pilot Jet
11. Choke Valve
12. Main Jet
13. Collar
14. Spring
15. Choke shaft
16. Main Nozzle
17. Valve Seat
18. Tube
19. Washer
20. Fuel Shutoff Solenoid
21. Float Bowl
22. Drain Screw
23. Gasket
24. Float
25. Pin
26. Snap Ring
27. Float Valve
28. Main Air Jet
29. Air Jet
30. Gasket
31. Cap
32. E-clip
33. Washer

# ENGINE OIL FLOW CHART




1. Rocker Arms and Valves
2. Pistons
3. Connecting Rods
4. Crankshaft
5. Crankshaft Main Bearings
6. Oil Pump Gear
7. Oil Pump
8. Pick-up Screen
9. Oil Pressure Relief Valve
10. Oil Filter
11. Oil Pressure Sensor
12. Camshaft
13. Tappets
14. Push Rods

# THEORY OF OPERATION

## LUBRICATION SYSTEM OPERATION

**Function:**

To provide pressurized oil to lubricate internal engine components.

**Theory of Operation:**

A positive displacement gerotor pump is used to pressurize the lubrication system. The lubrication system is protected by an oil pressure relief valve, low oil pressure switch, and an oil filter with bypass valve.

The oil pump draws oil from the sump through the pick-up screen. Pressure oil from the pump flows through the pump outlet passage past the oil pressure relief valve. The oil pressure relief valve limits the oil pressure to approximately 296 kPa (43 psi) and protects the oil pump from damage if an oil passage becomes blocked. If the oil pressure exceeds 296 kPa (43 psi), the relief valve opens allowing oil to return to the sump. The relief valve is not adjustable.

Pressure oil flows past the relief valve to the oil filter. The filter contains a bypass valve which opens at 78.5–117.5 kPa (11.4–17.1 psi) if the element becomes plugged to ensure engine lubrication.

An oil pressure switch mounted above the oil filter turns on a warning light if oil pressure is below 98 kPa (14.2 psi). Filtered pressure oil flows through a passage in the oil sump to the crankshaft main bearing (PTO side). Drilled passages in the crankshaft distribute oil from the main bearings to the connecting rod journals and crankshaft main bearings (flywheel side). A drilled passage in the connecting rods allows oil from the connecting rod journal to lubricate the piston and cylinder walls.

In the cylinder head, the rocker arms, valves, and pushrods are lubricated by an oil/air mixture carried through an upper lubrication passage from the breather chamber. As this oil/air mixture is swirled around the rocker arm chamber, the oil particles cling to the moving parts, lubricating them. Eventually these oil particles collect into a liquid state again in the lower portion of the rocker arm chamber. A small return passage is provided to return this liquid state oil back into the crankcase.

The camshaft gear, camshaft, tappets, coolant pump gear, governor gear, oil pump gear, and crankshaft gear are lubricated by oil splash generated by the internal moving parts during operation.

# TROUBLESHOOTING

## ENGINE & FUEL SYSTEM TROUBLESHOOTING CHART

| Problem or Symptom / Check or Solution | Engine cranks but will not start or starts hard. | Engine will not stay running, runs rough, or irregularly. | Engine stalls frequently. | Engine backfires. | Engine surges, or has uneven | Engine misses. | Engine has low power. | Engine has no spark. | Engine will not crank. | Lack of fuel in carburetor. | Engine floods. | Exhaust smoke black or uses | Exhaust smoke blue or has excessive oil consumption. | Engine has low oil pressure. | Fuel in oil. | Engine overheats. | Excessive engine noise or vibration. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Spark plug fouled, defective, or gap not correct. Incorrect spark plug. | | ● | | | | ● | ● | ● | | | | ● | | | ● | ● | |
| Defective ignition components. | ● | ● | ● | ● | ● | ● | ● | ● | | | | ● | | | ● | | |
| Starting motor worn. Cranking rpm too slow. | ● | | | | | | | | | | | | | | | | |
| Fuel filter or line restricted. Fuel pump weak, restricted, or leaking. Fuel stale, contains water, or wrong type. | ● | ● | ● | ● | ● | ● | ● | | | ● | | ● | ● | | | | |
| Fuel pump not operating. | ● | ● | ● | | ● | | ● | | | ● | | | | | | | |
| Air filter element(s) plugged, oil soaked, or restricted. | ● | ● | ● | | ● | ● | ● | | | | | ● | | | ● | | |
| Choke, throttle, or governor linkage misadjusted. Carburetor misadjusted. | ● | ● | ● | ● | ● | ● | ● | | | | ● | ● | | | ● | | |
| Carburetor worn, contaminated with debris or varnish. Passages plugged. Wrong jets. | ● | ● | ● | ● | ● | ● | ● | | | | | | | | ● | | |
| Carburetor, intake manifold, or cylinder head gaskets leaking or damaged. | ● | ● | ● | ● | ● | ● | ● | | | | | | | | | ● | ● |

# ENGINE & FUEL SYSTEM TROUBLESHOOTING CHART

| Problem or Symptom / Check or Solution | Engine cranks but will not start or starts hard. | Engine will not stay running, runs rough, or irregularly. | Engine stalls frequently. | Engine backfires. | Engine surges, or has uneven | Engine misses. | Engine has low power. | Engine has no spark. | Engine will not crank. | Lack of fuel in carburetor. | Engine floods. | Exhaust smoke black or uses | Exhaust smoke blue or has excessive oil consumption. | Engine has low oil pressure. | Fuel in oil. | Engine overheats. | Excessive engine noise or vibration. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low compression from worn piston, rings, cylinder, valves or warped head. | ● | ● | ● | | ● | ● | ● | | | | | | ● | | | | ● |
| Valve clearance incorrect. Burned or warped valves and seats. Defective springs. | ● | ● | ● | ● | ● | ● | ● | | ● | | | | | | | | |
| Engine oil viscosity or level incorrect. Engine oil filter restricted. | ● | | | | | | ● | | | | | | ● | ● | | ● | ● |
| Engine gaskets or seals leaking. | I | ● | ● | ● | ● | ● | ● | | | | | | | | | | |
| Crankcase breather restricted, reed valve damaged, clearance incorrect, or drain hole plugged. | ● | ● | ● | | ● | | ● | | ● | | | | ● | | | ● | |
| Valve guides or seals worn or leaking. Valve stems worn. | ● | ● | ● | ● | ● | ● | ● | | | | | | ● | | | | |
| Worn, stuck, or broken piston rings. Cylinder bore worn. Check compression and vacuum. | ● | ● | | | ● | | ● | | | | | | ● | | | | |
| Connecting rod or crankshaft bearings worn. Internal wear limits out of specification. | | | | | | | ● | | | | | | | ● | | ● | ● |
| Battery cables corroded, or battery weak. | | ● | ● | | | | | | ● | | | | | | | | |

# ENGINE TROUBLESHOOTING GUIDE

## Engine Hard to Start

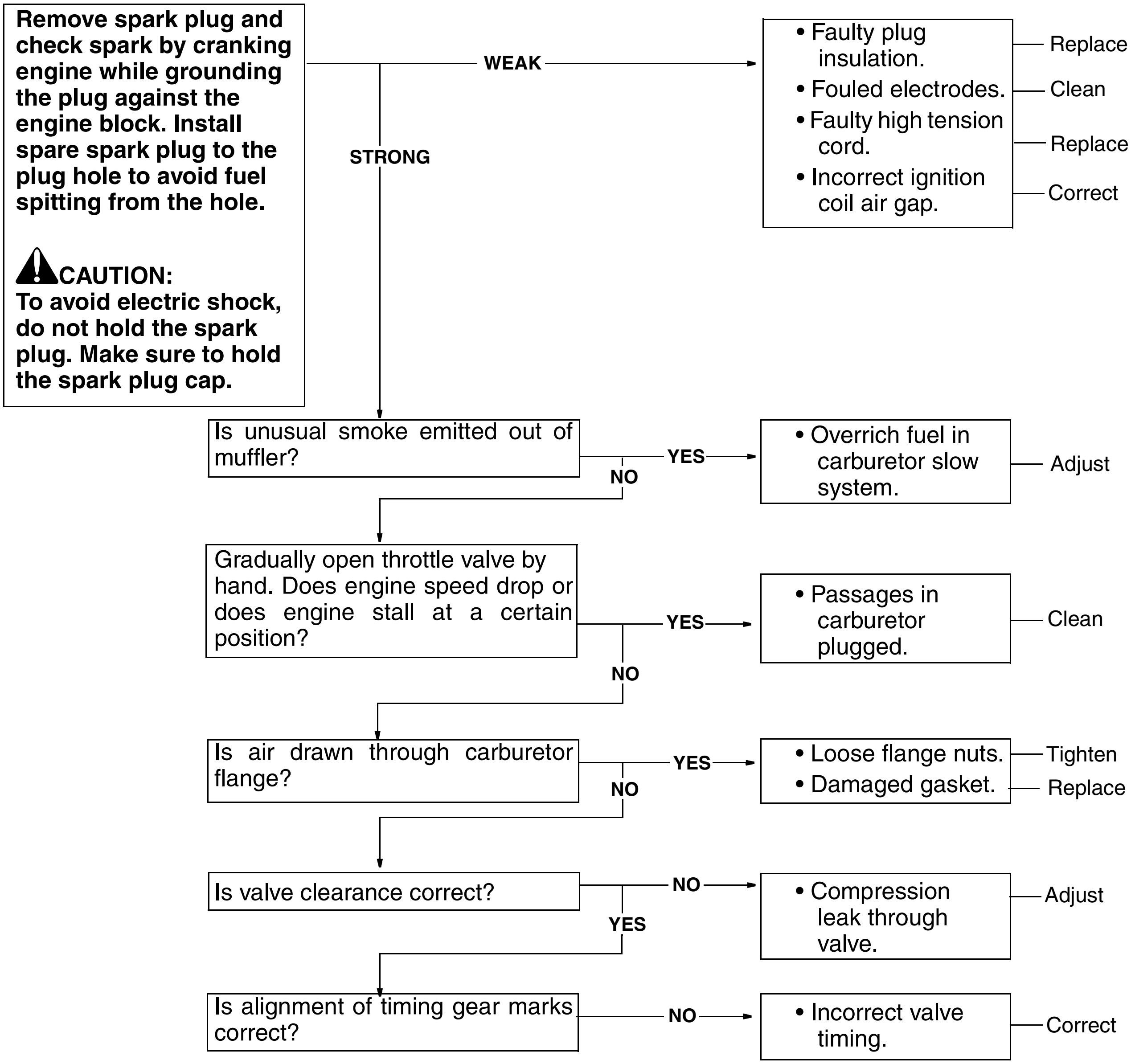
**Remove spark plug. Check spark by cranking engine while grounding the plug against the engine block. Install a spare spark plug to the spark plug hole to avoid fuel spitting from the hole.**

**CAUTION:**
**To avoid electric shock, do not hold the spark plug.**
**Make sure to hold the spark plug cap.**

- NO → Are sparks produced when spark plug is replaced?
  - YES → • Faulty spark plug. — Replace
  - NO → Are sparks produced between high tension lead and engine block with plug cap removed?
    - YES → • Faulty contact of plug cap terminal to lead. — Correct
    - NO → Are sparks produced between high tension lead and engine block when control unit is replaced?
      - YES → • Faulty control unit. — Replace
      - NO →
        - • Faulty ignition coil. — Replace
        - • Faulty high tension cord. — Replace
        - • Incorrect ignition coil air gap. — Correct
        - • Demagnetized flywheel. — Replace
- YES → Is compression sufficient?
  - YES → Crank engine several times, then remove spark plug and observe electrodes. Are they wet?
    - NO →
      - • No fuel in the tank. — Add
      - • Clogged fuel filter. — Clean
      - • Plugged air hole in tank cap. — Clean
      - • Plugged fuel line. — Clean
    - YES →
      - • Excessive use of choke. — Open choke
      - • Clogged air cleaner. — Clean
      - • Fuel level too high in float bowl. — Adjust
  - NO →
    - • Worn piston/piston rings. — Replace
    - • Stuck piston rings. — Clean or replace
    - • Worn cylinder bore. — Bore or replace
    - • Insufficient cylinder head tightening. — Retighten
    - • Faulty contact between valve and valve seat. — Lap
    - • Valve stuck open. — Adjust or repair
    - • Warped cylinder head. — Repair or replace
    - • Broken valve spring. — Replace
    - • Stuck valve. — Clean or grind
    - • Burned head gasket. — Replace

Check carburetor. →
- • Check for plugged fuel passage.
- • Check for plugged air passage.
- • Check float level.
- • Check carburetor setting.

## Engine Malfunctions at Low Speed



## Engine Runs Erratically

| | | |
|---|---|---|
| Problem in fuel system (lack of fuel). | • Dust or water in fuel pipe or fuel filter. | Clean |
| | • Air or vapor lock in fuel line. | Remove |
| | • Plugged air vent in fuel tank cap. | Clean |
| | • Plugged air/fuel passages in carburetor. | Clean |
| | • Too little opening of carburetor pilot air-screw. | Correct |
| Problem in governor system. | • Incorrect governor linkage adjustment. | Correct |
| | • Faulty governor spring. | Replace |
| | • Governor gear assembly malfunction. | Check |
| Engine knocks. | • Stale fuel. | Change |
| | • Excessive carbon deposit in engine. | Clean |
| | • Excessive engine load. | Adjust |
| | • Engine overheating. | See **Has Low Power** |

## Oil consumption Is Excessive

Is compression sufficient?

**YES** →

| | |
|---|---|
| • Plugged oil ring groove. | Clean |
| • High oil level. | Adjust |
| • Worn valve stems and valve guides. | Replace |
| • Oil leakage along governor shaft. | Replace |
| • Oil seals leaking. | Replace |
| • Head gasket leaking. | Replace |
| • Drain plug leaking. | Retighten or replace |
| • Breather valve clogged. | Clean |
| • Drain-back hole in tappet chamber plugged. | Clean |
| • Incorrect oil viscosity. | Change |

**NO** →

• Same as **Hard To Start**.

## Engine Has Low Power

Is engine overheated?

YES →
- Excessive engine load. — Adjust load
- Carburetor not properly adjusted. — Adjust
- Dirty or clogged air intake screens, shroud and engine fins. — Clean
- Carbon deposit in combustion chamber. — Clean
- Wrong spark plug. — Replace

NO ↓

Is lubricating condition normal?

NO →
- Too much or too little oil in crankcase. — Correct
- Excessively contaminated lubricating oil. — Change

YES ↓

Is unusual smoke emitted out of muffler?

YES →
- Air cleaner clogged. — Clean
- Carbon deposit in exhaust hole and muffler. — Clean
- Carburetor not properly adjusted. — Adjust
- Too much oil in crankcase. — Correct

NO ↓

Is compression sufficient?

NO →
- Same as **Hard To Start**.

## Fuel Consumption is Excessive

Is compression sufficient?

YES →
- Carburetor not properly adjusted. — Adjust
- Air cleaner clogged. — Clean
- High idling R.P.M. — Adjust
- Choke valve not fully open. — Open

NO →
- Same as **Hard To Start**.

# STARTING MOTOR TROUBLESHOOTING GUIDE

1. Disconnect spark plug cap, and ground the cap terminal.
2. Turn key switch to “START” position and check conditions below.

**CAUTION**

**Engine may be cranked in this test. Do not touch any rotating parts of engine and equipment during test.**

**IMPORTANT: If starting motor does not stop by engine switch “OFF”, disconnect negative (–) lead from battery as soon as possible.**

## Starting Motor Does Not Rotate

Is click sound from solenoid (switch)?

NO →

| | |
|---|---|
| • Faulty battery. | Charge or replace |
| • Faulty leads or connection. | Repair or replace |
| • Melted fuse. | Replace |
| • Faulty engine switch. | Repair or replace |
| • Faulty solenoid (switch). | Replace |

YES →

| | |
|---|---|
| • Weak battery. | Charge or replace |
| • Faulty leads or connection. (Solenoid to motor) | Repair or replace |
| • Faulty solenoid (switch). (Main terminal in solenoid) | Replace |
| • Faulty starting motor. | Repair or replace |

## Starting Motor Rotates Slow

Is battery normal and charged?

NO →

| | |
|---|---|
| • Weak battery. | Charge or replace |

YES →

| | |
|---|---|
| • Faulty leads or connection. (Solenoid to motor) | Repair or replace |
| • Faulty solenoid (switch). (Main terminal in solenoid) | Replace |
| • Faulty starting motor. | Repair or replace |
| • Faulty engine. | Repair or replace |

## Starting Motor Rotates But Can Not Crank Engine

Does pinion mesh with ring gear?

NO →

| | |
|---|---|
| • Worn pinion or ring gear. | Replace |
| • Incorrect starting motor alignment. | Correct |

YES →

| | |
|---|---|
| • Faulty clutch. | Replace |

## Starting Motor Does Not Stop With Engine Switch In "OFF" Position

Can stop starting motor by placing key switch "OFF"?

NO →

| | |
|---|---|
| • Faulty key switch. | Repair or replace |
| • Faulty solenoid (switch). | Replace |

YES →

| | |
|---|---|
| • Faulty pinion or ring gear | Repair or replace |
| • Incorrect starting motor alignment. | Correct |
| • Faulty pinion return mechanism. | Repair or replace |

# TESTS AND ADJUSTMENTS

## THROTTLE CABLE ADJUSTMENT

**Reason:**

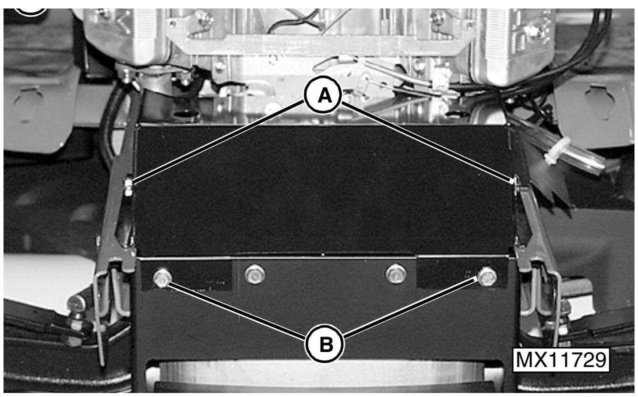
To make sure the throttle control arm contacts the slow idle stop at slow idle.

**Equipment:**

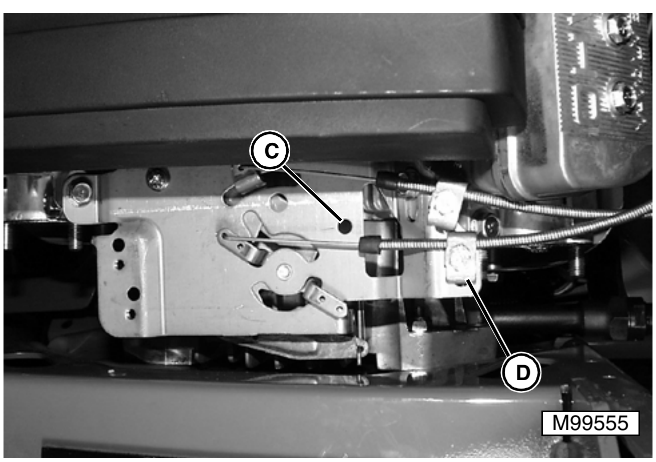
- 6 mm (15/64 in.) Drill Bit; or,
- 6 x 30 mm Flat Head Pin (45M7036)

**Procedure:**

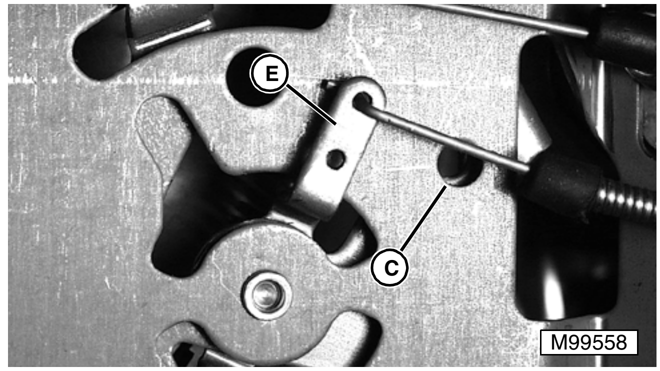
1. Park tractor on a flat surface. Turn engine OFF and engage parking brake.
2. Remove hood.




3. Remove two side (A) and two front (B) cap screws. Remove the upper muffler heat shield.




4. Loosen throttle cable clamp (D).




5. Align the hole (C) in the speed control lever (E) with the hole in the base plate by moving the speed control lever.
6. Insert a **6 mm (15/64 in.)** drill bit or pin through the base plate and speed control lever holes.
7. Pull up the cable housing until there is almost no slack in the throttle cable. Tighten throttle cable clamp.
8. Remove drill bit or pin.
9. Install upper muffler heat shield.
10. Install hood.

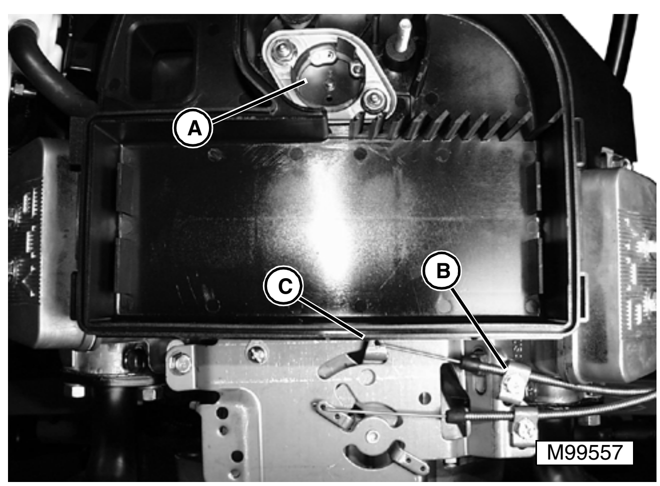
## CHOKE CABLE ADJUSTMENT

**Reason:**

To make sure the choke is fully closed when the choke control lever is in the full choke position.

**Procedure:**

1. Park tractor on a flat surface. Turn engine OFF and engage parking brake.
2. Remove hood.
3. Remove upper muffler heat shield, see previous procedure.



4. Remove air cleaner cover and filter.
5. Loosen choke cable clamp (B).
6. Place and hold the choke control lever (C) in the FULL CHOKE position.
7. Move the engine choke lever until the carburetor choke plate (A) is fully closed. Tighten choke cable clamp.

NOTE: *If the choke will not fully close when the engine choke lever is fully rotated clockwise, perform "Choke Plate Check and Adjustment".*

8. Move the choke control lever between the choke fully open and fully closed position several times. Ensure the choke plate fully opens and closes. Adjust cable as needed.
9. Install the air filter and air cleaner cover.
10. Install the upper heat shield and hood brackets.
11. Install the hood.

## CHOKE PLATE CHECK AND ADJUSTMENT

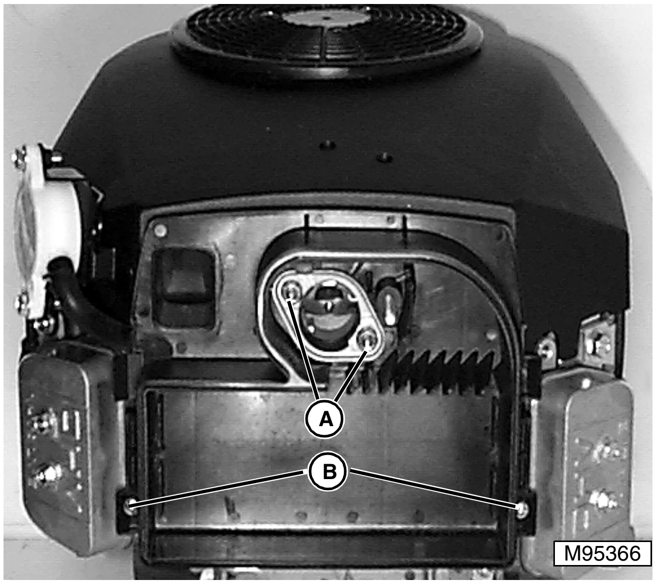
**Reason:**

To make sure the choke plate is fully closed when the choke control lever is in the full choke position.

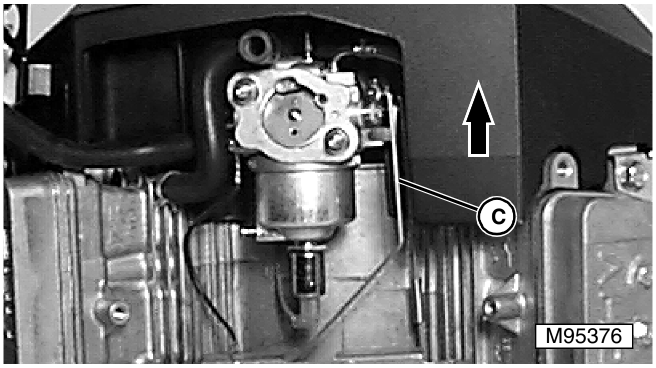
**Check Procedure:**

**IMPORTANT: Check and adjust choke cable before adjusting choke, to ensure accurate adjustment.**

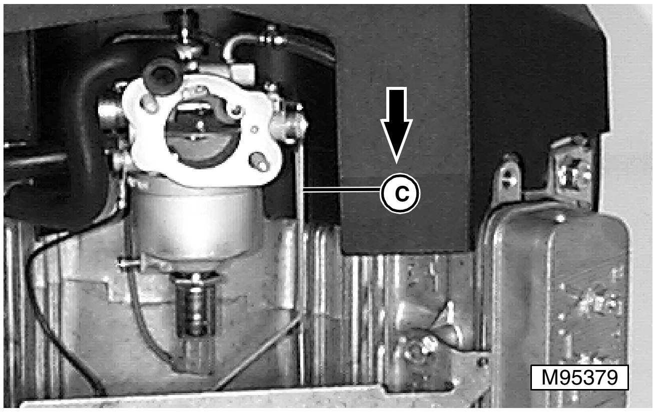
1. Check and adjust choke cable.




2. Remove the two screws (B) and two nuts (A) that hold the air cleaner base to the carburetor.
3. Carefully pull air cleaner base away from carburetor and remove crankcase vent tube from back of air cleaner base.
4. Place both nuts back on carburetor studs and secure finger tight only.
5. Move throttle control lever to full CHOKE position.




6. Try to move choke rod (C) toward carburetor (arrow). Choke rod should NOT move. If choke rod moves up, the choke plate is not fully closed.
7. Move choke control lever to fully open position.

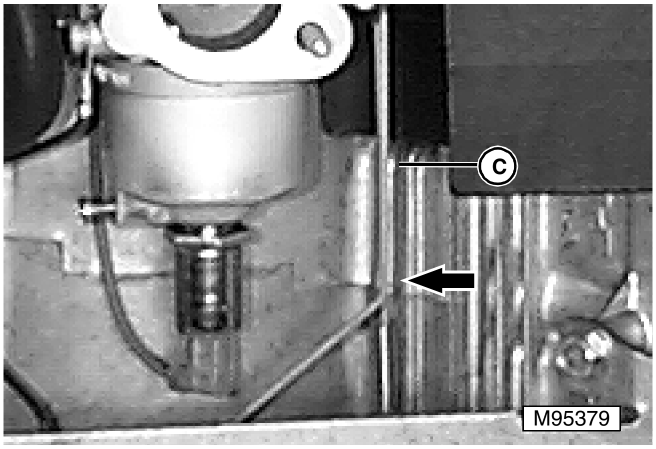



8. Try to move choke rod (C) down (arrow). Choke rod should NOT move. If choke rod moves down, the choke plate is not fully open.

**Results:**

- If choke rod DOES NOT move in either direction with choke control lever in the specific positions, choke operation is OK.
- If choke rod MOVES in either direction with throttle control lever in the specific positions, perform ADJUSTMENT procedure.

**Adjustment Procedure:**




1. Carefully bend the choke rod (C) at the corner (arrow) to balance the OPEN and CLOSED positions of the choke valve plate.
2. Bending the rod more will open the choke, while bending the rod straighter will close the choke valve.
3. Repeat Check Procedure.
4. Install air cleaner housing. Tighten nuts securing housing and carburetor to **6.9 N•m (61 lb-in.)** and screws securing housing to **3.9 N•m (35 lb-in.)**.
5. Install hood.

## GOVERNOR ADJUSTMENT

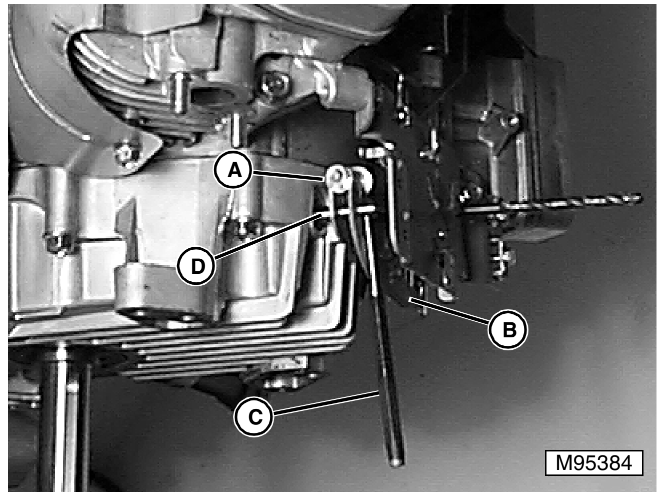
**Reason:**

To ensure the governor shaft contacts the fly-weight plunger when the engine is stopped.

**Procedure:**

*NOTE: Adjust throttle cable and choke plate before adjusting governor linkage.*

1. Adjust throttle cable and choke plate.
2. Move throttle control lever to FAST idle position.




3. Loosen nut (A).
4. Hold governor arm (B) fully clockwise.
5. Using a small pin (C), rotate shaft (D) counterclockwise as far as it will go.
6. Hold governor shaft and governor arm in place and tighten nut to **7.8 N•m (69 lb-in.)**.
7. Move throttle control lever through full range to be sure linkage is not binding.

## SLOW IDLE SPEED ADJUSTMENT

**Reason:**

The slow idle speed is not adjustable. Slow idle is governed at **1550 ± 75 rpm**.

The idle mixture screw can be adjusted within limiter range, and the slow idle stop can be set.

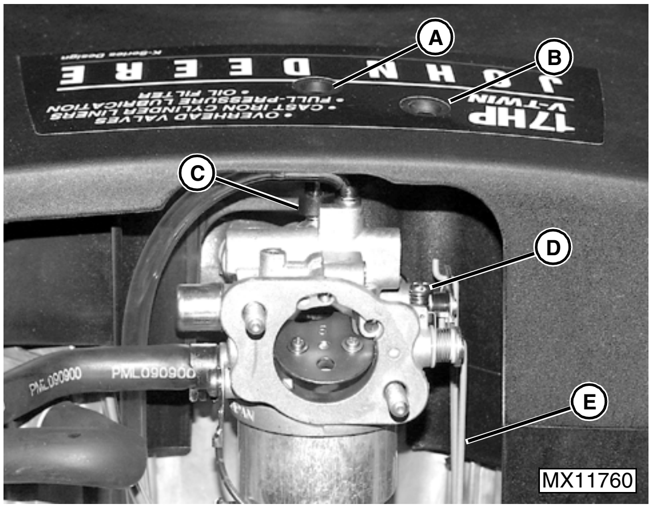
**Equipment:**

- JT07270 Digital Pulse Tachometer; or,
- JT05719 Photo Tachometer

**Procedure:**

1. Park machine on level surface.
2. Turn key switch OFF.
3. Move forward/reverse pedals to NEUTRAL position. Engage parking brake.
4. Raise hood.
5. Put reflective tape (for photo tachometer) on blower housing screen.

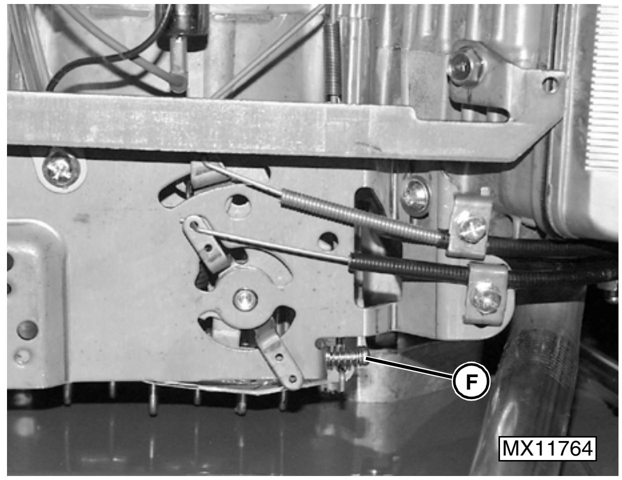
*NOTE: Idle mixture is factory set. Access idle mixture screw and slow idle stop screw through holes in front shroud. DO NOT force the idle mixture screw.*




Air Filter and Housing Removed for Clarity

6. Start engine. Run at MEDIUM speed for five minutes.
7. Move throttle control lever to SLOW idle position.
8. Initial Adjustment: Use a flat blade screwdriver through access hole (A) to turn idle mixture screw (C) clockwise until it contacts the limiter stop. Then turn idle mixture screw counterclockwise (approximately 1/2 turn) until it contacts the opposite limiter stop. Turn idle mixture screw clockwise to the midpoint between the limiter stops.
9. Turn idle mixture screw until best idle is obtained.
10. Pull throttle lever rod (E) down until movement stops (holds the throttle lever on the carburetor in the closed position and turns the governor arm clockwise all the way) when the idle stop screw (D) is contacted.
11. While maintaining contact (downward pressure), use a Phillips head screwdriver through access hole (B) to turn SLOW idle stop screw (D) counterclockwise until slow idle speed is **1450 rpm**.

*NOTE: Idle speed is governed at 1550 ± 75 rpm. When throttle lever rod is released, the idle stop screw should not be in contact with throttle rod.*




12. Release the throttle and adjust the low idle speed screw on the control plate (F) until the engine idles at **1550 ± 75 rpm**.

## FAST IDLE SPEED ADJUSTMENT

**Reason:**

To set engine fast idle speed setting.

**Equipment:**

- 6 mm (15/64 in.) Drill Bit; or,
- 6 x 30 mm Flat Head Pin (45M7036)
- JT07270 Digital Pulse Tachometer; or,
- JT05719 Photo Tachometer

**Procedure:**

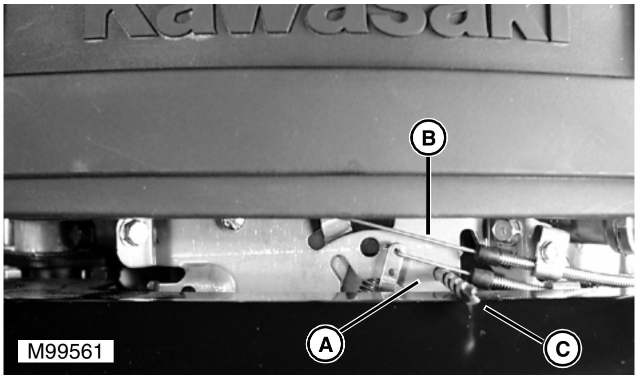
Before performing this procedure, adjust slow idle speed. See "SLOW IDLE SPEED ADJUSTMENT" on page 20.

1. Park machine on level surface.
2. Turn key switch OFF.
3. Move forward/reverse pedals to NEUTRAL position. Engage parking brake.
4. Remove hood.
5. Put reflective tape (for photo tachometer) on blower housing screen.
6. Start and run engine at MEDIUM idle for five minutes to warm engine.

**CAUTION**

**Engine will be HOT. Be careful not to burn hands.**

7. Move throttle control lever to FAST idle position.




8. Align hole in throttle arm (A) with hole in throttle control panel (B). Put the **6 mm (15/64-in.)** drill bit or pin (C) through holes to keep the throttle control arm from moving. Be sure drill bit is perpendicular to the throttle control panel.
9. Use photo tachometer to check engine rpm. Fast idle speed setting should be **3350 ± 50 rpm**.

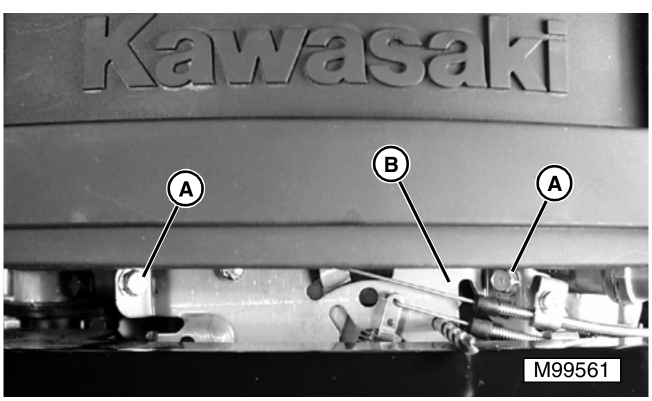
**Results:**

If fast idle speed does not meet the specifications:

- Adjust throttle control panel

*NOTE: Moving the control panel changes the governor spring tension to adjust fast idle.*

**IMPORTANT: DO NOT adjust high idle speed with the air cleaner removed.**




1. Loosen cap screws (A).
2. Move left-hand side of throttle control panel (B) up to increase rpm or down to decrease rpm.
3. Hold the throttle control panel and tighten cap screws to **6.9 N•m (61 lb-in.)**.
4. Remove the **6 mm (15/64-in.)** drill bit or pin.
5. Check fast idle speed, and readjust the idle speed as necessary.
6. Stop engine. Install hood.

## VALVE CLEARANCE, CHECK AND ADJUSTMENT

**Reason:**

To obtain the proper valve clearance that is critical for the valves to seat properly.

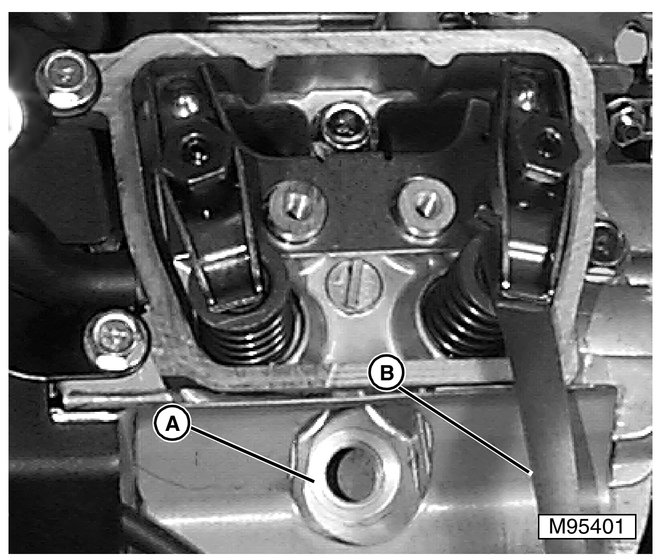
**Equipment:**

- Feeler Gauge (blade type)

**Procedure:**

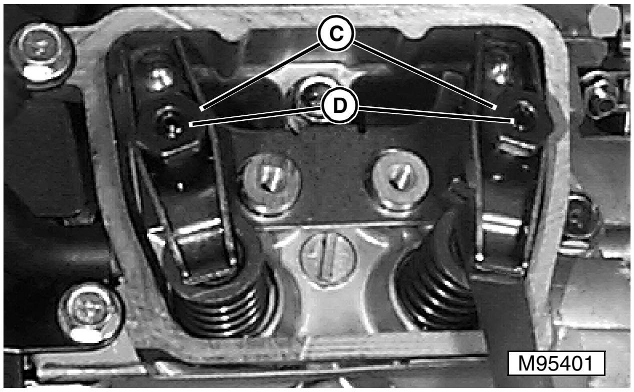
**IMPORTANT: Perform valve clearance check or adjustment when engine is cold.**

1. Park machine on level surface.
2. Turn key switch OFF. Allow engine to cool.
3. Move forward/reverse pedals to NEUTRAL position. Engage parking brake.
4. Remove hood.
5. Remove and ground spark plug lead. Remove spark plug.
6. Remove valve cover.




7. Turn crankshaft until piston, visible in spark plug hole (A), is at TDC (top dead center) of the compression stroke (both intake and exhaust valves will be closed).
8. Use a feeler gauge (B) to measure valve clearance. Valve clearance should be within specification.

**Results:**




1. If valve clearance does not meet the specifications, loosen jam nut (C). Turn screw (D) to adjust valve clearance to specifications.
2. Hold screw and tighten nut to specification. Recheck clearance.

**Specifications:**

**Valve Clearance . . . . . . . . . . . . . . . . 0.05 – 0.10 mm**
**. . . . . . . . . . . . . . . . . . . . . . . . . . .(0.002 – 0.004 in.)**
**Jam Nut Torque . . . . . . . . . . . . . . 6.9 N•m (61 lb-in.)**
**Valve Cover Cap Screw Torque. . 6.9 N•m (61 lb-in.)**
**Spark Plug Torque . . . . . . . . . . . 15 N•m (144 lb-in.)**

## CYLINDER COMPRESSION PRESSURE TEST

**Reason:**

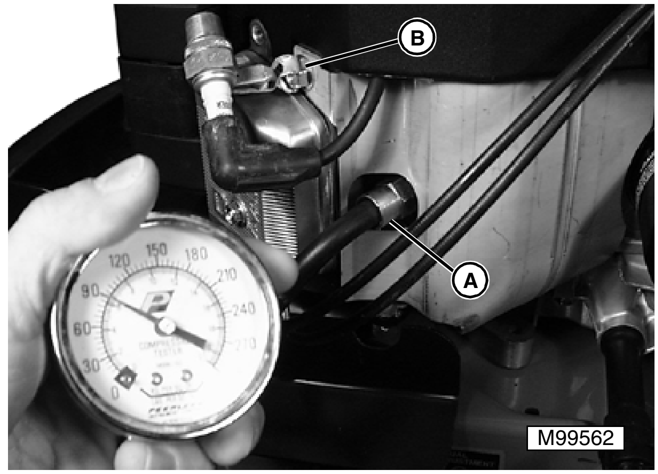
To determine the condition of the pistons, rings, cylinder walls, and valves.

**Test Equipment:**

• JDM59 Compression Gauge

**Procedure:**

1. Valve clearance must be adjusted properly before doing a compression test.
2. Run engine for five minutes to bring engine to operating temperature.
3. Park machine on level surface and turn key switch OFF.
4. Move forward/reverse pedals to NEUTRAL position.
5. Engage parking brake, raise hood and remove spark plugs.




6. Install JDM59 Compression Gauge (A) in one spark plug hole.
7. Ground high tension leads (B) or disconnect positive lead from ignition coil.
8. Move throttle control lever to FAST idle position.
9. Check that choke is fully open and that air filter is clean.

**IMPORTANT: DO NOT overheat starting motor during test. Starting motor duty cycle is 5 seconds ON, 10 seconds OFF.**

10. Crank engine for three to five compression strokes.
11. Record pressure reading.
12. Repeat test with other cylinder.

**Specifications:**

**Minimum Compression . . . . . . . . . 390 kPa (57 psi)**

*NOTE: The above specification is for an engine that has had sufficient running time to fully seat the rings. Relatively equal compression on both cylinders (but lower than specification) may not indicate a problem on a low-hour machine.*

• If above specification, adjust valves and check fuel and air intake systems. Check exhaust for restriction.
• If below specification, squirt clean engine oil into cylinder and repeat test.
• If compression pressure DOES NOT increase after retest; check for leaking valves, valve seats, or cylinder head gaskets.
• If compression pressure INCREASES after retest; check rings, pistons, and cylinder bores for broken rings, scoring, wear or damage. Replace as necessary.

# CRANKCASE VACUUM TEST

**Reason:**

To measure the amount of crankcase vacuum, verifying that the crankcase is not pressurized. A pressurized crankcase will force oil past the seals and gaskets and affect fuel pump operation.

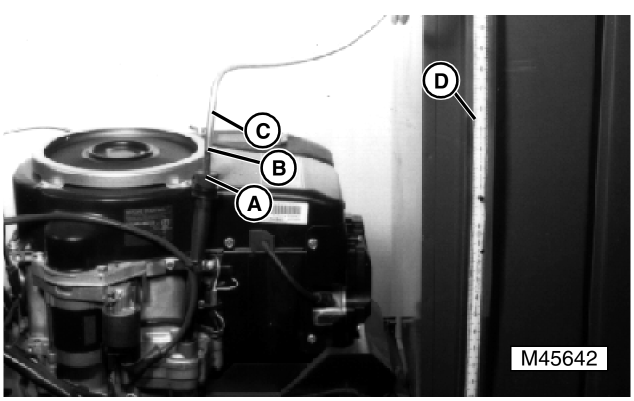
**Test Equipment:**

- 8741-F66 Plug
- JT05703 Barb Fitting
- JT05699 Line
- JT05698 U-Tube Manometer, or,
- JT03503 Crankcase Vacuum Test Kit

**Procedure Using JT05698 U-Tube Manometer:**

1. Park machine on level surface.
2. Turn key switch OFF.
3. Move forward/reverse pedals to NEUTRAL position. Engage parking brake.
4. Raise hood.
5. Remove dipstick.

**IMPORTANT: DO NOT make connection between U-tube manometer (D) and line (C) BEFORE engine is running or fluid in Manometer could be sucked into crankcase. DO NOT turn engine OFF until line (C) has been disconnected from manometer.**



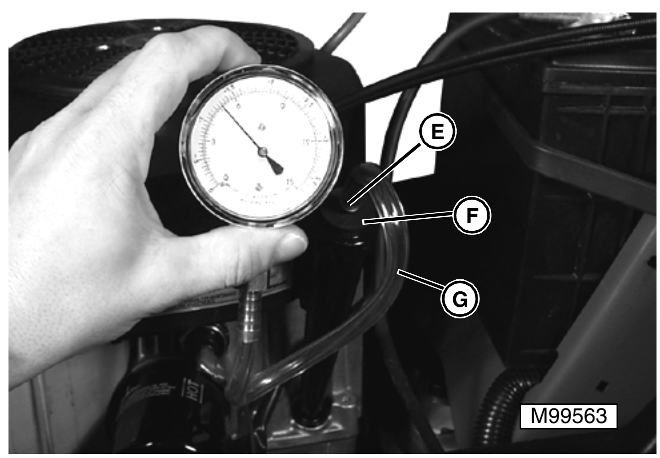

**A - Plug**
**B - Barb Fitting**
**C - Line**
**D - U-Tube Manometer**

6. Start and run engine at slow idle **(1550 ± 75 rpm)**.
7. Install 8741-F66 Plug (A) in dipstick hole.
8. Install JT05703 Barbed Fitting (B) in Plug and connect JT05699 Line (C).
9. Connect JT05698 Manometer (D) to Line (C).
10. Run engine at fast idle **(3350 ± 50 rpm)**.
11. Open manometer vent and record crankcase vacuum reading. Manometer should show a vacuum of **1.25 – 25 cm (0.5 – 10 in.)** of water at fast idle **(3350 ± 50 rpm)**.
12. Run engine at slow idle **(1550 ± 75 rpm)**. DO NOT TURN ENGINE OFF!
13. Disconnect line (C) from manometer (D).
14. Turn engine OFF.
15. Remove barbed fitting and plug from dipstick tube and install dipstick.

**Procedure Using JT03503 Crankcase Vacuum Kit:**

1. Park machine on level surface.
2. Raise engine hood and remove dipstick. Check dipstick/oil fill cap and o-ring for cracks or damage, replace as necessary.
3. Install appropriate size rubber plug in dipstick tube.
4. Insert barbed fitting (E) in rubber plug (F) so that clear line (G) to fitting can be connected at a later step.

**IMPORTANT: DO NOT make connection between test gauge and rubber plug BEFORE engine is running at FAST idle or gauge damage may result.**
**After test reading is made, DO disconnect test gauge WHILE engine is running at FAST idle to prevent damage to gauge.**




5. Hold finger over rubber plug hole to keep oil from spraying out. Start engine, move the throttle lever to fast idle and allow engine to reach operating temperature.
6. Connect gauge, clear line (G), and barbed fitting (E) to rubber plug (F).
7. Record crankcase vacuum reading. Gauge should show a vacuum of **1.25 – 25 cm (0.5 – 10 in.)** of water at fast idle **(3350 ± 50 rpm)**.

8. Disconnect barbed fitting, clear line, and gauge from rubber plug while engine is running at FAST idle. Hold finger over rubber plug hole to keep oil from spraying out.
9. Move throttle to SLOW idle and turn engine OFF.
10. Remove rubber plug and install dipstick.

**Specification:**

**Crankcase Vacuum @ 3350 rpm . . . . . 1.25 – 25 cm . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (0.5 – 10 in.)**

*NOTE: A new or low hour engine may have low vacuum readings because the rings have not seated.*

**Results:**

- If crankcase vacuum is BELOW specifications, check the following:

–Breather reed valve clearance and condition.
–Seals and gaskets for leakage.
–Fuel pump vacuum hose leakage.
–Rocker arm cover O-ring for leakage.
–Rings, piston, and cylinder bore for wear or damage.

## ENGINE OIL PRESSURE TEST

**Reason:**

To verify that the engine has enough oil pressure to lubricate internal components.

**Test Equipment:**

- JT03344 Pressure Gauge Assembly
- JT03017 Hose Assembly
- JT03349 Connector

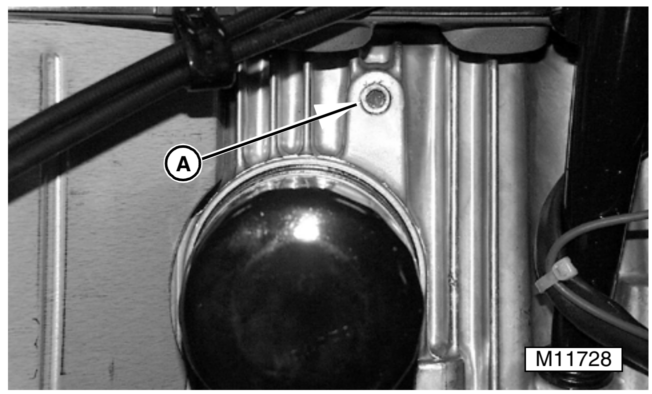
**Procedure:**

1. Park machine on level surface.
2. Turn key switch OFF. Allow engine to cool.
3. Move forward/reverse pedals to NEUTRAL position.
4. Engage parking brake.
5. Raise hood.

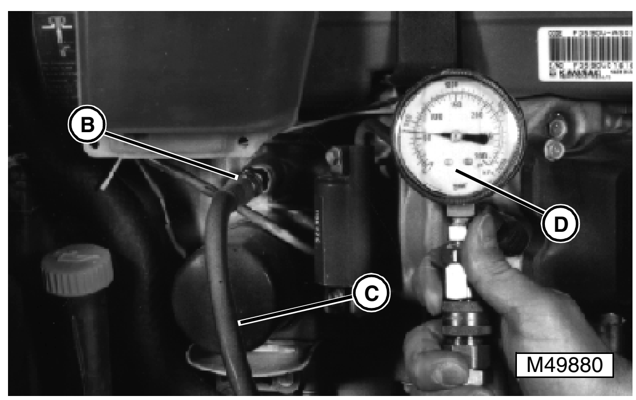
**CAUTION**

**Engine components are HOT. Be careful not to touch, especially the exhaust pipe or muffler while making adjustments. Wear protective eye glasses and clothing.**

6. Check engine oil level, bring level to full mark.




7. Remove plug above oil filter (A).




8. Install JT03349 Connector (B).
9. Connect JT03017 Hose Assembly (C) and JT03344 Pressure Gauge Assembly (D).
10. Monitor oil pressure while cranking engine. If no oil pressure is present, discontinue cranking engine. Determine and correct cause before running engine.

**IMPORTANT: If pressure reading is below 69 kPa (10 psi), STOP ENGINE IMMEDIATELY and determine cause.**

11. Start and run engine at MEDIUM idle for five minutes to heat engine oil to normal operating temperature.
12. Run engine at fast idle and check oil pressure. The oil pressure should be a minimum of **240 kPa (35 psi)**.

**Results:**

If oil pressure is BELOW specifications, inspect or replace the following:

- Oil pressure relief valve for broken or worn spring.
- Oil pressure relief valve for stuck or damaged valve.
- Worn or damaged oil pump.
- Oil pump suction screen or oil passages plugged.
- Excessive wear of connecting rod and main bearing journals.
- Oil filter plugged.

**Specifications:**

**Oil Pressure . . . . . . . . . . 240 – 310 kPa (35 – 45 psi)**

## FUEL PUMP TEST

**Reason:**

To check condition of fuel pump and determine fuel pressure.

**Test Equipment:**

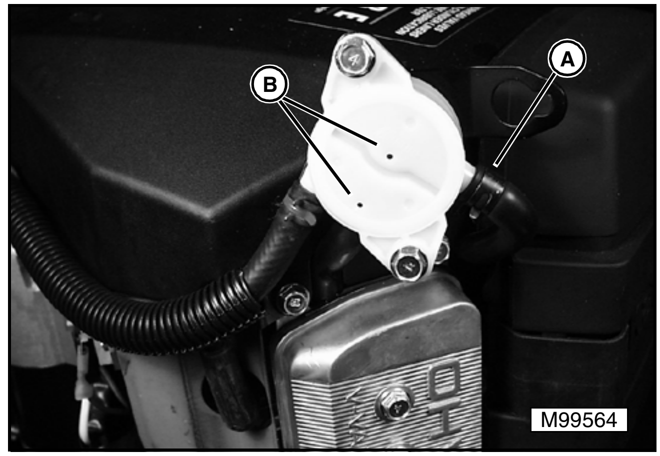
- Graduated Container

**Procedure:**

1. Park machine on level surface.
2. Turn key switch OFF.
3. Move forward/reverse pedals to NEUTRAL position. Engage parking brake.
4. Start and run engine at slow idle for one minute to fill carburetor with fuel.
5. Stop the engine.
6. Raise hood.

**CAUTION**

**Gasoline is extremely flammable. DO NOT SMOKE. Always work in a well ventilated area away from open flame or spark producing equipment; this includes equipment that utilizes pilot lights.**




1. Disconnect and plug fuel pump outlet hose (A).
2. Connect a length of fuel hose to fuel pump outlet and place other end in a graduated container.
3. Start and run engine at fast idle for 15 seconds, then stop the engine and record container measurement.

**Specifications:**

**Fuel Flow (Minimum/15 sec) . . . . . . . 65 mL (2.2 oz)**

**Results:**

If fuel pump pressure or flow does not meet the specifications, check the following:

- Inspect fuel filter.
- Fuel lines fuel tank cap for restrictions.
- Check vent holes (B) for plugging or clogging.
- Check crankcase vacuum.
- Replace fuel pump.

## SPARK TEST

**Reason:**

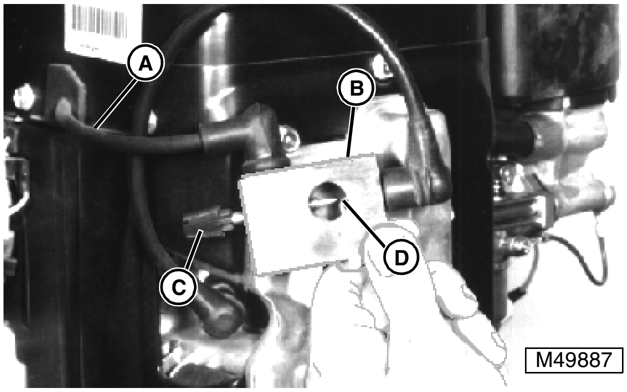
Check overall condition of ignition system.

**Test Equipment:**

- D-05351ST Spark Tester

**Procedure:**

1. Park machine on level surface.
2. Turn key switch OFF.
3. Move forward/reverse pedals to NEUTRAL position. Engage parking brake.
4. Raise hood.




5. Remove high tension lead (A) from spark plug.
6. Connect D-05351ST Spark Tester (B) to spark plug.
7. Connect high tension lead to spark tester.

**IMPORTANT: Do not adjust spark tester gap beyond 5 mm (0.2 in.) (5 turns), as damage to ignition components could occur.**

8. Adjust spark tester gap to **4.2 mm (0.166 in.) (4 turns)** with screw (C).
9. Crank engine and watch spark (D) at spark tester. If engine will start, watch spark with engine running. A steady, strong, blue spark should be observed.

**Results:**

- If spark is weak, or no spark is present, install a new spark plug and repeat test.
- If spark is still weak, or no spark is present, run tests on individual components to find the cause of the malfunction.

## SPARK PLUG GAP

**Equipment:**

- Feeler Gauge

**Procedure:**

1. Park machine on level surface.
2. Turn key switch OFF.
3. Move forward/reverse pedals to NEUTRAL position. Engage parking brake.
4. Raise hood.

**CAUTION**

**Engine components may be HOT. Be careful not to touch, especially the exhaust pipe or muffler while making adjustments.**

5. Remove spark plug.

**IMPORTANT: Do not clean spark plug with sand paper or abrasives. Engine scoring can result.**

6. Scrape or wire brush deposits from spark plug.
7. Inspect spark plug for cracked porcelain and pitted or damaged electrodes.


8. Check spark plug gap using a feeler gauge. Set gap to specification.
9. Install and tighten spark plug to specification.

**Specifications:**

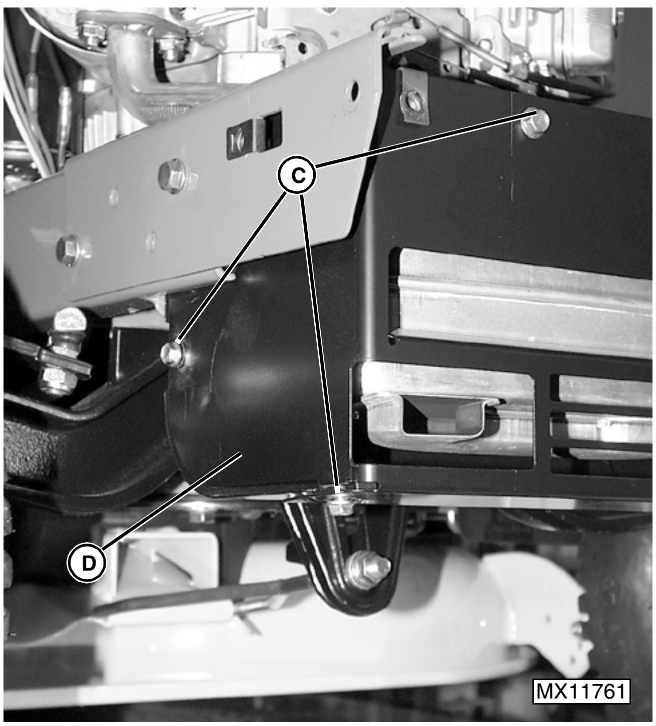
**Spark Gap . . . . . . . . . . . . . . . . . . . 1.0 mm (0.040 in.)**
**Spark Plug Torque . . . . . . . . . . . 15 N•m (132 lb-in.)**

# REPAIR

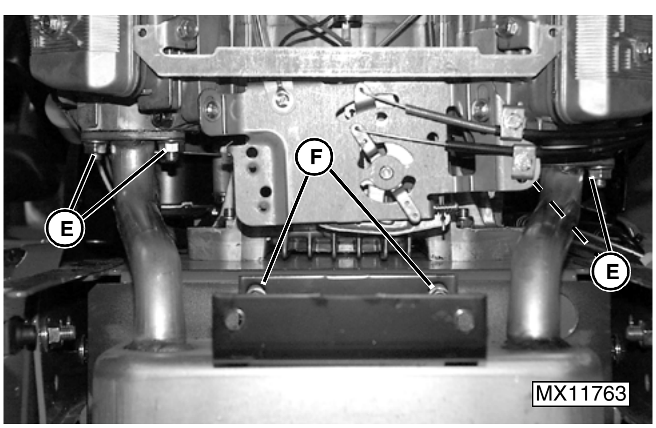
## ENGINE REMOVAL AND INSTALLATION

### Removal:

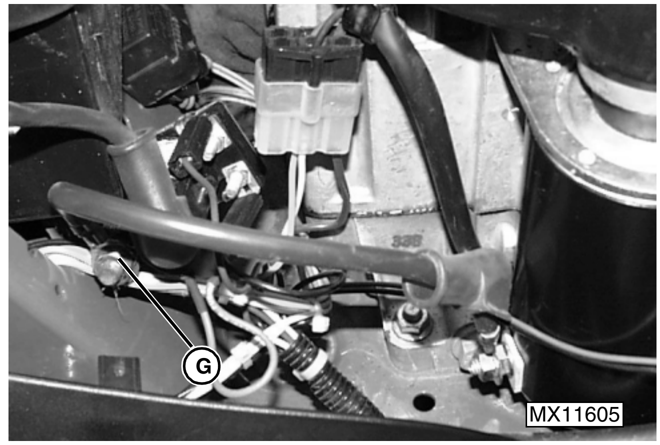
1. Park tractor on a flat surface. Turn engine OFF and engage parking brake.
2. Remove mower deck.
3. Remove engine hood.
4. Disconnect negative (-) battery cable at battery. Disconnect positive (+) battery cable at battery.
5. Remove four cap screws and upper muffler heat shield.



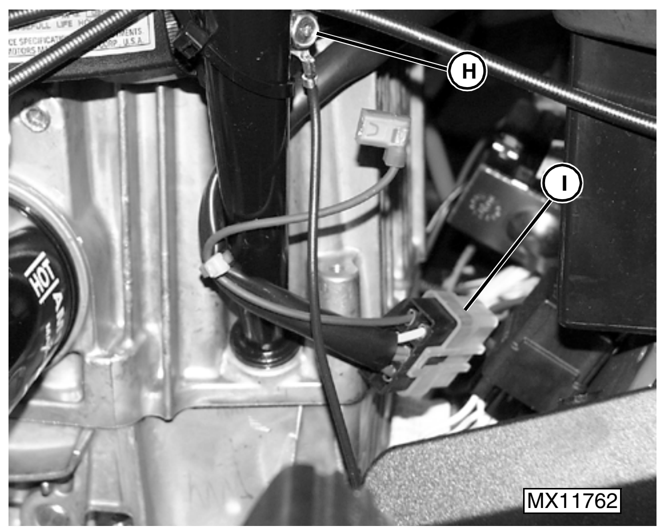

6. Remove three cap screws (C) from each side. Remove lower heat shield (D).



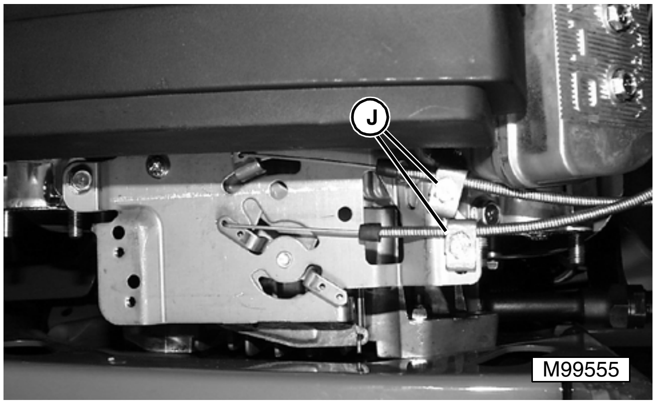

7. Remove lock washers and nuts (E) securing the muffler exhaust tubes to the cylinder heads.
8. Remove cap screws (F). Remove bracket, muffler, exhaust gaskets and rear heat deflector.




9. Remove starting motor lug nut and remove cable from starting motor.
10. Remove connection (G) from starting motor solenoid.




11. Disconnect engine wiring harness connector (I) from main wiring harness, and ground wires (H) from engine.




12. Loosen cap screws securing throttle and choke cable clamps (J). Remove cable ends from engine.

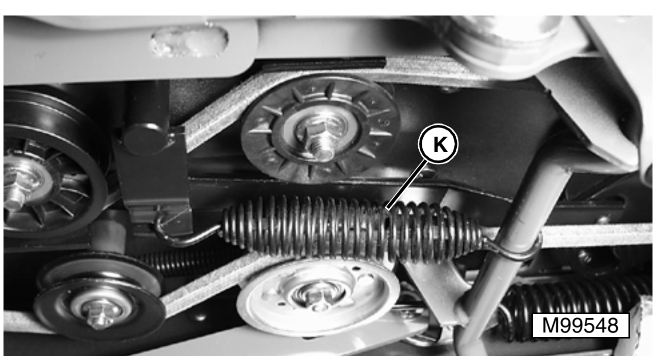
**CAUTION**

**Gasoline is explosive. DO NOT expose to flame or spark. Serious injury can result. Store in a properly marked, safe container. Wipe-up any spills IMMEDIATELY.**

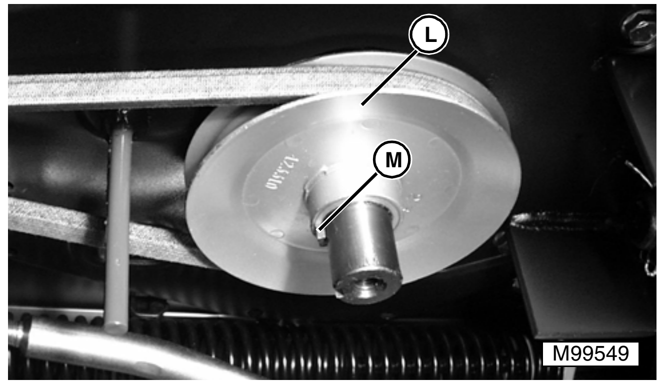
13. Disconnect fuel line from fuel pump. Plug fuel line end.
14. Drain engine oil. Capacity with filter is approximately **1.8 L (1.9 qt)**.
15. Remove electric PTO clutch. See "Electric Clutch Removal and Installation" in the Electrical section.

**CAUTION**

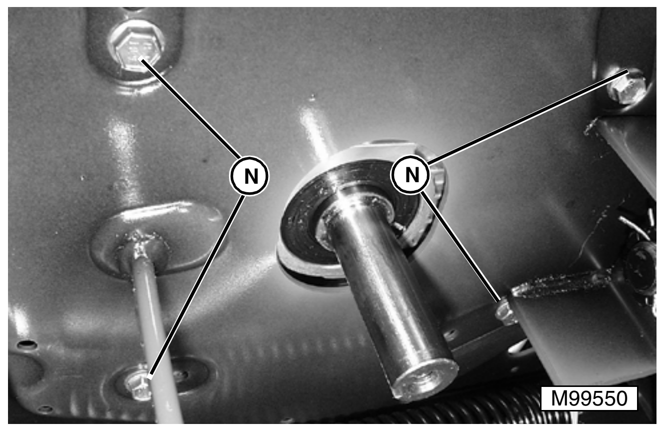
**The drive belt tension spring is under high tension when installed. Do remove spring without wearing face and hand protection.**




16. Disconnect drive belt tension spring (K).




17. Remove drive pulley (L) and key (M) from crankshaft.




18. Remove four cap screws (N) and lock nuts securing engine to frame.
19. Obtain the help of an assistant. Remove engine.

**Installation:**

Installation is performed in the reverse order of removal.

- Tighten engine mounting cap screws to specification.
- Install drive pulley, drive belt and tension spring.
- Install electric clutch.
- Install muffler. Tighten muffler lock nuts to specification.
- Install lower and upper heat shields.
- Connect fuel line.
- Connect throttle and choke cables to engine.
- Connect engine wiring harness to main wiring harness. Secure ground wire to engine.
- Connect wiring harness spade and lug connectors to starting motor.
- Fill engine with oil.
- Connect battery positive (+) cable and then battery negative (–) cable.

- Install left-hand and right-hand engine closeout panels (if removed).
- Adjust throttle and choke cables. See “THROTTLE CABLE ADJUSTMENT” on page 18 and “CHOKE CABLE ADJUSTMENT” on page 18.
- Install engine hood.

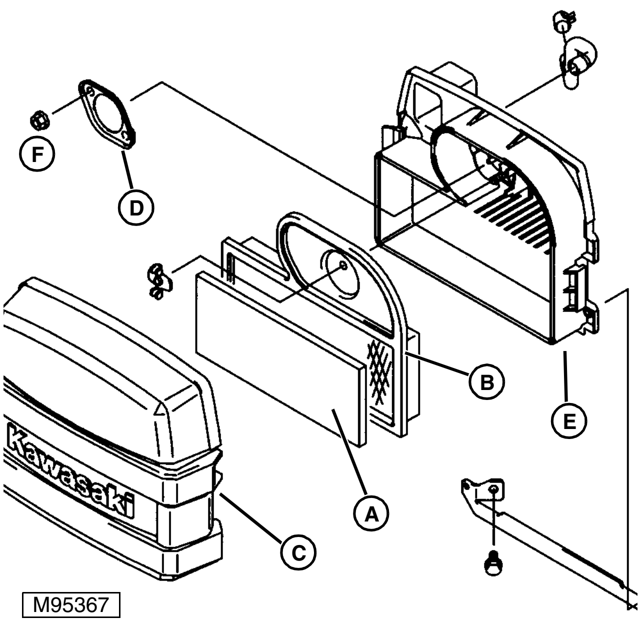
**Specifications:**

**Engine Mounting Cap Screw Torque . . . . . . 34 N•m . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . (25 lb-ft)**
**Muffler Lock Nut Torque . . . . . . . 6.9 N•m (61 lb-in.)**
**Oil Capacity w/ Filter (Approximate) . 1.8 L (1.9 qt)**

## AIR CLEANER ASSEMBLY

**IMPORTANT: Any time the air cleaner is removed, check for free choke operation during reassembly.**

1. Remove and disassemble air cleaner.




2. Wash foam element (A) in detergent and water. Dry element.
3. Apply 12 – 15 drops of clean engine oil to foam element (A). Wrap element with a clean rag and squeeze out excess oil.

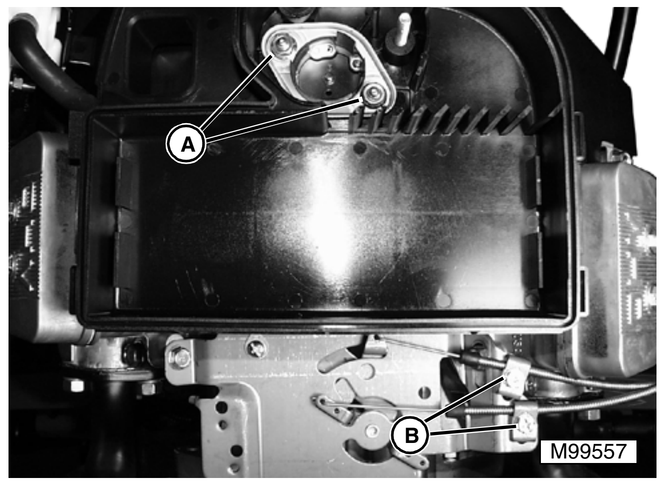
**IMPORTANT: Do not clean paper element with solvent or compressed air.**

4. Gently tap paper element (B) to remove dust.
5. Inspect element.
   - Element is still usable if you can see light through it and element appears clean.
   - Replace if oily, dirty, or damaged in any way.
6. Inspect cover (C), gasket (D), and base (E) for damage. Replace parts as necessary.
7. Assemble and install air cleaner.
8. Tighten lock nuts (F) to **6.9 N•m (61 lb-in.)**.

## CARBURETOR REMOVAL AND INSTALLATION

**Removal:**

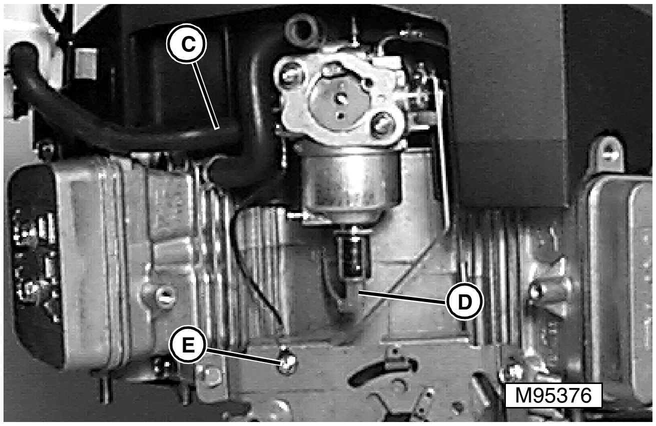
1. Unsnap and remove air cleaner cover and air filter.



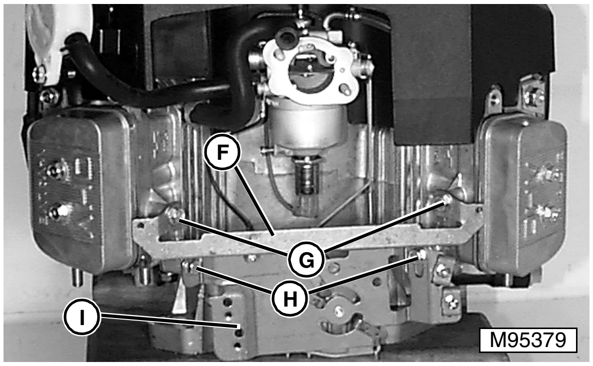

2. Loosen the clamps (B) securing the throttle and choke cables. Remove the cable ends from the engine.
3. Remove the two screws and two nuts (A) that hold the air cleaner base to the carburetor.
4. Carefully pull air cleaner base away from carburetor and remove crankcase vent tube from back of air cleaner base.

**CAUTION**

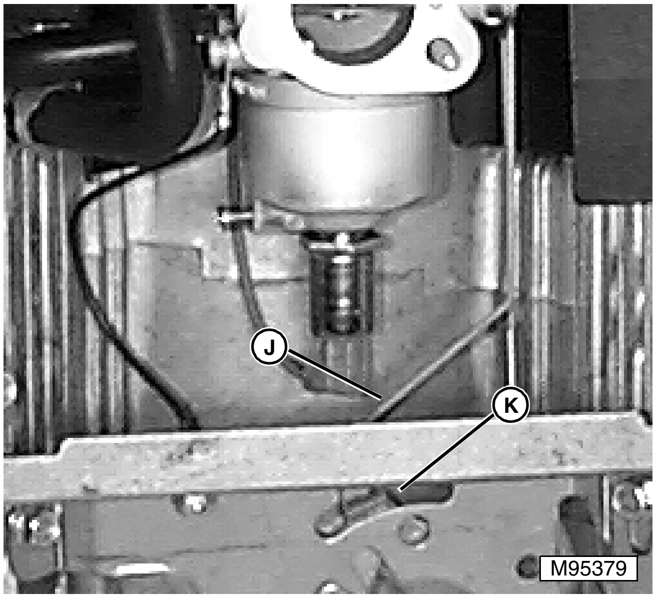
**Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment, including equipment that utilizes pilot lights.**




5. Remove and plug the fuel inlet hose (C).
6. Drain fuel from carburetor.
7. Disconnect wire connector (D) to the fuel shutoff solenoid and wire connector (E) grounding the fuel shutoff solenoid.




8. Remove two cap screws (G) holding the air cleaner mounting bracket (F) in place, and the two cap screws (H) holding the control panel (I) in place.
9. Carefully pull the control panel away from engine and disconnect the governor spring and choke rod from the control panel.




10. While pulling the carburetor forward disconnect the choke rod (J) and then the throttle link and throttle spring (K) from the carburetor.

**Installation is done in the reverse order of removal.**

- Tighten fasteners to specification.

**Torque Specifications:**

| | |
|---|---|
| **Ground Screw** | **3.4 N•m (30 lb-in.)** |
| **Air Cleaner Mounting Plate** | **6.9 N•m (61 lb-in.)** |
| **Control Panel Mounting Screws** | **6.9 N•m (61 lb-in.)** |
| **Air Cleaner Base Nuts** | **6.9 N•m (61 lb-in.)** |
| **Air Cleaner Base Screws** | **3.9 N•m (35 lb-in.)** |

**Disassembly:**

**CAUTION**

**Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment, this includes equipment that utilizes pilot lights.**

**IMPORTANT: To remove float, use a long nosed pliers on end of pin. Do not strike opposite end of pin. Damage to pin holder may result.**

1. Refer to component illustration shown for disassembly, assembly and component location.

2. There are several passage plug balls in carburetor body. DO NOT remove these plugs.
3. When removing the pilot air screw, carefully mark the position of the air screw limiter on the carburetor body so that it can be set to its original position when reinstalled.
4. Remove limiter. Be careful not to turn pilot air screw at this point.
5. Turn the pilot air screw clockwise and count the number of turns until screw is gently seated in the pilot passage.
6. Record the number of turns needed to close the pilot air screw.
7. Turn out the pilot air screw and replace with a new one.

**Clean/Inspect/Rebuild:**

**IMPORTANT: Do not clean holes or passages with small drill bits or wire.**

*NOTE: If all rubber and plastic parts cannot be removed for cleaning, use a cleaning solvent with a high flash point that will not damage these parts when cleaning.*

1. Remove rubber and plastic parts from carburetor. Soak all carburetor metal parts in carburetor cleaning solvent for 1/2 hour maximum.
2. Spray all passages with a carburetor cleaning spray to verify that all internal passages are open.

**CAUTION**

**Reduce compressed air to less than 210 kPa (30 psi) when using for cleaning purposes. Clear area of bystanders, guard against flying chips, and wear personal protection equipment including eye protection.**

**IMPORTANT: Avoid damage! Rinse carburetor body in warm water to neutralize corrosive action of cleaner on aluminum.**

3. Rinse carburetor with warm water and dry with compressed air. Do not use rags or paper to dry parts; lint may plug holes or passages.
4. Inspect all parts for wear or damage, replace as necessary.

*NOTE: Main jet high altitude kits are available.*

**Assembly:**

1. Install new pilot air screw until screw is gently seated.
2. Then open the screw the same number of turns as recorded prior to removal.
3. Align the limiter with the mark on the carburetor body to install, taking care not to turn the pilot air screw.
4. Install the throttle valve on the shaft with numerical mark on the valve facing to the outside.
5. Note the metering hole in the choke valve. Install the choke valve on the shaft so that the metering hole is towards outside of the carburetor.
6. Install the float pin so that it’s big diameter side faces the engine flange side. Float is plastic. The float cannot be adjusted. Replace if necessary.
7. Tighten all fasteners to specification listed.

**Specifications:**

| | |
|---|---|
| **Choke Valve Screws** | **0.7 N•m (6 lb-in.)** |
| **Throttle Valve Screws** | **1.0 N•m (9 lb-in.)** |
| **Pilot Jet** | **1.7 N•m (15 lb-in.)** |
| **Main Jet** | **0.7 N•m (6 lb-in.)** |
| **Valve Seat** | **2.0 N•m (17 lb-in.)** |
| **Main Nozzle** | **2.0 N•m (17 lb-in.)** |
| **Main Air Jet** | **0.7 N•m (6 lb-in.)** |
| **Pilot Air Jet** | **0.7 N•m (6 lb-in.)** |
| **Drain Screw** | **1.3 N•m (11 lb-in.)** |
| **Fuel Shutoff Solenoid** | **6.9 N•m (61 lb-in.)** |

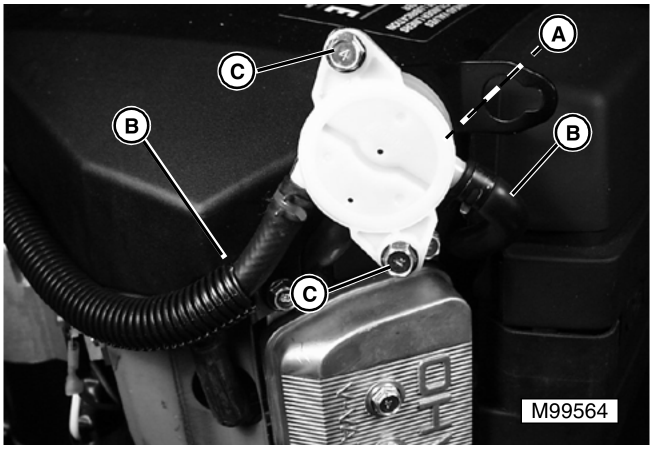
## FUEL PUMP REPLACEMENT

**Procedure:**

1. Park machine on level surface.
2. Turn key switch OFF.
3. Move forward/reverse pedals to NEUTRAL position. Engage parking brake.
4. Raise hood.

**CAUTION**

**Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment, this includes equipment that utilizes pilot lights.**



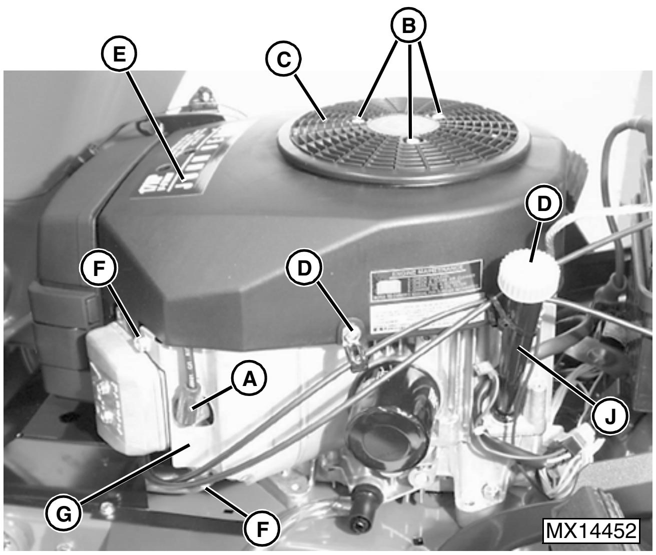

1. Disconnect vacuum line (A) (hidden from view) and fuel lines (B).
2. Remove two mounting screws (C).

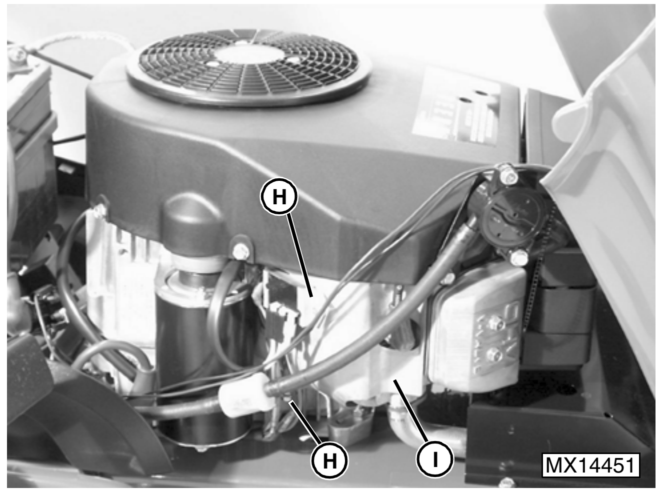
**Installation is done in the reverse order of removal.**

3. Replace fuel pump.
4. Tighten mounting screws to **16 N•m (142 lb-in.)**.

## BLOWER HOUSING REMOVAL AND INSTALLATION

**Removal:**




1. Disconnect spark plug caps (A).
2. Remove three screws (B) securing the flywheel screen (C) to the flywheel. Remove flywheel screen.
3. Remove four screws (D) (two on each side) securing the upper blower housing (E) to the block and lower housings. Remove upper blower housing.
4. Remove two screws (F) (upper photo) and remove left side lower blower housing (G).
5. Remove two screws (H) (lower photo) and remove left side lower blower housing (I).
6. Remove dipstick tube (J).

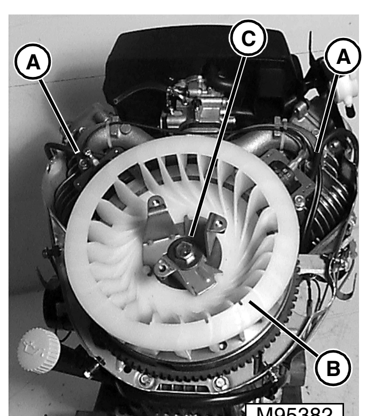
**Installation:**

Installation is done in the reverse order of removal.

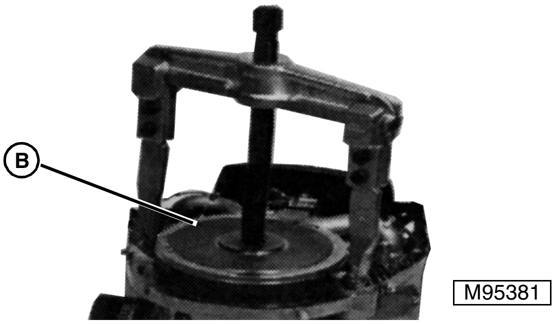
## FLYWHEEL REMOVAL AND INSTALLATION

**Procedure:**

1. Remove upper blower housing.



2. Remove both armature coils (A).
3. Hold flywheel (B) and remove cap screw (C).



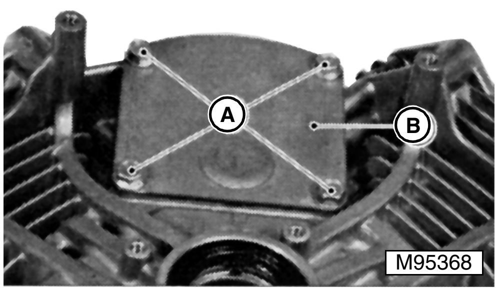

4. Remove flywheel (B) using a flywheel puller.

Installation is done in the reverse order of removal.

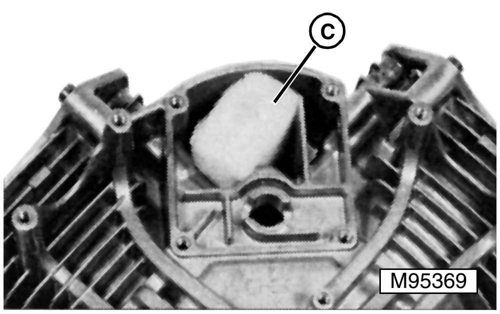
- Tighten nut to **56 N•m (41 lb-ft)**.
- Adjust armature air gap. See “ARMATURE AIR GAP ADJUSTMENT” on page 51.

## BREATHER INSPECTION

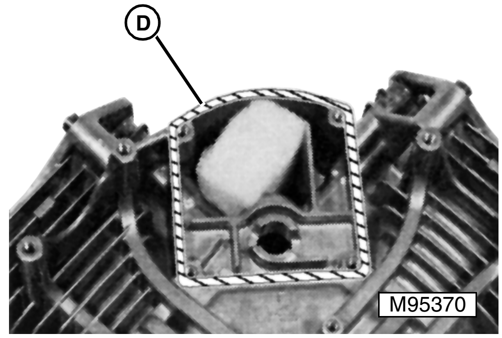
1. Remove screen and blower housing.
2. Remove fan and flywheel.
3. Remove carburetor and intake manifold.




4. Remove four screws (A) securing the breather chamber cover (B) to the crankcase.




5. Remove and replace breather element (C), or clean with solvent and allow to dry.

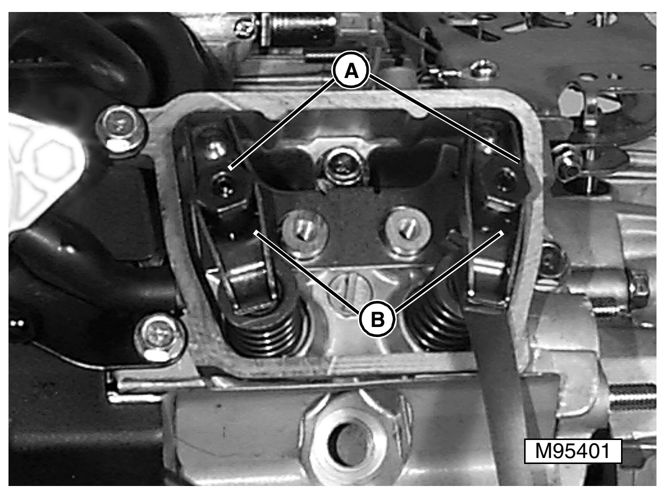



6. Apply sealant to the mating surface of the crankcase and install a new gasket (D).
7. Install the breather chamber cover and tighten four capscrews (A) to **6.9 N•m (61 lb-in.)**.
8. Install flywheel. See “FLYWHEEL REMOVAL AND INSTALLATION” on page 33.

## ROCKER ARM REMOVAL AND INSTALLATION

**Procedure:**

1. Remove rocker arm cover.
2. Turn crankshaft until piston is at TDC of compression stroke for the cylinder being worked on.




3. Remove valve clearance adjustment nut (A) and rocker arms (B).

**IMPORTANT: Mark push rods for reassembly in original locations.**

4. Inspect all parts for wear or damage. (See

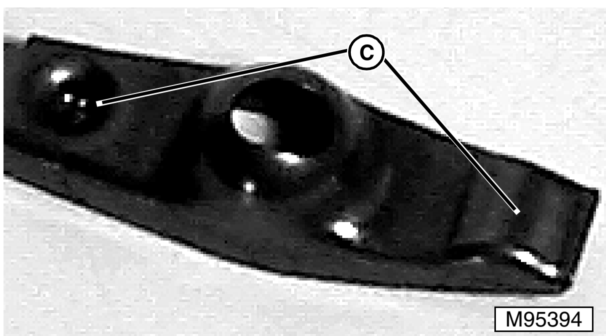
Inspection procedure.)

**Installation is done in the reverse order of removal.**

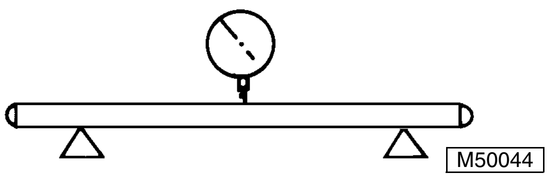
**IMPORTANT: Align rocker arms over push rods during assembly.**

1. Check and adjust valve clearance. See “VALVE CLEARANCE, CHECK AND ADJUSTMENT” on page 22.
2. Install rocker covers. Tighten rocker cover cap screws to **6.9 N•m (61 lb-in.)**.

**Inspection:**

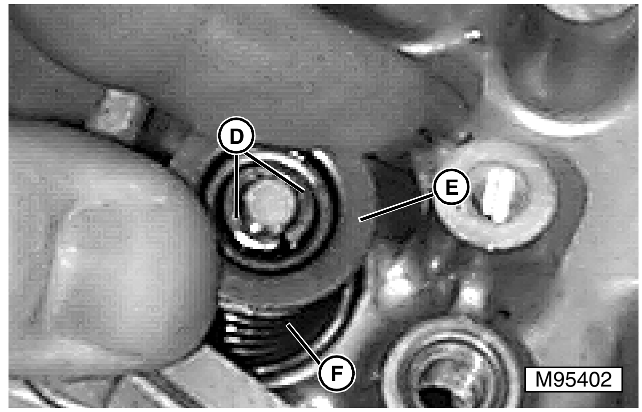



• Clean and inspect the rocker arm where it contacts the push rod and valve stem. If the contact points (C) are worn or damaged, replace the rocker arm.




• Inspect push rod for bend using V-blocks and a dial indicator. Turn rod slowly and read variation on indicator. Replace if variation is greater than **0.30 mm (0.012 in.)**.

**Disassembly & Assembly:**

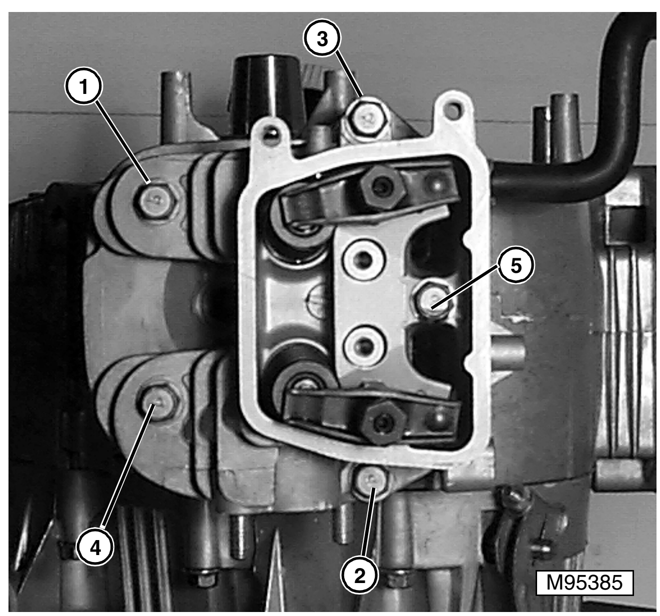



1. Compress valve spring and remove collet halves (D).
2. Remove spring retainer (E) and spring (F).

## CYLINDER HEAD REMOVAL AND INSTALLATION

**Procedure:**

1. Remove the following using procedures in this section:
   • Upper blower housing
   • Air cleaner and carburetor assemblies.
   • Muffler
   • Intake manifold
   • Spark plug




2. Remove rocker cover and gasket.
3. Turn crankshaft until piston is at Top Dead Center (TDC) of compression stroke for the cylinder being

worked on.

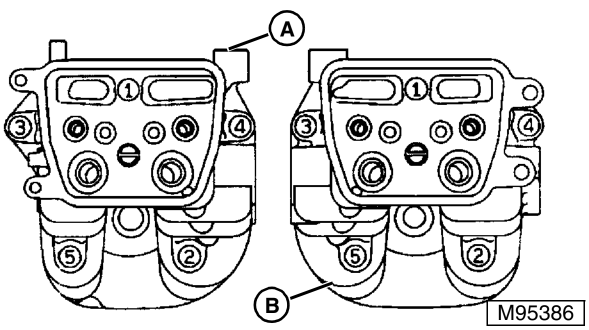
4. Loosen the cylinder head bolts 1/4 turn at a time, in sequence to prevent warping the cylinder head during removal.
5. Remove cylinder head assembly.
6. Mark push rods for installation in their original position during assembly.
7. Disassemble, clean and inspect cylinder head and valves.

**Installation:**

Installation is done in reverse order of removal.

**IMPORTANT: Gasket surfaces are coated with sealant. Do not damage surfaces or gasket during installation.**

8. Set cylinder to TDC of compression stroke for the cylinder being worked on.
9. Set the cylinder head with gasket onto crankcase.
10. Slide the push rods into the crankcase by sliding the end of the rods down along the inside wall of the crankcase.
11. Position the push rod end on the tappet.
12. Let the upper push rod end align under the rocker arms.

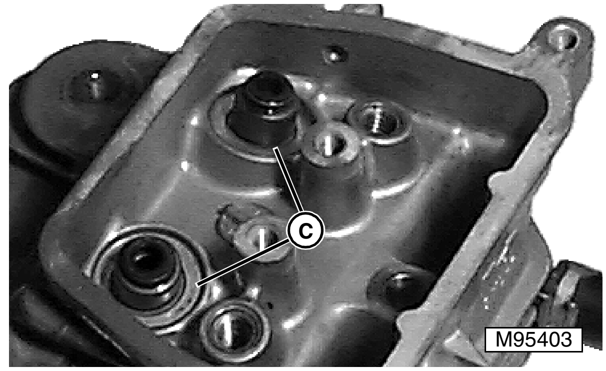



13. Torque should be applied in the sequence shown, to number one (A) and number two (B) cylinders, in **7 N•m (62 lb-in.)** increments.

**Torque Specifications:**

| | |
|---|---|
| **Initial Torque** | **7 N•m (62 lb-in.)** |
| **Second Torque** | **14 N•m (124 lb-in.)** |
| **Third Torque** | **21 N•m (186 lb-in.)** |
| **Final Torque** | **25 N•m (221 lb-in.)** |

14. Install the rocker arms. See “ROCKER ARM REMOVAL AND INSTALLATION” on page 34.
15. Check and adjust valve clearance. See “VALVE CLEARANCE, CHECK AND ADJUSTMENT” on page 22.
16. Install rocker covers. Tighten rocker cover cap screws to **6.9 N•m (61 lb-in.)**.




17. If necessary to replace stem seal, carefully pry up from bottom (C) with a screwdriver.
18. Inspect springs, valves, guides, and seals. (See Inspection procedure.)

## CYLINDER HEAD INSPECTION

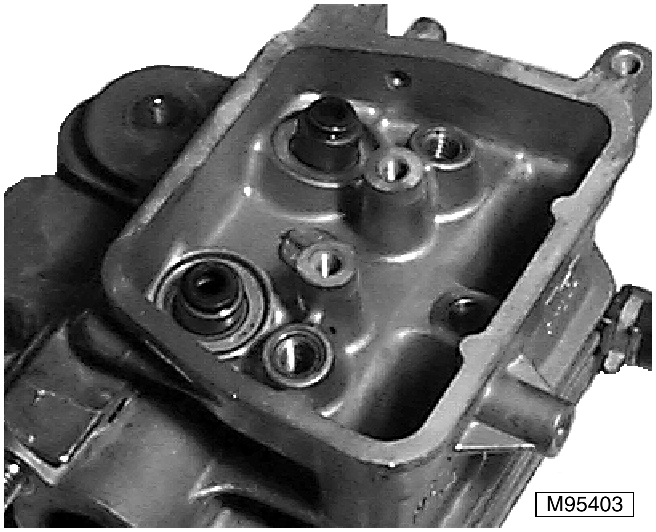
**Procedure:**

1. Remove cylinder heads. See “CYLINDER HEAD REMOVAL AND INSTALLATION” on page 35.
2. Remove carbon deposits from combustion chamber and gasket surface using SCOTCH-BRITE® abrasive pads or an equivalent.

**⚠ CAUTION**

**Reduce compressed air to less than 210 kPa (30 psi) when using for cleaning purposes. Clear area of bystanders, guard against flying chips, and wear personal protection equipment including eye protection.**

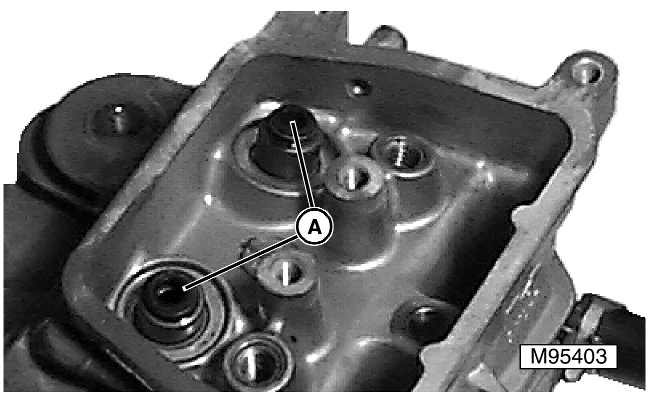
3. Clean head with a suitable solvent and dry with compressed air.
4. Inspect for cracks or broken cooling fins.
5. Inspect gasket surface for burrs and nicks.
6. Inspect head gasket for burns and traces of gas leakage. Replace if necessary.
7. Check that oil drainback passages are not plugged.




8. Put cylinder head on a surface plate. Check for distortion at several points around the head using a feeler gauge. Replace head if distortion is more than **0.05 mm (0.002 in.)**.

**Valve Guides:**

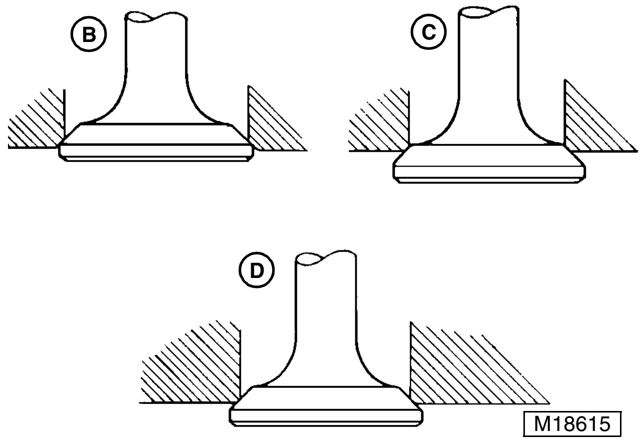
*NOTE: Intake and exhaust valve guides cannot be replaced. Replace cylinder head if worn.*




1. Clean inside of valve guides (A) with valve guide cleaner.
2. Measure inside diameter of valve guides in several places down the length of the guide. Replace cylinder head if inside diameter is greater than **6.08 mm (0.239 in.)**.

**Valve Seats:**

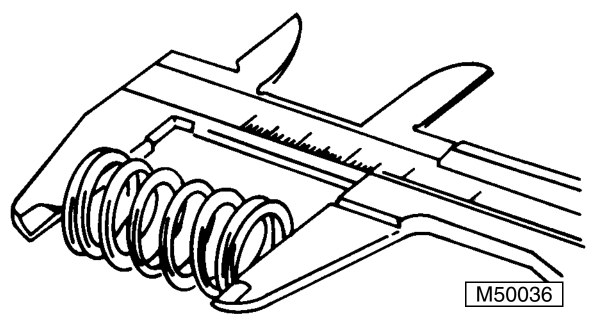
1. If valve seats are loose, warped or distorted beyond reconditioning, replace cylinder head. Pitted or worn seats can be re-faced using a seat cutter.




2. Check valve seating pattern for correct width and evenness all around. (Note seat too deep (B), seat too high (C) and correct seat position (D) above.) If valve seat width is not within **0.6 – 0.9 mm (0.024 – 0.035 in.)**, recondition valve seat.
3. Lap valve after reconditioning with lapping compound and recheck valve seating surface for proper width and evenness of seating pattern. (See "Lap Valves".)

**Valve Springs:**

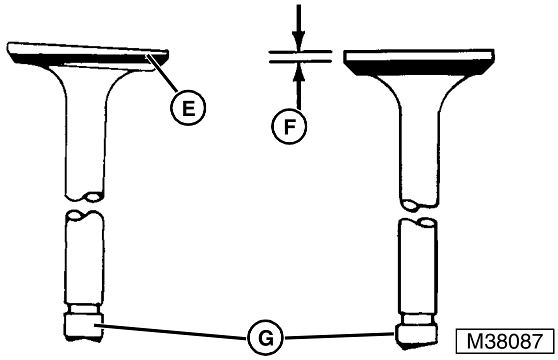
1. Inspect spring for pitting, rust, and burrs. Replace if necessary.




2. Measure spring free length. Replace spring if measurement is less than **26.7 mm (1.05 in.)**.

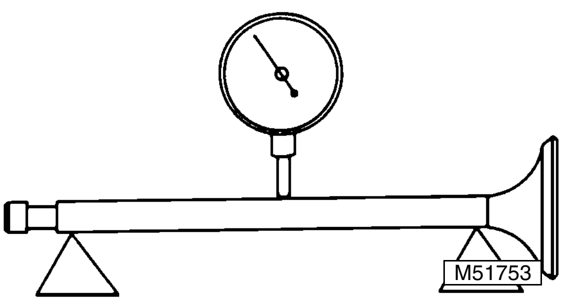
**Intake and Exhaust Valves:**

1. Remove carbon from valve head, face, and stem with a power-operated wire brush. Be sure carbon is removed, not merely burnished.
2. Inspect valve head, face, and stems for defects. Replace if necessary.




3. Replace warped valves (E) or valves with less than **0.35 mm (0.014 in.)** margin (F).


4. Measure outside diameter of valve stem (G). Replace valve if diameter is less than specification.




5. Check valve stem for bend using V-blocks and a dial indicator. Turn valve slowly and read variation on indicator. Replace if variation is greater than **0.03 mm (0.001 in.)**.

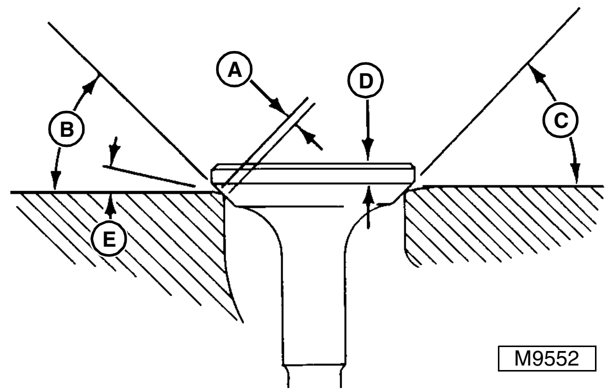
**Minimum Valve Stem OD Specifications:**

**Intake. . . . . . . . . . . . . . . . . . . . . . 5.95 mm (0.234 in.)**
**Intake. . . . . . . . . . . . . . . . . . . . . . 5.93 mm (0.233 in.)**

## RECONDITION VALVE SEATS

**Procedure:**

1. Inspect valve seats for damage. If seats are warped or distorted beyond reconditioning, replace cylinder head. Pitted or worn seats can be refaced using a seat cutter.




2. To recondition seat, cut at 45° angle (B) to clean up seat. Cut narrowing angle (E) at 30°. Finish cut at 45° (B) to establish seating surface width (A).
3. Cut valve seating surface (A) as close as possible to specifications.
4. Lap valves to seats after re-facing. (See "Lap Valves".)
5. Center valve seat on the valve face.
6. Check seat for good contact using Prussian Blue Compound.

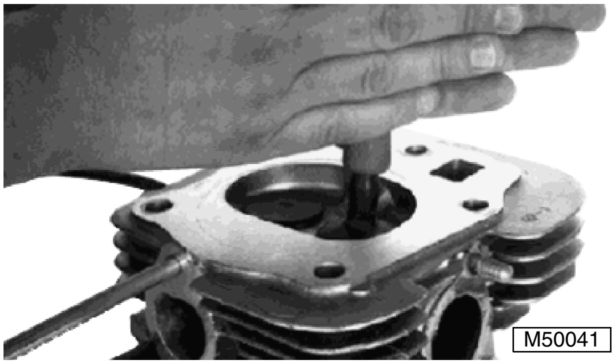
**Specifications:**

**A-Valve Seat Surface . . . . . . . . . . . . 0.60 – 0.90 mm**
**. . . . . . . . . . . . . . . . . . . . . . . . . . (0.024 – 0.035 in.)**
**B-Valve Seat Angle. . . . . . . . . . . . . . . . . . . . . . . .45°**
**C-Valve Face Angle . . . . . . . . . . . . . . . . . . . . . . .45°**
**D-Valve Margin (Minimum) . . . . 0.35 mm (0.014 in.)**
**E-Valve Narrowing Angle. . . . . . . . . . . . . . . . . . . .30°**

## LAP VALVES

If valve seat does not make proper contact, lap the valve into the seat.

1. Apply a small amount of fine lapping compound to face of valve.

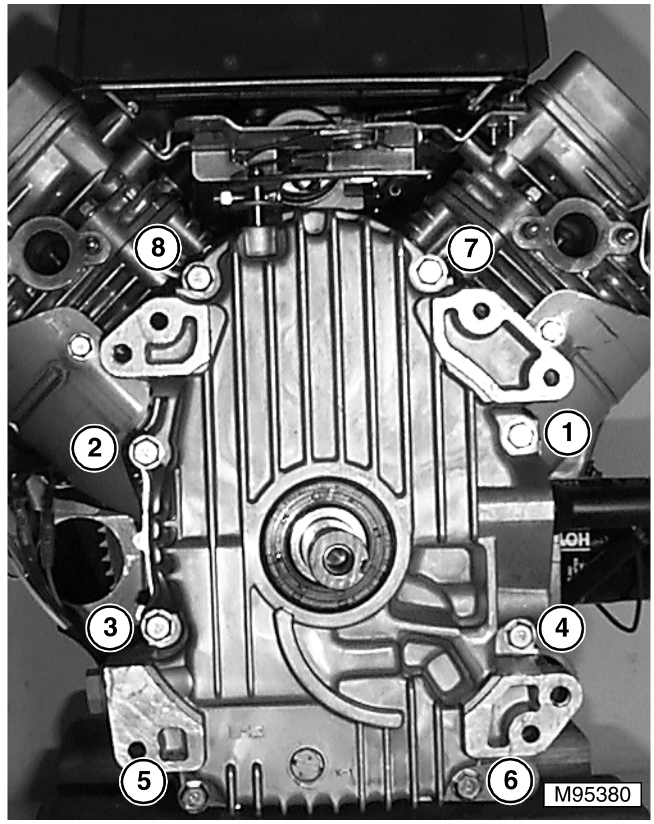



2. Grip top of valve with a vacuum cup tool and rotate valve to lap valve to seat.
3. Lift valve from seat every 8 to 10 strokes. Lap until a uniform ring appears around the surface of the valve face.
4. Wash all parts in solvent to remove lapping compound. Dry all parts.
5. Check position of lap mark on valve face. Lap mark must be on or near center of valve face.

## CRANKCASE COVER REMOVAL AND INSTALLATION

1. Drain crankcase. Capacity (with filter) is approximately **1.7 L (1.8 qt)**.
2. Remove crankcase cover and gasket.
3. Clean crankcase and crankcase cover gasket surfaces.

*NOTE: Do not force cover. Gears must mesh for proper positioning.*




4. Install gasket and cover. Tighten cap screws to specification in two steps. Use the sequence shown above.

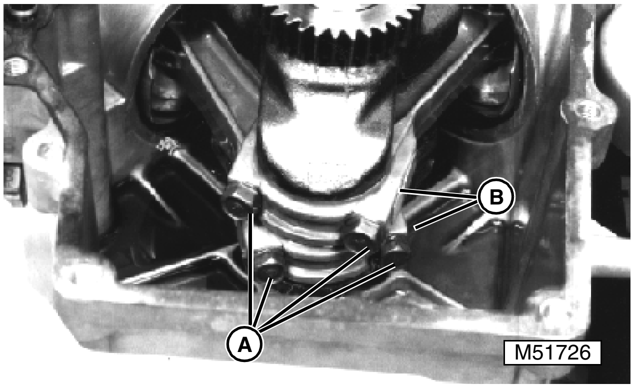
**Torque Specifications:**

**Initial Torque . . . . . . . . . . . . . . . . . . 10 N•m (88 lb-in.)**
**Final Torque . . . . . . . . . . . . . . . . 25 N•m (221 lb-in.)**

## PISTON AND CONNECTING ROD

**Removal:**

1. Remove cylinder head.
2. Split the crankcase.
3. Remove the camshaft.
4. Turn the crankshaft to expose the connecting rod cap screws.




5. Remove the cap screws (A) and take off the connecting rod caps (B). Note the orientation of the connecting rod caps for correct installation.
6. Check cylinder bore for carbon and varnish ridges. These ridges can cause piston damage if not removed.
7. If necessary, remove ridges from top of cylinder bore with a ridge reamer.
8. Push piston and connecting rod into the cylinder and pull out of the cylinder bore.

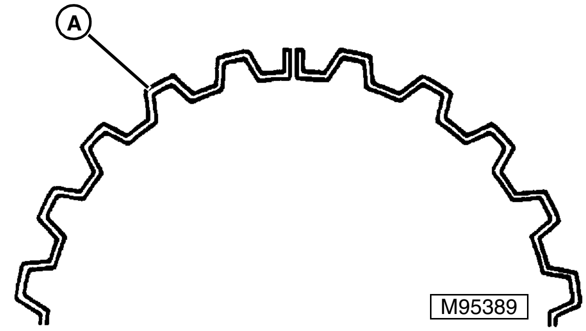
**Disassembly:**

- Analyze piston and piston ring wear.
- Remove piston rings with a piston ring expander.
- Inspect all parts for wear or damage. Replace as necessary.

*NOTE: Location of the arrow match mark on the piston head in relation to "K" mark on the connecting rod. Keep parts together as a set.*

1. Remove one of the piston pin snap rings with a needle nose pliers.
2. Remove the piston pin by pushing it out of the side of the piston that has the ring removed.
3. Using a piston ring pliers, remove the top and second rings.
4. Remove the three piece oil ring.

**Assembly:**

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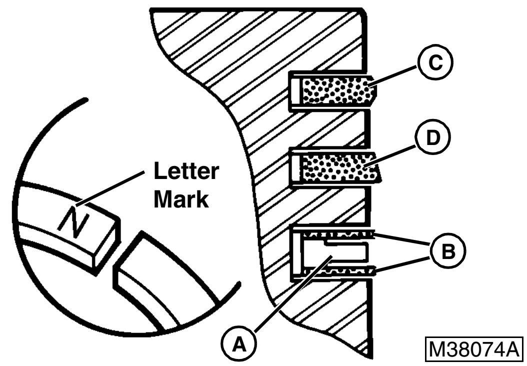
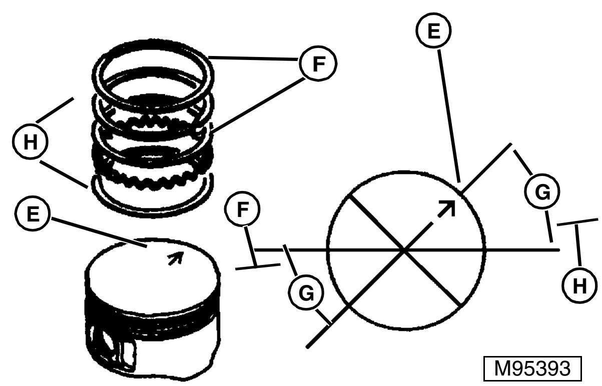
1. Install the expander (A) in the piston oil ring groove so that the expander ends touch together as shown. Be sure that the ends do not overlap.



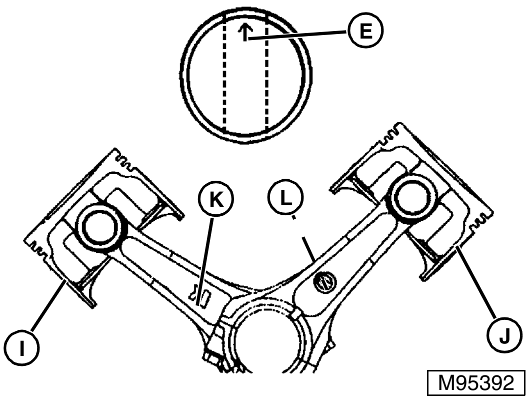

**A - Expander**
**B - Steel Oil Rails**
**C - First Chrome-Plated Compression Ring**
**D - Second Compression Ring**

2. Install the upper and lower steel oil rails (B). The oil rails can be installed with either side up.




**E - Arrow match mark**
**F - Top ring end gap, upper steel rail end gap**
**G- 30° - 45°**
**H - Second ring end gap, lower steel rail end gap**

3. Install the chrome-plated top ring and second ring with “N” mark facing up. The rings should turn freely in the grooves.
4. Align the piston and rings with the piston ring end gap as shown above.



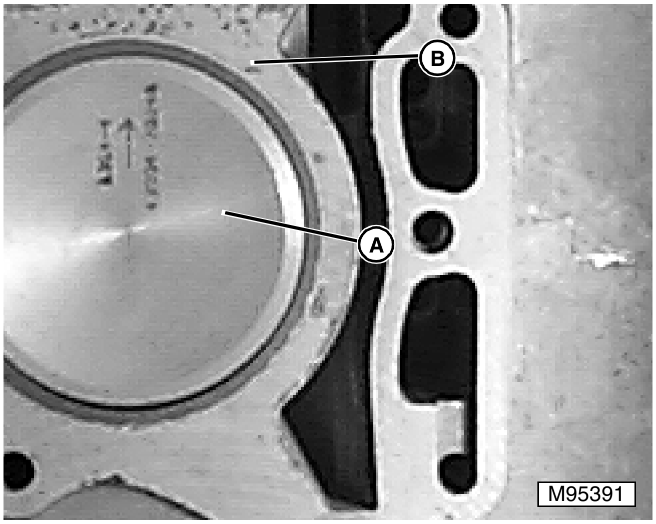

**E - Arrow Match Mark**
**I - No. 1 Cylinder Piston**
**J - No. 2 Cylinder Piston**
**K - “K” Mark**
**L - “K” Mark on opposite side**

5. Apply a light film of clean engine oil to piston pin and connecting rod bearing during assembly.
6. No. 1 cylinder piston:
   Align the arrow match mark on the piston head with opposite the raised letter “K” mark on the connecting rod.
7. No. 2 cylinder piston:
   Align the arrow match mark on the piston head with the raised letter “K” mark on the connecting rod.
8. Install piston pin and snap ring. Compress snap ring only enough to install the snap ring.
9. Fit a new piston pin snap ring into the side of the piston so that the ring opening of the snap ring does not coincide with the notch in the edge of the piston pin hole.

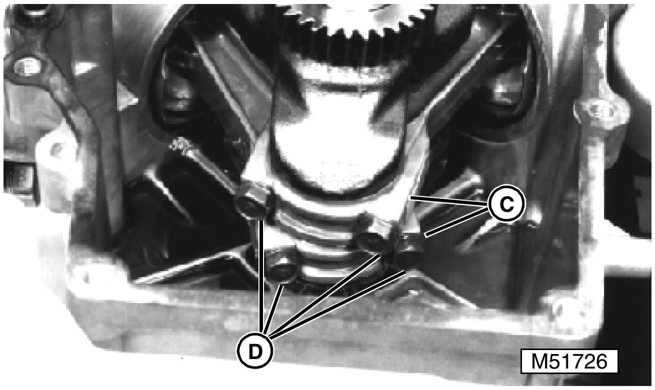
### Installation:

1. Deglaze cylinder bore.
2. Apply a light film of oil to piston and rings. Compress rings with a ring compressor.


3. Apply a light film of oil to piston skirt, cylinder bore, connecting rod bearing surface and cap screws.




4. Install piston assembly in cylinder bore with engraved match mark/arrow (A) on piston head facing flywheel side (B) of engine.

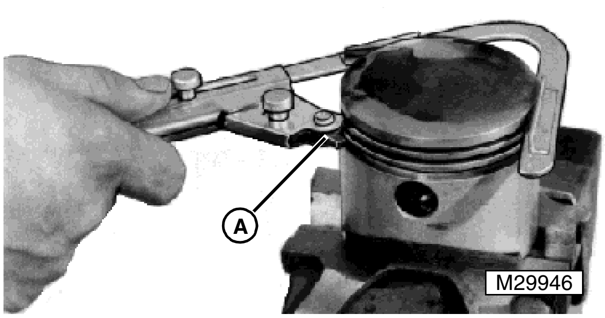



5. Install connecting rod cap (C) and cap screws (D). Tighten cap screws to **5.9 N•m (52 lb-in.)**.
6. Install crankcase cover and cylinder head.

**Piston Inspection:**

**IMPORTANT: Do not use a caustic cleaning solution or a wire brush to clean piston.**

1. Remove all deposits from the piston.




2. Clean carbon from piston ring grooves with a ring groove cleaner (A). If cleaning tool is not available, break an old ring and use it to carefully clean groove.
3. Check that oil return passages in grooves are open.
4. Inspect piston for scoring or fractures. Replace piston if damaged.

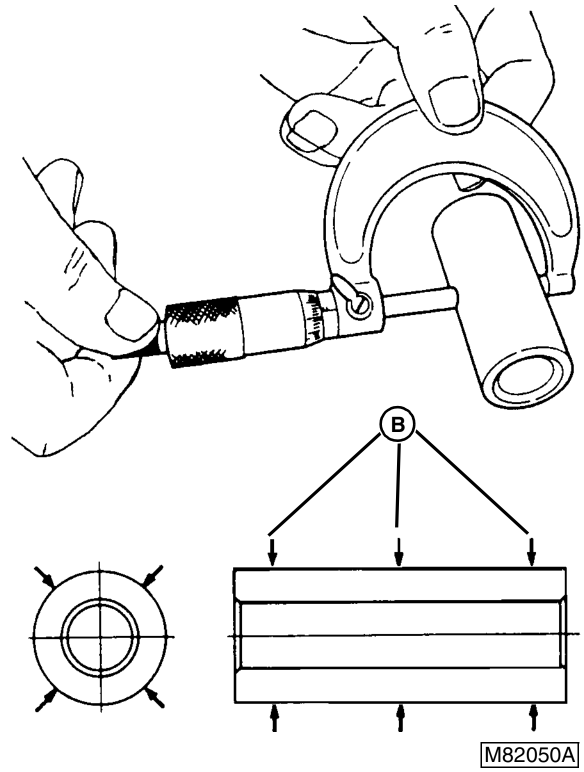
*NOTE: Inspect the piston ring grooves visually. Replace the piston if the ring grooves show wear or damage.*


5. Measure ring grooves for wear at several points around piston. Replace piston if clearance is greater than specifications.

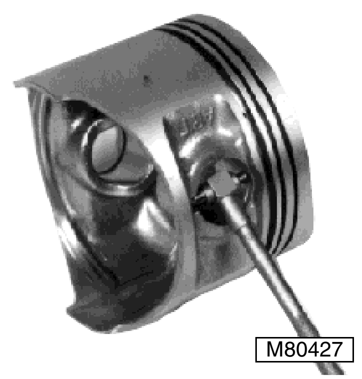
**Piston Ring Side Clearance Specifications:**

**1st Ring. . . . . . . . . . . . . . . . . . . . 0.15 mm (0.006 in.)**
**2nd Ring . . . . . . . . . . . . . . . . . . . 0.12 mm (0.005 in.)**

6. The oil ring is a three piece assembled ring. It is difficult to measure the ring groove clearance and thickness. Visually inspect the oil ring groove only.

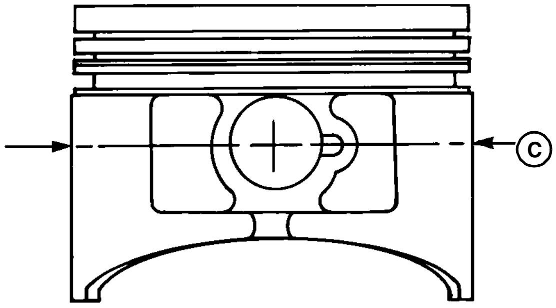



7. Measure piston pin diameter at six places (B). Replace pin if any measurement is less than **15.96 mm (0.628 in.)**.




8. Measure piston pin bore. Replace piston if measurement is greater than **16.08 mm (0.633 in.)**.

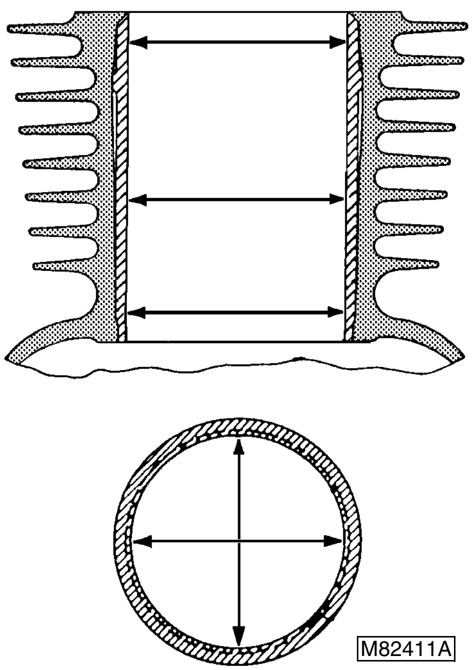
*NOTE: If the engine has had a previous major overhaul, oversize piston and rings may have been installed. Piston and rings are available in 0.50 mm (0.020 in.) oversize.*




M80398

9. Measure piston OD (C) perpendicular to piston pin bore. Replace the piston if the diameter is less than specifications.

*NOTE: If the engine has had a previous major overhaul the bore may be oversize and oversize piston and rings may have been installed.*



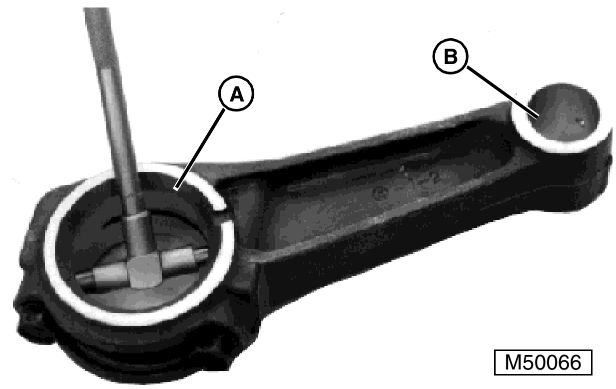
M82411A

10. Measure cylinder bore diameter at three positions; top, middle and bottom. Measure along the crankshaft centerline and the direction of crankshaft rotation at all three positions.
11. If cylinder bore exceeds wear limit, rebore cylinder or replace cylinder block. (See Resize Cylinder Bore procedure.)

*NOTE: If the cylinder is rebored, an oversize piston and rings must be installed.*

**Connecting Rod:**

1. Analyze crankshaft and connecting rod wear.
2. Clean and inspect rod. Replace if scored.
3. Install connecting rod cap. Tighten to **5.9 N•m (52 lb-in.)**.

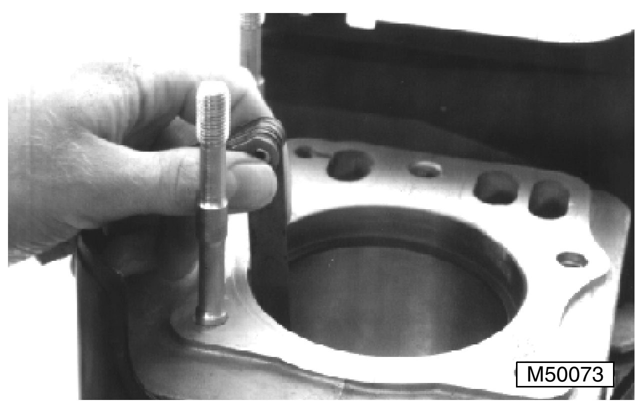



M50066

4. Measure connecting rod crankshaft bearing diameter (A) and piston pin diameter (B). Replace connecting rod if either measurement is greater than specifications.

**Piston Rings:**

1. Measure thickness of top and second piston rings at several places. If thickness is less than **1.40 mm (0.055 in.)**, replace piston ring.



M50073

2. Check piston ring end gap. Install each ring squarely in bore approximately **25.4 mm (1.0 in.)** down from top of cylinder.
3. Check end gap. Replace if end gap is greater than specifications.

**Ring Groove Side Clearance Specifications:**

**1st Ring. . . . . . . . . . . . . . . . . . . . 0.15 mm (0.006 in.)**
**2nd Ring . . . . . . . . . . . . . . . . . . . 0.12 mm (0.005 in.)**

**Piston OD Specifications:**

**Standard Piston . . . . . . . . . . . . 67.79 mm (2.669 in.)**
**Oversized Piston . . . . . . . . . . . 68.29 mm (2.689 in.)**

**Cylinder Bore ID:**

**Standard Bore 67.98 – 68.00 mm (2.676 – 2.677 in.)**
**Oversized Bore 68.48 – 68.50 mm (2.696 – 2.697 in.)**
**Bore Out-of-Round . . . . . . . . . 0.01 mm (0.0004 in.)**
**Wear Limit. . . . . . . . . . . . . . . . 0.056 mm (0.0022 in.)**

**Connecting Rod Bearing ID (Wear Limit):**

**Crankshaft Bearing . . . . . . . . 35.055 mm (1.380 in.)**
**Piston Pin Bearing . . . . . . . . . . 16.05 mm (0.633 in.)**

**End Gap Specifications:**

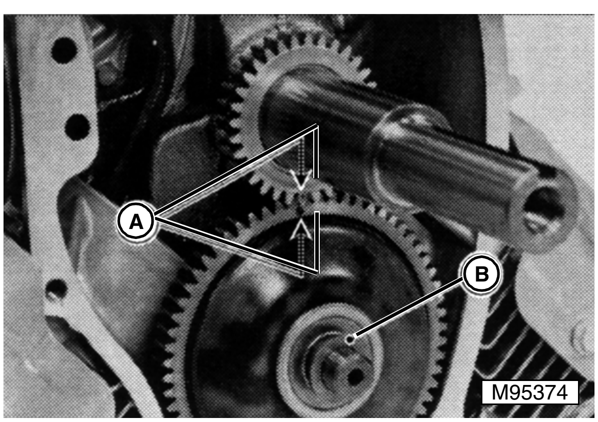
**Top Ring . . . . . . . . . . . . . . . . . . . 0.70 mm (0.028 in.)**
**Second Ring . . . . . . . . . . . . . . . . 0.78 mm (0.031 in.)**
**Oil Control Ring . . . . . . . . . . . . . 1.05 mm (0.041 in.)**

## CAMSHAFT AND TAPPETS

**Removal/Installation:**

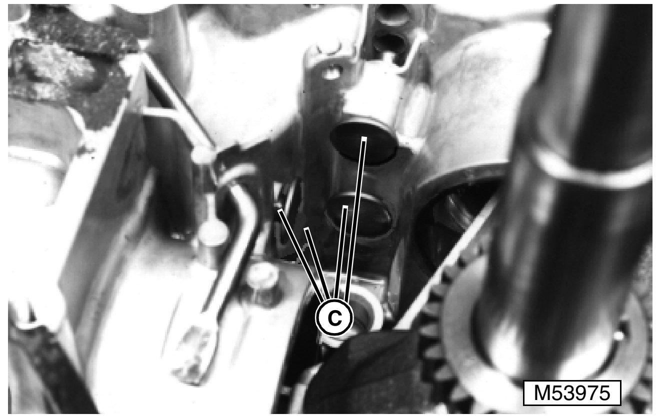
1. Remove fuel pump.
2. Remove rocker arm assemblies.
3. Remove crankcase cover.

**IMPORTANT: Align timing marks to prevent damage to tappets when removing camshaft.**




4. Rotate crankshaft until timing marks (A) align.
5. Remove and inspect camshaft (B).

*NOTE: Mark tappets so they can be installed in their original guides during assembly.*



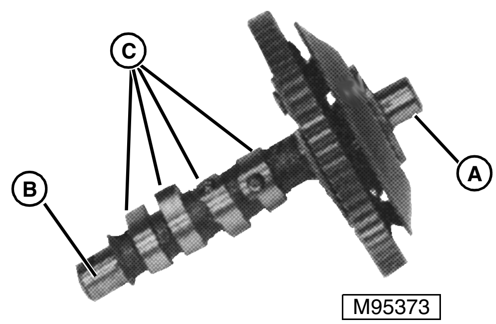

6. Remove and inspect tappets (C) for wear or damage. Replace if necessary.

**Installation is done in the reverse order of removal.**

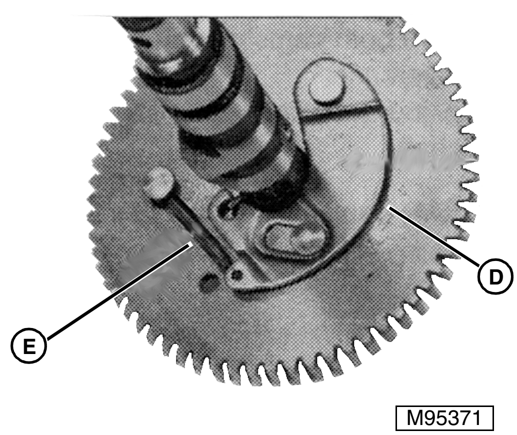
- Align timing marks when installing camshaft.

**Inspection:**

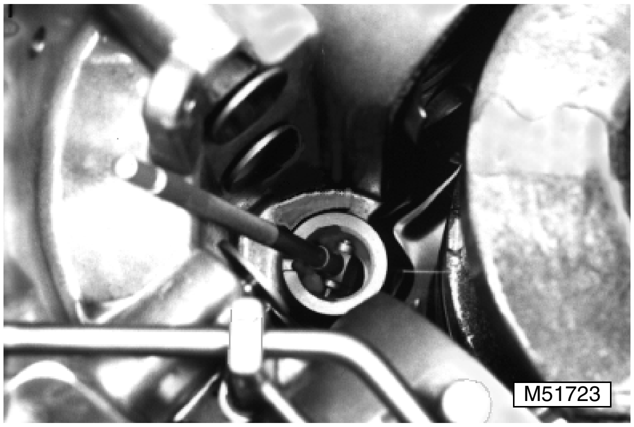
1. Inspect camshaft gear for worn or broken teeth.



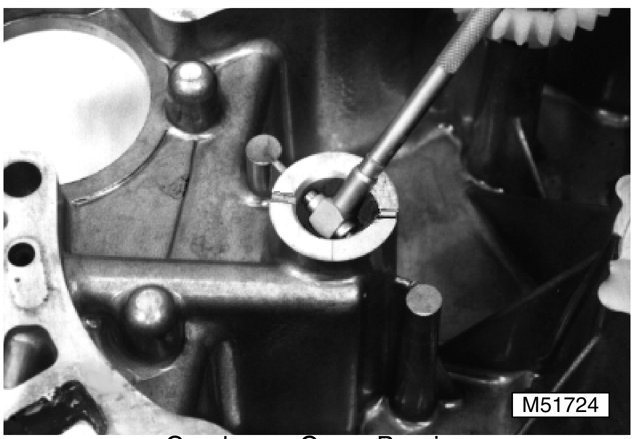

2. Measure PTO side journal (A), flywheel side journal (B) and lobes (C). Replace camshaft and tappets if any measurement is less than specifications.



3. Inspect automatic compression release (ACR) weight (D) for damage.
4. Inspect spring (E). Replace if worn or damaged.
5. Shake the camshaft assembly and check that the ACR weight (D) swings smoothly.




Cylinder Block Bearing




Crankcase Cover Bearing

6. Measure camshaft bearings in cylinder block and crankcase cover. Replace block or cover if either diameter is greater than **16.13 mm (0.635 in.)**.

**Camshaft Specifications (Minimum):**

**Side Journals . . . . . . . . . . . . . . 15.98 mm (0.629 in.)**
**Cam Lobe Height . . . . . . . . . . . 29.13 mm (1.147 in.)**

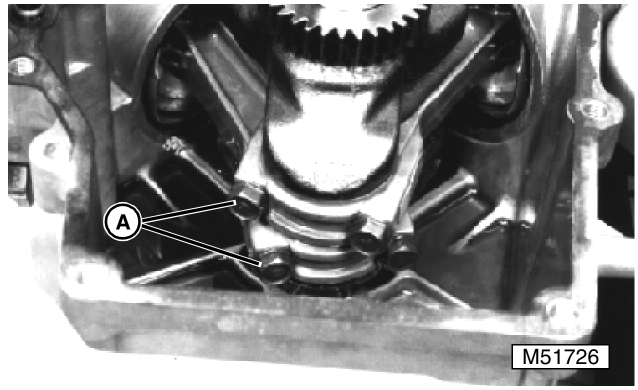
## CRANKSHAFT AND MAIN BEARINGS

**Removal/Installation:**

1. Remove flywheel and split crankcase.
2. Remove camshaft.

**IMPORTANT: Connecting rod caps must be installed on the same connecting rods they were removed from.**

3. Mark connecting rod caps to aid in installation.




4. Remove connecting rod caps (A) and push pistons to top of cylinder.
5. Remove crankshaft.
6. Inspect crankshaft for wear or damage.

**Installation is done in the reverse order of removal.**

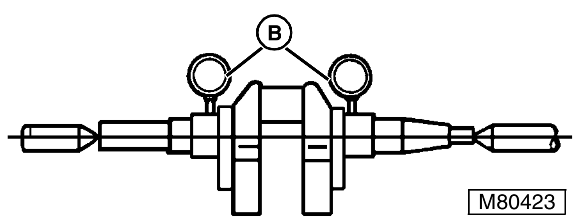
- Cover keyway on flywheel end of crankshaft with tape to prevent seal damage when installing crankshaft.
- Apply a light film of clean engine oil on crankshaft bearing surfaces before installation.
- Pack oil seals with lithium base grease.
- Install connecting rod caps and tighten to **5.9 N•m (52 lb-in.)**.

**Inspection:**

1. Analyze crankshaft and connecting rod wear.

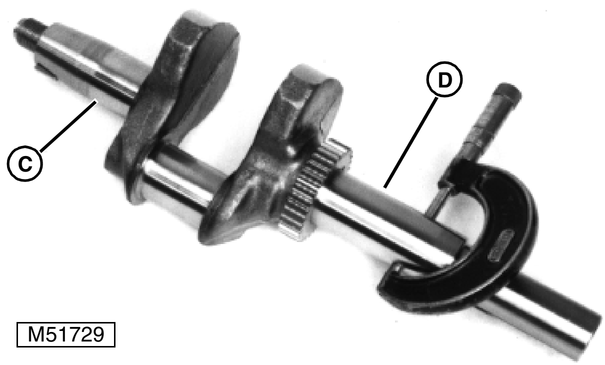
**IMPORTANT: A bent crankshaft must be replaced; it cannot be straightened.**

2. Clean and inspect crankshaft. Replace if scratched or damaged.



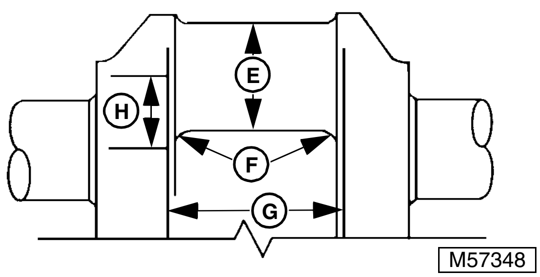

3. Place crankshaft into an alignment jig and slowly rotate crankshaft. Use dial indicators (B) to measure maximum Total Indicated Runout (TIR). If runout exceeds **0.05 mm (0.002 in.)**, replace

crankshaft.



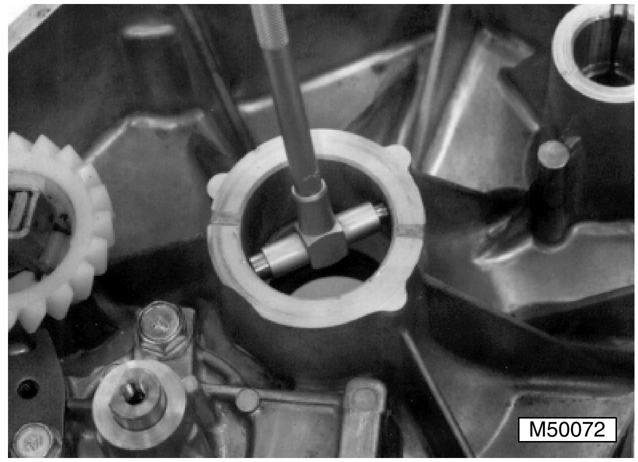

4. Measure main bearing journal diameters. If PTO side journal (D) OD is less than **34.90 mm (1.374 in.)** replace crankshaft. If flywheel side journal (C) OD is less than **34.93 mm (1.375 in.)** replace crankshaft.

*NOTE: If the engine has had a previous overhaul, connecting rod journal may have been resized for undersized rod. A 0.50 mm (0.020 in.) undersized rod is available.*




5. Measure connecting rod journal diameter (E) and inspect journal radii (F) for cracks. Connecting rod journal can be resized to accept undersized rod. Have grinding done by a reliable repair shop.

   If undersized journal diameter is less than specifications, replace crankshaft.




6. Measure crankshaft main bearing diameter in crankcase and crankcase cover. Replace crankcase cover or crankcase if diameter is greater than **35.15 mm (1.384 in.)**.

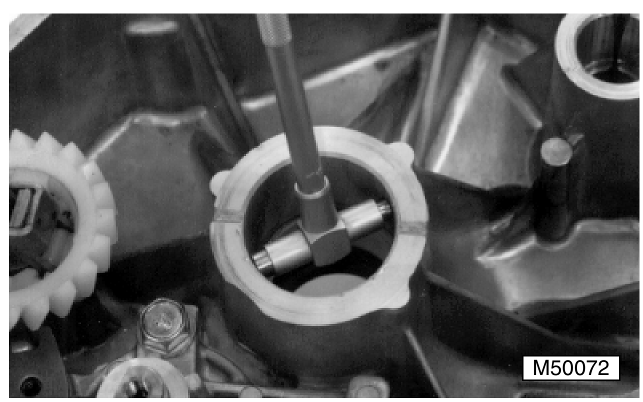
**Connecting Rod Journal OD (Wear Limit):**

**Standard . . . . . . . . . . . . . . . . . . 34.93 mm (1.375 in.)**

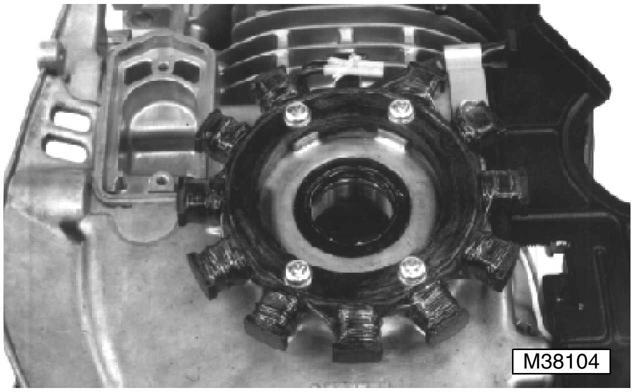
**Resizing Specifications:**

**E-Connecting Rod Journal . . . .34.470 – 34.457 mm**
**. . . . . . . . . . . . . . . . . . . . . . . . . . (1.357 – 1.356 in.)**
**G-Maximum. . . . . . . . . . . . . . . . 39.40 mm (1.551 in.)**
**H-Maximum . . . 34.05 – 33.95 mm (1.340 – 1.337 in.)**

## CRANKSHAFT OIL SEALS




1. Flywheel End: Remove crankshaft.




2. PTO End: Remove crankcase cover.
- Remove worn or damaged seals using a screwdriver.
- Use a driver set to install seals with lip toward inside of engine. Press in seals until flush with flange surface.
- Pack lithium based grease inside lips of seals.

**Replacement:**

1. Remove crankshaft.
- Remove worn or damaged seal using a screwdriver. Install seal with spring-held seal lip toward inside of engine using seal and driver set. Press in seal until flush with hub.
- Pack lithium based grease inside lips of seal.

## DEGLAZE CYLINDER BORE

1. Deglaze cylinder bore using a rigid hone with a 220 to 300 grit stone.
2. Use hone as instructed by manufacturer to obtain 45° crosshatch pattern.

**IMPORTANT: Do not use gasoline, kerosene, or commercial solvent to clean cylinder bores. Solvents will not remove all abrasives from cylinder walls.**

3. Clean cylinder walls using clean white rags and warm soapy water. Continue to clean cylinder until white rags show no discoloration.

## RESIZE CYLINDER BORE

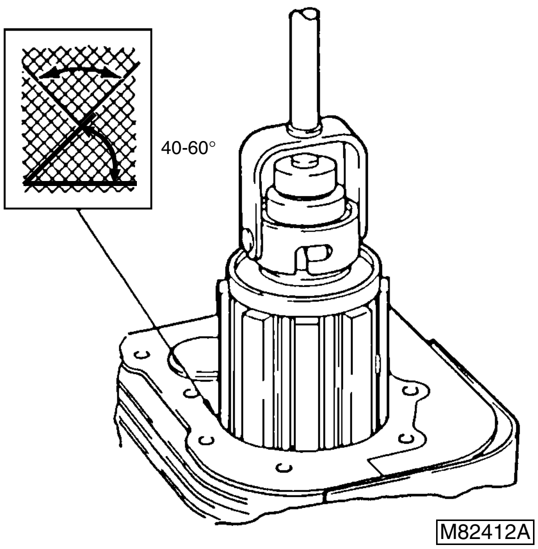
**IMPORTANT: Check stone for wear or damage. Use correct stone for the job.**

The cylinder block can be resized to use **0.50 mm (0.020 in.)** oversize pistons and rings. Have a reliable repair shop resize the block, or use the drill press and honing tool. Resize cylinder with a honing tool to initial and final bore specifications.

**Procedure:**

1. Align center of bore to drill press center.
2. Lower and raise hone until ends extend **20 – 25 mm (0.75 – 1.0 in.)** past ends of cylinder.
3. Adjust hone so lower end is even with end of cylinder bore.
4. Adjust rigid hone stones until they contact narrowest point of cylinder.
5. Coat inside of cylinder with honing oil. Turn hone by hand. Adjust if too tight.
6. Run drill press between 200 – 250 rpm. Move hone up and down in cylinder approximately 20 times per minute.

*NOTE: Measure bore when cylinder is cool.*




7. Stop press and check cylinder diameter.

*NOTE: Finish should not be smooth, but have a 40-60° cross-hatch pattern.*

8. Check bore for size, taper, and out-of-round.
9. Hone the cylinder an additional 0.006 – 0.008 mm (0.0002 – 0.0003 in.) for final bore specifications. This allows for shrinkage when cylinder cools.

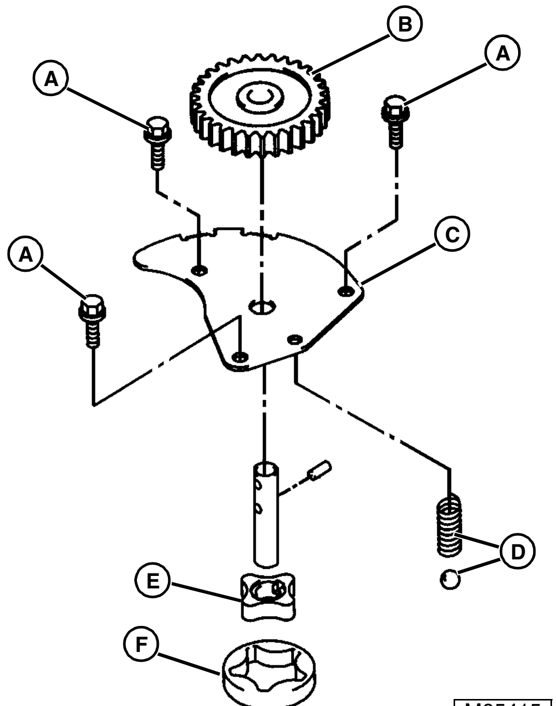
**IMPORTANT: DO NOT use gasoline or commercial solvents to clean cylinder bores. Solvents will not remove metal particles produced during honing.**

10. Clean the cylinder thoroughly using soap, warm water and clean rags. Continue to clean cylinder until white rags show no discoloration.
11. Dry the cylinder. Apply engine oil to cylinder wall.

## OIL PUMP

### Disassembly & Assembly:

1. Remove crankcase cover. See “CRANKCASE COVER REMOVAL AND INSTALLATION” on page 39.




M95415

2. Remove the three mounting cap screws (A) and lift the oil pump gear and shaft assembly (B) and cover plate (C) out of the crankcase.
3. Remove relief valve spring and ball (D).
4. Remove the inner (E) and outer (F) rotors
5. Inspect all parts for wear or damage.

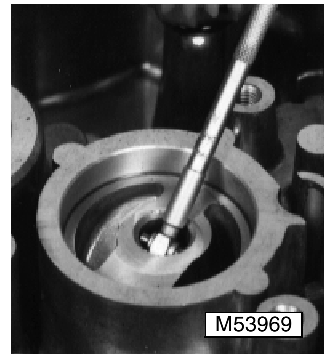
**Assembly is done in the reverse order of disassembly.**

- Fill rotor housing with engine oil for initial lubrication.
- Install the outer (F) and inner (E) rotors
- Install relief valve ball and spring (D).
- Install oil pump gear and shaft assembly (B), cover plate (C), and secure with three cap screws (A).
- Tighten the three cap screws (A) to **6.9 N•m (61 lb-in.)**.

### Inspection:

1. Inspect all parts for wear or damage. Replace as necessary.

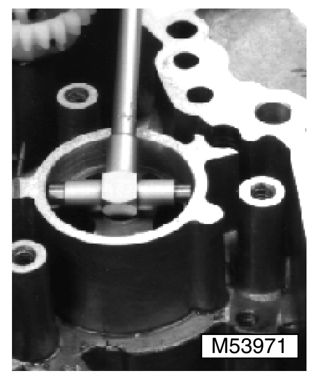
M53968



M53969

2. Measure rotor shaft diameter. If shaft OD is less than **10.92 mm (0.430 in.)**, replace shaft.
3. Measure rotor shaft bearing. If bearing ID is greater than **11.07 mm (0.436 in.)**, replace crankcase cover.

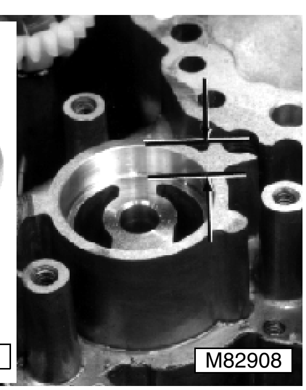
M53970



M53971

4. Measure outside diameter of outer rotor. If OD is less than **40.47 mm (1.593 in.)**, replace outer rotor.
5. Measure inside diameter of rotor housing. If ID is greater than **40.80 mm (1.606 in.)**, replace crankcase cover.

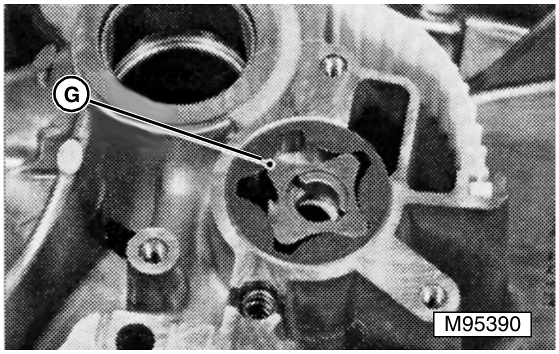
M80015



M82908

6. Measure thickness of outer rotor. If thickness is less than **9.83 mm (0.387 in.)**, replace rotor.

7. Measure outer rotor housing depth. If depth is greater than **10.23 mm (0.403 in.)**, replace crankcase cover.



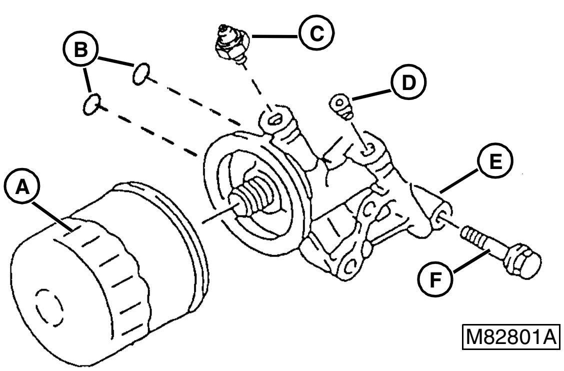

8. Measure inner to outer rotor clearance (G). If clearance is greater than **0.2 mm (0.008 in.)**, replace both rotors.


9. Measure relief valve spring. If free length is less than **19.50 mm (0.770 in.)**, replace spring.

# OIL FILTER MANIFOLD

**Removal & Installation:**

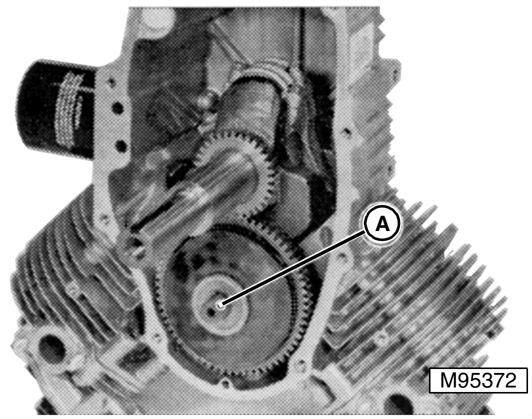
- Apply pipe sealant with TEFLON to threads of oil pressure switch (C).



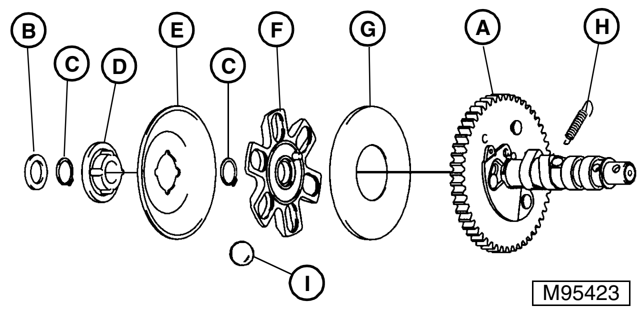

**A - Oil Filter**
**B - Seals**
**C - Oil Pressure Sender Switch**
**D - Plug**
**E - Manifold**
**F - Mounting Cap Screw (3 used)**

# GOVERNOR INSPECTION AND REPLACEMENT

1. Remove crankcase cover. See “CRANKCASE COVER REMOVAL AND INSTALLATION” on page 39.
2. Remove rocker covers and push rods.




3. Turn engine upside down and remove camshaft (A).




**A - Camshaft**
**B - Washer**
**C - Snap Ring**
**D - Sleeve**
**E - Governor Plate**
**F - Ball Guide**
**G - Ball Plate**
**H - Automatic Compression Release Spring**
**I - Steel Balls (6 total)**

4. Disassemble the governor assembly from the camshaft.
5. Inspect governor for wear or damage. Replace if necessary.
6. When assembling, be sure the steel balls are seated in slots on the ball guide and that the snap rings are fully seated in their grooves.

## GOVERNOR SHAFT INSPECTION AND REPLACEMENT

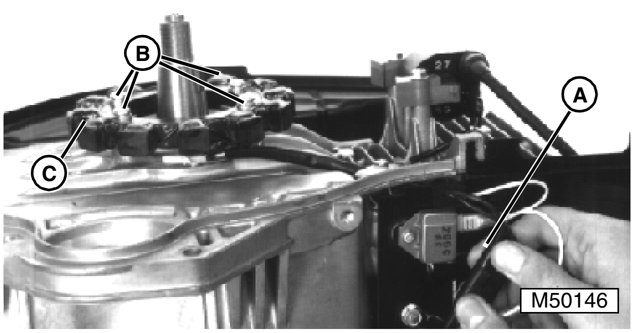
*NOTE: It is not necessary to remove governor shaft unless damaged.*

1. Remove crankcase cover. See "CRANKCASE COVER REMOVAL AND INSTALLATION" on page 39.
2. Unscrew the governor shaft plate screws and pull the governor shaft out of the crankcase cover.
3. Replace the oil seal if the lip shows signs of leakage or it has been damaged.
4. Inspect governor shaft (A) for wear or damage. Replace if necessary.

**Installation is done in the reverse order of removal.**

5. Apply clean engine oil to the governor shaft.
6. Insert the governor shaft into the crankcase.
7. Install the governor shaft plate to the shaft and tighten the screws to **2 N•m (18 lb-in.)**.
8. Check that governor shaft turns freely within its operating range.
9. If oil seal has been removed, press a new seal into crankcase with the seal lip to the inside.
10. Press the seal in **flush** - **1.0 mm (0.04 in.)** below crankcase surface.

## STATOR REMOVAL AND INSTALLATION

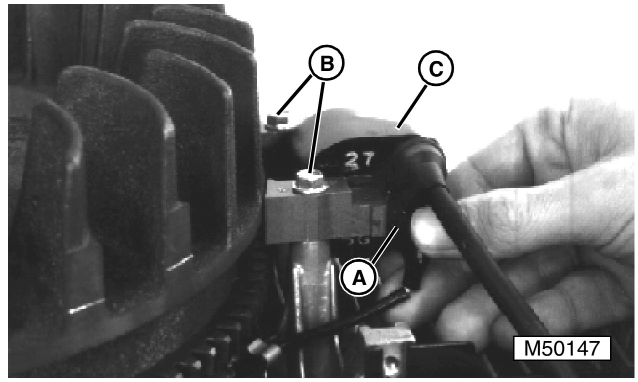



1. Remove flywheel.
2. Disconnect stator lead (A).
3. Remove screws (B) and stator (C).

**Installation:**

Installation is done in the reverse order of removal.

## ARMATURE REMOVAL AND INSTALLATION

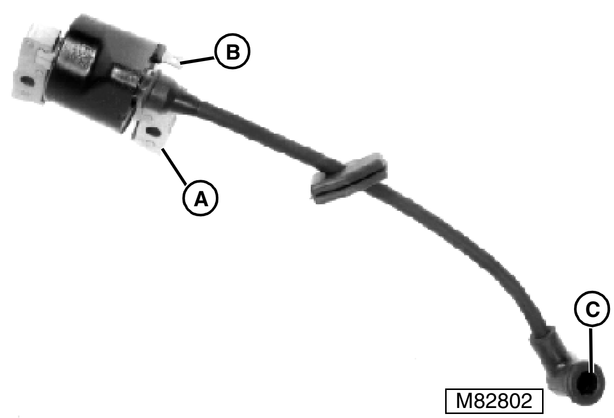



1. Remove blower housing.
2. Disconnect wiring lead (A).
3. Remove cap screws (B) and armature with coil (C).
4. Test armature with coil. (See Test procedure.)

**Installation is done in the reverse order of removal.**

- Adjust armature air gap. (See Adjustment procedure.)

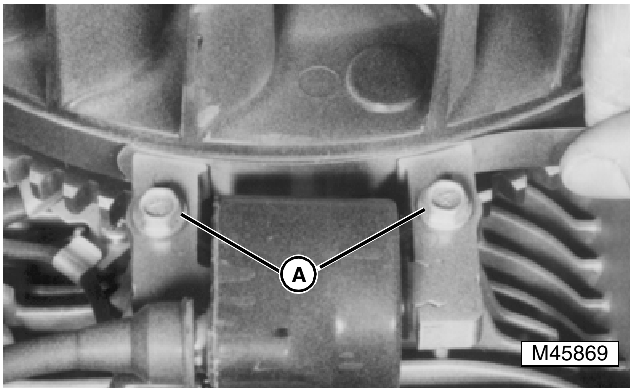
**Test:**




1. Measure resistance between each point as shown in the chart. If resistance is not within specification, replace armature with coil.

| | A | B | C |
|---|---|---|---|
| A | | OL | 9.0 k |
| B | 1.9 m | | 1.9 m |
| C | 9.0 k | OL | |

# ARMATURE AIR GAP ADJUSTMENT




1. Center flywheel magnet under armature.
2. Insert a **0.30 mm (0.012 in.)** feeler gauge between flywheel and armature.
3. Push armature against flywheel and tighten screws (A) to **7.8 N•m (69 lb-in.)**.
4. Turn flywheel to remove feeler gauge.

**Specifications:**

**Air Gap . . . . . . . . 0.25 – 0.40 mm (0.010 – 0.016 in.)**

# STARTING MOTOR

**Analyze Condition:**

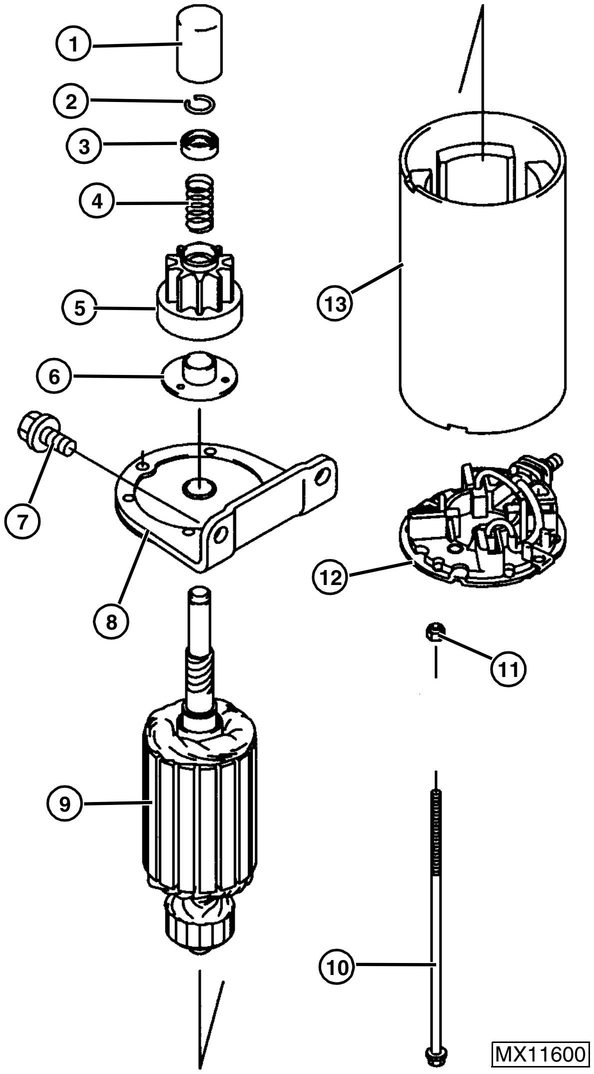
The starting motor overheats because of:

- Long cranking.
- Armature binding.

The starting motor operates poorly because of:

- Armature binding.
- Dirty or damaged starting motor drive.
- Badly worn brushes or weak brush springs.
- Excessive voltage drop in cranking system.
- Battery or wiring defective.
- Shorts, opens, or grounds in armature.

*NOTE: Starting motor repair is limited to brushes, end caps, and starting motor drive. Fields in starting motor are permanent magnets and are not serviceable. If housing or armature is damaged, replace starting motor.*




1. Cover
2. C-Ring
3. Retainer
4. Spring
5. Pinion
6. Bushing
7. Mounting Bolt
8. End Cover
9. Armature
10. Thru Bolt
11. Nut
12. Brush Holder Assembly
13. Housing

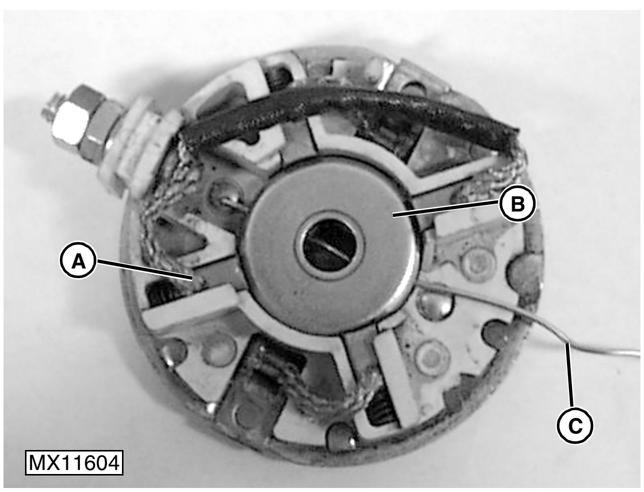
**Required Tools:**

- JDG1087 C-Ring Remover
- JDG1086 C-Ring Installer

**Disassembly and Assembly:**

1. Mark body and covers for correct alignment during reassembly.
2. Remove shaft cover and use a C-Ring Removal tool, JDG1087 to remove the C-Ring.
3. Remove retainer (C), spring (D), pinion (E) and bushing (F).
4. Remove thru bolts (J), and cover (L) from housing (M).
5. Hold the armature (I) and the brush end cap assembly (L) against a work surface while sliding the Housing off the armature.
6. Inspect parts for wear or damage.
7. Test starting motor armature and brushes. (See Inspection/Test procedures.)

**Assembly is done in the reverse order of disassembly.**



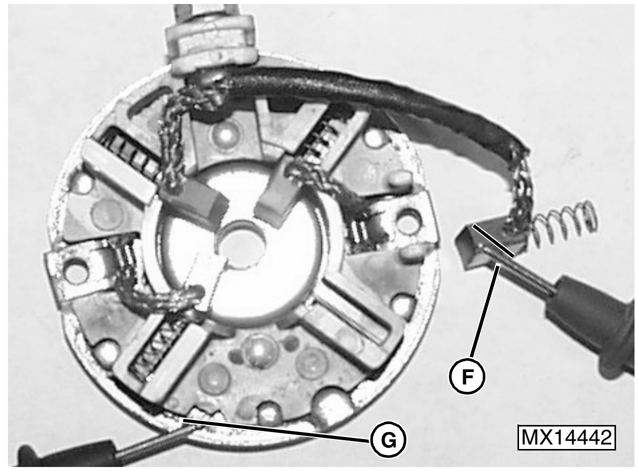

*NOTE: Use the washer (B) in the end cap to hold the brushes (A) in the retracted position and allow installation of the end cover over the armature. Place a piece of wire (C) behind the washer to hold it in position, and then withdraw the wire as the assembly is lowered over the end of the armature.*

Apply a lithium based lubricant sparingly to:

- Armature shaft splines.
- Points where the shaft contacts the cover.

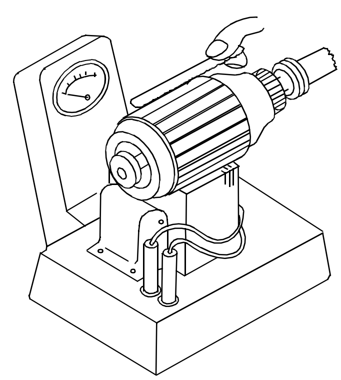
**Inspection/Test:**

1. Measure field coil brush lengths. If any brush measures less than **10.5 mm (0.413 in.)** in length, replace all the brushes.
2. Inspect brush springs for wear or damage. Replace if necessary.




3. Test for brush continuity. Touch one probe of tester to field coil brush (F) and the other probe to the end cap housing (G). Be sure the brush lead is not touching the housing. If there is not continuity, the brush assembly must be replaced.

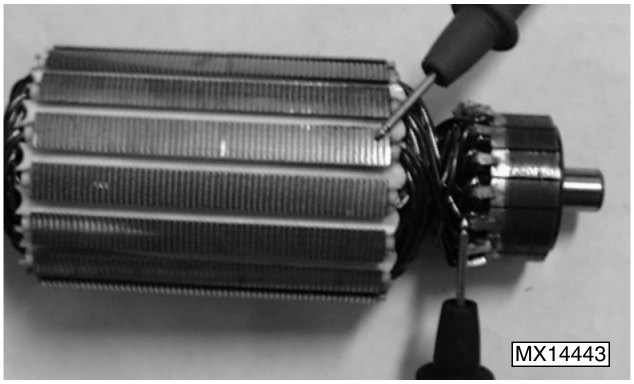
**IMPORTANT: Do not clean armature with solvent. Solvent can damage insulation on windings. Use only mineral spirits and a brush.**



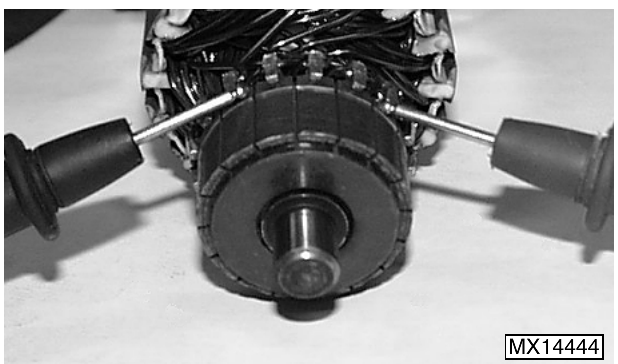
4. Locate short circuits by rotating armature on a growler while holding a hacksaw blade or steel strip on armature. The hacksaw blade will vibrate in area of short circuit.

*NOTE: Shorts between bars are sometimes caused by dirt or copper between bars. Inspect for this condition.*

5. If test indicates short circuited windings, clean the commutator of dust and fillings. Check armature again. If test still indicates short circuit, replace armature.


MX14443

6. Test for grounded windings using an ohmmeter. Touch probes on each commutator bar. Armature windings are connected in parallel, so each commutator bar needs to be checked. If test shows continuity, the winding is grounded and the armature must be replaced.


MX14444

7. Test for open circuited windings using an ohmmeter. Touch probes on each commutator bar. If test shows no continuity, there is an open circuit and armature must be replaced.

## NO-LOAD AMPERAGE DRAW AND RPM TEST

**Reason:**

To determine if starting motor is binding or has excessive amperage draw under no-load.

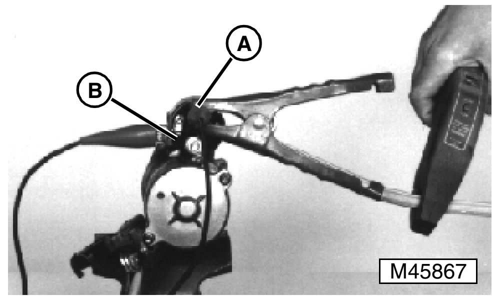
**Test Equipment:**

- JT05712 Current Gun
- JT03719 Photo Tachometer

**Procedure:**

**IMPORTANT: Complete this test in 20 seconds or less to prevent starting motor damage.**

*NOTE: Check that battery is fully charged and of proper size to ensure accuracy of test.*



M45867

1. Connect jumper cables to battery.
2. Connect negative cable to starting motor body. Connect positive cable to terminal (A).
3. Use jumper wire to briefly connect terminals (A and B). Measure starting motor amperage and rpm. Maximum starting motor amperage is 50 amps at 5000 rpm.

**Results:**

- If amperage is out of specification, check for binding or seizing bearings, sticking brushes, dirty or worn commutator. Repair or replace starting motor.

## STARTING SOLENOID TEST

**Reason:**

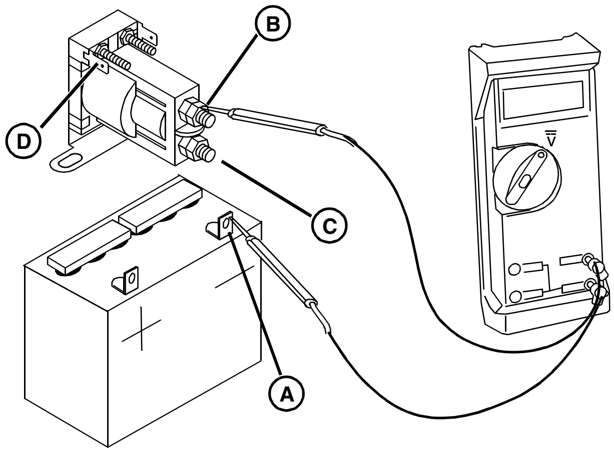
To determine if starting solenoid is defective.

**Test Equipment:**

- Volt Ohm Meter (VOM)

**Procedure:**

*NOTE: Check that battery is fully charged and of proper size to ensure accuracy of test.*




1. Park machine on level surface.
2. Turn key switch to OFF position and put transmission in NEUTRAL.
3. Engage parking brake
4. Disconnect and ground spark plug leads.
5. Connect VOM to negative (-) battery terminal (A) and terminal (B) of starting motor solenoid. Check for battery voltage. If no battery voltage check for loose connections or corrosion at battery terminals and solenoid terminals. If voltage is present go to the next step.
6. Connect VOM to negative (-) battery terminal (A) and terminal (C) of starting motor solenoid. Momentarily turn ignition switch to START position and check for battery voltage. If voltage is present, starting solenoid is not defective.

If no voltage is present, go to the next step.

7. Connect VOM to negative (-) battery terminal (A) and terminal (D) (Purple Wire) of starting motor solenoid. Momentarily turn ignition key to START position and check for battery voltage.

If no voltage is present, check the purple wire and connections.

If battery voltage is present check the Black wire and connections between the starting solenoid and frame ground. If connections are OK, starting motor solenoid is defective.

**Results:**

- If starter motor solenoid proves defective in the final test, it must be replaced.

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# THEORY OF OPERATION INFORMATION

The theory of operation stories divide the electrical system into individual circuits by function. Each circuit is isolated from the main wiring schematic and only shows the components that are used in it. The story contains information on function, operating conditions, and theory of operation. The circuit schematics are drawn with the components in the operating position, with the power, or battery positive, into them across the top and the ground, or battery negative, across the bottom.

# DIAGNOSTIC INFORMATION

The diagnostic procedures is used to test the complete circuit regardless of the problem or complaint. Select a symptom or system from the quick check or troubleshooting chart and follow the test procedures under that heading.

The diagnostic procedure lists:

- Test conditions
- Test sequence
- Test location
- Normal reading
- Check or test to perform if reading is not normal

When performing the test or check, be sure to set your machine up to the test conditions listed and follow the sequence carefully. The middle **"NORMAL"** column gives the reading or condition that should be obtained when performing the test or check. If the results of the test or check are not normal, perform the test, check, or adjustment listed in the third **"IF NOT NORMAL"** column to repair the malfunction. The detailed tests or adjustments referred to in the **"IF NOT NORMAL"** column are located at the end of that group. The system diagram that accompanies each test procedure is drawn to resemble machine components. The key number on the art matches the number in the **"TEST LOCATION"** column and the leader line points to the exact point the test is to be made.

# WIRE COLOR ABBREVIATION CHART

| | |
|---|---|
| Blk | Black |
| Blu | Blue |
| Brn | Brown |
| Grn | Green |
| Gry | Gray |
| Org | Orange |
| Pnk | Pink |
| Pur | Purple |
| Red | Red |
| Tan | Tan |
| Wht | White |
| Yel | Yellow |
| Blk/Wht | Black/White |
| Blu/Wht | Blue/White |
| Brn/Wht | Brown/White |
| Brn/Yel | Brown/Yellow |
| Dk Blu | Dark Blue |
| Dk Brn/Lt Grn | Dark Brown/Light Green |
| Dk Brn/Red | Dark Brown/Red |
| Dk Brn/Yel | Dark Brown/Yellow |
| Dk Grn | Dark Green |
| Lt Blue | Light Blue |
| Lt Grn | Light Green |
| Org/Wht | Orange/White |
| Pnk/Blk | Pink/Black |
| Pur/Wht | Purple/White |
| Red/Blk | Red/Black |
| Red/Wht | Red/White |
| Wht/Blk | White/Black |
| Wht/Red | White/Red |
| Yel/Blk | Yellow/Black |
| Yel/Red | Yellow/Red |
| Yel/Wht | Yellow/White |

# READING ELECTRICAL SCHEMATICS

The schematic is made up of individual circuits laid out in a sequence of related functions. It is formatted with all power wires (A) across the top and all ground wires (B) across the bottom. Current flow is generally from top to bottom through each circuit and component. All components are shown in the OFF position. The diagram does not list connector (C) information unless needed to avoid confusion. If the connector is shown, the number next to it is the terminal pin location (D) in the connector.

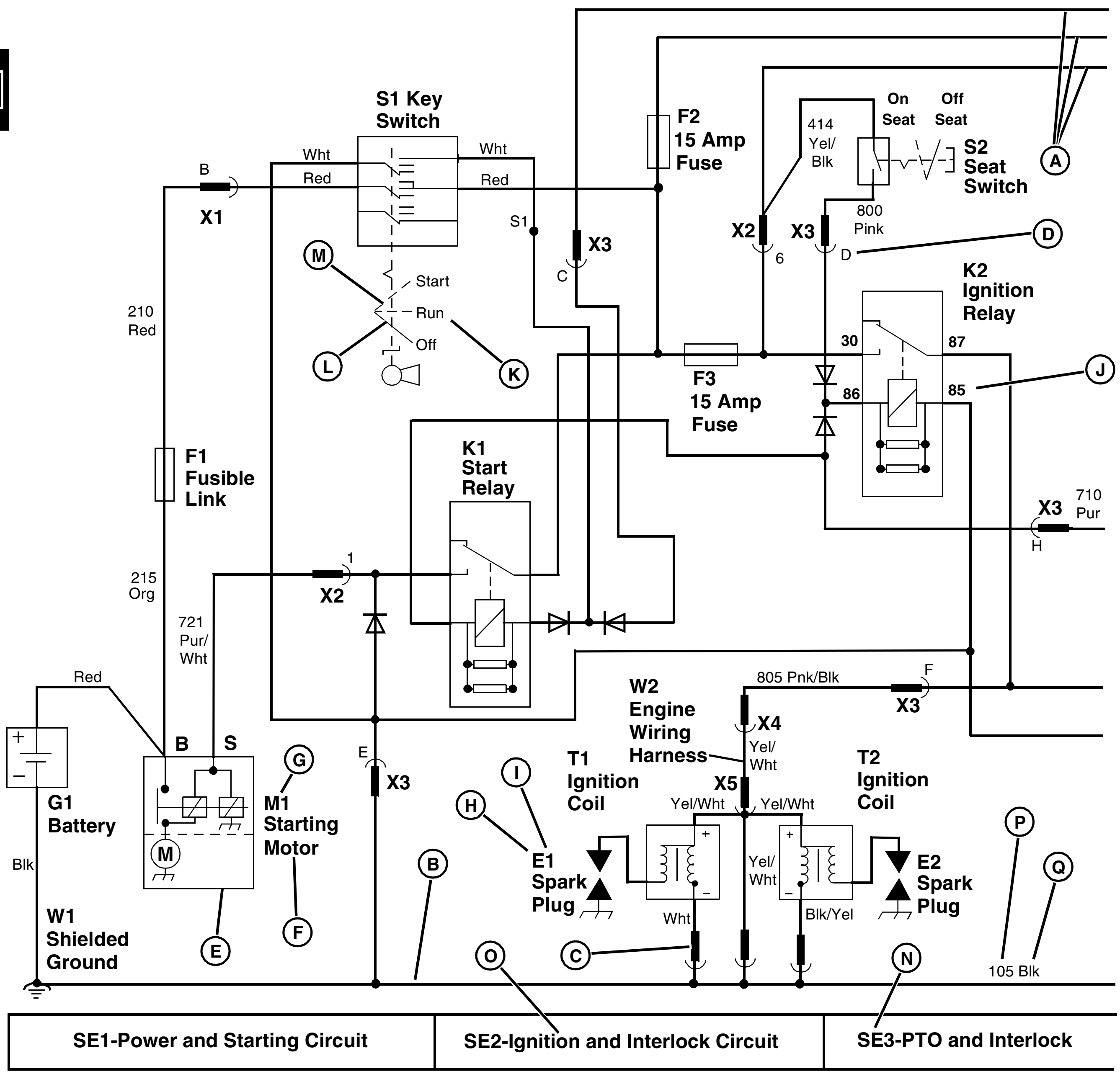
Each component is shown by a symbol (E), its name (F), and an identification code (G). The identification code contains a device identifying letter (H) and number (I).

The identifying letter is always the same for a specific component, but the identifying numbers are numbered consecutively from upper left to lower right. The terminal designation (J) is placed directly outside the symbol next to the connecting wire path. Switch positions (K) are also placed directly outside the symbol. The solid line (L) shows the position the switch is currently in and dash lines (M) represent other switch positions.

Each circuit is identified at the bottom of the drawing by a section number (N) and section name (O).

The circuit number (P) and wire color (Q) of the wires are shown directly next to the wire path.

The same component name and identification code are used consistently on all diagrams in this section. Components can be easily cross-referenced.

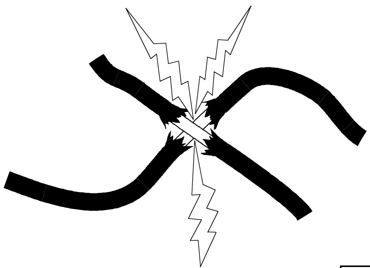


# COMMON CIRCUIT TESTS

### Shorted Circuit:

A shorted circuit may result in the wrong component operating (i.e. improper wire-to-wire contact). To test for a shorted or improperly wired circuit:

1. Turn component switch ON.
2. Start at the controlling switch of the component that should not be operating.
3. Follow the circuit and disconnect wires at connectors until component stops operating.
4. Shorted or improper connections will be the last two wires disconnected.

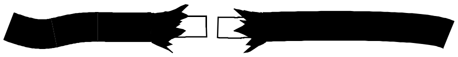


M85600 mif

### High Resistance or Open Circuit:

High resistance or open circuits usually result in slow, dim or no component operation (i.e. poor, corroded, or disconnected connections). Voltage at the component will be low when the component is in operation. To test for high resistance and open circuits:

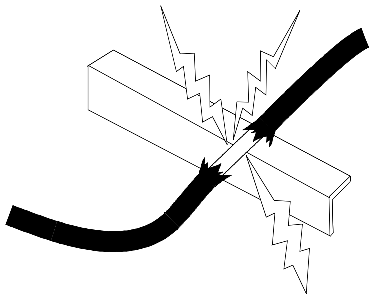
1. Check all terminals and grounds of the circuit for corrosion.
2. If terminals are not corroded or loose, the problem is in the component or wiring.



M85601 mif

### Grounded Circuit:

Grounded circuits usually result in no component operation, a blown fuse, or a blown fusible link.



M85602 mif

# CONDUCTORS FOR 12 VOLT CIRCUITS

| STRANDED CONDUCTORS FOR 12 VOLT CIRCUITS | | | | | | |
|---|---|---|---|---|---|---|
| SAE WIRE SIZE (GAUGE) | 20 | 18 | 16 | 14 | 12 | 10 |
| METRIC WIRE SIZE (MM) | 0.5 | 0.8 | 1.0 | 2.0 | 3.0 | 5.0 |
| TYPICAL STRANDING | 7 X 28 | 16 X 30 | 19 X 29 | 19 X 27 | 19 X 25 | 19 X 23 |
| MINIMUM CONDUCTOR AREA IN CIRCULAR MILS | 1072 | 1537 | 2336 | 3702 | 5833 | 9343 |

# SPECIFICATIONS

**Battery:**

Voltage . . . . . . . . 12 VDC

**Ignition:**

**LTR155 (Kohler Engine):**

Air gap . . . . . . . . 0.2 – 0.3 mm (0.008 – 0.012 in.)

**LTR166 (Briggs & Stratton Engine):**

Air gap . . . . . . . . 0.2 – 0.3 mm (0.008 – 0.012 in.)

**LTR180 (Kawasaki Engine):**

Air gap . . . . . . . . 0.25 – 0.40 (0.010 – 0.016 in.)

**Spark Plug:**

**LTR155 (Kohler Engine):**

Type . . . . . . . . Champion RC12YC
Gap . . . . . . . . 0.76 mm (0.030 in.)
Torque . . . . . . . . 24.4 – 29.8 N•m (18 – 22 lb-ft)

**LTR166 (Briggs & Stratton Engine):**

Type . . . . . . . . Champion RC12YC
Gap . . . . . . . . 1.02 mm (0.040 in.)
Torque . . . . . . . . 20 N•m (180 lb-in.)

**LTR180 (Kawasaki Engine)**

Type . . . . . . . . Champion RCJ8Y
Gap . . . . . . . . 1.0 mm (0.040 in.)
Torque . . . . . . . . 15 N•m (132 lb-in.)

**Starting Motor:**

**LTR155 (Kohler Engine):**

Type . . . . . . . . Bendix
Starting motor amp draw (on vehicle) . . . . . . . . 180 amps (max.)
Starting motor no-load amp draw (free running) . . . . . . . . 50 amps (max.)

**LTR166 (Briggs & Stratton Engine):**

Type . . . . . . . . Bendix
Starting motor amp draw (on vehicle) . . . . . . . . 90 – 100 amps
Starting motor no-load amp draw (free running) . . . . . . . . 35 amps (max.)

**LTR180 (Kawasaki Engine)**

Type . . . . . . . . Bendix
Starting motor no-load max. amp draw (free running) . . . . . . . . 50 amps @ 6000 rpm

**Stator:**

**LTR155 w/3 Amp Charger (S/N –020000):**

Size . . . . . . . . 3 amps
Unregulated Amperage (Minimum) at Fast Idle . . . . . . . . 2 - 3 amps
Charging Lead Voltage (Minimum) at Fast Idle . . . . . . . . 28 volts DC
Lighting Lead Voltage (Minimum) at Fast Idle . . . . . . . . 15 volts AC

**LTR155 w/15 Amp Charger (S/N 020001–):**

Size . . . . . . . . 15 amps
Regulated Amperage (Minimum) at Fast Idle . . . . . . . . 3 – 15 amps
Regulated Voltage (Minimum) at Fast Idle . . . . . . . . 12.2 – 14.7 volts DC

Unregulated Voltage (Minimum) at Fast Idle . . . . . . . . . . . . . . . . . . . . . . . . 28 volts AC

**LTR166 (Briggs & Stratton Engine):**

Size . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 16 amps
Regulated Amperage (Minimum) at Fast Idle. . . . . . . . . . . . . . . . . . . . . . . . 3 – 16 amps
Regulated Voltage (Minimum) at Fast Idle . . . . . . . . . . . . . . . . . . . . 12.2 – 14.7 volts DC
Unregulated Voltage (Minimum) at Fast Idle . . . . . . . . . . . . . . . . . . . . . . . . 30 volts AC

**LTR180 (Kawasaki Engine):**

Size . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 13 amps
Regulated Amperage (Minimum) at Fast Idle. . . . . . . . . . . . . . . . . . . . . . . . 3 – 13 amps
Regulated Voltage (Minimum) at Fast Idle . . . . . . . . . . . . . . . . . . . . 12.2 – 14.7 volts DC
Unregulated Voltage (Minimum) at Fast Idle . . . . . . . . . . . . . . . . . . . . . . . . 29 volts AC

**Lighting:**

Headlights . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . GE 1156 or equivalent

# SCHEMATIC AND WIRING HARNESS LEGEND—LTR155

E1—Spark Plug (SE3, W2)

E2—RH Headlight (SE5, W3)

E3—LH Headlight (SE5, W3)

F1—Fusible Link (SE1, W1)

G1—Battery (SE1, W1)

G2—Stator (SE4, W2)

H1—Grass Collection System (GCS) Full Alarm (SE2, W1)

K1—Starting Motor Solenoid (SE1, W1)

K2—Seat Relay (SE2, W1)

K3—RIO Latch Relay (SE2, W1)

K4—Shunt Relay (SE3, W1)

M1—Starting Motor (SE1, W1)

S1—Key Switch (SE1, W1)

S2—Seat Switch (SE2, W1)—(3 Position Key Switch)

S2—RIO Switch (SE2, W1)—(4 Position Key Switch)

S3—GCS Enable Switch (SE2, W1)

S4—PTO Switch (SE2, W1)

S5—RIO Switch (SE2, W1)—(3 Position Key Switch)

S5—Seat Switch (SE2, W1)—(4 Position Key Switch)

S6—Brake Switch (SE2, W1)

S7—RIS Switch (SE2, W1)

S8—GCS Bag In Place Switch (SE2, W1)

S9—GCS Bag Full Switch (SE2, W1)

T1—Magneto Ignition (SE3, W2)

V1—Diode (SE3, W1)

V2—Diode (SE4, W2)

W1—Shielded Ground (SE1, W1)

Y1—Fuel Shutoff Solenoid (SE4, W2) (Optional)

**CONNECTORS:**

X1—W1 Main Wiring Harness to W2 Engine Wiring Harness (SE3, W1; SE5, W1)

X2—W1 Main Wiring Harness to V1 Diode (SE3, W1)

X3—W1 Main Wiring Harness to Y1 Fuel Shutoff Solenoid (SE3, W1)

X4—W1 Main Wiring Harness to W3 Headlight Wiring Harness (SE5, W1)

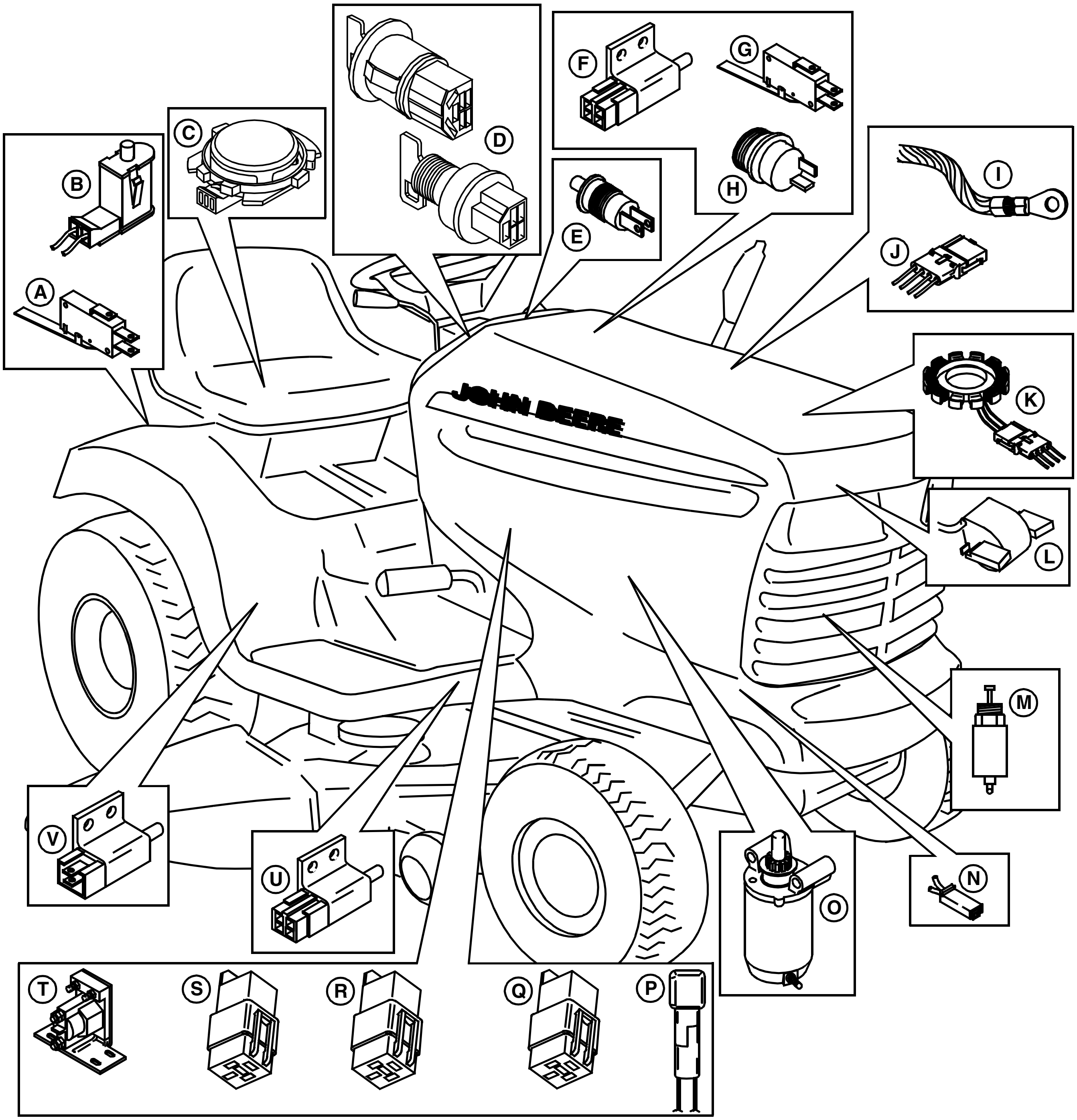
**WIRING HARNESSES:**

W1—Main Wiring Harness

W2—Kohler Engine Wiring Harness

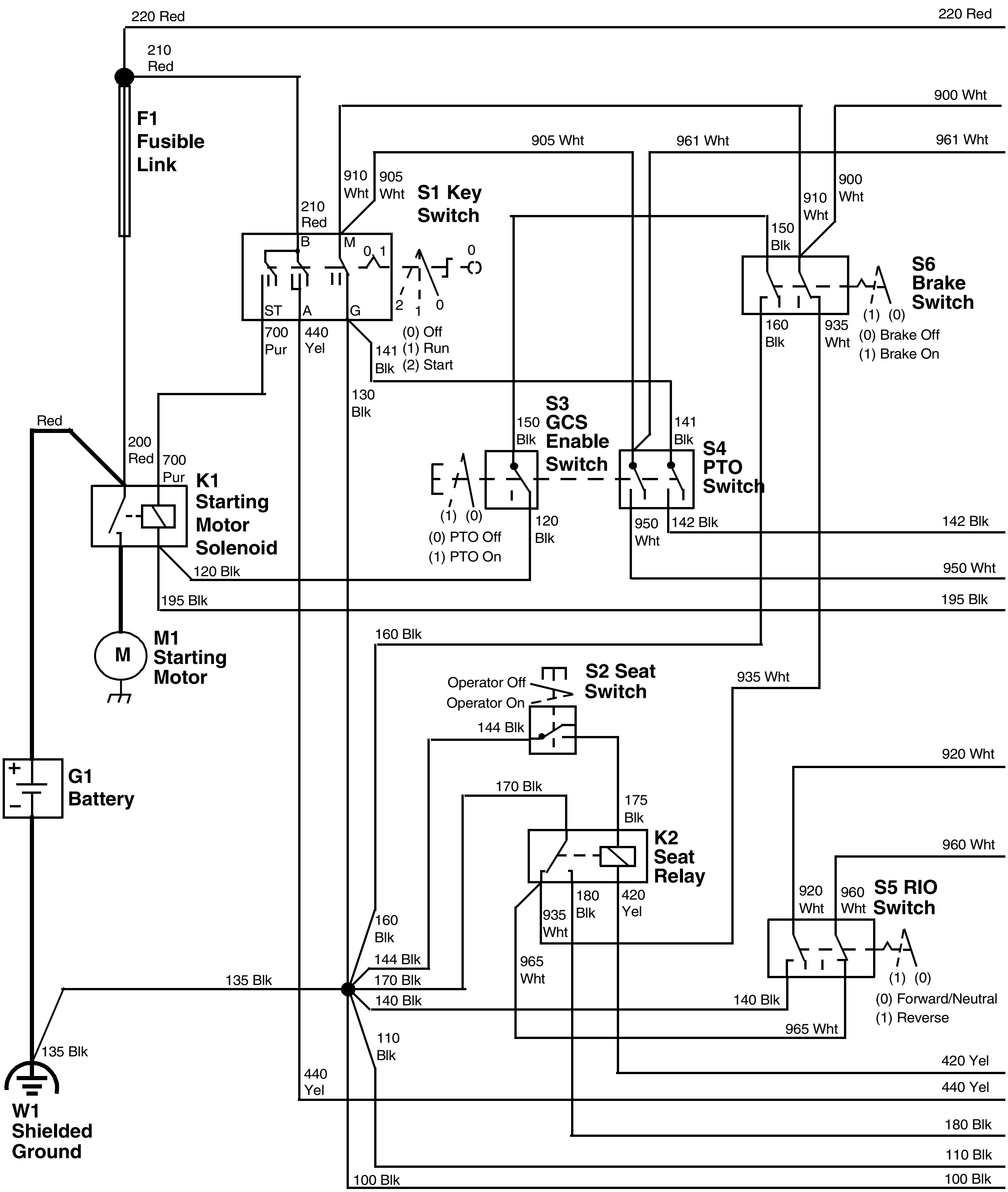
W3—Headlight Wiring Harness

# COMPONENT LOCATION—LTR155




| | | | |
|---|---|---|---|
| A. S9 Bag Full Switch | G. S3 GCS Enable Switch | M. Y1 Fuel Shutoff Solenoid | S. K2 Seat Relay |
| B. S8 Bag in Place Switch | H. H1 GCS Full Alarm | N. X4 Headlight Connector | T. K1 Starting Motor Relay |
| C. S2 Seat Switch | I. W1 Shielded Ground | O. M1 Starting Motor | U. S6 Brake Switch |
| D. S1 Key Switch | J. X1 Engine Connector | P. V1 Diode | V. S5 RIO Switch |
| E. S7 RIS Switch | K. G2 Stator | Q. K4 Shunt Relay | |
| F. S4 PTO Switch | L. T1 Magneto Ignition | R. K3 RIO Latch Relay | |

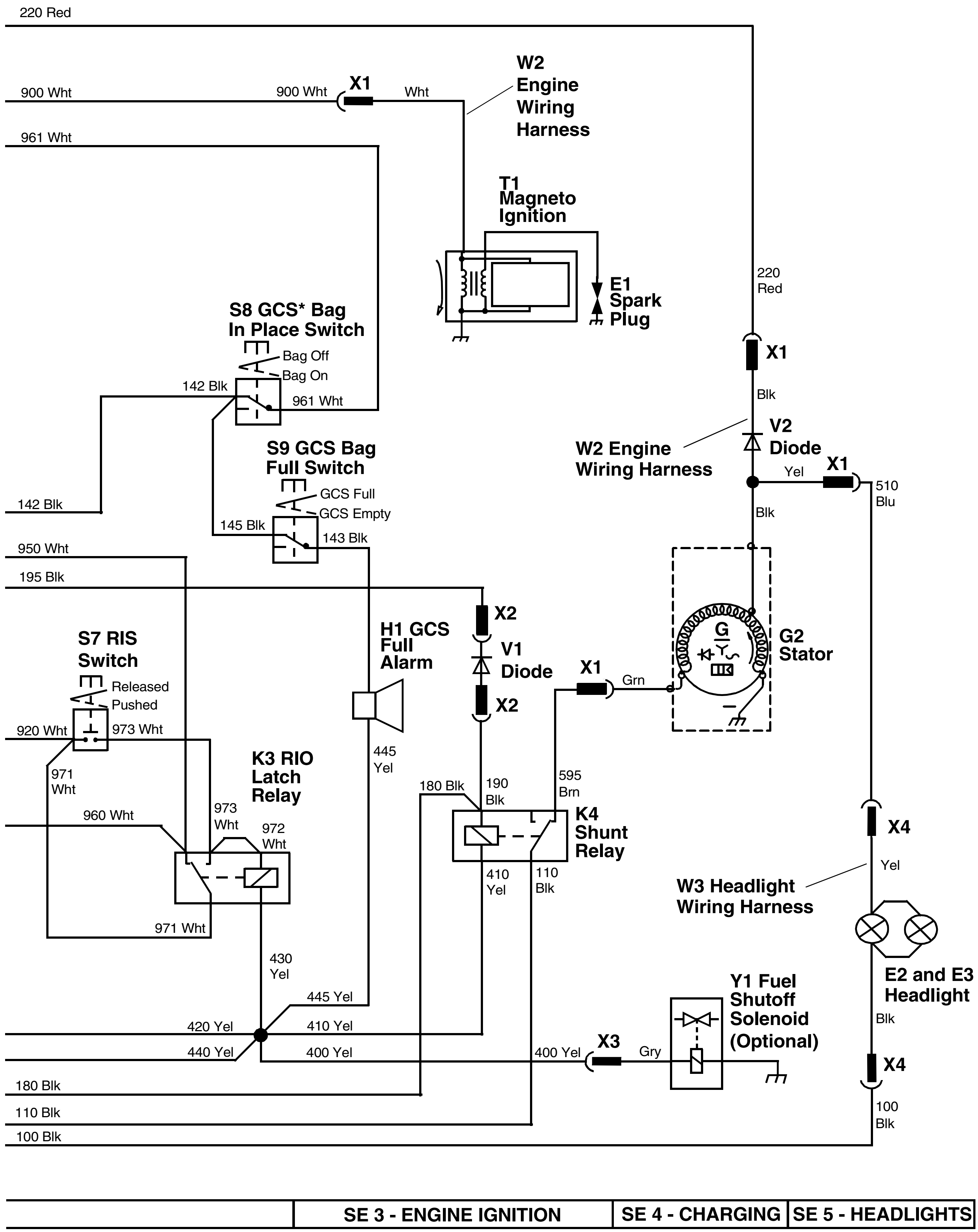
# ELECTRICAL SCHEMATIC—LTR155 w/3 AMP CHARGER




* NOTE: GCS is Grass Collection system

| SE 1 - STARTING | SE 2 - MAGNETO KILL & START INTERLOCK |
|---|---|

# ELECTRICAL SCHEMATIC—LTR155 w/3 AMP CHARGER (cont.)



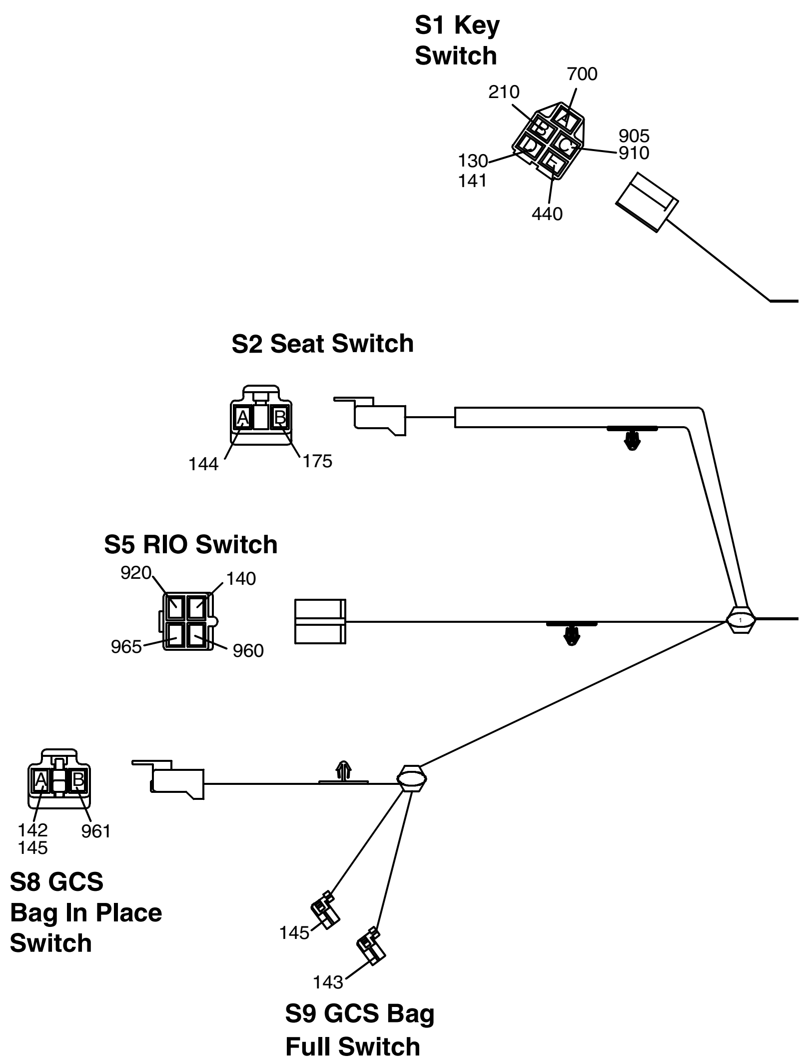
# W1 MAIN WIRING HARNESS—LTR155 w/3 AMP CHARGER

S/N –020000

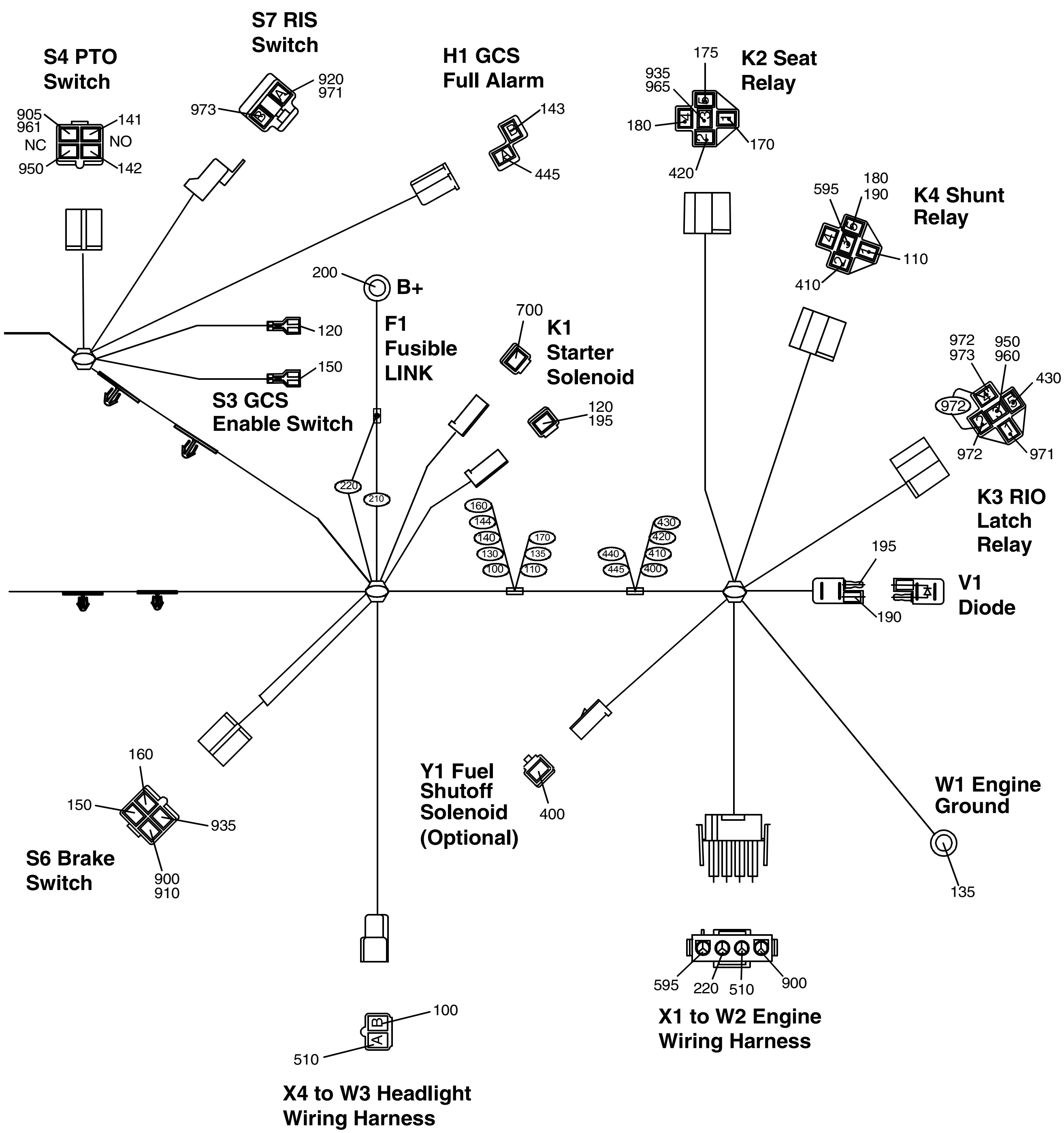
| Circuit No. | Wire Size | Color | Connection Point |
|---|---|---|---|
| 100 | 0.8 | Blk | X4, Splice |
| 110 | 0.8 | Blk | K4, Splice |
| 120 | 0.8 | Blk | K1, S3 |
| 130 | 0.8 | Blk | S1, Splice |
| 135 | 2.0 | Blk | W1, Splice |
| 140 | 0.8 | Blk | S5, Splice |
| 141 | 0.8 | Blk | S4, S1 |
| 142 | 0.8 | Blk | S8, S4 |
| 143 | 0.8 | Blk | H1, S9 |
| 144 | 0.8 | Blk | S2, Splice |
| 145 | 0.8 | Blk | S8, S9 |
| 150 | 0.8 | Blk | S6, S3 |
| 160 | 0.8 | Blk | S6, Splice |
| 170 | 0.8 | Blk | K2, Splice |
| 175 | 0.8 | Blk | K2, S2 |
| 180 | 0.8 | Blk | K4, K2 |
| 190 | 0.8 | Blk | V1, K4 |
| 195 | 0.8 | Blk | V1, K1 |
| 200 | 0.5 | Fuse Link | K1, F1 |
| 210 | 1.0 | Red | F1, S1 |
| 220 | 2.0 | Red | F1, X1 |
| 400 | 0.8 | Yel | Y1, Splice |
| 410 | 0.8 | Yel | K4, Splice |
| 420 | 0.8 | Yel | K2, Splice |
| 430 | 0.8 | Yel | K3, Splice |
| 440 | 0.8 | Yel | S1, Splice |
| 445 | 0.8 | Yel | H1, Splice |
| 510 | 0.8 | Blu | X1, X4 |
| 595 | 2.0 | Brn | X1, K4 |
| 700 | 0.8 | Pur | S1, K1 |
| 900 | 0.8 | Wht | X1, S6 |
| 905 | 0.8 | Wht | S4, S1 |
| 910 | 0.8 | Wht | S6, S1 |
| 920 | 0.8 | Wht | S5, S7 |
| 935 | 0.8 | Wht | S6, K2 |
| 950 | 0.8 | Wht | K3, S4 |

| Circuit No. | Wire Size | Color | Connection Point |
|---|---|---|---|
| 960 | 0.8 | Wht | K3, S5 |
| 961 | 0.8 | Wht | S8, S4 |
| 965 | 0.8 | Wht | S5, K2 |
| 971 | 0.8 | Wht | K3, S7 |
| 972 | 0.8 | Wht | K3, K3 |
| 973 | 0.8 | Wht | K3, S7 |

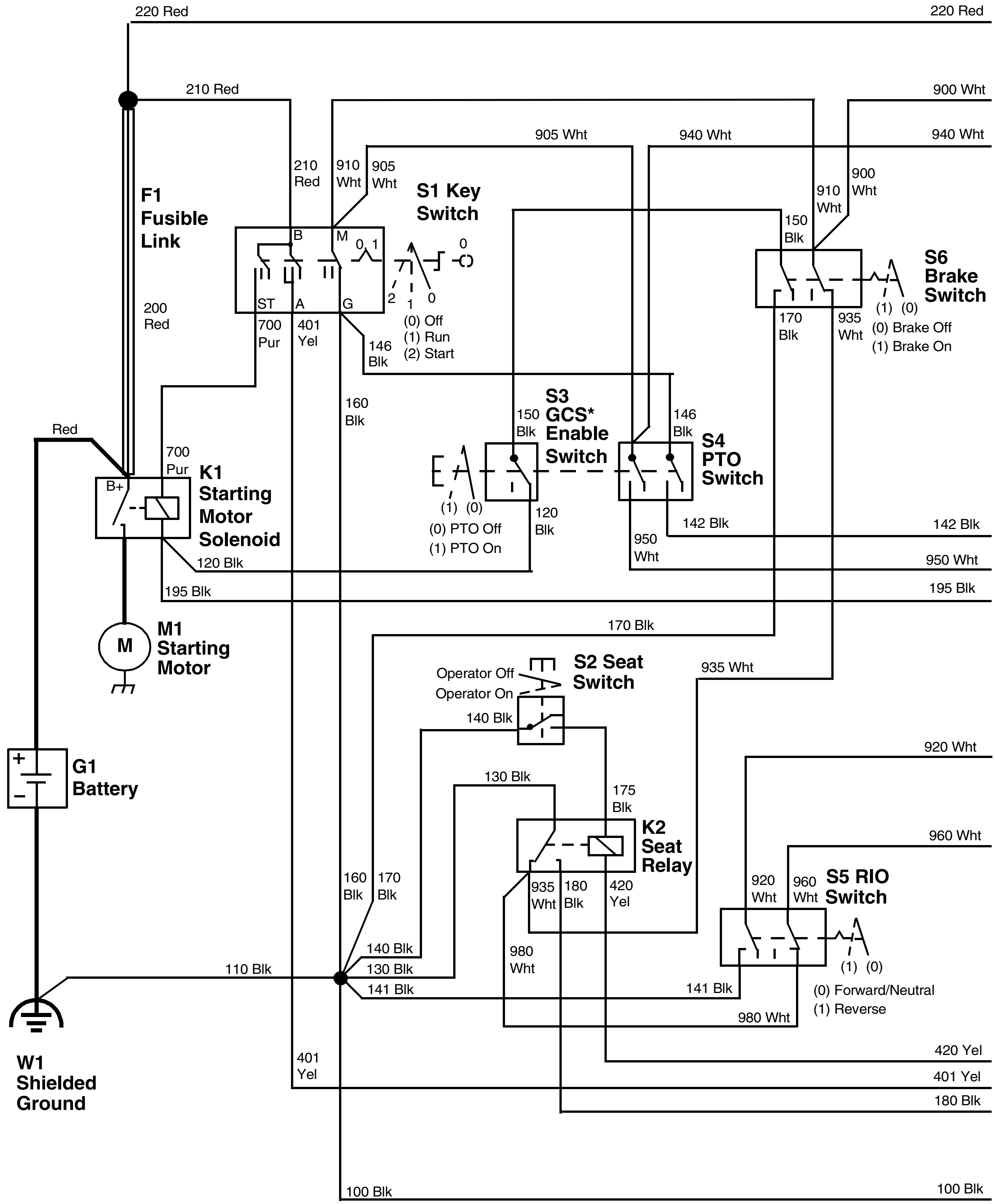
*** NOTE: GCS is Grass Collection system**



# W1 MAIN WIRING HARNESS—LTR155 w/3 AMP CHARGER (cont.)



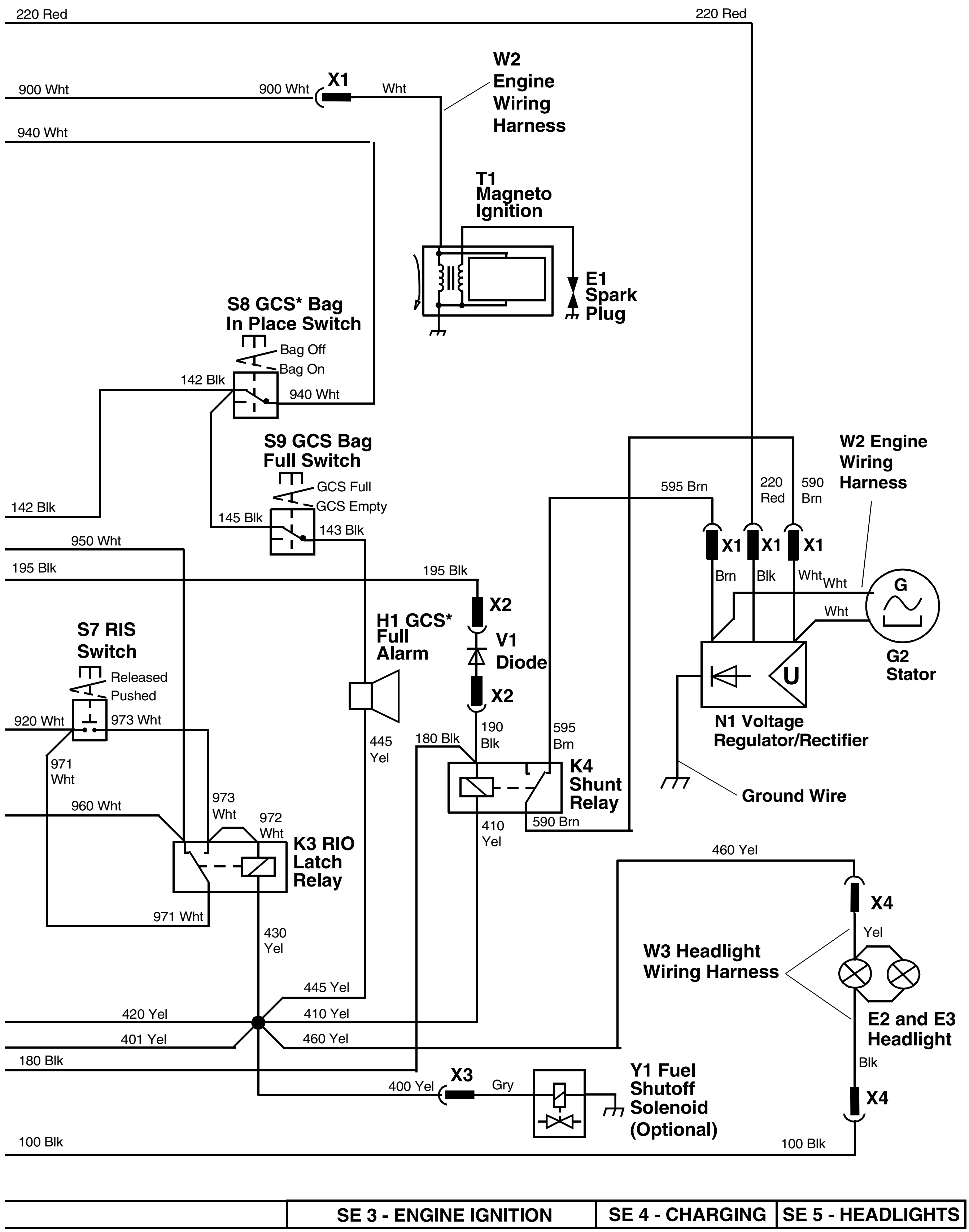
# ELECTRICAL SCHEMATIC—LTR155 w/15 AMP CHARGER




*** NOTE: GCS is Grass Collection System**

| SE 1 - STARTING | SE 2 - MAGNETO KILL & START INTERLOCK |
|---|---|

# ELECTRICAL SCHEMATIC—LTR155 w/15 AMP CHARGER (cont.)



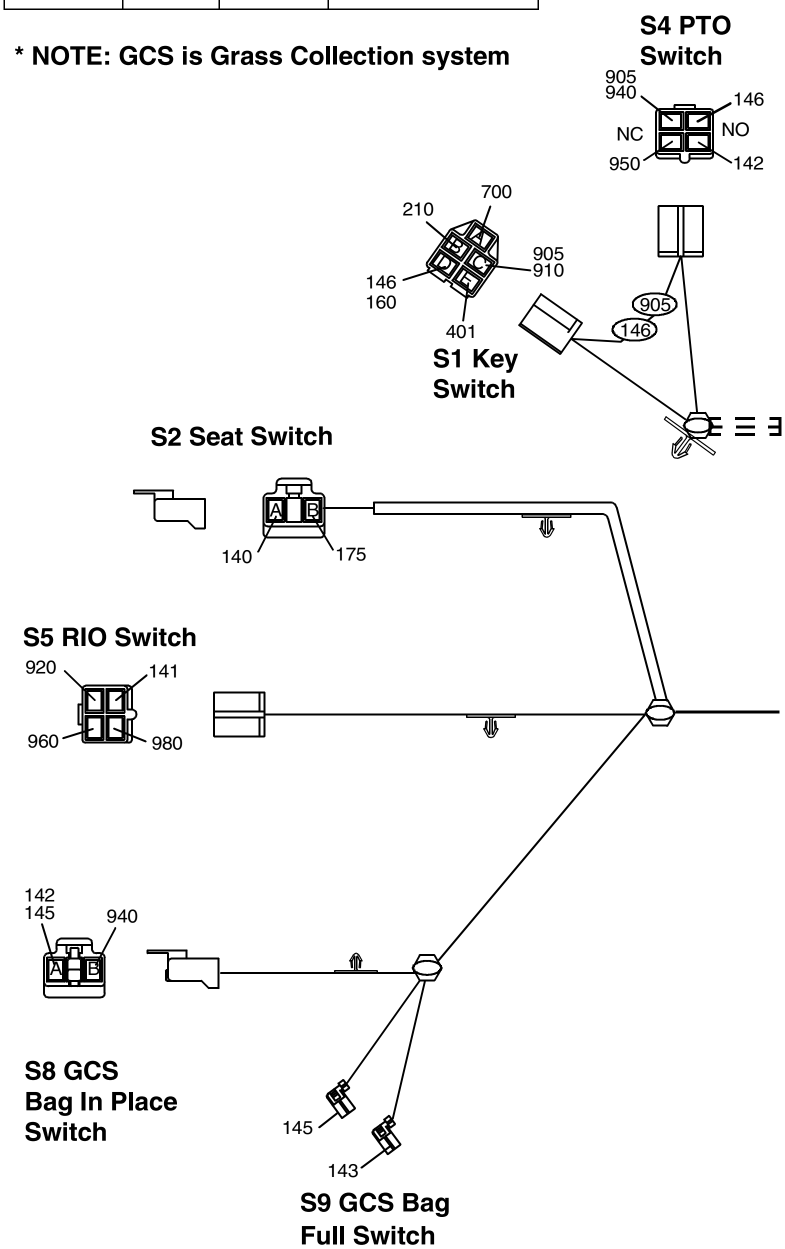
# W1 MAIN WIRING HARNESS—LTR155 w/15 AMP CHARGER

S/N 020001–

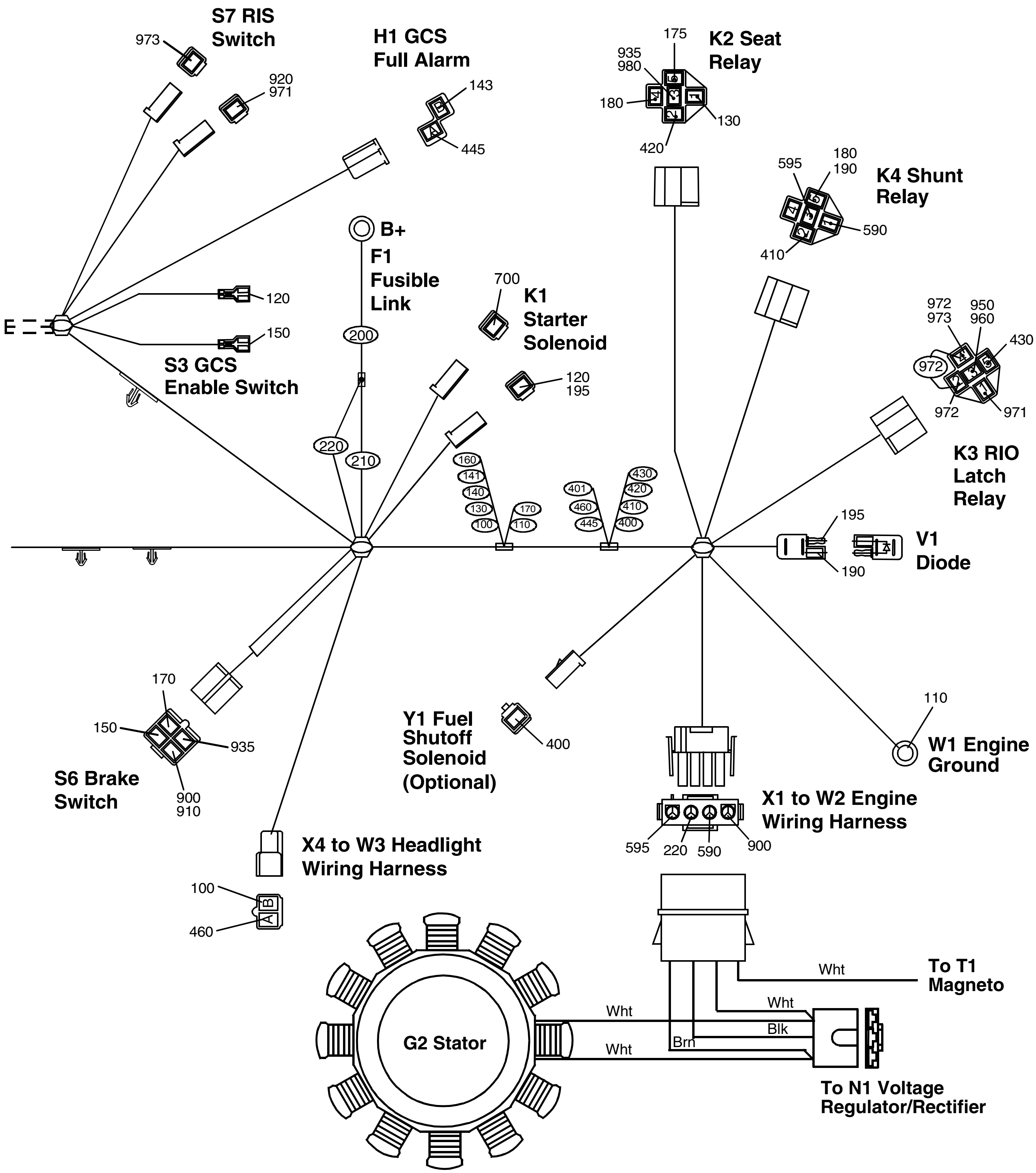
| Circuit No. | Wire Size | Color | Connection Point |
|---|---|---|---|
| 100 | 0.8 | Blk | X4, Splice |
| 110 | 1.0 | Blk | Splice, W1 Gnd |
| 120 | 0.8 | Blk | K1, S3 |
| 130 | 0.8 | Blk | K2, Splice |
| 140 | 0.8 | Blk | S2, Splice |
| 141 | 0.8 | Blk | S5, Splice |
| 142 | 0.8 | Blk | S8, S4 |
| 143 | 0.8 | Blk | H1, S9 |
| 145 | 0.8 | Blk | S8, S9 |
| 146 | 0.8 | Blk | S1, S4 |
| 150 | 0.8 | Blk | S6, S3 |
| 160 | 0.8 | Blk | S1, Splice |
| 170 | 0.8 | Blk | S6, Splice |
| 175 | 0.8 | Blk | K2, S2 |
| 180 | 0.8 | Blk | K4, K2 |
| 190 | 0.8 | Blk | V1, K4 |
| 195 | 0.8 | Blk | V1, K1 |
| 200 | 0.8 | Fuse Link | K1, 210/220 |
| 210 | 1.0 | Red | 200 (F1), S1 |
| 220 | 2.0 | Red | 200 (F1), X1 |
| 400 | 0.8 | Yel | Y1, Splice 401 |
| 401 | 0.8 | Yel | S1, Splice |
| 410 | 0.8 | Yel | K4, Splice 401 |
| 420 | 0.8 | Yel | K2, Splice 401 |
| 430 | 0.8 | Yel | K3, Splice 401 |
| 445 | 0.8 | Yel | H1, Splice 401 |
| 460 | 0.8 | Yel | X4, Splice 401 |
| 590 | 2.0 | Brn | X1, K4 |
| 595 | 2.0 | Brn | X1, K4 |
| 700 | 0.8 | Pur | S1, K1 |
| 900 | 0.8 | Wht | X1, S6 |
| 905 | 0.8 | Wht | S4, S1 |
| 910 | 0.8 | Wht | S6, S1 |
| 920 | 0.8 | Wht | S5, S7 |
| 935 | 0.8 | Wht | S6, K2 |
| 940 | 0.8 | Wht | S8, S4 |
| 950 | 0.8 | Wht | K3, S4 |
| 960 | 0.8 | Wht | K3, S5 |
| 971 | 0.8 | Wht | K3, S7 |

| Circuit No. | Wire Size | Color | Connection Point |
|---|---|---|---|
| 972 | 0.8 | Wht | K3, K3 |
| 973 | 0.8 | Wht | K3, S7 |
| 980 | 0.8 | Wht | K2, S5 |

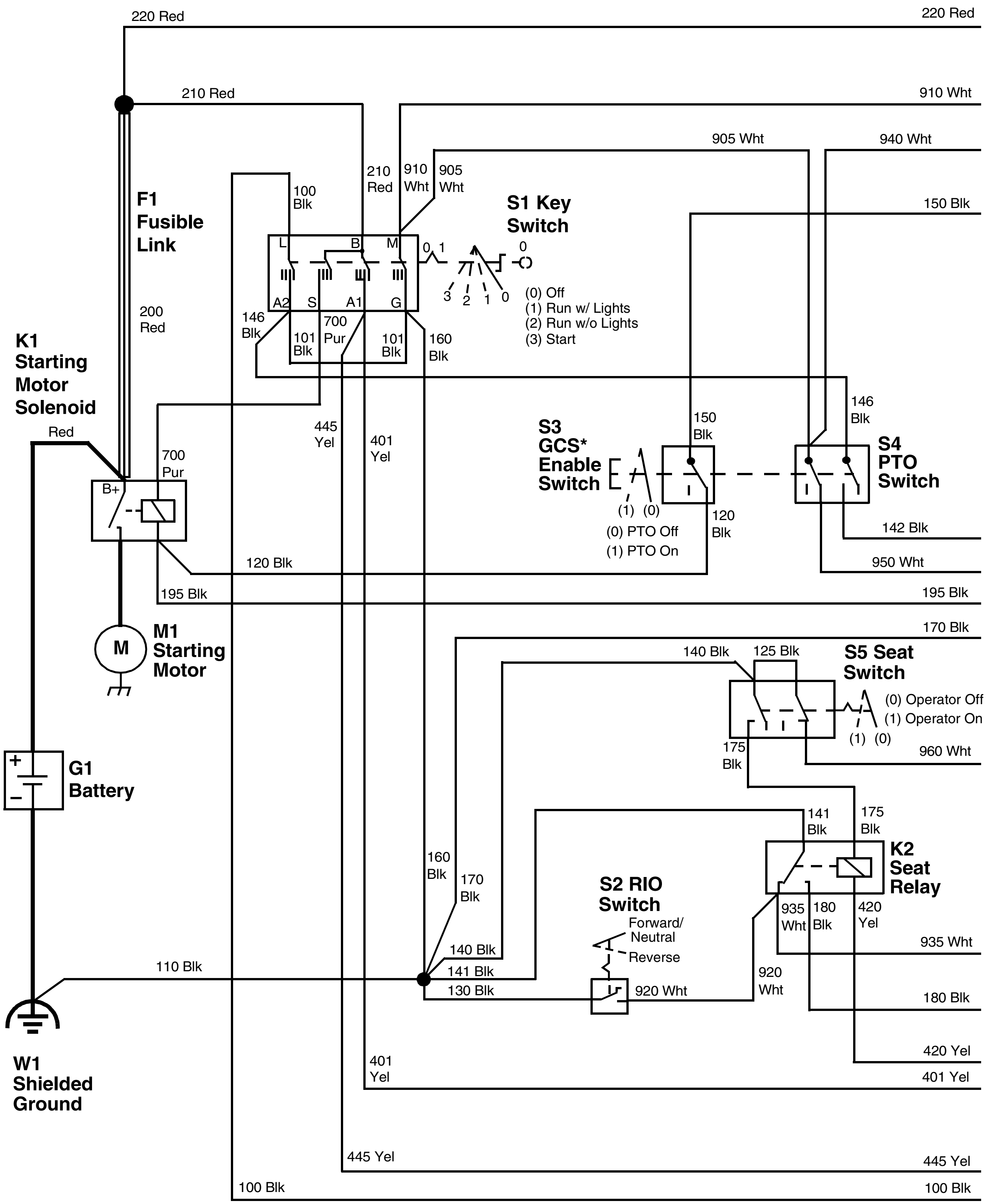
*** NOTE: GCS is Grass Collection system**



# W1 MAIN WIRING HARNESS—LTR155 w/15 AMP CHARGER (cont.)



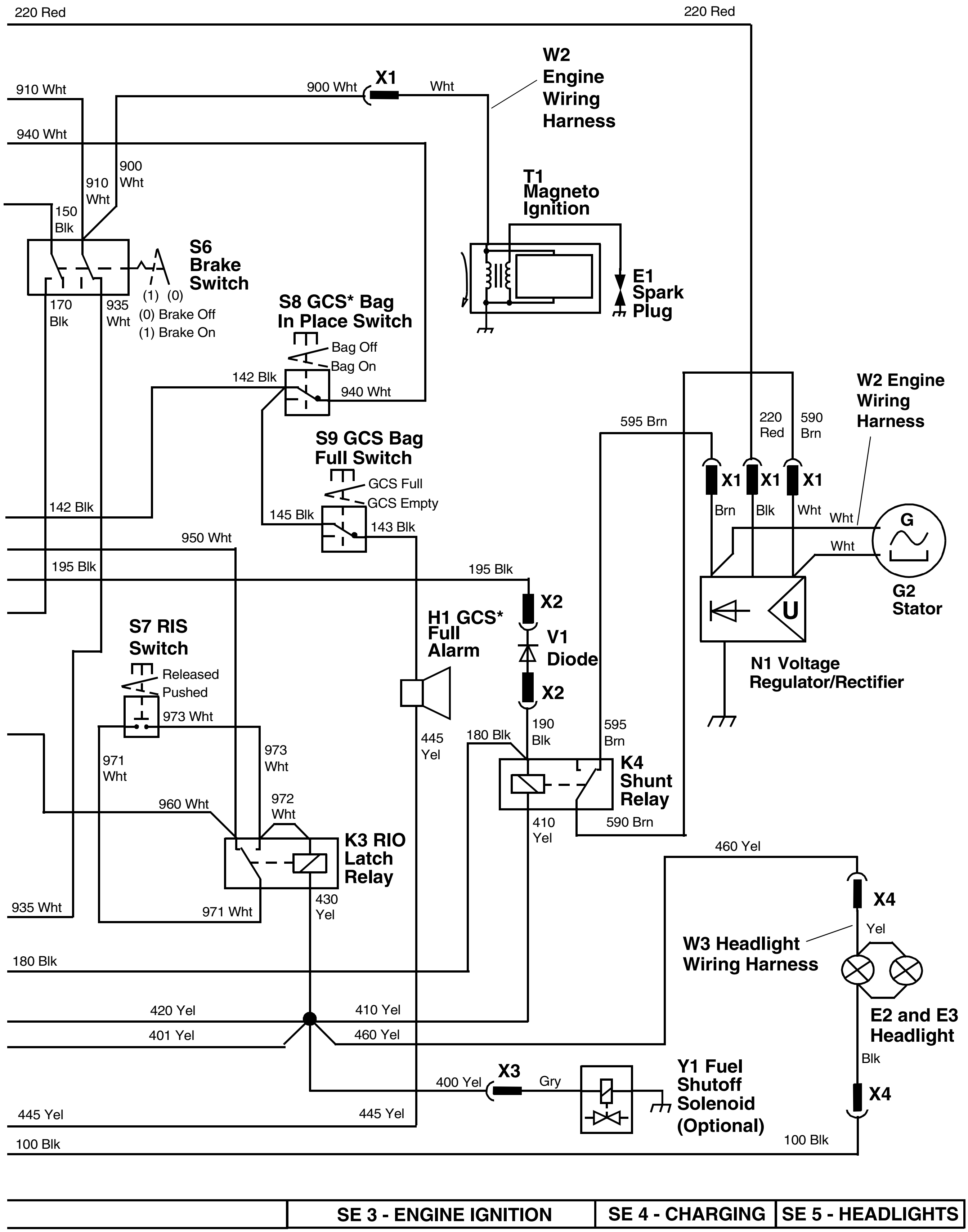
# ELECTRICAL SCHEMATIC—LTR155 w/4 POSITION KEY SWITCH




*** NOTE: GCS is Grass Collection System**

| SE 1 - STARTING | SE 2 - MAGNETO KILL & START INTERLOCK |
|---|---|

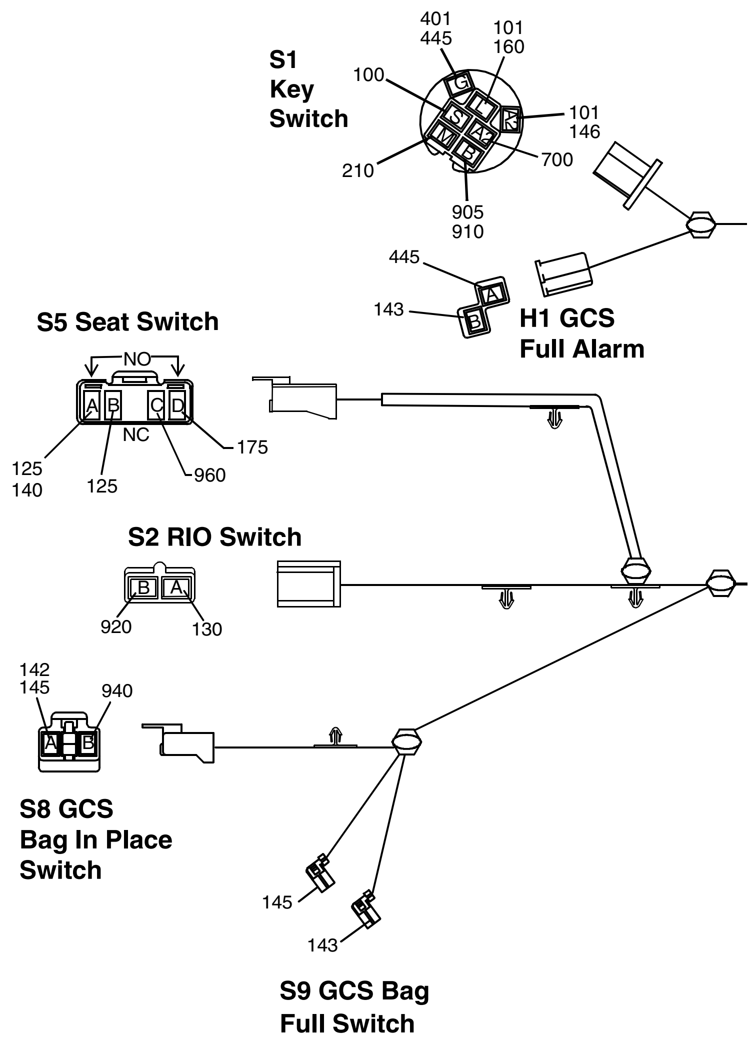
# ELECTRICAL SCHEMATIC—LTR155 w/4 POSITION KEY SWITCH (cont.)



# W1 MAIN WIRING HARNESS—LTR155 w/4 POSITION KEY SWITCH

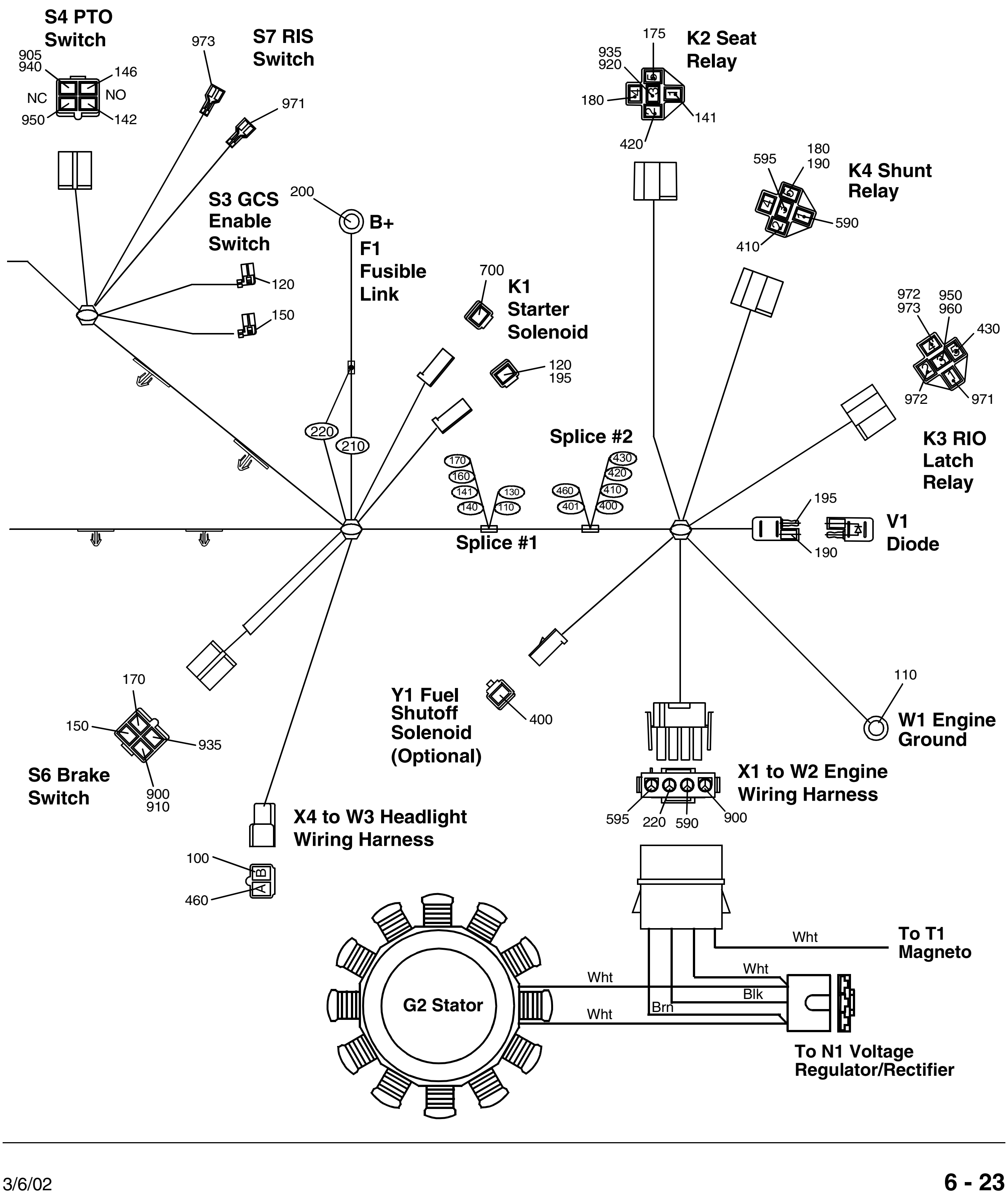
| Circuit No. | Wire Size | Color | Connection Point |
|---|---|---|---|
| 100 | 0.8 | Blk | X4, S1 |
| 101 | 0.8 | Blk | S1, S1 |
| 110 | 2.0 | Blk | Splice #1, W1 |
| 120 | 0.8 | Blk | K1, S3 |
| 125 | 0.8 | Blk | S5, S5 |
| 130 | 0.8 | Blk | Splice #1, S2 |
| 140 | 0.8 | Blk | Splice #1, S5 |
| 141 | 0.8 | Blk | Splice #1, K2 |
| 142 | 0.8 | Blk | S8, S4 |
| 143 | 0.8 | Blk | H1, S9 |
| 145 | 0.8 | Blk | S8, S9 |
| 146 | 0.8 | Blk | S1, S4 |
| 150 | 0.8 | Blk | S3, S6 |
| 160 | 0.8 | Blk | Splice #1, S1 |
| 170 | 0.8 | Blk | Splice #1, S6 |
| 175 | 0.8 | Blk | K2, S5 |
| 180 | 0.8 | Blk | K4, K2 |
| 190 | 0.8 | Blk | V1, K4 |
| 195 | 0.8 | Blk | V1, K1 |
| 200 | 0.8 | Fuse Link | F1, 210/220 |
| 210 | 1.0 | Red | 200 (F1), S1 |
| 220 | 2.0 | Red | 200 (F1), X1 |
| 400 | 0.8 | Yel | Splice #2, Y1 |
| 401 | 0.8 | Yel | S1, Splice #2 |
| 410 | 0.8 | Yel | K4, Splice #2 |
| 420 | 0.8 | Yel | K2, Splice #2 |
| 430 | 0.8 | Yel | K3, Splice #2 |
| 445 | 0.8 | Yel | H1, S1 |
| 460 | 0.8 | Yel | X4, Splice #2 |
| 590 | 2.0 | Brn | X1, K4 |
| 595 | 2.0 | Brn | X1, K4 |
| 700 | 0.8 | Pur | S1, K1 |
| 900 | 0.8 | Wht | X1, S6 |
| 905 | 0.8 | Wht | S4, S1 |
| 910 | 0.8 | Wht | S6, S1 |
| 920 | 0.8 | Wht | S2, K2 |
| 935 | 0.8 | Wht | S6, K2 |

| Circuit No. | Wire Size | Color | Connection Point |
|---|---|---|---|
| 940 | 0.8 | Wht | S8, S4 |
| 950 | 0.8 | Wht | K3, S4 |
| 960 | 0.8 | Wht | K3, S5 |
| 971 | 0.8 | Wht | K3, S7 |
| 972 | 0.8 | Wht | K3, K3 |
| 973 | 0.8 | Wht | K3, S7 |




* NOTE: GCS is Grass Collection system

# W1 MAIN WIRING HARNESS—LTR155 w/4 POSITION KEY SWITCH (cont.)



# SCHEMATIC AND WIRING HARNESS LEGEND—LTR166

E1—Spark Plug (SE4, W2)

E2—Spark Plug (SE4, W2)

E3—RH Headlight (SE5, W4)

E4—LH Headlight (SE5, W4)

F1—Fusible Link (SE1, W1)

G1—Battery (SE1, W1)

G2—Stator (SE4, W3)

H1—Grass Collection System (GCS) Full Alarm (SE3, W1)

K1—Starting Motor Solenoid (SE1, W1)

K2—RIO Latch Relay (SE2, W1)

M1—Starting Motor (SE1, W1)

S1—Key Switch (SE1, W1)

S2—Seat Switch (SE2, W1)

S3—GCS Enable Switch (SE2, W1)

S4—RIO Switch (SE2, W1)

S5—PTO Switch (SE2, W1)

S6—Brake Switch (SE2, W1)

S7—RIS Switch (SE2, W1)

S8—GCS Bag In Place Switch (SE2, W1)

S9—GCS Bag Full Switch (SE2, W1)

T1—Magneto Ignition (SE3, W2)

T2—Magneto Ignition (SE3, W2)

V1—Diode (SE3, W2)

V2—Diode (SE3, W2)

V3—Diode (SE4, W2) Only with 3 Amp Charger

W1—Shielded Ground (SE1, W1)

Y1—Fuel Shutoff Solenoid (SE3, W2)

**CONNECTORS:**

X1—W1 Main Wiring Harness to Y1 Fuel Shutoff Solenoid (SE3, W1)

X2—W1 Main Wiring Harness to W2 Engine Wiring Harness (SE3, W1)

X3—W1 Main Wiring Harness to W3 Engine Wiring Harness (SE4, W1)

X4—W1 Main Wiring Harness to W4 Headlight Wiring Harness (SE5, W1)

**WIRING HARNESSES:**

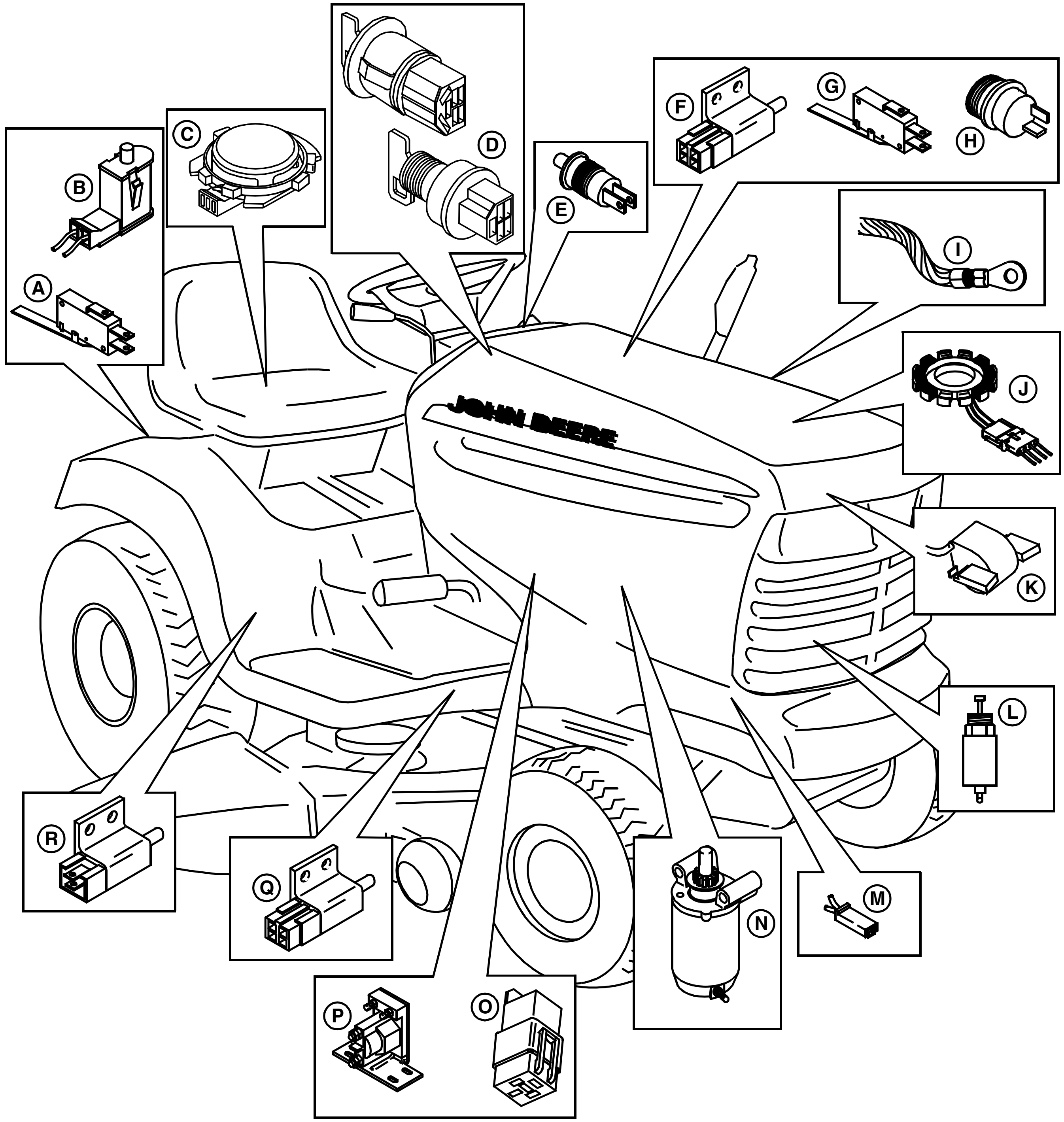
W1—Main Wiring Harness

W2—B&S Engine Wiring Harness

W3—B&S Engine Wiring Harness

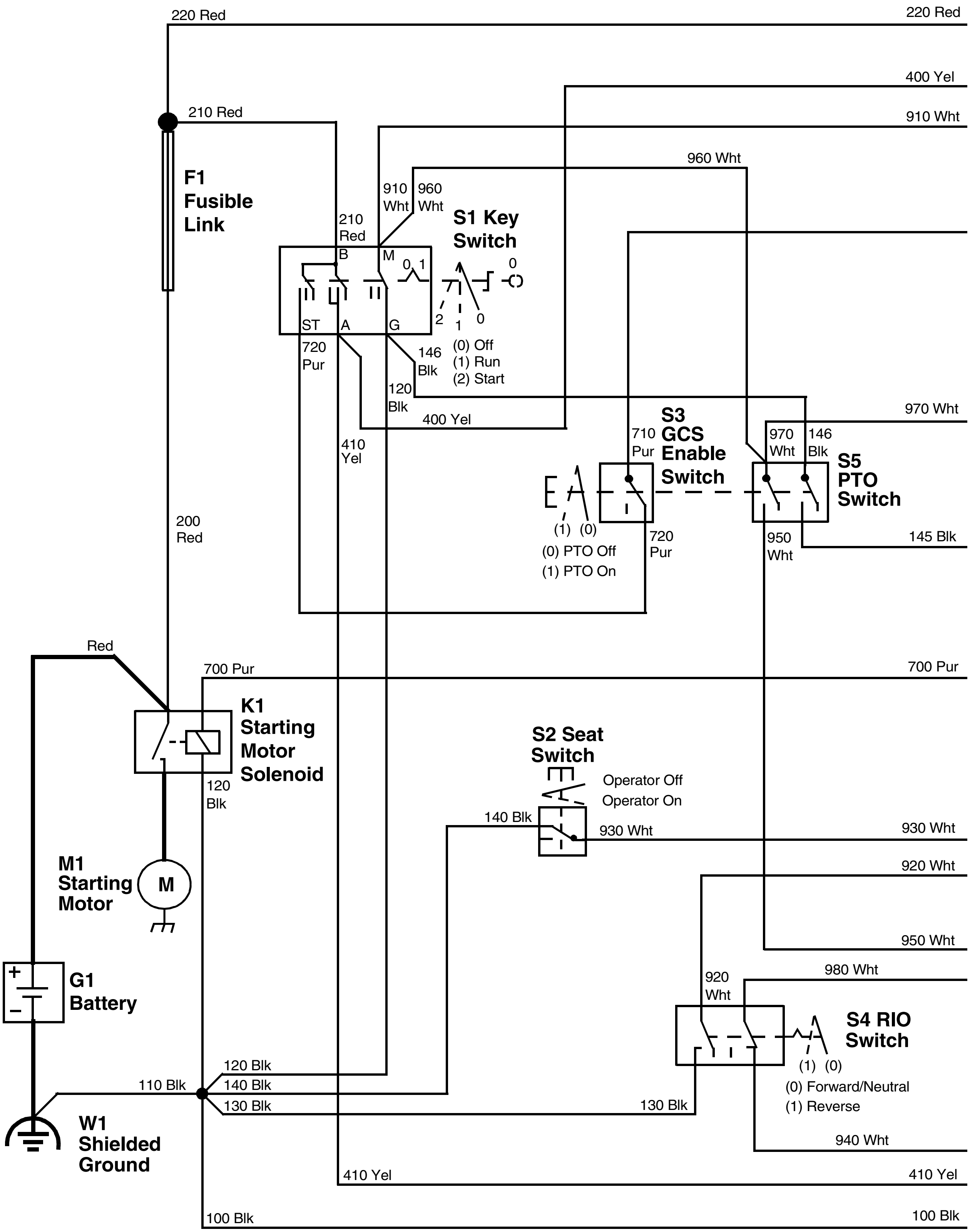
W4—Headlight Wiring Harness

# COMPONENT LOCATION—LTR166




| | | | |
|---|---|---|---|
| A. S9 Bag Full Switch | F. S5 PTO Switch | K. T1 & T2 Magneto Ignition | P. K1 Starting Motor Relay |
| B. S8 Bag in Place Switch | G. S3 GCS Enable Switch | L. Y1 Fuel Shutoff Solenoid | Q. S6 Brake Switch |
| C. S2 Seat Switch | H. H1 GCS Full Alarm | M. X4 Headlight Connector | R. S4 RIO Switch |
| D. S1 Key Switch | I. W1 Shielded Ground | N. M1 Starting Motor | |
| E. S7 RIS Switch | J. G2 Stator | O. K2 RIO Latch Relay | |

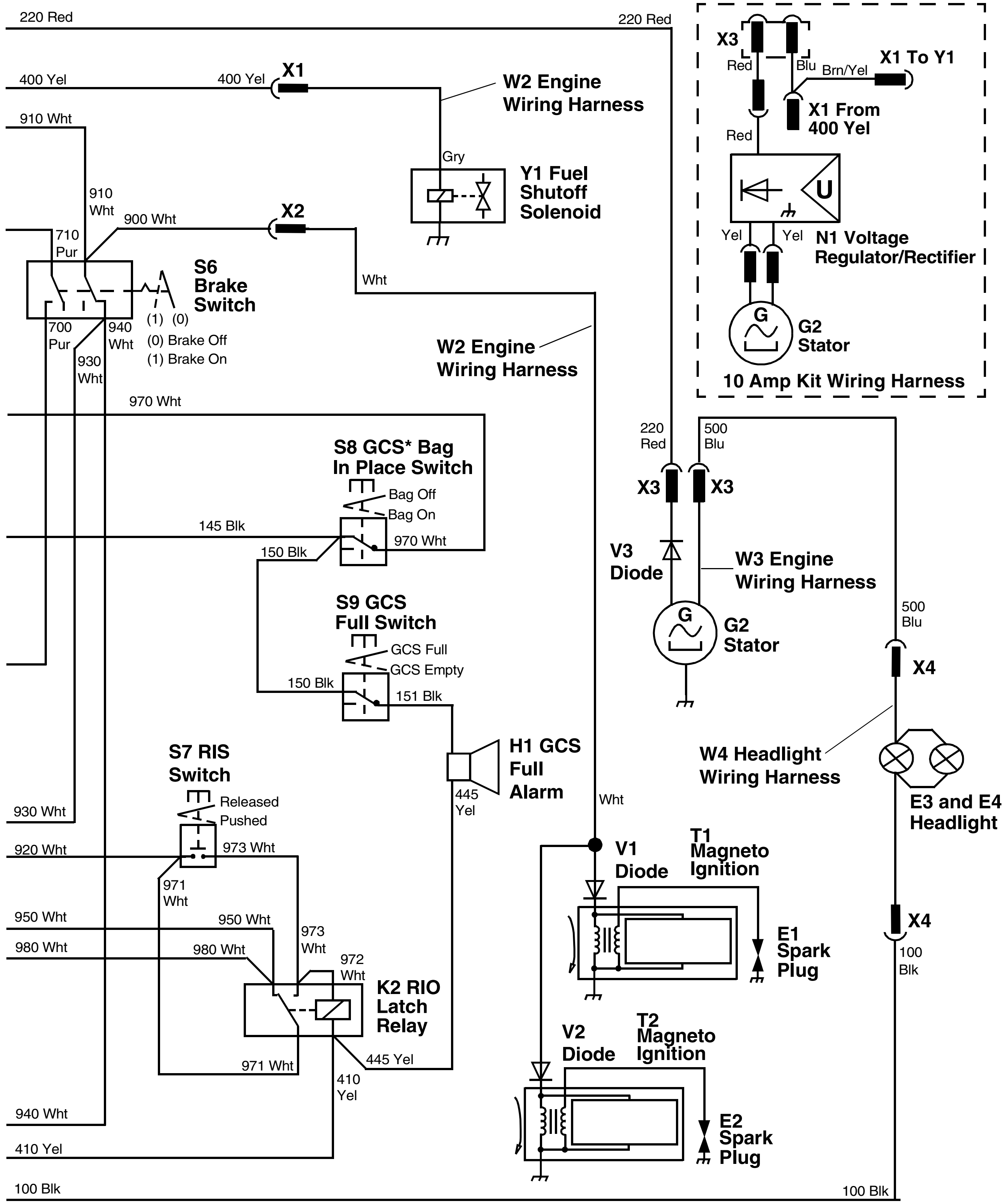
# ELECTRICAL SCHEMATIC—LTR166




* NOTE: GCS is Grass Collection system

| SE 1 - STARTING | SE 2 - MAGNETO KILL & START INTERLOCK |
|---|---|

# ELECTRICAL SCHEMATIC—LTR166 (cont.)

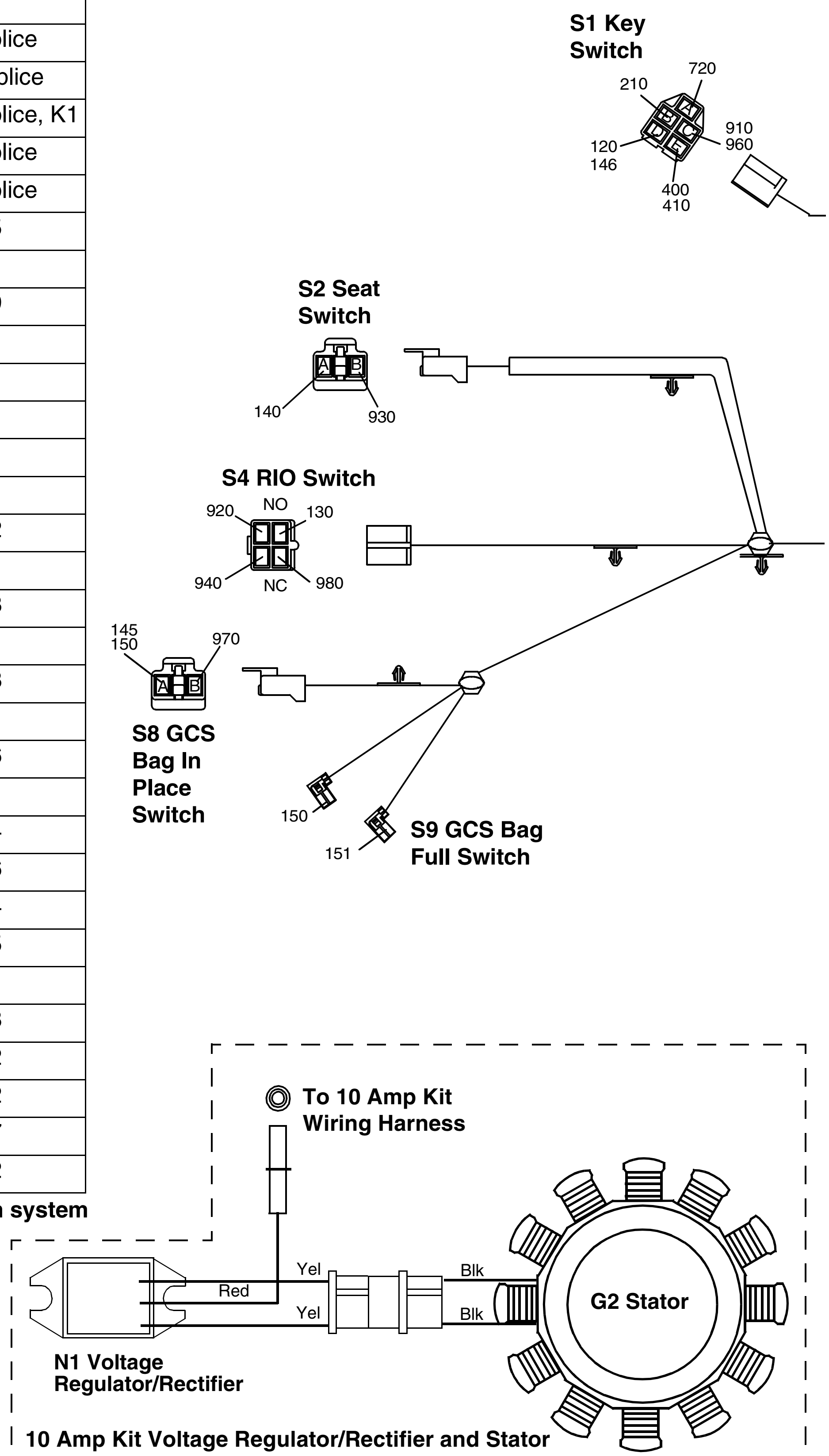



| | SE 3 - ENGINE IGNITION | SE 4 - CHARGING | SE 5 - HEADLIGHTS |
|---|---|---|---|

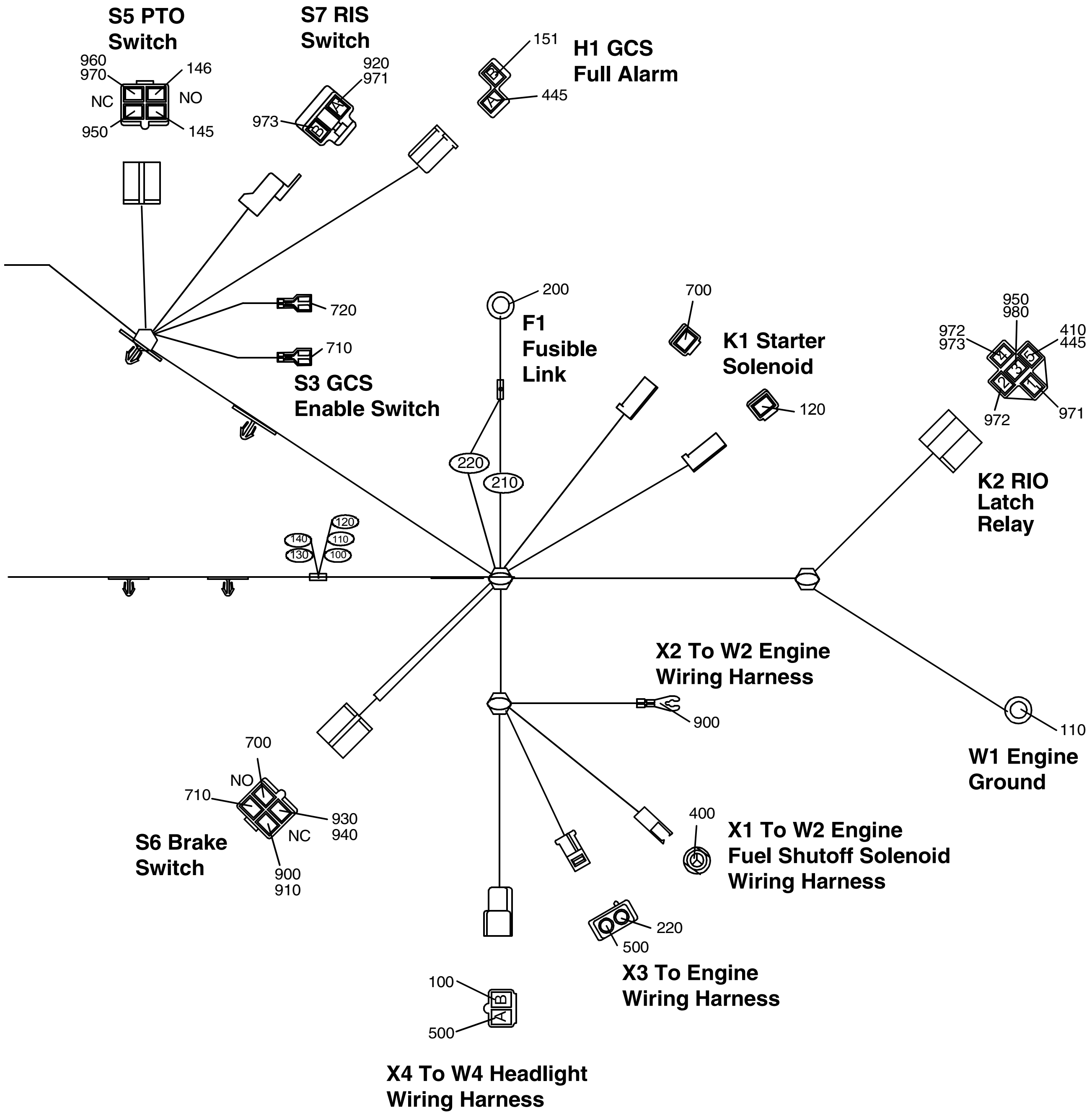
# W1 MAIN WIRING HARNESS—LTR166

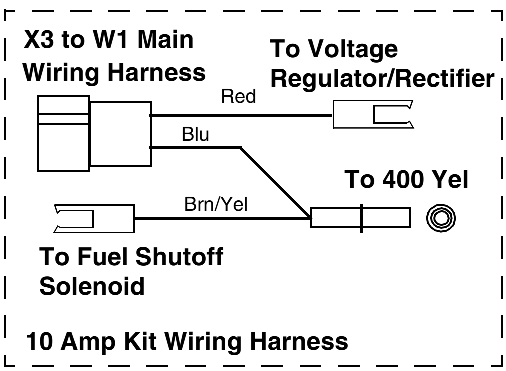
| Circuit No. | Wire Size | Color | Connection Point |
|---|---|---|---|
| 100 | 0.8 | Blk | X4, Splice |
| 110 | 2.0 | Blk | W1, Splice |
| 120 | 0.8 | Blk | S1, Splice, K1 |
| 130 | 0.8 | Blk | S4, Splice |
| 140 | 0.8 | Blk | S2, Splice |
| 145 | 0.8 | Blk | S8, S5 |
| 146 | 0.8 | Blk | S5, S1 |
| 150 | 0.8 | Blk | S8, S9 |
| 151 | 0.8 | Blk | S9, H1 |
| 200 | 0.5 | Fuse Link | K1, F1 |
| 210 | 0.8 | Red | F1, S1 |
| 220 | 1.0 | Red | F1, X3 |
| 400 | 0.8 | Yel | S1, X1 |
| 410 | 0.8 | Yel | S1, K2 |
| 445 | 0.8 | Yel | K2, H1 |
| 500 | 0.8 | Blu | X4, X3 |
| 700 | 0.8 | Pur | S6, K1 |
| 710 | 0.8 | Pur | S6, S3 |
| 720 | 0.8 | Pur | S3, S1 |
| 900 | 0.8 | Wht | X2, S6 |
| 910 | 0.8 | Wht | S6, S1 |
| 920 | 0.8 | Wht | S7, S4 |
| 930 | 0.8 | Wht | S2, S6 |
| 940 | 0.8 | Wht | S6, S4 |
| 950 | 0.8 | Wht | K2, S5 |
| 960 | 0.8 | Wht | S5, S1 |
| 970 | 0.8 | Wht | S5, S8 |
| 971 | 0.8 | Wht | S7, K2 |
| 972 | 0.8 | Wht | K2, K2 |
| 973 | 0.8 | Wht | K2, S7 |
| 980 | 0.8 | Wht | S4, K2 |

*** NOTE: GCS is Grass Collection system**

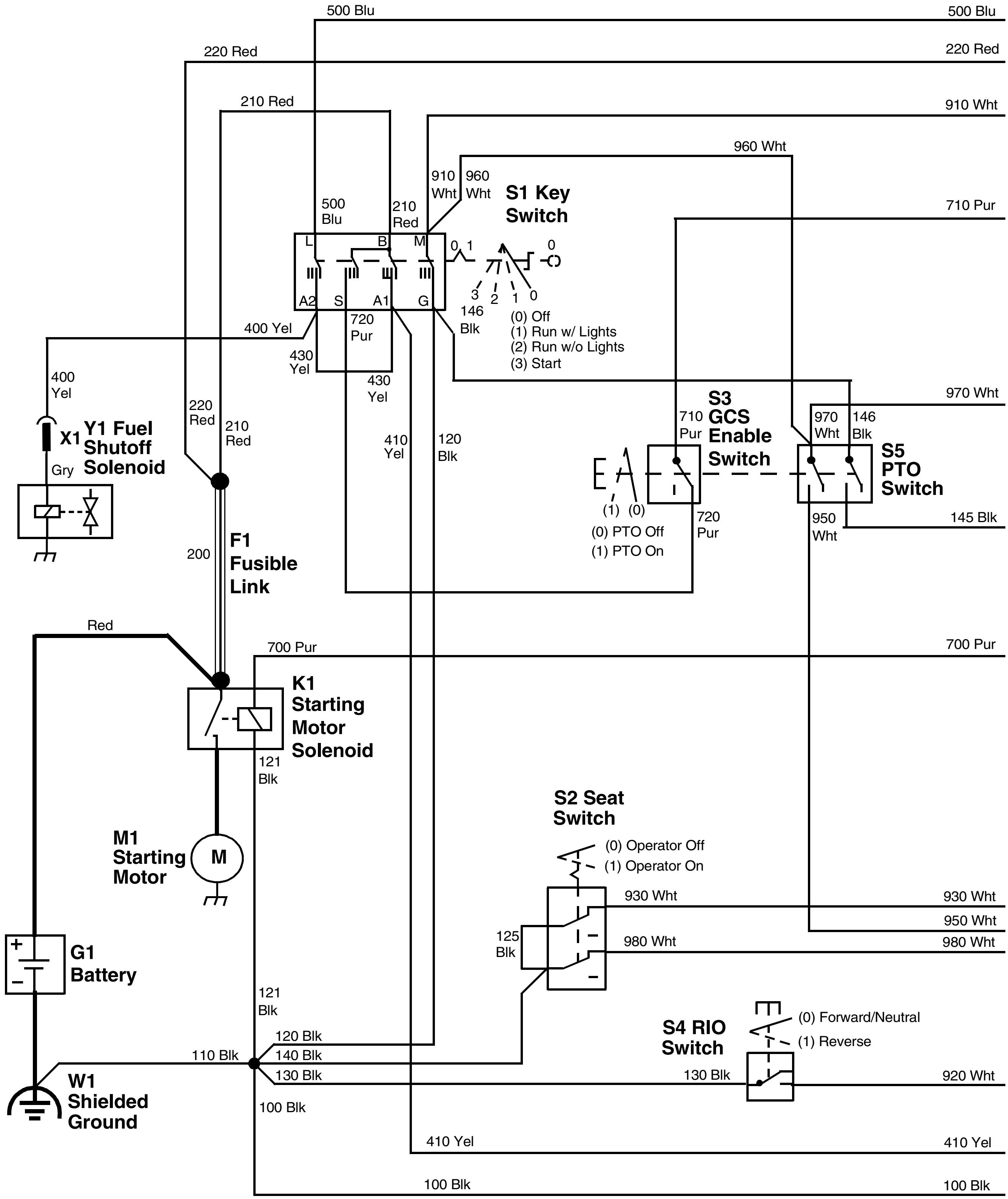


# W1 MAIN WIRING HARNESS—LTR166 (cont.)



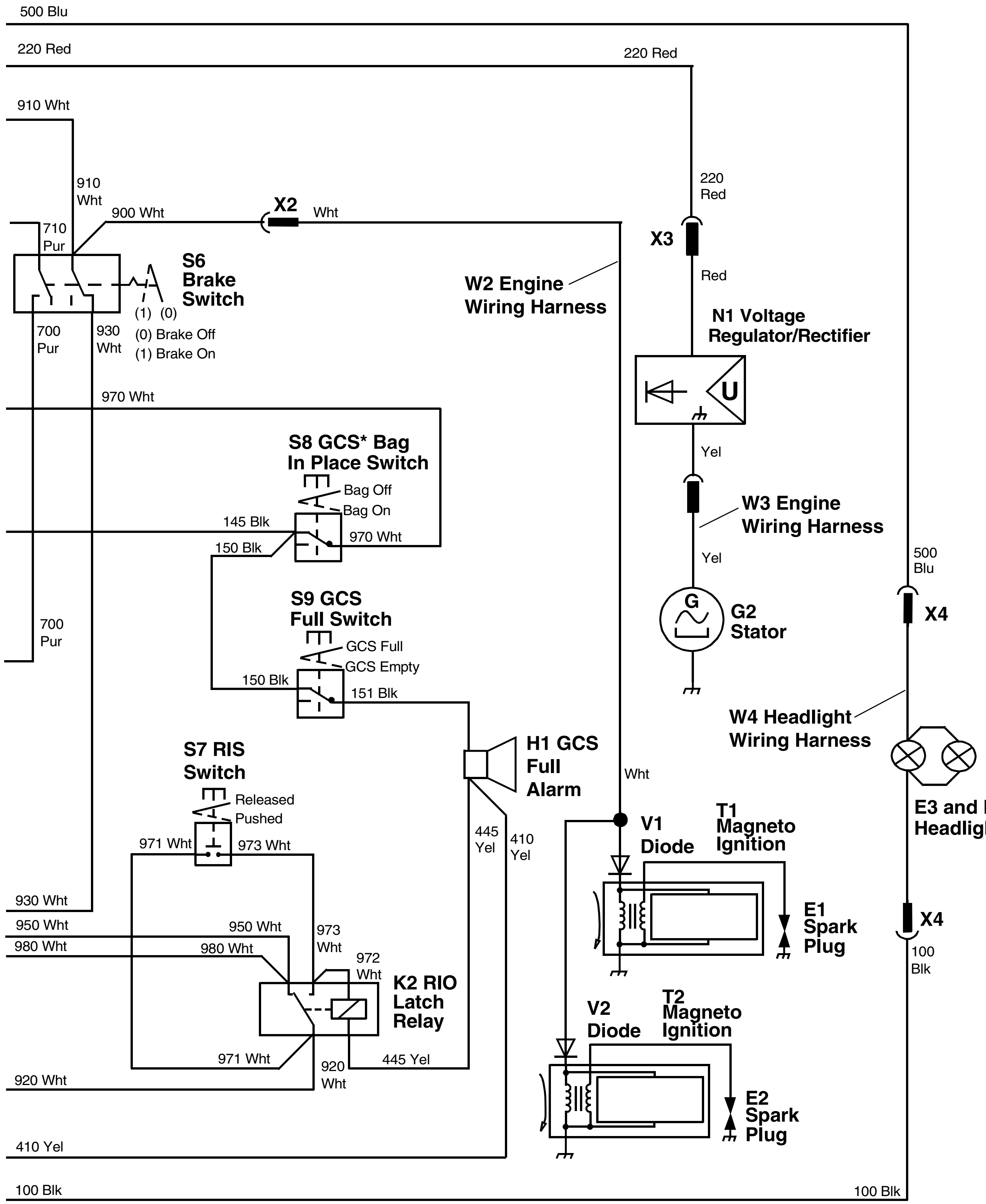
# ELECTRICAL SCHEMATIC—LTR166 w/4 POSITION KEY SWITCH




* NOTE: GCS is Grass Collection system

| SE 1 - STARTING | SE 2 - MAGNETO KILL & START INTERLOCK |
|---|---|

# ELECTRICAL SCHEMATIC—LTR166 w/4 POSITION KEY SWITCH (cont.)

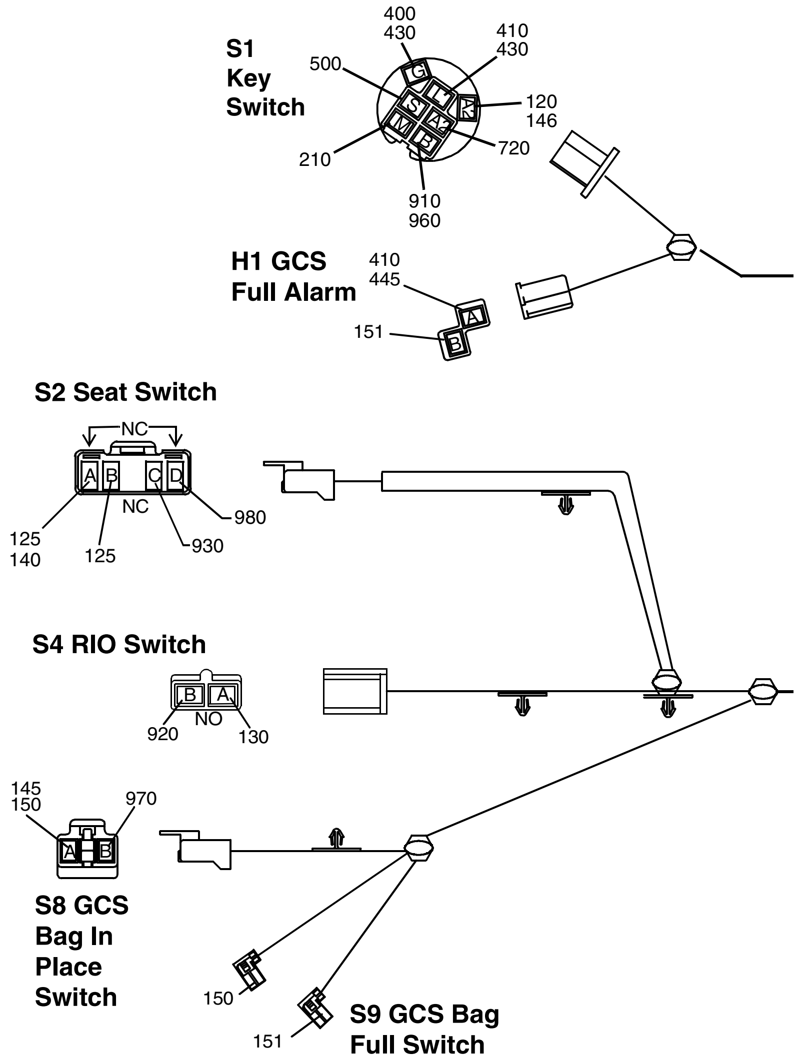



| | SE 3 - ENGINE IGNITION | SE 4 - CHARGING | SE 5 - HEADLIGHTS |
|---|---|---|---|

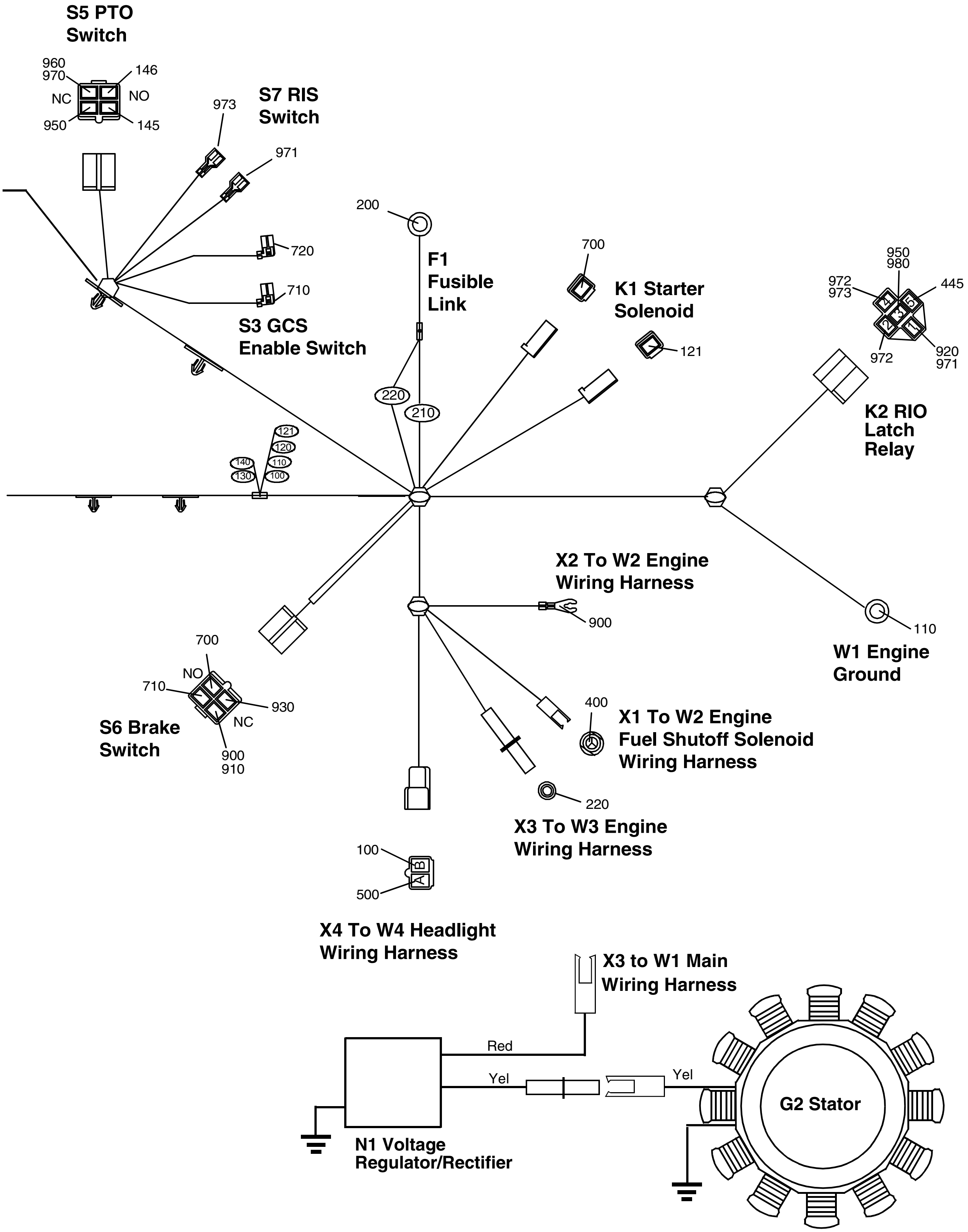
# W1 MAIN WIRING HARNESS—LTR166 w/4 POSITION KEY SWITCH

| Circuit No. | Wire Size | Color | Connection Point |
|---|---|---|---|
| 100 | 0.8 | Blk | X4, S1, Splice |
| 110 | 2.0 | Blk | W1, Splice |
| 120 | 0.8 | Blk | S1, Splice |
| 121 | 0.8 | Blk | K1, Splice |
| 125 | 0.8 | Blk | S2 |
| 130 | 0.8 | Blk | S4, Splice |
| 140 | 0.8 | Blk | S2, Splice |
| 145 | 0.8 | Blk | S8, S5 |
| 146 | 0.8 | Blk | S5, S1 |
| 150 | 0.8 | Blk | S8, S9 |
| 151 | 0.8 | Blk | S9, H1 |
| 200 | 0.5 | Fuse Link | F1 |
| 210 | 0.8 | Red | F1, S1 |
| 220 | 1.0 | Red | F1, X3 |
| 400 | 0.8 | Yel | S1, X1 |
| 410 | 0.8 | Yel | S1, H1 |
| 430 | 0.8 | Yel | S1 |
| 445 | 0.8 | Yel | K2, H1 |
| 500 | 0.8 | Blu | X4, S1 |
| 700 | 0.8 | Pur | S6, K1 |
| 710 | 0.8 | Pur | S6, S3 |
| 720 | 0.8 | Pur | S3, S1 |
| 900 | 0.8 | Wht | X2, S6 |
| 910 | 0.8 | Wht | S6, S1 |
| 920 | 0.8 | Wht | K2, S4 |
| 930 | 0.8 | Wht | S2, S6 |
| 950 | 0.8 | Wht | K2, S5 |
| 960 | 0.8 | Wht | S5, S1 |
| 970 | 0.8 | Wht | S5, S8 |
| 971 | 0.8 | Wht | S7, K2 |
| 972 | 0.8 | Wht | K2, K2 |
| 973 | 0.8 | Wht | K2, S7 |
| 980 | 0.8 | Wht | S2, K2 |

*** NOTE: GCS is Grass Collection System**



# W1 MAIN WIRING HARNESS—LTR166 w/4 POSITION KEY SWITCH (cont.)



# SCHEMATIC AND WIRING HARNESS LEGEND—LTR180

E1—Spark Plug (SE4, W2)

E2—Spark Plug (SE4, W2)

E3—RH Headlight (SE5, W4)

E4—LH Headlight (SE5, W4)

F1—Fusible Link (SE1, W1)

G1—Battery (SE1, W1)

G2—Stator (SE4, W3)

H1—Grass Collection System (GCS) Full Alarm (SE3, W1)

K1—Starting Motor Solenoid (SE1, W1)

K2—RIO Latch Relay (SE2, W1)

M1—Starting Motor (SE1, W1)

P1—Hour Meter (SE2, W1)

S1—Key Switch (SE1, W1)

S2—Seat Switch (SE2, W1)

S3—GCS Enable Switch (SE2, W1)

S4—RIO Switch (SE2, W1)

S5—PTO Switch (SE2, W1)

S6—Brake Switch (SE2, W1)

S7—RIS Switch (SE2, W1)

S8—GCS Bag In Place Switch (SE2, W1)

S9—GCS Bag Full Switch (SE2, W1)

T1—Magneto Ignition (SE3, W2)

T2—Magneto Ignition (SE3, W2)

V1—Diode (SE3, W2)

V2—Diode (SE3, W2)

W1—Shielded Ground (SE1, W1)

Y1—Fuel Shutoff Solenoid (SE3, W2)

**CONNECTORS:**

X1—W1 Main Wiring Harness to Y1 Fuel Shutoff Solenoid (SE3, W1)

X2—W1 Main Wiring Harness to W2 Engine Wiring Harness (SE3, W1)

X3—W1 Main Wiring Harness to W3 Engine Wiring Harness (SE4, W1)

X4—W1 Main Wiring Harness to W4 Headlight Wiring Harness (SE5, W1)

**WIRING HARNESSES:**

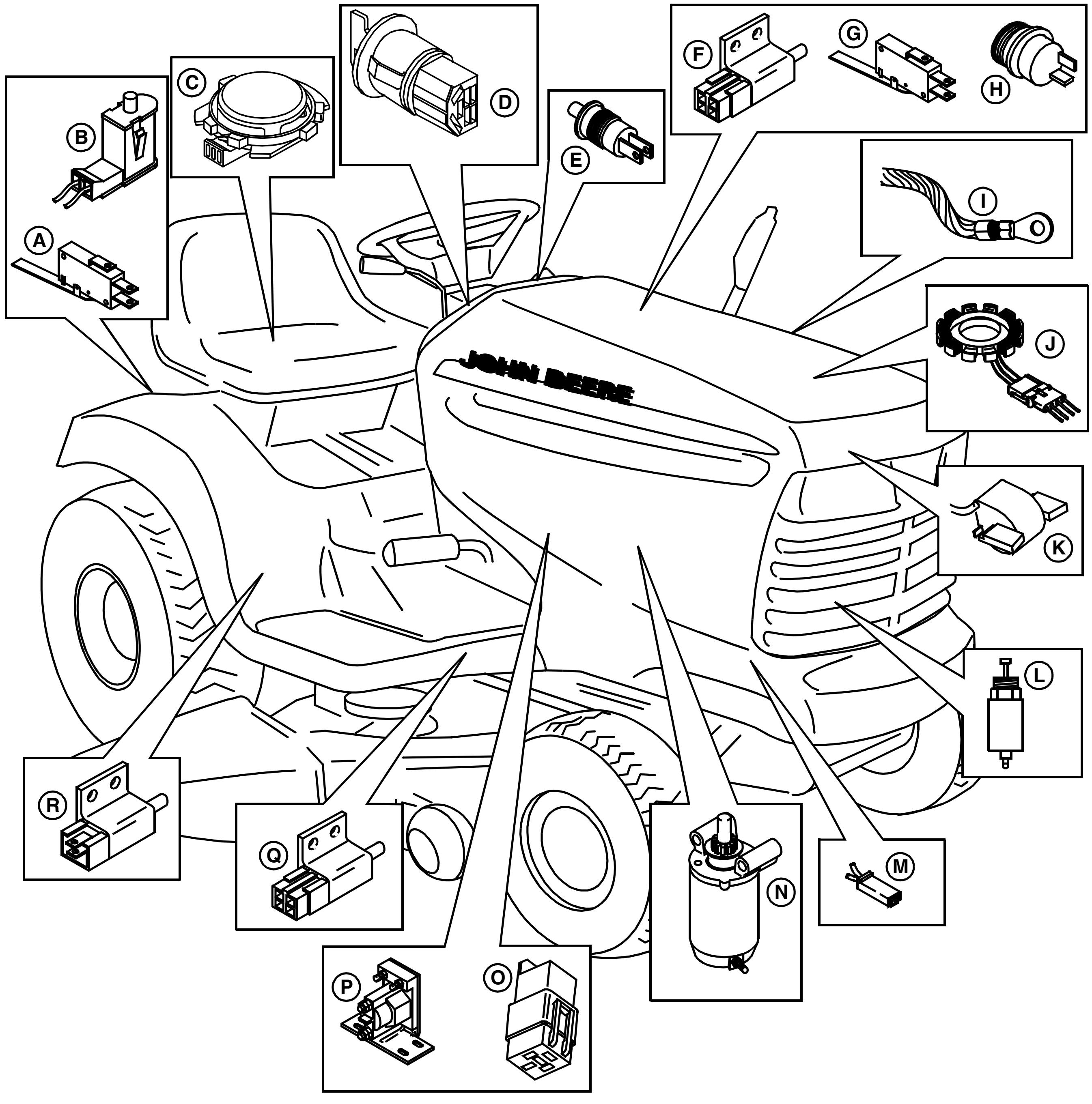
W1—Main Wiring Harness

W2—B&S Engine Wiring Harness

W3—B&S Engine Wiring Harness

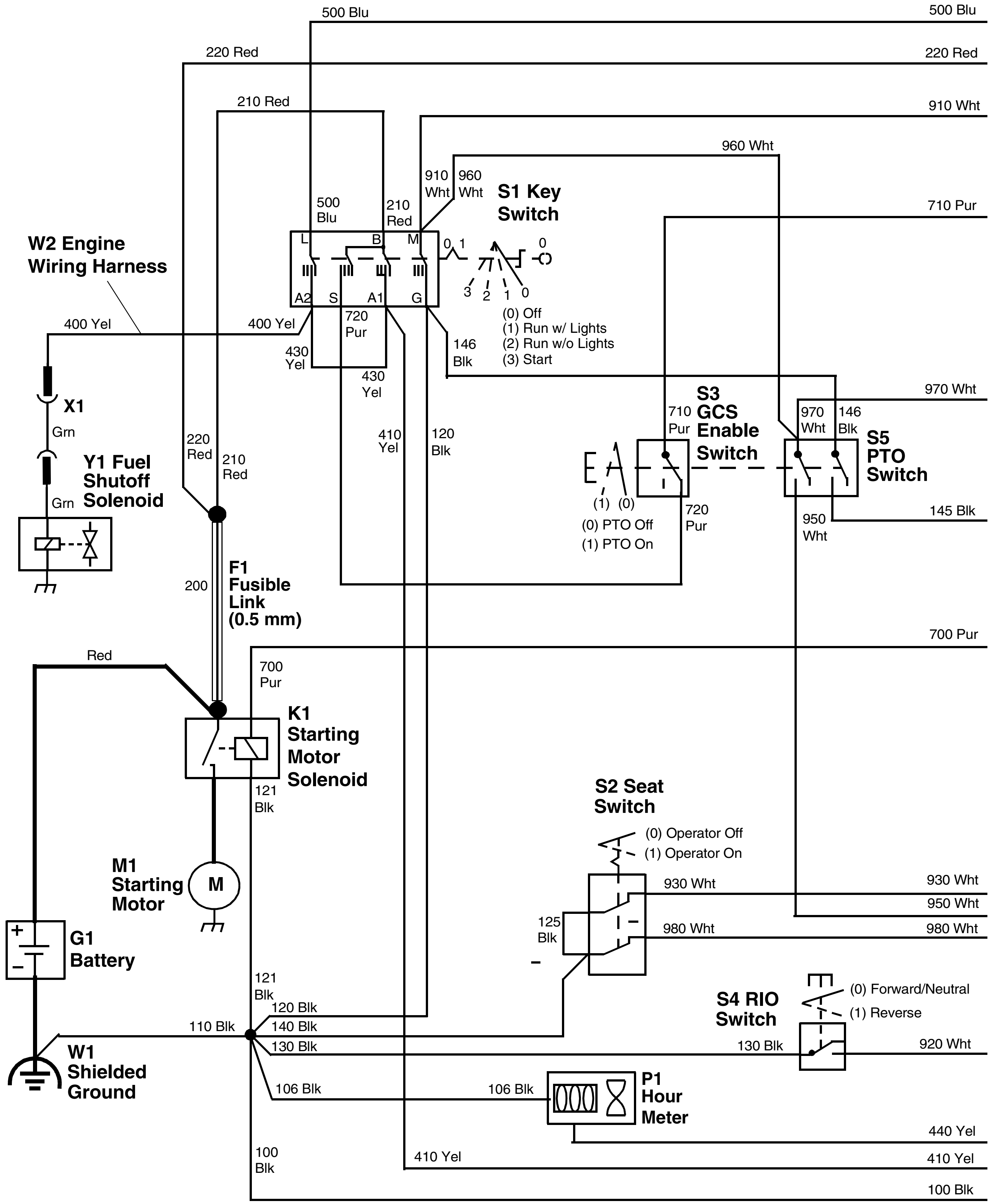
W4—Headlight Wiring Harness

# COMPONENT LOCATION—LTR180




| | | | |
|---|---|---|---|
| A. S9 Bag Full Switch | F. S5 PTO Switch | K. T1 & T2 Magneto Ignition | P. K1 Starting Motor Relay |
| B. S8 Bag in Place Switch | G. S3 GCS Enable Switch | L. Y1 Fuel Shutoff Solenoid | Q. S6 Brake Switch |
| C. S2 Seat Switch | H. H1 GCS Full Alarm | M. X4 Headlight Connector | R. S4 RIO Switch |
| D. S1 Key Switch | I. W1 Shielded Ground | N. M1 Starting Motor | |
| E. S7 RIS Switch | J. G2 Stator | O. K2 RIO Latch Relay | |

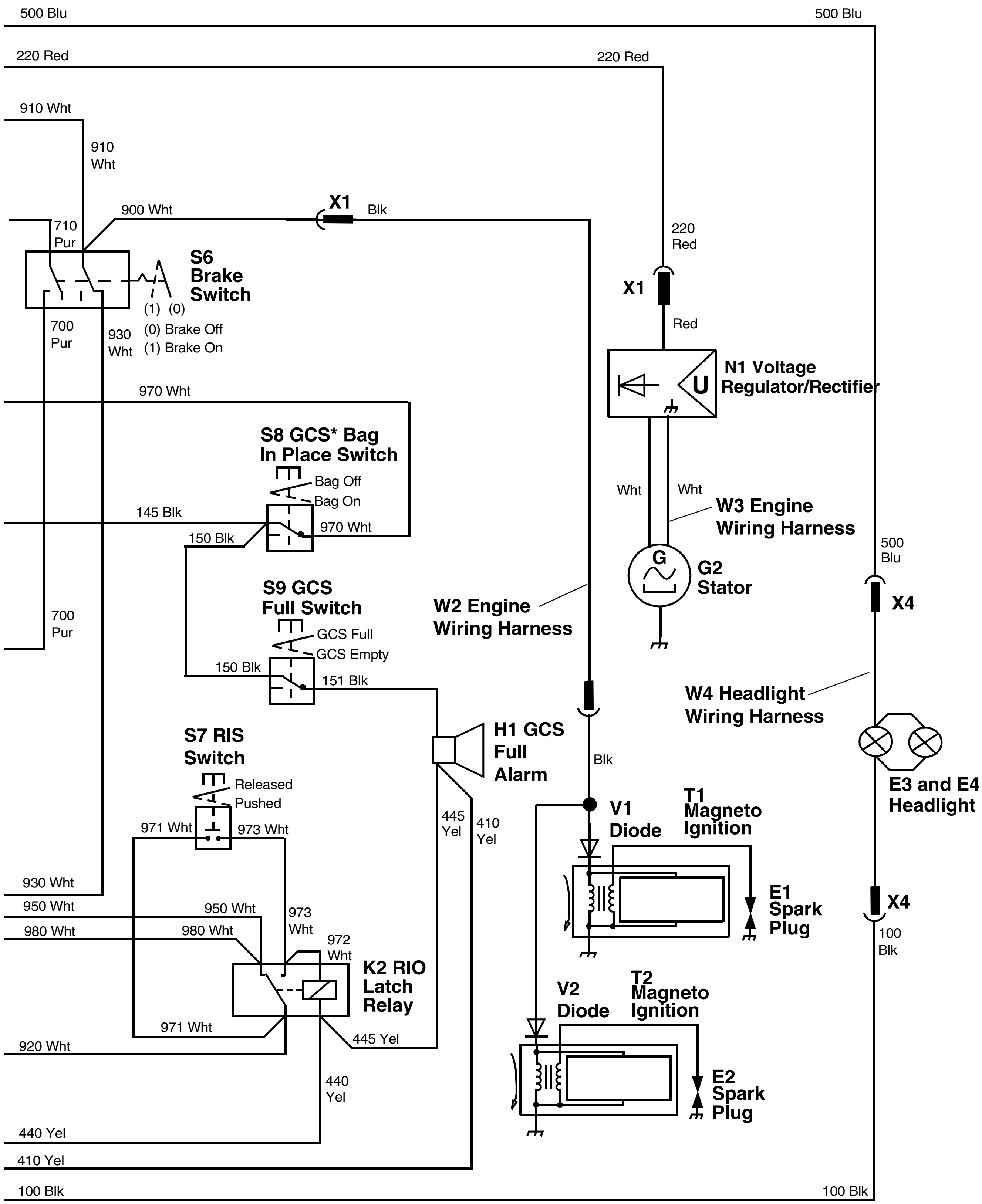
# ELECTRICAL SCHEMATIC—LTR180




| SE 1 - STARTING | SE 2 - MAGNETO KILL & START INTERLOCK |
|---|---|

*** NOTE: GCS is Grass Collection system**

# ELECTRICAL SCHEMATIC—LTR180 (cont.)

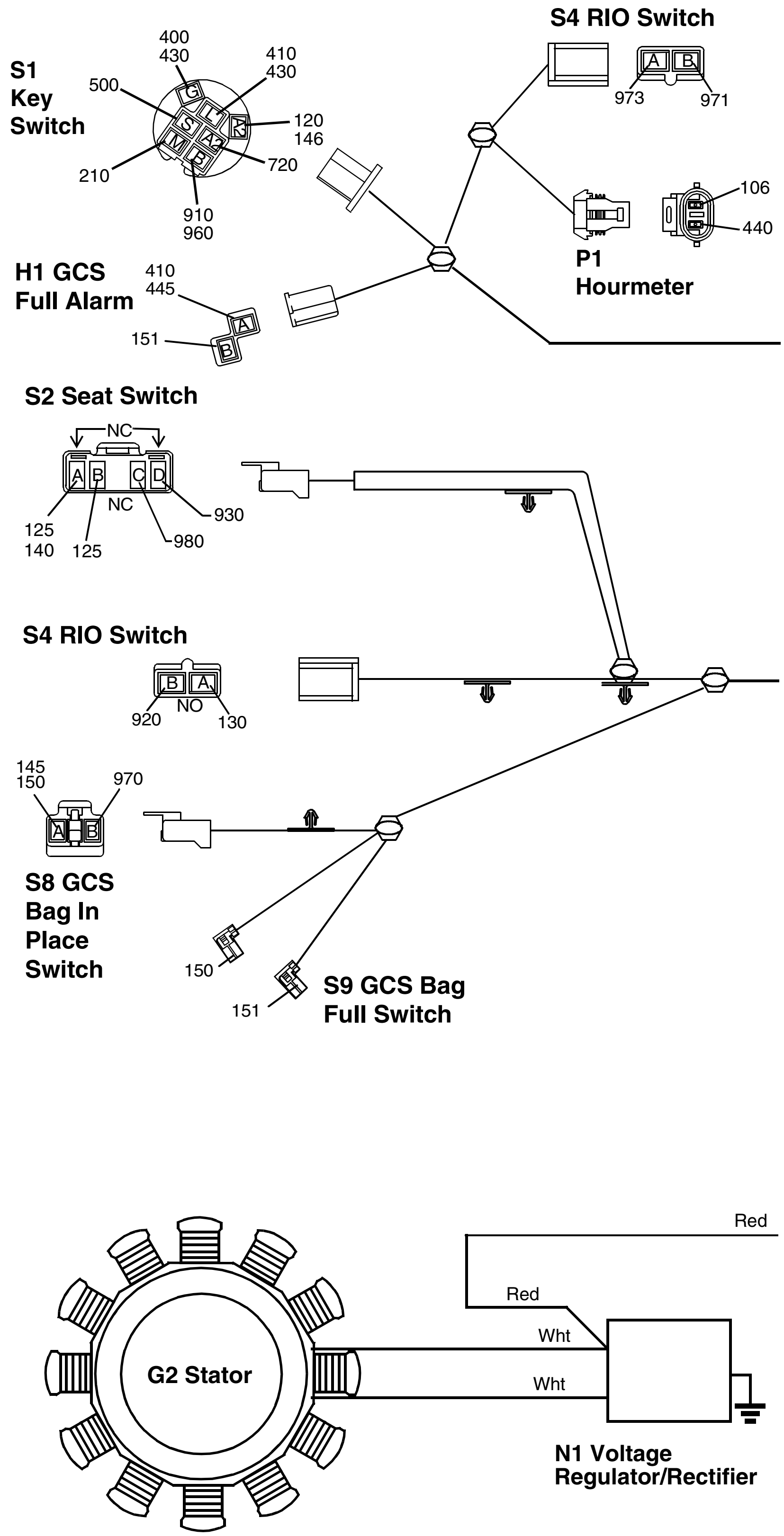



| | SE 3 - ENGINE IGNITION | SE 4 - CHARGING | SE 5 - HEADLIGHTS |
|---|---|---|---|

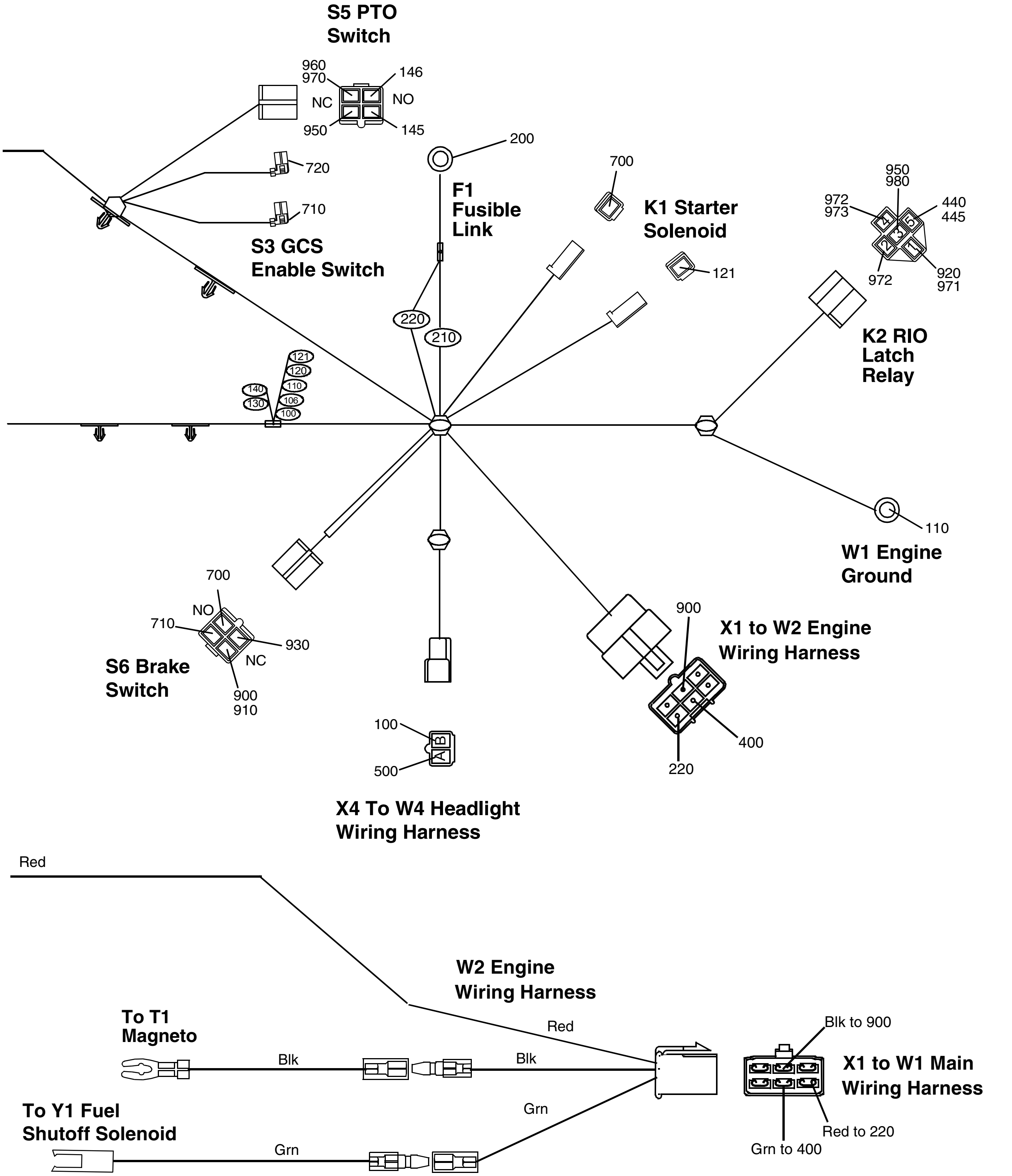
# W1 MAIN WIRING HARNESS—LTR180

| Circuit No. | Wire Size | Color | Connection Point |
|---|---|---|---|
| 100 | 0.8 | Blk | X4, S1, Splice |
| 106 | 0.8 | Blk | P1, Splice |
| 110 | 2.0 | Blk | W1, Splice |
| 120 | 0.8 | Blk | S1, Splice |
| 121 | 0.8 | Blk | K1, Splice |
| 125 | 0.8 | Blk | S2 |
| 130 | 0.8 | Blk | S4, Splice |
| 140 | 0.8 | Blk | S2, Splice |
| 145 | 0.8 | Blk | S8, S5 |
| 146 | 0.8 | Blk | S5, S1 |
| 150 | 0.8 | Blk | S8, S9 |
| 151 | 0.8 | Blk | S9, H1 |
| 200 | 0.5 | Fuse Link | F1 |
| 210 | 0.8 | Red | F1, S1 |
| 220 | 1.0 | Red | F1, X1 |
| 400 | 0.8 | Yel | S1, X1 |
| 410 | 0.8 | Yel | S1, H1 |
| 430 | 0.8 | Yel | S1 |
| 440 | 0.8 | Yel | K2, P1 |
| 445 | 0.8 | Yel | K2, H1 |
| 500 | 0.8 | Blu | X4, S1 |
| 700 | 0.8 | Pur | S6, K1 |
| 710 | 0.8 | Pur | S6, S3 |
| 720 | 0.8 | Pur | S3, S1 |
| 900 | 0.8 | Wht | X1, S6 |
| 910 | 0.8 | Wht | S6, S1 |
| 920 | 0.8 | Wht | K2, S4 |
| 930 | 0.8 | Wht | S2, S6 |
| 950 | 0.8 | Wht | K2, S5 |
| 960 | 0.8 | Wht | S5, S1 |
| 970 | 0.8 | Wht | S5, S8 |
| 971 | 0.8 | Wht | S7, K2 |
| 972 | 0.8 | Wht | K2, K2 |
| 973 | 0.8 | Wht | K2, S7 |
| 980 | 0.8 | Wht | S2, K2 |

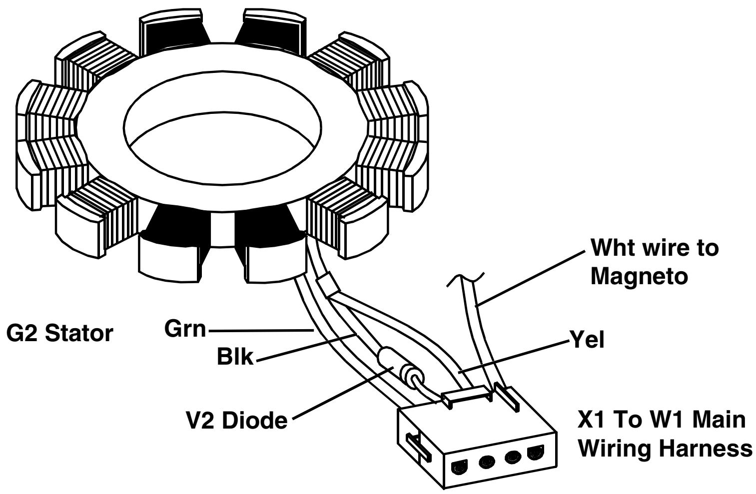
*** NOTE: GCS is Grass Collection System**



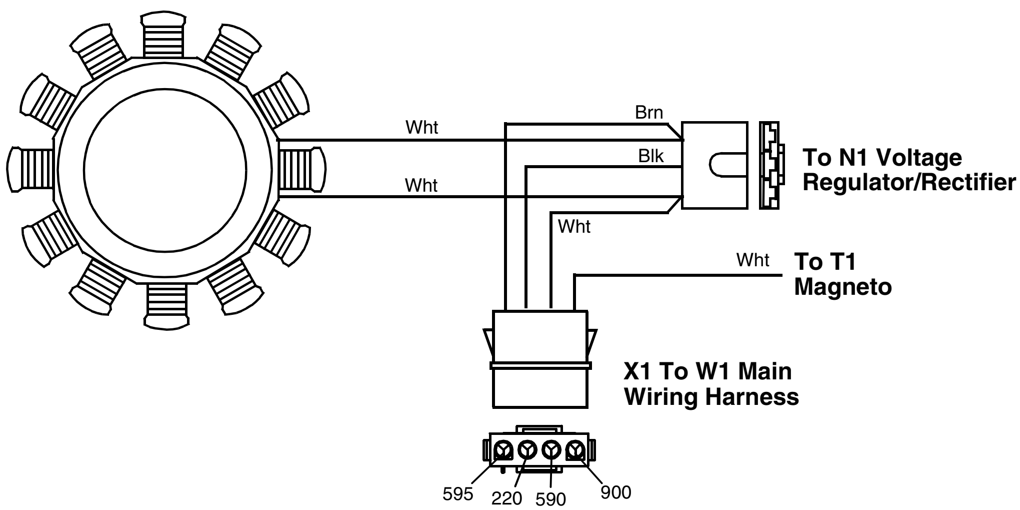
# W1 MAIN WIRING HARNESS—LTR180 (cont.)



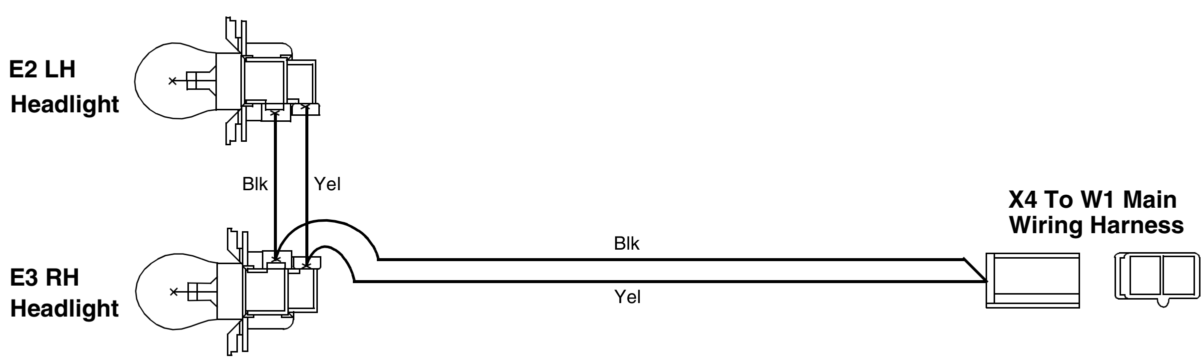
## W2 ENGINE WIRING HARNESS—LTR155 w/3 AMP CHARGER



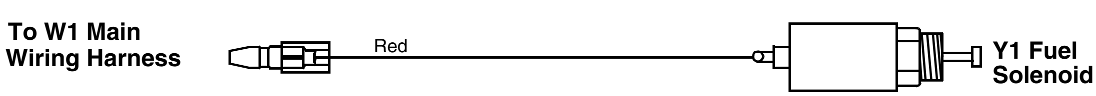

## W2 ENGINE WIRING HARNESS—LTR155 w/15 AMP CHARGER



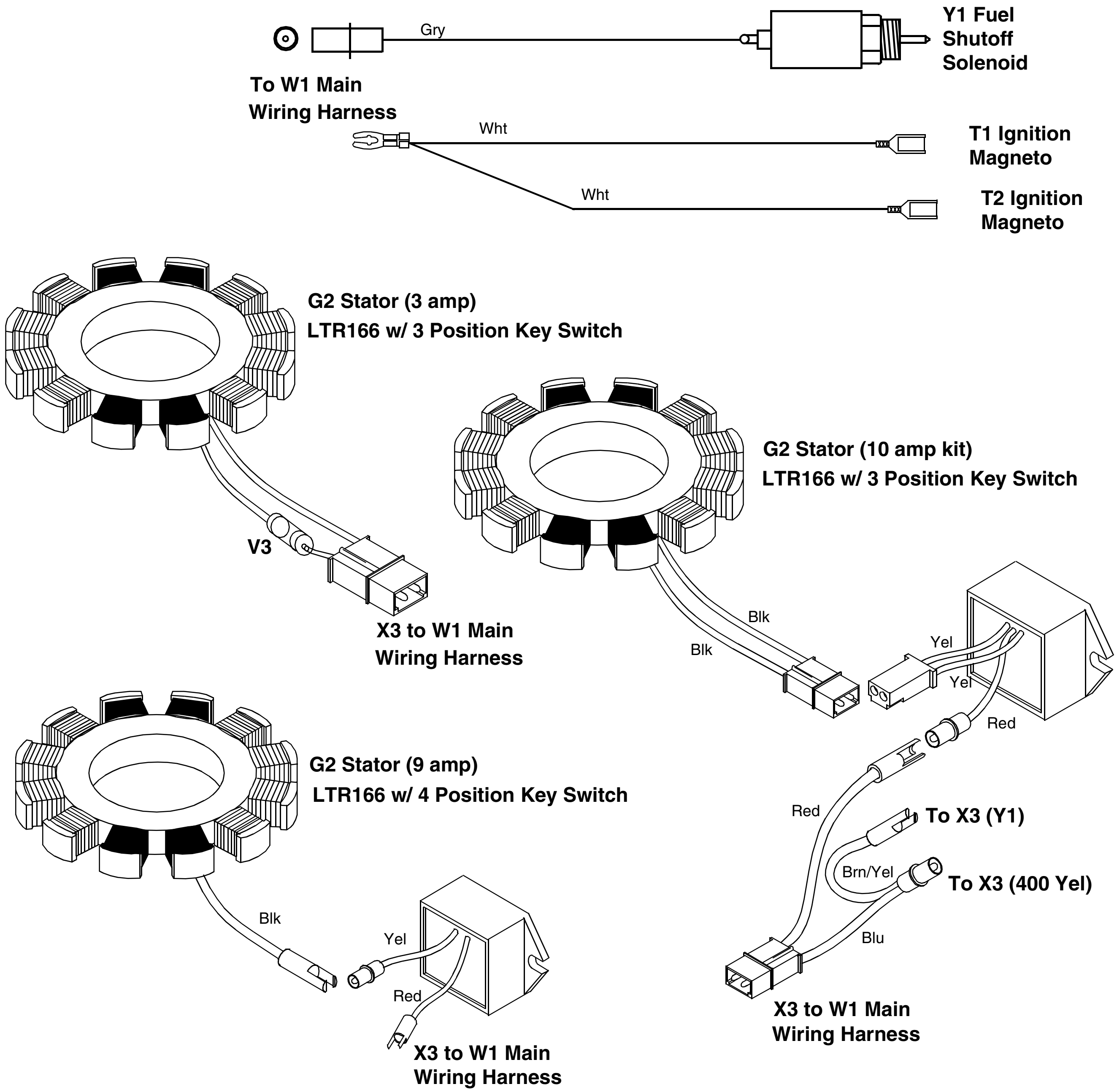

## W3 HEADLIGHT WIRING HARNESS—LTR155



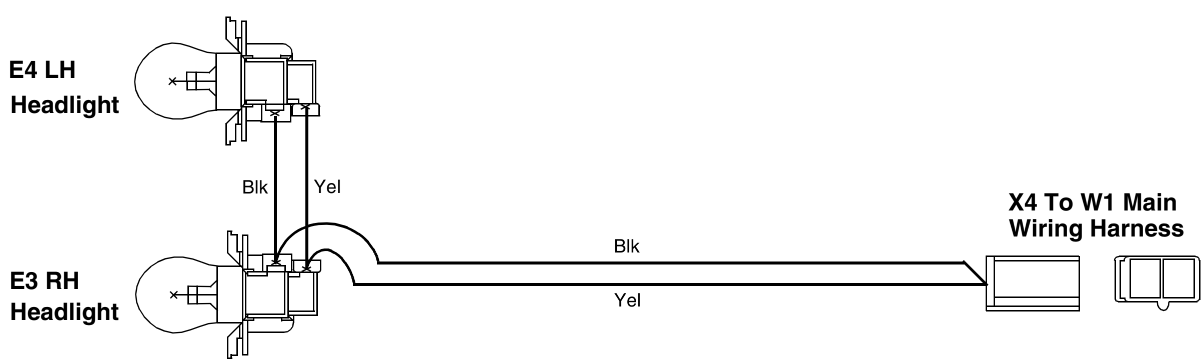

## Y1 FUEL SHUTOFF SOLENOID—LTR155 (optional)



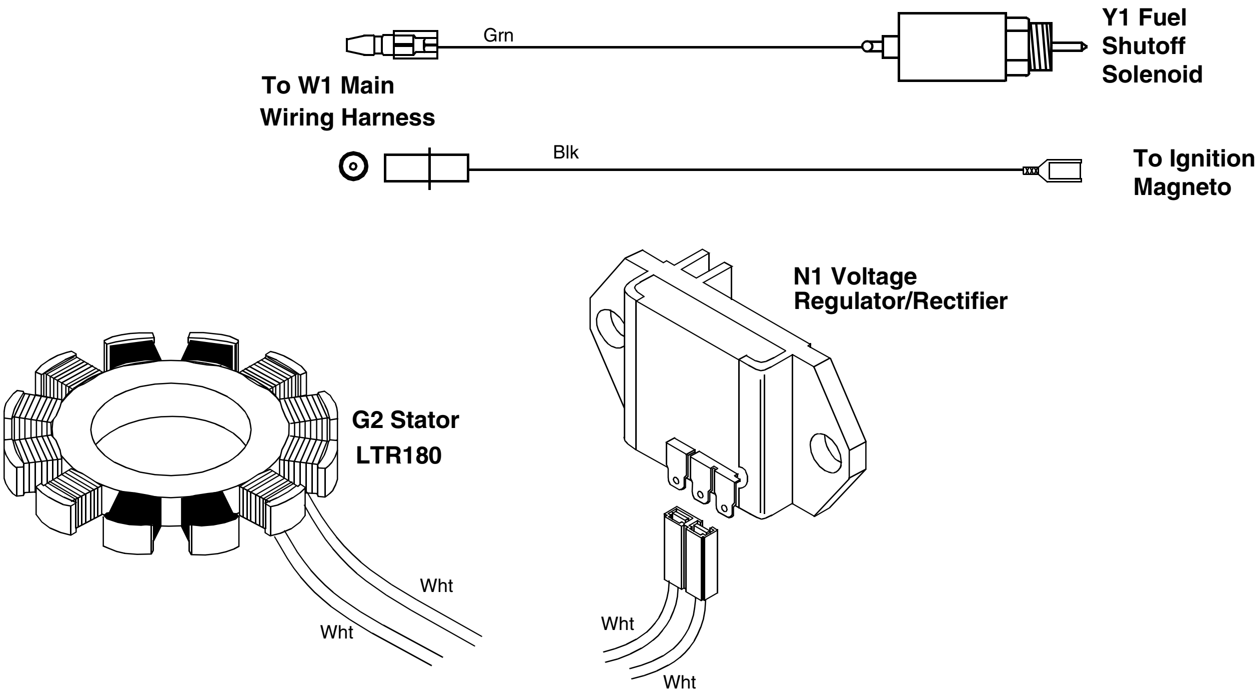
# W2 & W3 ENGINE WIRING HARNESSES—LTR166



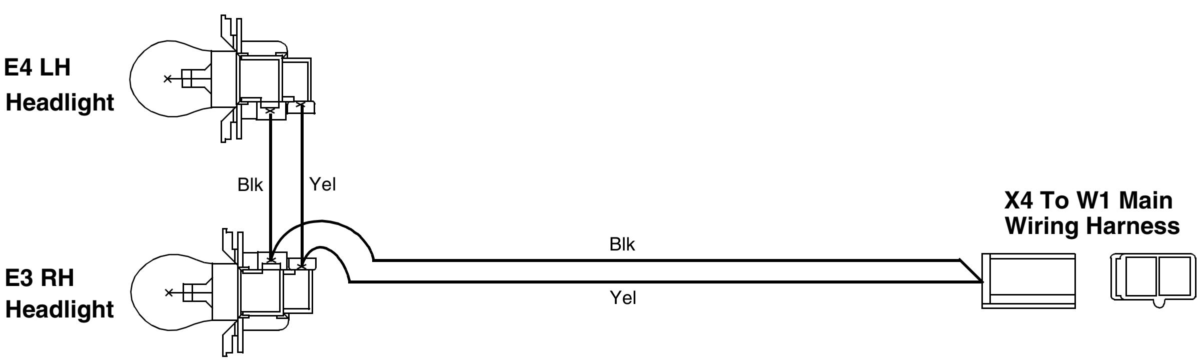

# W4 HEADLIGHT WIRING HARNESS—LTR166



# W2 & W3 ENGINE WIRING HARNESSES—LTR180




# W4 HEADLIGHT WIRING HARNESS—LTR180



# TROUBLESHOOTING

This chart will give possible solutions to a problem or refer you to the probable circuit diagnostic sequence.

| Problem or Symptom / Check or Solution | Battery will not maintain charge | Slow cranking speed | Engine will not crank | Engine cranks but will not start | Headlights not working | Engine will not shut off | Engine sputters while mowing | Engine kills when PTO is engaged | Engine stalls in reverse (PTO OFF) |
|---|---|---|---|---|---|---|---|---|---|
| **Test battery** | ● | ● | ● | | | | | | |
| **Test charging system** | ● | | | | ● | | | | |
| **Loose/corroded/shorted connection** | ● | ● | ● | ● | ● | ● | | | |
| **Test starting motor solenoid** | | | ● | | | | | | |
| **Test starting motor** | | ● | ● | | | | | | |
| **Test shunt relay (LTR155)** | ● | ● | ● | ● | ● | | | | |
| **Test PTO switch/adjustment** | | | ● | | | ● | | | |
| **Test brake switch/adjustment** | | | ● | | | ● | | | |
| **Test F1 fuselink** | | | ● | | | | | | |
| **Test seat switch/adjustment** | | | | ● | | ● | | | |
| **Test seat relay K3 (LTR155)** | | | | ● | | ● | | | |
| **See Engine Troubleshooting** | ● | ● | ● | ● | | | | | |
| **Magneto kill circuit grounded** | | | | ● | | | | | |
| **Magneto kill circuit open** | | | | | | ● | | | |
| **Ignition module defective** | | | | ● | | ● | | | |
| **Spark plug or ignition wire defective** | | | | ● | | | | | |
| **Key switch defective** | | | ● | ● | | ● | | | |
| **Lighting coil circuit defective** | | | | | ● | | | | |
| **Bulbs burned out** | | | | | ● | | | | |
| **Test/adjust bag in place switch** | | | | | | | ● | ● | |
| **Test/replace RIO switch** | | | | | | | | | ● |

# THEORY OF OPERATION AND DIAGNOSIS

## POWER CIRCUIT OPERATION—LTR155 w/3 AMP CHARGER

**Function:**

Provides unswitched power to the primary components and switched power to secondary components whenever the battery is connected.

**Operating Conditions, Unswitched Circuits:**

Voltage must be present at the following components with the key switch in the OFF position:

- Battery Positive Terminal
- Starting Motor Solenoid Positive Contact Stud
- Key Switch
- Red Wire at Engine Wiring Harness Connector

The positive battery cable connects the battery to the starting motor solenoid bolt.

The ground cable connection is equally important as the positive cable. Proper starting operation depends on these cables and connections to carry the high current for its operation.

The fusible link and 210 Red wire provide unswitched voltage to the key switch.

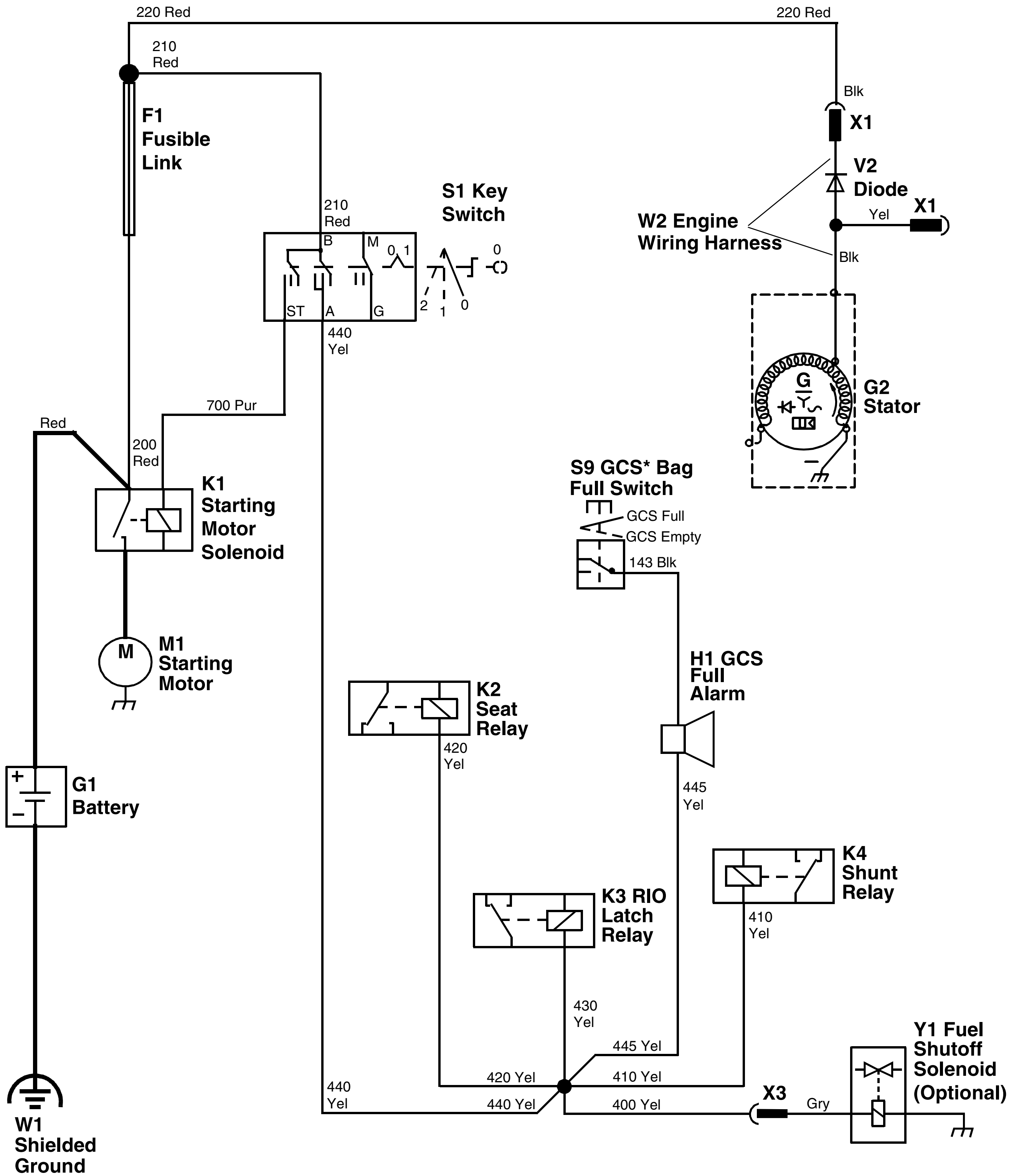
The fusible link and 220 Red wire provide unswitched voltage to the engine wiring harness connector.

**Operating Conditions, Switched Circuits:**

Placing the key switch in the RUN position provides voltage from 210 Red wire through the key switch to the 440, 400, 410, 420, 430, and 445 Yel wires. These wires supply input signal voltage to the three system interlock relays, the GCS full alarm and the fuel shutoff solenoid (if equipped). The relays will not energize until another switch(es) is actuated.

Placing the key switch in the START position (See “CRANKING CIRCUIT OPERATION—LTR155 w/3 AMP CHARGER” on page 60) provides voltage to the starting motor solenoid coil through the key switch contacts to the 700 Pur wire. The ground for this circuit is provided for the starting motor solenoid by the 120 Blk wire, GCS enable switch contacts (normally closed), 150 Blk wire, brake switch contacts (normally open), 160 and 135 Blk wires.

# POWER CIRCUIT SCHEMATIC—LTR155 w/3 AMP CHARGER




* Grass Collection System (GCS)

# POWER CIRCUIT DIAGNOSIS—LTR155 w/3 AMP CHARGER

**Test Conditions:**

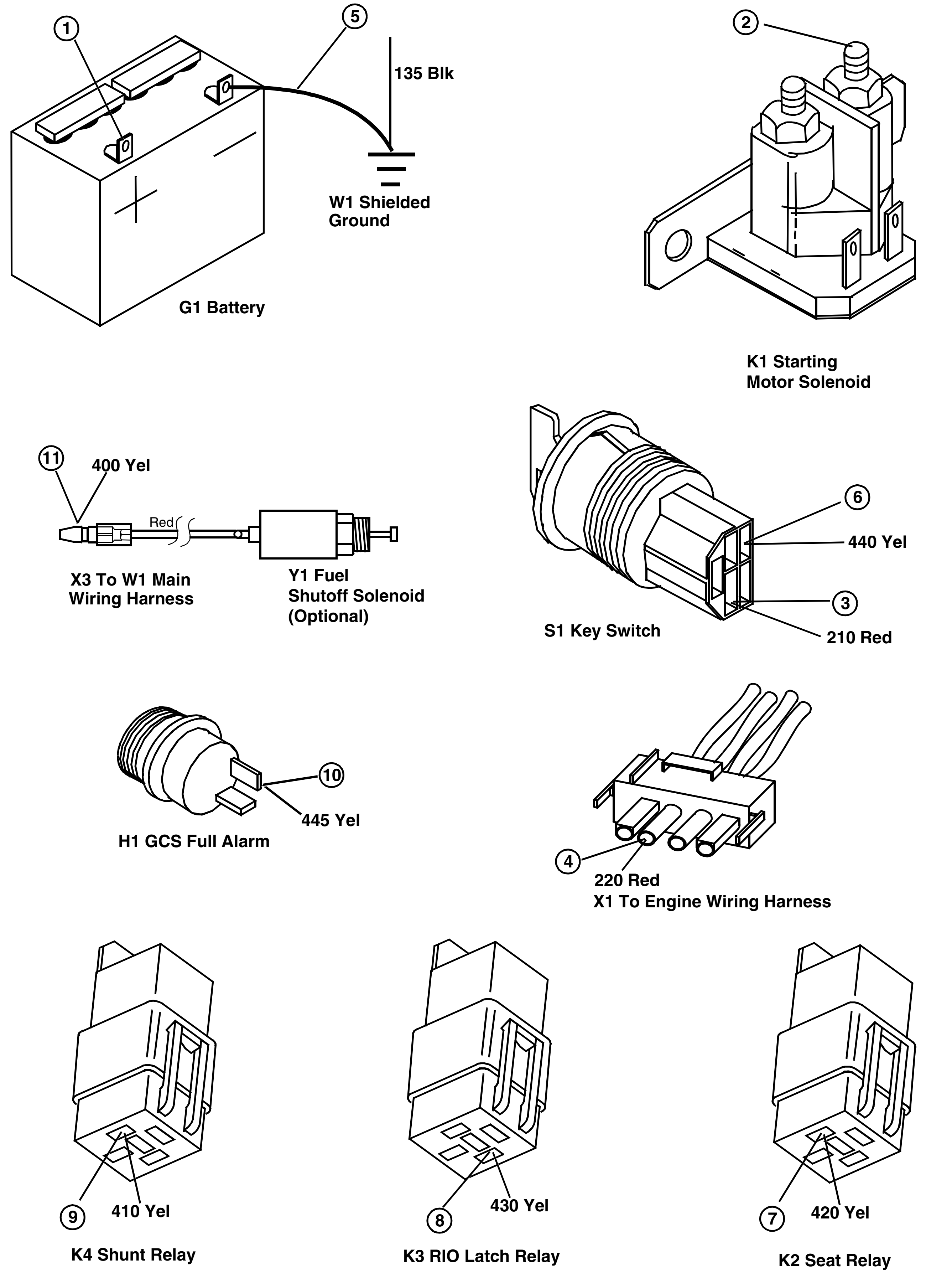
- Key switch in OFF position

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Positive and negative battery post | 12.4 volts or above | Clean battery terminals and test battery. |
| 2. Starting motor solenoid stud terminal | Battery voltage | Clean and check battery cable and tighten connections. |
| 3. Key switch | Battery voltage | Check F1 fusible link, 210 Red wire connections. Replace fuseible link. |
| 4. Engine connector | Battery voltage | Check wire 220 Red wire and connections. |
| 5. Ground cable frame connection to negative battery terminal | Less than 0.1 ohm resistance | Check harness wires and negative cable connections to frame, removing any paint, rust or corrosion. Clean negative battery connection to battery post. |

**Test Conditions:**

- Key switch in RUN position
- Engine OFF

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 6. Key switch | Battery voltage | Replace key switch |
| 7. Seat Relay | Battery voltage | Check 420 Yel wire and connections |
| 8. RIO Latch Relay | Battery voltage | Check 430 Yel wire and connections |
| 9. Shunt Relay | Battery voltage | Check 410 Yel wire and connections |
| 10. Grass Collection System (GCS) Full Alarm | Battery voltage | Check 445 Yel wire and connections |
| 11. Fuel Shutoff Solenoid | Battery Voltage | Check 400 Yel wire and connections |


1
5
135 Blk
W1 Shielded Ground
G1 Battery
2
K1 Starting Motor Solenoid
11
400 Yel
Red
X3 To W1 Main Wiring Harness
Y1 Fuel Shutoff Solenoid (Optional)
6
440 Yel
3
210 Red
S1 Key Switch
10
445 Yel
H1 GCS Full Alarm
4
220 Red
X1 To Engine Wiring Harness
9
410 Yel
K4 Shunt Relay
8
430 Yel
K3 RIO Latch Relay
7
420 Yel
K2 Seat Relay

# POWER CIRCUIT OPERATION—LTR155 w/15 AMP CHARGER

**Function:**

Provides unswitched power to the primary components and switched power to secondary components whenever the battery is connected.

**Operating Conditions, Unswitched Circuits:**

Voltage must be present at the following components with the key switch in the OFF position:

- Battery Positive Terminal
- Starting Motor Solenoid Positive Contact Stud
- Key Switch
- Red Wire at Engine Wiring Harness Connector

The positive battery cable connects the battery to the starting motor solenoid bolt.

The ground cable connection is equally important as the positive cable. Proper starting operation depends on these cables and connections to carry the high current for its operation.

The fusible link and 210 Red wire provide unswitched voltage to the key switch.

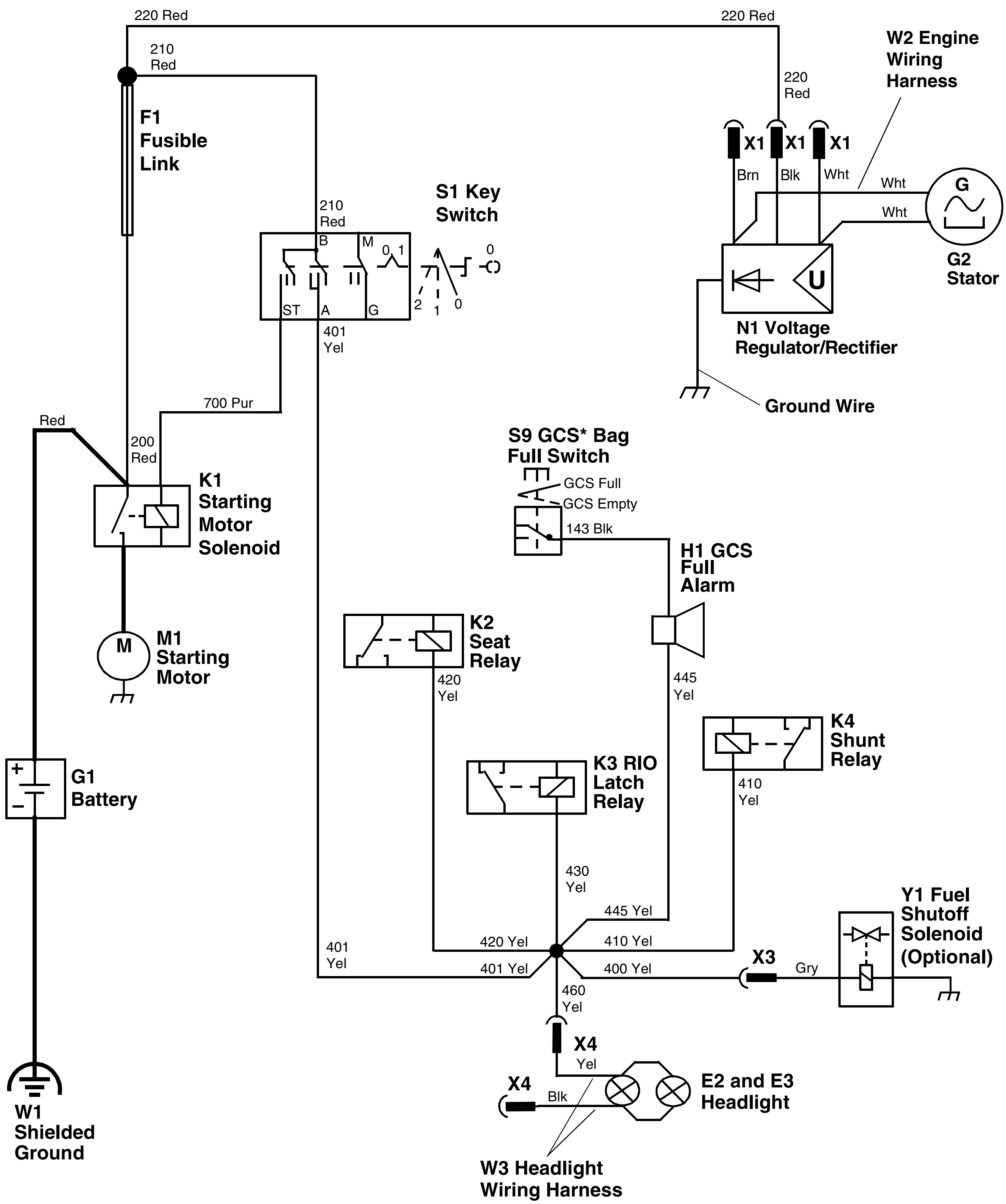
The fusible link and 220 Red wire provide unswitched voltage to the engine wiring harness connector.

**Operating Conditions, Switched Circuits:**

Placing the key switch in the RUN position provides voltage from 210 Red wire through the key switch to the 400, 401, 410, 420, 430, 445 and 460 Yel wires. These wires supply input signal voltage to the three system interlock relays, the headlights, the GCS full alarm and the fuel shutoff solenoid (if equipped). The relays will not energize until another switch(es) is actuated.

Placing the key switch in the START position (See "CRANKING CIRCUIT OPERATION—LTR155 w/15 AMP CHARGER" on page 64) provides voltage to the starting motor solenoid coil through the key switch contacts to the 700 Pur wire. The ground for this circuit is provided for the starting motor solenoid by the 120 Blk wire, GCS enable switch contacts (normally closed), 150 Blk wire, brake switch contacts (normally open), 170 and 110 Blk wires.

# POWER CIRCUIT SCHEMATIC—LTR155 w/15 AMP CHARGER




* Grass Collection System (GCS)

# POWER CIRCUIT DIAGNOSIS—LTR155 w/15 AMP CHARGER

**Test Conditions:**

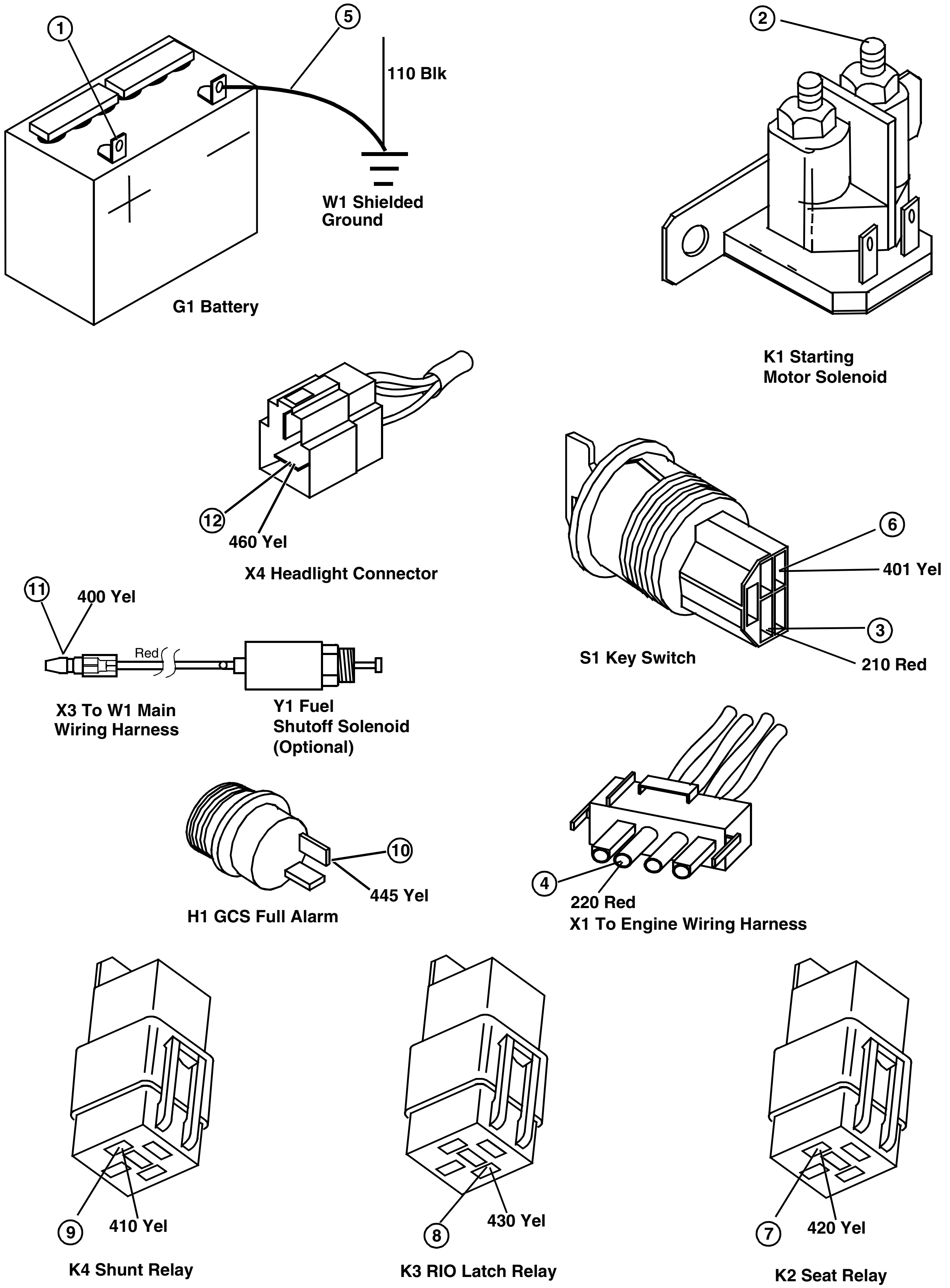
- Key switch in OFF position

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Positive and negative battery post | 12.4 volts or above | Clean battery terminals and test battery. |
| 2. Starting motor solenoid stud terminal | Battery voltage | Clean and check battery cable and tighten connections. |
| 3. Key switch | Battery voltage | Check F1 fusible link, 210 Red wire connections. Replace fuseible link. |
| 4. Engine connector | Battery voltage | Check wire 220 Red wire and connections. |
| 5. Ground cable frame connection to negative battery terminal | Less than 0.1 ohm resistance | Check harness wires and negative cable connections to frame, removing any paint, rust or corrosion. Clean negative battery connection to battery post. |

**Test Conditions:**

- Key switch in RUN position
- Engine OFF

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 6. Key switch | Battery voltage | Replace key switch |
| 7. Seat Relay | Battery voltage | Check 420 Yel wire and connections |
| 8. RIO Latch Relay | Battery voltage | Check 430 Yel wire and connections |
| 9. Shunt Relay | Battery voltage | Check 410 Yel wire and connections |
| 10. Grass Collection System (GCS) Full Alarm | Battery voltage | Check 445 Yel wire and connections |
| 11. Fuel Shutoff Solenoid | Battery Voltage | Check 400 Yel wire and connections |
| 12. X4 Headlight Wire Harness Connector | Battery Voltage | Check 460 Yel wire and connections |


1
5
110 Blk
W1 Shielded Ground
G1 Battery
2
K1 Starting Motor Solenoid
12
460 Yel
X4 Headlight Connector
6
401 Yel
3
S1 Key Switch
210 Red
11
400 Yel
Red
X3 To W1 Main Wiring Harness
Y1 Fuel Shutoff Solenoid (Optional)
10
445 Yel
H1 GCS Full Alarm
4
220 Red
X1 To Engine Wiring Harness
9
410 Yel
K4 Shunt Relay
8
430 Yel
K3 RIO Latch Relay
7
420 Yel
K2 Seat Relay

# POWER CIRCUIT OPERATION—LTR155 w/4 POSITION KEY SWITCH

**Function:**

Provides unswitched power to the primary components and switched power to secondary components whenever the battery is connected.

**Operating Conditions, Unswitched Circuits:**

Voltage must be present at the following components with the key switch in the OFF position:

- Battery Positive Terminal
- Starting Motor Solenoid Positive Contact Stud
- Key Switch
- Red Wire at Engine Wiring Harness Connector

The positive battery cable connects the battery to the starting motor solenoid bolt.

The ground cable connection is equally important as the positive cable. Proper starting operation depends on these cables and connections to carry the high current for its operation.

The fusible link and 210 Red wire provide unswitched voltage to the key switch.

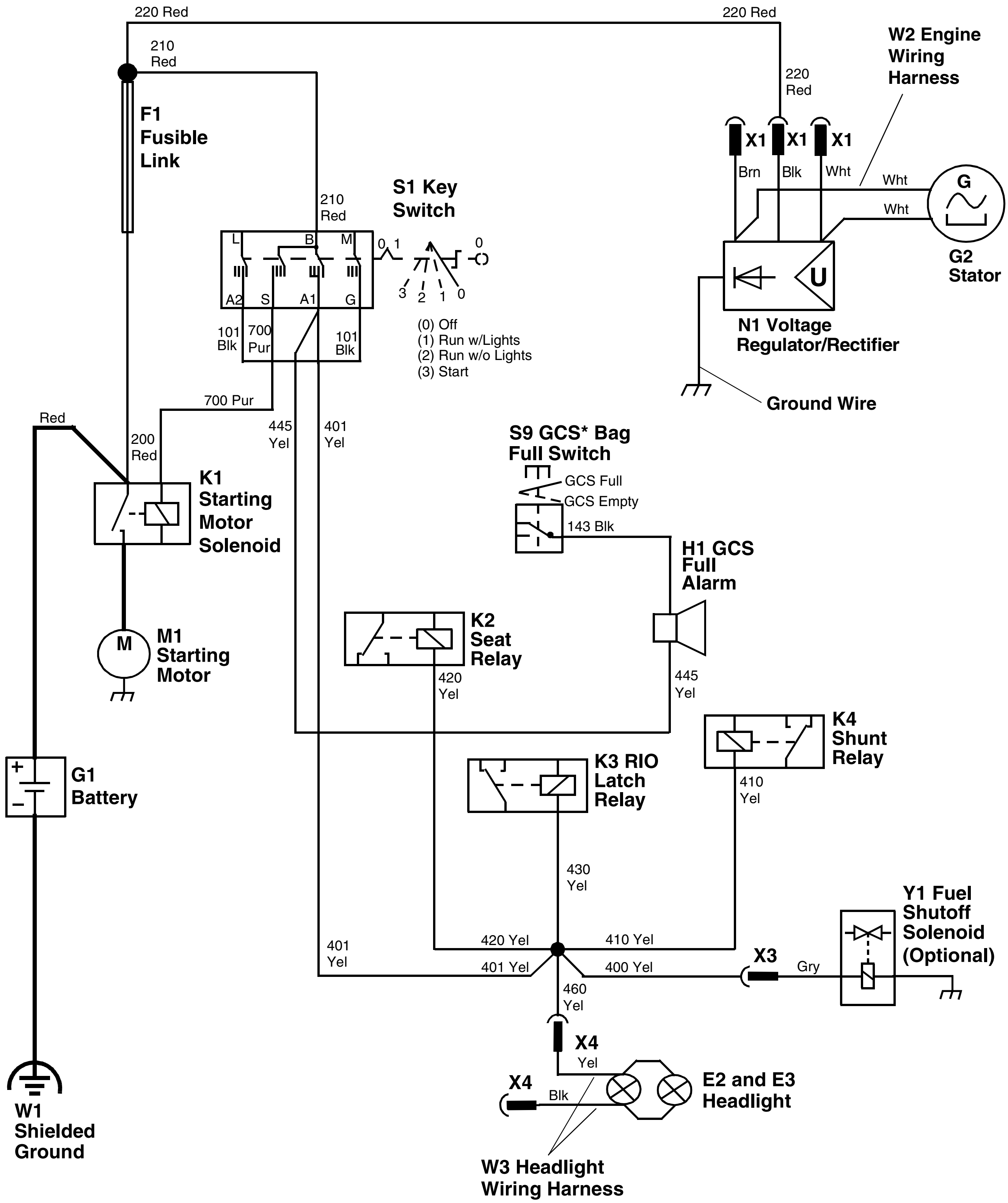
The fusible link and 220 Red wire provide unswitched voltage to the engine wiring harness connector.

**Operating Conditions, Switched Circuits:**

Placing the key switch in the RUN position provides voltage from 210 Red wire through the key switch to the 400, 401, 410, 420, 430, 445 and 460 Yel wires. These wires supply input signal voltage to the three system interlock relays, the headlights, the GCS full alarm and the fuel shutoff solenoid (if equipped). The relays will not energize until another switch(es) is actuated.

Placing the key switch in the START position (See “CRANKING CIRCUIT OPERATION—LTR155 w/15 AMP CHARGER” on page 64) provides voltage to the starting motor solenoid coil through the key switch contacts to the 700 Pur wire. The ground for this circuit is provided for the starting motor solenoid by the 120 Blk wire, GCS enable switch contacts (normally closed), 150 Blk wire, brake switch contacts (normally open), 170 and 110 Blk wires.

# POWER CIRCUIT SCHEMATIC—LTR155 w/4 POSITION KEY SWITCH




* Grass Collection System (GCS)

# POWER CIRCUIT DIAGNOSIS—LTR155 w/4 POSITION KEY SWITCH

**Test Conditions:**

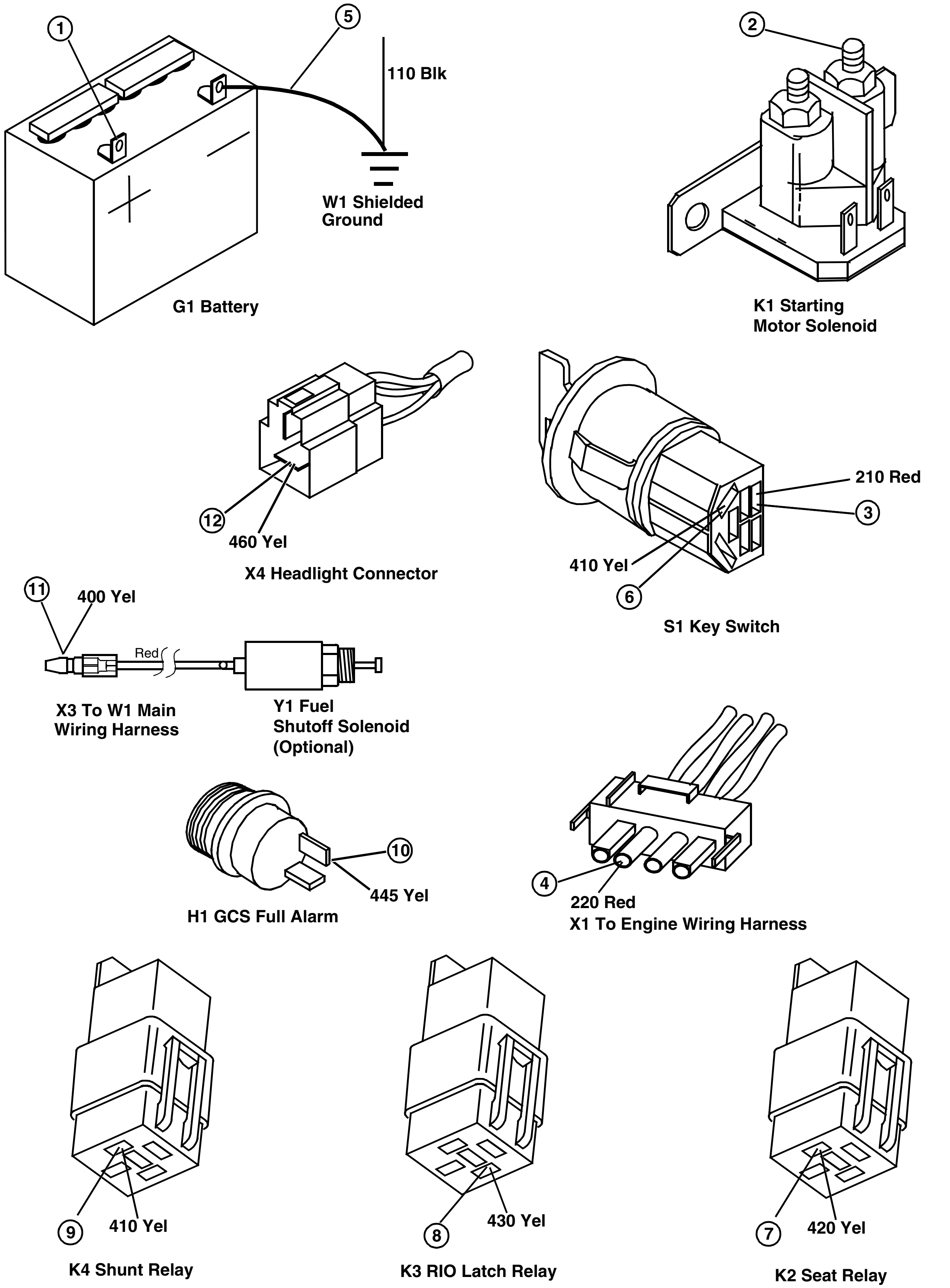
- Key switch in OFF position

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Positive and negative battery post | 12.4 volts or above | Clean battery terminals and test battery. |
| 2. Starting motor solenoid stud terminal | Battery voltage | Clean and check battery cable and tighten connections. |
| 3. Key switch | Battery voltage | Check F1 fusible link, 210 Red wire connections. Replace fuseible link. |
| 4. Engine connector | Battery voltage | Check wire 220 Red wire and connections. |
| 5. Ground cable frame connection to negative battery terminal | Less than 0.1 ohm resistance | Check harness wires and negative cable connections to frame, removing any paint, rust or corrosion. Clean negative battery connection to battery post. |

**Test Conditions:**

- Key switch in RUN position
- Engine OFF

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 6. Key switch | Battery voltage | Replace key switch |
| 7. Seat Relay | Battery voltage | Check 420 Yel wire and connections |
| 8. RIO Latch Relay | Battery voltage | Check 430 Yel wire and connections |
| 9. Shunt Relay | Battery voltage | Check 410 Yel wire and connections |
| 10. Grass Collection System (GCS) Full Alarm | Battery voltage | Check 445 Yel wire and connections |
| 11. Fuel Shutoff Solenoid | Battery Voltage | Check 400 Yel wire and connections |
| 12. X4 Headlight Wire Harness Connector | Battery Voltage | Check 460 Yel wire and connections |


1
5
110 Blk
W1 Shielded Ground
G1 Battery
2
K1 Starting Motor Solenoid
12
460 Yel
X4 Headlight Connector
210 Red
3
410 Yel
6
S1 Key Switch
11
400 Yel
Red
X3 To W1 Main Wiring Harness
Y1 Fuel Shutoff Solenoid (Optional)
10
445 Yel
H1 GCS Full Alarm
4
220 Red
X1 To Engine Wiring Harness
9
410 Yel
K4 Shunt Relay
8
430 Yel
K3 RIO Latch Relay
7
420 Yel
K2 Seat Relay

# POWER CIRCUIT OPERATION—LTR166 & LTR180

### Function:

Provides unswitched power to the primary components and switched power to secondary components whenever the battery is connected.

### Operating Conditions, Unswitched Circuits:

Voltage must be present at the following components with the key switch in the OFF position:

- Battery Positive Terminal
- Starting Motor Solenoid Positive Contact Stud
- Key Switch
- Red Wire at Engine Wiring Harness Connector

The positive battery cable connects the battery to the starting motor solenoid bolt.

The ground cable connection is equally important as the positive cable. Proper starting operation depends on these cables and connections to carry the high current for its operation.

The fusible link and 210 Red wire provide unswitched voltage to the key switch.

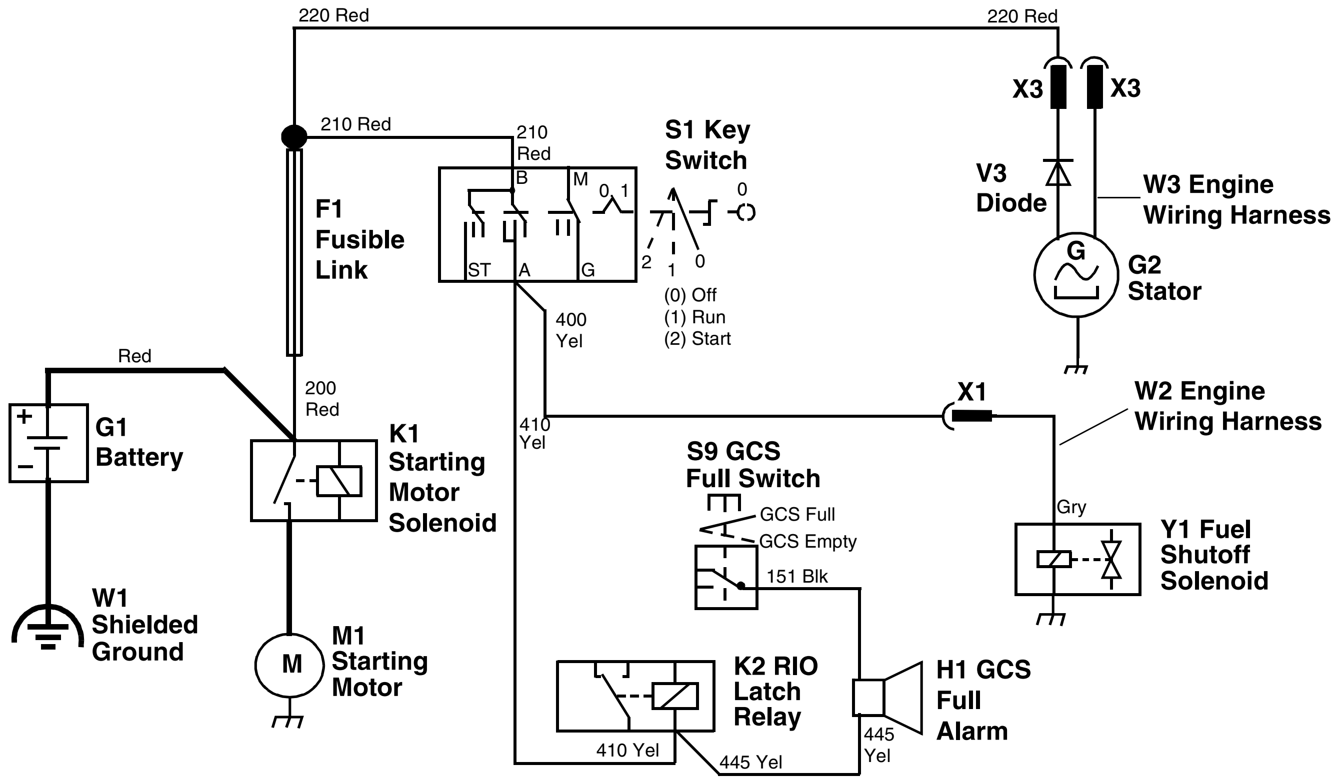
The fusible link and 220 Red wire provide unswitched voltage to the engine wiring harness connector.

### Operating Conditions, Switched Circuits:

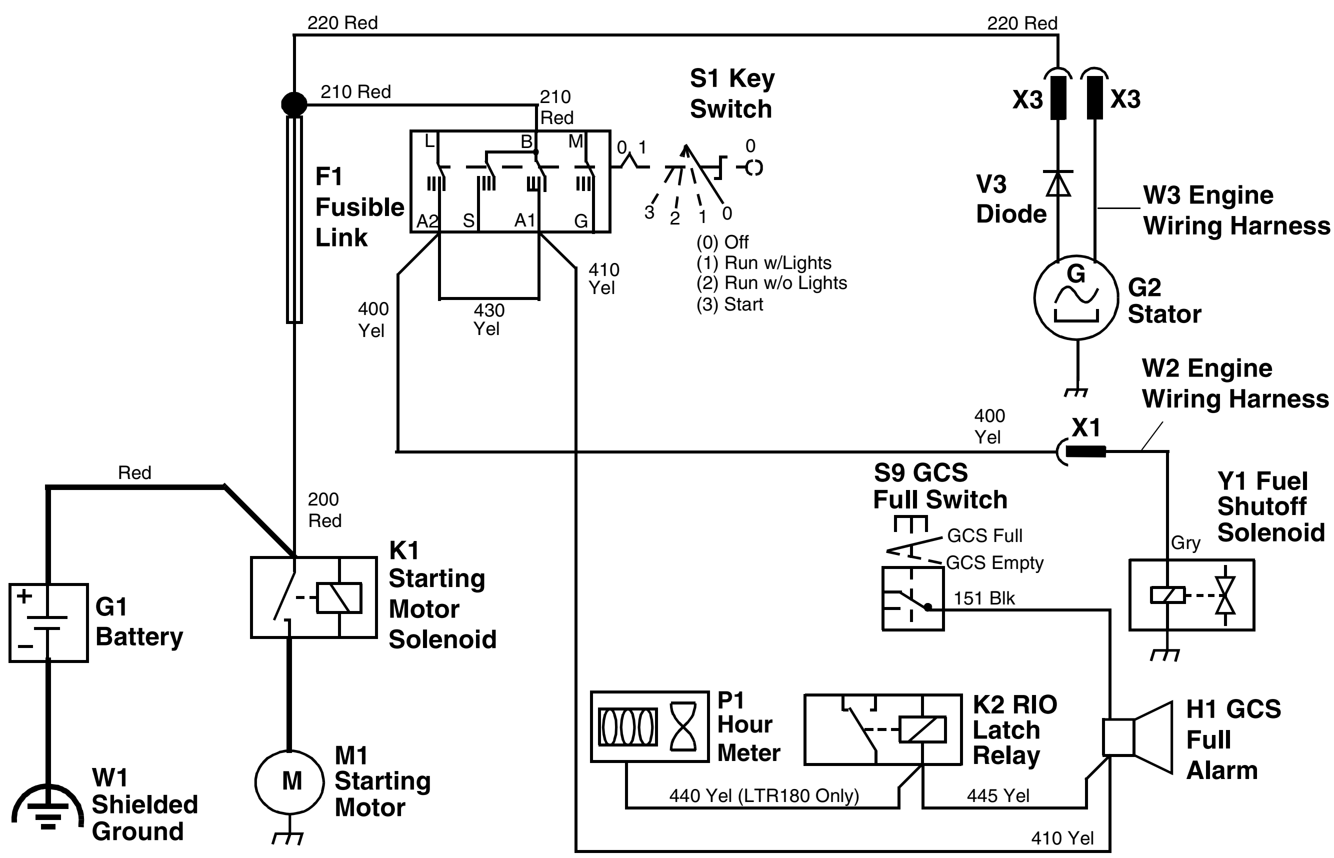
Placing the key switch in the RUN position provides voltage from 210 Red wire through the key switch to the 400, 410 and 445 Yel wires. These wires supplies input signal voltage to the fuel shutoff solenoid, RIO latch relay and the GCS full alarm. The relay and alarm will not energize until another switch(s) are actuated.

Placing the key switch in the START position (See "CRANKING CIRCUIT OPERATION—LTR166 & LTR180" on page 68.) provides voltage to the starting motor solenoid coil through the key switch contacts, 720 Pur wire, GCS enable switch contacts (normally closed), 710 Pur wire, brake switch contacts (normally open), and 700 Pur wire.

# POWER CIRCUIT SCHEMATIC—LTR166 w/3 POSITION KEY SWITCH




# POWER CIRCUIT SCHEMATIC—LTR166 & 180 w/4 POSITION KEY SWITCH



# POWER CIRCUIT DIAGNOSIS—LTR166 & LTR180

**Test Conditions:**

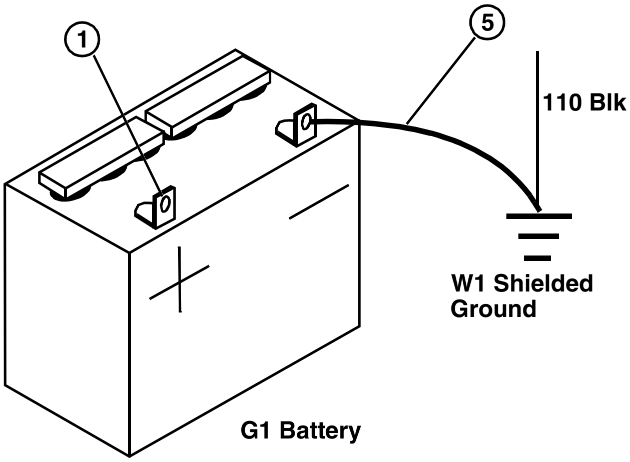
- Key switch in OFF position

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Positive and negative battery post | 12.4 volts or above | Clean battery terminals and test battery. |
| 2. Starting motor solenoid stud terminal | Battery voltage | Clean and check battery cable and tighten connections. |
| 3. Key switch | Battery voltage | Check F1 fusible link, 210 Red wire connections. Replace fuseible link. |
| 4. Engine connector | Battery voltage | Check wire 220 Red wire and connections. |
| 5. Ground cable frame connection to negative battery terminal | Less than 0.1 ohm resistance | Check harness wires and negative cable connections to frame, removing any paint, rust or corrosion. Clean negative battery connection to battery post. |

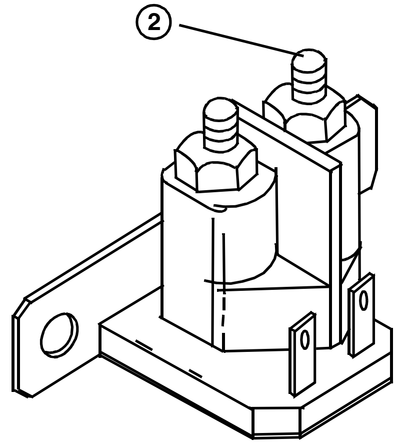
**Test Conditions:**

- Key switch in RUN position
- Engine OFF

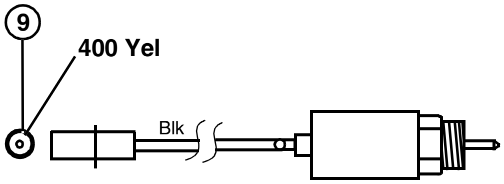
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 6. Key switch | Battery voltage | Replace key switch. |
| 7. RIO latch relay | Battery voltage | Check 410 Yel wire and connections (3 Position key switch only). |
| 8. GCS full alarm | Battery voltage | Check 445 Yel wire and connections. |
| 9. Fuel Shutoff Solenoid | Battery Voltage | Check 400 Yel wire and connections. |




G1 Battery

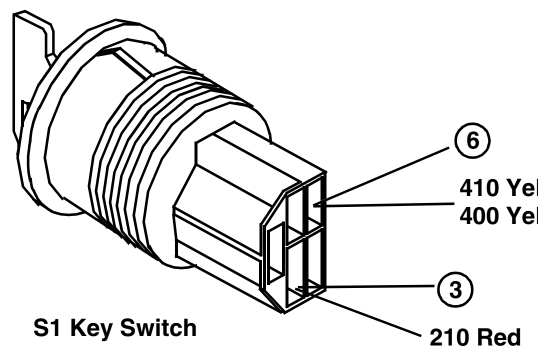



K1 Starting Motor Solenoid

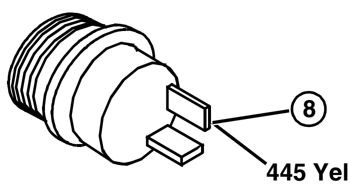



X1 To W1 Main Wiring Harness

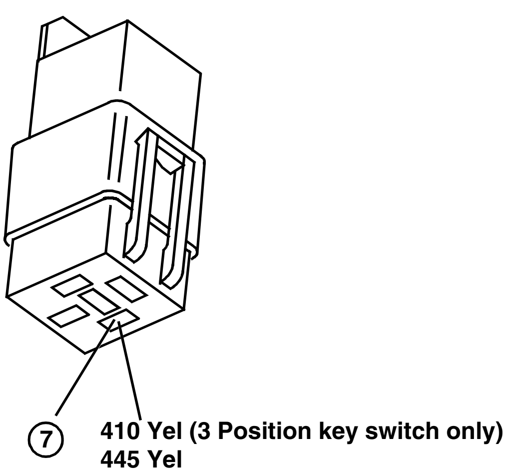
Y1 Fuel Shutoff Solenoid



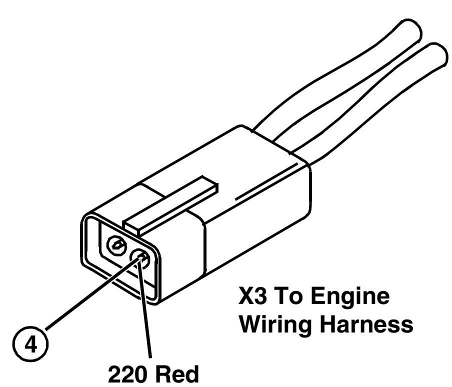

S1 Key Switch




H1 GCS Full Alarm




K2 RIO Latch Relay




X3 To Engine Wiring Harness

# CRANKING CIRCUIT OPERATION—LTR155 w/3 AMP CHARGER

**Function:**

To energize the starting motor solenoid and engage the starting motor which cranks the engine.

**Operating Conditions:**

To crank the engine the key switch must be in the START position, the brake must be ON and the PTO must be in the OFF (disengaged) position. The operator DOES NOT have to be on the seat to crank the engine.

**Theory of Operation:**

Current flows from the battery through F1 fusible link to the key switch. With key switch in the START position current flows through the key switch, through 700 Pur wire to the starting motor solenoid.

The GCS enable switch and brake switch are used in the starting motor solenoid ground circuit to prevent the engine from cranking if the PTO is engaged or the brake is not engaged.

A ground circuit for the starting motor solenoid is provided through the 120 Blk wire, GCS enable switch contacts (normally closed), 150 Blk wire, brake switch contacts (normally open), 160 and 135 Blk wires.

With the starting motor solenoid energized, high battery current flows across the starting motor solenoid contacts to the starting motor, causing it to crank the engine.

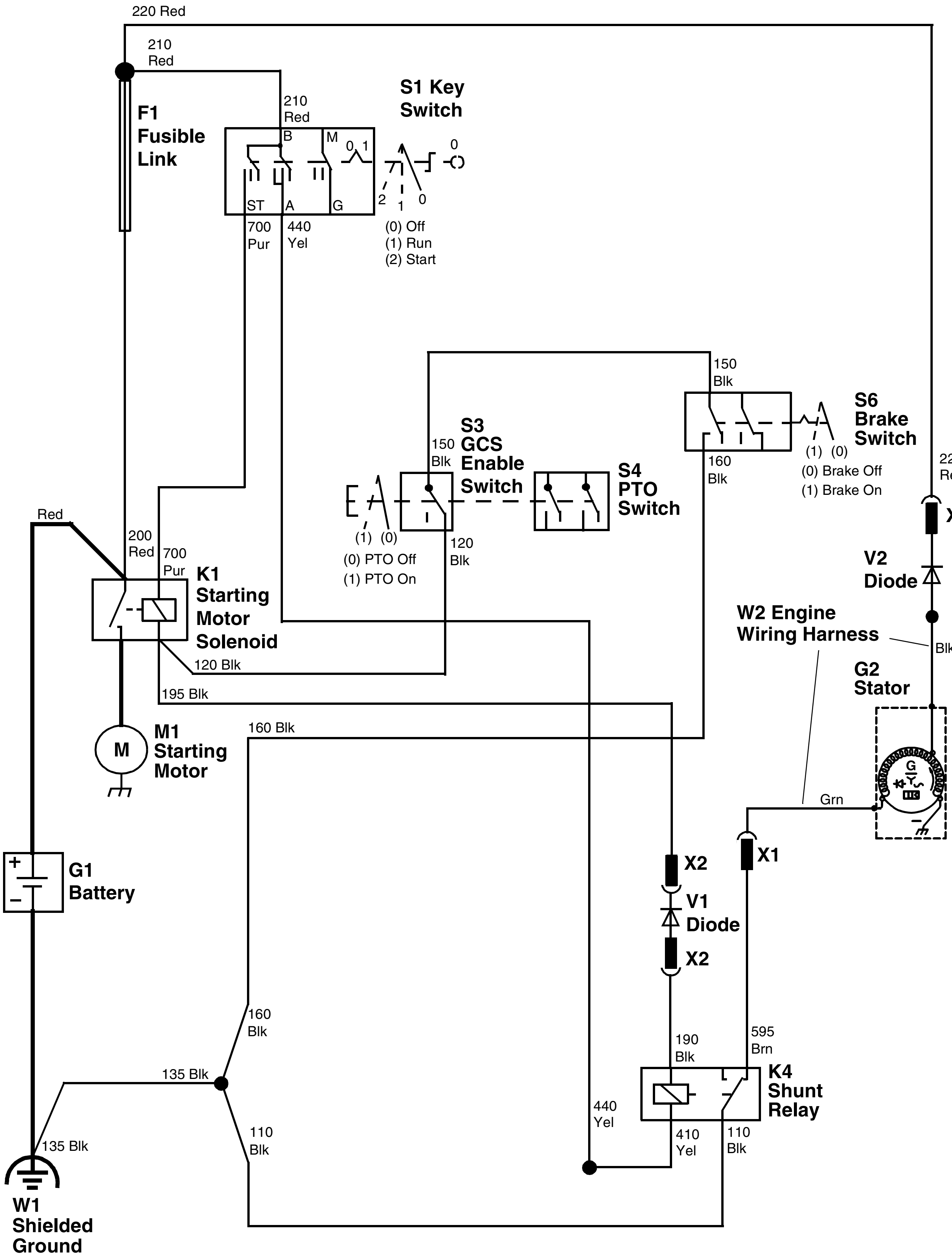
During the cranking operation the shunt relay is energized to remove the electrical load on the stator used to stop the engine from rotating when shutting off the engine. See “CHARGING & SHUNT CIRCUIT OPERATION—LTR155 w/3 AMP CHARGER” on page 88.

With the key switch in the RUN or START position the current flows across the key switch from the 210 Red wire to the 440 an d 410 Yel wires and the shunt relay.

The ground circuit for the shunt relay is provided through the 190 Blk wire, V1 diode, 195 and 120 Blk wire, GCS enable switch contacts (normally closed), 150 Blk wire, brake switch contacts (normally open), 160 and 135 Blk wires.

This circuit then opens the shunt relay contacts breaking the current path from the stator to ground, removing the electrical load on the stator.

# CRANKING CIRCUIT SCHEMATIC—LTR155 w/3 AMP CHARGER



# CRANKING CIRCUIT DIAGNOSIS—LTR155 w/3 AMP CHARGER

**Test Conditions:**

- Key switch in OFF position
- Park brake ON
- PTO OFF
- Spark plug disconnected

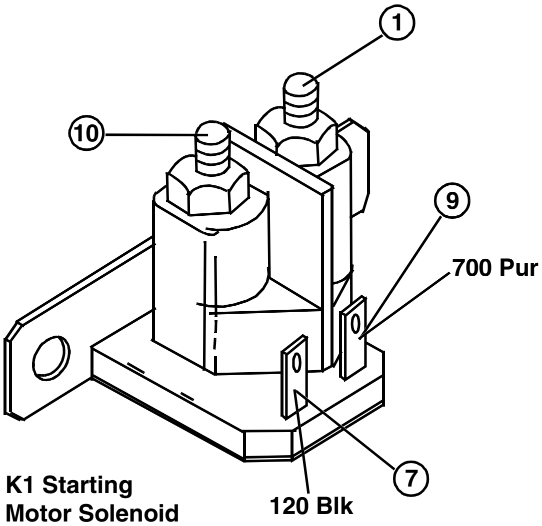
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Starting motor solenoid | Battery voltage | See “POWER CIRCUIT OPERATION—LTR155 w/3 AMP CHARGER” on page 44. |
| 2. Key switch | Battery voltage | See “POWER CIRCUIT OPERATION—LTR155 w/3 AMP CHARGER” on page 44. |
| 3. Brake switch | Continuity to ground | Check 135 and 160 Blk wire and connections. |
| 4. Brake switch | Continuity to ground | Replace brake switch. |
| 5. Grass Collection System (GCS) enable switch | Continuity to ground | Check 150 Blk wire and connections. |
| 6. Grass Collection System (GCS) enable switch | Continuity to ground | Replace GCS enable switch. |
| 7. Starting motor solenoid | Continuity to ground | Check 120 Blk wire and connections. |

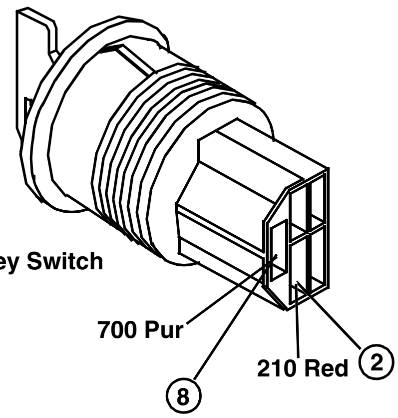
**Test Conditions:**

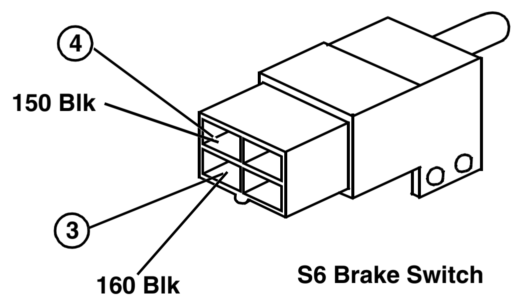
- Key switch in START position while preforming each test step
- Park brake ON
- PTO OFF
- Spark Plug disconnected

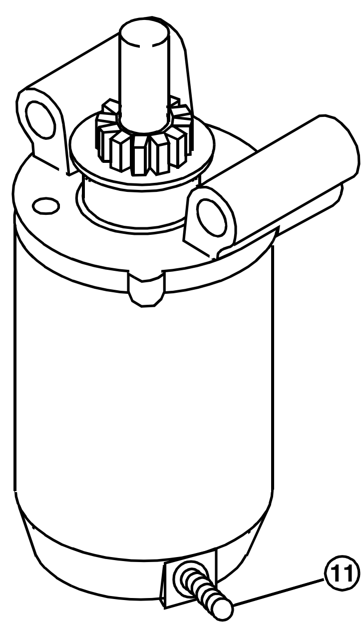
*NOTE: Engine will turn over during this test.*

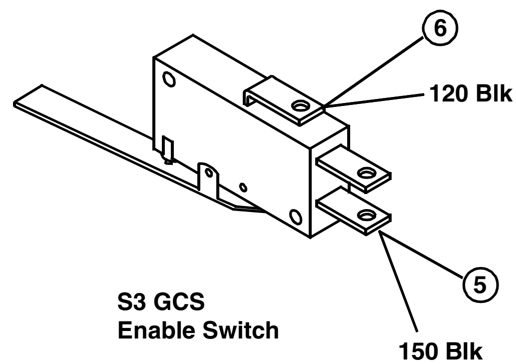
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 8. Key switch | Battery voltage | Replace key switch. |
| 9. Starting motor solenoid | Battery voltage | Check 700 Pur wire and connections. |
| 10. Starting motor solenoid | Battery voltage | Replace starting motor solenoid. |
| 11. Starting motor | Battery voltage | Check Red starting motor cable.“STARTING MOTOR AMPERAGE DRAW—LOADED” on page 144. |


1
10
9
700 Pur
7
K1 Starting
Motor Solenoid
120 Blk


S1 Key Switch
700 Pur
210 Red
2
8


4
150 Blk
3
160 Blk
S6 Brake Switch


11
M1 Starting Motor


6
120 Blk
5
S3 GCS
Enable Switch
150 Blk

# CRANKING CIRCUIT OPERATION—LTR155 w/15 AMP CHARGER

**Function:**

To energize the starting motor solenoid and engage the starting motor which cranks the engine.

**Operating Conditions:**

To crank the engine the key switch must be in the START position, the brake must be ON and the PTO must be in the OFF (disengaged) position. The operator DOES NOT have to be on the seat to crank the engine.

**Theory of Operation:**

Current flows from the battery through F1 fusible link to the key switch. With key switch in the START position current flows through the key switch, through 700 Pur wire to the starting motor solenoid.

The GCS enable switch and brake switch are used in the starting motor solenoid ground circuit to prevent the engine from cranking if the PTO is engaged or the brake is not engaged.

A ground circuit for the starting motor solenoid is provided through the 120 Blk wire, GCS enable switch contacts (normally closed), 150 Blk wire, brake switch contacts (normally open), 170 and 110 Blk wires.

With the starting motor solenoid energized, high battery current flows across the starting motor solenoid contacts to the starting motor, causing it to crank the engine.

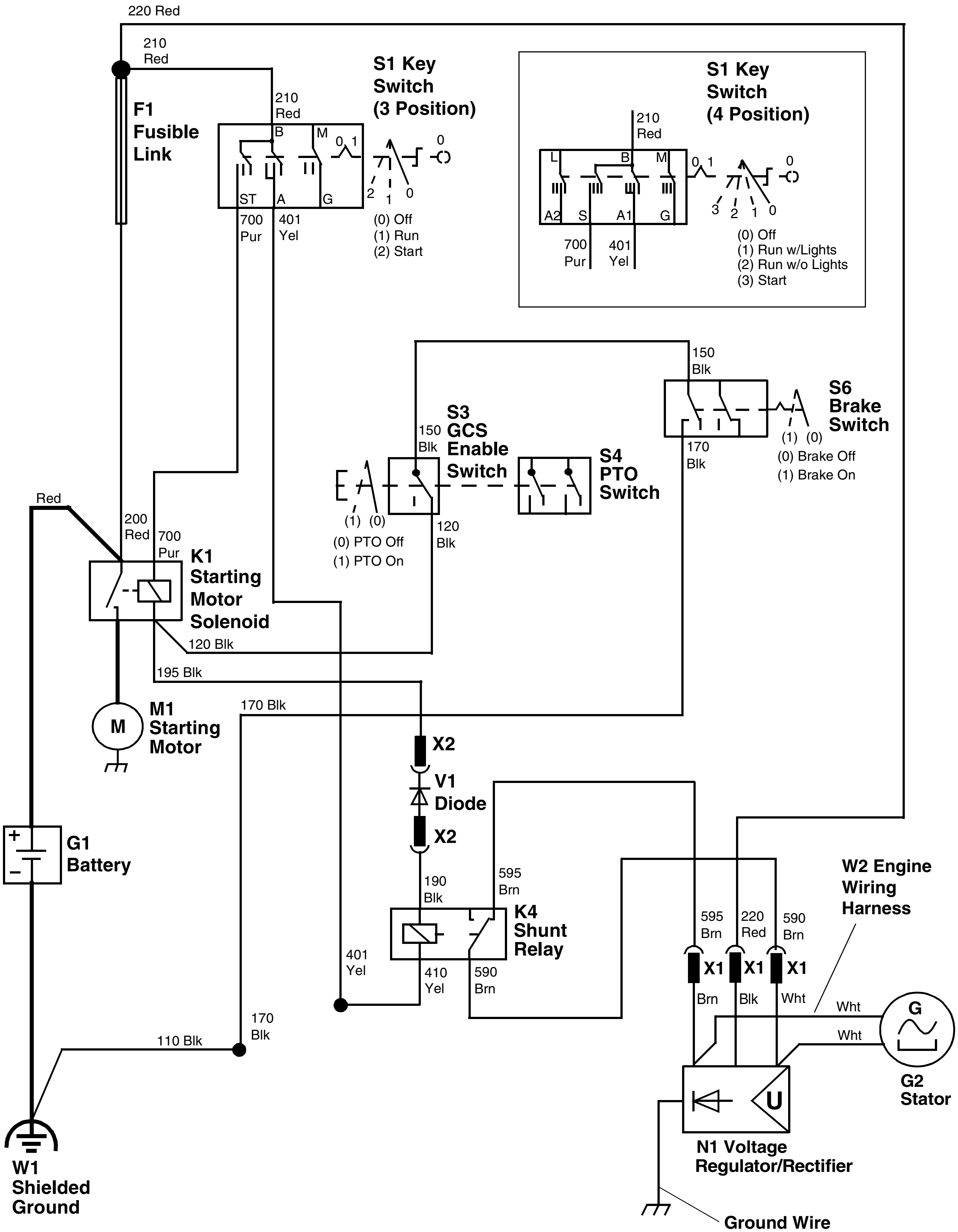
During the cranking operation the shunt relay is energized to remove the electrical load on the stator used to stop the engine from rotating when shutting off the engine. See “CHARGING & SHUNT CIRCUIT OPERATION—LTR155 w/15 AMP CHARGER” on page 92.

With the key switch in the RUN or START position the current flows across the key switch from the 210 Red wire to the 401 an d 410 Yel wires and the shunt relay.

The ground circuit for the shunt relay is provided through the 190 Blk wire, V1 diode, 195 and 120 Blk wire, GCS enable switch contacts (normally closed), 150 Blk wire, brake switch contacts (normally open), 170 and 110 Blk wires.

This circuit then opens the shunt relay contacts breaking the current path from the stator to ground, removing the electrical load on the stator.

# CRANKING CIRCUIT SCHEMATIC—LTR155 w/15 AMP CHARGER



# CRANKING CIRCUIT DIAGNOSIS—LTR155 w/15 AMP CHARGER

**Test Conditions:**

- Key switch in OFF position
- Park brake ON
- PTO OFF
- Spark plug disconnected

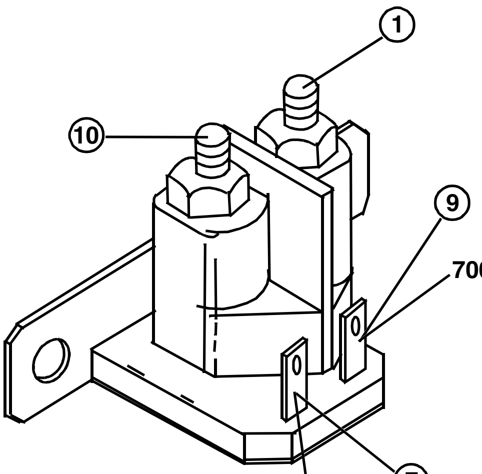
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Starting motor solenoid | Battery voltage | See “POWER CIRCUIT OPERATION—LTR155 w/15 AMP CHARGER” on page 48. |
| 2. Key switch | Battery voltage | See “POWER CIRCUIT OPERATION—LTR155 w/15 AMP CHARGER” on page 48. |
| 3. Brake switch | Continuity to ground | Check 110 and 170 Blk wire and connections. |
| 4. Brake switch | Continuity to ground | Replace brake switch. |
| 5. Grass Collection System (GCS) enable switch | Continuity to ground | Check 150 Blk wire and connections. |
| 6. Grass Collection System (GCS) enable switch | Continuity to ground | Replace GCS enable switch. |
| 7. Starting motor solenoid | Continuity to ground | Check 120 Blk wire and connections. |

**Test Conditions:**

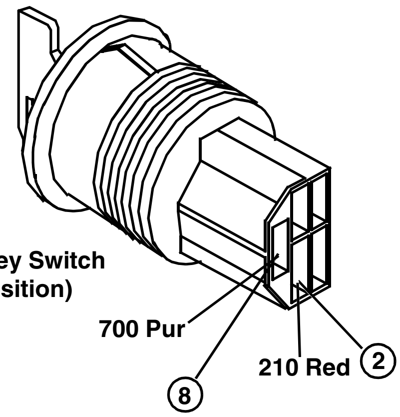
- Key switch in START position while preforming each test step
- Park brake ON
- PTO OFF
- Spark Plug disconnected

*NOTE: Engine will turn over during this test.*

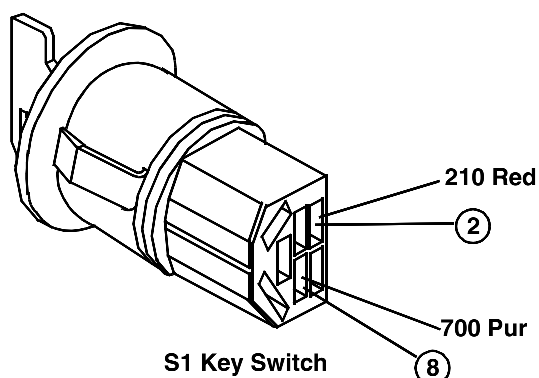
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 8. Key switch | Battery voltage | Replace key switch. |
| 9. Starting motor solenoid | Battery voltage | Check 700 Pur wire and connections. |
| 10. Starting motor solenoid | Battery voltage | Replace starting motor solenoid. |
| 11. Starting motor | Battery voltage | Check Red starting motor cable.“STARTING MOTOR AMPERAGE DRAW—LOADED” on page 144. |



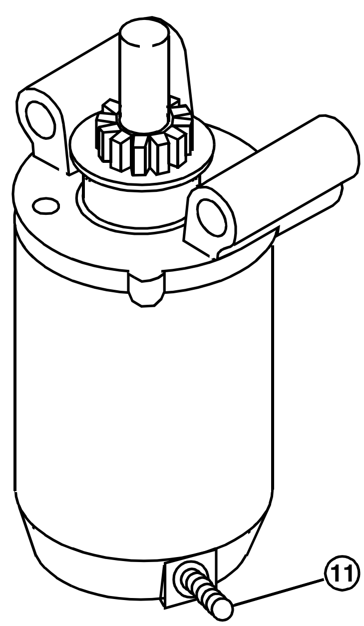

K1 Starting Motor Solenoid



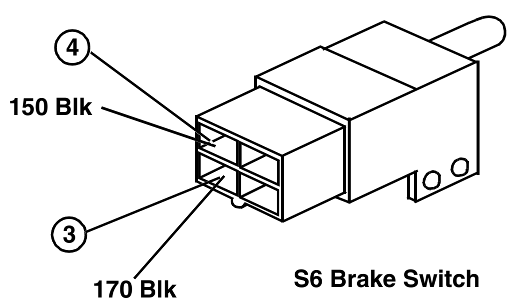

S1 Key Switch (3 Position)



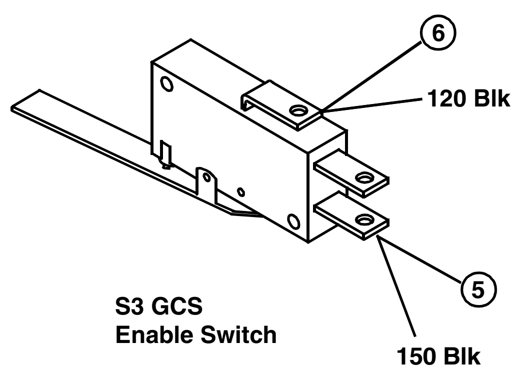

S1 Key Switch (4 Position)




M1 Starting Motor




S6 Brake Switch




S3 GCS Enable Switch

# CRANKING CIRCUIT OPERATION—LTR166 & LTR180

**Function:**

To energize the starting motor solenoid and engage the starting motor which cranks the engine.

**Operating Conditions:**

To crank the engine the key switch must be in the START position, the brake must be ON and the PTO must be in the OFF (disengaged) position. The operator DOES NOT have to be on the seat to crank the engine.

**Theory of Operation:**

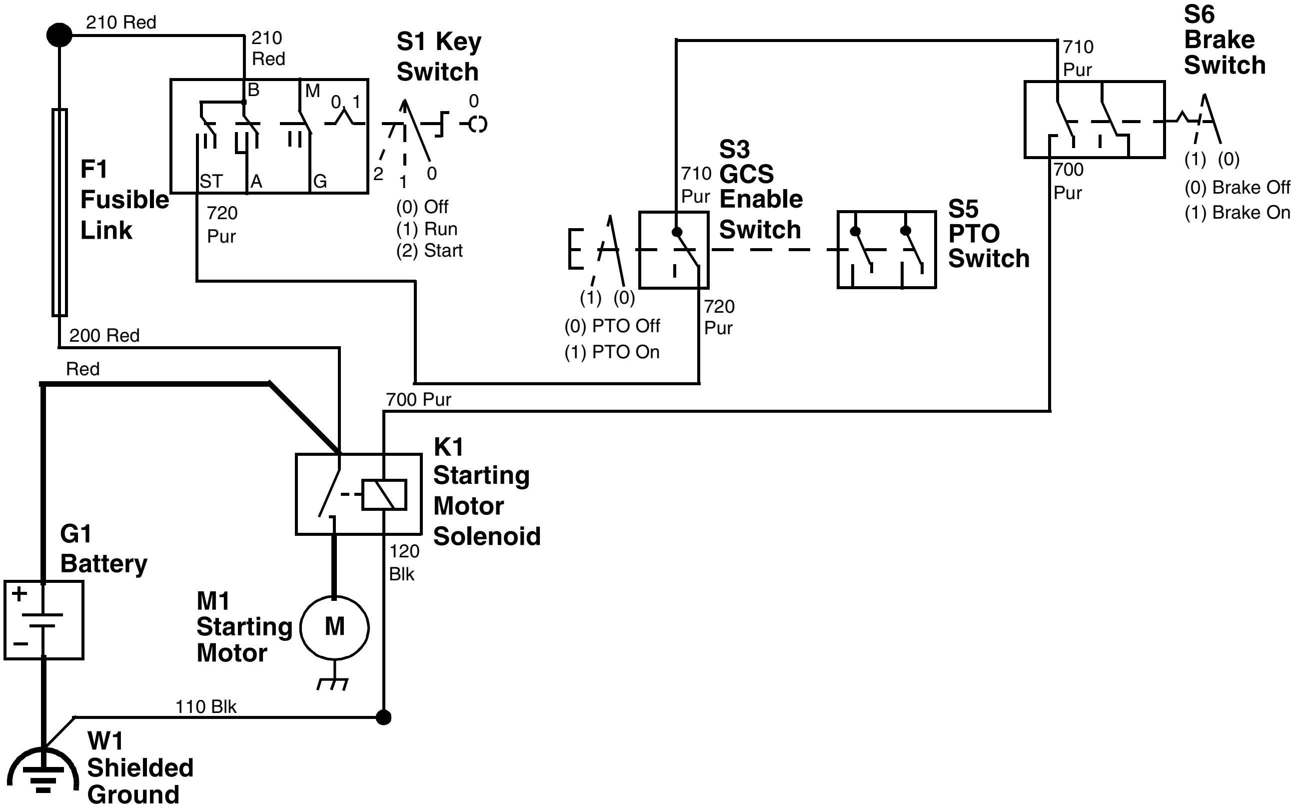
Current flows from the battery through F1 fusible link to the key switch. With key switch in the START position current flows through the key switch, through 720 Pur wire, GCS enable switch contacts (normally closed), 710 Pur wire, brake switch contacts (normally open), and 700 Pur wire to the starting motor solenoid.

The GCS enable switch and brake switch are used in the starting motor solenoid power circuit to prevent the engine from cranking if the PTO is engaged or the brake is not engaged.

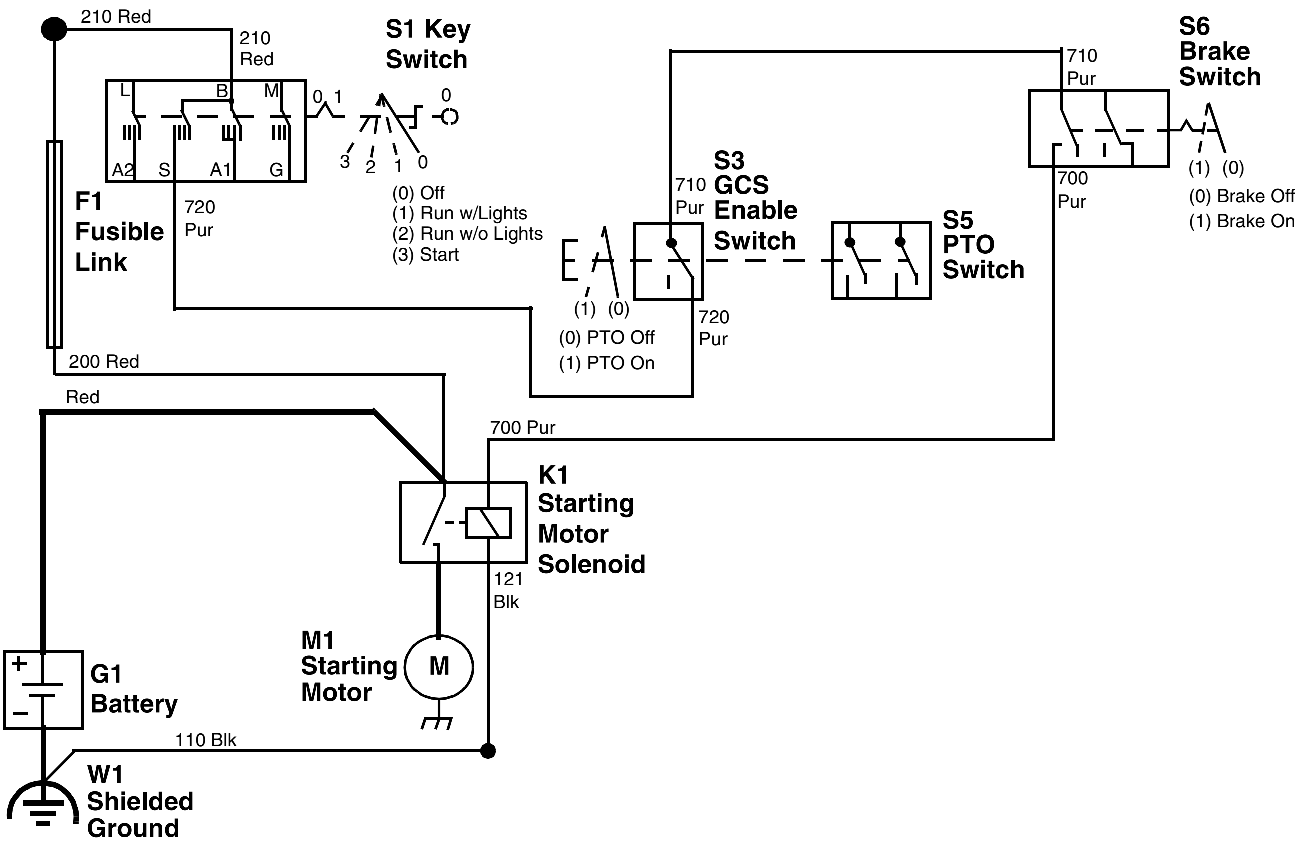
A ground circuit for the Starting motor solenoid is provided through the 120 (3 Position key switch), or 121 (4 Position key switch) and 110 Blk wires.

With the Starting motor solenoid energized, high battery current flows across the starting motor solenoid contacts to the starting motor, causing it to crank the engine.

## CRANKING CIRCUIT SCHEMATIC—LTR166 w/3 POSITION KEY SWITCH




## CRANKING CIRCUIT SCHEMATIC - LTR166/180 w/4 POSITION KEY SWITCH



# CRANKING CIRCUIT DIAGNOSIS—LTR166

**Test Conditions:**

- Key switch in OFF position
- Park brake ON
- PTO OFF
- Spark plug disconnected

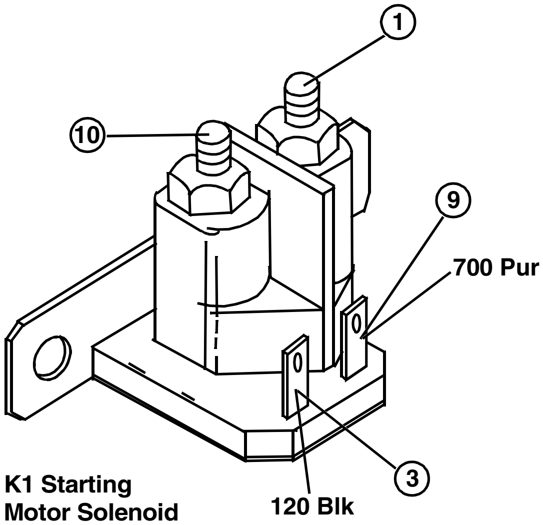
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Starting motor solenoid | Battery voltage | Check Red battery cable and battery. |
| 2. Key switch | Battery voltage | Check F1 fusible link and 210 Red wire and connections. |
| 3. Starting motor solenoid | Continuity to ground | Check 120 (3 Position key switch), or 121 (4 Position key switch) and 110 Blk wires and connections. |

**Test Conditions:**

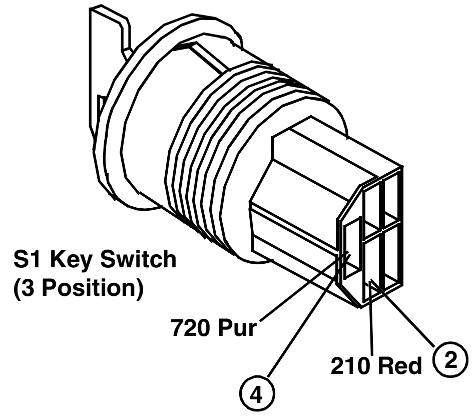
- Key switch in START position while preforming each test step
- Park brake ON
- PTO OFF
- Spark Plug disconnected

*NOTE: Engine will turn over during this test.*

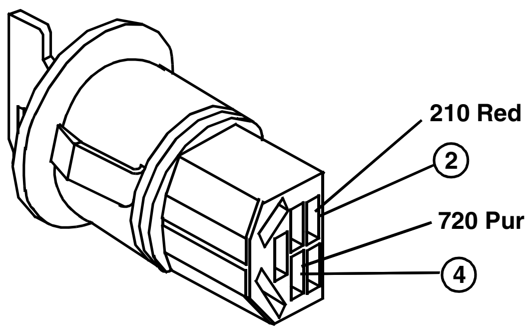
| | | |
|---|---|---|
| 4. Key switch | Battery voltage | Replace key switch |
| 5. Grass Collection System (GCS) enable switch | Battery voltage | Check 720 Pur wire and connections. |
| 6. Grass Collection System (GCS) enable switch | Battery voltage | Replace GCS enable switch. |
| 7. Brake switch | Battery voltage | Check 710 Pur wire and connections. |
| 8. Brake switch | Battery voltage | Replace brake switch. |
| 9. Starting motor solenoid | Battery voltage | Check 700 Pur wire and connections. |
| 10. Starting motor solenoid | Battery voltage | Replace starting motor solenoid. |
| 11. Starting motor | Battery voltage | Check Red starting motor cable.“STARTING MOTOR AMPERAGE DRAW—LOADED” on page 144. |



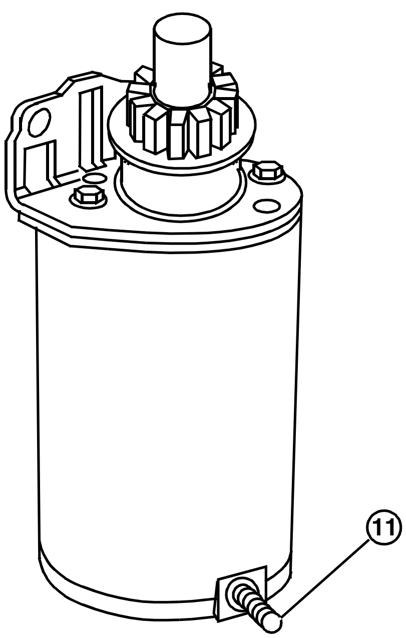

K1 Starting Motor Solenoid



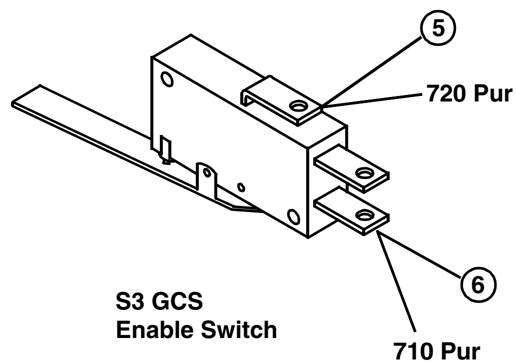

S1 Key Switch (3 Position)



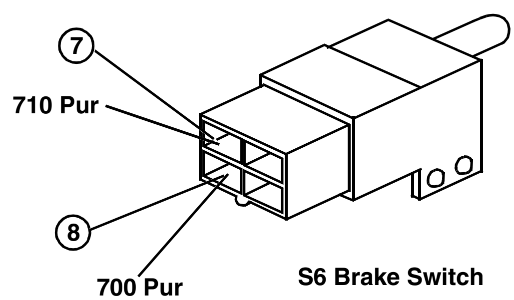

S1 Key Switch (4 Position)




M1 Starting Motor




S3 GCS Enable Switch




S6 Brake Switch

# IGNITION & SHUTOFF CIRCUIT OPERATION—LTR155

### Function:

To create a spark at the correct time that ignites the fuel/air mixture in the cylinder. To ground the system to keep the engine from starting or to shut off the engine.

### Operating Conditions:

To produce a spark, the key switch must be in the START or RUN position. The operator can be ON or OFF the seat; however, the PTO must be disengaged and the brake switch must be engaged (brake pedal depressed or park brake on) to start the engine.

Once the engine is running, the operator must be ON the seat to disengage the brake and/or engage the PTO.

The engine will shutoff under any of the following conditions:

- When the key switch is turned to the OFF position
- If the operator leaves the seat without locking the parking brake
- If the operator leaves the seat with the PTO on (engaged)
- If the operator places the tractor in reverse with the PTO engaged without pressing the reverse implement switch (RIS)
- If the PTO is engaged without having the GCS bag properly in place

### System Operation

#### Ignition:

When the engine is turning over (see “CRANKING CIRCUIT OPERATION—LTR155 w/3 AMP CHARGER” on page 60) the flywheel magnets induces current into the magneto ignition coil, which in turn produces current high enough to jump the spark plug gap, creating spark to ignite the engine fuel/air mixture.

### System Operation

#### Shutoff:

The engine is shut off by grounding both sides of the ignition primary coil. With the ignition primary coil grounded, a spark cannot be produced.

Placing the key switch in the OFF position creates one path to ground for the Wht wire from the engine magneto, 900, 910 Wht wires, key switch contacts (normally closed), 130 and 135 Blk wires (3 amp charger) or 160 and 110 Blk wires (15 amp charger).

Another path to ground is created with the key switch in the ON position, any time the operator is OFF the seat (seat switch OPEN). The seat switch creates a ground path for the seat relay when the operator is on the seat. With the seat relay energized, the contacts are shifted from the normally closed set of contacts to the normally open set. This breaks the path to ground for the magneto ignition and creates a path to ground for the shunt relay. The shunt relay is then energized and breaks the path to ground for the stator which places a load on the engine to cause it to stop spinning faster on shut down. See “CHARGING & SHUNT CIRCUIT OPERATION—LTR155 w/3 AMP CHARGER” on page 88.

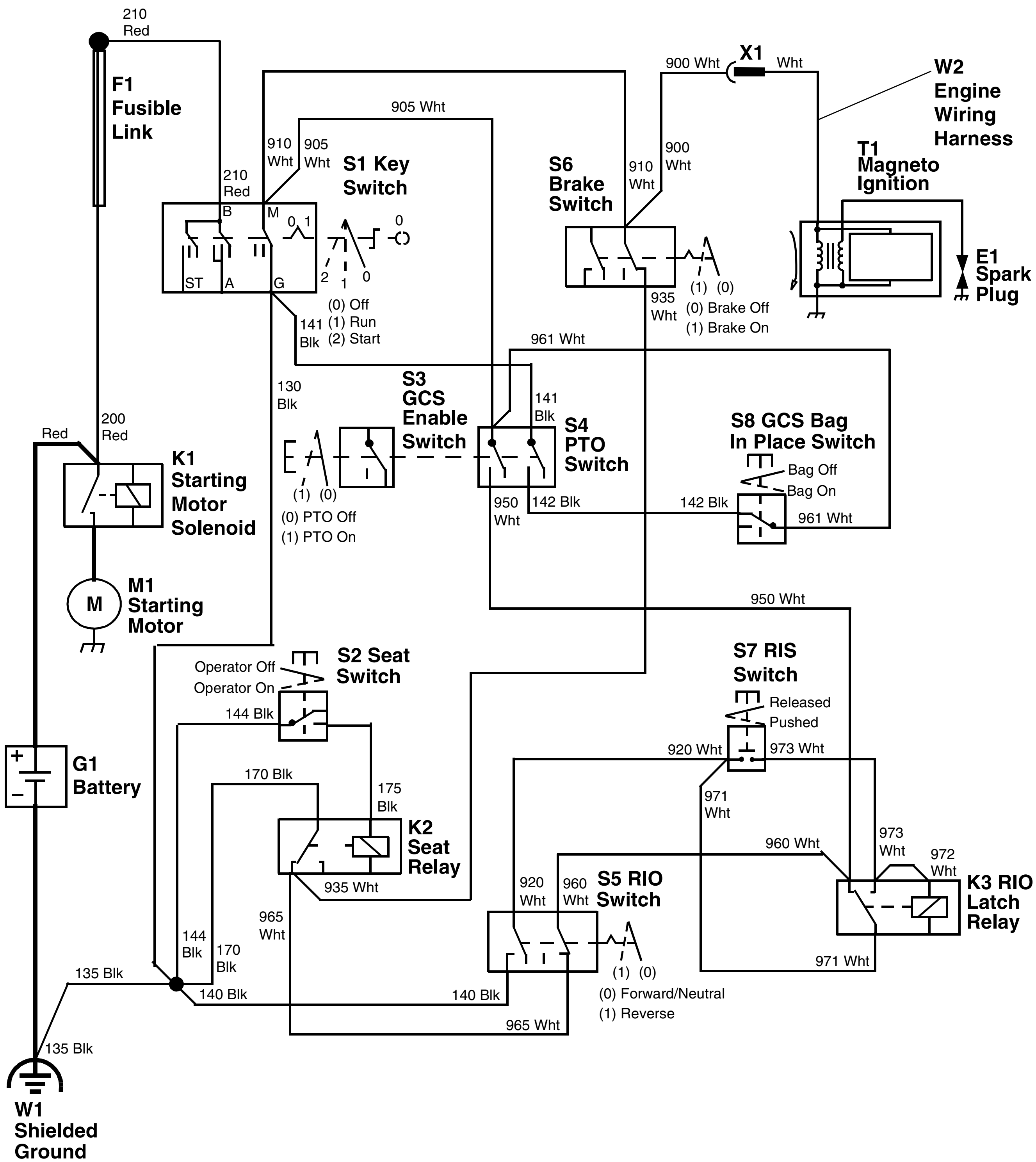
If the brake were off when the operator leaves the seat the ground path would be created from the magneto Wht wire, 900 Wht wire, brake switch contacts (normally closed), 935 Wht wire, Seat relay contacts (normally closed), 170 and 135 Blk wires (3 amp charger) or 130 and 110 Blk wires (15 amp charger).

If the PTO were engaged when the operator leaves the seat the ground path would be created from the magneto Wht wire, 900, 910, and 905 Wht wires, PTO contacts (normally closed), 950 and 960 Wht wires, RIO switch contacts (normally closed), 965 Wht wire (3 amp charger) or 980 Wht wire (15 amp charger), seat relay contacts (normally closed), 170 and 135 Blk wires (3 amp charger) or 130 and 110 Blk wires (15 amp charger).

A fourth path to ground will be created with engine running, if the operator places the tractor in reverse while the PTO is engaged and the Reverse Implement Switch is not pressed. See “PTO with RIO CIRCUIT OPERATION—LTR155” on page 104.

Finally the Grass Collection System (GCS) will cause the engine to shutoff if the PTO is engaged and the GCS bag is not properly in place. During this condition the path to ground for the magneto Wht wire is created through the 900, 910, 905, and 961 Wht wires (3 amp charger) or 940 Wht wire (15 amp charger), GCS bag in place switch contacts (normally closed), 142 Blk wire, PTO switch contacts (normally open), 141, 130, and 135 Blk wires (3 amp charger) or 146, 160 and 110 Blk wires (15 amp charger).

# IGNITION & SHUTOFF CIRCUIT SCHEMATIC—LTR155 w/3 AMP CHARGER



# IGNITION & SHUTOFF CIRCUIT DIAGNOSIS—LTR155 w/3 AMP CHARGER

**Test Conditions:**

- Key switch in OFF position
- Park brake ON
- PTO OFF (DISENGAGED)
- Engine cool to avoid burns

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Spark plug | Spark plug not fouled<br>Correct air gap | Adjust air gap<br>Replace spark plug |

**Test Conditions:**

- Key switch in START position
- Park brake ON
- PTO OFF (DISENGAGED)

*NOTE: Engine will turn over and can start during this test*

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 2. Spark plug tester installed. See "GCS BAG FULL SWITCH TEST" on page 155 | Spark present at tester | No spark: Check armature air gap. Check for grounded primary lead. Check for continuity between engine kill wire and ground (should be infinite).<br>Check ignition coil.<br>Weak Spark: Check spark plug(s) |

**Test Conditions:**

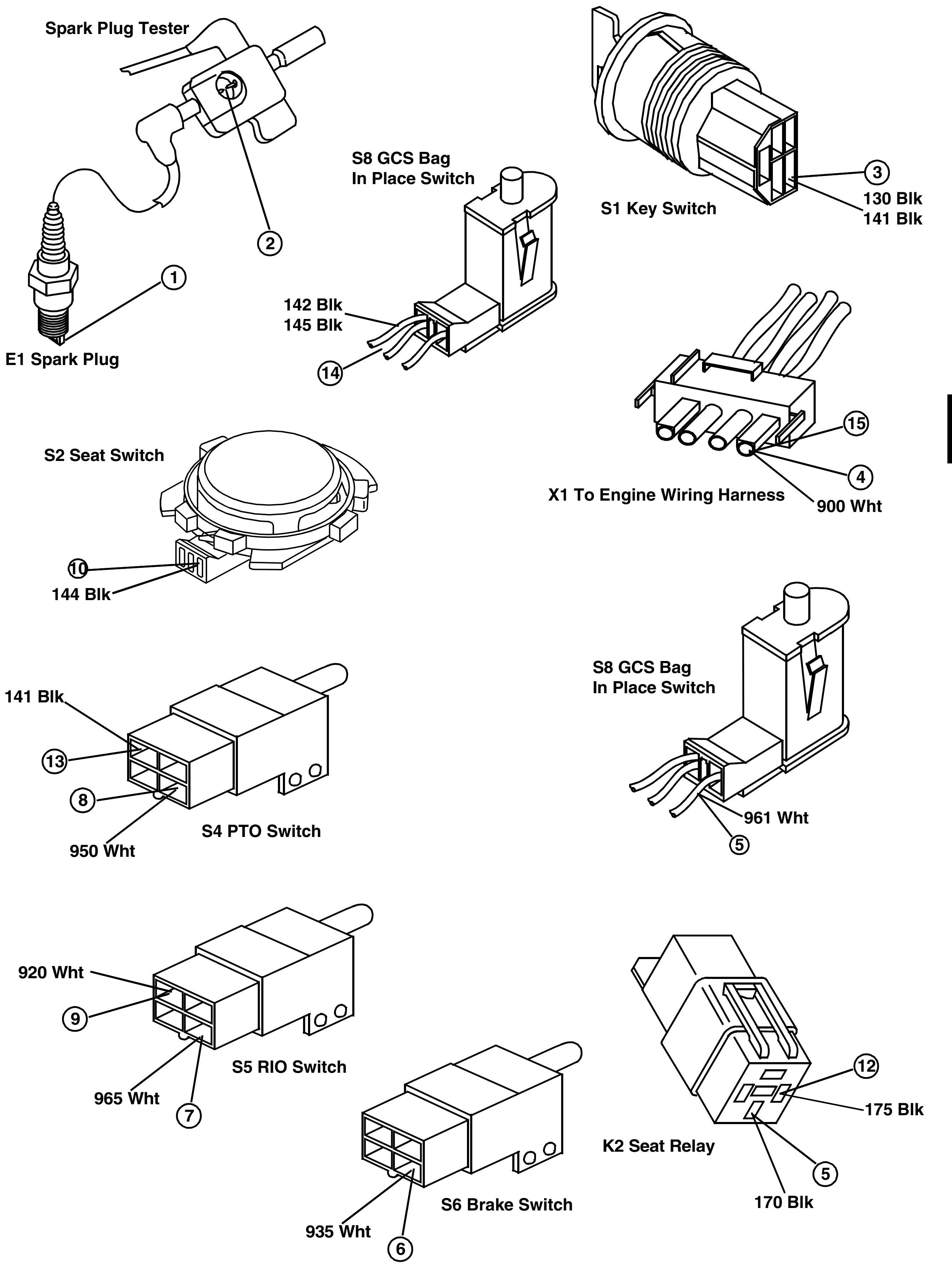
- Key switch in OFF position
- Park brake ON
- PTO OFF (DISENGAGED)
- Engine wiring harness disconnected from main wiring harness

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 3. Key switch | Continuity to ground. | Check 135 and 130 Blk wires and connections. |
| 4. X1 Engine harness connector | Continuity to ground | Check 910 and 900 Wht wires and connections. If OK, replace key switch. |
| 5. Grass Collection System (GCS) bag in place switch | Continuity to ground | Check 961 and 905 Wht wires and connections. If OK, replace key switch. |
| 6. Seat relay | Continuity to ground | Check 135 and 170 Blk wires and connections. |
| 7. Brake switch | Continuity to ground | Check 935 Wht wire and connections. If OK, replace the seat relay. |
| 8. RIO switch | Continuity to ground | Check 965 Wht wire and connections. |
| 9. PTO switch | Continuity to ground | Check 950 and 960 Wht wires and connections. If OK, replace the RIO switch. |
| 10. RIO switch | Continuity to ground | Check 920 and 971 Wht wires and connections. If OK, replace RIO latch relay. |
| 11. Seat switch | Continuity to ground | Check 135 and 144 Blk wires and connections. |

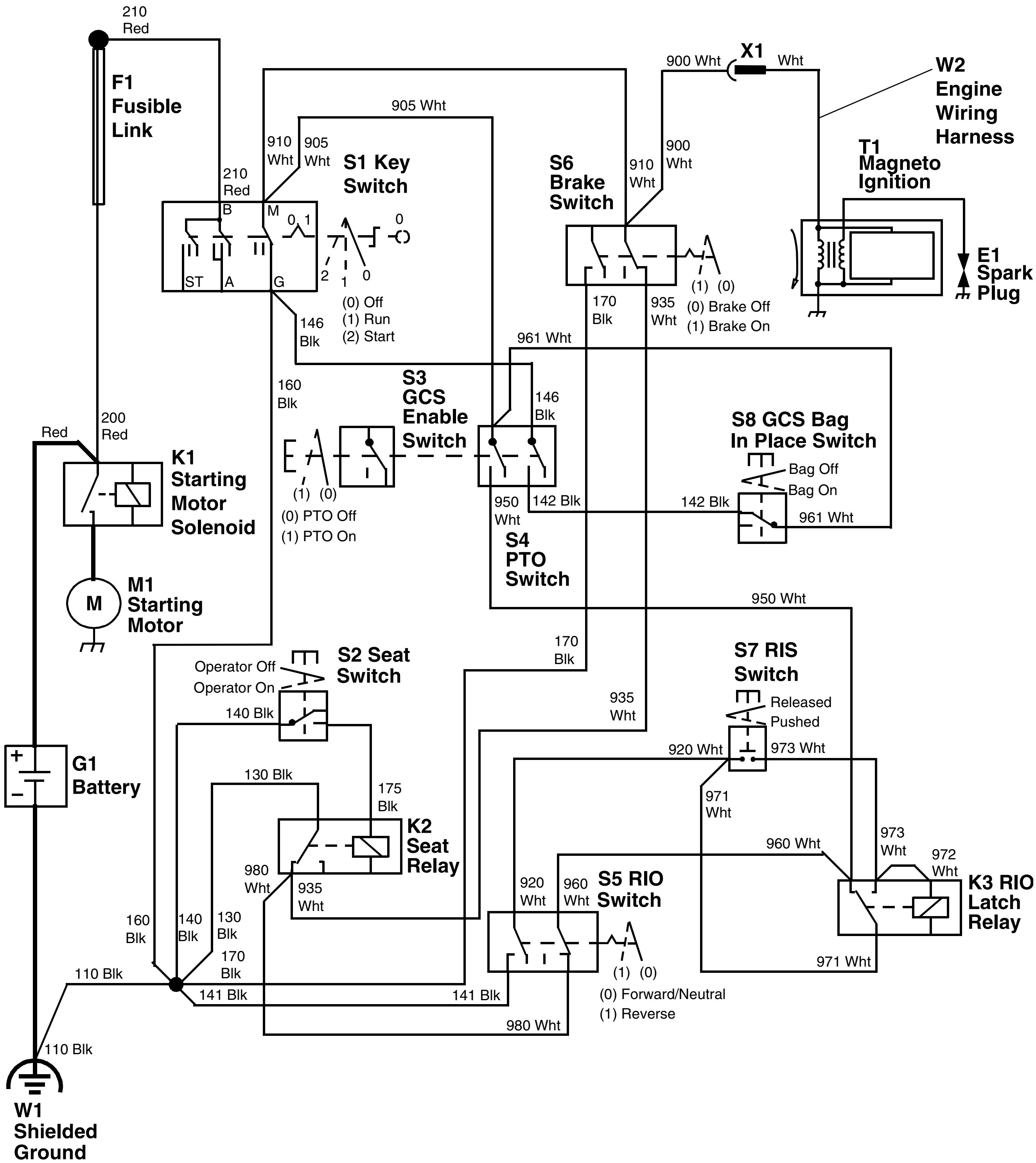
**Test Conditions:**

- Key switch in RUN position (Engine NOT running)
- Park brake ON
- Seat switch ON
- PTO ON (ENGAGED)
- GCS bag in place switch BAG OFF position
- Engine wiring harness disconnected from main wiring harness

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 12. Seat relay | Continuity to ground | Check 175 Blk wire and connections. If OK replace seat switch. |
| 13. PTO switch | Continuity to ground | Check 141, 130 and 135 Blk wires and connections. |
| 14. Grass Collection System (GCS) bag in place switch | Continuity to ground | Check 142 Blk wire and connections. If OK, replace PTO switch.. |
| 15. X1 Engine harness connector | Continuity to ground | Check 961, 905, 910 and 900 Wht wires and connections. If OK, replace GCS bag in place switch. |


Spark Plug Tester
2
1
E1 Spark Plug
S8 GCS Bag
In Place Switch
142 Blk
145 Blk
14
S1 Key Switch
3
130 Blk
141 Blk
15
4
X1 To Engine Wiring Harness
900 Wht
S2 Seat Switch
10
144 Blk
141 Blk
13
8
950 Wht
S4 PTO Switch
S8 GCS Bag
In Place Switch
961 Wht
5
920 Wht
9
965 Wht
7
S5 RIO Switch
S6 Brake Switch
935 Wht
6
12
175 Blk
K2 Seat Relay
5
170 Blk

# IGNITION & SHUTOFF CIRCUIT SCHEMATIC—LTR155 w/15 AMP CHARGER



# CIRCUIT DIAGNOSIS—LTR155 w/15 AMP CHARGER

**Test Conditions:**

- Key switch in OFF position
- Park brake ON
- PTO OFF (DISENGAGED)
- Engine cool to avoid burns

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Spark plug | Spark plug not fouled<br>Correct air gap | Adjust air gap<br>Replace spark plug |

**Test Conditions:**

- Key switch in START position
- Park brake ON
- PTO OFF (DISENGAGED)

*NOTE: Engine will turn over and can start during this test*

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 2. Spark plug tester installed. See "GCS BAG FULL SWITCH TEST" on page 155 | Spark present at tester | No spark: Check armature air gap. Check for grounded primary lead. Check for continuity between engine kill wire and ground (should be infinite).<br>Check ignition coil.<br>Weak Spark: Check spark plug(s) |

**Test Conditions:**

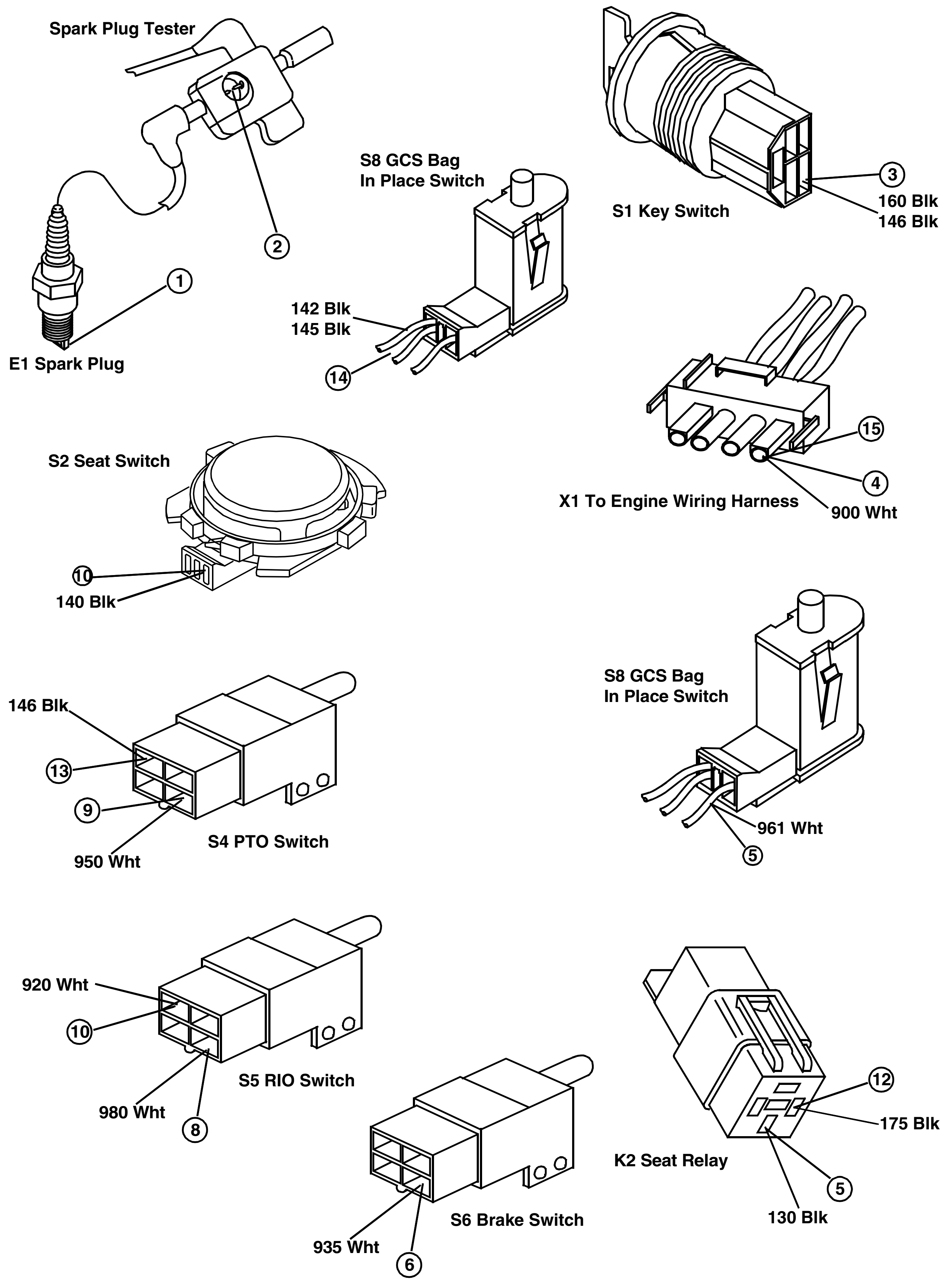
- Key switch in OFF position
- Park brake ON
- PTO OFF (DISENGAGED)
- Engine wiring harness disconnected from main wiring harness

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 3. Key switch | Continuity to ground. | Check 110 and 160 Blk wires and connections. |
| 4. X1 Engine harness connector | Continuity to ground | Check 910 and 900 Wht wires and connections. If OK, replace key switch. |
| 5. Grass Collection System (GCS) bag in place switch | Continuity to ground | Check 961 and 905 Wht wires and connections. If OK, replace key switch. |
| 6. Seat relay | Continuity to ground | Check 110 and 130 Blk wires and connections. |
| 7. Brake switch | Continuity to ground | Check 935 Wht wire and connections. If OK, replace the seat relay. |
| 8. RIO switch | Continuity to ground | Check 980 Wht wire and connections. |
| 9. PTO switch | Continuity to ground | Check 950 and 960 Wht wires and connections. If OK, replace the RIO switch. |
| 10. RIO switch | Continuity to ground | Check 920 and 971 Wht wires and connections. If OK, replace RIO latch relay. |
| 11. Seat switch | Continuity to ground | Check 110 and 140 Blk wires and connections. |

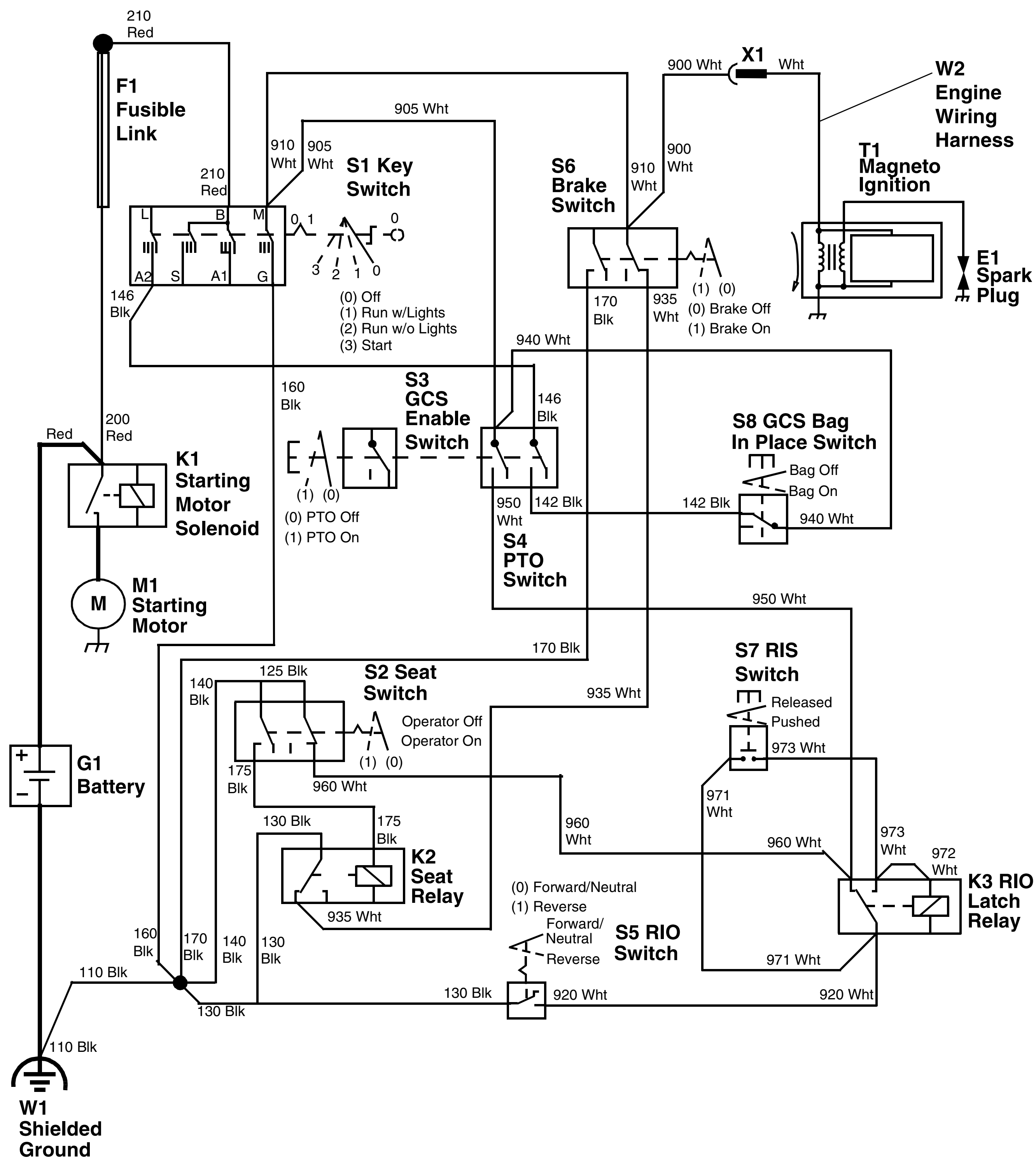
**Test Conditions:**

- Key switch in RUN position (Engine NOT running)
- Park brake ON
- Seat switch ON
- PTO ON (ENGAGED)
- GCS bag in place switch BAG OFF position
- Engine wiring harness disconnected from main wiring harness

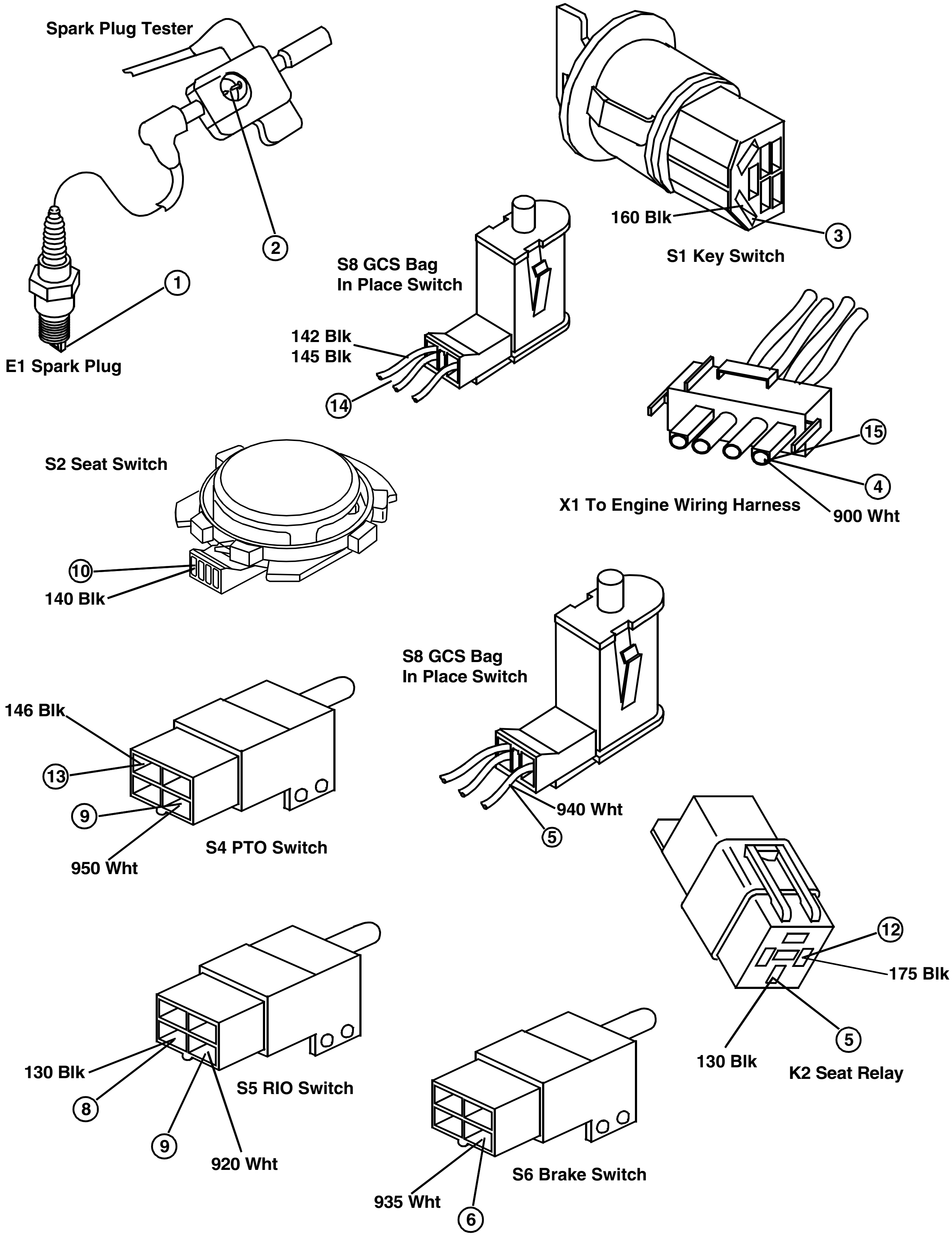
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 12. Seat relay | Continuity to ground | Check 175 Blk wire and connections. If OK replace seat switch. |
| 13. PTO switch | Continuity to ground | Check 146, 160 and 110 Blk wires and connections. |
| 14. Grass Collection System (GCS) bag in place switch | Continuity to ground | Check 142 Blk wire and connections. If OK, replace PTO switch. |
| 15. X1 Engine harness connector | Continuity to ground | Check 940, 905, 910 and 900 Wht wires and connections. If OK, replace GCS bag in place switch. |


Spark Plug Tester
2
1
E1 Spark Plug
S8 GCS Bag
In Place Switch
142 Blk
145 Blk
14
S1 Key Switch
3
160 Blk
146 Blk
15
4
X1 To Engine Wiring Harness
900 Wht
S2 Seat Switch
10
140 Blk
146 Blk
13
9
950 Wht
S4 PTO Switch
S8 GCS Bag
In Place Switch
961 Wht
5
920 Wht
10
980 Wht
8
S5 RIO Switch
S6 Brake Switch
935 Wht
6
12
175 Blk
K2 Seat Relay
5
130 Blk

# CIRCUIT SCHEMATIC—LTR155 w/4 POSITION KEY SWITCH



# CIRCUIT DIAGNOSIS—LTR155 w/4 POSITION KEY SWITCH



**Test Conditions:**

- Key switch in OFF position
- Park brake ON
- PTO OFF (DISENGAGED)
- Engine cool to avoid burns

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Spark plug | Spark plug not fouled<br>Correct air gap | Adjust air gap<br>Replace spark plug |

**Test Conditions:**

- Key switch in START position
- Park brake ON
- PTO OFF (DISENGAGED)

*NOTE: Engine will turn over and can start during this test*

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 2. Spark plug tester installed. See "GCS BAG FULL SWITCH TEST" on page 155 | Spark present at tester | No spark: Check armature air gap. Check for grounded primary lead. Check for continuity between engine kill wire and ground (should be infinite).<br>Check ignition coil.<br>Weak Spark: Check spark plug(s) |

**Test Conditions:**

- Key switch in OFF position
- Park brake ON
- PTO OFF (DISENGAGED)
- Engine wiring harness disconnected from main wiring harness

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 3. Key switch | Continuity to ground. | Check 160 and 110 Blk wires and connections to ground. |
| 4. X1 Engine harness connector | Continuity to ground | Check 910 and 900 Wht wires and connections. If OK, replace key switch. |
| 5. Grass Collection System (GCS) bag in place switch | Continuity to ground | Check 940 and 905 Wht wires and connections. If OK, replace key switch. |
| 6. Seat relay | Continuity to ground | Check 110 and 130 Blk wires and connections. |
| 7. Brake switch | Continuity to ground | Check 935 Wht wire and connections. If OK, replace the seat relay. |
| 8. RIO switch | Continuity to ground | Check 130 Blk wire and connections |
| 9. PTO switch | Continuity to ground | Check 950 and 960 Wht wires and connections. If OK, replace the RIO switch. |
| 10. RIO switch | Continuity to ground | Check 920 and 971 Wht wires and connections. If OK, replace RIO latch relay. |
| 11. Seat switch | Continuity to ground | Check 110 and 140 Blk wires and connections. |

**Test Conditions:**

- Key switch in RUN position (Engine NOT running)
- Park brake ON
- Seat switch ON
- PTO ON (ENGAGED)
- GCS bag in place switch BAG OFF position
- Engine wiring harness disconnected from main wiring harness

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 12. Seat relay | Continuity to ground | Check 175 Blk wire and connections. If OK replace seat switch. |
| 13. PTO switch | Continuity to ground | Check 146, 160 and 110 Blk wires and connections. |
| 14. Grass Collection System (GCS) bag in place switch | Continuity to ground | Check 142 Blk wire and connections. If OK, replace PTO switch. |
| 15. X1 Engine harness connector | Continuity to ground | Check 940, 905, 910 and 900 Wht wires and connections. If OK, replace GCS bag in place switch. |

# IGNITION & SHUTOFF CIRCUIT OPERATION—LTR166 & LTR180

### Function:

To create a spark at the correct time that ignites the fuel/air mixture in the cylinder. To ground the system to keep the engine from starting or to shut off the engine.

### Operating Conditions:

To produce a spark, the key switch must be in the START or RUN position. The operator can be ON or OFF the seat; however, the PTO must be disengaged and the brake switch must be ENGAGED (brake pedal depressed or park brake on) to start the engine.

Once the engine is running, the operator must be ON the seat to disengage the brake and/or engage the PTO.

The engine will shutoff under any of the following conditions:

- When the key switch is turned to the OFF position
- If the operator leaves the seat without locking the parking brake
- If the operator leaves the seat with the PTO on (engaged)
- If the operator places the tractor in reverse with the PTO engaged without pressing the reverse implement switch (RIS)
- If the PTO is engaged without having the GCS bag properly in place

### System Operation

### Ignition:

The ignition system is a transistor-controlled magneto design. Ignition timing is controlled by the transistor and is not adjustable. The engine is shut off by grounding both sides of the ignition primary coil. With the ignition primary coil grounded, a spark cannot be produced.

When the engine is turning over, (see “CRANKING CIRCUIT OPERATION—LTR166 & LTR180” on page 68), the flywheel magnets induces current into the magneto ignition coil, which in turn produces current high enough to jump the spark plug gap, creating spark to ignite the engine fuel/air mixture.

### System Operation

### Shutoff:

The engine is shut off by grounding both sides of the ignition primary coil. With the ignition primary coil grounded, a spark cannot be produced.

Placing the key switch in the OFF position creates one path to ground for the Wht wire from the engine magneto, 900, 910 Wht wires, key switch contacts (normally closed), 120 and 110 Blk wires.

Another path to ground is created with the key switch in the ON position, any time the operator is OFF the seat (seat switch CLOSED) without having the brakes locked on or by having the PTO engaged. The seat switch creates a ground path for the magneto ignition through either the brake switch or the PTO switch.

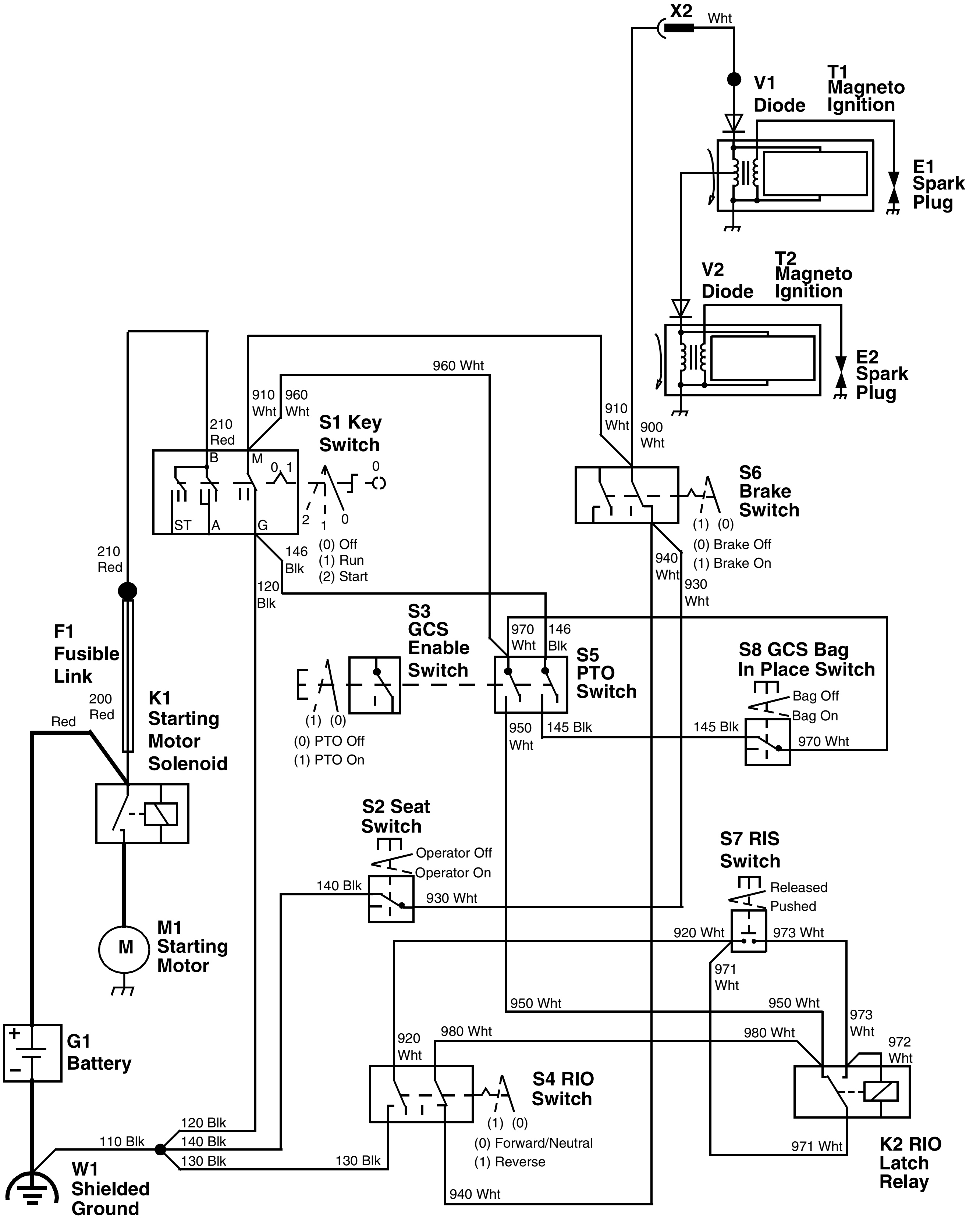
If the brake were off when the operator leaves the seat the ground path would be created from the magneto Wht wire, 900 Wht wire, brake switch contacts (normally closed), 930 Wht wire, Seat switch contacts (normally closed), 140 and 110 Blk wires.

If the PTO were engaged when the operator leaves the seat the ground path would be created from the magneto Wht wire, 900, 910, and 960 Wht wires, PTO contacts (normally closed), 950 and 980 Wht wires, RIO switch contacts (normally closed), 940 and 930 Wht wire (w/3 Position key switch), 920 Wht wire (w/4 Position key switch) seat switch contacts (normally closed), 140 and 110 Blk wires.

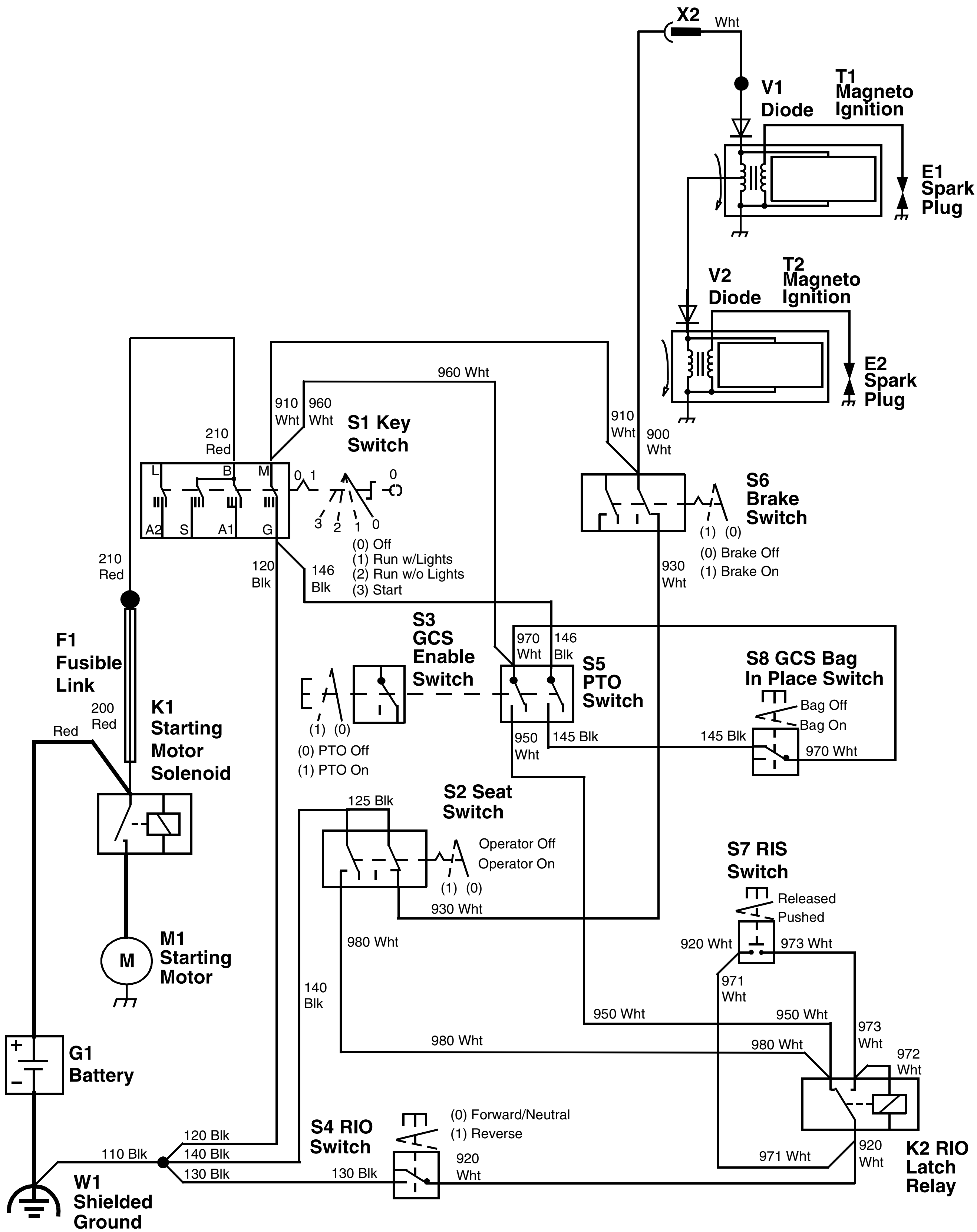
A fourth path to ground will be created with engine running, if the operator places the tractor in reverse while the PTO is engaged and the Reverse Implement Switch is not pressed. See “PTO with RIO CIRCUIT OPERATION—LTR166 w/3 POSITION KEY SWITCH” on page 110.

Finally the Grass Collection System (GCS) will cause the engine to shutoff if the PTO is engaged and the GCS bag is not properly in place. During this condition the path to ground for the magneto Wht wire is created through the 900, 910, 960, and 970 Wht wires, GCS bag in place switch contacts (normally closed), 145 Blk wire, PTO switch contacts (normally open), 146, 120, and 110 Blk wires.

# CIRCUIT SCHEMATIC—LTR166



# CIRCUIT SCHEMATIC—LTR166 & LTR180 w/4 POSITION KEY SWITCH



# IGNITION & SHUTOFF CIRCUIT DIAGNOSIS—LTR166 & LTR180

**Test Conditions:**

- Key switch in OFF position
- Park brake ON
- PTO OFF (DISENGAGED)
- Engine cool to avoid burns

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Spark plug | Spark plug not fouled<br>Correct air gap | Adjust air gap<br>Replace spark plug |

**Test Conditions:**

- Key switch in START position
- Park brake ON
- PTO OFF (DISENGAGED)

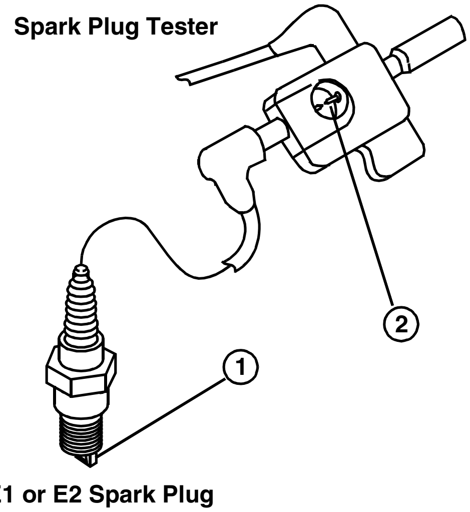
*NOTE: Engine will turn over and can start during this test*

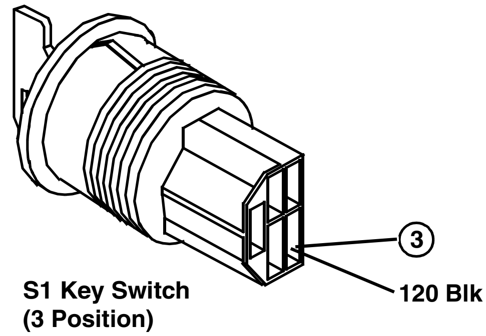
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 2. Spark plug tester installed. See "GCS BAG FULL SWITCH TEST" on page 155 | Spark present at tester | No spark: Check armature air gap. Check for grounded primary lead. Check for continuity between engine kill wire and ground (should be infinite)<br>Check ignition coil<br>Weak Spark: Check spark plug(s) |

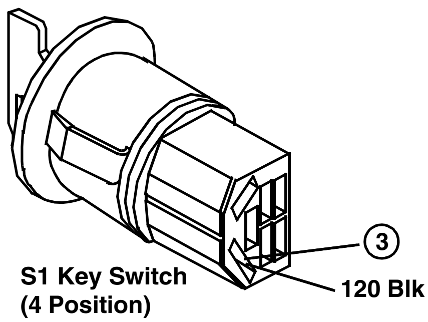
**Test Conditions:**

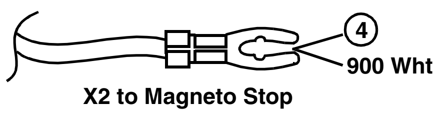
- Key switch in OFF position
- Park brake ON
- PTO OFF (DISENGAGED)
- Engine wiring harness disconnected from main wiring harness

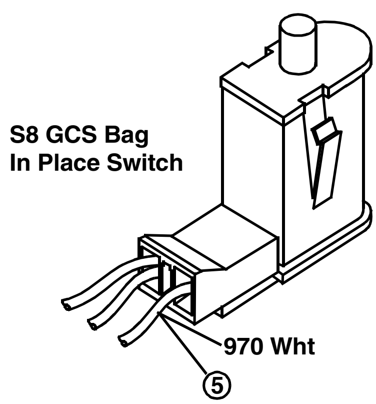
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 3. Key switch | Continuity to ground | Check 110 and 120 Blk wires and connections. |
| 4. X2 Engine connector | Continuity to ground | Check 910 and 900 Wht wires and connections. If OK, replace key switch. |
| 5. Grass Collection System (GCS) bag in place switch | Continuity to ground | Check 960 and 970 Wht wires and connections. If OK, replace key switch. |
| 6. Seat switch | Continuity to ground | Check 140 and 110 Blk wires and connections. |
| 7. RIO switch | Continuity to ground | Check 930 and 940 Wht wires and connections (3 Position key switch), 920 Wht (4 Position key switch). If OK, replace seat switch. |
| 8. PTO switch | Continuity to ground | Check 980 and 950 Wht wires and connections. If OK, replace RIO switch. |
| 9. RIO switch | Continuity to ground | Check 920 and 971 Wht wires and connections. If OK, replace RIO latch relay. |

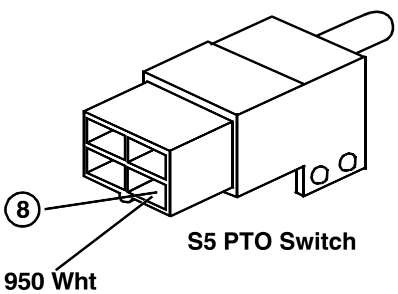

Spark Plug Tester
2
1
E1 or E2 Spark Plug

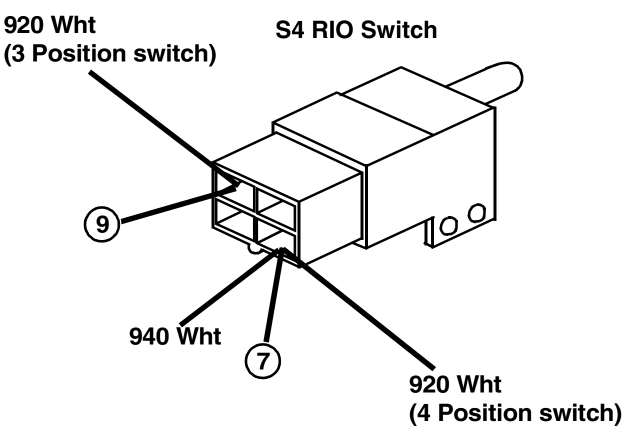

3
120 Blk
S1 Key Switch
(3 Position)

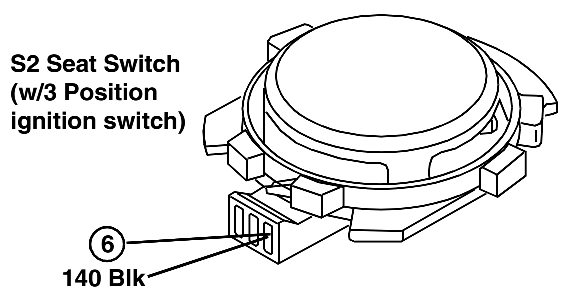

3
120 Blk
S1 Key Switch
(4 Position)

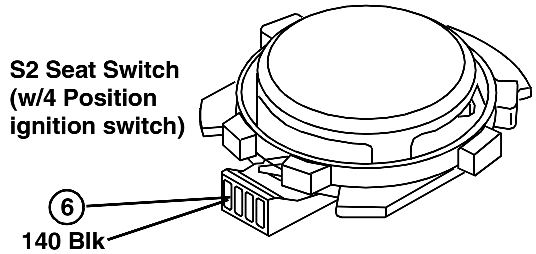

4
900 Wht
X2 to Magneto Stop


S8 GCS Bag
In Place Switch
970 Wht
5


8
950 Wht
S5 PTO Switch


920 Wht
(3 Position switch)
S4 RIO Switch
9
940 Wht
7
920 Wht
(4 Position switch)


S2 Seat Switch
(w/3 Position
ignition switch)
6
140 Blk


S2 Seat Switch
(w/4 Position
ignition switch)
6
140 Blk

# IGNITION & SHUTOFF CIRCUIT DIAGNOSIS—LTR166/180, cont.

**Test Conditions:**

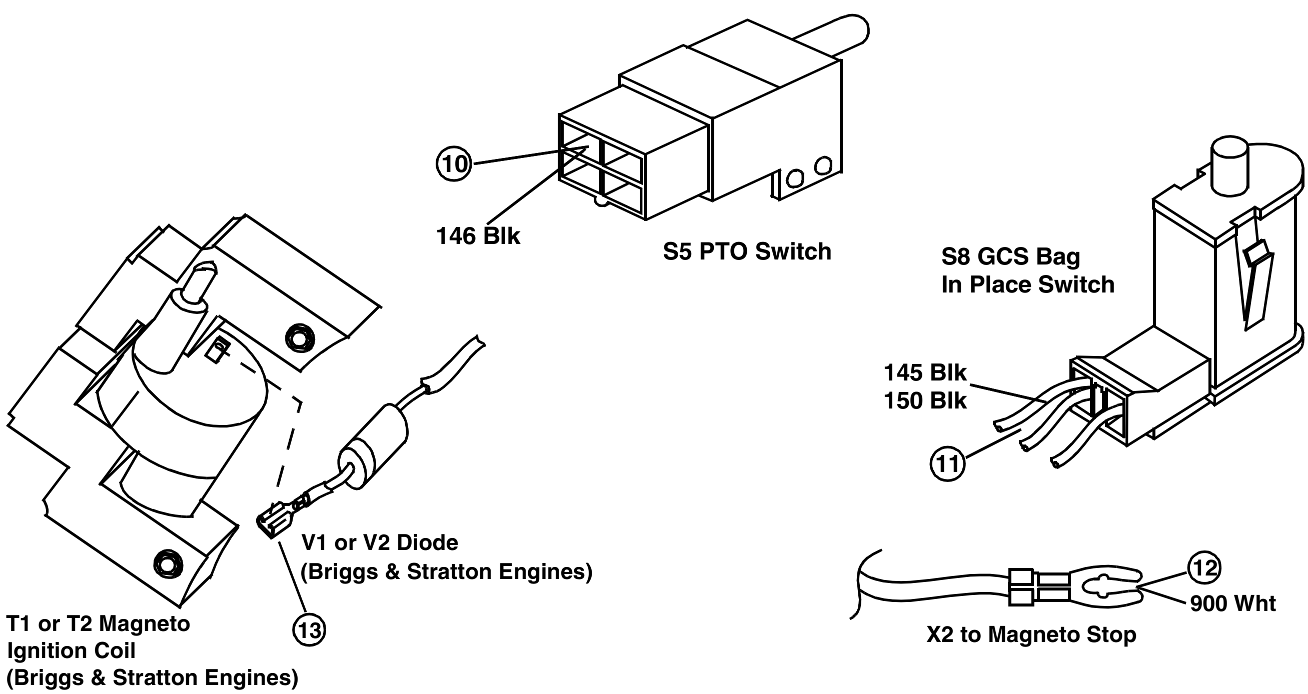
- Key switch in RUN position (Engine NOT running)
- Park brake ON
- Seat switch ON
- PTO ON (ENGAGED)
- GCS bag in place switch BAG OFF position
- Engine wiring harness disconnected from main wiring harness

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 10. PTO switch | Continuity to ground | Check 146, 120 and 110 Blk wires and connections. |
| 11. GCS bag in place switch | Continuity to ground | Check 145 Blk wire and connections. If OK, replace PTO switch. |
| 12. X1 Engine harness connector | Continuity to ground | Check 970, 960, 910 and 900 Wht wires and connections. If OK, replace GCS bag in place switch. |

**Test Conditions: (Briggs & Stratton Engines ONLY – Test performed if engine will NOT shut off when operator leaves seat with EITHER PTO ENGAGED or brake switch OFF.)**

- Key switch in OFF position (Closes fuel valve to stop engine)
- Allow engine to cool, and remove engine cover to access ignition coils
- Disconnect diode(s) from ignition coil(s)
- Operator OFF seat
- PTO ON (ENGAGED); or, Park brake OFF

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 13. Ignition coil diode(s) | Continuity to ground with diode disconnected from ignition coil | Faulty diode(s)<br>Replace diode(s) |



# CHARGING & SHUNT CIRCUIT OPERATION—LTR155 w/3 AMP CHARGER

### Function:

To maintain battery voltage at 12.4 volts or higher, to provide electrical power to light the headlights, and to reduce the time it takes for the engine to shut down.

### Operating Conditions:

The engine must be running for both the charging system to operate, and the headlights to be on.

The shunt circuit is functional when the engine is turned off.

### System Operation:

The stator provides DC current for charging the battery, an independent AC circuit for headlights, and an additional independent AC circuit that is used to place a load on the alternator when the engine is shut off.

Current for lights is available as long as the engine is running. The output depends upon engine speed, so brightness of the lights changes with engine speed.

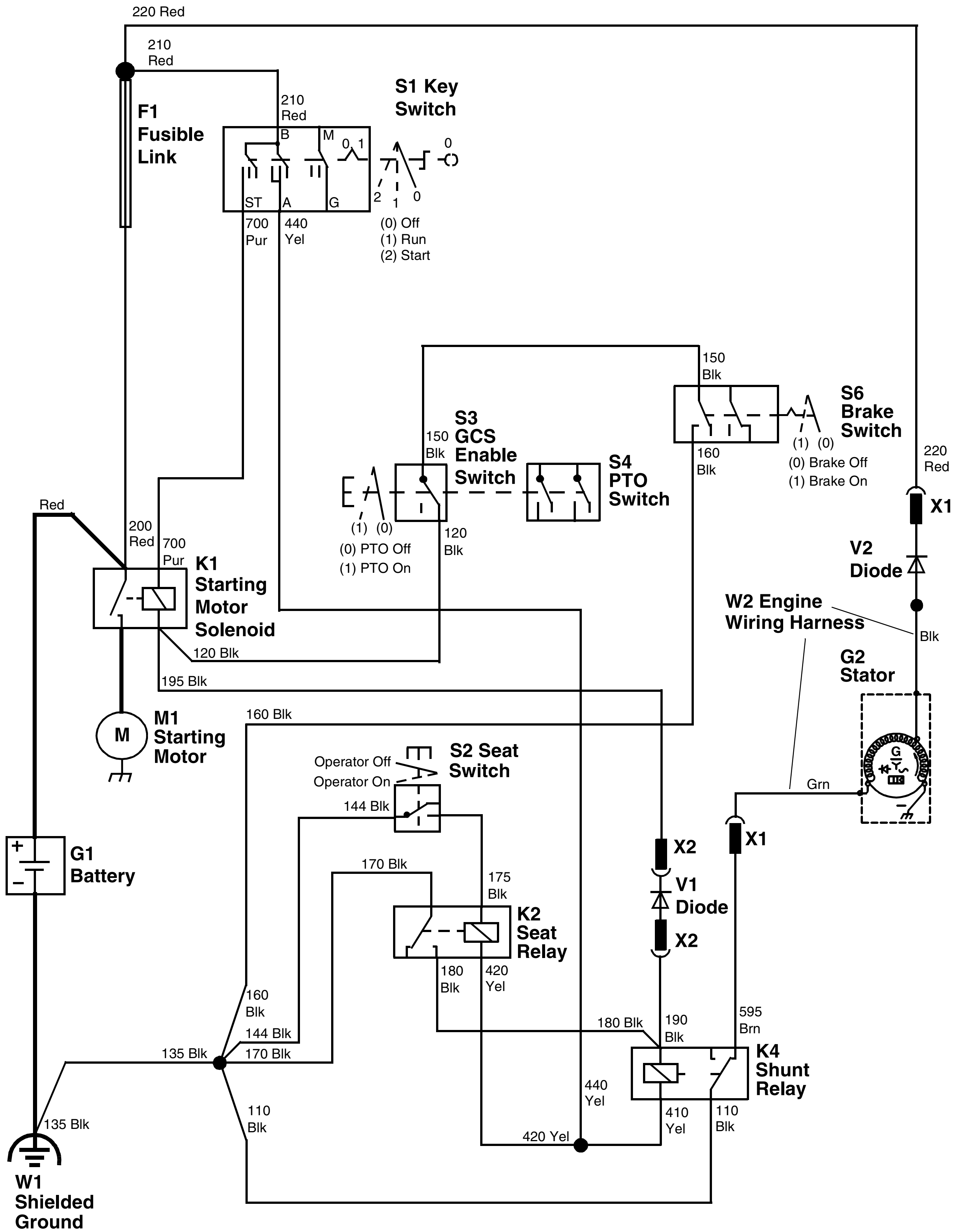
Magnets mounted to the flywheel rotate around two coils of wire, (the stator), mounted underneath the flywheel. As the magnets rotate, current is generated in the coiled wire and converted, with a diode, to DC current to charge the battery.

The current from the DC side of the stator is unregulated and is rated at 3 amps. The output rises from 2 amps at idle to 3 amps at full throttle.

The shunt circuit is used to cause the engine to stop faster when the engine is shut off. When the key switch is in the RUN position and the PTO is off and the brake is on, or the operator is on the seat, the shunt relay is energized and opens the contacts that connect one phase of the alternator to ground. This reduces the load on the alternator to 2-3 amps for recharging the battery and 3-5 amps for illuminating the headlights.

When the ignition is grounded to shut the engine off, (See “IGNITION & SHUTOFF CIRCUIT OPERATION—LTR155” on page 72), the shunt relay is deenergized. This allows contact across the normally closed set of contacts, grounding the alternator. This places a load on the alternator, which in turn places a load on the engine. Since the engine ignition system has been turned off, the engine has no power to turn the extra load. The result is that the engine stops spinning faster.

# CIRCUIT SCHEMATIC—LTR155 w/3 AMP CHARGER



# CHARGING & SHUNT CIRCUIT DIAGNOSIS—LTR155 w/3 AMP CHARGER

**Test Conditions:**

- Key switch RUN position, engine RUNNING at full throttle
- Engine connector unplugged
- Park brake ON
- PTO OFF

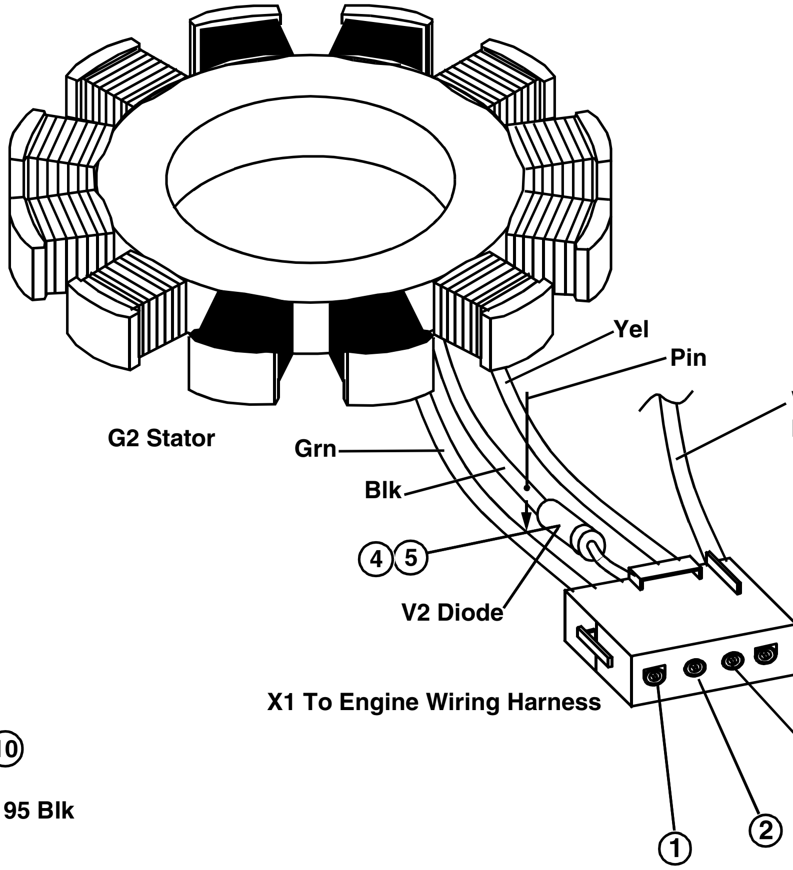
*NOTE: Engine connector must be plugged back together to shut engine off*

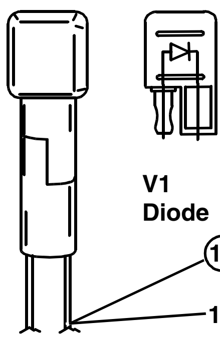
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Engine connector, Grn wire | 45 volts AC or higher | Replace stator. |
| 2. Engine connector, Blk wire | 6.5 volts DC or higher | Check diode, if diode is OK, replace stator. |
| 3. Engine connector, Yel wire | 14.5 volts AC or higher | Replace stator. |

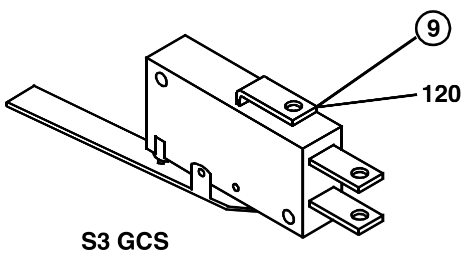
**Test Conditions:**

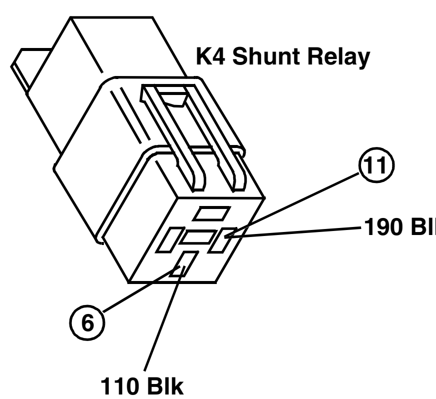
- Key switch OFF
- PTO OFF
- Park Brake ON

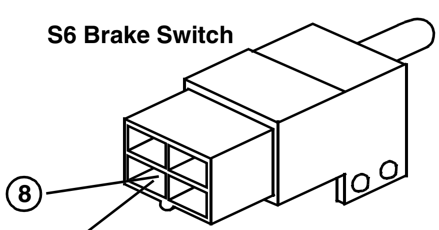
| | | |
|---|---|---|
| 4. Stator wire harness, diode | Continuity with black test lead clipped to connector pin, and red test lead clipped to pin piercing wire behind diode | Replace Diode. |
| 5. Stator wire harness, diode | No continuity with black test lead clipped to pin piercing wire behind diode, and red test lead clipped to connector pin | Replace Diode. |
| 6. Shunt relay | Continuity to ground | Check 110 and 135 Blk wire and connections. |
| 7. X1 Engine connector | Continuity to ground | Check 595 Brn wire and connections. If OK, replace shunt relay. |
| 8. Brake switch | Continuity to ground | Check 160 and 110 Blk wires and connections. |
| 9. Grass Collection System (GCS) enable switch | Continuity to ground | Check 150 Blk wire and connections. If OK, replace brake switch. |
| 10. Diode connector | Continuity to ground | Check 195 Blk wire and connections. |
| 11. Shunt relay | Continuity to ground | Check 190 Blk wire and connections. If OK, replace V1 diode. |

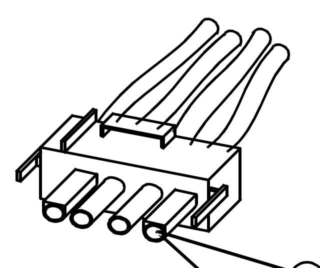

Yel
Pin
Wht wire to Magneto
G2 Stator
Grn
Blk
4 5
V2 Diode
X1 To Engine Wiring Harness
3
2
1


V1
Diode
10
195 Blk


9
120 Blk
S3 GCS
Enable Switch


K4 Shunt Relay
11
190 Blk
6
110 Blk


S6 Brake Switch
8
160 Blk


7
595 Brn
X1 To Engine Wiring Harness

# CHARGING & SHUNT CIRCUIT OPERATION—LTR155 w/15 AMP CHARGER

**Function:**

To maintain battery voltage at 12.4 volts or higher and to reduce the time it takes for the engine to shut down.

**Operating Conditions:**

The engine must be running for the charging system to operate.

The charging system is a permanent magnet and stator design. Charging output is controlled by the (N1) voltage regulator/rectifier.

With the engine running, current flows from the voltage regulator/rectifier to the battery positive (+) terminal through the 220 Red wire, F1 fusible link, 200 Red wire and battery cable. The circuit allows the voltage regulator/rectifier to charge the battery.

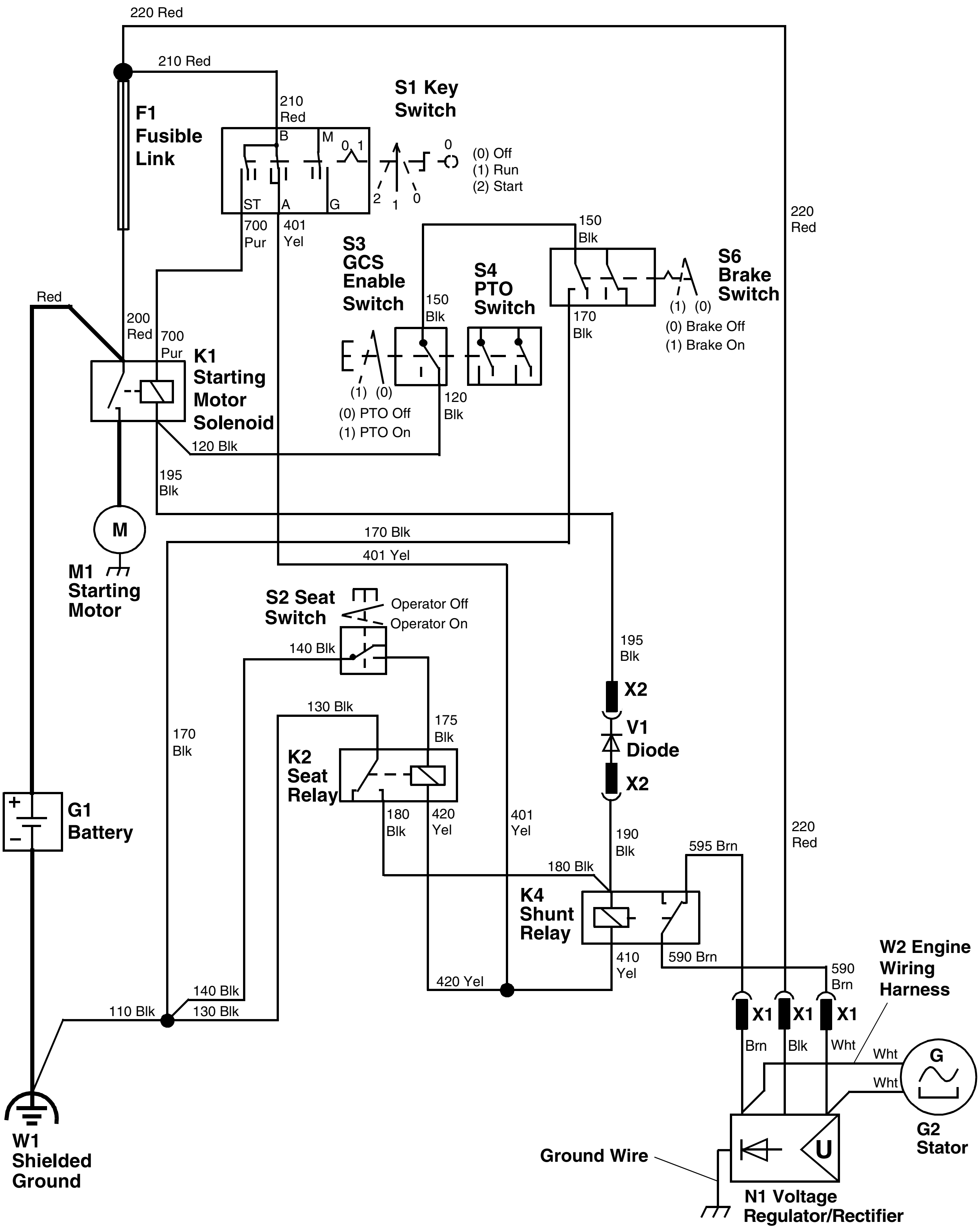
As the flywheel turns, a permanent magnet located in the flywheel induces AC current in the stator (G2) windings. The AC current flows to the regulator/rectifier. The regulator/rectifier converts the AC current to DC current needed to charge the battery.

When voltage drops below 14.7 VDC, the voltage regulator/rectifier allows DC current to flow to the battery to charge it. As the battery becomes fully charged, the regulator reduces current flow to the battery.

The shunt circuit is used to cause the engine to stop faster when the engine is shut off. When the key switch is in the RUN position and the PTO is off and the brake is on, or the operator is on the seat, the shunt relay is energized and opens the contacts that connect the two stator leads, 590 and 595 Brn, together.

When the ignition is grounded to shut the engine off, (See “IGNITION & SHUTOFF CIRCUIT OPERATION—LTR155” on page 72); the shunt relay is deenergized. This allows contact across the normally closed set of contacts of the shunt relay, shorting the two stator leads together. This places a full output load on the stator, which in turn places a load on the engine. Since the engine ignition system has been turned off, the engine has no power to turn the extra load. The result is that the engine stops spinning faster.

# CIRCUIT SCHEMATIC—LTR155 w/15 AMP CHARGER



# CHARGING & SHUNT CIRCUIT DIAGNOSIS—LTR155 w/15 AMP CHARGER

**Test Conditions:**

- Key switch OFF
- PTO OFF
- Park Brake ON

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Voltage regulator/rectifier | Battery voltage, 12.4 volts or higher. | Check 220 Red wire, fusible link and connections. If OK, test battery. |
| 2. Voltage regulator/rectifier | Continuity to ground | Check battery negative cable and shielded ground. |
| 3. Brake switch | Continuity to ground | Check 170 and 110 Blk wires and connections. |
| 4. Grass Collection System (GCS) enable switch | Continuity to ground | Check 150 Blk wire and connections. If OK, replace brake switch. |
| 5. Shunt relay | Continuity to ground | Check 190 and 195 Blk wires and connections. Test V1 diode. See “DIODE TEST” on page 150. |
| 6. W1 main wiring harness X1 Engine connector | Continuity between terminals | Check 590 and 595 Brn wires and connections. If OK, replace shunt relay. |

**Test Conditions:**

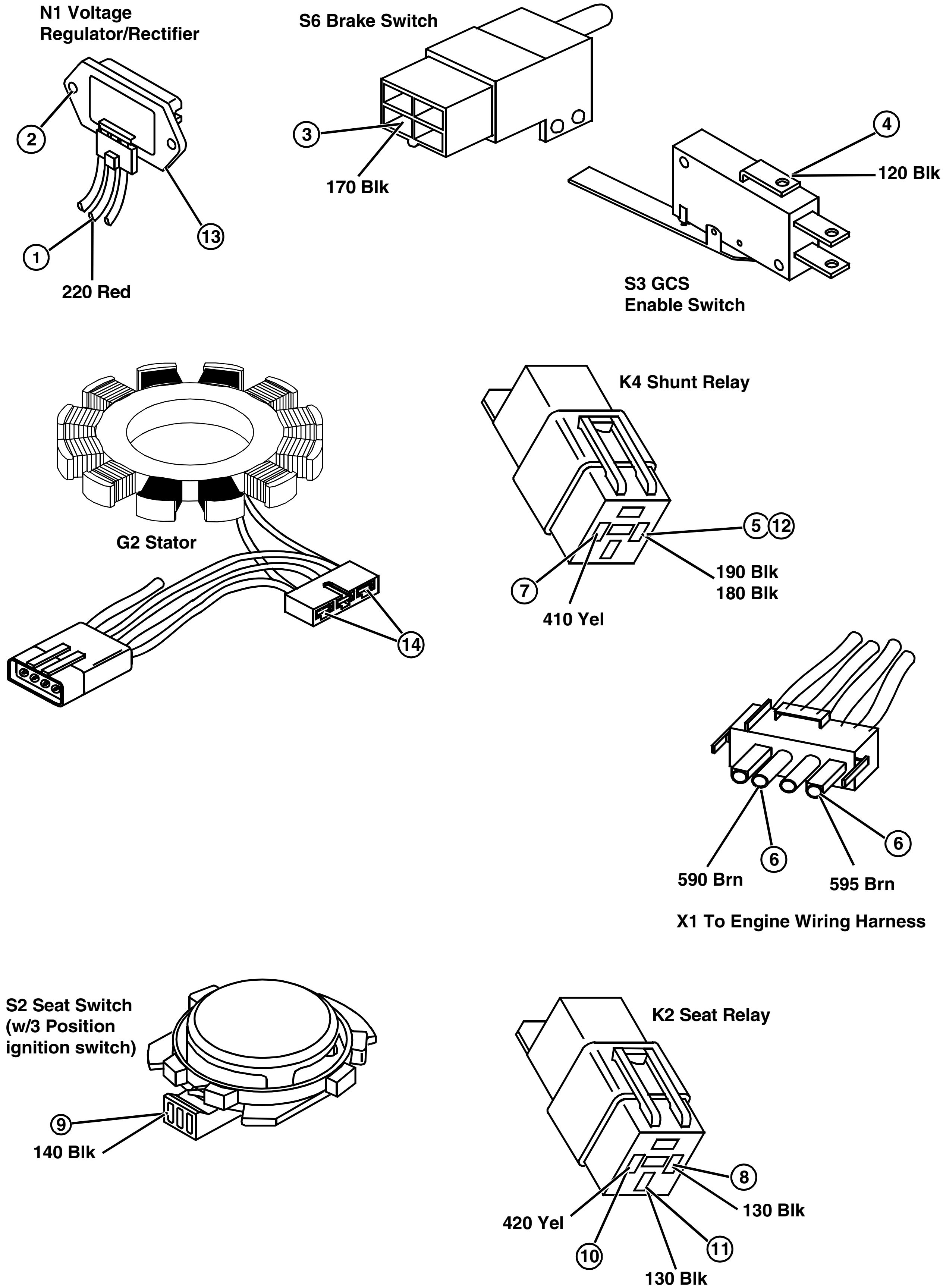
- Key switch in RUN position
- PTO OFF
- Seat switch ON (operator ON seat)
- Park brake OFF

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 7. Shunt relay | Battery voltage | Check 410 and 401 Yel wires and connections. If OK, replace key switch. |
| 8. Seat relay | Battery voltage | Check 420 and 401 Yel wires and connections. If OK, replace key switch. |
| 9. Seat Switch | Continuity to ground | Check 140 and 110 Blk wires and connections. |
| 10. Seat relay | Continuity to ground | Check 175 Blk wire and connections. If OK, replace the seat switch. |
| 11. Seat relay | Continuity to ground | Check 130 and 110 Blk wires and connections. |
| 12. Shunt relay | Continuity to ground | Check 180 Blk wire and connections. If OK, replace the seat relay. |

**Test Conditions:**

- As defined in test section

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 13. Voltage regulator/rectifier. See “VOLTAGE REGULATOR/ RECTIFIER TEST—LTR155 w/15 AMP CHARGER” on page 149. | Passes test | Replace regulator/rectifier. |
| 14. Stator. See “STATOR OUTPUT TEST w/15 AMP CHARGER” on page 147. | Passes test | Replace stator. |


N1 Voltage
Regulator/Rectifier
2
1
13
220 Red
S6 Brake Switch
3
170 Blk
4
120 Blk
S3 GCS
Enable Switch
K4 Shunt Relay
5 12
190 Blk
180 Blk
7
410 Yel
G2 Stator
14
6
6
590 Brn
595 Brn
X1 To Engine Wiring Harness
S2 Seat Switch
(w/3 Position
ignition switch)
9
140 Blk
K2 Seat Relay
8
130 Blk
420 Yel
10
11
130 Blk

# CHARGING & SHUNT OPERATION—LTR155 w/4 POSITION KEY SWITCH

**Function:**

To maintain battery voltage at 12.4 volts or higher and to reduce the time it takes for the engine to shut down.

**Operating Conditions:**

The engine must be running for the charging system to operate.

The charging system is a permanent magnet and stator design. Charging output is controlled by the (N1) voltage regulator/rectifier.

With the engine running, current flows from the voltage regulator/rectifier to the battery positive (+) terminal through the 220 Red wire, F1 fusible link, 200 Red wire and battery cable. The circuit allows the voltage regulator/rectifier to charge the battery.

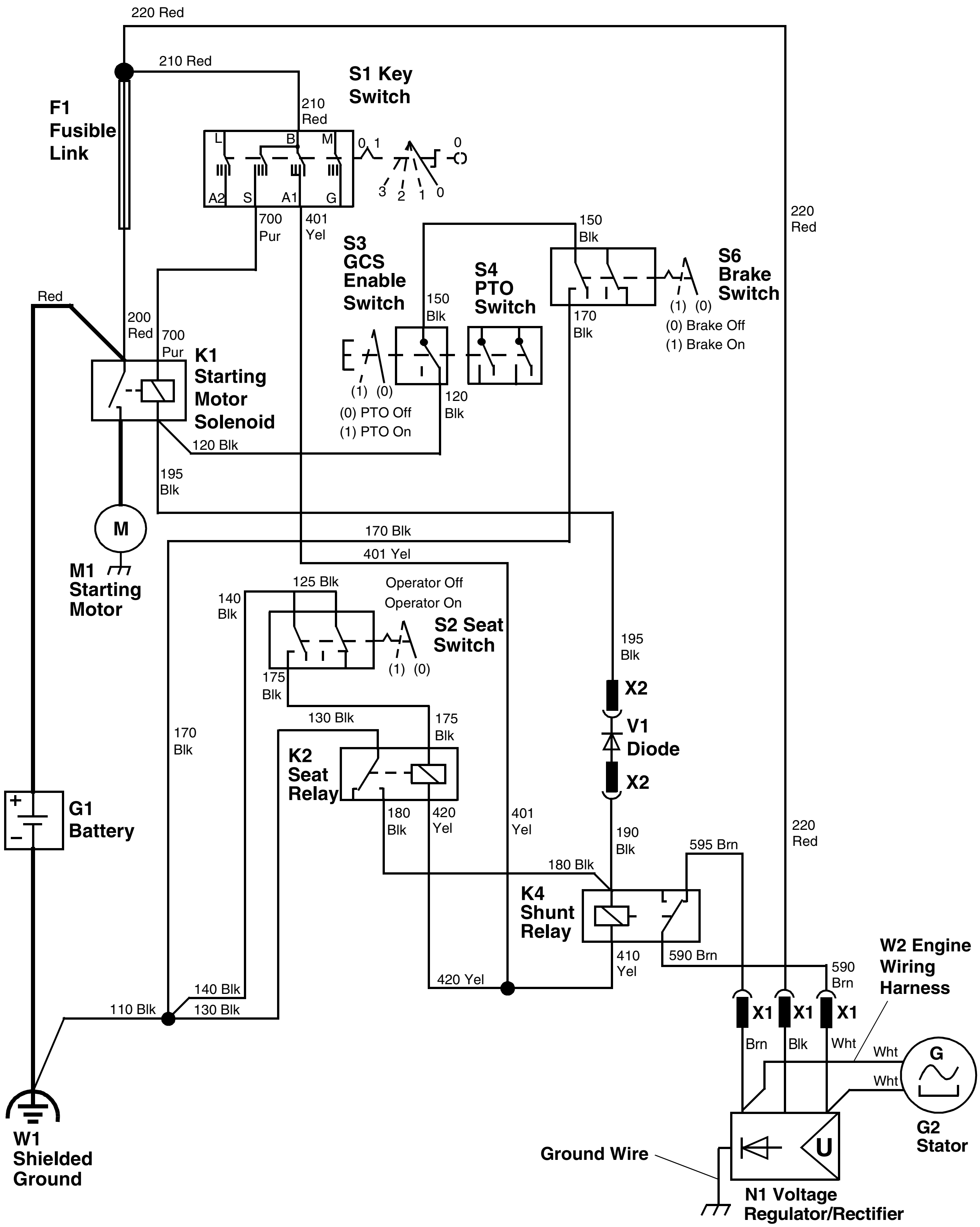
As the flywheel turns, a permanent magnet located in the flywheel induces AC current in the stator (G2) windings. The AC current flows to the regulator/rectifier. The regulator/rectifier converts the AC current to DC current needed to charge the battery.

When voltage drops below 14.7 VDC, the voltage regulator/rectifier allows DC current to flow to the battery to charge it. As the battery becomes fully charged, the regulator reduces current flow to the battery.

The shunt circuit is used to cause the engine to stop faster when the engine is shut off. When the key switch is in the RUN position and the PTO is off and the brake is on, or the operator is on the seat, the shunt relay is energized and opens the contacts that connect the two stator leads, 590 and 595 Brn, together.

When the ignition is grounded to shut the engine off, (See “IGNITION & SHUTOFF CIRCUIT OPERATION—LTR155” on page 72); the shunt relay is deenergized. This allows contact across the normally closed set of contacts of the shunt relay, shorting the two stator leads together. This places a full output load on the stator, which in turn places a load on the engine. Since the engine ignition system has been turned off, the engine has no power to turn the extra load. The result is that the engine stops spinning faster.

# CHARGING & SHUNT SCHEMATIC—LTR155 w/4 POSITION KEY SWITCH



# CHARGING & SHUNT DIAGNOSIS—LTR155 w/4 POSITION KEY SWITCH

**Test Conditions:**

- Key switch OFF
- PTO OFF
- Park Brake ON

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Voltage regulator/rectifier | Battery voltage, 12.4 volts or higher. | Check 220 Red wire, fusible link and connections. If OK, test battery. |
| 2. Voltage regulator/rectifier | Continuity to ground | Check battery negative cable and shielded ground. |
| 3. Brake switch | Continuity to ground | Check 170 and 110 Blk wires and connections. |
| 4. Grass Collection System (GCS) enable switch | Continuity to ground | Check 150 Blk wire and connections. If OK, replace brake switch. |
| 5. Shunt relay | Continuity to ground | Check 190 and 195 Blk wires and connections. Test V1 diode. See "DIODE TEST" on page 150. |
| 6. W1 main wiring harness X1 Engine connector | Continuity between terminals | Check 590 and 595 Brn wires and connections. If OK, replace shunt relay. |

**Test Conditions:**

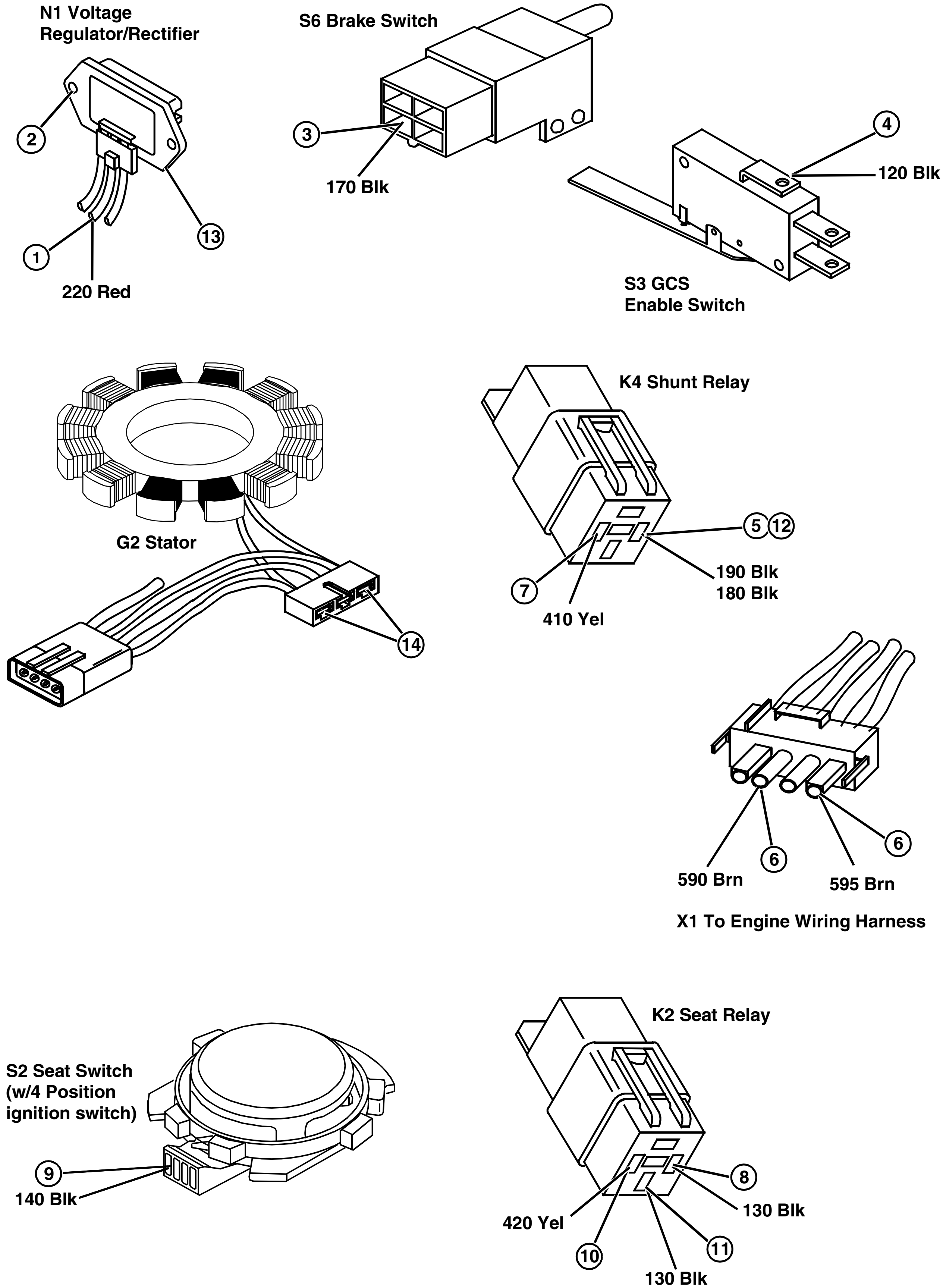
- Key switch in RUN position
- PTO OFF
- Seat switch ON (operator ON seat)
- Park brake OFF

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 7. Shunt relay | Battery voltage | Check 410 and 401 Yel wires and connections. If OK, replace key switch. |
| 8. Seat relay | Battery voltage | Check 420 and 401 Yel wires and connections. If OK, replace key switch. |
| 9. Seat Switch | Continuity to ground | Check 140 and 110 Blk wires and connections. |
| 10. Seat relay | Continuity to ground | Check 175 Blk wire and connections. If OK, replace the seat switch. |
| 11. Seat relay | Continuity to ground | Check 130 and 110 Blk wires and connections. |
| 12. Shunt relay | Continuity to ground | Check 180 Blk wire and connections. If OK, replace the seat relay. |

**Test Conditions:**

- As defined in test section

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 13. Voltage regulator/rectifier. See "VOLTAGE REGULATOR/ RECTIFIER TEST—LTR155 w/15 AMP CHARGER" on page 149. | Passes test | Replace regulator/rectifier. |
| 14. Stator. See "STATOR OUTPUT TEST w/15 AMP CHARGER" on page 147. | Passes test | Replace stator. |



N1 Voltage Regulator/Rectifier
2
13
1
220 Red
S6 Brake Switch
3
170 Blk
4
120 Blk
S3 GCS Enable Switch
G2 Stator
14
K4 Shunt Relay
5 12
7
410 Yel
190 Blk
180 Blk
6
6
590 Brn
595 Brn
X1 To Engine Wiring Harness
S2 Seat Switch (w/4 Position ignition switch)
9
140 Blk
K2 Seat Relay
8
130 Blk
420 Yel
10
11
130 Blk

# CHARGING CIRCUIT OPERATION—LTR166

**Function:**

To maintain battery voltage at 12.4 volts or higher, and provide electrical power to light the headlights.

**Operating Conditions:**

The engine must be running for both the charging system to operate, and the headlights to be on.

**System Operation:**

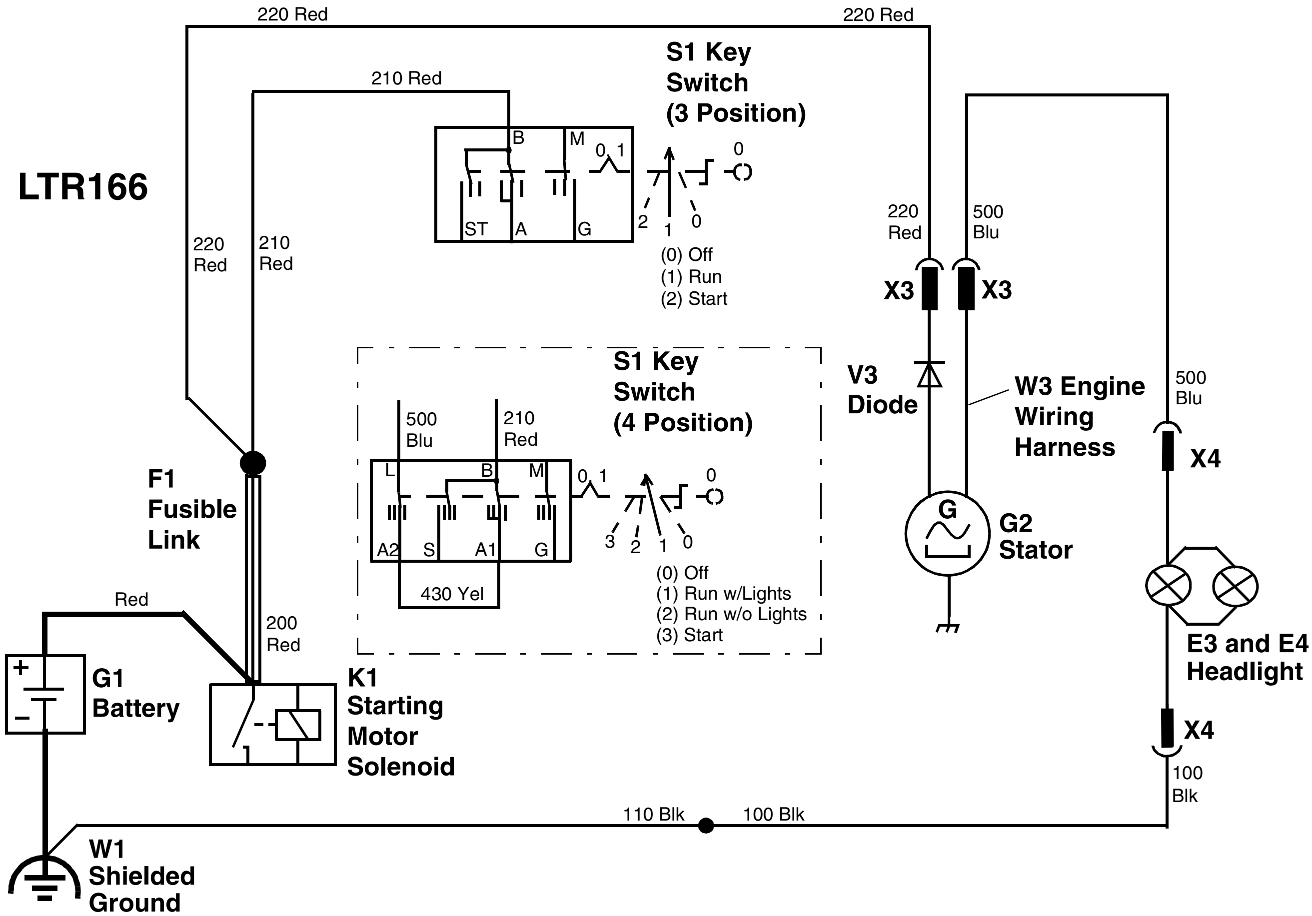
The dual circuit stator provides DC current for charging the battery and an independent AC circuit for headlights.

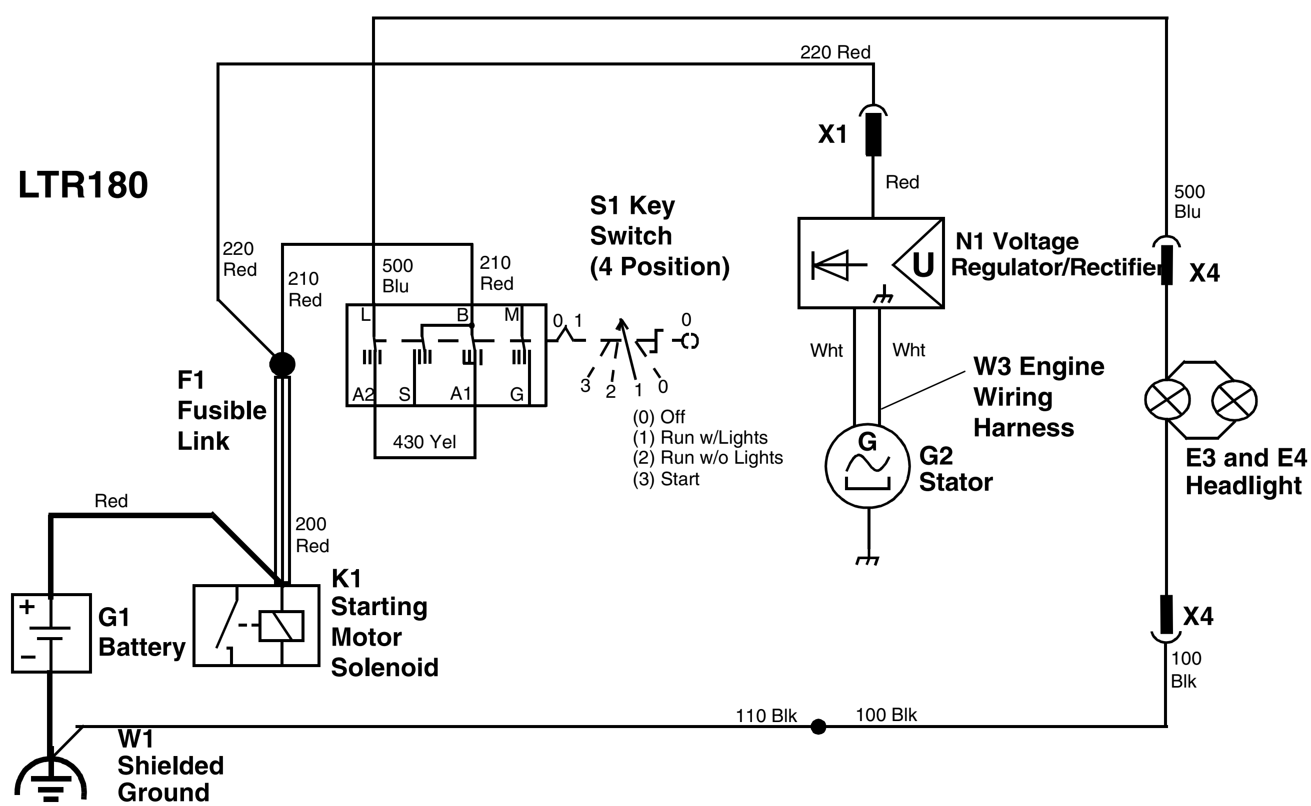
Current for lights is available as long as the engine is running. The output depends upon engine speed, so brightness of the lights changes with engine speed.

Magnets mounted to the flywheel rotate around two coils of wire, (the stator), mounted underneath the flywheel. As the magnets rotate, current is generated in the coiled wire and converted, with a diode, to DC current to charge the battery.

The current from the DC side of the stator is unregulated and is rated at 3 amps. The output rises from 2 amps at 2400 RPM to 3 amps at 3600 RPM.

# CHARGING CIRCUIT SCHEMATIC—LTR166 & LTR180



# CHARGING CIRCUIT DIAGNOSIS—LTR166

**Test Conditions:**

- Key switch RUN position, engine RUNNING at full throttle
- Stator connector unplugged
- Park brake ON
- PTO OFF

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Stator connector, DC lead | 2 – 4 amps | Check diode in DC wire |
| 2. Stator connector, AC lead | 14 volts AC or higher | Replace stator |

**Test Conditions:**

- Key switch OFF
- PTO OFF
- Park Brake ON

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 3. Stator connector, Diode | Continuity with black test lead clipped to connector pin, and red test lead clipped to pin piercing wire behind diode. | Replace diode |
| 4. Stator connector, Diode | No continuity with black test lead clipped to pin piercing wire behind diode, and red test lead clipped to connector pin. | Replace diode |

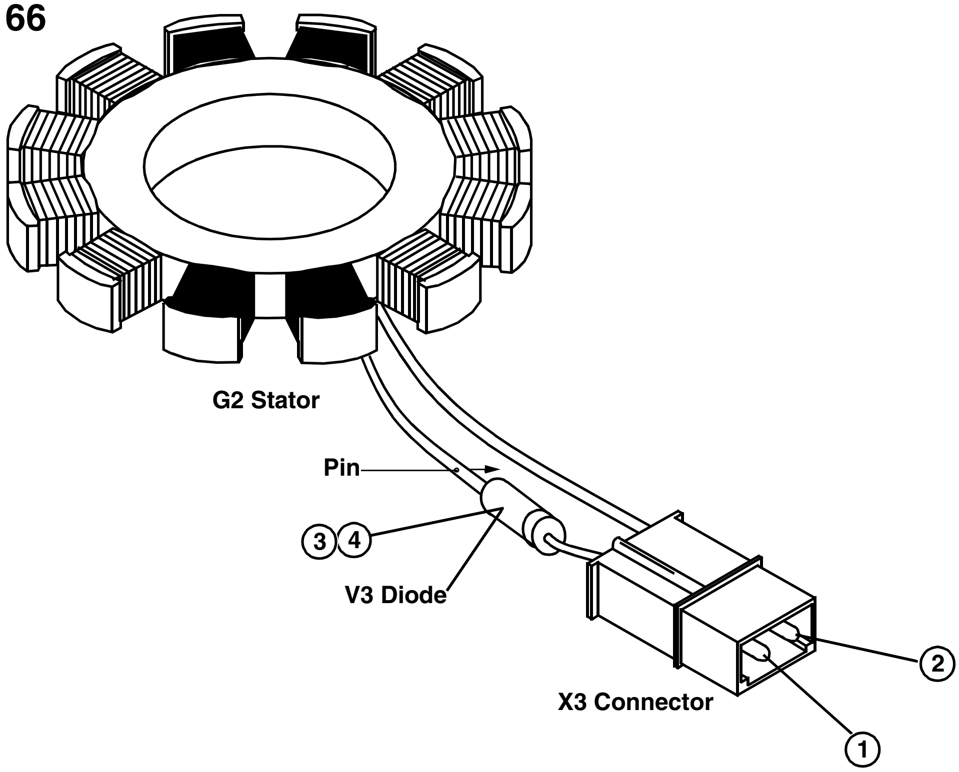
# CHARGING CIRCUIT DIAGNOSIS—LTR180

**Test Conditions:**

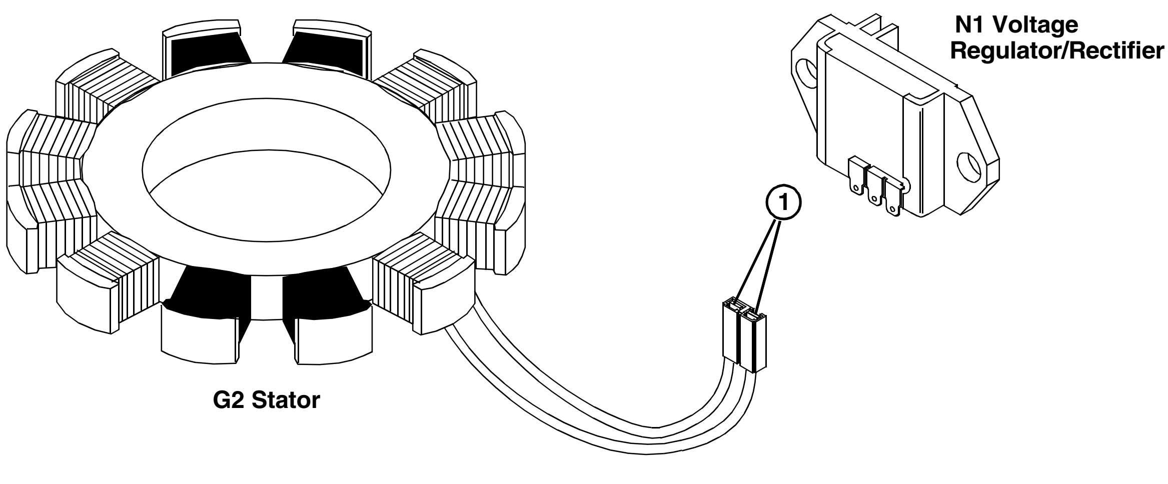
- Key switch RUN position, engine RUNNING at full throttle
- Stator connector unplugged
- Park brake ON
- PTO OFF

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Stator connector, AC lead | 28 volts AC or higher | Test stator. See “VOLTAGE REGULATOR/RECTIFIER TEST—LTR180 w/13 AMP CHARGER” on page 149 |

## LTR166




## LTR180



# PTO with RIO CIRCUIT OPERATION—LTR155

**Function:**

To provide a safety interlock when the tractor is being operated in reverse while the PTO is engaged, by providing a ground path to be used by either the ignition coil to shutoff the engine, or the RIO latch relay to open its contacts (normally closed) used to provide the ignition ground path, and use it for its own ground path. An operator who deems it necessary, and chooses to keep the PTO engaged while backing up, must take a deliberate action to actuate the RIS switch, by pushing the button momentarily while pressing the reverse pedal.

**RIO Operating Conditions:**

The key switch must be in the RUN position, engine running, the operator must be ON the seat, the PTO ENGAGED, and the RIS switch must be pushed (momentary) while starting operation in reverse.

**Theory of Operation:**

The Reverse Implement Option (RIO) is controlled by a relays and two switches wired in a circuit with the ignition coil. This combination of components provide for control of three different functional situations:

- PTO OFF with any drive function
- PTO ON and operating in reverse without activating the RIO circuit
- PTO ON and operating in reverse while activating the RIO circuit

**PTO OFF**

When the PTO is disengaged, the tractor will operate in both forward and reverse without activating any other switch(s). The PTO switch is pressed in and breaks (opens) the ground path interlock with the RIO circuit switches for the ignition coil and the engine will continue to run normally.

**PTO ON and operating in reverse without activating the RIO circuit**

*NOTE: Wires listed below are for the 3 amp charging system. For other models, please see appropriate wiring diagrams in the next few pages.*

During this condition when the PTO is engaged and the tractor is operated in reverse, there is a ground path created for the ignition coil through wires 135 and 140 Blk, RIO switch contacts (normally open), 920, 971 Wht wires, RIO latch relay contacts (normally closed), 950 Wht wire, PTO switch contacts (normally open), 905, 910, 900 Wht wires, and the ignition coil. This will ground the ignition coil and cause the engine to shutoff.

**PTO ON and operating in reverse while activating the RIO circuit**

During this condition, when the PTO is engaged and the tractor is operated in reverse, there is a ground path created for the RIO latch relay, both momentary and continuous. The momentary ground path allows the RIO latch relay to pull in, closing the contacts between the common and normally open contacts of the relay. With the relay normally open contacts now closed, the continuous ground path is created through the RIO switch to hold the RIO latch relay in the ON position while the reverse pedal is activated.

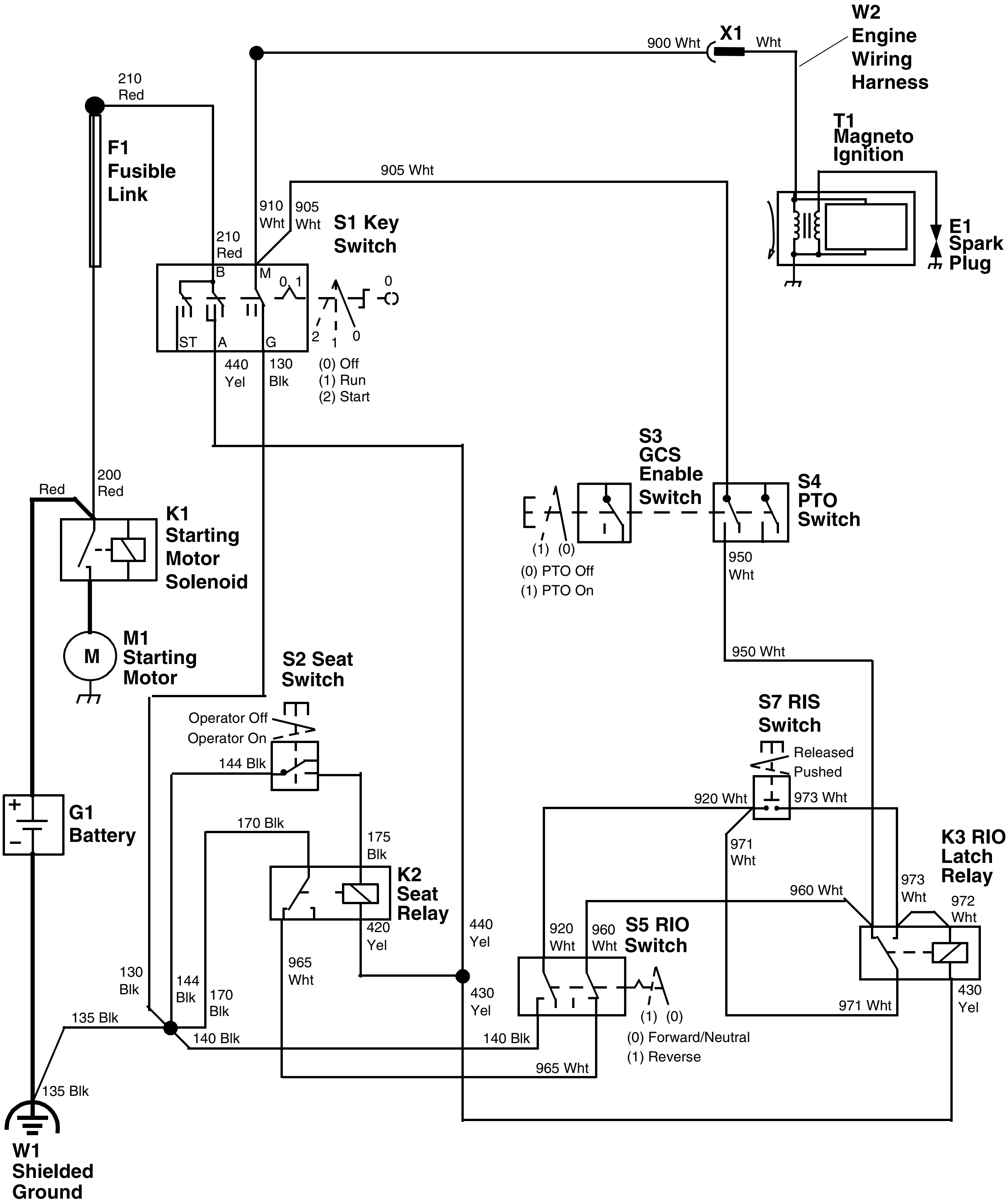
Pushing the RIS switch button provides a ground across the relay from wires 972, 973 Wht, RIS switch contacts (normally open), 920 Wht, RIO switch contacts (normally open), 140 and 135 Blk wires while the tractor is in reverse.

The momentary path is connected into the continuous path when the RIS switch is pushed and closes its contacts to connect wires 972, 973 Wht to 920 Wht wires.

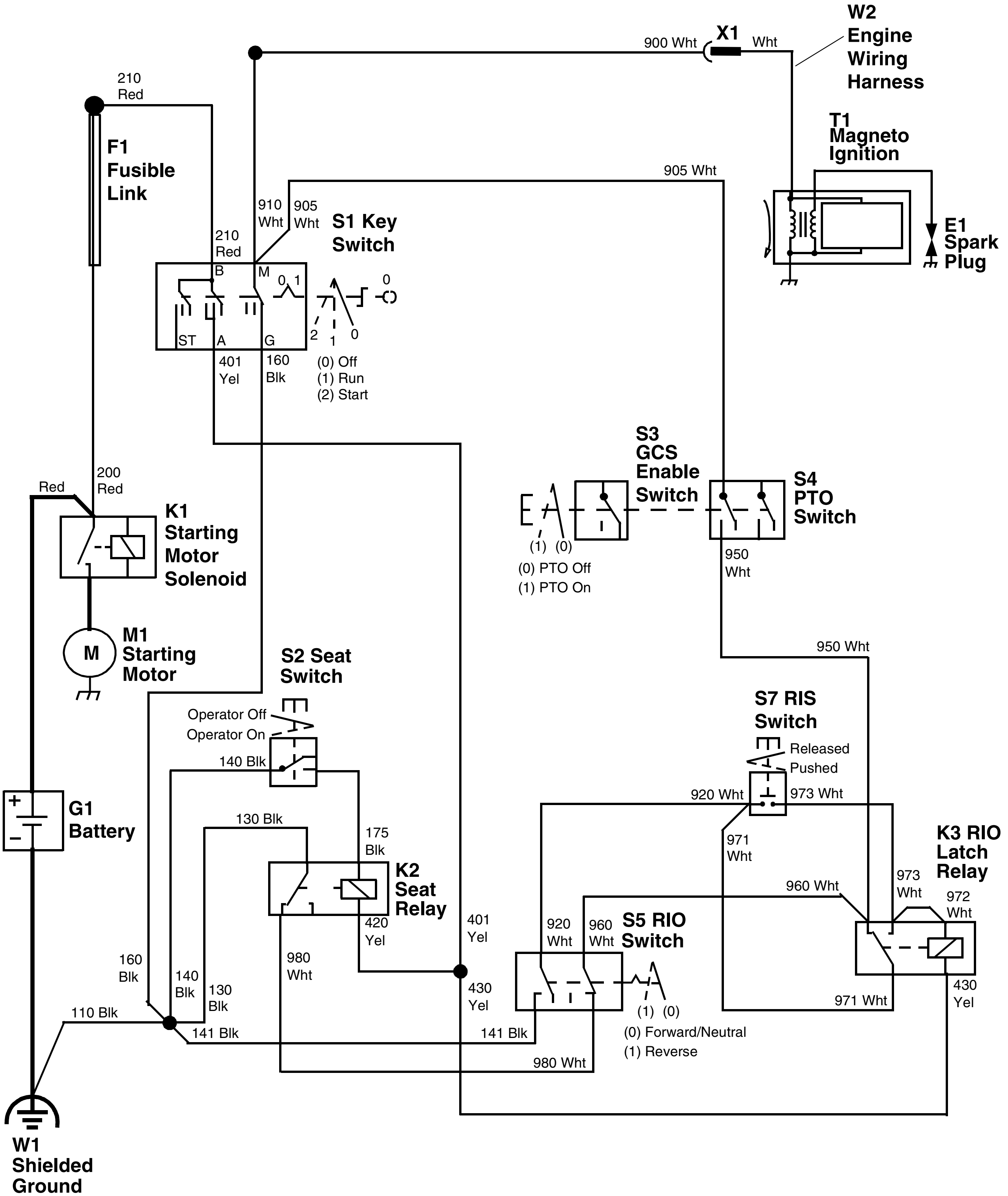
The continuous path is through wires 135 and 140 Blk, RIO switch contacts (normally open), 920, 971 Wht wires, RIO latch relay contacts (normally open), and 972 Wht wire.

When the operator places the foot pedal(s) back to neutral or forward, the RIO switch is allowed to return to its normal (static) condition, breaking the ground path holding the latch relay in the ON condition. This allows the circuit to be self reset and ready for the next reverse operation with PTO engaged.

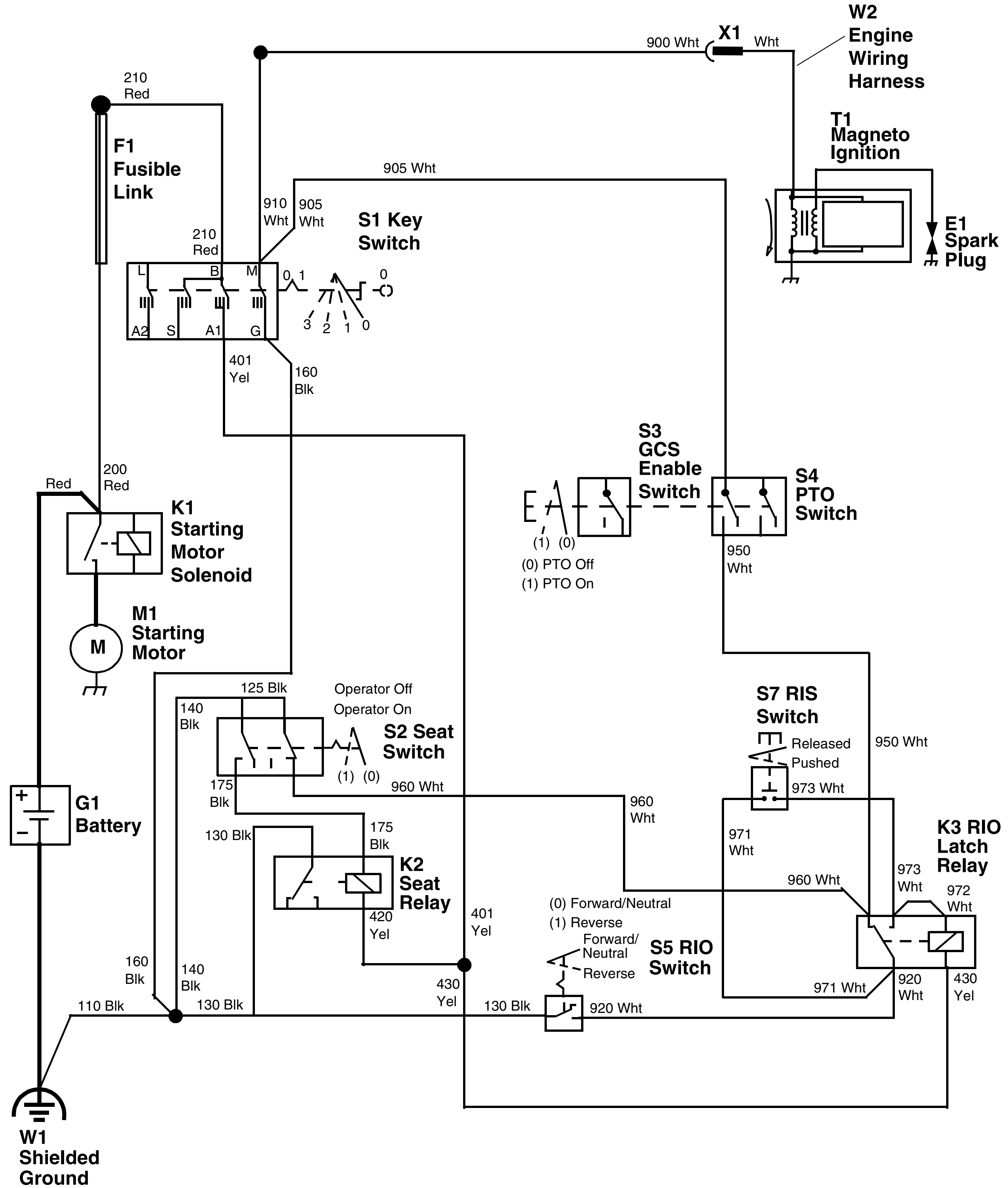
# PTO with RIO CIRCUIT SCHEMATIC—LTR155 w/3 AMP CHARGER



# PTO with RIO CIRCUIT SCHEMATIC—LTR155 w/15 AMP CHARGER



# PTO with RIO CIRCUIT SCHEMATIC—LTR155 w/4 POSITION KEY SWITCH



# PTO with RIO CIRCUIT DIAGNOSIS—LTR155

**Test Conditions:**

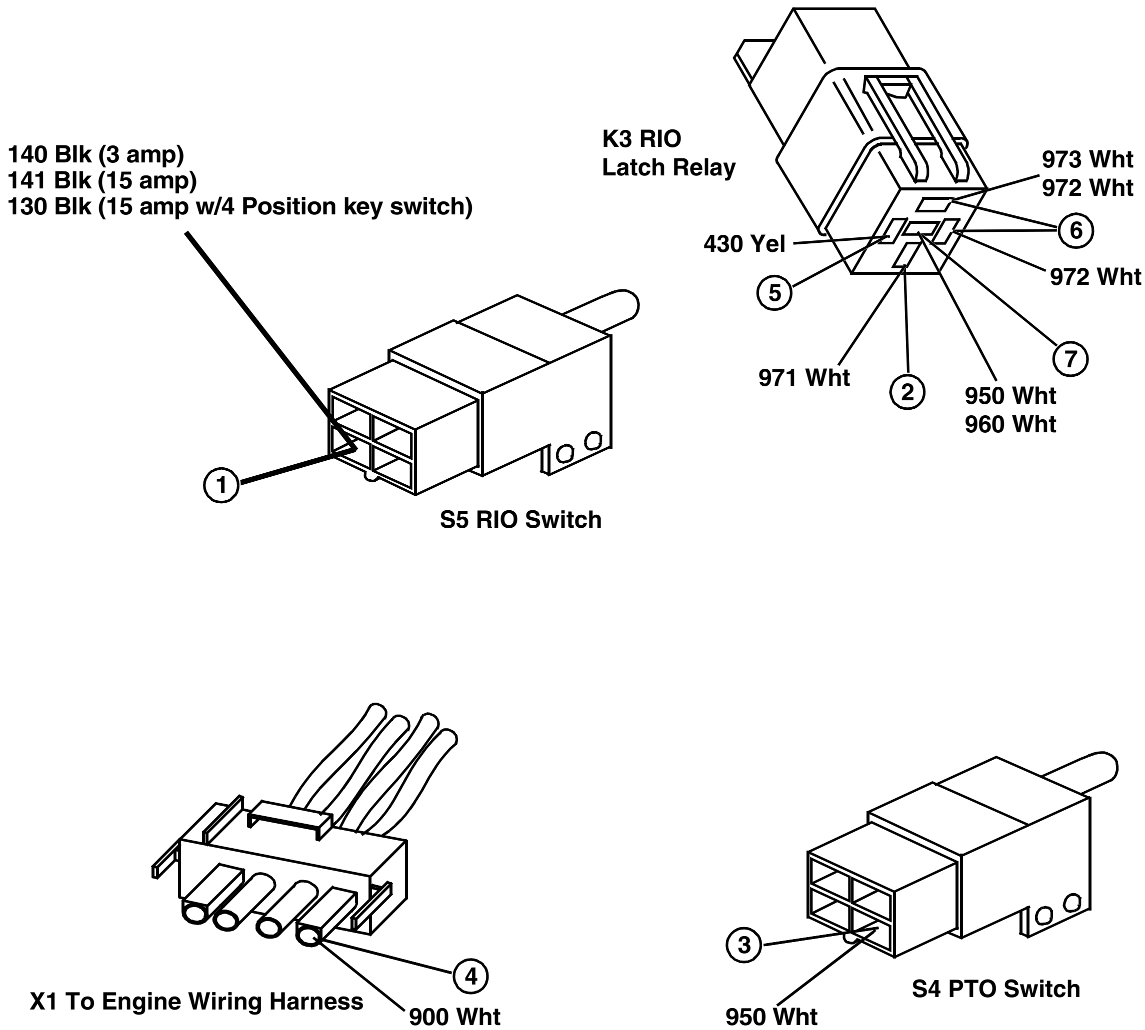
- Key switch in RUN position (engine not running)
- Park brake ON
- PTO ON
- Reverse pedal pressed down

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. RIO switch | Continuity to ground | Check 140 and 135 Blk wires (3 amp charger), 141 and 110 (15 amp charger), or 130 and 110 (4 Position switch) and connections. |
| 2. RIO latch relay | Continuity to ground | Check 971 and 920 Wht wires and connections. If OK, replace RIO switch. |
| 3. PTO switch | Continuity to ground | Check 950 Wht wire and connections. If OK, replace RIO latch relay. |
| 4. X1 Engine connector | Continuity to ground | Check 900, 910 and 905 Wht wires and connections. If OK, replace PTO switch. |

**Test Conditions:**

- Key switch in RUN position (engine not running)
- Park brake ON
- PTO ON
- Press and hold RIS switch while pressing down on the reverse pedal

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 5. RIO latch relay | Battery voltage | Check 430 and 440 Yel wires (3 amp charger, 430 and 401 (15 amp charger and w/4 Position key switch), and connections. See “POWER CIRCUIT OPERATION—LTR155 w/3 AMP CHARGER” on page 44. |
| 6. RIO latch relay | Continuity to ground | Check 972 and 973 Wht wires and connections. Test RIS switch. See “RIS SWITCH TEST” on page 153. |
| 7. RIO latch relay | NO continuity to ground | Test RIO latch relay. See “RELAY TEST” on page 150.<br>Test RIO switch. See “BRAKE AND RIO SWITCH TEST” on page 152. |


140 Blk (3 amp)
141 Blk (15 amp)
130 Blk (15 amp w/4 Position key switch)
1
S5 RIO Switch
K3 RIO
Latch Relay
973 Wht
972 Wht
6
430 Yel
5
972 Wht
7
971 Wht
2
950 Wht
960 Wht
4
X1 To Engine Wiring Harness
900 Wht
3
950 Wht
S4 PTO Switch

# PTO with RIO CIRCUIT OPERATION—LTR166 w/3 POSITION KEY SWITCH

### Function:

To provide a safety interlock when the tractor is being operated in reverse while the PTO is engaged, by providing a ground path to be used by either the ignition coil to shutoff the engine, or the RIO latch relay to open its contacts (normally closed) used to provide the ignition ground path, and use it for its own ground path. An operator who deems it necessary, and chooses to keep the PTO engaged while backing up, must take a deliberate action to actuate the RIS switch, by pushing the button momentarily while pressing the reverse pedal.

### RIO Operating Conditions:

The key switch must be in the RUN position, engine running, the operator must be ON the seat, the PTO ENGAGED, and the RIS switch must be pushed (momentary) while starting operation in reverse.

### Theory of Operation:

The Reverse Implement Option (RIO) is controlled by a relays and two switches wired in a circuit with the ignition coil. This combination of components provide for control of three different functional situations:

- PTO OFF with any drive function
- PTO ON and operating in reverse without activating the RIO circuit
- PTO ON and operating in reverse while activating the RIO circuit

### PTO OFF

When the PTO is disengaged, the tractor will operate in both forward and reverse without activating any other switch(s). The PTO switch is pressed in and breaks (opens) the ground path interlock with the RIO circuit switches for the ignition coil and the engine will continue to run normally.

### PTO ON and operating in reverse without activating the RIO circuit

During this condition when the PTO is engaged and the tractor is operated in reverse, there is a ground path created for the ignition coil through wires 110 and 130 Blk, RIO switch contacts (normally open), 920 and 971 Wht wires, RIO latch relay contacts (normally closed), 950 Wht wire, PTO switch contacts (normally open), 960, 910, 900 Wht wires, and the ignition coil. This will ground the ignition coil and cause the engine to shutoff. See “IGNITION & SHUTOFF CIRCUIT OPERATION—LTR166 & LTR180” on page 82.

### PTO ON and operating in reverse while activating the RIO circuit

During this condition, when the PTO is engaged and the tractor is operated in reverse, there is a ground path created for the RIO latch relay, both momentary and continuous. The momentary ground path allows the RIO latch relay to pull in, closing the contacts between the common and normally open contacts of the relay. With the relay normally open contacts now closed, the continuous ground path is created through the RIO switch to hold the RIO latch relay in the ON position while the reverse pedal is activated.

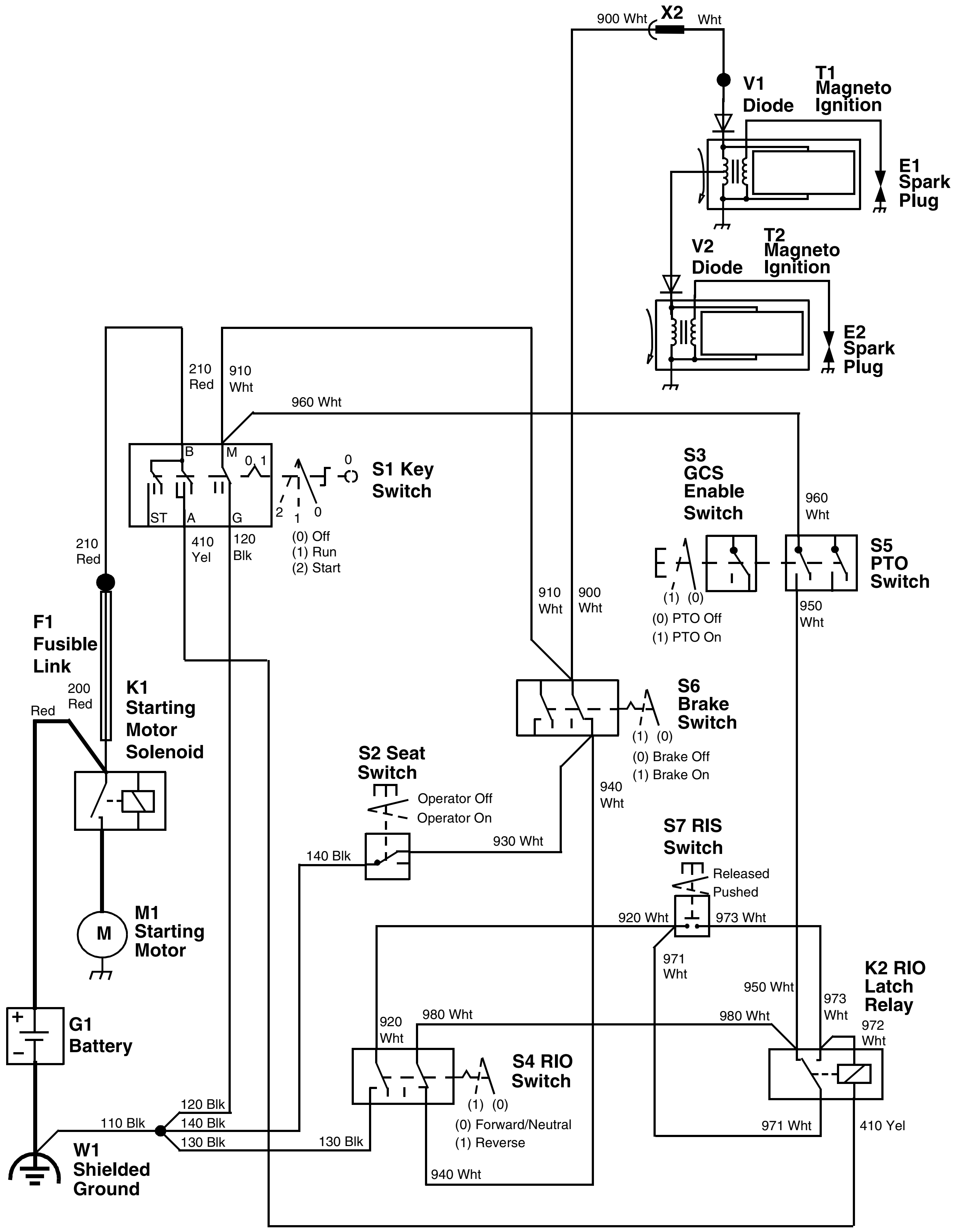
Pushing the RIS switch button provides a ground across the relay from wires 972, 973 Wht, RIS switch contacts (normally open), 920 Wht wire, RIO switch contacts (normally open), 130 and 110 Blk wires to ground, while the tractor is in reverse.

The momentary path is connected into the continuous path when the RIS switch is pushed and closes its contacts to connect wires 972, 973 Wht to the 920 Wht wire.

The continuous path is through wires 110 and 130 Blk, RIO switch contacts (normally open), 920 and 971 Wht wires, RIO latch relay contacts (normally open), and 972 Wht wire.

When the operator places the foot pedal(s) back to neutral or forward, the RIO switch is allowed to return to its normal (static) condition, breaking the ground path holding the latch relay in the ON condition. This allows the circuit to be self reset and ready for the next reverse operation with PTO engaged.

# PTO with RIO CIRCUIT SCHEMATIC—LTR166 w/3 POSITION KEY SWITCH



# PTO with RIO CIRCUIT DIAGNOSIS—LTR166w/3 POSITION KEY SWITCH

**Test Conditions:**

- Key switch in RUN position (engine not running)
- Park brake ON
- PTO ON
- Reverse pedal pressed down

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. RIO switch | Continuity to ground | Check 130 and 110 Blk wires and connections. |
| 2. RIO latch relay | Continuity to ground | Check 971 and 920 Wht wires and connections. If OK, replace RIO switch. |
| 3. PTO switch | Continuity to ground | Check 950 Wht wire and connections. If OK, replace RIO latch relay. |
| 4. X2 Engine connector | Continuity to ground | Check 900, 910 and 960 Wht wires and connections. If OK, replace PTO switch. |

**Test Conditions:**

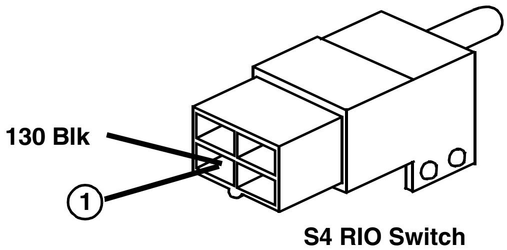
- Key switch in RUN position (engine not running)
- Park brake ON
- PTO ON
- Press and hold RIS switch while pressing down on the reverse pedal

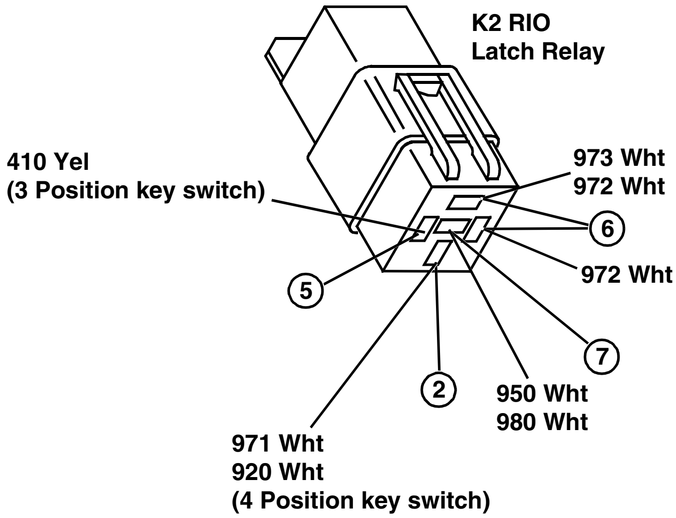
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 5. RIO latch relay | Battery voltage | Check 410 Yel wire and connections. See “POWER CIRCUIT OPERATION—LTR166 & LTR180” on page 56. |
| 6. RIO latch relay | Continuity to ground | Check 972 and 973 Wht wires and connections. Test RIS switch. See “RIS SWITCH TEST” on page 153. |
| 7. RIO latch relay | NO continuity to ground | Test RIO latch relay. See “RELAY TEST” on page 150.<br>Test RIO switch. See “BRAKE AND RIO SWITCH TEST” on page 152. |

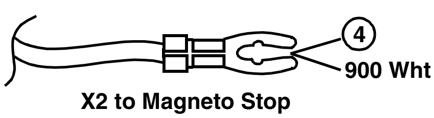
**Test Conditions:(Briggs & Stratton Engines ONLY – Test performed if engine will NOT shut off when operator leaves seat with EITHER PTO ENGAGED or brake switch OFF.)**

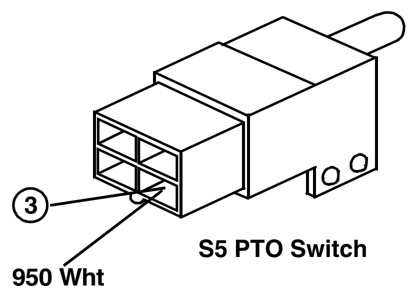
- Key switch in OFF position (Closes fuel valve to stop engine)
- Operator OFF seat
- Allow engine to cool, and remove engine cover to access ignition coils
- Disconnect diode(s) from ignition coil(s)
- PTO ON (ENGAGED); or, Park brake OFF

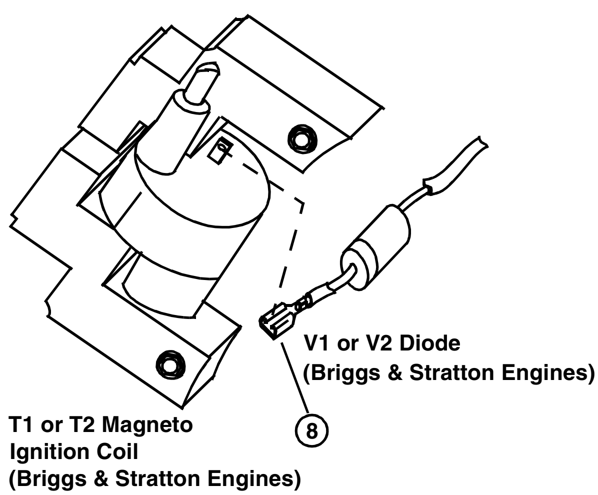
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 8. Ignition coil diode(s) | Continuity to ground with diode disconnected from ignition coil | Faulty diode(s)<br>Replace diode(s) |


130 Blk
1
S4 RIO Switch


K2 RIO
Latch Relay
410 Yel
(3 Position key switch)
973 Wht
972 Wht
6
972 Wht
5
7
2
950 Wht
980 Wht
971 Wht
920 Wht
(4 Position key switch)


4
900 Wht
X2 to Magneto Stop


3
950 Wht
S5 PTO Switch


V1 or V2 Diode
(Briggs & Stratton Engines)
8
T1 or T2 Magneto
Ignition Coil
(Briggs & Stratton Engines)

# PTO w/ RIO CIRCUIT OPERATION—LTR166/180 w/4 POSITION KEY SWITCH

**Function:**

To provide a safety interlock when the tractor is being operated in reverse while the PTO is engaged, by providing a ground path to be used by either the ignition coil to shutoff the engine, or the RIO latch relay to open its contacts (normally closed) used to provide the ignition ground path, and use it for its own ground path. An operator who deems it necessary, and chooses to keep the PTO engaged while backing up, must take a deliberate action to actuate the RIS switch, by pushing the button momentarily while pressing the reverse pedal.

**RIO Operating Conditions:**

The key switch must be in the RUN position, engine running, the operator must be ON the seat, the PTO ENGAGED, and the RIS switch must be pushed (momentary) while starting operation in reverse.

**Theory of Operation:**

The Reverse Implement Option (RIO) is controlled by a relays and two switches wired in a circuit with the ignition coil. This combination of components provide for control of three different functional situations:

- PTO OFF with any drive function
- PTO ON and operating in reverse without activating the RIO circuit
- PTO ON and operating in reverse while activating the RIO circuit

**PTO OFF**

When the PTO is disengaged, the tractor will operate in both forward and reverse without activating any other switch(s). The PTO switch is pressed in and breaks (opens) the ground path interlock with the RIO circuit switches for the ignition coil and the engine will continue to run normally.

**PTO ON and operating in reverse without activating the RIO circuit**

During this condition when the PTO is engaged and the tractor is operated in reverse, there is a ground path created for the ignition coil through wires 110 and 130 Blk, RIO switch contacts (normally open), 920 Wht wire, RIO latch relay contacts (normally closed), 950 Wht wire, PTO switch contacts (normally open), 960, 910, 900 Wht wires, and the ignition coil. This will ground the ignition coil and cause the engine to shutoff. See “IGNITION & SHUTOFF CIRCUIT OPERATION—LTR166 & LTR180” on page 82.

**PTO ON and operating in reverse while activating the RIO circuit**

During this condition, when the PTO is engaged and the tractor is operated in reverse, there is a ground path created for the RIO latch relay, both momentary and continuous. The momentary ground path allows the RIO latch relay to pull in, closing the contacts between the common and normally open contacts of the relay. With the relay normally open contacts now closed, the continuous ground path is created through the RIO switch to hold the RIO latch relay in the ON position while the reverse pedal is activated.

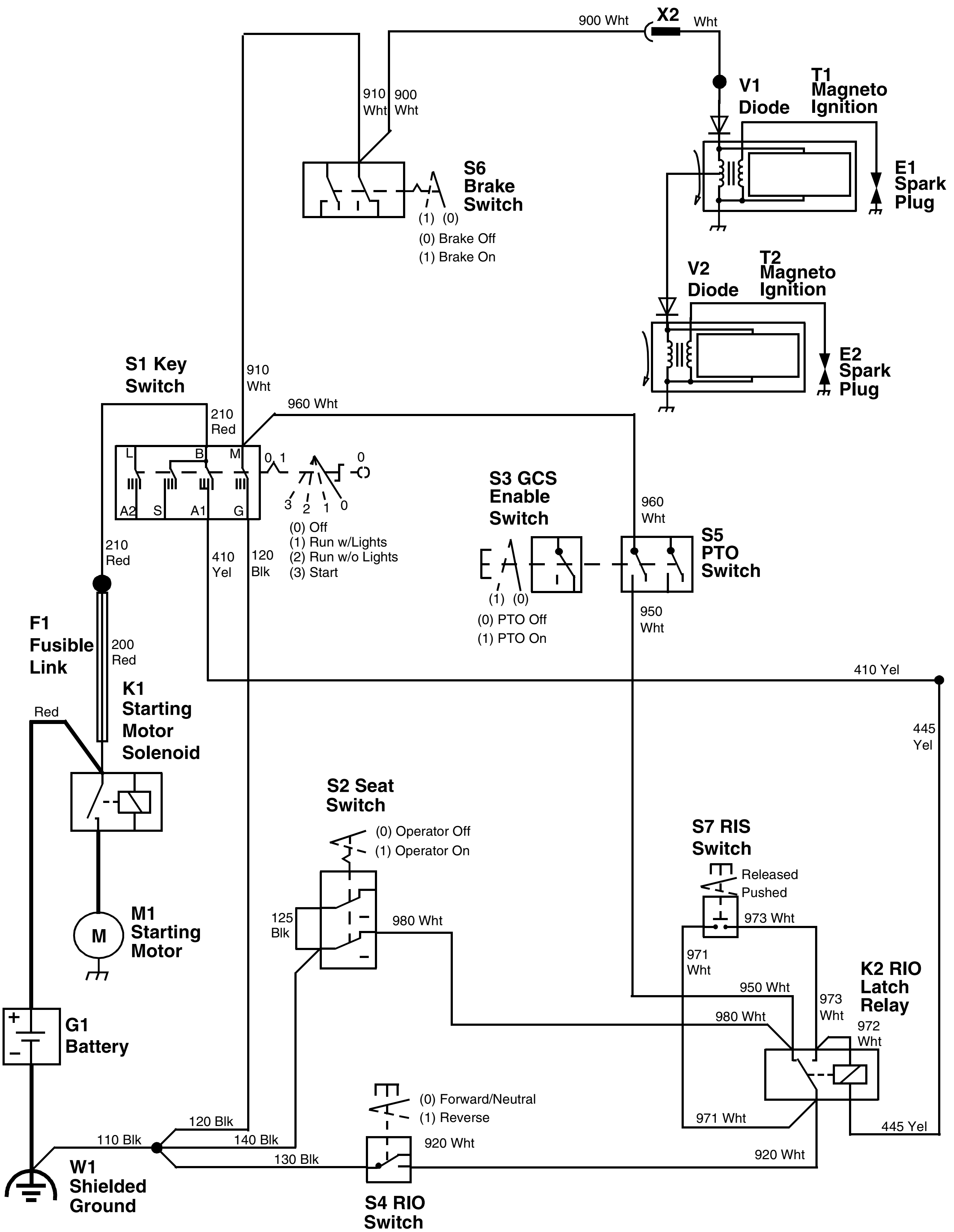
Pushing the RIS switch button provides a ground across the relay from wires 972, 973 Wht, RIS switch contacts (normally open), 971 and 920 Wht wires, RIO switch contacts (normally open), 130 and 110 Blk wires to ground, while the tractor is in reverse.

The momentary path is connected into the continuous path when the RIS switch is pushed and closes its contacts to connect wires 972, 973 Wht to the 920 Wht wire.

The continuous path is through wires 110 and 130 Blk, RIO switch contacts (normally open), 920 Wht wire, RIO latch relay contacts (normally open), and 972 Wht wire.

When the operator places the foot pedal(s) back to neutral or forward, the RIO switch is allowed to return to its normal (static) condition, breaking the ground path holding the latch relay in the ON condition. This allows the circuit to be self reset and ready for the next reverse operation with PTO engaged.

# PTO w/RIO CIRCUIT SCHEMATIC - LTR166/180 w/4 POSITION KEY SWITCH



# PTO w/RIO CIRCUIT DIAGNOSIS—LTR166/180 w/4 POSITION KEY SWITCH

**Test Conditions:**

- Key switch in RUN position (engine not running)
- Park brake ON
- PTO ON
- Reverse pedal pressed down

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. RIO switch | Continuity to ground | Check 130 and 110 Blk wires and connections. |
| 2. RIO latch relay | Continuity to ground | Check 971 and 920 Wht wires and connections. If OK, replace RIO switch. |
| 3. PTO switch | Continuity to ground | Check 950 Wht wire and connections. If OK, replace RIO latch relay. |
| 4. X2 Engine connector | Continuity to ground | Check 900, 910 and 960 Wht wires and connections. If OK, replace PTO switch. |

**Test Conditions:**

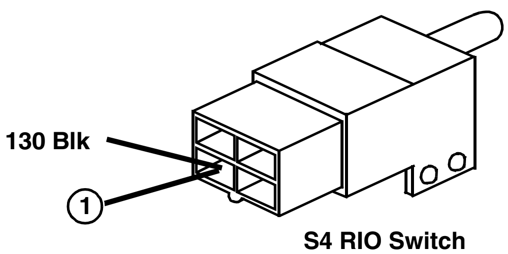
- Key switch in RUN position (engine not running)
- Park brake ON
- PTO ON
- Press and hold RIS switch while pressing down on the reverse pedal

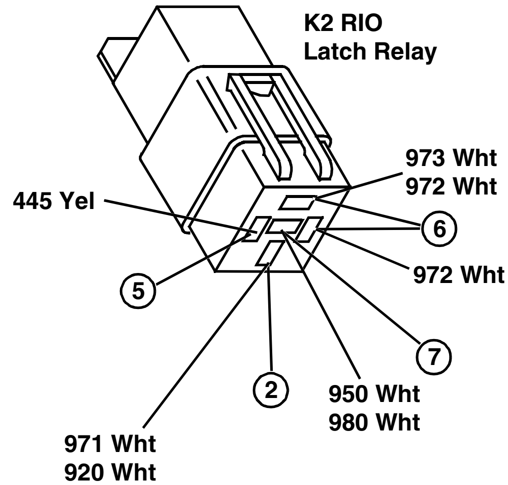
| | | |
|---|---|---|
| 5. RIO latch relay | Battery voltage | Check 445 Yel wire and connections. See “POWER CIRCUIT OPERATION—LTR166 & LTR180” on page 56. |
| 6. RIO latch relay | Continuity to ground | Check 972 and 973 Wht wires and connections. Test RIS switch. See “RIS SWITCH TEST” on page 153. |
| 7. RIO latch relay | NO continuity to ground | Test RIO latch relay. See “RELAY TEST” on page 150.<br>Test RIO switch. See “BRAKE AND RIO SWITCH TEST” on page 152. |

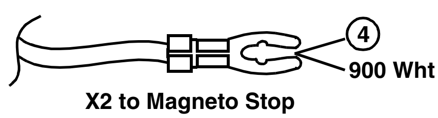
**Test Conditions:(Briggs & Stratton Engines ONLY – Test performed if engine will NOT shut off when operator leaves seat with EITHER PTO ENGAGED or brake switch OFF.)**

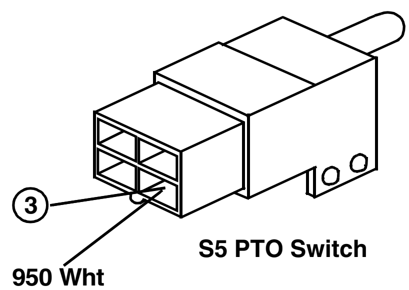
- Key switch in OFF position (Closes fuel valve to stop engine)
- Operator OFF seat
- Allow engine to cool, and remove engine cover to access ignition coils
- Disconnect diode(s) from ignition coil(s)
- PTO ON (ENGAGED); or, Park brake OFF

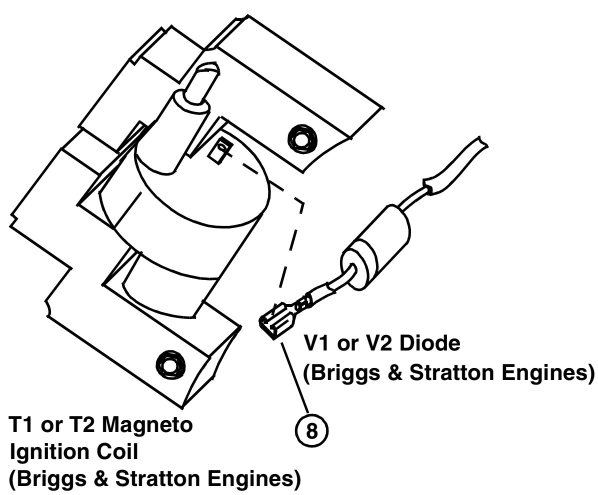
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 8. Ignition coil diode(s) | Continuity to ground with diode disconnected from ignition coil | Faulty diode(s)<br>Replace diode(s) |


130 Blk
1
S4 RIO Switch


K2 RIO
Latch Relay
973 Wht
972 Wht
445 Yel
6
972 Wht
5
7
2
950 Wht
980 Wht
971 Wht
920 Wht


4
900 Wht
X2 to Magneto Stop


3
950 Wht
S5 PTO Switch


V1 or V2 Diode
(Briggs & Stratton Engines)
8
T1 or T2 Magneto
Ignition Coil
(Briggs & Stratton Engines)

# GRASS COLLECTION SYSTEM (GCS) CIRCUIT OPERATION—LTR155

**Function:**

To insure that the grass collection system is properly in place on the tractor, and to alert the operator when the grass collection container is full.

**Operating Conditions:**

With the engine running and the PTO engaged, the GCS circuit is activated. The GCS circuit has two functions. The first function is to shut off the engine when the PTO is engaged and the collection container is not properly in place on the tractor. The second function is to alert the operator when the grass collection container is full.

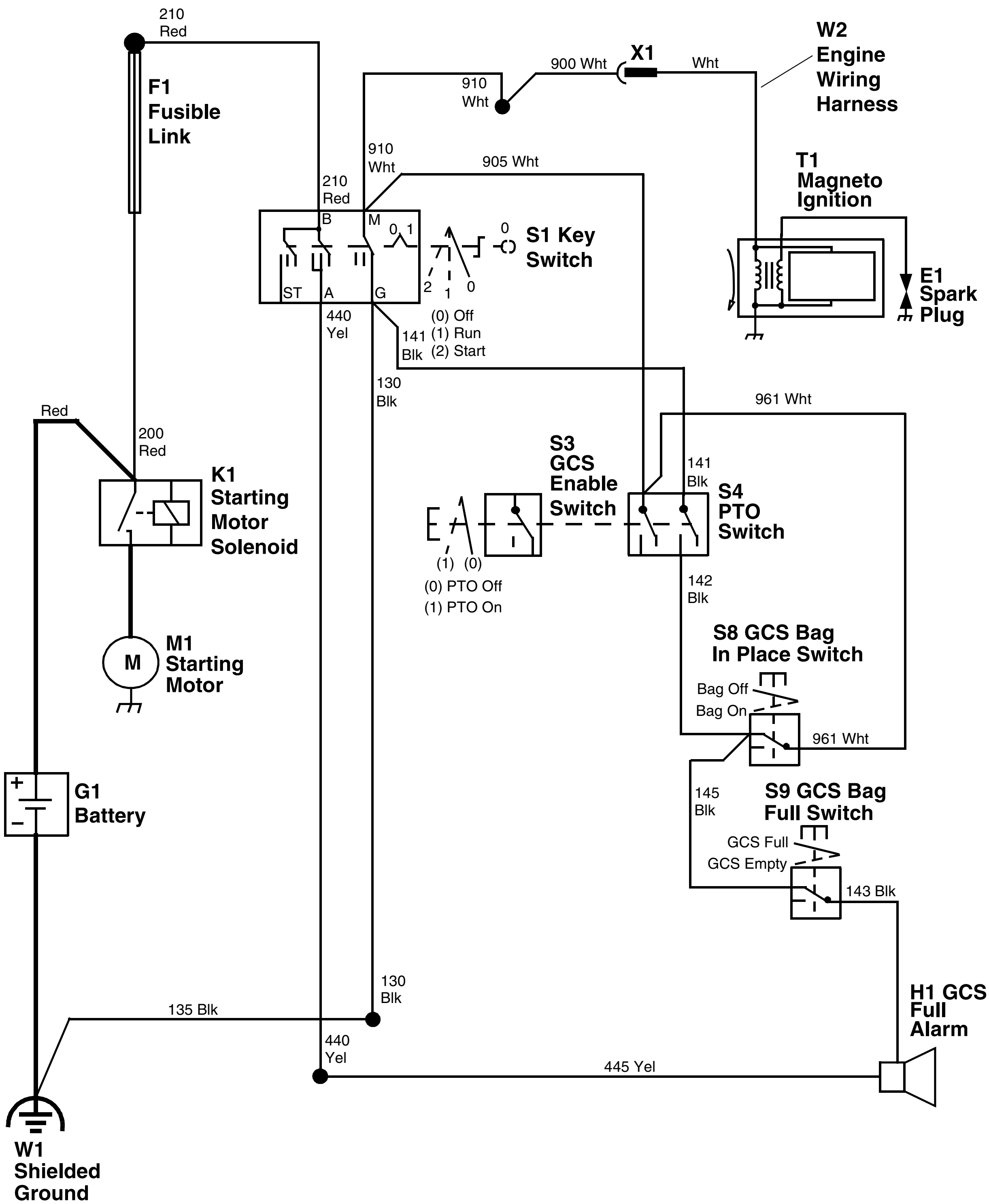
**System Operation:**

**LTR155 w/3 amp charger:**

The first function of the GCS circuit is to shut off the engine when the PTO is engaged if the grass collection container is not properly in place on the tractor. Under this condition a ground path is created from the 135, 130 and 141 Blk wires to the PTO switch. With the PTO engaged, the PTO switch contacts are closed, connecting the 141 Blk wire to the 142 Blk wire and the GCS bag in place switch. If the grass collection container IS NOT in place, the GCS bag in place switch contacts will be closed and connects the 142 Blk wire to the 961, 905, 910, 900 Wht wire and the magneto ignition. This will then ground the ignition and shut off the engine.

The second function of the GCS circuit is to alert the operator when the grass collection container is full. With the key switch in the run position, power is supplied to the GCS full alarm via the 440 and 445 Yel wires. For this condition to function, a ground path is created from the 135, 130 and 141 Blk wires to the PTO switch. With the PTO engaged the PTO switch contacts are closed connecting the 141 Blk wire to the 142 and 145 Blk wires and the GCS bag full switch. If the grass collection container IS full the GCS full switch contacts will be closed and connects the 145 Blk wire to the 143 Blk wire and the GCS full alarm. This will then complete the circuit allowing the alarm to sound, warning the operator that the grass collection container is full.

# GCS CIRCUIT SCHEMATIC—LTR155 w/3 AMP CHARGER

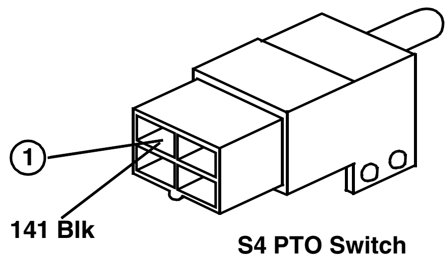


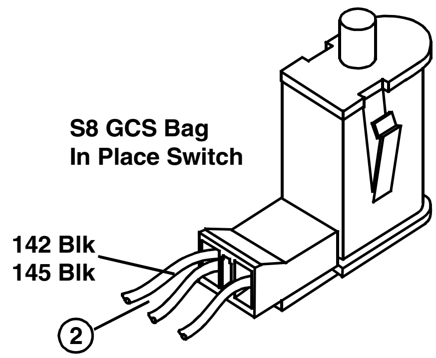
# (GCS) CIRCUIT DIAGNOSIS—LTR155 w/3 AMP CHARGER

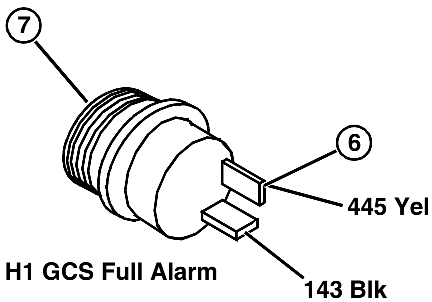
**Test Conditions:**

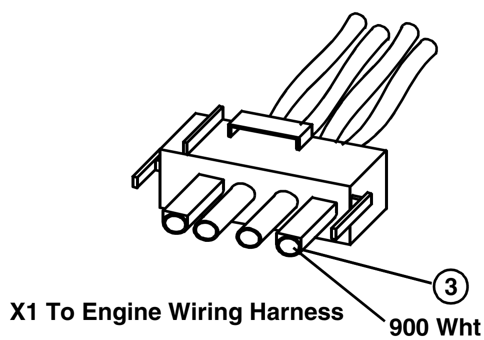
- Key switch in RUN position (engine not running)
- Park brake ON
- PTO ON
- GCS collection container cover OPEN

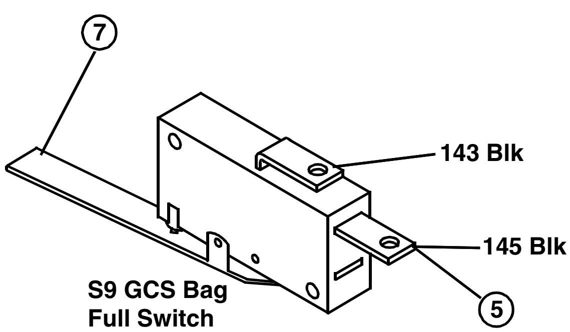
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. PTO switch | Continuity to ground | Check 141, 130 and 135 Blk wires and connections. |
| 2. Grass Collection System (GCS) bag in place switch | Continuity to ground | Check 142 Blk wire and connections. If OK, replace PTO switch. |
| 3. X1 Engine connector, Wht wire | Continuity to ground | Check 900, 910, 905 and 961 Wht wires and connections. If OK, replace GCS bag in place switch. |
| 4. Key switch | Battery voltage | Check battery connections, F1 fusible link and 210 Red wire and connections. See “POWER CIRCUIT OPERATION—LTR155 w/3 AMP CHARGER” on page 44. |
| 5. Grass Collection System (GCS) bag full switch | Continuity to ground | Check 145 and 142 Blk wires and connections. If OK, replace PTO switch. |
| 6. Grass Collection System (GCS) full alarm | Battery voltage | Check 445 and 440 Yel wires and connections. If OK, replace key switch. |
| 7. Grass Collection System (GCS) bag full switch lever lifted | Alarm sounding | Check 143 Blk wire and connection. If OK, test GCS bag full switch. See “GCS BAG FULL SWITCH TEST” on page 155, and GCS bag full alarm; See “GCS BAG FULL ALARM TEST” on page 156. Replace defective component. |

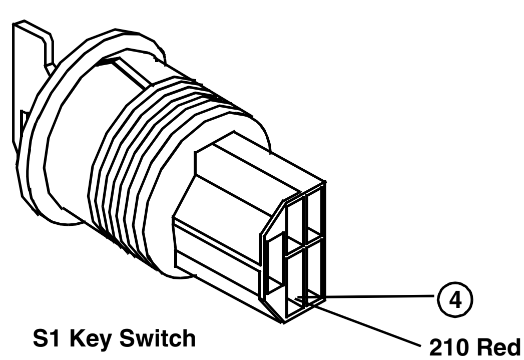

1
141 Blk
S4 PTO Switch


S8 GCS Bag
In Place Switch
142 Blk
145 Blk
2


7
6
445 Yel
H1 GCS Full Alarm
143 Blk


3
X1 To Engine Wiring Harness
900 Wht


7
143 Blk
145 Blk
S9 GCS Bag
Full Switch
5


4
S1 Key Switch
210 Red

# GRASS COLLECTION SYSTEM OPERATION—LTR155 w/15 AMP CHARGER

**Function:**

To insure that the grass collection system is properly in place on the tractor, and to alert the operator when the grass collection container is full.

**Operating Conditions:**

With the engine running and the PTO engaged, the GCS circuit is activated. The GCS circuit has two functions. The first function is to shut off the engine when the PTO is engaged and the collection container is not properly in place on the tractor. The second function is to alert the operator when the grass collection container is full.

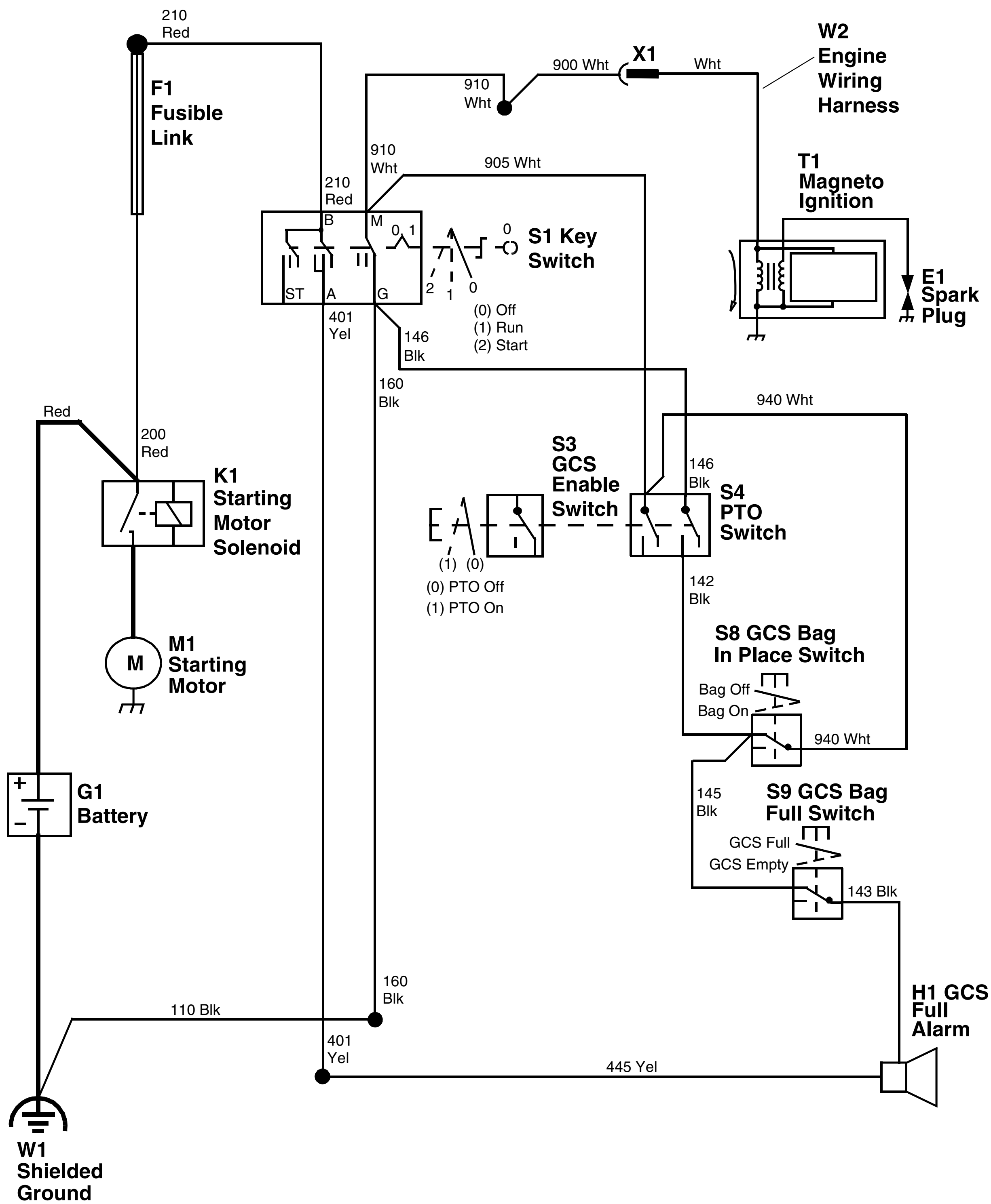
**System Operation:**

**LTR155 w/15 amp charger:**

The first function of the GCS circuit is to shut off the engine when the PTO is engaged if the grass collection container is not properly in place on the tractor. Under this condition a ground path is created from the 110, 160 and 146 Blk wires to the PTO switch. With the PTO engaged, the PTO switch contacts are closed, connecting the 146 Blk wire to the 142 Blk wire and the GCS bag in place switch. If the grass collection container IS NOT in place, the GCS bag in place switch contacts will be closed and connects the 142 Blk wire to the 940, 905, 910, 900 Wht wire and the magneto ignition. This will then ground the ignition and shut off the engine.

The second function of the GCS circuit is to alert the operator when the grass collection container is full. With the key switch in the run position, power is supplied to the GCS full alarm via the 401 and 445 Yel wires. For this condition to function, a ground path is created from the 110, 160 and 146 Blk wires to the PTO switch. With the PTO engaged the PTO switch contacts are closed connecting the 146 Blk wire to the 142 and 145 Blk wires and the GCS bag full switch. If the grass collection container IS full the GCS full switch contacts will be closed and connect the 145 Blk wire to the 143 Blk wire and the GCS full alarm. This will then complete the circuit allowing the alarm to sound, warning the operator that the grass collection container is full.

# GRASS COLLECTION SYSTEM SCHEMATIC LTR—155 w/15 AMP CHARGER

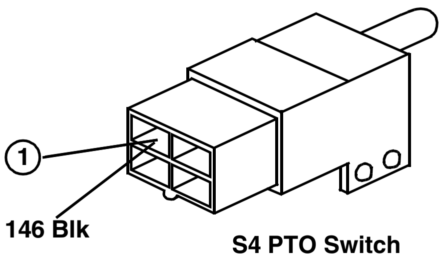


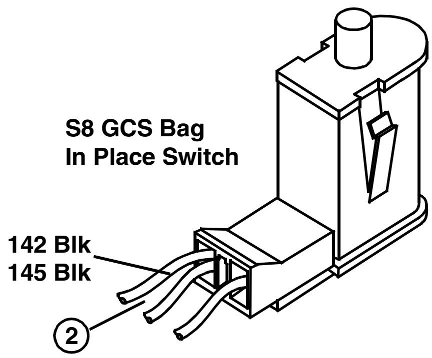
# GRASS COLLECTION SYSTEM DIAGNOSIS—LTR155 w/15 AMP CHARGER

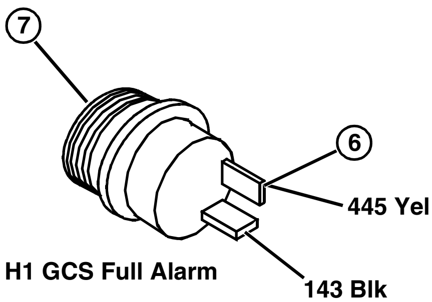
**Test Conditions:**

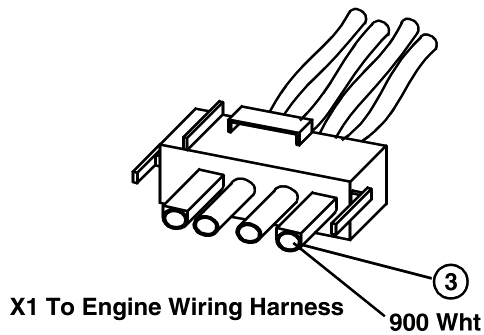
- Key switch in RUN position (engine not running)
- Park brake ON
- PTO ON
- GCS collection container cover OPEN

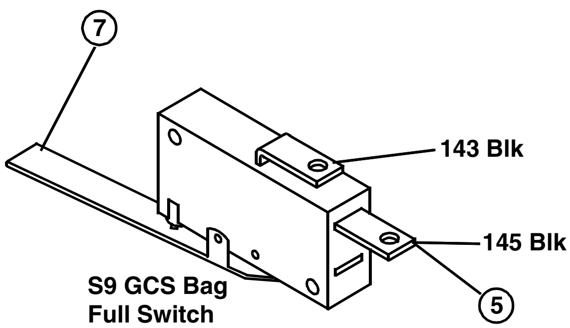
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. PTO switch | Continuity to ground | Check 146, 160 and 110 Blk wires and connections. |
| 2. Grass Collection System (GCS) bag in place switch | Continuity to ground | Check 142 Blk wire and connections. If OK, replace PTO switch. |
| 3. X1 Engine connector, Wht wire | Continuity to ground | Check 900, 910, 905 and 940 Wht wires and connections. If OK, replace GCS bag in place switch. |
| 4. Key switch | Battery voltage | Check battery connections, F1 fusible link and 210 Red wire and connections. See “POWER CIRCUIT OPERATION—LTR155 w/15 AMP CHARGER” on page 48. |
| 5. Grass Collection System (GCS) bag full switch | Continuity to ground | Check 145 and 142 Blk wires and connections. If OK, replace PTO switch. |
| 6. Grass Collection System (GCS) full alarm | Battery voltage | Check 445 and 401 Yel wires and connections. If OK, replace key switch. |
| 7. Grass Collection System (GCS) bag full switch lever lifted | Alarm sounding | Check 143 Blk wire and connection. If OK, test GCS bag full switch. See “GCS BAG FULL SWITCH TEST” on page 155, and GCS bag full alarm; See “GCS BAG FULL ALARM TEST” on page 156. Replace defective component. |

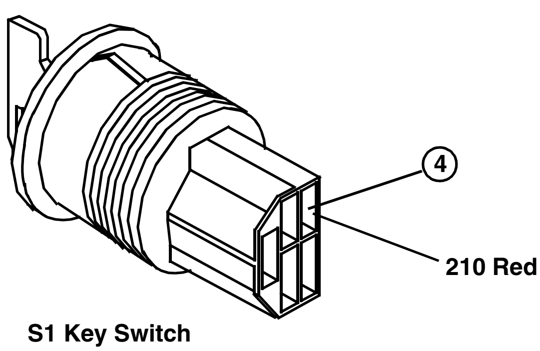

1
146 Blk
S4 PTO Switch


S8 GCS Bag
In Place Switch
142 Blk
145 Blk
2


7
6
445 Yel
H1 GCS Full Alarm
143 Blk


3
X1 To Engine Wiring Harness
900 Wht


7
143 Blk
145 Blk
S9 GCS Bag
Full Switch
5


4
210 Red
S1 Key Switch

# GCS CIRCUIT OPERATION—LTR155 w/4 POSITION KEY SWITCH

**Function:**

To insure that the grass collection system is properly in place on the tractor, and to alert the operator when the grass collection container is full.

**Operating Conditions:**

With the engine running and the PTO engaged, the GCS circuit is activated. The GCS circuit has two functions. The first function is to shut off the engine when the PTO is engaged and the collection container is not properly in place on the tractor. The second function is to alert the operator when the grass collection container is full.

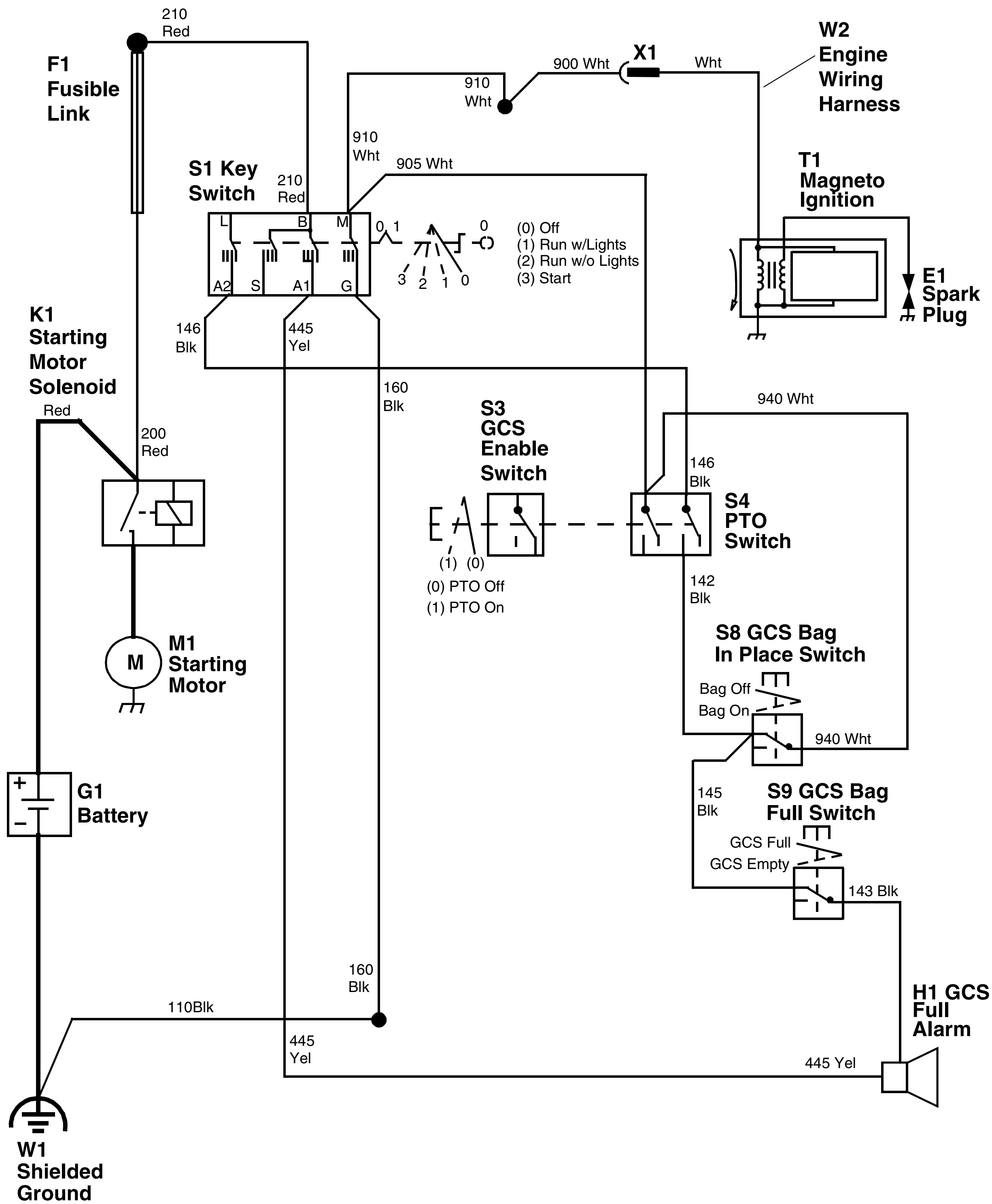
**System Operation:**

**LTR155 w/15 amp charger and 4 Position key switch:**

The first function of the GCS circuit is to shut off the engine when the PTO is engaged if the grass collection container is not properly in place on the tractor. Under this condition a ground path is created from the 110, 160 and 146 Blk wires to the PTO switch. With the PTO engaged, the PTO switch contacts are closed, connecting the 146 Blk wire to the 142 Blk wire and the GCS bag in place switch. If the grass collection container IS NOT in place, the GCS bag in place switch contacts will be closed and connects the 142 Blk wire to the 940, 905, 910, 900 Wht wire and the magneto ignition. This will then ground the ignition and shut off the engine.

The second function of the GCS circuit is to alert the operator when the grass collection container is full. With the key switch in the run position, power is supplied to the GCS full alarm via the 445 Yel wire. For this condition to function, a ground path is created from the 110, 160 and 146 Blk wires to the PTO switch. With the PTO engaged the PTO switch contacts are closed connecting the 141 Blk wire to the 142 and 145 Blk wires and the GCS bag full switch. If the grass collection container IS full the GCS full switch contacts will be closed and connects the 145 Blk wire to the 143 Blk wire and the GCS full alarm. This will then complete the circuit allowing the alarm to sound, warning the operator that the grass collection container is full.

# GCS CIRCUIT SCHEMATIC—LTR 155 w/4 POSITION KEY SWITCH

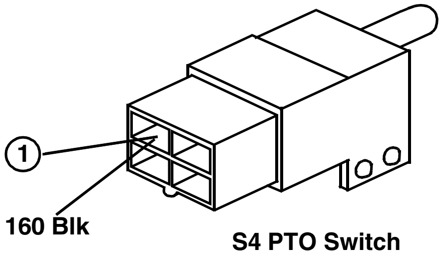


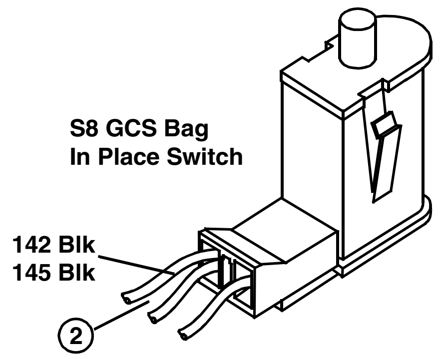
# GCS CIRCUIT DIAGNOSIS—LTR155 w/4 POSITION KEY SWITCH

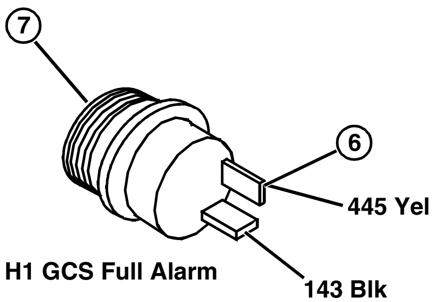
**Test Conditions:**

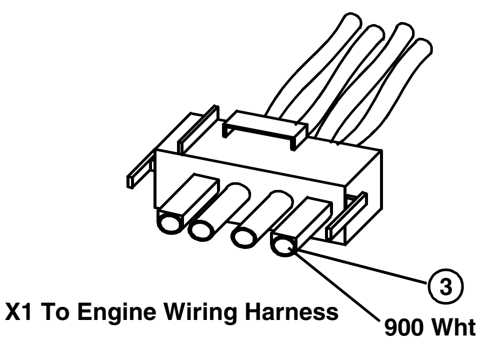
- Key switch in RUN position (engine not running)
- Park brake ON
- PTO ON
- GCS collection container cover OPEN

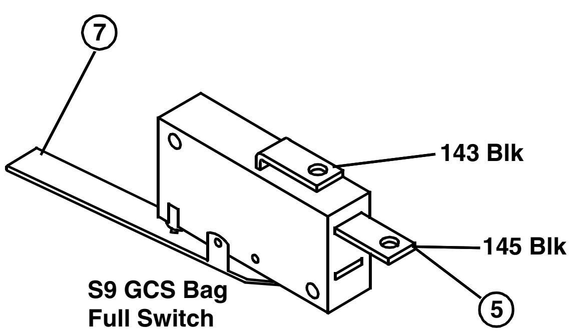
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. PTO switch | Continuity to ground | Check 160, 146 and 110 Blk wires and connections. |
| 2. Grass Collection System (GCS) bag in place switch | Continuity to ground | Check 142 Blk wire and connections. If OK, replace PTO switch. |
| 3. X1 Engine connector, Wht wire | Continuity to ground | Check 900, 910, 905 and 940 Wht wires and connections. If OK, replace GCS bag in place switch. |
| 4. Key switch | Battery voltage | Check battery connections, F1 fusible link and 210 Red wire and connections. See “POWER CIRCUIT OPERATION—LTR155 w/4 POSITION KEY SWITCH” on page 52. |
| 5. Grass Collection System (GCS) bag full switch | Continuity to ground | Check 145 and 142 Blk wires and connections. If OK, replace PTO switch. |
| 6. Grass Collection System (GCS) full alarm | Battery voltage | Check 445 Yel wire and connection. If OK, replace key switch. |
| 7. Grass Collection System (GCS) bag full switch lever lifted | Alarm sounding | Check 143 Blk wire and connection. If OK test GCS bag full switch. See “GCS BAG FULL SWITCH TEST” on page 155, and GCS bag full alarm; See “GCS BAG FULL ALARM TEST” on page 156. Replace defective component. |

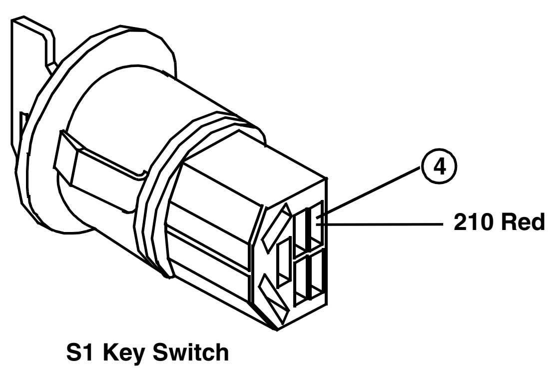

1
160 Blk
S4 PTO Switch


S8 GCS Bag
In Place Switch
142 Blk
145 Blk
2


7
6
445 Yel
H1 GCS Full Alarm
143 Blk


3
X1 To Engine Wiring Harness
900 Wht


7
143 Blk
145 Blk
S9 GCS Bag
Full Switch
5


4
210 Red
S1 Key Switch

# GRASS COLLECTION SYSTEM (GCS) CIRCUIT OPERATION— LTR166 & LTR180

**Function:**

To insure that the grass collection system is properly in place on the tractor, and to alert the operator when the grass collection container is full.

**Operating Conditions:**

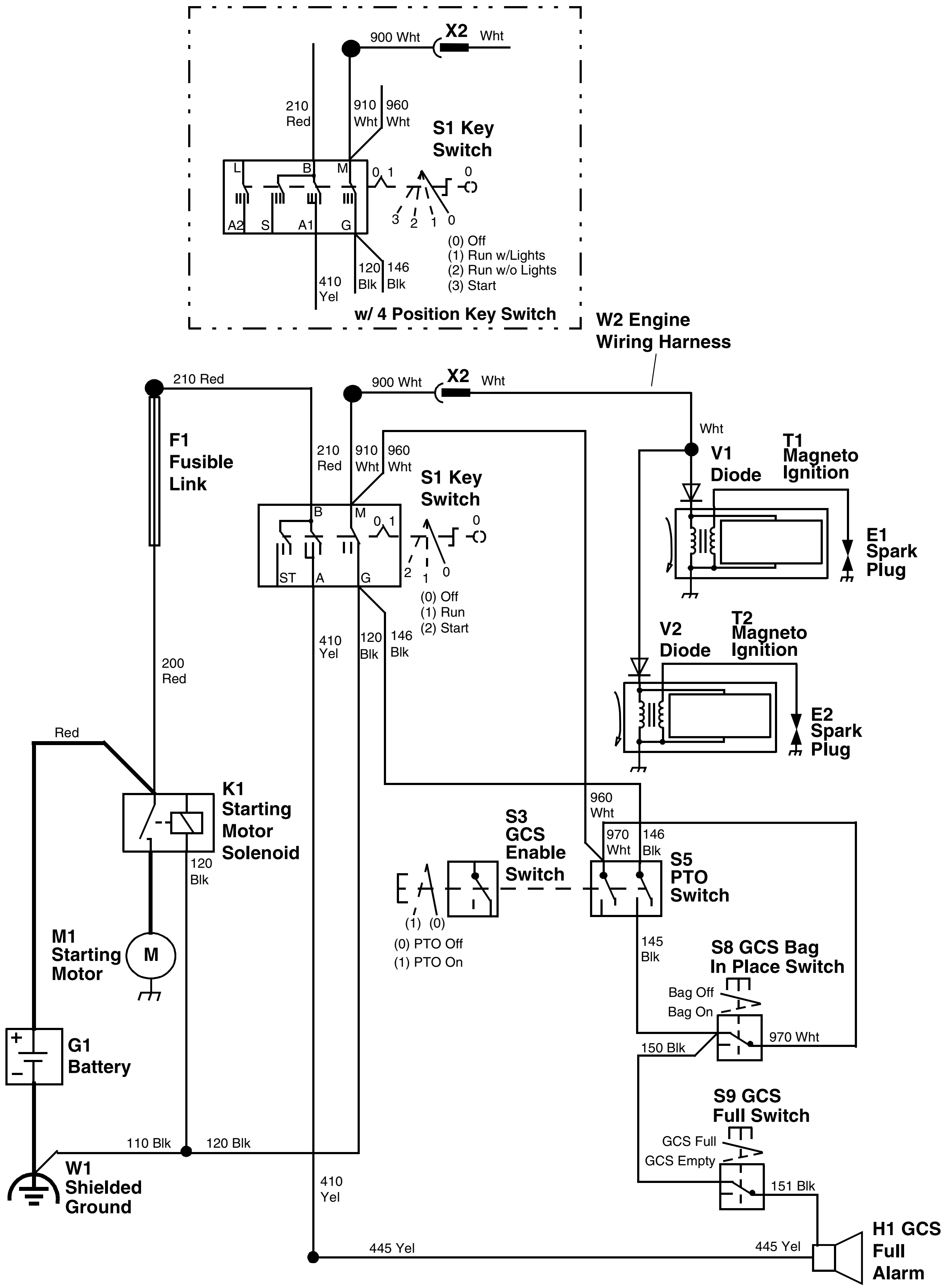
With the engine running and the PTO engaged, the GCS circuit is activated. The GCS circuit has two functions. The first function is to shut off the engine when the PTO is engaged and the collection container is not properly in place on the tractor. The second function is to alert the operator when the grass collection container is full.

**System Operation:**

The first function of the GCS circuit is to shut off the engine when the PTO is engaged if the grass collection container is not properly in place on the tractor. Under this condition a ground path is created from the 110, 120 and 146 Blk wires to the PTO switch. With the PTO engaged the PTO switch contacts are closed connecting the 146 Blk wire to the 145 Blk wire and the GCS bag in place switch. If the grass collection container IS NOT in place, the GCS bag in place switch contacts will be closed and connect the 145 Blk wire to the 970, 960, 910, 900 Wht wire and the magneto ignition. This will then ground the ignition and shut off the engine.

The second function of the GCS circuit is to alert the operator when the grass collection container is full. With the key switch in the run position, power is supplied to the GCS full alarm via the 410 and 445 Yel wires. For this condition to function a ground path is created from the 110, 120 and 146 Blk wires to the PTO switch. With the PTO engaged the PTO switch contacts are closed connecting the 146 Blk wire to the 145 and 150 Blk wires and the GCS bag full switch. If the grass collection container IS full the GCS full switch contacts will be closed and connect the 150 Blk wire to the 151 Blk wire and the GCS full alarm. This will then complete the circuit allowing the alarm to sound, warning the operator that the grass collection container is full.

# GRASS COLLECTION SYSTEM (GCS) CIRCUIT SCHEMATIC—LTR166/180

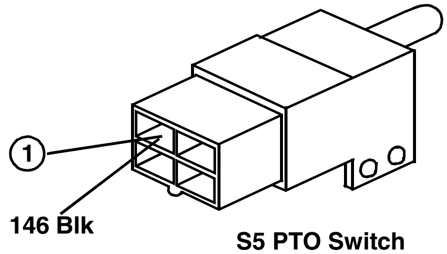


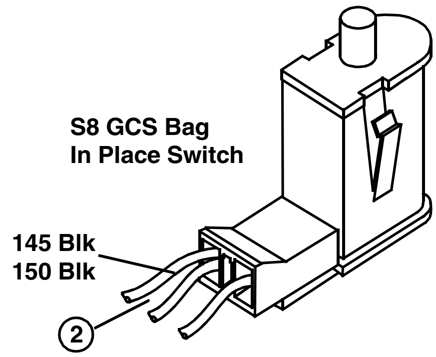
# GRASS COLLECTION SYSTEM (GCS) CIRCUIT DIAGNOSIS—LTR166/180

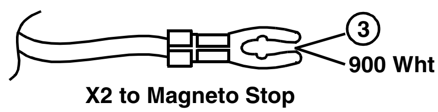
**Test Conditions:**

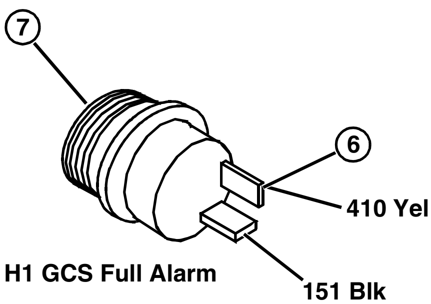
- Key switch in RUN position (engine not running)
- Park brake ON
- PTO ON
- GCS collection container cover OPEN

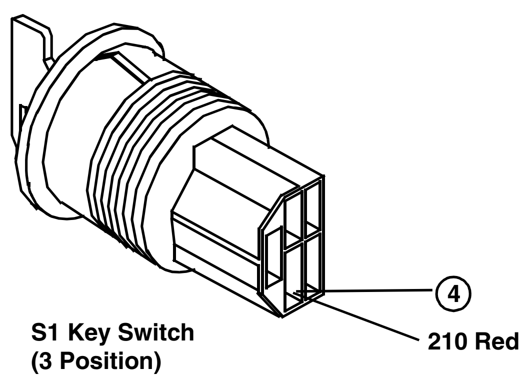
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. PTO switch | Continuity to ground | Check 146, 120 and 110 Blk wires and connections. |
| 2. Grass Collection System (GCS) bag in place switch | Continuity to ground | Check 145 Blk wire and connections. If OK, replace PTO switch. |
| 3. X1 Engine connector, Wht wire | Continuity to ground | Check 900, 910, 960 and 970 Wht wires and connections. If OK, replace GCS bag in place switch. |
| 4. Key switch | Battery voltage | Check battery connections, F1 fusible link and 210 Red wire and connections. See “POWER CIRCUIT OPERATION—LTR166 & LTR180” on page 56. |
| 5. Grass Collection System (GCS) bag full switch | Continuity to ground | Check 150 and 145 Blk wires and connections. If OK, replace PTO switch. |
| 6. Grass Collection System (GCS) full alarm | Battery voltage | Check 410 and 445 Yel wires and connections. If OK, replace key switch. |
| 7. Grass Collection System (GCS) bag full switch lever lifted | Alarm sounding | Check 151 Blk wire and connection. If OK test GCS bag full switch. See “GCS BAG FULL SWITCH TEST” on page 155, and GCS bag full alarm; See “GCS BAG FULL ALARM TEST” on page 156. Replace defective component. |

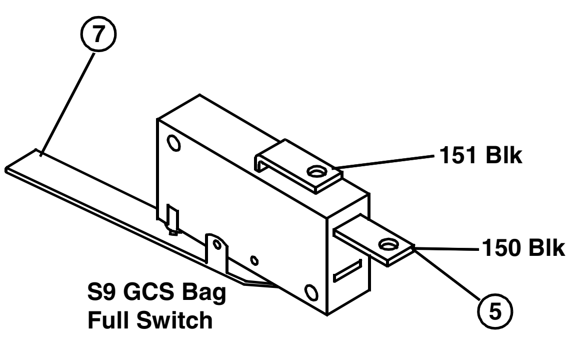

1
146 Blk
S5 PTO Switch

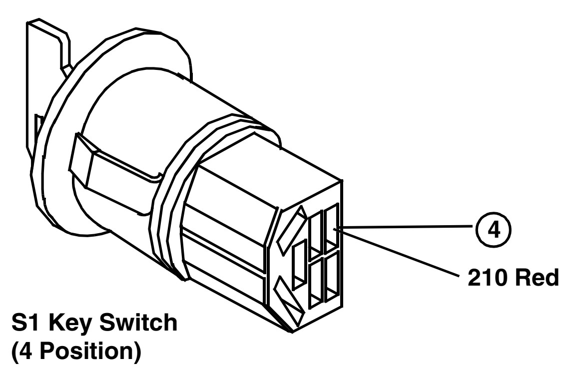

S8 GCS Bag
In Place Switch
145 Blk
150 Blk
2


3
900 Wht
X2 to Magneto Stop


7
6
410 Yel
H1 GCS Full Alarm
151 Blk


4
S1 Key Switch
(3 Position)
210 Red


7
151 Blk
150 Blk
S9 GCS Bag
Full Switch
5


4
210 Red
S1 Key Switch
(4 Position)

## HEADLIGHT CIRCUIT OPERATION—LTR155 w/3 AMP CHARGER

**Function:**

Provides power to the headlights.

**Operating Conditions:**

The engine must be running.

**Theory of Operation:**

The dual circuit stator provides DC current for charging the battery and an independent AC circuit for headlights.

Current for lights is available as long as the engine is running. The output depends upon engine speed, so brightness of the lights changes with engine speed.

The W3 headlight wiring harness is attached to the W1 main wiring harness. Power from the G2 Stator flows through the 510 Blu wire to the headlight harness connector (X4), Yel wire, headlights, Blk wire, (X4) connector, 100 and 135 Blk wire to ground.

## LTR155 w/15 AMP CHARGER

**Operating Conditions:**

The key switch must be in the run or start position.

**Theory of Operation:**

The headlight will be illuminated when ever the key switch is in either the RUN or START positions.

Power for the headlights is provided from the battery positive terminal through the F1 fusible link, 210 Red wire, S1 key switch, 401 and 460 Yel wires, to the headlight harness connector (X4), Yel wire, and headlights.

Blk wire, (X4) connector, 100 and 110 Blk wire to ground.

The ground for the headlights is provided from the headlights wiring harness Blk wire, (X4) connector, to the W1 main wiring harness 100 and 110 Blk wires to ground.

## LTR155 w/15 AMP CHARGER and 4 POSITION KEY SWITCH

**Operating Conditions:**

The key switch must be in position 1 with or without starting the engine.

**Theory of Operation:**

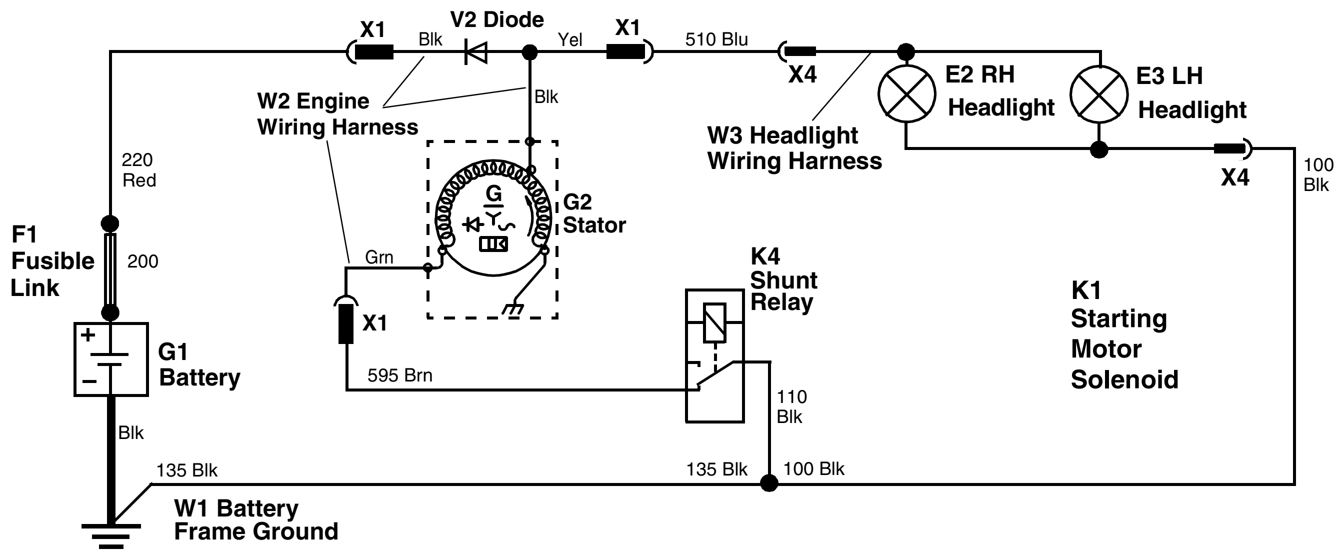
The headlight will be illuminated when ever the key switch turned to position 1, one position counterclockwise from the standard running position (position 2).

Power for the headlights is provided from the battery positive terminal through the F1 fusible link, 210 Red wire, S1 key switch, 401 and 460 Yel wires, to the headlight harness connector (X4), Yel wire, and headlights.

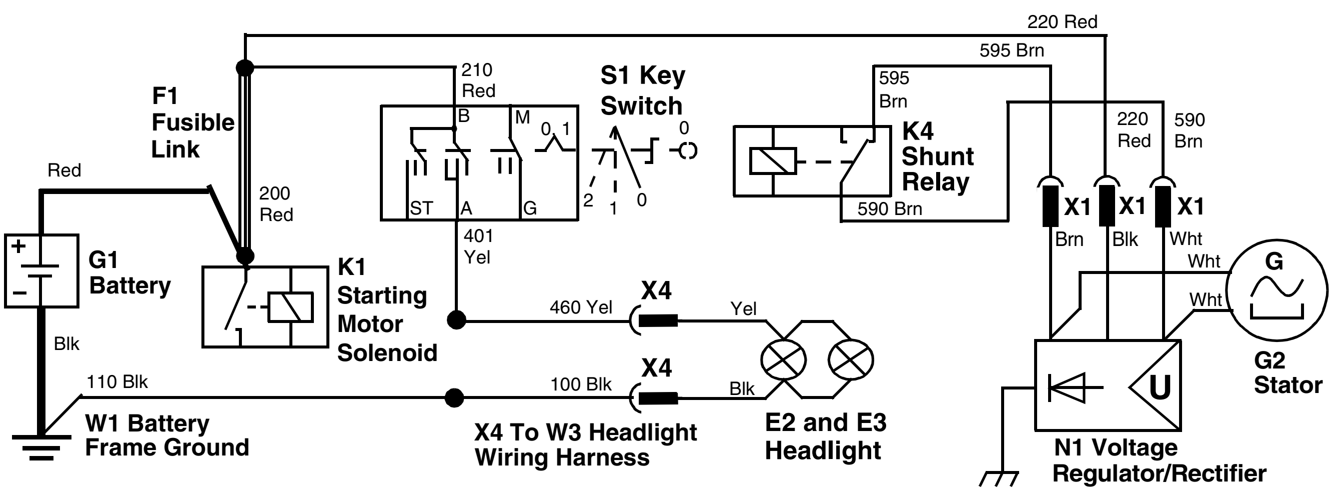
Blk wire, (X4) connector, 100 and 110 Blk wire to ground.

The ground for the headlights is provided from the headlights wiring harness Blk wire, (X4) connector, to the W1 main wiring harness 100 and 110 Blk wires to ground.

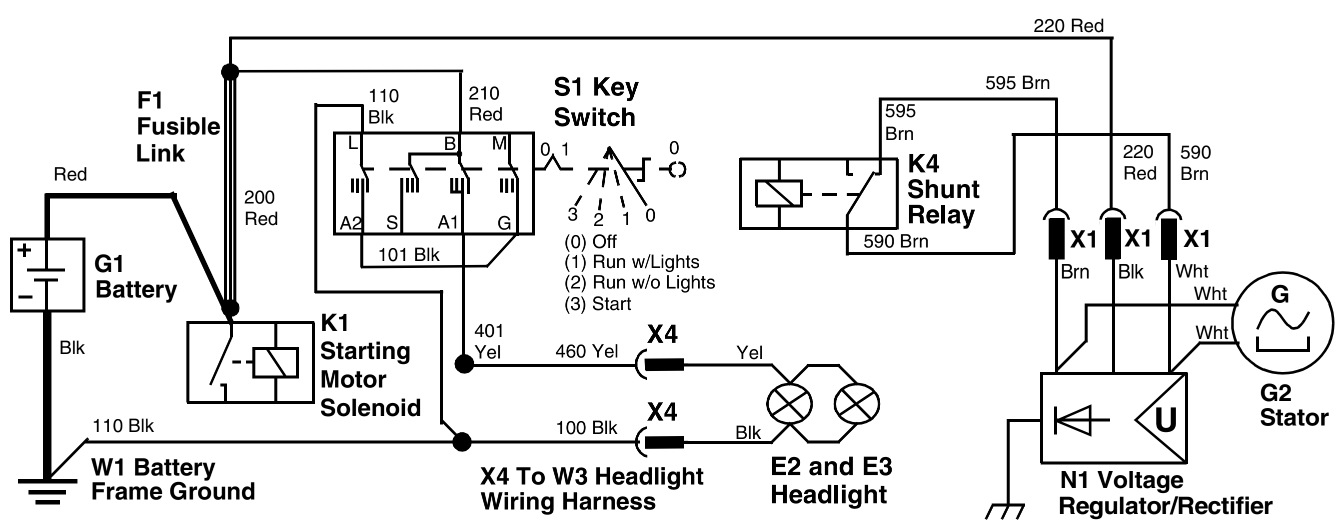
# W3 HEADLIGHT CIRCUIT SCHEMATIC—LTR155 w/3 AMP CHARGER




## LTR155 w/15 AMP CHARGER




## LTR155 w/15 AMP CHARGER and 4 POSITION KEY SWITCH



# HEADLIGHT CIRCUIT OPERATION—LTR166

**Operating Conditions:**

The engine must be running.

**Theory of Operation:**

The dual circuit stator provides DC current for charging the battery and an independent AC circuit for headlights.

Current for lights is available as long as the engine is running. The output depends upon engine speed, so brightness of the lights changes with engine speed.

The W4 headlight wiring harness is attached to the W1 main wiring harness. Power from the G2 Stator flows through the 500 Blu wire to the headlight harness connector (X4), Yel wire, headlights, Blk wire, (X4) connector, 100 and 110 Blk wire to ground.

# LTR166/180 w/4 POSITION KEY SWITCH

**Operating Conditions:**

The key switch must be in position 1 with or without starting the engine.

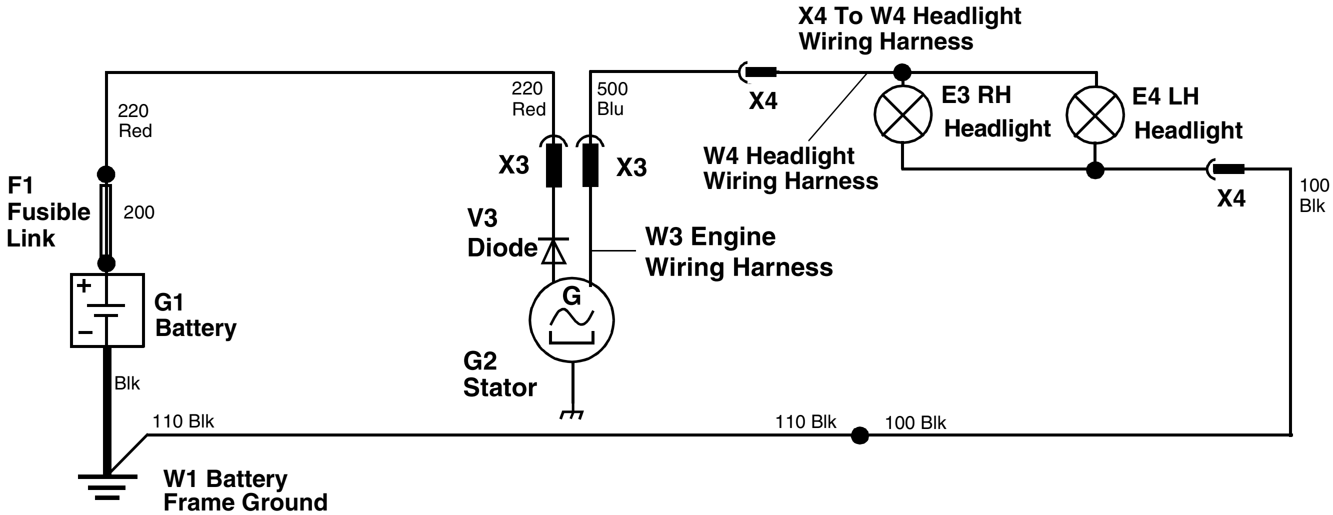
**Theory of Operation:**

The tractor can be operated with or without the headlights on.

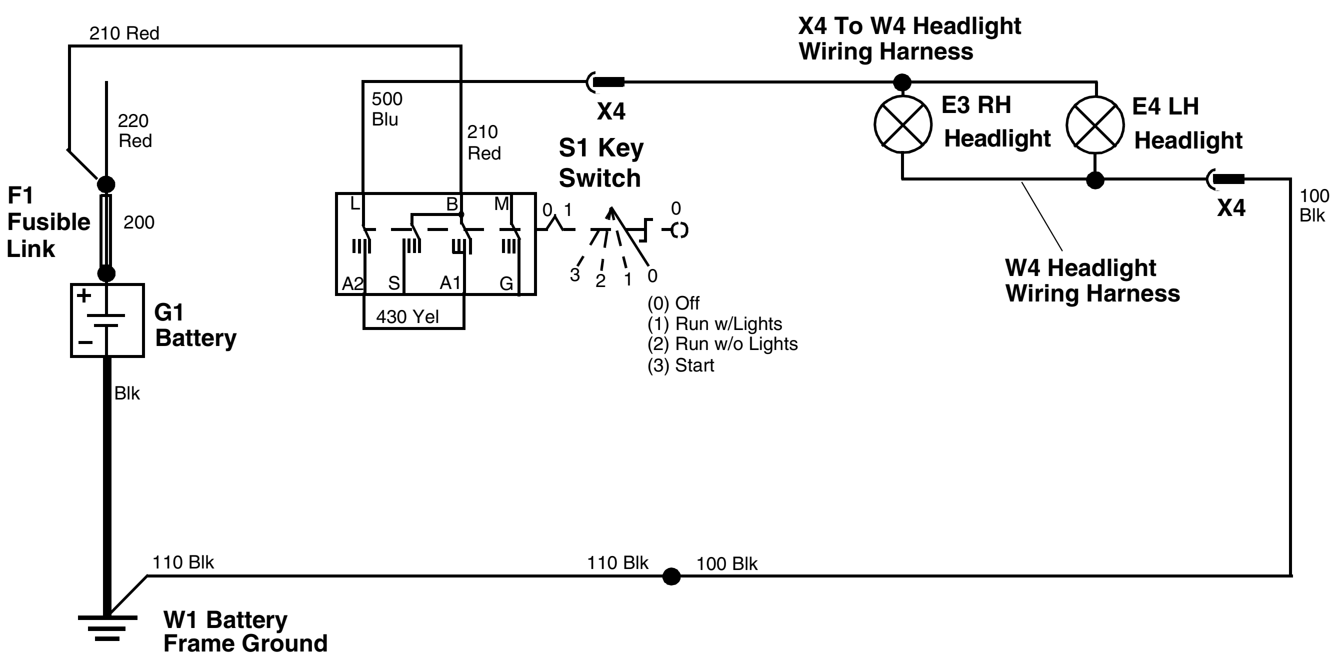
The headlights will be illuminated when ever the key switch turned to position 1, one position counterclockwise from the standard running position (position 2).

The W4 headlight wiring harness is attached to the W1 main wiring harness. Power from the keyswitch is provided through the 500 Blu wire to the headlight harness connector (X4), Yel wire, headlights, Blk wire, (X4) connector, 100 and 110 Blk wire to ground.

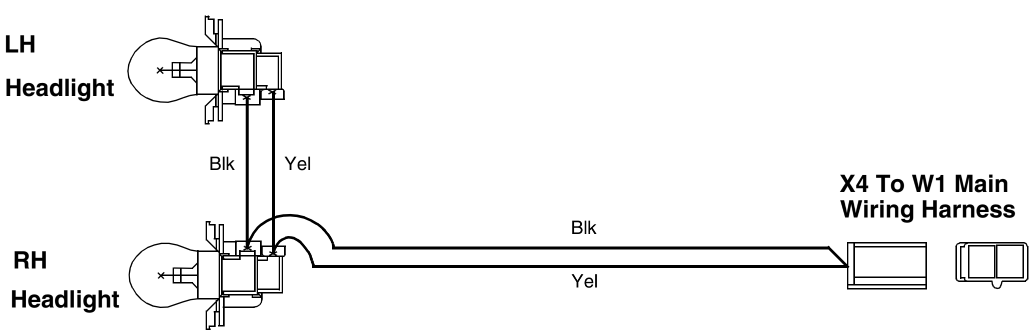
# W4 HEADLIGHT CIRCUIT SCHEMATIC—LTR166




# LTR166/180 w/4 POSITION KEY SWITCH




# HEADLIGHT WIRING HARNESS—LTR155/LTR166/LTR180

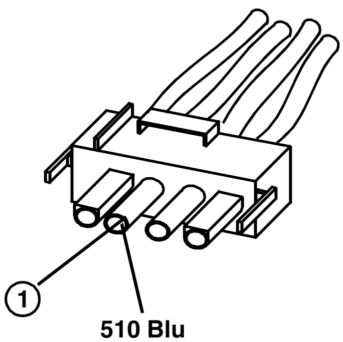


# HEADLIGHT CIRCUIT DIAGNOSIS—LTR155/LTR166/LTR180

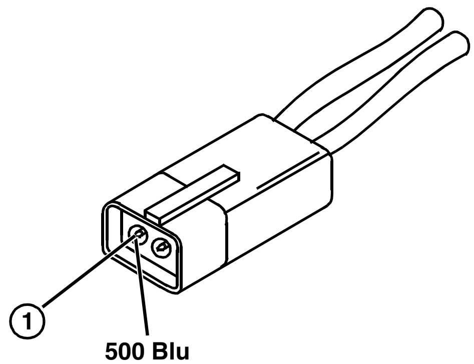
**Test Conditions:**

- Engine must be RUNNING
- Park brake ENGAGED (ON)

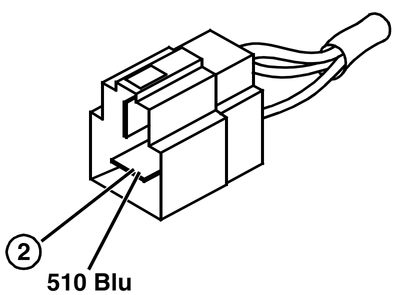
| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. X1 Engine wire harness LTR155 w/3 amp charger and LTR166 | Battery voltage | See Charging Circuit |
| 2. X4 headlight wiring harness connector | Battery voltage | Check 510 Blu wire and connections LTR155 w/3 amp charger.<br>or<br>Check 460 Yel wire and connections LTR155 w/15 amp charger and LTR 155 w/15 amp charger and 4 Position key switch.<br>or<br>Check 500 Blu wire and connections LTR166. |
| 3. X4 headlight wiring harness connector. (LTR155 w/15 amp charger only) | Continuity to ground | Check 100 and 110 Blk wires and connections. |
| 4. RH headlight | Battery voltage | Check headlight wiring harness and connector. |
| 5. RH headlight | Greater than 0 volts - less than 0.2 volts | 0 volts: Replace headlight<br>Greater than 0.2 volts: Check harness connector (X4) and 100, 110, 135 Blk wires and connections. |
| 6. LH headlight | Battery voltage | Check Blk jumper wire and connections between headlights. |
| 7. LH headlight | Greater than 0 volts - less than 0.2 volts | 0 volts: Replace headlight<br>Greater than 0.2 volts: Check Yel jumper wire and connections between headlights. |



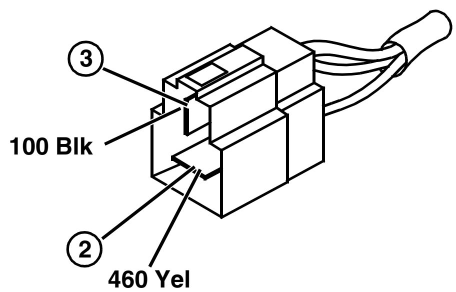

X1 To Engine Wiring Harness
LTR155 w/3 Amp Charger



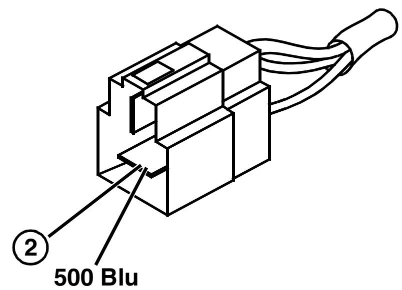

X3 To Engine Wiring
Harness LTR166
(w/3 Position key switch only)



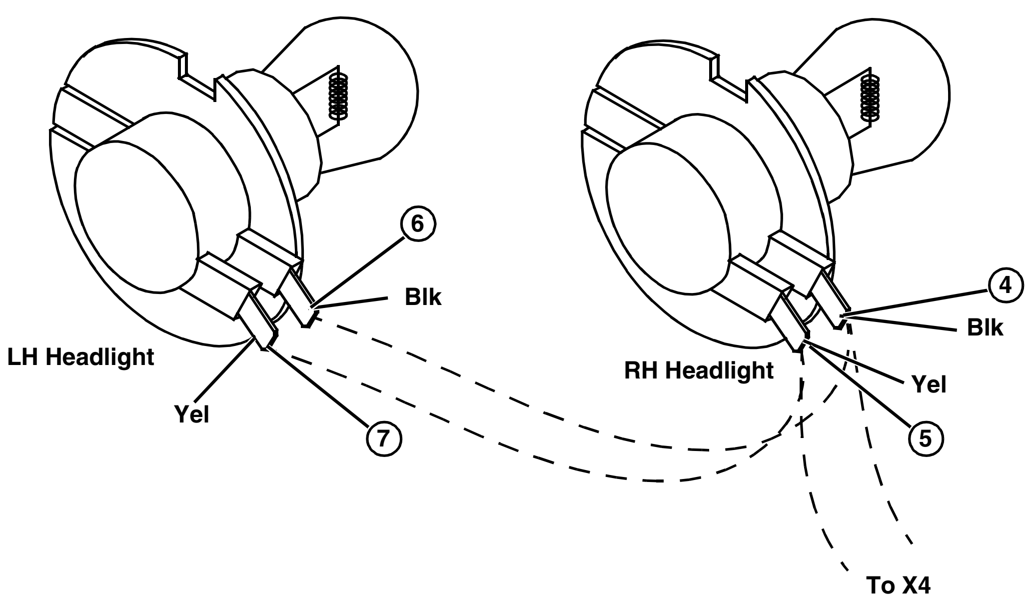

X4 Headlight Connector
LTR155 w/3 Amp Charger




X4 Headlight Connector
LTR155 w/15 Amp Charger
and LTR155 w/15 Amp Charger
and 4 Position key switch




X4 Headlight Connector
LTR166/LTR180



# TESTS AND ADJUSTMENTS

## GROUND CIRCUIT TESTS

**Reason:**

To check for opens, loose terminal wire crimps, poor connections, or corrosion in the ground circuit. The voltmeter method checks ground connections under load.

**Equipment:**

- Ohmmeter or Voltmeter

**Ohmmeter Procedure:**

1. Turn key switch to OFF position. Engage park brake.
2. Connect ohmmeter negative (BLACK) lead to negative (-) terminal of battery. Put meter positive (RED) lead on negative terminal of battery and record reading. Reading should be **0.1 ohm** or less.
3. Put meter RED lead on ground terminal of circuit or component to be tested that is closest to the battery negative terminal. Resistance reading must be very close to or the same as the battery negative terminal reading. Work backwards from the battery on the ground side of the problem circuit until the resistance reading increases above 0.1 ohms. The problem is between the last two test points. If a problem is indicated, disconnect the wiring harness connector to isolate the wire or component and check resistance again. Maximum allowable resistance in the circuit is 0.1 ohms. Check both sides of connectors closely as disconnecting and connecting may temporarily solve problem.

**Voltmeter Procedure:**

1. Put transmission in NEUTRAL. Engage park brake. Put PTO switch in OFF position. Turn key switch to ON position.
2. Connect voltmeter negative (BLACK) lead to negative (-) terminal of battery.
3. Put meter positive (RED) lead on ground terminal of component to be tested. Be sure the component circuit is activated (key switch on, switches closed) so voltage will be present at the component. Record voltage. Voltage must be greater than 0 but less than 1 volt. Some components will have a very small voltage reading on the ground side and still be operating correctly.

**Results:**

- If resistance is above 0.1 ohms, check for open wiring, loose terminal wire crimps, poor connections, or corrosion in the ground circuit.
- If voltage is 0, the component is open.
- If voltage is greater than 1 volt, the ground circuit is bad. Check for open wiring, loose terminal wire crimps, poor connections, or corrosion in the ground circuit.

## BATTERY VOLTAGE AND SPECIFIC GRAVITY TESTS

**Reason:**

To check voltage and determine condition of battery.

**Equipment:**

- Voltmeter or JTO5685 Battery Tester
- Hydrometer Procedure
- Clean battery terminals and top of battery

**Procedure:**

> **⚠ CAUTION**
>
> **Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, eat holes in clothing, and cause blindness if splashed into the eyes.**
>
> **Avoid the hazard by:**
>
> - **Filling batteries in a well-ventilated area**
> - **Wearing eye protection and rubber gloves**
> - **Avoiding breathing fumes when electrolyte is added**
> - **Avoid spilling or dripping electrolyte**
> - **Use proper jumpstart procedure**
>
> **If you spill acid on yourself:**
>
> - **Flush your skin with water**
> - **Apply baking soda or lime to help neutralize the acid**
> - **Flush your eyes with water for 10—15 minutes. Get medical attention immediately**
>
> **If acid is swallowed:**
>
> - **Drink large amounts of water or milk**
> - **Then drink milk of magnesia, beaten eggs, or vegetable oil**
> - **Get medical attention immediately**

1. Inspect battery terminals and case for breakage or cracks.
2. Check electrolyte level in each battery cell. Add clean, soft water as needed. If water added, charge battery for 20 minutes at 10 amps.
3. Remove surface charge by placing a small load on the battery for 15 seconds.
4. Check battery voltage with voltmeter or JTO5685 Battery Tester.
5. Check specific gravity of each cell with a hydrometer.

**Specifications:**

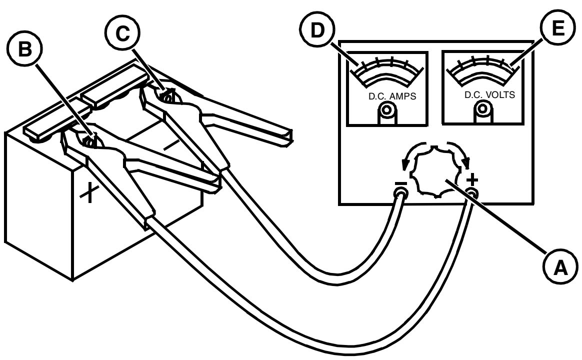
**Minimum battery voltage . . . . . . . . . . . . . 12.4 volts**
**Minimum specific gravity**
**. . . . . . . . . 1.225 with less than 50 point variation**

**Results:**

- Battery voltage less than 12.4 VDC, charge battery.
- Battery voltage more than 12.4 VDC, test specific gravity.
- All cells less than 1.175, charge battery at 10 amp rate.
- All cells less than 1.225 with less than 50 point variation, charge battery at 10 amp rate.
- All cells more than 1.225 with less than 50 point variation, load test battery.
- More than 50 point variation: replace battery.

## BATTERY—LOAD TEST

1. Remove battery.




2. Turn load knob (A) counterclockwise to OFF position.
3. Connect tester positive (red) cable to battery positive (+) terminal (B).
4. Connect tester negative (black) cable to battery negative (–) terminal (C).
5. Turn load knob (A) of tester clockwise (in) until amperage reading (D) is equal to:
- cold cranking amperage rating of battery (use blue scale).

or

- three times ampere hour rating (use black scale).

6. Hold for 15 seconds and turn load knob (A) of tester counterclockwise (out) into OFF position.
7. Repeat Steps 8 and 9 above and read condition of battery at DC Volts scale (E).

**Results:**

- If battery DOES NOT pass test and has NOT been charged, charge battery and retest.
- If battery DOES NOT pass test and HAS BEEN charged, replace battery.

## BATTERY—CHARGE

**Reason:**

To increase battery charge after battery has been discharged.

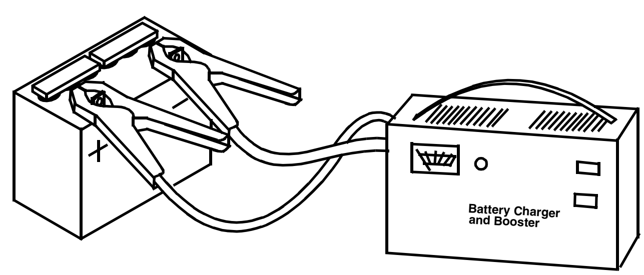
**Equipment:**

- Battery charger (variable rate)

**Procedure:**

*NOTE: See “BATTERY VOLTAGE AND SPECIFIC GRAVITY TESTS” on page 140 before charging battery.*

1. Connect variable rate charger to battery.




*NOTE: Maximum charge time at boost setting is 10 minutes. Allow an additional 5 minutes for each 10 degrees below 70 degrees F.*

2. Start charger at slow rate. Increase charge rate one setting at a time. Check charger ammeter after 1 minute at each setting. Maintain 10 amp charge rate. Use boost setting as necessary.
3. Check if battery is accepting a 10 amp charge after 10 minutes at boost setting.

**Results:**

- Battery will not accept 10 amp charge after 10 minutes at boost setting: replace battery.
- Battery is accepting 10 amp charge after 10 minutes at boost setting, and battery did not need water: go to steps 6 and 7.
- Battery is accepting 10 amp charge after 10 minutes at boost setting, but battery did need water or all cells were below 1.175: go to steps 4 and 5.

4. Set charger at 15 – 25 amps.

**IMPORTANT: Decrease charge rate if battery gases or bubbles excessively or becomes too warm to touch.**

5. Check specific gravity after 30 minutes (60 minutes for maintenance-free battery).

**Results:**

- More than 50 point variation between cells: replace battery.
- Less than 50 point variation between cells: go to steps 6 and 7.

*NOTE: If battery was discharged at slow or unknown rate, charge at 10 – 15 amps for 6 – 12 hours (Maintenance-free battery: 12 – 24 hours). If battery was discharged at fast rate, charge at 20 – 25 amps for 2 – 4 hours (Maintenance-free battery: 4 – 8 hours).*

6. Continue charging battery until specific gravity is 1.230 – 1.265 points.
7. Load test battery. See “BATTERY—LOAD TEST” on page 141.

# STARTING MOTOR SOLENOID TEST

**Reason:**

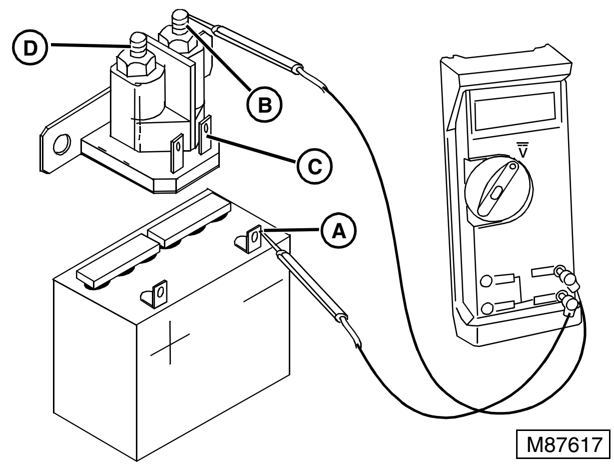
To determine if starting motor solenoid is defective.

**Equipment:**

- Volt Ohm Meter

**Procedure:**

1. Park machine on level surface.
2. Turn key switch to OFF position.
3. Move Forward/Reverse pedals to NEUTRAL position.
4. Engage park brake.
5. Raise hood.
6. Disconnect and ground spark plug lead.




7. Connect VOM to negative (–) battery terminal (A) and terminal (B) of starting motor solenoid. Check for battery voltage.

**Results:**

- No battery voltage – Check battery positive (+) terminal and starting motor solenoid terminal (B) for loose connections. Clean any corrosion.
- Battery voltage – go to next step.

8. Connect VOM to negative (–) battery terminal (A) and terminal (C) (Pur wire) of starting motor solenoid.
9. Momentarily turn ignition key to START position and check for battery voltage.

**Results:**

- No battery voltage – Check Pur wire and connections.
- Battery voltage – Check Blk wire and connections between starting motor solenoid and frame ground. If OK, go to next step.

10. Connect VOM to negative (–) battery terminal (A) and terminal (D) of starting motor solenoid.
11. Momentarily turn ignition key to START position and check for battery voltage.

**Results**

- No battery voltage – starting motor solenoid is defective.
- Battery voltage – starting motor solenoid is OK.

## STARTING MOTOR AMPERAGE DRAW—NO-LOAD

**Reason:**

To determine starting motor condition under no-load conditions.

**Required Tools:**

- JT05791 Multimeter (C)
- JT02153 Current Clamp (A)
- JTO7270 Hand-Held Digital Tachometer (B)
- 12 Volt Battery
- Jumper Cables

**Procedure:**

**CAUTION**

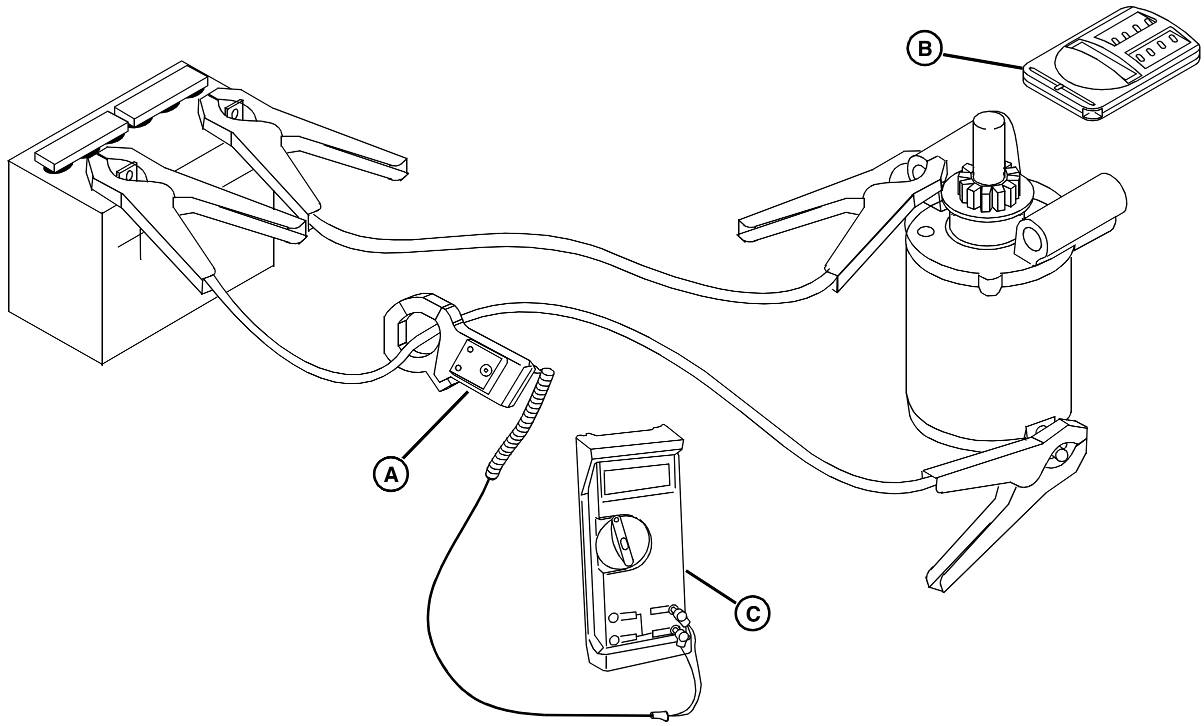
**Do not clamp starting motor housing in vise or strike with a hammer. Clamp only on the mounting bracket. Starting motors contain two ceramic magnets that can be broken or cracked if the motor housing is hit, deformed or dented.**

1. Park machine on level surface.
2. Turn key switch to OFF position.
3. Move Forward/Reverse pedals to NEUTRAL position.
4. Engage park brake.
5. Raise hood.
6. Remove starting motor. See “STARTING MOTOR REMOVAL AND INSTALLATION—LTR155” on page 160.
7. Clamp the starting motor mounting bracket in a vise.
8. Connect the NEG jumper cable to the battery NEG post and the frame of the starting motor.
9. Connect the POS jumper cable to the POS post of the battery.
10. Connect current clamp RED lead to the VOLTS jack of the multimeter and the BLACK lead of the current clamp to the COM jack on the multimeter.
11. Clamp jaws of current clamp around the positive jumper cable.
12. Set the current clamp to 2000A and the multimeter to 300mV.
13. Adjust the DCA ZERO ADJUST dial on the current clamp for a zero reading on the multimeter.

*NOTE: The core of the jaws may hold some magnetic force after the current clamp has been used for measurement. If you cannot zero adjust the display, open the jaws and snap them closed several times.*

14. Momentarily touch the POS jumper cable lead to the starting motor POS post and read the starting motor amperage draw.

*NOTE: If using a multimeter other than JT05791, use a meter that will read millivolts. Millivolts = current in amps; 1mV= 1 amp.*



**Specifications:**

**LTR155**
**Maximum starting motor amp draw . . . . 50 amps**
**LTR166**
**Maximum starting motor amp draw . . . . 35 amps**
**LTR180**
**Maximum starting motor amp draw . . . . 50 amps**

**Result:**

- If amperage is above specification, check starting motor for binding or damaged.

## STARTING MOTOR AMPERAGE DRAW—LOADED

**Reason:**

To determine amperage needed to crank the engine.

**Required Tools:**

- JT05791 Multimeter
- JT02153 Current Clamp

**Procedure:**

1. Park machine on level surface.
2. Turn key switch to OFF position.
3. Move Forward/Reverse pedals to NEUTRAL position.
4. Engage park brake.
5. Raise hood.
6. Disconnect and ground spark plug lead.


LTR155 Shown

7. Connect current clamp (B) RED lead to the VOLTS jack of the multimeter and the BLACK lead of the current clamp to the COM jack on the multimeter.
8. Clamp jaws of current clamp around the positive battery cable.
9. Set the current clamp to 2000A and the multimeter to 300mV.
10. Adjust the DCA ZERO ADJUST dial on the current clamp for a zero reading on the multimeter.

*NOTE: The core of the jaws may hold some magnetic force after the current clamp has been used for measurement. If you cannot zero adjust the display, open the jaws and snap them closed several times.*

11. Crank the engine and read the starting motor amperage draw.

*NOTE: If using a multimeter other than JT05791, use a meter that will read millivolts. Millivolts = current in amps; 1mV = 1 amp.*

**Specifications:**

**LTR155**

**Maximum starting motor amp draw . . . . . 180 amps**

**LTR166**

**Maximum starting motor amp draw . . . . . 100 amps**

**Result:**

- If amperage is above specification check starting motor for binding or damaged wires or windings.
- If starting motor is good, check internal engine, traction or PTO drive for binding or damage.

# REGULATED AMPERAGE TEST

**Reason:**

To determine charging output of rectifier/regulator.

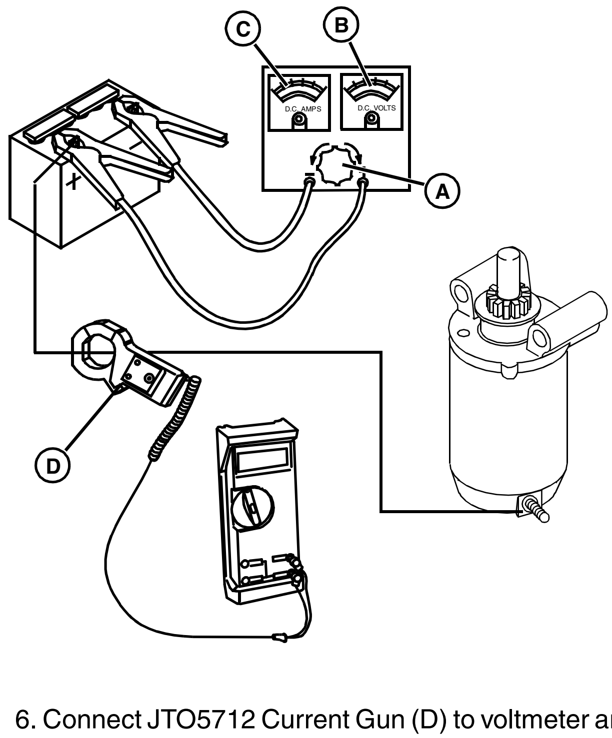
**Test Equipment:**

- Voltmeter
- JT05712 Current Gun
- JT05685 Battery Tester

**Procedure:**

1. Park machine on level surface.
2. Turn key switch OFF.
3. Move Forward/Reverse pedals to NEUTRAL position.
4. Engage parking brake.
5. Raise hood.

*NOTE: Battery must be in a good state of charge at 12 to 15 VDC.*




6. Connect JTO5712 Current Gun (D) to voltmeter and put around positive (red) battery cable going to starting motor. Set current gun for DC current.

**IMPORTANT: Turn load knob (A) fully counterclockwise (out) into OFF position BEFORE making any test connections.**

7. Connect battery tester to battery.

**IMPORTANT: Perform this test quickly to prevent damage to battery tester. DO NOT apply full load to battery for more than 5 – 10 seconds.**

8. Turn load knob clockwise (in) until voltage on voltage tester scale (B) (note: left side of tester (C) shows amps) reads **11 volts for 5 seconds only** to partially drain battery.
9. Quickly turn load knob completely counter-clockwise (out) to OFF position.
10. Start and run engine at **fast idle**. Battery voltage should read **between 12.2 – 15.0 VDC**.
11. Turn load knob clockwise (in) until voltage on tester voltage scale (B) reads 11 volts and look at current gun for a minimum reading of **13.5 amps**.
12. Quickly turn load knob completely counter-clockwise (out) to OFF position.
13. After load test, voltage scale should return to voltage level prior to test.

**Results:**

- If reading does not meet specifications, test stator voltage output. (See *STATOR OUTPUT TEST* procedure.)
- If stator voltage output meets specifications and voltage and ground to the regulator/rectifier is verified, replace the regulator/rectifier.

# REGULATED VOLTAGE TEST

**Reason:**

To determine regulated voltage output of the regulator/rectifier.

**Test Equipment:**

- Voltmeter

**Procedure:**

1. Park machine on level surface.
2. Turn key switch OFF.
3. Move Forward/Reverse pedals to NEUTRAL position.
4. Engage parking brake.
5. Raise hood.
6. Remove surface charge from battery by placing a small load on the battery for 15 seconds.
7. Set voltmeter for 25 or 50 DC volt scale.
8. Connect voltmeter positive (red) lead to battery positive (+) terminal (A).

9. Connect voltmeter negative (black) lead to battery negative (–) terminal (B).
10. Start and run engine at **fast idle**.
11. Read voltmeter several times during 5 minutes of running time. Voltage should remain between **12.2 – 14.7 volts DC**.

**Results:**

- If the DC voltage remains below the minimum specification, test stator voltage output. (See *STATOR OUTPUT TEST* procedure.)
- If the DC voltage goes above the maximum specification, replace the regulator/rectifier.

## FLYWHEEL MAGNET TEST

**Reason:**

To make sure flywheel magnet(s) have enough force to induce current into ignition coil.

**Equipment:**

- Screwdriver.

**Procedure:**

1. Park machine on level surface.
2. Turn key switch to OFF position.
3. Move Forward/Reverse pedals to NEUTRAL position.
4. Engage park brake.
5. Raise hood.
6. Remove flywheel blower housing from engine.
7. Loosely hold screwdriver blade about 25 mm (1.0 in.) away from magnet.

**Results:**

- Magnet should attract blade to it.
- If blade is NOT attracted to magnet, flywheel must be replaced.

## ALTERNATOR DC OUTPUT TEST—LTR155 w/3 AMP CHARGER

**Reason:**

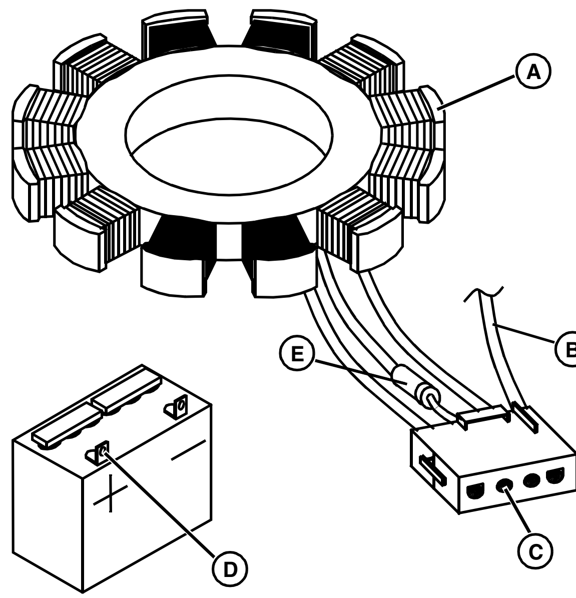
To determine proper output of stator.

**Equipment:**

- Multimeter

**Procedure:**

1. Disconnect connector from G2 stator (A).
2. Set multimeter for DC amps.




3. Insert RED test lead into 10 A receptacle in meter.
4. Insert BLACK test lead into COM receptacle in meter.
5. Attach RED test clip to DC output pin (C) in connector (Note: White wire (B) goes to Magneto).
6. Attach BLACK test lead clip to positive (+) battery terminal (D).
7. Start engine and run at full throttle.
8. Check output.

**Specifications:**

**DC output at full throttle . . . . . . . . . . . . . 2 – 4 amps**

**Results:**

- Output will vary with battery voltage. If battery voltage is at its maximum, output will be approximately 2 amps.
- If no or low output is found, test V2 diode (E).

# STATOR OUTPUT TEST w/15 AMP CHARGER

**Reason:**

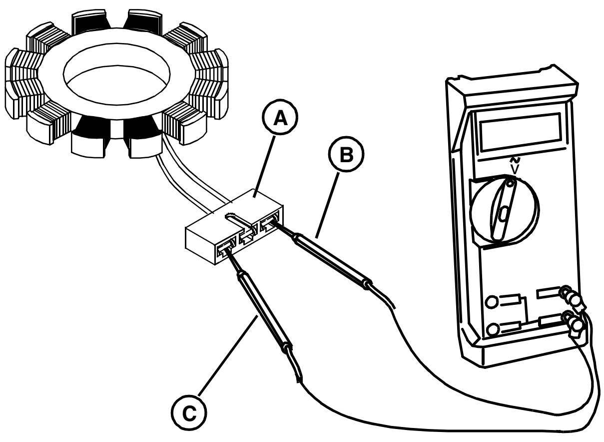
To measure AC voltage output of stator and verify correct resistance of stator.

**Equipment:**

• Fluke Multi-Meter (Set to AC volt scale)

**Procedure:**

1. Park machine on level surface.
2. Turn key switch to OFF position.
3. Move Forward/Reverse pedals to NEUTRAL position.
4. Engage park brake.
5. Raise hood.
6. Set meter to 50 VAC or Autorange scale.
7. Disconnect regulator/rectifier connector.




8. Start and run at **fast idle (3350 ± 75 RPM)**.
9. Connect red test lead (B) to connector (A).
10. Connect black test lead (C) to connector (A).
11. Measure stator voltage. Voltage should read a **minimum of 28 volts AC**.

**Results:**

• If voltage is less than specification, test stator with an ohmmeter.

12. Stop engine.
13. Change meter to ohms scale.
14. Measure resistance across stator leads. Resistance should read **0.1 to 0.2 ohms**.

**Results:**

• If resistance is infinite ohms, stator is open. Replace stator.

15. Measure resistance from each stator lead to ground. Resistance should read **infinite ohms**.

**Results:**

• If resistance (or continuity) is measured, stator leads are shorted to ground. Replace stator.

# ALTERNATOR DIODE TEST— LTR155 w/3 AMP CHARGER

**Reason:**

To determine alternator diode is functioning correctly.

**Equipment:**

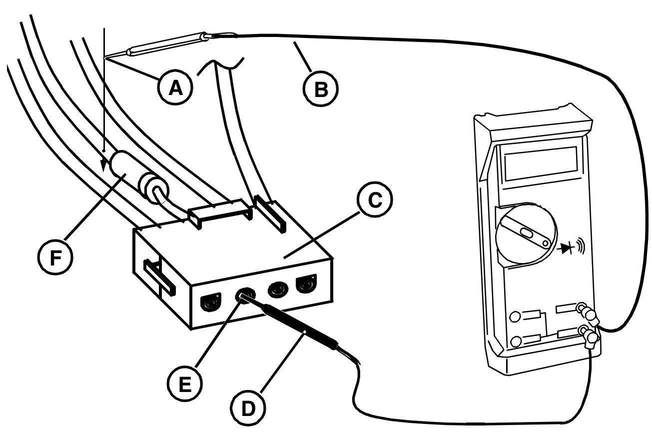
• Multimeter with diode test function.

**Test Connections:**

• Set multimeter for Diode Test position.

**Procedure:**

1. Disconnect X1 wiring harness connector (C) from stator.




2. Insert RED test lead into VOLTS receptacle in meter.
3. Insert BLACK test lead into COM receptacle in meter.
4. Attach RED test lead (B) clip to point (A). (It may be necessary to pierce wire with a pin as shown.)
5. Attach BLACK test lead (D) clip to point (E). (DC output pin)

• If meter beeps once, diode (F) is OK.

• If meter makes a continuous tone, diode is defective (shorted). Replace diode.

• If meter displays “OL”, proceed to step 6.

6. Reverse test leads.

• If meter beeps once, diode is installed backwards. Replace diode.

• If meter still displays OL, diode is defective (open). Replace diode.

## ALTERNATOR DC OUTPUT TEST—LTR166

**Reason:**

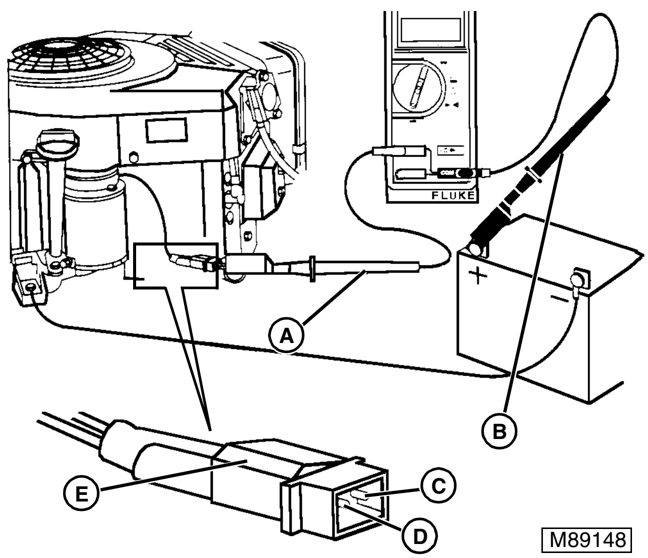
To determine proper output of stator.

**Equipment:**

• Multimeter

**Procedure:**

1. Disconnect connector from stator.
2. Set multimeter for DC amps.




3. Insert RED test lead into 10 A receptacle in meter.
4. Insert BLACK test lead into COM receptacle in meter.
5. Attach RED test (A) clip to DC output pin (D) in connector (Note: Raised rib on connector (E) indicates DC pin side, and also note AC outpin pin (C)).
6. Attach BLACK test lead (B) clip to positive (+) battery terminal.
7. Start engine and run at full throttle.
8. Check output.

**Specifications:**

**DC output at full throttle . . . . . . . . . . . . . 2 – 4 amps**

**Results:**

• Output will vary with battery voltage. If battery voltage is at its maximum, output will be approximately 2 amps.

• If no or low output is found, test diode.

## ALTERNATOR DIODE TEST—LTR166

**Reason:**

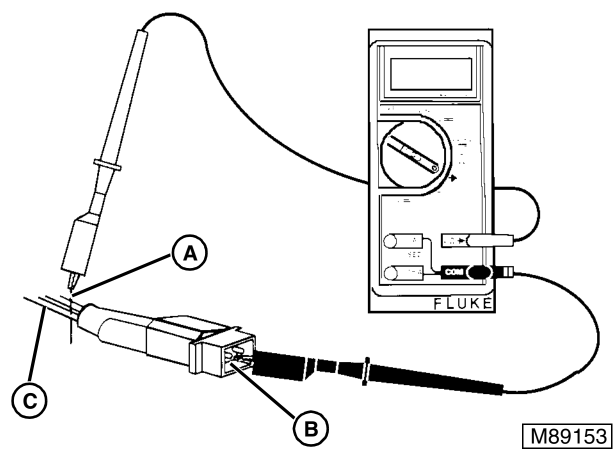
To determine alternator diode is functioning correctly.

**Equipment:**

• Multimeter with diode test function.

**Procedure:**

1. Disconnect connector from stator.
2. Set multimeter for Diode Test position.




3. Insert RED test lead into VOLTS receptacle in meter.
4. Insert BLACK test lead into COM receptacle in meter.
5. Attach RED test lead clip to point (A). (It may be necessary to pierce red wire (C) with a pin as shown).
6. Attach BLACK test lead clip to point (B). (DC output pin)

• If meter beeps once, diode is OK.

• If meter makes a continuous tone, diode is defective (shorted). Replace diode.

• If meter displays “OL”, proceed to step 7.

7. Reverse test leads.

• If meter beeps once, diode is installed backwards. Replace diode.

• If meter still displays OL, diode is defective (open). Replace diode.

# VOLTAGE REGULATOR/RECTIFIER TEST—LTR155 w/15 AMP CHARGER

**Reason:**

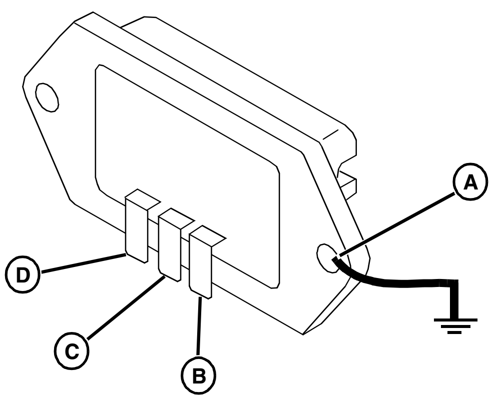
To verify proper operation capability of the voltage regulator/rectifier.

**Equipment:**

- Fluke Multi-Meter (Set to Ohms scale)

**Procedure:**

1. Park machine on level surface.
2. Turn key switch to OFF position.
3. Move Forward/Reverse pedals to NEUTRAL position.
4. Engage park brake.
5. Raise hood.




6. Disconnect stator connector from the voltage regulator/rectifier.
7. Set the Multi-Meter to the Ohms scale.
8. Measure resistance between each point as shown in the chart. If resistance is not within specification, replace voltage regulator/rectifier.

| | A | B | C | D |
|---|---|---|---|---|
| A | | 8 - 9 M | 8 - 9 M | 31.2 M |
| B | OL | | 0.2 | OL |
| C | OL | 0.2 | | OL |
| D | 31.2 M | 8 - 9M | 8 - 9 M | |

# VOLTAGE REGULATOR/RECTIFIER TEST—LTR180 w/13 AMP CHARGER

**Reason:**

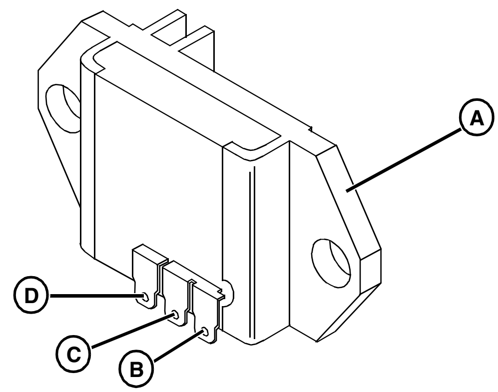
To verify proper operation capability of the voltage regulator/rectifier.

**Equipment:**

- Multimeter

**Procedure:**

1. Disconnect stator connector from the voltage regulator/rectifier.
2. Set the multi-meter to the Ohms scale.




3. Measure resistance between each point as shown in the chart.

| | A | B | C | D |
|---|---|---|---|---|
| A | | OL | OL | OL |
| B | OL | | 0.0 | 500 - OL |
| C | OL | 0.2 | | 500 - OL |
| D | 7.8 k - OL | 800 - OL | 800 - OL | |

4. If resistance is not within specification, replace voltage regulator/rectifier.

# DIODE TEST

### Reason:

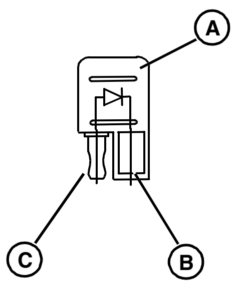
To verify that diode has proper continuity.

### Equipment:

- Ohmmeter or continuity tester

### Procedure:

1. Remove diode from connector.




2. Connect ohmmeter red (+) lead to pin (C) of diode (A). Connect ohmmeter black (-) lead to pin (B) of diode. Check for continuity.
3. Reverse test leads. Check for continuity.

### Results:

- Diode must have continuity in one direction only. Replace defective diode.

# RELAY TEST

### Reason:

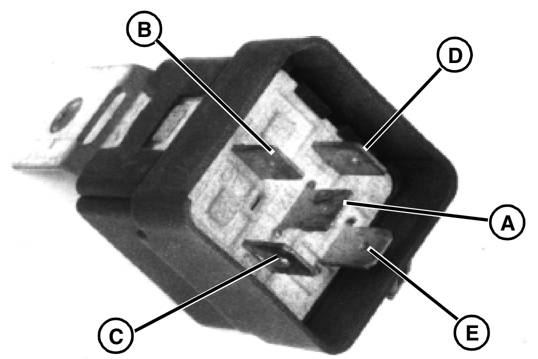
To check relay terminal continuity in the energized and de-energized condition.

### Equipment:

- Ohmmeter or continuity tester

### Procedure:

1. Park machine on level surface.
2. Engage park brake.
3. Turn key switch OFF.
4. Disconnect relay connector.
5. Check terminal continuity using an ohmmeter or continuity tester.

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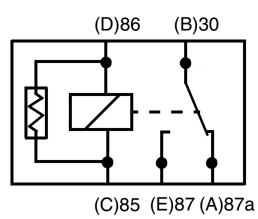



### Results:

- There should be continuity between terminals (A) and (B), and between terminals (C) and (D).
- There should NOT be continuity between terminals (E) and (B).

6. Connect a jumper wire from battery positive (+) terminal to relay terminal (C). Connect a jumper wire from relay terminal (D) and ground (-).

### Results:

- There should be continuity between terminals (E) and (B).
- If continuity is NOT correct, replace relay.

# 3 POSITION KEY SWITCH TEST

**Reason:**

To determine proper operation of key switch.

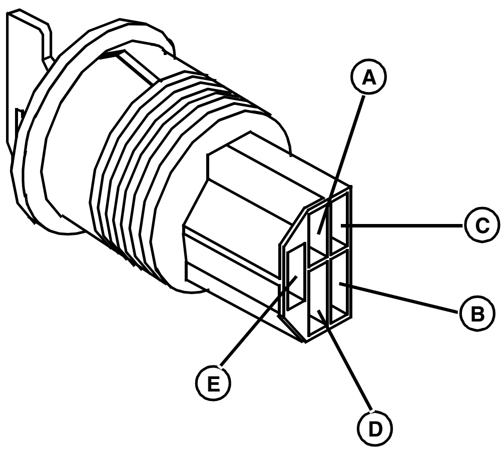
**Equipment:**

- Ohmmeter

**Test Conditions:**

- Set ohmmeter for 1X ohms scale
- Remove connector from back of key switch

**Procedure:**




1. Connect meter leads to pairs of switch posts and compare to specifications.
2. For ignition circuit, turn key switch from OFF to RUN position.
3. For starting circuit, turn key switch from RUN to START position.

**Specifications:**

**Switch in OFF**

**. . . . . . . . . . . . . . . . . . continuity between A and B**
**. . . . . . . . . . . . . . . no continuity between C and D**

**Switch in RUN**

**. . . . . . . . . . . . . . . . . . continuity between C and D**
**. . . . . . . . . . . . . . . no continuity between A and B**

**Switch in START**

**. . . . . . . . . . . . . . . . . . continuity between C and D**
**. . . . . . . . . . . . . . . . . . continuity between C and E**
**. . . . . . . . . . . . . . . . . . continuity between D and E**
**. . . . . . . . . . . . . . . no continuity between A and B**

**Results:**

- If key switch does not pass all tests, replace switch.

# 4 POSITION KEY SWITCH TEST

**Reason:**

To determine proper operation of key switch.

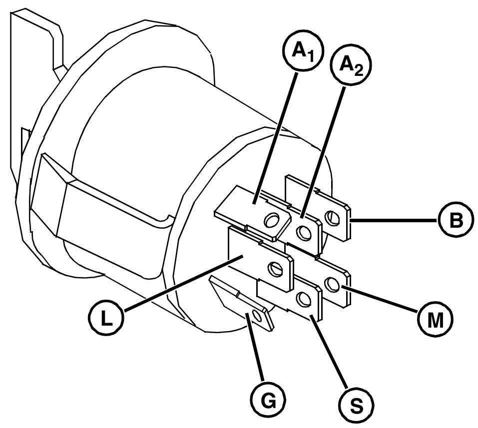
**Equipment:**

- Ohmmeter

**Test Conditions:**

- Set ohmmeter for 1X ohms scale
- Remove connector from back of key switch

**Procedure:**




1. Connect meter leads to pairs of switch posts and compare to specifications.
2. For ignition circuit, turn key switch from OFF to RUN position.
3. For starting circuit, turn key switch from RUN to START position.

**Specifications:**

**Switch in OFF (Stop)**

**. . . . . . . . . . . . . . continuity between M, G and $A_1$**

**Switch in RUN 1 (With Lights)**

**. . . . . . . . . . . . . . . . . continuity between B and $A_1$**
**. . . . . . . . . . . . . . . . . continuity between L and $A_2$**

**Switch in RUN 2 (Without Lights)**

**. . . . . . . . . . . . . . . . . continuity between B and $A_1$**

**Switch in START**

**. . . . . . . . . . . . . . . . continuity between B, S and $A_1$**

**Results:**

- If key switch does not pass all tests, replace switch.

# BRAKE AND RIO SWITCH TEST

**Reason:**

To determine proper operation of Brake or RIO switch.

**Equipment:**

- Ohmmeter

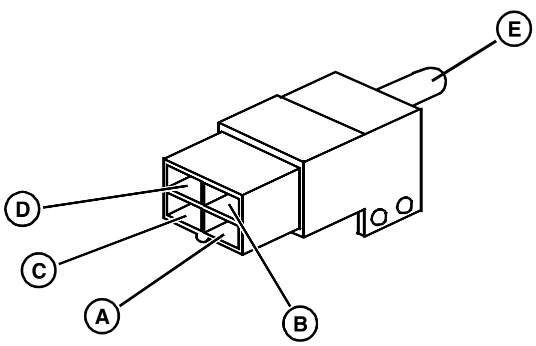
**Test Connections:**

- Set ohmmeter for 1X scale

*NOTE: On analog (swing needle) Ohmmeters, set zero point before each test.*

**Procedure:**

1. Remove connector from Brake or RIO switch.
2. Remove switch to be tested from machine.




3. Connect meter leads to pairs of switch posts and compare to specifications.
4. Press and release plunger (E) of switch.

**Specifications:**

**Switch plunger not pressed**
**. . . . . . . . . . . . .continuity between posts A and B**
**. . . . . . . . . . no continuity between posts C and D**
**Switch plunger pressed**
**. . . . . . . . . . no continuity between posts A and B**
**. . . . . . . . . . . . .continuity between posts C and D**

**Results:**

- If Brake or RIO switch does not pass all tests, replace switch.

# PTO SWITCH TEST

**Reason:**

To determine proper operation of the PTO switch.

**Equipment:**

- Ohmmeter

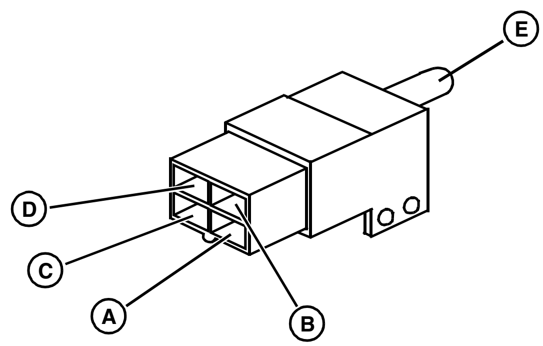
**Test Connections:**

- Set ohmmeter for 1X scale

*NOTE: On analog (swing needle) Ohmmeters, set zero point before each test.*

**Procedure:**

1. Remove connector from PTO switch.
2. Remove switch from behind dash panel of tractor.




3. Connect meter leads to pairs of switch posts and compare to specifications.
4. Press and release plunger (E) of switch.

**Specifications:**

**Switch plunger not pressed**
**. . . . . . . . . . . . .continuity between posts A and B**
**. . . . . . . . . . . . .continuity between posts C and D**
**Switch plunger pressed**
**. . . . . . . . . . no continuity between posts A and B**
**. . . . . . . . . . no continuity between posts C and D**

**Results:**

- If PTO switch does not pass all tests, replace switch.

# RIS SWITCH TEST

**Reason:**

To determine proper operation of RIS switch.

**Equipment:**

• Ohmmeter

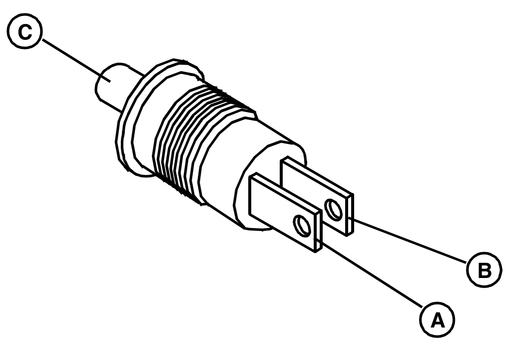
**Test Connections:**

• Set ohmmeter for 1X scale

*NOTE: On analog (swing needle) Ohmmeters, set zero point before each test.*

**Procedure:**

1. Remove connector from RIS switch.




2. Connect one lead of meter to terminal (A) of switch.
3. Connect other lead of meter to terminal (B) of switch.
4. Press and release plunger (C) of switch.

**Specifications:**

**Switch plunger not pressed**
**. . . . . . . . . . no continuity between posts A and B**
**Switch plunger pressed**
**. . . . . . . . . . . . .continuity between posts A and B**

**Results:**

• If RIS switch does not pass both tests, replace switch.

# SEAT SWITCH TEST

**Reason:**

To determine proper operation of seat switch.

**Equipment:**

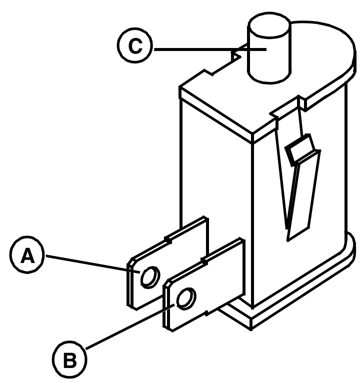
• Ohmmeter

**Test Connections:**

• Set ohmmeter for 1X ohms scale

**Procedure:**

1. Remove connector from seat switch.




2. Connect one lead of meter to terminal (A) of switch.
3. Connect other lead of meter to terminal (B) of switch.
4. Press and release seat switch plunger (C).

**Specifications:**

**LTR155 (normally open)**

**Seat switch plunger not pressed**
**. . . . . . . . . . . no continuity between post A and B**
**Seat switch plunger pressed**
**. . . . . . . . . . . . . .continuity between post A and B**

**LTR166 (normally closed)**

**Seat switch plunger not pressed**
**. . . . . . . . . . . . . .continuity between post A and B**
**Seat switch plunger pressed**
**. . . . . . . . . . . no continuity between post A and B**

**Results:**

• If the seat switch does not pass both tests, replace switch.

## SEAT SWITCH TEST (USED W/4 POSITION KEY SWITCH)

**Reason:**

To determine proper operation of seat switch.

**Equipment:**

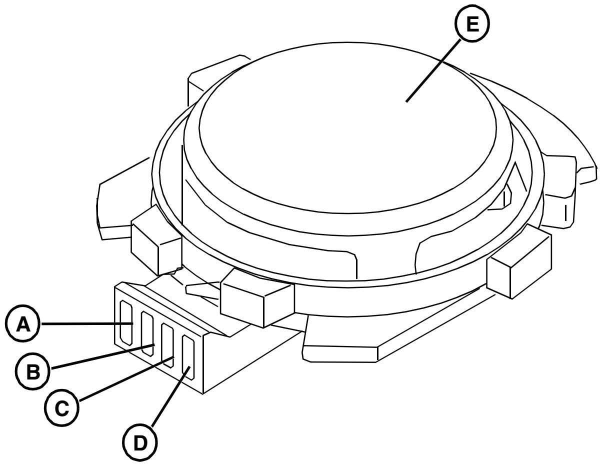
- Ohmmeter

**Test Connections:**

- Set ohmmeter for 1X ohms scale

**Procedure:**

1. Remove connector from seat switch.




2. Connect meter leads to pairs of switch posts and compare to specifications.
3. Press and release plunger (E) of switch.

**Specifications:**

**Seat switch plunger not pressed**
**. . . . . . . . . . continuity between terminal B and C**
**. . . . . no continuity between any other terminals**
**Seat switch plunger pressed**
**. . . . . . . . . . continuity between terminal A and D**
**. . . . . no continuity between any other terminals**

**Results:**

- If the seat switch does not pass test, replace switch.

## GCS BAG IN PLACE SWITCH TEST

**Reason:**

To determine proper operation of GCS bag in place switch.

**Equipment:**

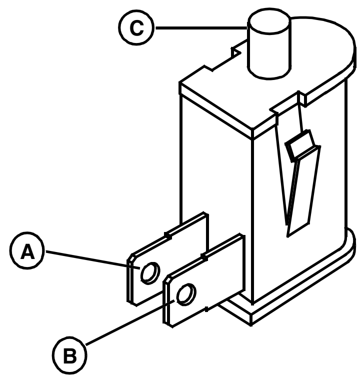
- Ohmmeter

**Test Connections:**

- Set ohmmeter for 1X ohms scale

**Procedure:**

1. Remove connector from bag in place switch.




2. Connect one lead of meter to terminal (A) of switch.
3. Connect other lead of meter to terminal (B) of switch.
4. Press and release the switch plunger (C).

**Specifications:**

**Switch plunger not pressed**
**. . . . . . . . . . . . . .continuity between post A and B**
**Switch plunger pressed**
**. . . . . . . . . . . no continuity between post A and B**

**Results:**

- If the GCS bag in place switch does not pass both tests, replace switch.

# GCS BAG FULL SWITCH TEST

**Reason:**

To determine proper operation of GCS bag in place switch.

**Equipment:**

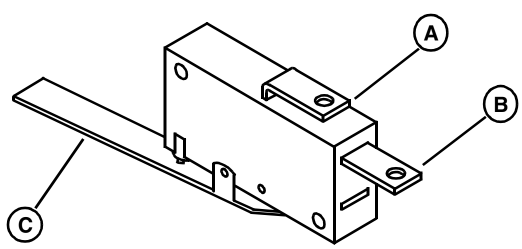
• Ohmmeter

**Test Connections:**

• Set ohmmeter for 1X ohms scale

**Procedure:**

1. Remove connector from bag full switch.




2. Connect one lead of the meter to the COM terminal (A) of the switch.
3. Connect the other lead of the meter to the NO terminal (B) of the switch.
4. Press and release the switch lever (C).

**Specifications:**

**Switch plunger not pressed**
**. . . . . . . . . . . no continuity between post A and B**
**Switch plunger pressed**
**. . . . . . . . . . . . . .continuity between post A and B**

**Results:**

• If the GCS bag full switch does not pass both tests, replace switch.

# GCS ENABLE SWITCH TEST

**Reason:**

To determine proper operation of GCS enable switch.

**Equipment:**

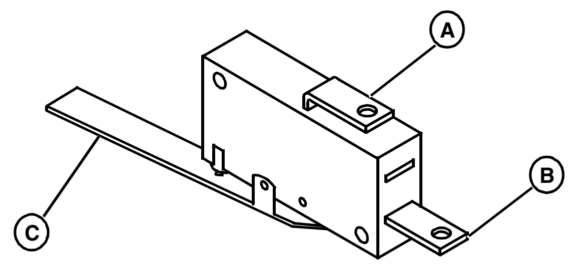
• Ohmmeter

**Test Connections:**

• Set ohmmeter for 1X ohms scale

**Procedure:**

1. Remove connector from GCS enable switch.




2. Connect one lead of the meter to the COM terminal (A) of the switch.
3. Connect the other lead of the meter to terminal (B) of the switch.
4. Press and release the switch lever (C) and note the results.

**Specifications:**

**Switch lever not pressed**
**. . . . . . . . . . . . . .continuity between post A and B**
**Switch lever pressed**
**. . . . . . . . . . . no continuity between post A and B**

**Results:**

• If the GCS enable switch does not pass both tests, replace switch.

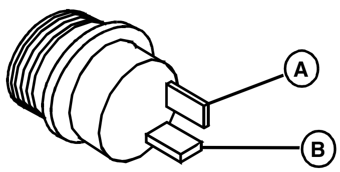
## GCS BAG FULL ALARM TEST

**Reason:**

To determine proper operation of GCS bag full alarm.

**Procedure:**

1. Remove connector from bag full alarm.




2. Connect a jumper wire from battery positive (+) terminal to the alarm positive terminal (A).
3. Connect another jumper wire from alarm negative terminal (B) and ground (-).
4. The alarm should sound with a intermittent beeping tone.

**Results:**

- If the GCS bag full alarm does not produce an intermittent beeping tone, replace the alarm.

## FUEL SHUTOFF SOLENOID TEST

**Reason:**

To determine if the fuel shutoff plunger retracts when the solenoid is energized.

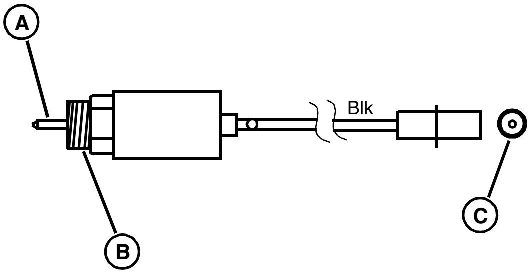
**Test Equipment:**

- 2 Jumper wires

**Procedure:**

> **⚠ CAUTION**
>
> **Keep gasoline away from sparks, flame, or hot engine parts or personal injury can result.**

1. Disconnect fuel shutoff solenoid connector.
2. Remove fuel shutoff solenoid, washer and float bowl.




3. Connect a jumper wire from the battery positive (+) terminal to solenoid terminal (C).

*NOTE: It may be necessary to push plunger (A) inward slightly for plunger to retract.*

4. Connect a jumper wire from the battery negative (-) terminal to solenoid threads (B). Plunger should now retract with the solenoid energized.
5. Remove jumper wire from the battery negative (-) terminal. Plunger should extend.

**Results:**

- If plunger does not move, replace solenoid.

## SPARK TEST

**Reason:**

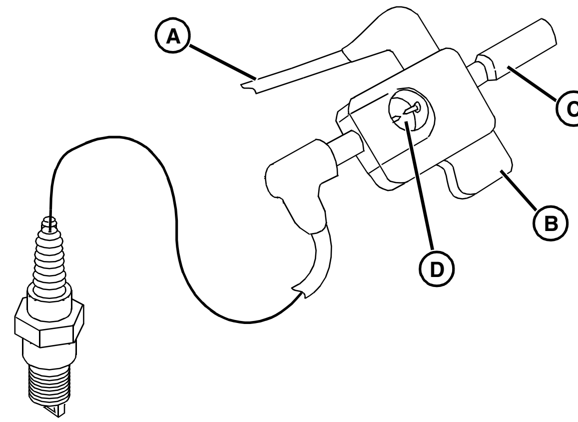
To check overall condition of ignition system.

**Equipment:**

- D-05351ST Spark Tester

**Procedure:**

1. Park machine on level surface.
2. Turn key switch to OFF position.
3. Move Forward/Reverse pedals to NEUTRAL position.
4. Raise hood.
5. Wheels blocked and park brake ON.
6. Remove high tension lead (A) from spark plug and connect to spark tester (B).




7. Connect spark tester lead to spark plug.
8. Adjust spark tester gap to **4.2 mm (0.166 in.)** with screw (C).

*NOTE: Do not adjust spark tester gap beyond 5.0 mm (0.200 in.) as damage to ignition system components could occur.*

9. Turn key switch to RUN position and start engine.
10. Watch spark (D) at spark tester.

**Results:**

- If engine will start, watch spark with engine running. There should be a strong, steady, blue spark.
- If spark is weak, or if no spark, install a new spark plug and test again.
- If spark is still weak, or still no spark, run tests on individual components to find cause of malfunction.

# IGNITION DIODE TEST (LTR166)

**Reason:**

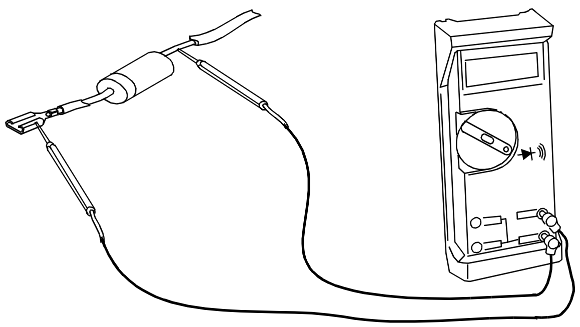
To verify correct function of diodes in engine stop circuit. If a diode fails "open", the cylinder with the open diode will continue to run when the engine is shut off. If a diode fails "short", the cylinder with the shorted diode will not run (no spark).

**Equipment:**

- Ohmmeter

**Procedure:**

1. Park machine on level surface.
2. Turn key switch to OFF position.
3. Move Forward/Reverse pedals to NEUTRAL position.
4. Engage park brake.
5. Place PTO switch in OFF position.
6. Remove engine blower housing.
7. Disconnect diode grounding wire from ignition coil.



8. Set meter to diode test range.

*NOTE: The meter will measure and display voltage drop across diode when set to diode test range.*

9. Place one meter lead on connector and second meter lead on opposite side of diode.
10. Reverse position of meter leads and retest.

*NOTE: If using ohmmeter for test, resistance in one direction will be approximately 80,000 ohms, and reading will "fall" during testing. Ohmmeter reading in opposite direction will be between 4 and 5 mega-ohms and "rise" during testing.*

**Results:**

- Meter should "beep" once in one meter lead position only.
- Meter has continuous tone in either position, diode is shorted, replace diode.
- Meter displays "OL" in both positions, diode is "open", replace diode.

# REPAIR

## RIO SWITCH ADJUSTMENT

**Reason:**

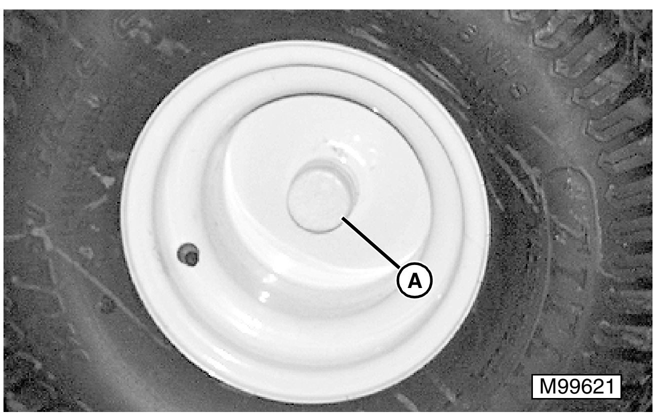
To set the proper air gap between the RIO switch and the pivot bracket so that the RIO switch is activated at the proper time.

**Equipment:**

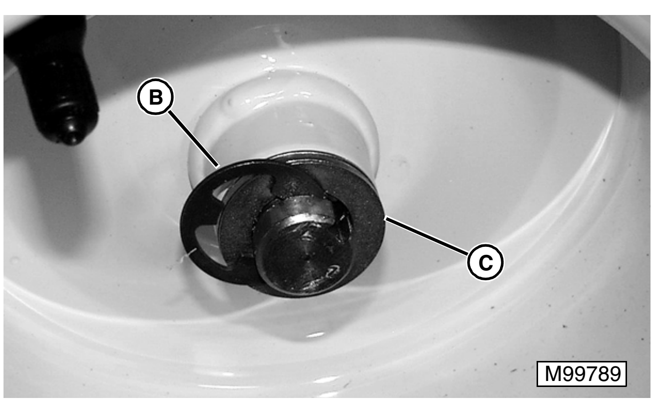
- Feeler Gauge (Blade type)

**Procedure:**

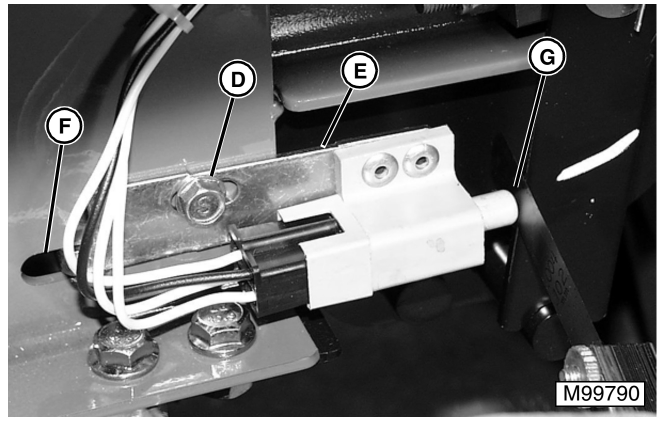
1. Park machine on level surface.
2. Turn key switch OFF.
3. Move PTO/RIP switch to OFF position.
4. Move Forward/Reverse pedals to NEUTRAL position.
5. Engage parking brake.
6. Raise rear of tractor and support on suitable stands to allow for removal of the right rear wheel and tire assembly.



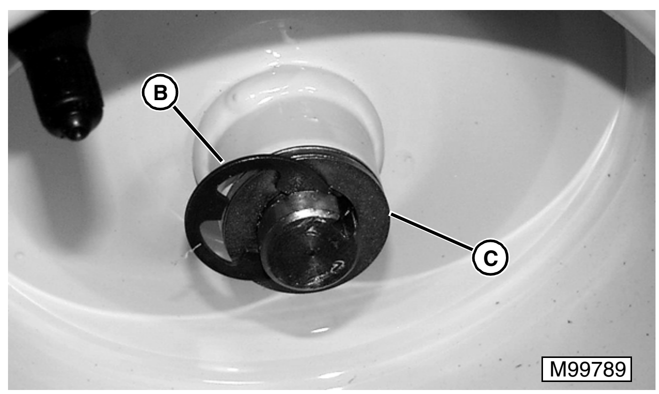

7. Remove wheel center cap (A) on the right rear wheel.



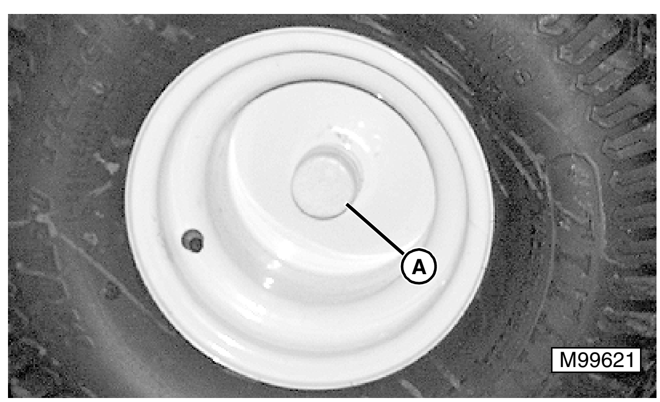

8. Remove E-clip (B) and washers (C).
9. Remove wheel and tire assembly.




10. Loosen the M6 capscrew (D) and slide the RIO switch and bracket assembly (E) in the slot (F) and set air gap (G) to **1 mm (0.04 in.).**
11. Hold the switch and bracket assembly firmly in place and tighten the M6 capscrew (D) to **6 N•m (54 lb-in.)**.
12. Assemble right rear wheel and tire assembly.
13. Install the key in keyway and slide rear wheel and tire assembly onto transaxle shaft.




14. Place the spacer washers (C) on the axle and install the E-clip (B).

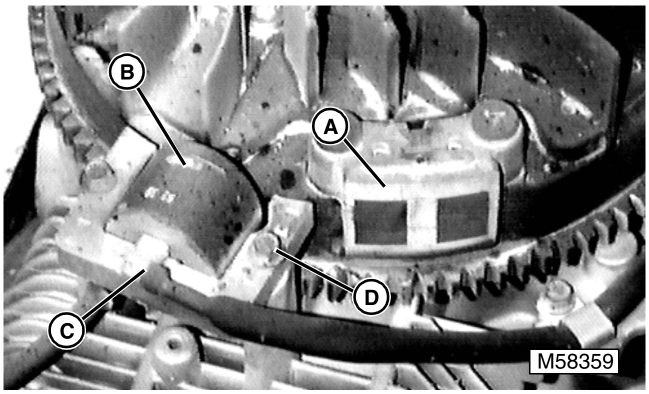


15. Snap the wheel center cap (A) over the right rear wheel hub.
16. Remove the support stands and lower the rear of the tractor back to the ground.

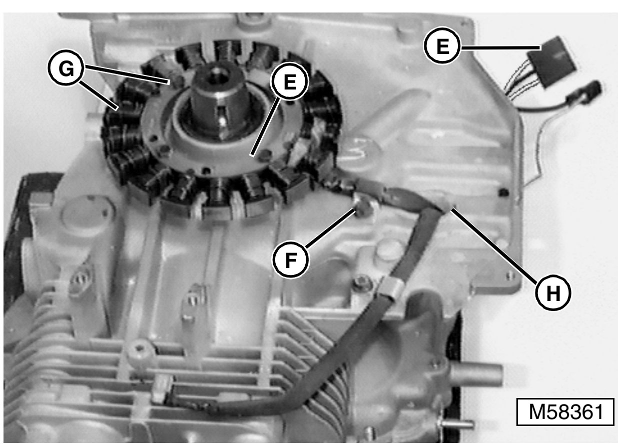
**Specifications:**

**Air Gap . . . . . . . . . . . . . . . . . . . . . . . . 1 mm (0.04 in.)**
**Adjustment Screw . . . . . . . . . . . . . . 6 N•m (54 lb-in.)**

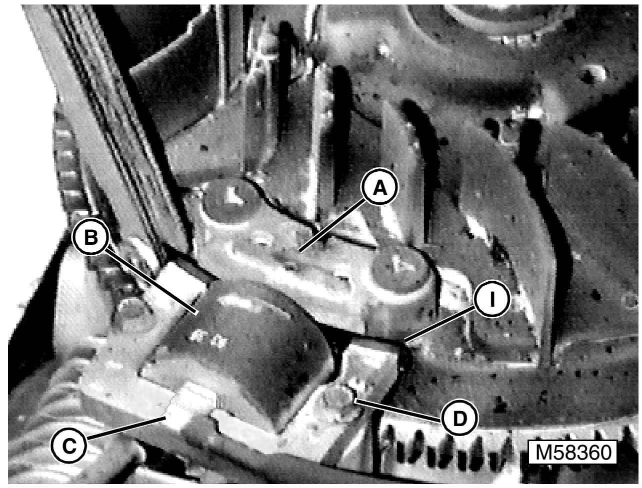
## STATOR & IGNITION MODULE REMOVAL AND INSTALLATION—LTR155




1. Turn flywheel magnet (A) away from ignition module (B).
2. Disconnect wire (C) from terminal.
3. Remove cap screws (D) and ignition module.
4. Remove flywheel.




5. Remove two white stator wires from connector (E).
6. Remove clamp (F).
7. Remove cap screws and stator (G).
8. Inspect for damage.
9. Thread stator wires through hole in (H) crankcase and install in connector (E). Fasten clamp (F).
10. Install stator and tighten cap screws to **4 N•m (35 lb-in.)**.
11. Install flywheel and tighten cap screw to **68 N•m (50 lb-ft)**.
12. Rotate magnet away from module mount. Install module loosely.




13. Align flywheel magnet (A) with mounting posts for ignition module (B).
14. Place **0.2 – 0.3 mm (0.008 – 0.012 in.)** feeler gauge blade (I) or shim stock across magnet face.

**IMPORTANT: Ensure flywheel magnet (A) is centered on ignition module (B) so all three poles of the ignition module are properly gapped from the flywheel magnet.**

15. Slide ignition module (B) against feeler gauge so all three poles mate with the feeler gauge blade (I).
16. Tighten the ignition module capscrews (D) to **5.1 N•m (45 lb-in.)**.
17. Remove feeler gauge and connect wire (C) to terminal.

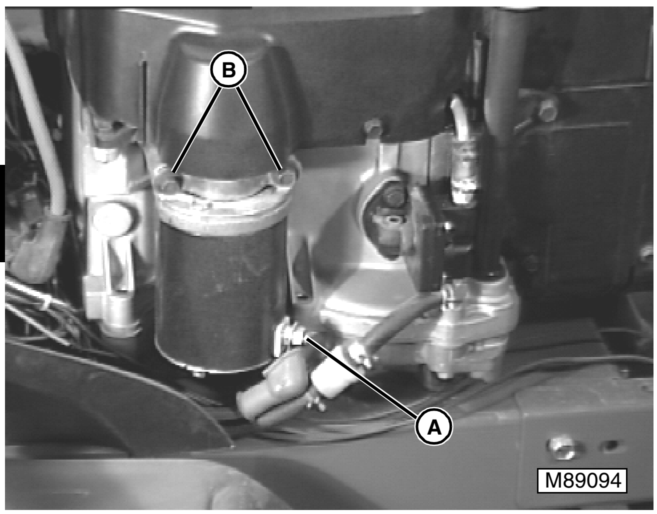
**Specifications:**

**Ignition module air gap**
**. . . . . . . . . . . . . . . 0.2 – 0.3 mm (0.008 – 0.012 in.)**
**Module cap screws . . . . . . . . . . . 5.1 N•m (45 lb-in.)**
**Stator cap screws . . . . . . . . . . . . . . 4 N•m (35 lb-in.)**
**Flywheel cap screw . . . . . . . . . . . . . 68 N•m (50 lb-ft)**

# STARTING MOTOR REMOVAL AND INSTALLATION—LTR155

**Procedure:**

1. Park machine on level surface.
2. Turn key switch to OFF position.
3. Move Forward/Reverse pedals to NEUTRAL position.
4. Engage park brake.
5. Raise hood.
6. Disconnect battery negative terminal (–).



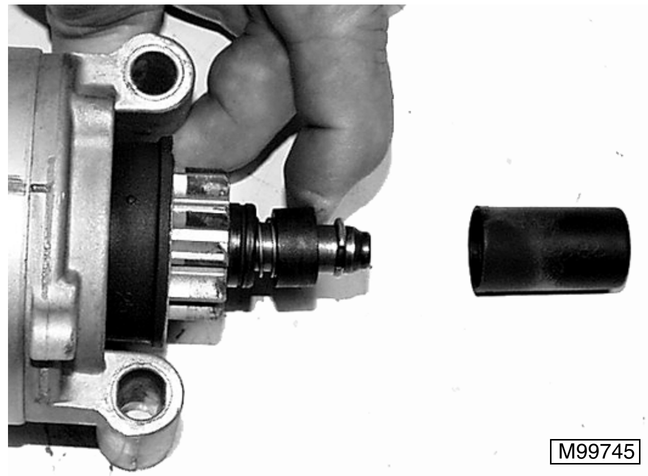

7. Disconnect battery terminal (A) from starting motor.
8. Remove the two capscrews (B) securing the starting motor to the engine.

**Installation:**

9. Position starting motor on engine and install starting motor retaining capscrews. Tighten capscrews to **24 N·m (18 lb-ft)**.
10. Connect battery cable to starting motor and reconnect battery negative cable.

# STARTING MOTOR DRIVE REPLACEMENT—LTR155

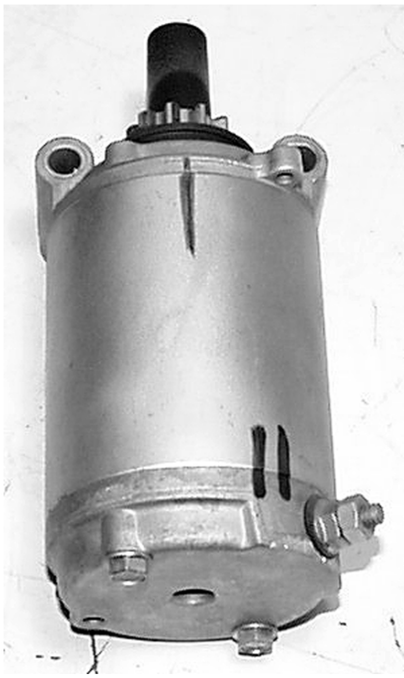
*NOTE: Check for available service parts before disassembling motor.*




1. Remove starting motor. Remove dust cover.
2. Compress retainer and remove stop clip.
3. Disassemble bendix drive.
4. Replace with new bendix drive kit.

## BRUSH REPLACEMENT AND ARMATURE TEST—LTR155

**IMPORTANT: Starting motor armature should be tested anytime the starting motor is disassembled.**

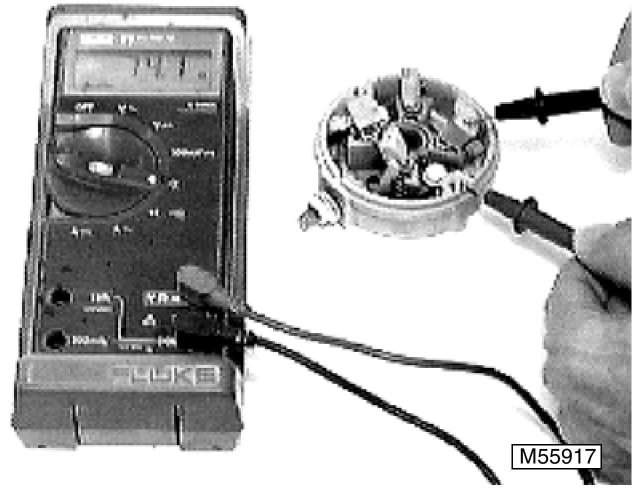


M99746

1. Mark or scribe top and bottom end caps to frame for reassembly.
2. Remove long cap screws and separate top end cap and armature from frame and bottom end cap (brush holder).

M55918

3. Clean contact points of negative brushes. Using an ohmmeter, check for continuity between brushes and end cap. Replace brushes if no continuity is indicated.



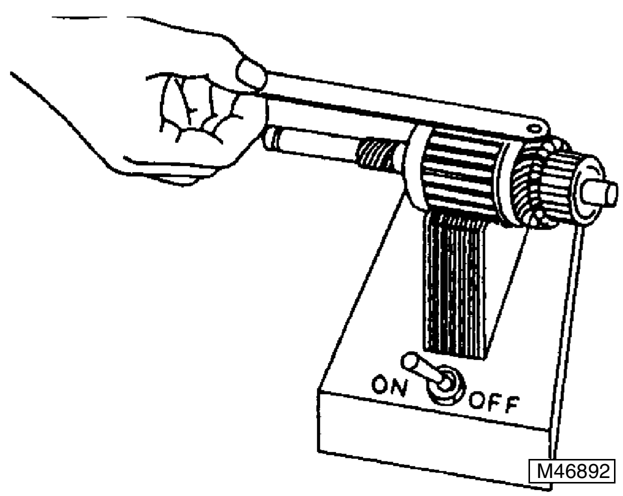
M55917

4. Clean stud terminal, if threads are stripped replace stud.
5. Replace insulator if cracked.
6. Clean contact points of positive brushes. Using an ohmmeter, check for no continuity between positive brushes and end cap and stud terminal and end cap. Replace brushes if continuity is indicated.

**IMPORTANT: Use mineral spirits only to clean armature windings.**

*NOTE: If commutator is grooved or damaged, turn it on a lathe or replace it.*

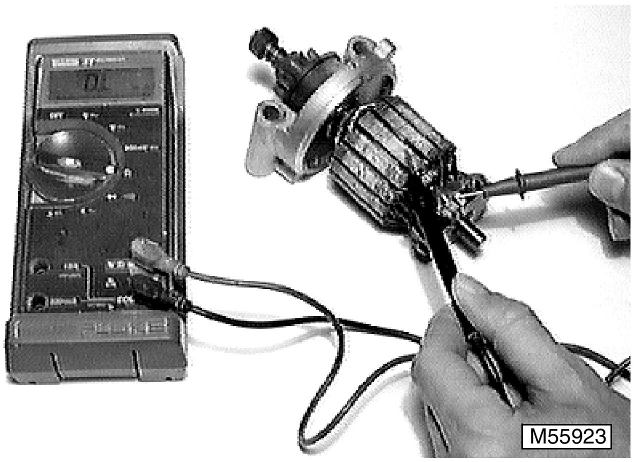
7. Clean commutator of armature with crocus cloth. DO NOT use emery cloth.




M46892

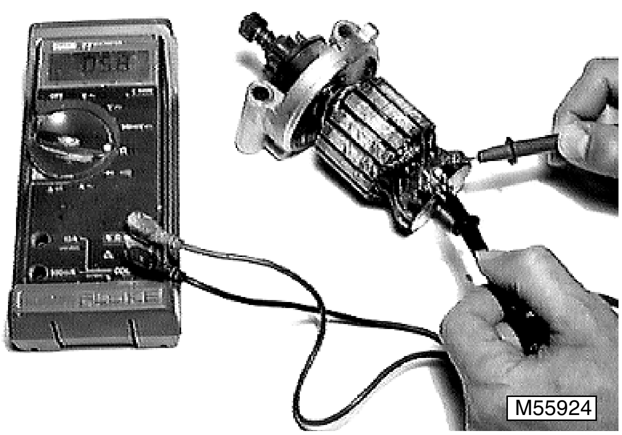
8. Rotate armature on a growler while holding a steel strip (hacksaw blade) on armature. Strip will vibrate in area that is shorted.

*NOTE: Shorts between bars are sometimes caused by dirt or copper between bars. Clean and retest before replacing armature.*



M55923

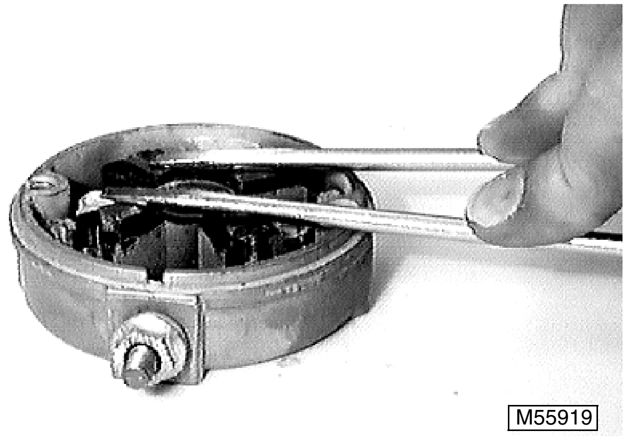
9. Check for grounded windings using an ohmmeter. If any continuity is indicated the winding is grounded and must be replaced.



M55924

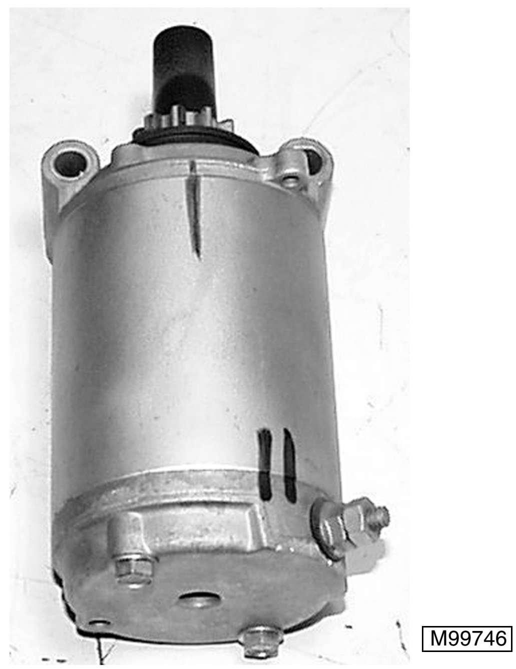
*NOTE: Armature windings are connected in parallel, each bar must be tested.*

10. Check for open windings with an ohmmeter. If no continuity is indicated, there is an open circuit and armature must be replaced.
11. Match upper case marks and carefully assemble top end cap and armature in frame.



M55919

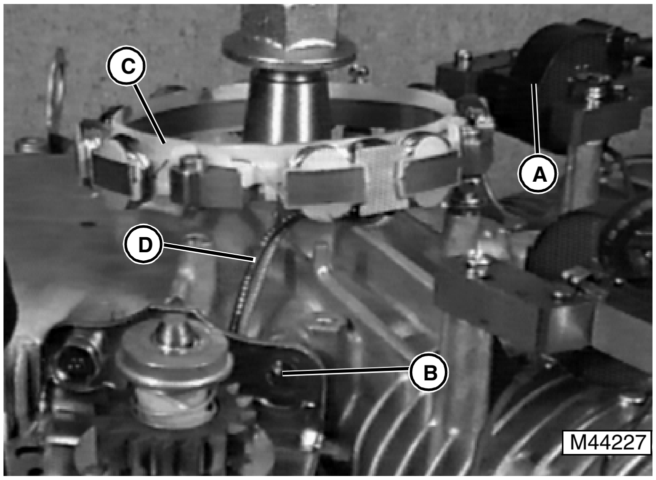
12. Compress brushes into brush holders of bottom end cap using two thin screwdrivers.



M99746

13. Match lower case marks and carefully assemble starting motor so brushes rest on commutator. Remove screwdrivers carefully.
14. Install long cap screws and tighten evenly.

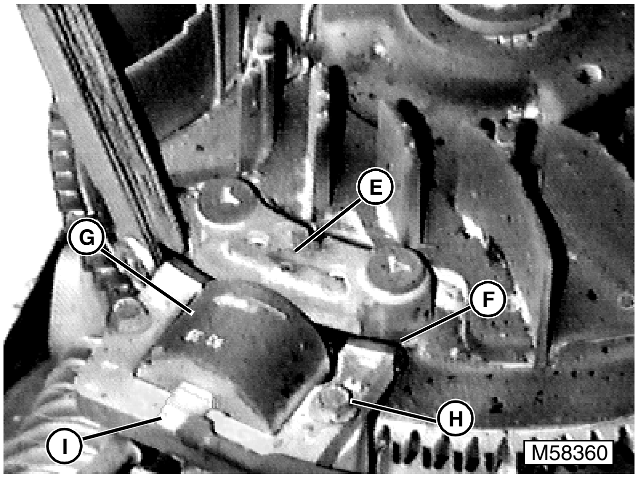
# STATOR AND IGNITION MODULE REMOVAL AND INSTALLATION—LTR166




1. Remove upper blower housing.
2. Turn flywheel magnet away from ignition module (A).
3. Disconnect wire from ignition module.
4. Remove cap screws and ignition module.
5. Remove flywheel nut and flywheel.
6. Inspect flywheel for damage, broken fins, damaged keyway, and damaged key.
7. Remove starting motor bracket (B).
8. Remove cap screws and stator (C).
9. Inspect for damage.
10. Install stator and tighten to **4 N•m (35 lb-in.)**.

**IMPORTANT: Ensure stator wires are routed behind stator wire hub (D) to prevent interference with flywheel rotation.**

11. Route wires back to original position.
12. Install flywheel and tighten nut to **175 N•m (125 lb-ft)**.
13. Rotate magnet away from ignition module mount. Install ignition modules by pushing the module away from flywheel as far as possible and tighten one screw. Repeat for second module.




14. Align flywheel magnet (E) with mounting posts for ignition module.
15. Place **0.2 – 0.3 mm (0.008 – 0.012 in.)** feeler gauge blade (F) or shim stock across magnet face.

**IMPORTANT: Ensure flywheel magnet (E) is centered on ignition module (G) so all three poles of the ignition module are properly gapped from the flywheel magnet.**

16. Position ignition module (G) so all three poles mate with the feeler gauge blade (F) and its two mounting holes align with mounting posts.
17. Tighten cap screws (H) to **5.1 ± 1.1 N•m (45 ± 10 lb-in.)**.
18. Repeat steps 13 - 17 for second module.
19. Connect ground wire (I) on each module.

**Specifications:**

**Ignition module air gap . . . . . . . . . . . . . . . 0.2 – 0.3 mm (0.008 – 0.012 in.)**
**Module cap screws . . . 5.1 ± 1.1 N•m (45 ± 10 lb-in.)**
**Stator cap screws . . . . . . . . . . . . . . 4 N•m (35 lb-in.)**
**Flywheel nut . . . . . . . . . . . . . . . . . 175 N•m (125 lb-ft)**

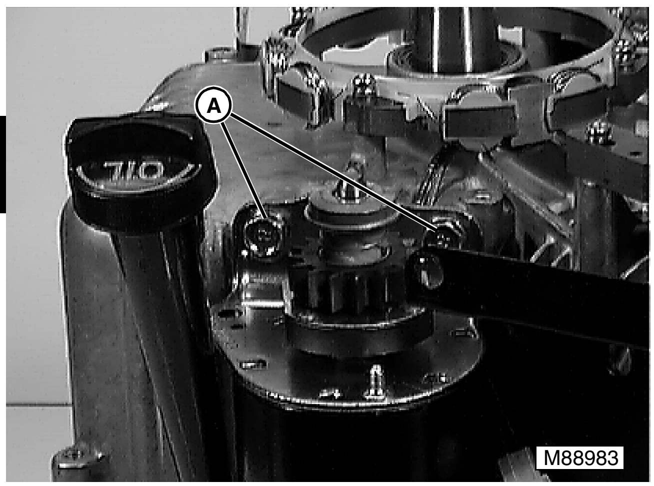
20. Install starting motor and bracket.
21. Install upper blower housing.

## STARTING MOTOR REMOVAL AND INSTALLATION—LTR166

**Procedure:**

1. Disconnect negative (–) battery cable.
2. Disconnect wires from the starting motor cable lug.

*NOTE: Upper blower housing, flywheel, plate (below and surrounding stator), and starting motor gear cover plate removed for clarity and/or ease of starting motor removal.*




3. Remove starting motor bolts (A).
4. Install starting motor mounting bolts and tighten to specification.

**Specification:**

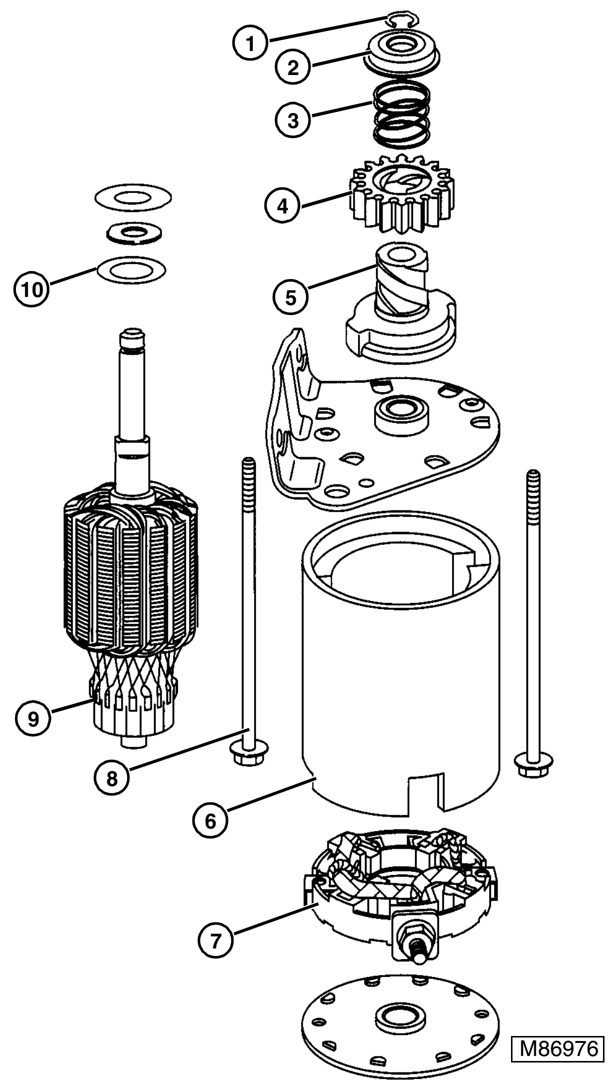
**Mounting Bolts . . . . . . . . . . . . . 15.8 N•m (140 lb-in.)**

5. Install starting motor pinion gear cover plate, plate (below and surrounding stator), flywheel and upper blower housing (if removed.).

## STARTING MOTOR DISASSEMBLY—LTR166

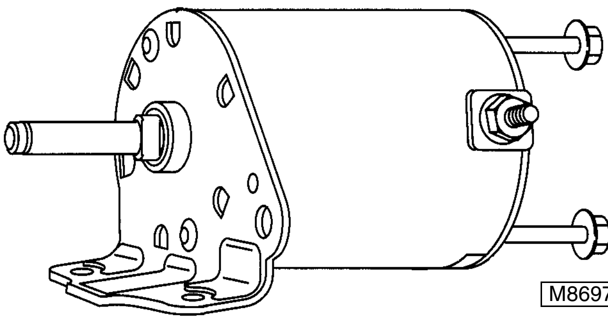
**CAUTION**

**DO NOT clamp motor housing in a vise or strike with a steel hammer. Starter motors contain two powerful magnets that can be broken or cracked if the motor housing is deformed or damaged.**



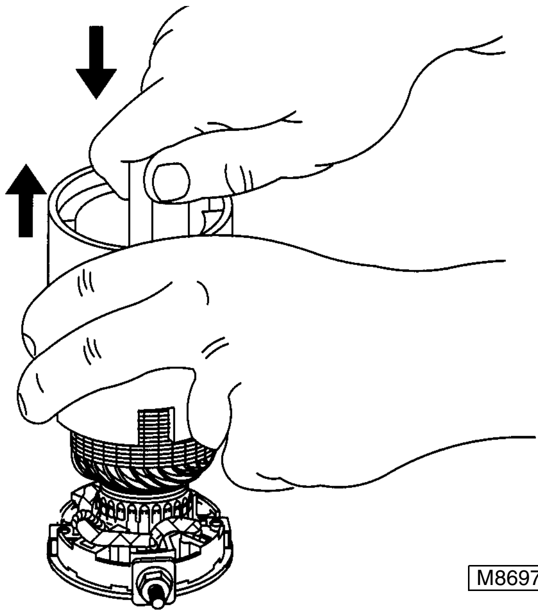

1. C-Ring
2. Retainer
3. Spring
4. Pinion Gear
5. Helix (Clutch)
6. Body
7. Brush Holder
8. Thru Bolt
9. Armature
10. Wave Washer

1. Refer to Pinion Gear Replacement to remove pinion gear assembly. (See “STARTING MOTOR PINION GEAR REPLACEMENT—LTR166” on page 168.)



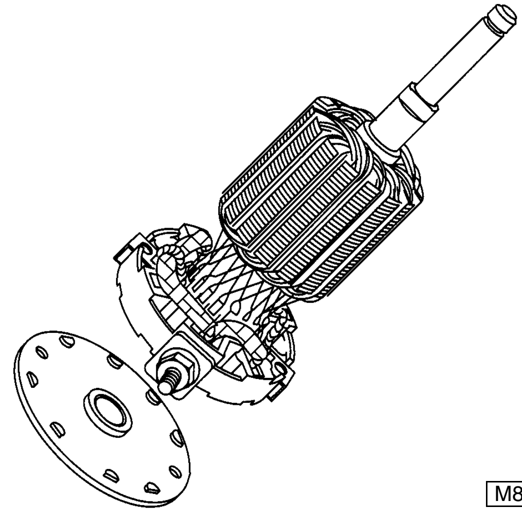
M86977

2. Remove bolts and inspect bushing for wear. If worn, replace drive head end assembly.



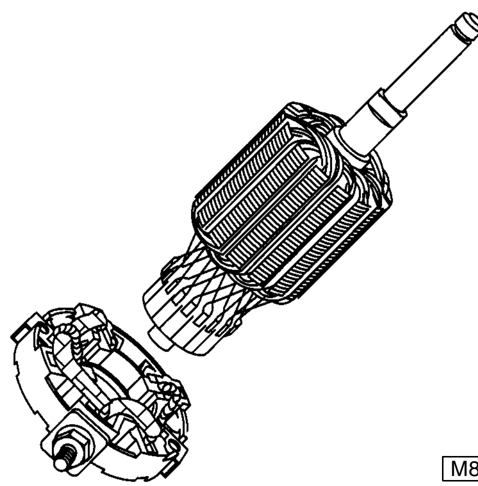
M86978

3. Hold the armature and bearing end cap against a work surface while sliding housing off the armature. (This allows the armature to remain in the bearing end cap and brush holder for inspection of brush contact to armature.)



M86979

4. While holding brush holder and armature, remove bearing end cap from armature.

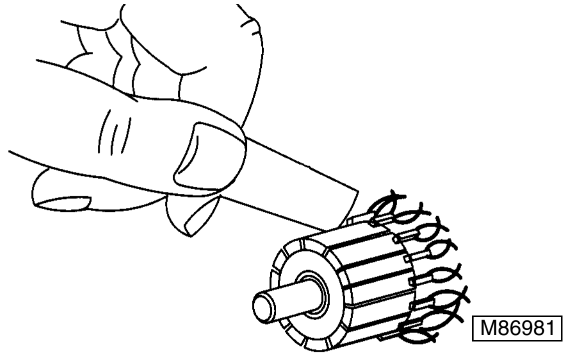


M86980

5. Remove brush holder from armature commutator.

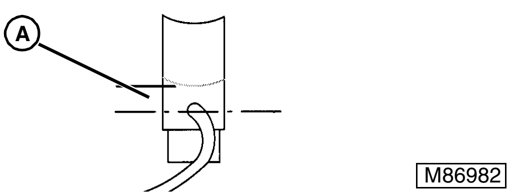
**CAUTION**

**DO NOT use emery cloth to clean the commutator. The particles from the cloth will become embedded in the commutator and cause rapid brush wear.**




*NOTE: The bearing housing and armature should not be soaked in a cleaning solution.*
*Fine sandpaper, such as crocus cloth, can be used to clean the armature.*
*The commutator may also be machined with the use of a diamond cutting tool to no less than **31.24 mm (1.23 in.)** outside diameter.*

6. Slots between the commutator bars should be cleaned as shown using a broken piece of hacksaw blade.
7. If it is suspected that the armature field coil, magnets or motor housing is defective, a new part should be tried in the motor. If proper testing equipment is available, check the suspected armature or field coil to determine if it is defective (opens or grounds).



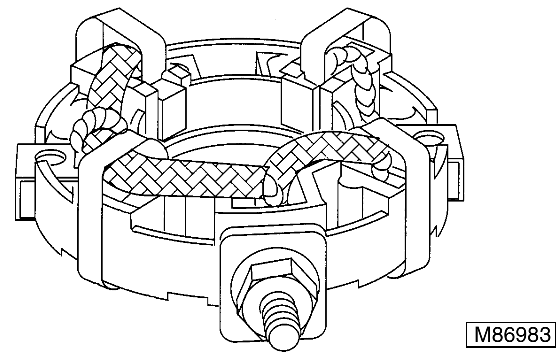

8. The brushes should be checked for proper seating, weak brush springs, dirt, oil or corrosion.
9. If brushes are worn to specification shown (A), replace brushes.

**Specification (Minimum):**

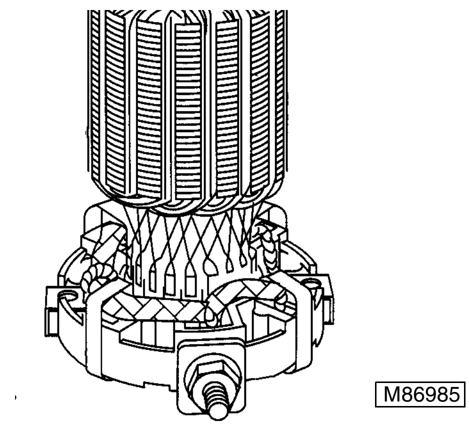
**Brush Length (A) . . . . . . . . . . . . . . . 3 mm (0.125 in.)**

When all parts have been thoroughly cleaned, lightly lubricate the bearings with #20 oil.

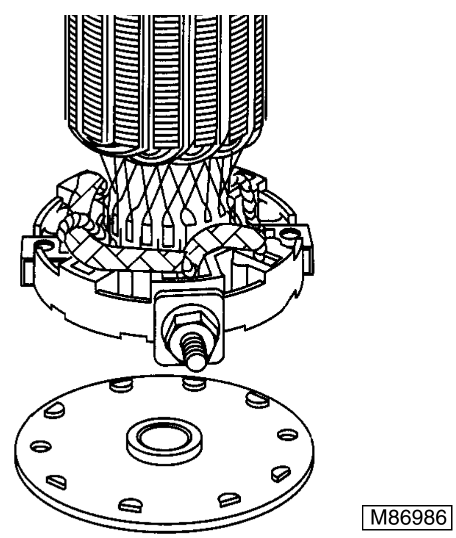
## STARTING MOTOR ASSEMBLY—LTR166



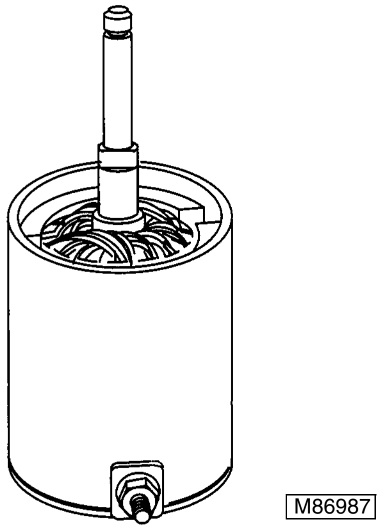

1. Place brushes in their slots and hold brushes with retainers.



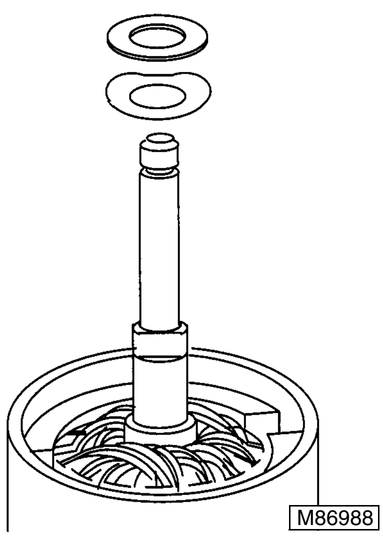

2. Place armature commutator in brush holder and remove brush retainers.



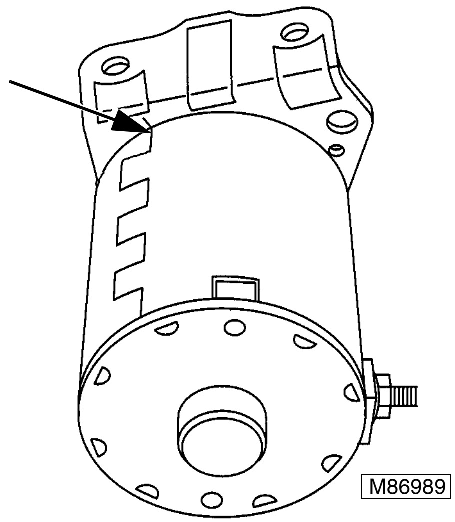

3. Install bearing end plate on armature commutator journal making sure plate indexes with brush holder.



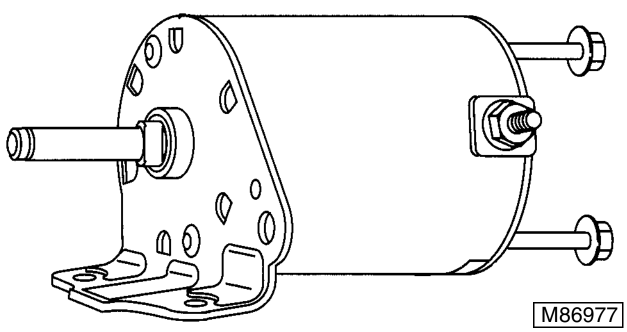

4. Slide motor housing over armature with the notch toward brush holder.




5. Place wave washer on armature shaft with concave side up. Then place flat washer on armature.




6. Place drive end cap on starting motor housing making sure that mark on cap lines up with housing seam.




7. Install thru bolts in starting motor hand tight, use starting motor clutch to check for binding of armature shaft and correct if it binds, Then tighten to specification.
8. Install starting motor drive.
9. Install starting motor and tighten bolts to the following:

**Torque Specifications:**

**Thru Bolts . . . . . . . . . . . . . . . . . . . 5.7 N•m (50 lb-in.)**
**Mounting Bolts . . . . . . . . . . . . . 15.8 N•m (140 lb-in.)**

## STARTING MOTOR PINION GEAR REPLACEMENT—LTR166

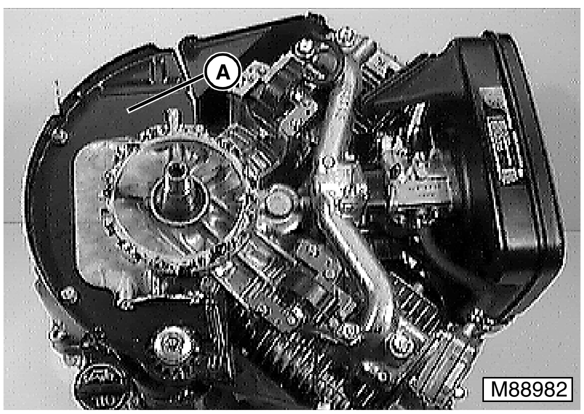
*NOTE: If only the pinion gear is to be replaced, the starting motor does not have to be removed from the engine.*

**Required Tools:**

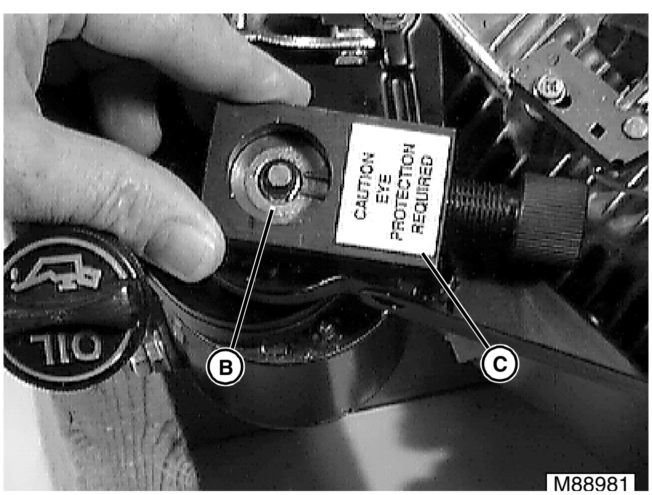
- JDG1087 C-Ring Remover
- JDG1086 C-Ring Installer

**Procedure:**

1. Disconnect negative (–) battery cable.
2. Remove upper blower housing and flywheel.



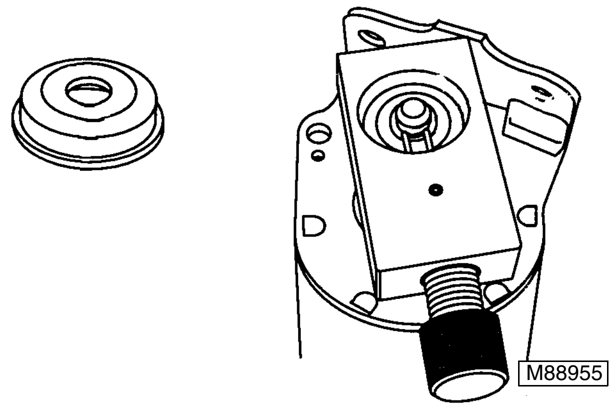

The plate (A) surrounding and below the stator does not have to be removed.

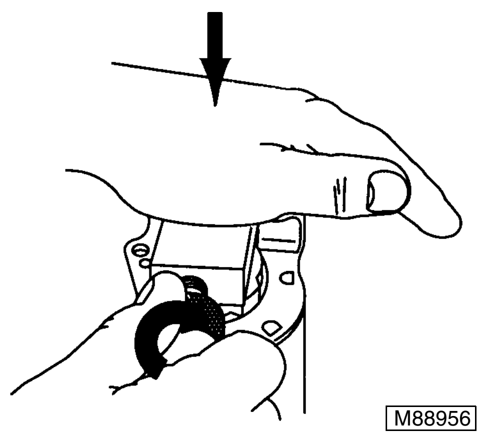



3. Position C-ring (B) using screw driver tip so C-ring removal tool (C) can be aligned properly.

**CAUTION**

**To Prevent eye injury, always wear eye protection when removing C-ring.**

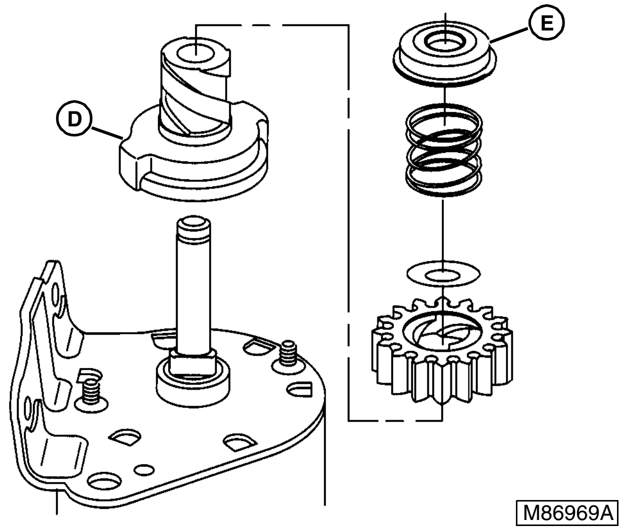



4. Install C-ring removal tool over retainer, and compress spring.

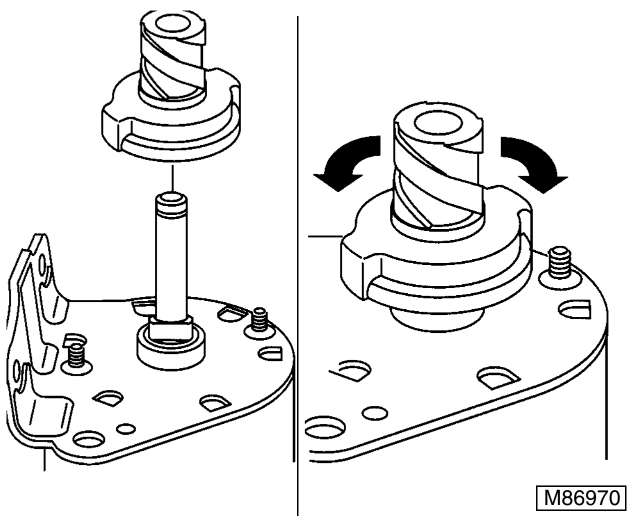
**IMPORTANT: The C-ring is not reusable once removed.**

5. Screw in handle until drive pins on tool forces the C-ring from starting motor shaft.

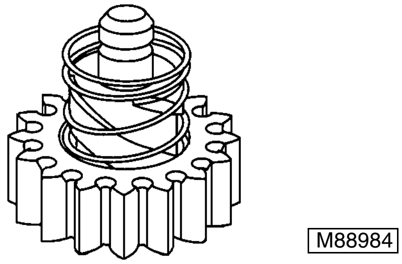



6. Remove retainer (E), spring, flat washer, wave washer, gear and starting motor clutch (D).
7. Before installing starting motor clutch, apply a lithium based lubricant sparingly around base of helix.

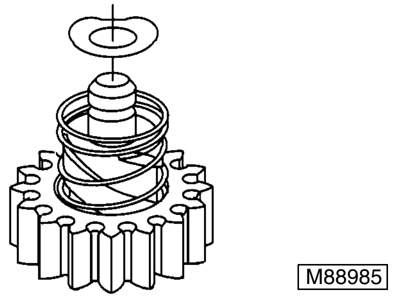
*NOTE: Do not use mineral spirit based lubricants to lubricate helix.*



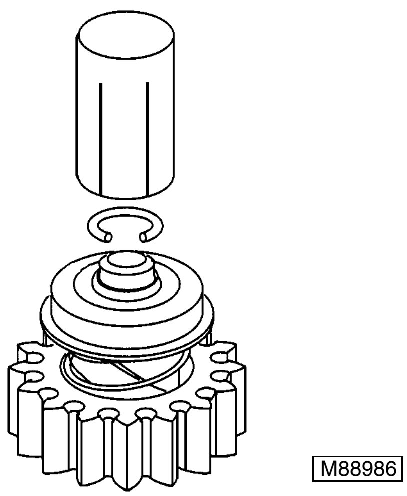

8. Place starting motor clutch on starting motor shaft, rotate clutch until it drops into place.




9. Install pinion gear with beveled side of teeth up, then install return spring making sure spring is in recess of starting motor gear.




10. Place wave washer with concave side up on starting motor clutch spline.




11. Place retainer and new C-ring on starting motor shaft.
12. Align one of the slots on the C-ring installer with open end of C-ring.
13. Use a hammer to drive snap ring down until it engages groove in starting motor shaft. Then make sure retainer is all the way up against the snap ring.
14. Install flywheel, upper blower housing and reconnect negative (–) battery cable.

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# SPECIFICATIONS

### Transaxle

Type . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Tuff Torq® K46 Transaxle
Travel Speed-Forward . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 0 – 8.0 km/h (0 – 5.0 mph)
Travel Speed-Reverse . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 0 – 4.7 km/h (0 – 2.9 mph)

### Traction Drive Belt

Distance Between Plastic Caps of Compression Spring
(Belt Tensioner Assembly). . . . . . . . . . . . . . . . . . . . . . . . . 32 – 34 mm (1.26 – 1.34 in.)

### Brake

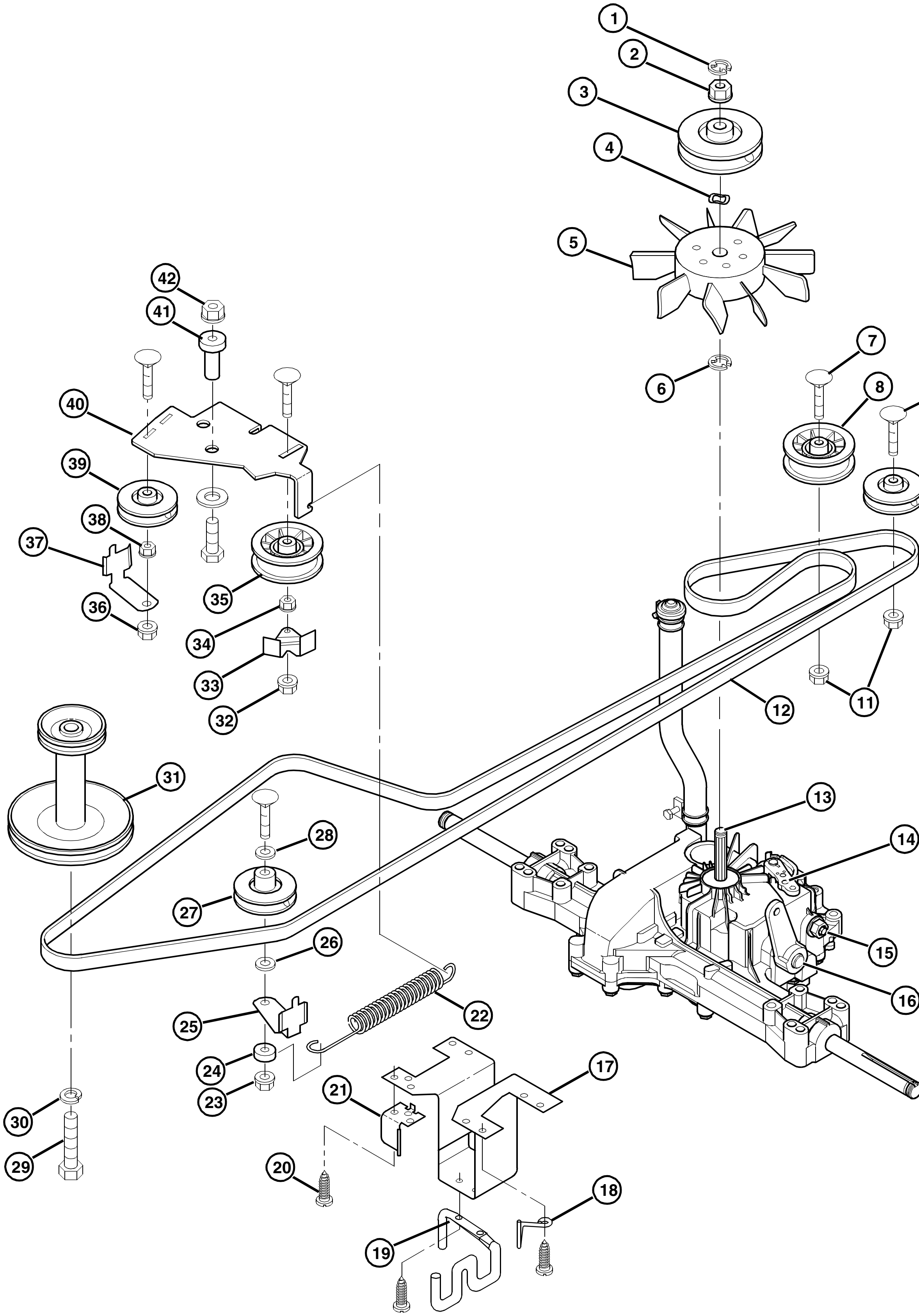
Brake Type . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Wet Disk
Brake Capacity . . . . . . . . 351.5 N•m (259 lb-ft) with 11.3 N•m (100 lb-in.) on brake arm
Brake Lever Travel (Maximum) . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 30°

# TORQUE SPECIFICATIONS

Flat Idler Nut On Idler Arm Assembly . . . . . . . . . . . . . . . . . . . . . . . . 26 N•m (228 lb-in.)
Transaxle Mounting Cap Screws. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 40 N•m (30 lb-ft)

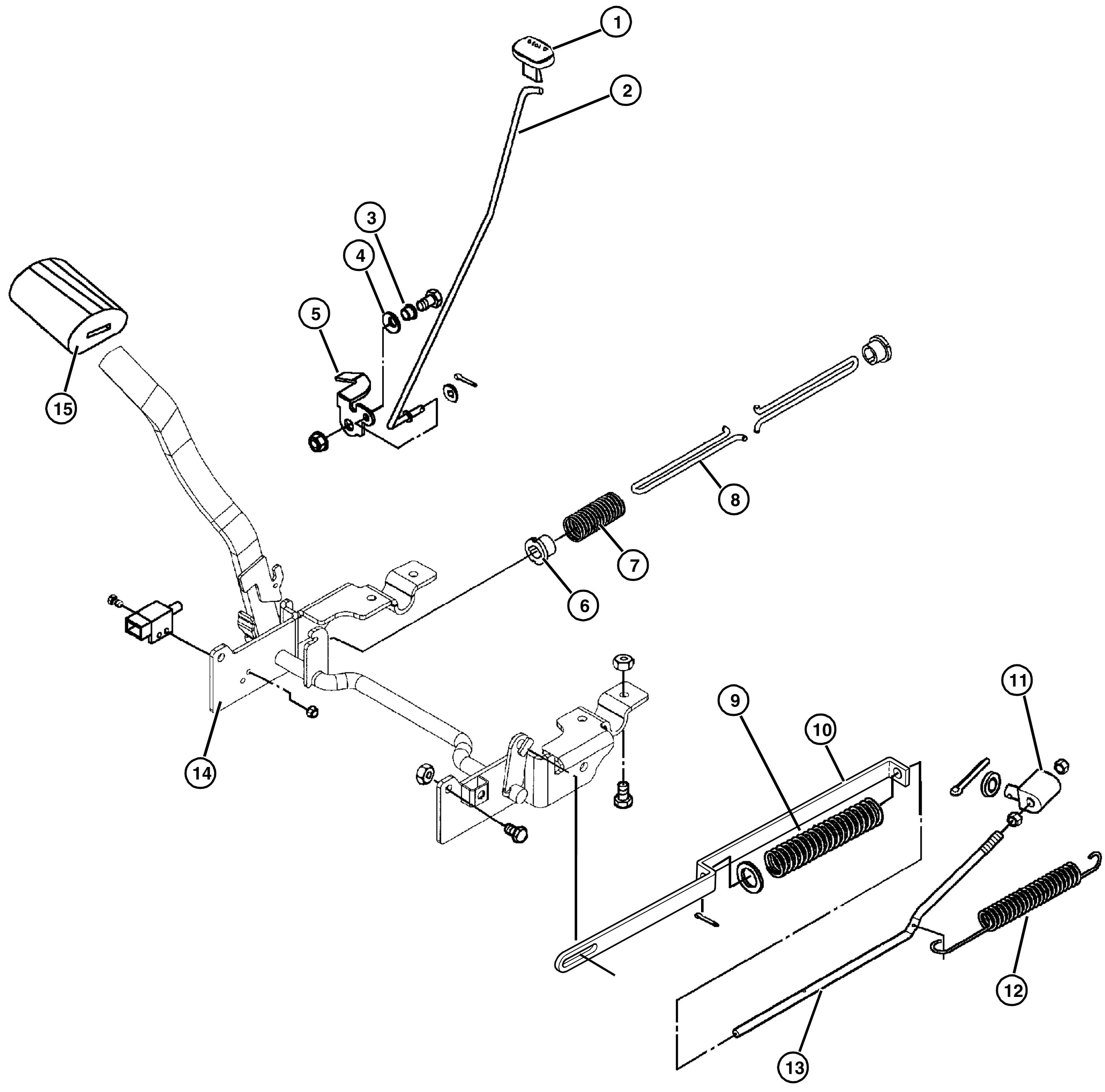
# COMPONENT LOCATION

## DRIVE COMPONENTS



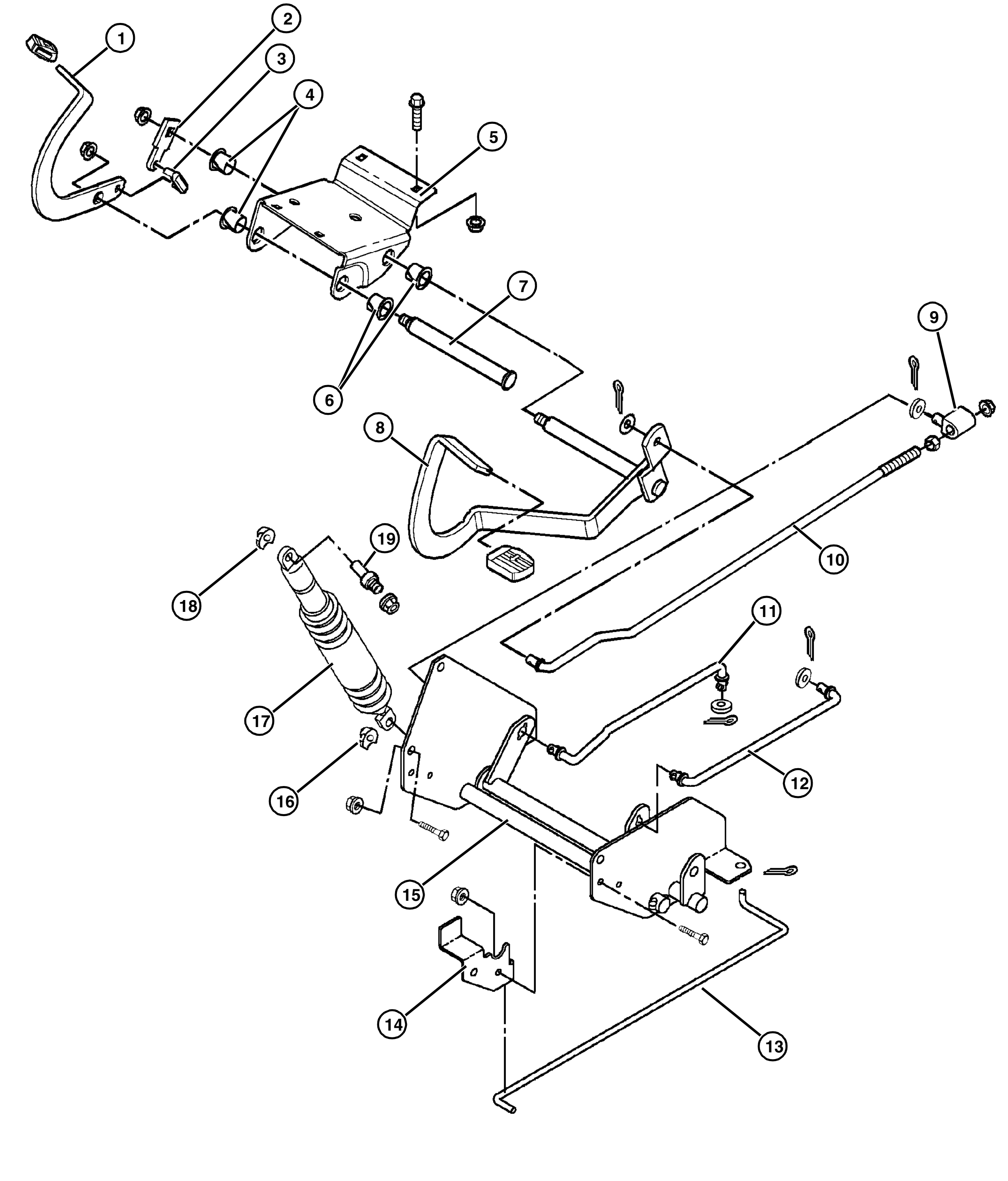
1. Snap ring
2. Lock Nut
3. Sheave
4. Spring Washer
5. Fan
6. Snap ring
7. Bolt
8. Idler
9. Bolt
10. Idler
11. Flange Nut
12. Drive Belt
13. Input Shaft
14. Freewheeling Lever
15. Eccentric Cam
16. Brake Shaft
17. Bracket
18. Belt Guide
19. Belt Guide
20. Screw
21. Guide
22. Extension spring
23. Flange Nut
24. Bushing
25. Guard
26. Spacer
27. Idler
28. Spacer
29. Bolt
30. Lock Washer
31. Drive Sheave
32. Flange Nut
33. Belt Guide
34. Flange Nut
35. Idler
36. Flange Nut
37. Belt Guide
38. Flange Nut
39. Idler
40. Arm
41. Bushing
42. Flange Nut

# BRAKE PEDAL AND LINKAGE




| | | | |
|---|---|---|---|
| 1. Park Brake Handle | 2. Park Brake Rod | 3. Bushing | 4. Spring Washer |
| 5. Park Brake Latch | 6. Cap | 7. Compression Spring | 8. Link |
| 9. Compression Spring | 10. Strap | 11. Rod End | 12. Brake Return Spring |
| 13. Brake Rod | 14. Brake Pedal Assembly | 15. Pedal Pad | |

# FORWARD AND REVERSE PEDALS AND LINKAGE




| | | | |
|---|---|---|---|
| 1. Reverse Pedal | 2. Reverse Arm | 3. U-Shaped Link | 4. Bushings |
| 5. Pedal Bracket | 6. Bushings | 7. Reverse Shaft | 8. Forward Pedal |
| 9. Rod End | 10. F/R Control Rod | 11. Control Rod (Brake) | 12. Control Rod (F/R) |
| 13. Freewheeling Rod | 14. Rod Bracket | 15. Cross Shaft Assembly | 16. Clip |
| 17. Shock Absorber | 18. Clip | 19. Stud | |

# THEORY OF OPERATION

The hydrostatic power train is separated into the following systems:

- Traction Drive Belt System
- Transaxle
- Forward and Reverse Pedals
- Freewheel System
- Brake System

# TRACTION DRIVE BELT SYSTEM

**Function:**

The traction drive belt transfers power from the engine to the input sheave of the hydrostatic transaxle.

**Theory of Operation:**

The traction drive belt is driven by the upper pulley of the engine drive sheave. The traction belt transmits engine power to the input sheave of the hydrostatic transaxle.

The traction drive belt is tensioned by two idler sheaves, which are mounted on a spring loaded bracket. The tension spring runs forward and hooks to the forward fixed idler sheave mounting stud.

# TRANSAXLE

**Function:**

The function of the transaxle is to transfer power from the traction drive belt system (driven by the engine), to the rear wheels, and allow the operator to select ground speed and direction.

**Theory of Operation:**

The drive belt turns the transaxle input pulley, and transaxle input shaft. This, in turn drives the transaxle hydrostatic pump. When the hydrostatic drive is in neutral, the pump pistons do not move up and down in their bores, therefore, no pressure is built up in the pump. When the operator engages the forward or reverse pedals, the pedal linkage tilts a swash plate inside the transaxle. This causes the pump pistons to travel up and down in their bores. The pump pistons create hydraulic pressure which drives the hydrostatic motor. The motor drives the rear axle and wheels through a reduction gear and differential assembly.

The transaxle provides infinite ground speed selections up to 5 mph in forward and up to 2.9 mph in reverse.

# FORWARD AND REVERSE PEDALS

**Theory of Operation:**

**Neutral:**

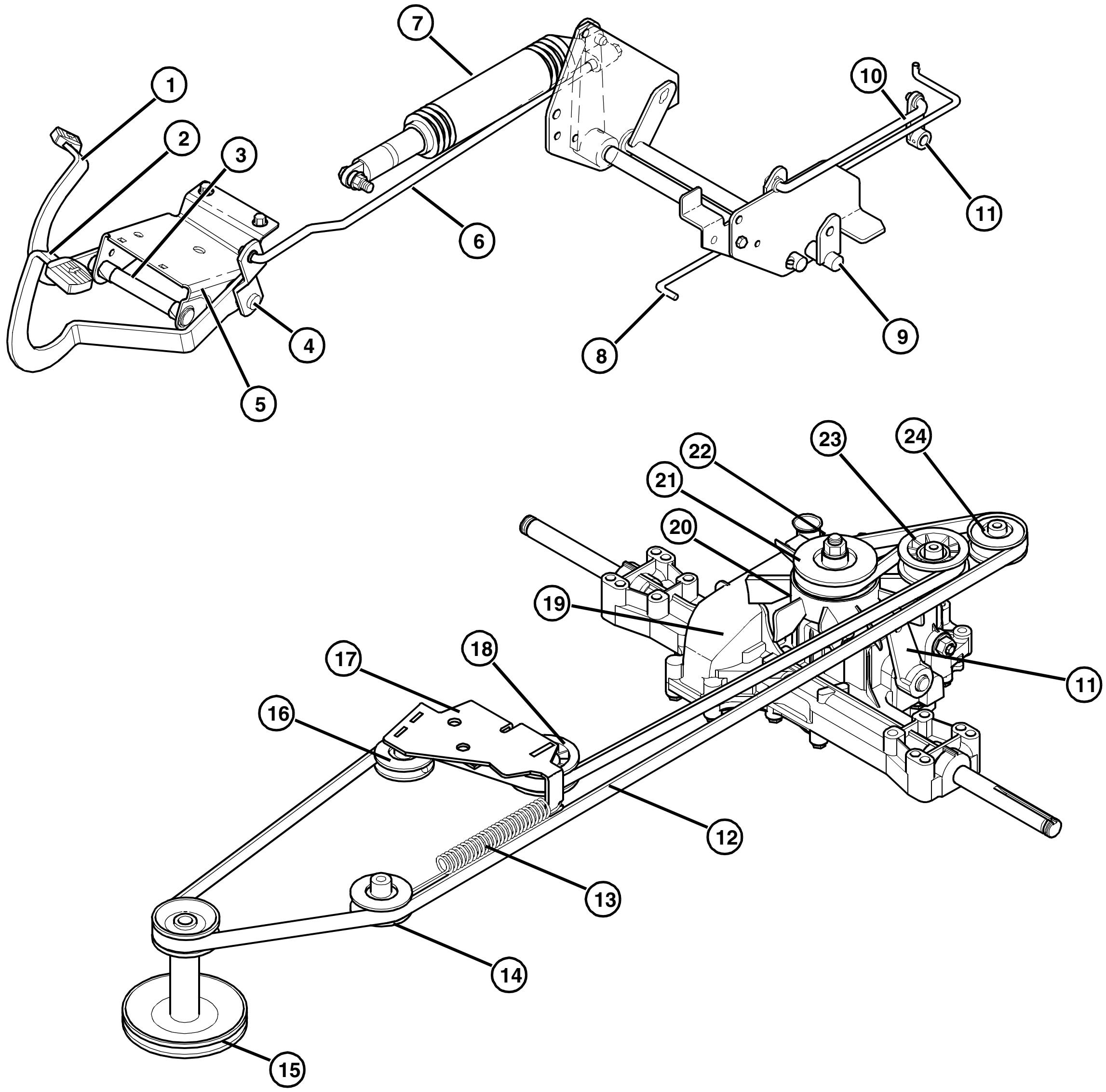
When the engine is running, the traction drive belt turns the transaxle input pulley, cooling fan, and input shaft. The input shaft turns the hydrostatic pump input shaft and pump body, inside the transaxle. When the forward/reverse pedals are not depressed, the control lever on the transaxle holds the control linkage in the NEUTRAL (centered) position, and the drive axles do not turn.

**Forward:**

When the forward pedal is depressed, the forward shaft is rotated, pulling the forward/reverse control rod forward, turning the cross shaft, and pulling the control rod forward. This pulls the control lever on the transaxle forward, turning the control shaft inside the transaxle, and causing the drive axles to turn in the FORWARD direction.

**Reverse:**

When the reverse pedal is depressed, a link on the reverse pedal engages the forward pedal shaft, raising the forward pedal. This moves the forward/reverse control rod rearward, turning the cross shaft, and pushing the control rod rearward. This pushes the control lever on the transaxle rearward, turning the control shaft inside the transaxle, and causing the drive axles to turn in the REVERSE direction.



| | | | |
|---|---|---|---|
| 1. Reverse Pedal | 2. Forward Pedal | 3. Reverse Shaft | 4. Forward Shaft |
| 5. Pedal Bracket | 6. F/R Control Rod | 7. Shock Absorber | 8. Freewheeling Rod |
| 9. Brake Cross Shaft | 10. Control Rod | 11. Control Lever | 12. Traction Drive Belt |
| 13. Idler Tension Spring | 14. Fixed Idler Sheave | 15. Engine Drive Sheave | 16. V-Idler |
| 17. Idler Arm Assembly | 18. Flat Idler | 19. Transaxle | 20. Cooling Fan |
| 21. Input Sheave | 22. Input Shaft | 23. Flat Idler | 24. V-Idler |

## FREEWHEEL SYSTEM

**Function:**

The freewheel system allows the operator to move the tractor with the engine off and the brake released.

**Theory of Operation:**

When the freewheel rod is pulled forward, the freewheel rod rotates the freewheeling shaft. When the freewheeling shaft rotates, the operator is allowed to push the tractor in forward or reverse directions with the engine off and the brake released.

> **⚠ CAUTION**
>
> **DO NOT operate freewheel valve with engine running. Damage to hydrostatic transmission can occur.**

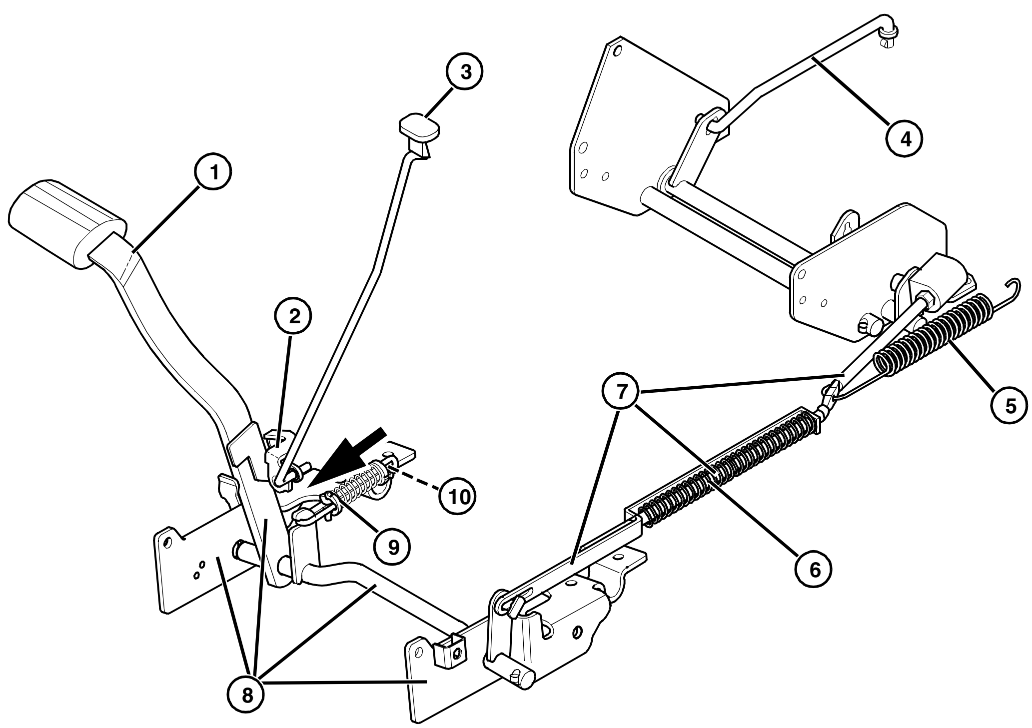
## BRAKE SYSTEM

**Function:**

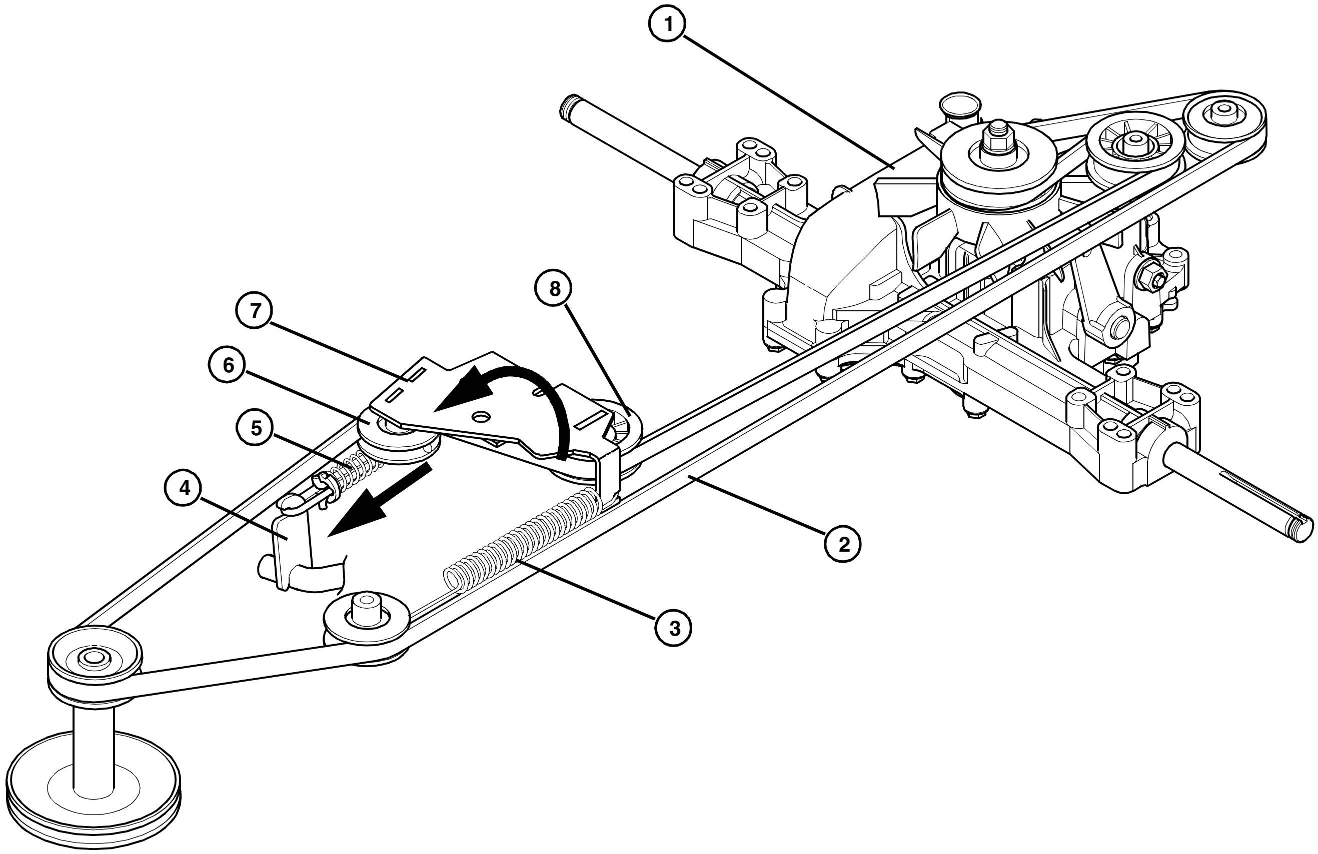
The brake system provides the operator with a method to mechanically stop the movement of the tractor. The brake system also provides a parking brake function through the use of a mechanical locking mechanism which, when engaged, holds the brake pedal in the depressed position.

**Theory of Operation:**

When the brake pedal is depressed, the compression spring is compressed, pulling on the idler arm assembly, removing tension from the traction drive belt. The brake also pulls on the brake rod assembly, which pulls on a lever on the cross shaft assembly. This turns the cross shaft, and pulls on the brake rod on the opposite side, turning the brake lever on the transaxle. The transaxle brake lever actuates a wet disk brake inside the transaxle which is attached to the hydrostatic motor, which is linked to the axle shafts through a reduction gear and differential assembly.




1. Brake Pedal
2. Park Brake Latch
3. Park Brake
4. Brake Rod
5. Brake Return Spring
6. Compression Spring
7. Brake Rod Assembly
8. Brake Pedal Assembly
9. Compression spring
10. Rod to Idler Arm Assembly




| | | | |
|---|---|---|---|
| 1. Transaxle | 2. Traction Drive Belt | 3. Idler Tension Spring | 4. Brake Pedal Assembly |
| 5. Compression spring | 6. V-Idler | 7. Idler Arm assembly | 8. Flat Idler |

# TROUBLESHOOTING

| Problem or Symptom / Check or Solution | Belt jumping off or slapping | Lack of drive in one wheel or both | Loses power under load, belt slips, or erratic drive | Jerky or aggressive engagement | Cannot get full forward or reverse speed | Input shaft /pulley will not turn | Returns to neutral during operation or under load | Noisy operation | Leaking lubricant | Brakes will not stop tractor | Park brake will not hold | Transaxle overheats | Freewheel valve pushes hard | Creeps in neutral |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Belt sheaves and idlers loose, out of adjustment, worn, or damaged—tighten, replace, or adjust properly | ● | ● | ● | ● | ● | ● | | ● | | | | | | |
| Belt worn, frayed, glazed, or stretched—replace belt | ● | ● | ● | ● | | | | ● | | | | | | |
| Tensioning spring weak or broken—replace as necessary | ● | ● | ● | | | | | ● | | | | | | |
| Accumulation of grass and other debris in cooling fins or around moving parts of transmission | | ● | ● | | | ● | | ● | | ● | ● | ● | ● | ● |
| Brake pedal linkage out of adjustment—adjust properly | | ● | ● | ● | | ● | ● | | | ● | ● | ● | ● | |
| Brake components out of adjustment— adjust properly or replace transaxle | | ● | | ● | | ● | ● | | | ● | ● | ● | ● | |
| Foot pedal linkage bent, worn, out of adjustment, or broken—replace or adjust properly | | ● | ● | ● | ● | ● | ● | | | | | ● | | ● |
| Neutral return linkage worn, bent, or broken—replace as necessary | | ● | | | | ● | | | | | | | ● | ● |
| Internal transaxle components worn, stripped, or broken—replace as necessary | | ● | ● | ● | | ● | ● | ● | | | | ● | | ● |
| Transaxle case mountings loose, worn, or broken—replace mountings or transaxle | ● | ● | | ● | | | | ● | | | | | ● | ● |

| Problem or Symptom / Check or Solution | Belt jumping off or slapping | Lack of drive in one wheel or both | Loses power under load, belt slips, or erratic drive | Jerky or aggressive engagement | Cannot get full forward or reverse speed | Input shaft /pulley will not turn | Returns to neutral during operation or under load | Noisy operation | Leaking lubricant | Brakes will not stop tractor | Park brake will not hold | Transaxle overheats | Freewheel valve pushes hard | Creeps in neutral |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fan and/or pulley loose or damaged—tighten or replace | ● | | | | | ● | | ● | | | | ● | | |
| Hydrostatic oil filter plugged | | ● | ● | | ● | | | ● | | | | ● | | |
| Incorrect type or volume of lubricant used—replace with correct type and volume | | ● | ● | ● | | | ● | ● | ● | | | ● | | ● |
| Wheels and axle keys, key ways, or snap rings worn—replace as necessary | | ● | ● | | ● | | | ● | | | | | | |
| Transaxle case halves cap screws loose or stripped | | | | | | | | ● | ● | | | | | |
| Freewheeling mechanism or linkage damaged | | ● | ● | | ● | | | ● | | | | ● | ● | |
| Engine performance problems—see Engine Section | | ● | ● | | | | | | | | | | | |

# DIAGNOSTICS

**Test Conditions:**

- Tractor on level surface
- Engine OFF
- Front wheels blocked
- Rear wheels raised off surface with axle housings on jack stands

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Fan | Fan in good condition and tight | Replace snap ring and/or splined collar<br>Replace |
| 2. Drive belt | Belt in good condition, not glazed, split, unraveled, or stretched | Replace drive belt |
| 3. Idler tensioning spring | Tensioning spring installed and not damaged | Install spring<br>Repair or replace |
| 4. Sheaves and idlers, belt traction drive system | Drive sheaves and idlers in good condition and adjusted properly<br><br>Belt not slipping, squealing, or vibrating excessively | Adjust idler assembly<br>Repair or replace<br><br>Check belt condition, check adjustment and condition of idlers and guides. Adjust, repair or replace components as needed |
| 5. Hydro housing exterior | No cracks, leaks, or loose hardware | Tighten hardware<br>Replace transaxle<br>Replace any damaged components |
| 6. Axles | Axles straight | Replace transaxle as needed |
| 7. Wheels and tires | Air pressure equal in driving tires | Adjust air pressure |
| | Driving tires have same circumference | Match tires for same circumference |
| | Wheels not bent or out of round | Repair or replace wheels as necessary |
| 8. Axles, wheels, and tires | Axles, wheels, and tires in good shape and functioning properly | Check axles and wheel for straitness, check condition of keys and keyways, washers, and snap rings. Check tires for tread wear and proper inflation. Repair or replace components as needed |
| 9. Engine performance | Engine running smoothly throughout throttle range | Adjust, tune, or repair engine |
| 10. Stroking Control Arm: (lack of forward or reverse speed) | Linkage should stroke control until it reaches the stop inside the transaxle (Forward) and should stroke about 2/3 stroke in reverse | Adjust or repair as needed |

# TESTS AND ADJUSTMENTS

## TRACTION DRIVE SYSTEM TEST

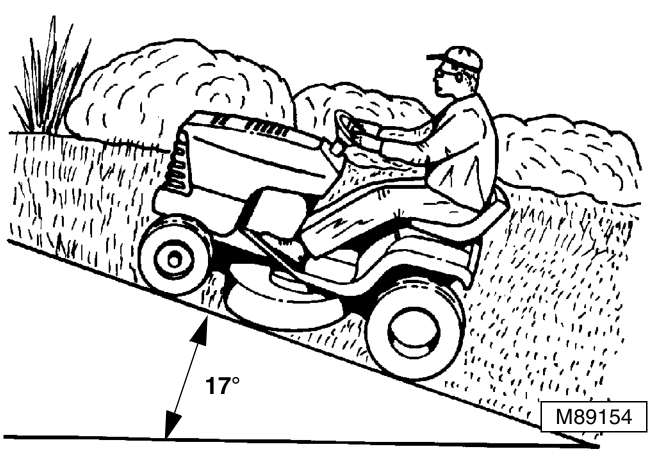
**Reason:**

To ensure forward drive, neutral return, brake linkages and belt drive system maintain traction up a 17° slope. To ensure that transport (freewheeling) valve assembly and linkage allow tractor to be pushed when engaged and to drive tractor when disengaged. Also to ensure tractor returns to neutral, engages the brake, stops tractor within specification, and holds tractor stationary in PARK position on a 17° slope or less.

**Test Drive:**

> **⚠ CAUTION**
>
> **DO NOT engage FORWARD foot pedal too aggressively during the 17° slope test drive. Tractor may tip over backwards. It is recommended that the mower deck be installed before performing the 17° slope test.**

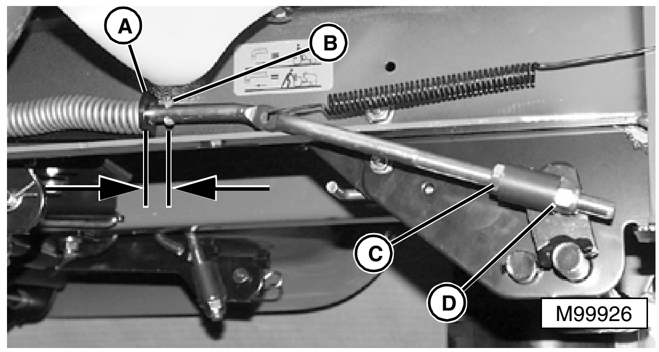
1. Attach mower deck to tractor.
2. Carefully test drive tractor to see if traction drive system pulls tractor steadily up a 17° slope.
3. If tractor fails traction test, the drive belt may be excessively worn, stretched, glazed or unraveling. Replace or adjust tension if above conditions exist.




4. Drive or push tractor onto a 17° slope, depress the brake pedal and lock it in the PARK position.
5. FORWARD and REVERSE pedals must return to NEUTRAL position, PARK brake must hold tractor in a stationary position on slope and tractor must not creep downward once park brake is locked into position.
6. Drive tractor on dry pavement in a safe, open and level area at fast idle in the forward direction. Apply a “panic stop” force (no more than 50 pounds of force)—tractor **must stop** within **1.5 M (5 ft)** and both wheels should **“lock-up”**, leaving skid marks on pavement.
7. If any test fails, the brake linkage must be adjusted or components replaced.

## BRAKE LINKAGE ADJUSTMENT

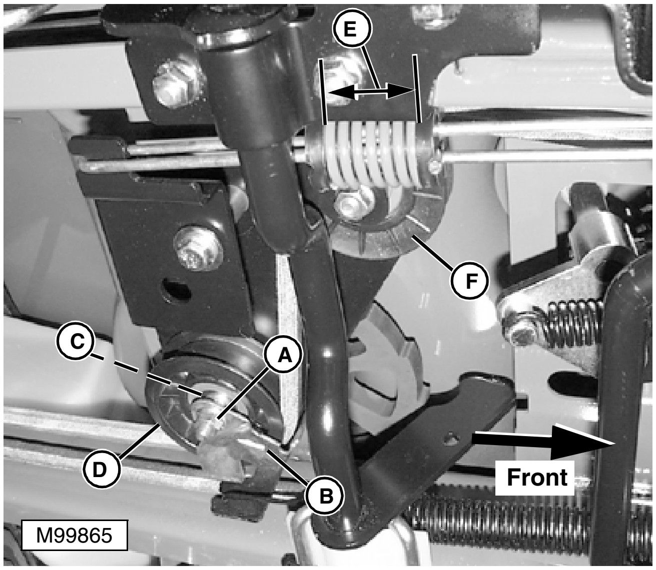
1. Park tractor on level surface.
2. Turn key switch to **STOP** position.
3. Engage park brake. Brake should engage.
4. If the brake does not engage, adjust as follows:




5. With park brake engaged, measure the gap between the compression spring bracket (A) and the tabs (B) on the brake rod. The gap should measure **6 – 7 mm (0.24 – 0.28 in.)** when the park brake is engaged.
6. If gap is not within specification, adjust to obtain the proper gap:
   - Loosen the jam nut (C).
   - Turn the lock nut (D) *clockwise* to *increase* the gap.
   - Turn the lock nut *counterclockwise* to *decrease* the gap.
   - Tighten the jam nut and recheck the gap measurement.
7. Release parking brake and check for a dragging brake, adjust as necessary.

## DRIVE BELT TENSION ADJUSTMENT

1. Engage park brake.




2. Remove belt guide nut (A) and belt guide (B).
3. Loosen idler nut (C) and slide idler (D) forward to increase distance between plastic caps of compression spring (E).
4. Tighten idler nut.
5. Release park brake and measure distance between plastic caps of compression spring (E).
6. Repeat steps 2 thru 5 until distance between plastic caps of compression spring (E) is **32-34 mm (1.26-1.34 in.)**.
7. Tighten idler nut (C) to specification.
8. Install belt guide (B).

**Specifications:**

**Compression Spring . . 32 – 34 mm (1.26 – 1.34 in.)**
**Idler Nut . . . . . . . . . . . . . . . . . . . . 26 N•m (228 lb-in.)**

*NOTE: If dimension between caps of compression spring (E) will not reach 32 mm (1.26 in.) by adjusting idler (D), it may be necessary to move the V-idler (F) rearward.*

## NEUTRAL CREEP ADJUSTMENT

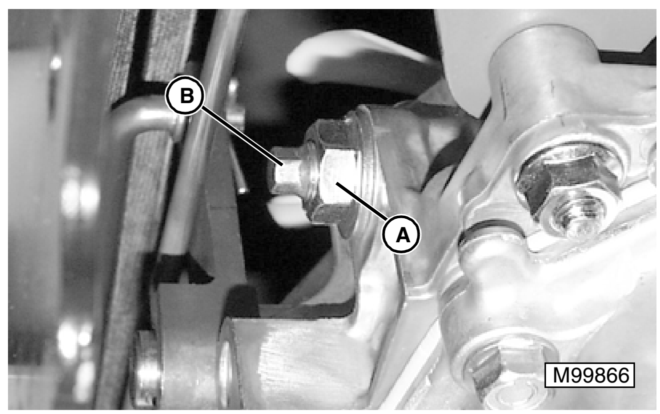
**Reason:**

If the tractor creeps forward or backward with the forward/reverse pedals in the neutral position, parking brake released, and the engine running, the neutral eccentric must be adjusted.

**Procedure:**

1. Park tractor on level surface.
2. Turn key switch to **STOP** position.
3. Move forward/reverse pedals to **NEUTRAL** position. Release parking brake.
4. Lift rear of tractor until wheels are off the ground. Support on suitable stands.
5. Place blocks in front of and behind front wheels.

*NOTE: The eccentric shaft is located on the left side of the transaxle above and behind of the left hand axle.*




**CAUTION**

**Keep hands away from transaxle cooling fan and wheels during procedure to avoid injury.**

*NOTE: Engine will not start with seat switch disconnected. Use a jumper wire to bypass switch.*

6. Start and run engine at FAST idle.
7. Loosen locknut (A) on eccentric (B) and rotate eccentric to eliminate neutral creep.
8. Hold eccentric in position with a wrench and tighten lock nut.
9. Check forward/reverse pedal height adjustment.

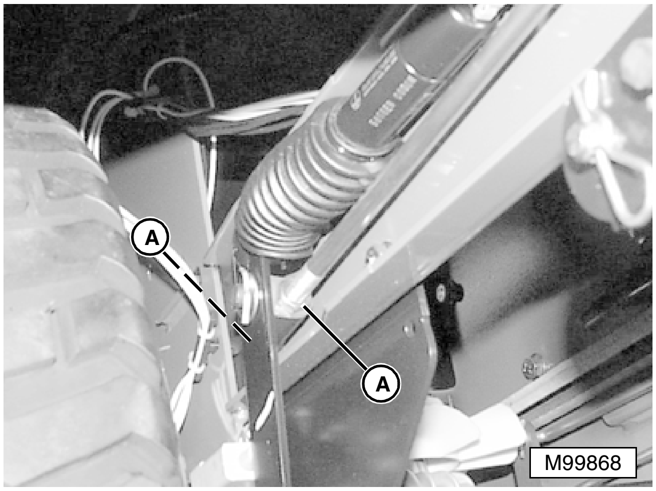
# FORWARD AND REVERSE PEDAL ADJUSTMENT

**Reason:**

To ensure full travel speeds can be reached in forward and reverse directions. This also ensures that the transaxle swash plate and control arm will not act as a mechanical stop for the pedal linkage.

**Procedure:**

1. Push each travel pedal forward by hand while watching for pedal contact with the foot rest.
2. If one pedal makes contact and the other pedal does not, an adjustment is needed.




3. Loosen both nuts (A) and move the rod in the appropriate direction and tighten nuts. Repeat this procedure until both pedals make contact with the foot rest.

# TRANSPORT (FREEWHEEL) TEST

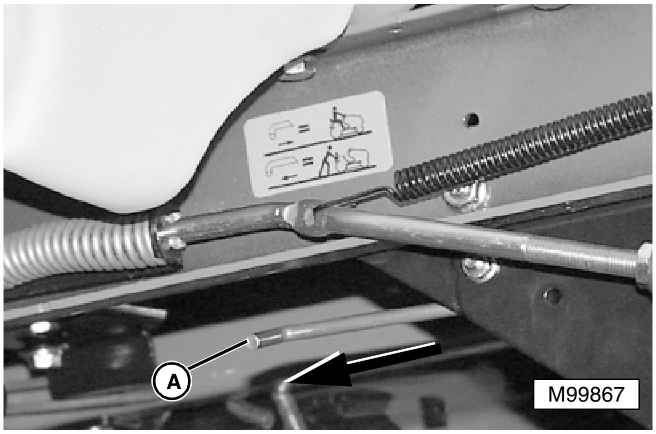
**Reason:**

To ensure that tractor can be moved manually without damage to transaxle when freewheel rod is pulled.

**Procedure:**

> ⚠ **CAUTION**
>
> **DO NOT operate freewheel valve with engine running or damage to hydrostatic transmission can occur.**

1. Release park brake.




*NOTE: Left rear wheel removed for clarity of photo.*

2. With engine off and forward/reverse pedals disengaged, pull freewheel rod (A) to the freewheel position (forward).
3. Push tractor forward at least 3 M (10 ft). Tractor should push easily the entire distance.
4. Push tractor backwards the same distance. Tractor should push easily the entire distance.
5. If tractor pushes hard in forward or reverse direction, internal transaxle components could be damaged or worn. Inspect freewheeling linkage or replace transaxle.

**IMPORTANT: After using Transport (Freewheel), be sure to push engagement rod completely back into tractor. If not completely engaged the transaxle will not operate properly, will be excessively noisy and could be damaged.**

# REPAIR

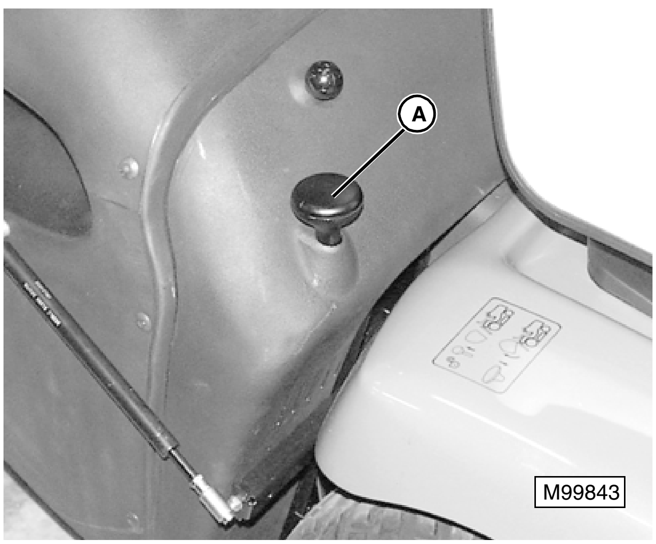
## TRANSAXLE REMOVAL AND INSTALLATION

### Removal:

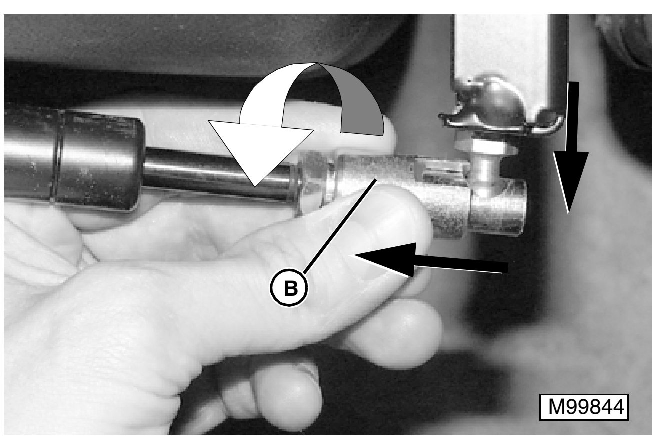
1. Remove mower deck.
2. Engage park brake to release tension on traction drive belt.

**IMPORTANT: During transaxle removal, rear of tractor must be supported *by the frame*.**

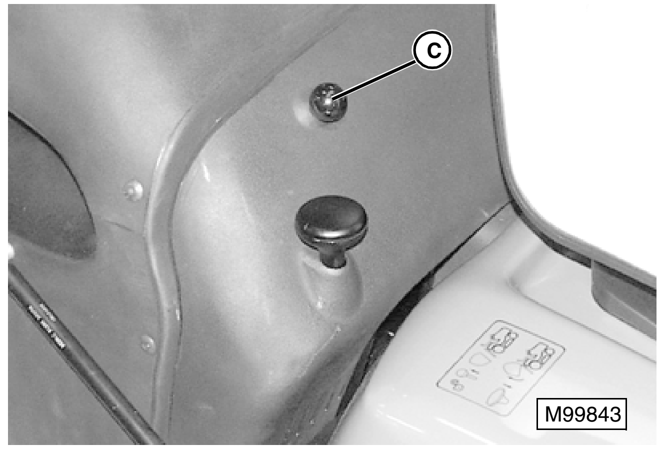
3. Raise rear of tractor, and support using suitable stands.
4. Remove rear wheels. (See “REAR WHEEL REMOVAL/INSTALLATION” on page 5 in “MISCELLANEOUS” section.)



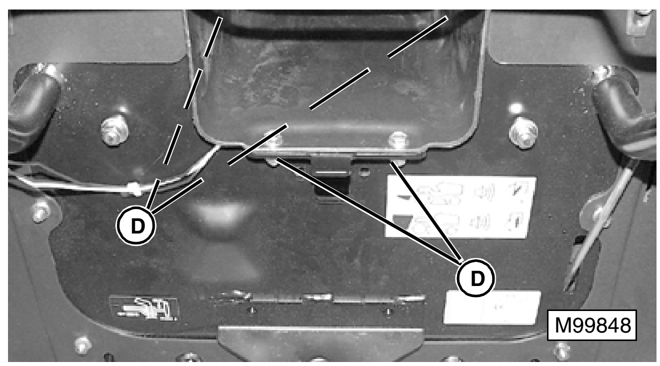

5. Push down on knob (A) to open grass collector hopper.



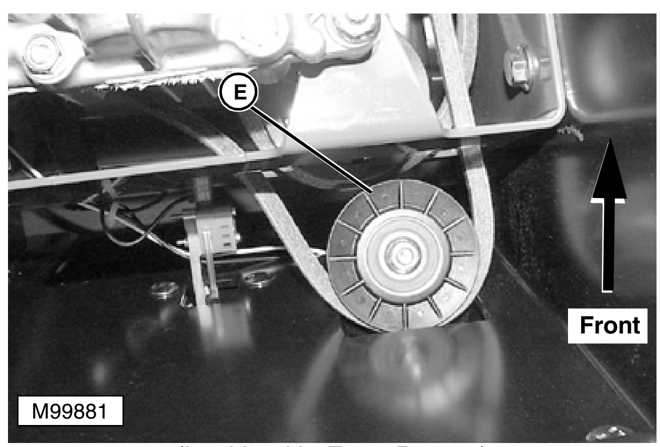

6. Remove end of gas lift assist cylinder from hopper by pulling back on locking collar (B), and turning. Pull end of cylinder off of ball stud.
7. Support grass collector hopper, and repeat for other side.




8. Pull up on release handle (C) to unlock hopper support brackets.
9. Lift grass collector hopper off of rear of tractor.

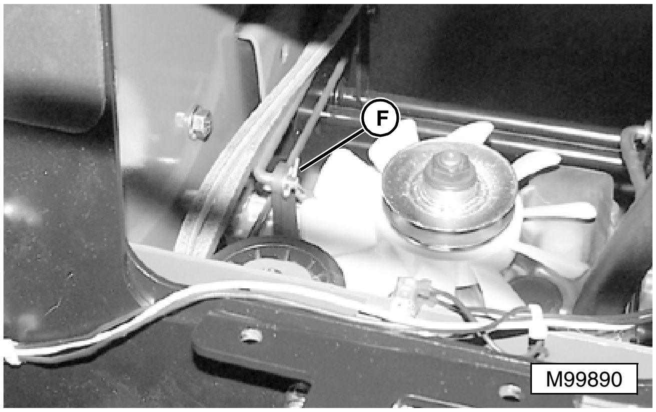



10. Remove four cap screws and lock nuts (D). Move chute toward the front and remove from the underside of the tractor.

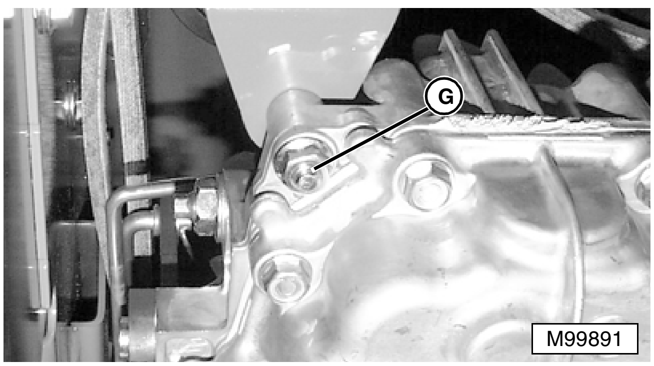



(Looking Up From Bottom)

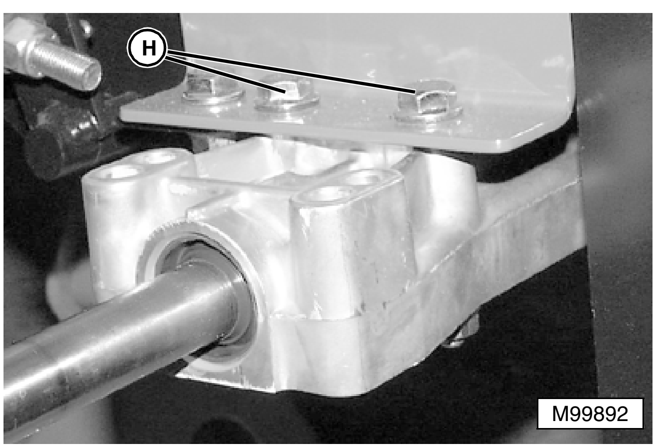
11. At rear of tractor, between grass collector back plate assembly, and hitch plate, locate fixed idler sheave (E). Remove nut and carriage bolt retaining idler sheave to hitch extension plate.
12. Remove idler sheave.
13. Slip belt off of transaxle drive sheave.



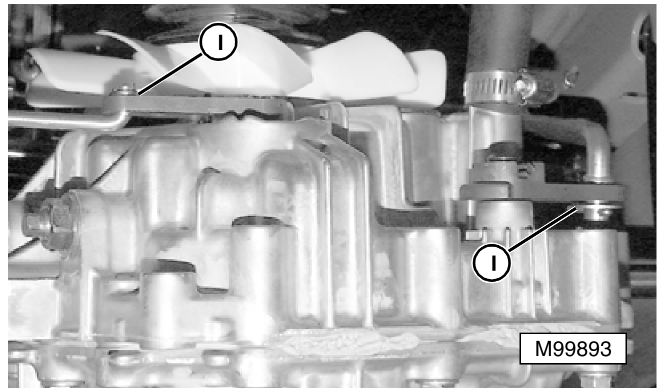

14. Remove cotter pin and washer (F), and disconnect control rod from transaxle control lever.




15. Locate cap screw and nut (G) at retaining rear of transaxle to frame. Remove cap screw and nut.
16. Support transaxle using a floor or transmission jack.




17. Remove four cap screws (H) and nuts attaching transaxle to frame.
18. Lower transaxle slightly to gain access to control rods.




19. Remove cotter pins and washers (I) attaching control rod, and freewheeling rod to transaxle control levers. Disconnect rods from transaxle.
20. Lower transaxle and remove from tractor.

**Installation:**

*NOTE: Freewheeling and forward/reverse control rods must be in holes of transaxle levers before transaxle is installed into tractor frame.*

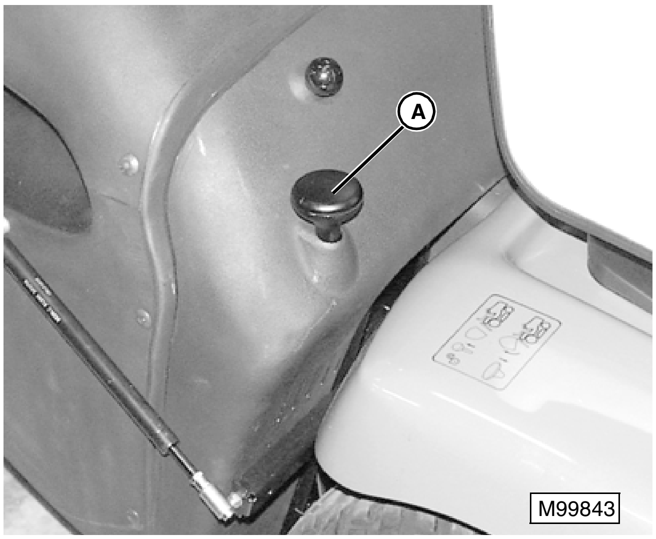
Install in reverse order of removal.

- Tighten cap screws to **40 N•m (30 lb-ft)**.

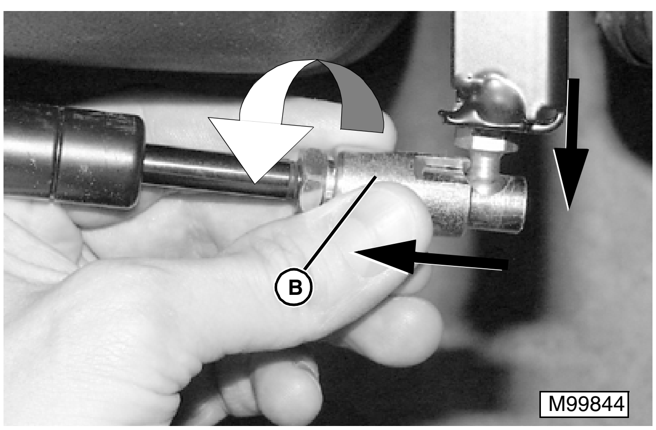
# TRACTION DRIVE BELT REMOVAL AND INSTALLATION

**Procedure:**

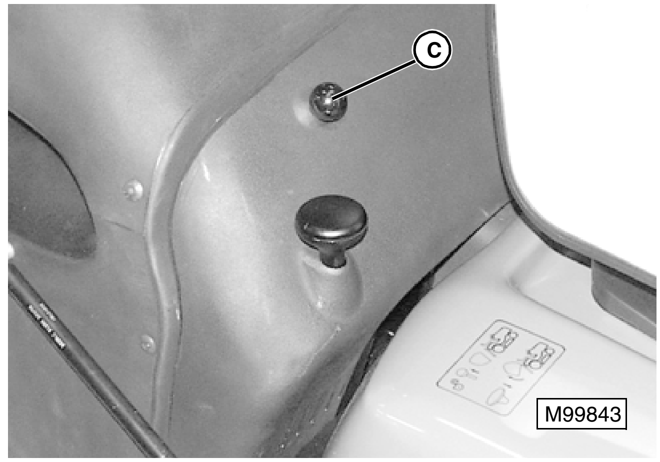
1. Park tractor on a level surface. Turn engine OFF. Remove ignition key.
2. Engage park brake to relieve tension on traction drive belt.
3. Remove mower deck.



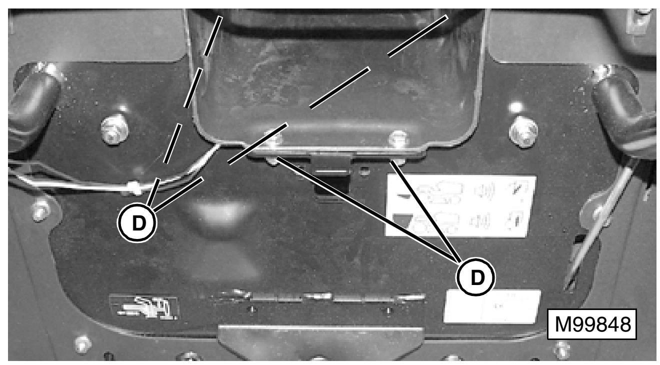

4. Push down on knob (A) to open grass collector hopper.



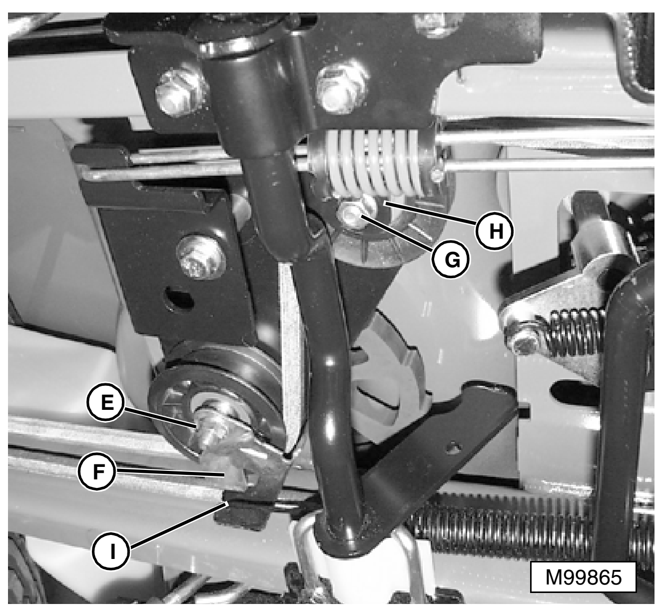

5. Remove end of gas lift assist cylinder from hopper by pulling back on locking collar (B), and turning. Pull end of cylinder off of ball stud.
6. Support grass collector hopper, and repeat for other side.




7. Pull up on release handle (C) to unlock hopper support brackets.
8. Lift grass collector hopper off of rear of tractor.




9. Remove four cap screws and lock nuts (D). Move chute toward the front and remove from the underside of the tractor.
10. Raise tractor and support on suitable stands to gain easy access to underside of frame.

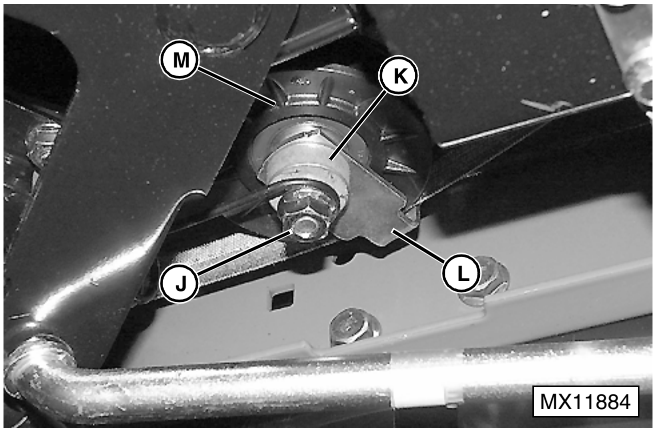


11. Remove nut (E) and belt guide (F).
12. Remove nut (G) and belt guide (H).
13. Slip traction drive belt off of flat idler and V-idler sheaves.
14. Disengage park brake.

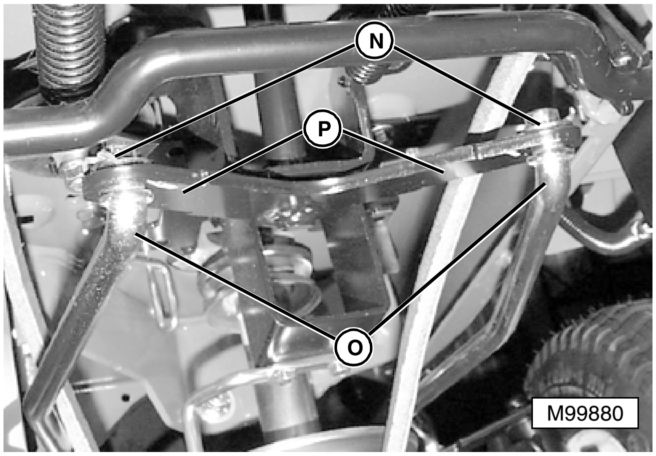
**CAUTION**

**TENSIONED SPRING. Idler assembly tensioning spring is under high tension. Wear gloves and eye protection when removing spring.**

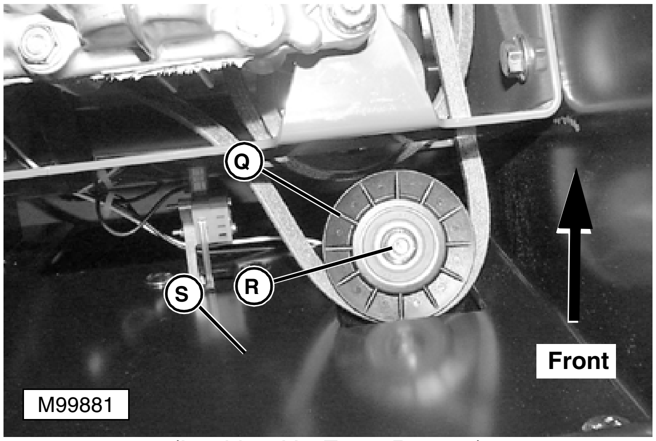
15. Using a suitable spring puller, disconnect idler tensioning spring (I) from idler assembly. Remove spring.




16. Remove nut (J), spacer (K), and belt guide (L). Disconnect belt from idler sheave (M).




17. Remove two cotter pins and washers (N). Disconnect tie rods (O) from steering arms (P).

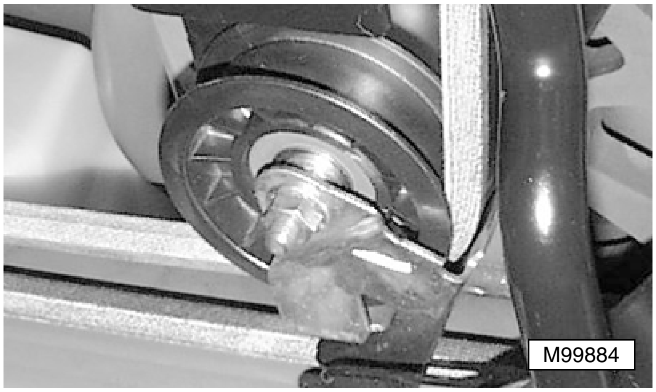



(Looking Up From Bottom)

18. At rear of tractor, between grass collector back plate assembly, and hitch plate, locate fixed idler sheave (Q). Remove nut and carriage bolt (R) retaining idler (N) to hitch extension plate (S).
19. Remove traction drive belt from the tractor.

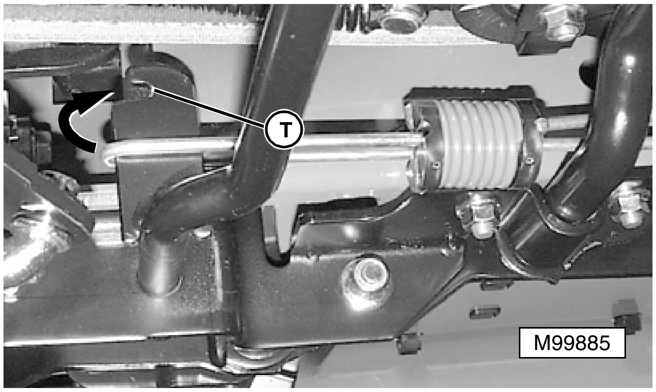
**Installation:**

Installation is the reverse of removal.




- Check guides on idler sheaves. Guides should be positioned so that belt is approximately 3 mm (0.125 in.) away on all sides.

**IMPORTANT: V-idler in rear should be pushed forward before tightening, while the flat idler in rear should be pushed rearward. This needs to be done to prevent the belt from jumping off the flat idler.**



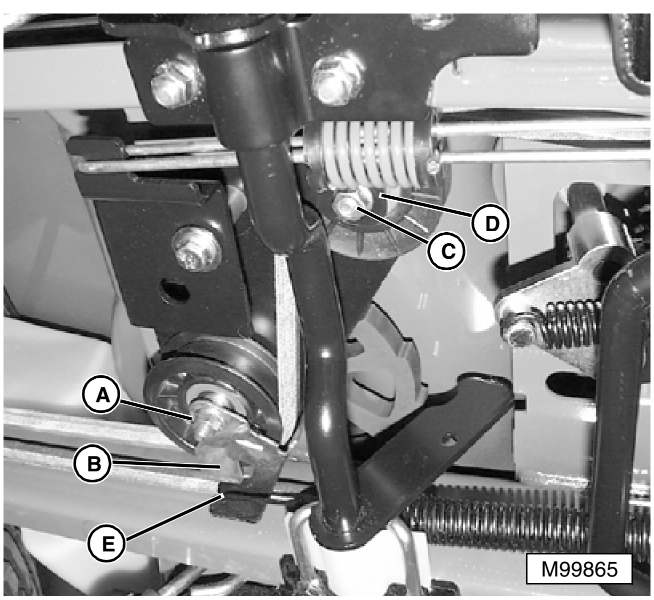

• With park brake released, check drive belt tension. If tension is not correct, check compression spring to make sure that it has not slipped out of slot (T) on brake shaft lever as shown.

## TRACTION DRIVE BELT TENSIONER ASSEMBLY

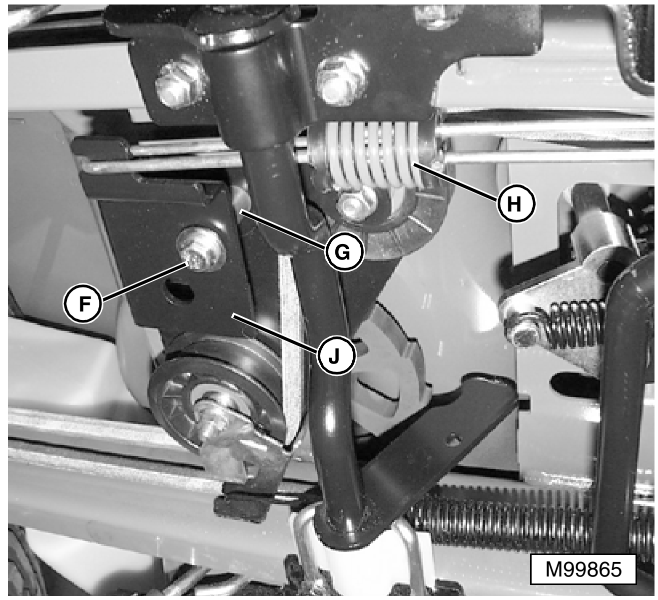
**Removal:**

1. Remove mower deck.
2. Engage park brake to relieve tension on traction drive belt.

> **⚠ CAUTION**
>
> **TENSIONED SPRING. The drive belt tension spring is under high tension when installed. Wear approved eye protection and gloves when removing to minimize the risk of personal injury.**



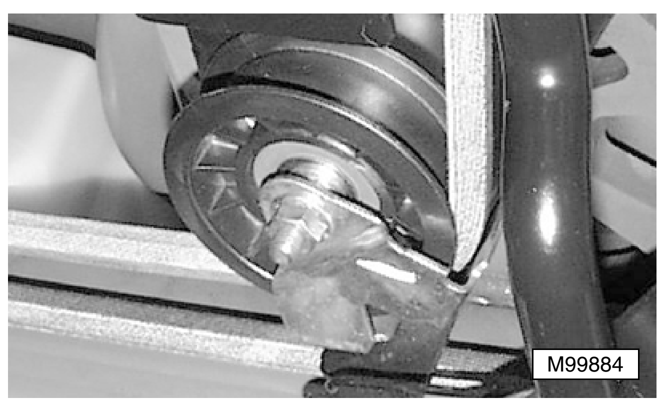

3. Remove nut (A) and belt guide (B).
4. Remove nut (C) and belt guide (D).
5. Slip traction drive belt off of flat idler and V-idler sheaves.
6. Disengage park brake.
7. Using a suitable spring puller, disconnect idler tensioning spring (E) from idler assembly. Remove spring.



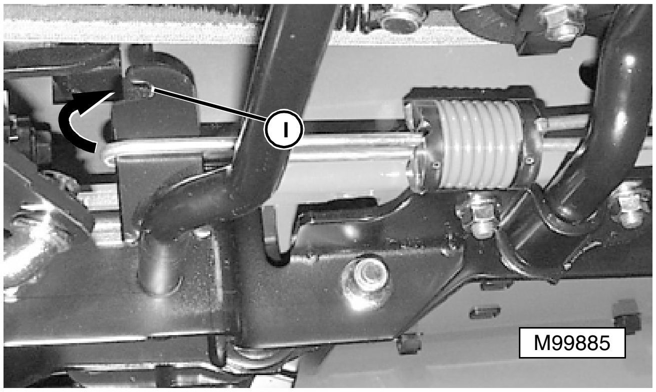

8. Remove cap screw and washer (F) retaining tensioner assembly to frame.
9. Remove spacer (G), compression spring (H), and tensioner assembly (J).
10. Inspect flat and V-idlers and bearings for smooth operation, wear, or damage. Replace as needed.

**Installation:**

Installation is the reverse of removal.




• Check guides on idler sheaves. Guides should be positioned so that belt is approximately **3 mm (0.125 in.)** away on all sides.

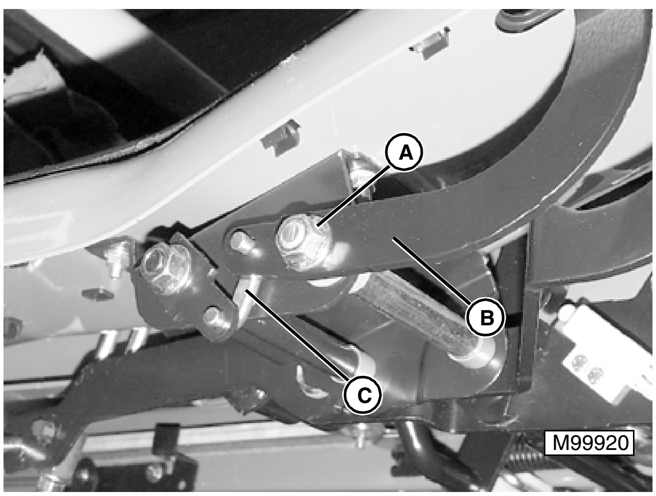



- With park brake released, check drive belt tension. If tension is not correct, check compression spring to make sure that it has not slipped out of slot (I) on brake shaft lever as shown.

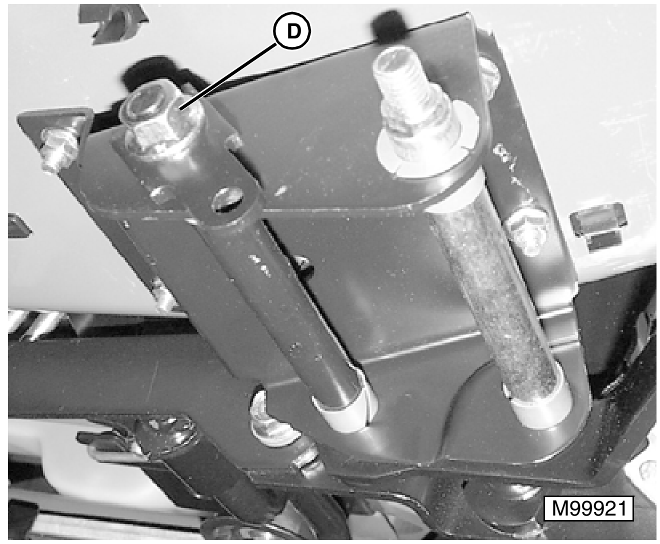
## CONTROL PEDALS AND LINKAGE

**Pedal Bushing Replacement:**

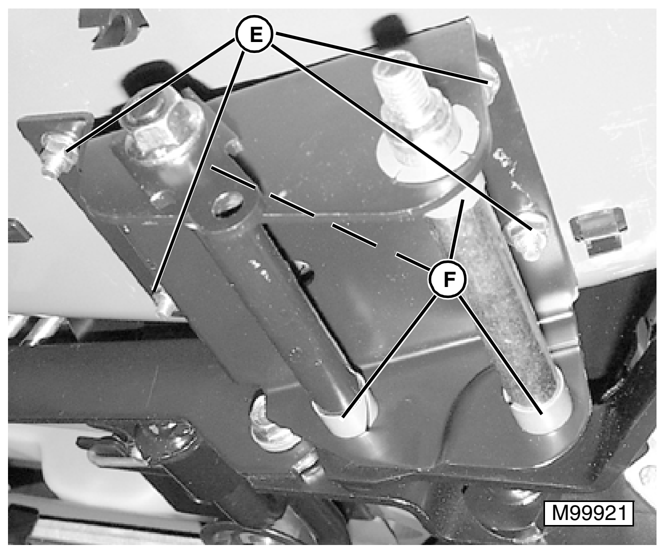
1. Remove mower deck.




2. Remove nut (A) attaching reverse pedal (B) to control shaft. Remove pedal and U-shaped link (C).




3. Loosen nut (D) on forward control shaft.




4. Remove four nuts (E) retaining pedal assembly to fender deck.
5. Lower pedal assembly to allow removal of forward and reverse control shafts. Replace bushings (F) or other parts as needed.

**Installation:**

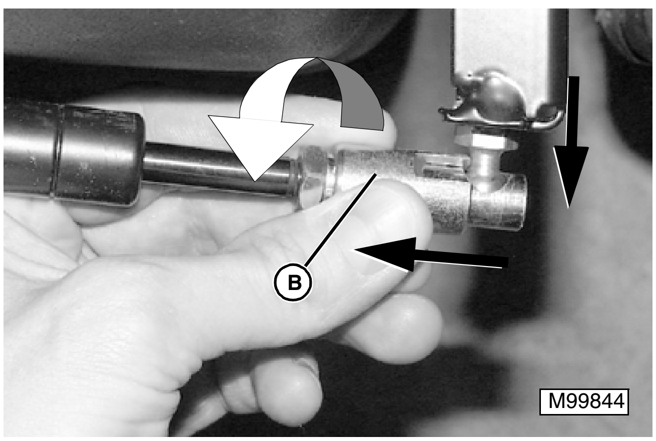
Installation is the reverse of removal.

- Perform pedal adjustment. (See “FORWARD AND REVERSE PEDAL ADJUSTMENT” on page 17.)

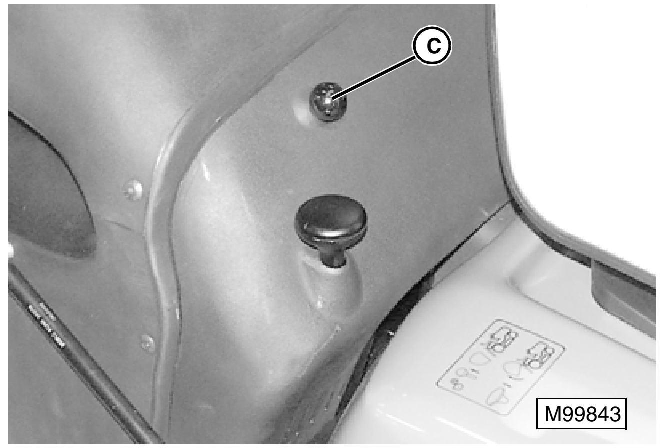
**Pedal Assembly Removal:**

1. Remove mower deck.

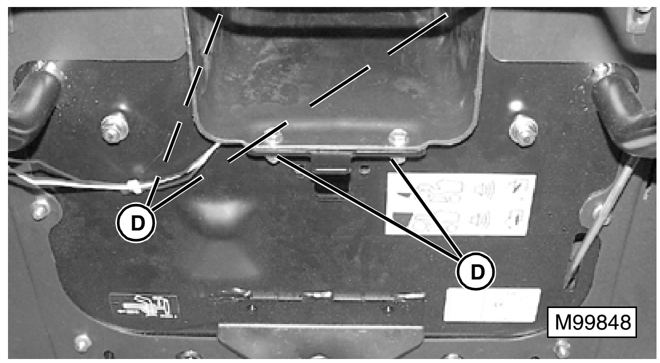

2. Push down on knob (A) to open grass collector hopper.



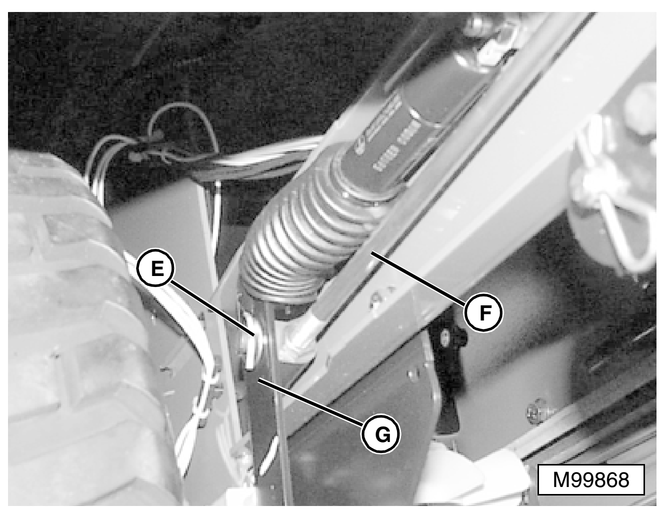

3. Remove end of gas lift assist cylinder from hopper by pulling back on locking collar (B), and turning. Pull end of cylinder off of ball stud.
4. Support grass collector hopper, and repeat for other side.



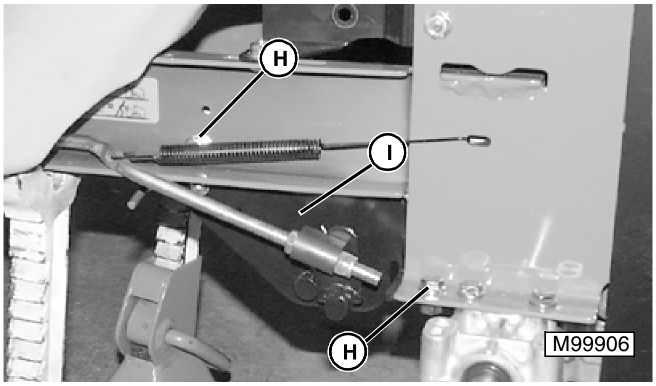

5. Pull up on release handle (C) to unlock hopper support brackets.
6. Lift grass collector hopper off of rear of tractor.




7. At rear of tractor, remove four cap screws and lock nuts (D) that are holding the chute. Move grass chute toward the front and remove from the underside of the tractor.

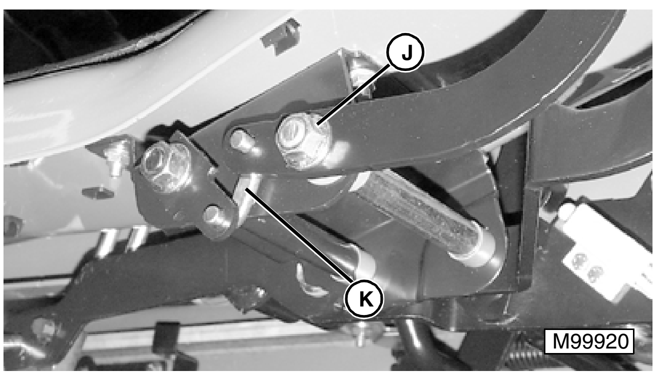



8. Remove cotter pin and washer (E) attaching forward/reverse control rod (F) to cross shaft lever (G).

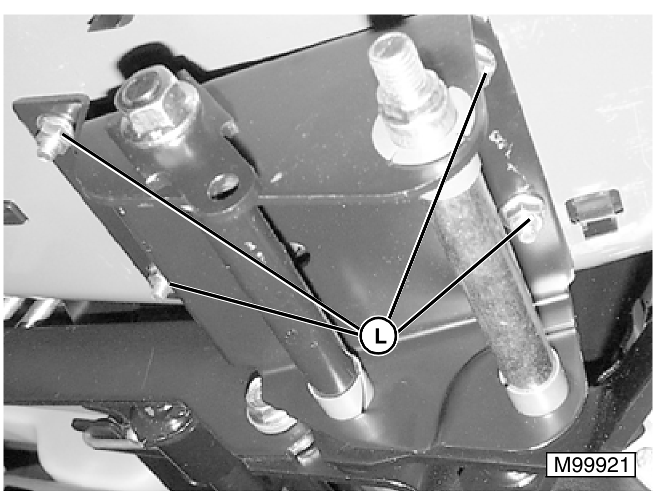



*NOTE: Left rear wheel removed for clarity of photo.*

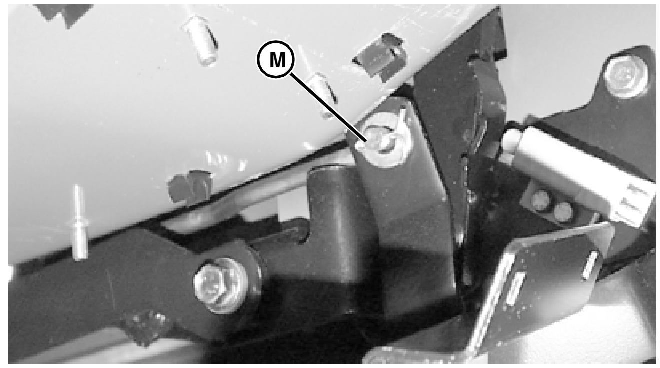
9. In front of left rear tire, locate cap screws and nuts (H) mounting cross shaft assembly (I) to frame. Remove cap screws and nuts. Repeat for right side.
10. Move cross shaft assembly slightly left and disconnect forward/reverse control rod from cross shaft lever.




11. Remove nut (J) attaching reverse pedal to control shaft. Remove pedal and U-shaped link (K).
12. Remove the forward pedal pad.
13. Remove right foot mat.




14. Remove four nuts (L) retaining pedal assembly to fender deck.




15. Lower pedal assembly to gain access to forward/ reverse control rod end. Remove cotter pin and washer (M) connecting rod to pedal assembly. Disconnect rod from pedal assembly.
16. Remove pedal assembly.
17. Remove control rod.

**Installation:**

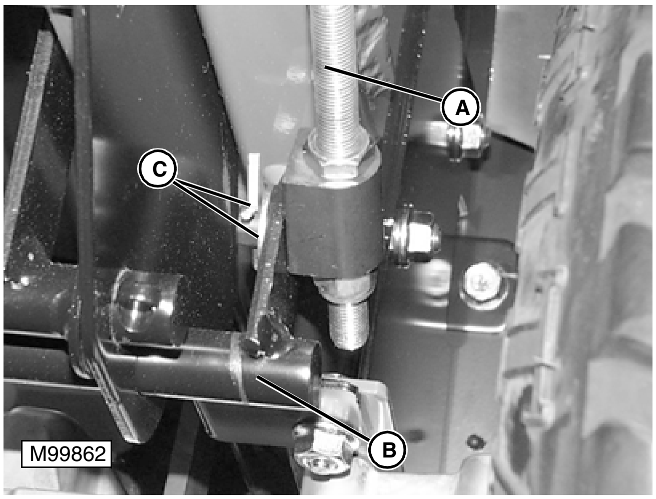
Installation is the reverse of removal.

- After installation is complete, perform forward/ reverse pedal adjustment. (See “FORWARD AND REVERSE PEDAL ADJUSTMENT” on page 17.)

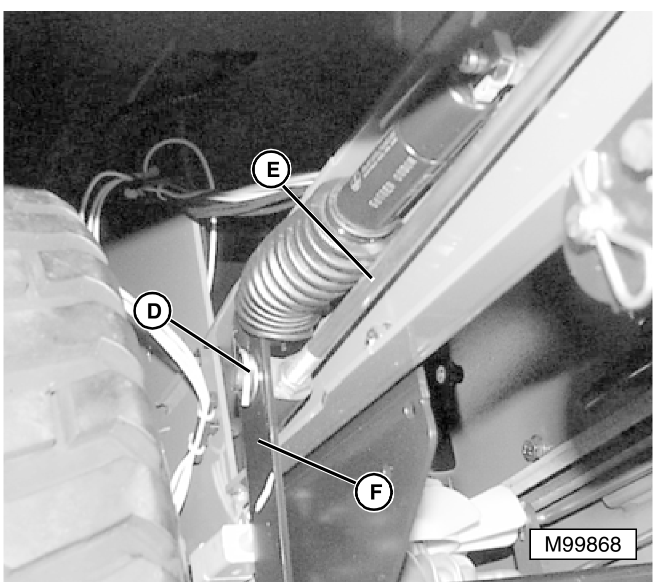
# CROSS SHAFT ASSEMBLY

**Removal:**

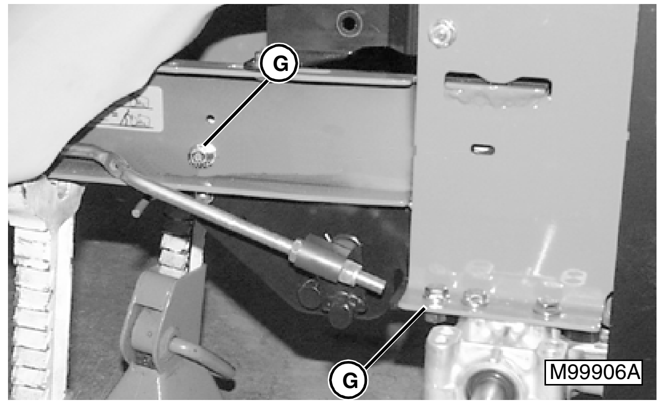
*NOTE: Cross shaft assembly provides mechanical linkage for both brake, and forward/reverse control assemblies.*



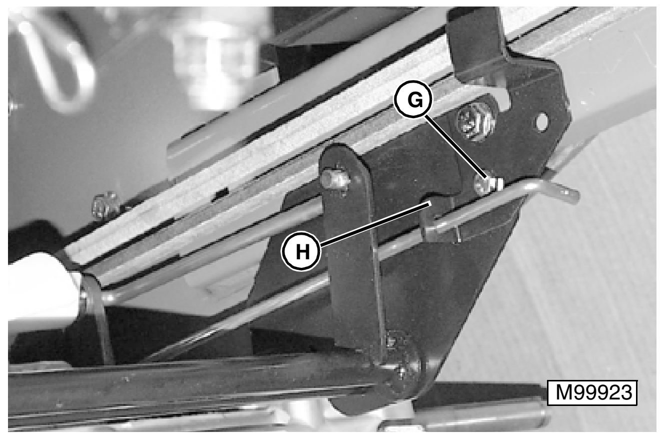

1. Near left rear tire, locate brake rod (A) and brake cross shaft (B). Remove cotter pin and washer (C), and disconnect brake rod end from brake cross shaft.



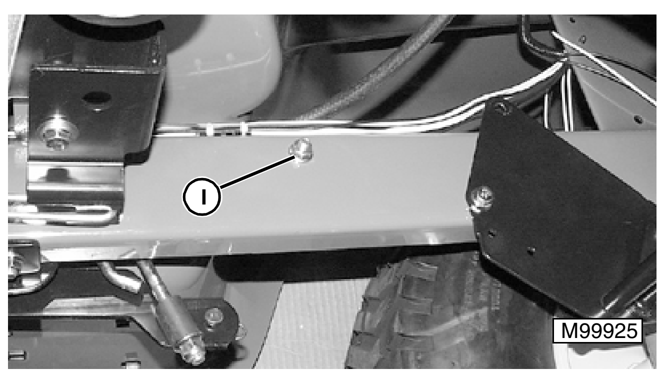

2. Remove cotter pin and washer (D) attaching forward/reverse control rod (E) to cross shaft lever (F).




*NOTE: Left rear wheel removed for clarity of photo.*




3. Remove cap screw and nut (G) retaining freewheeling rod bracket (H) to cross shaft assembly. Remove bracket.
4. In front of left rear tire, locate cap screws and nuts mounting cross shaft assembly to frame. Remove cap screws and nuts. Repeat for right side.
5. Move cross shaft assembly slightly left and disconnect forward/reverse control rod from cross shaft lever.




6. Remove nut (I) on stud attaching front of shock absorber to frame.

7. Turn shafts as needed to disconnect keyed ends of brake and forward/reverse control rods from cross shaft levers.
8. Remove cross shaft assembly from the tractor.

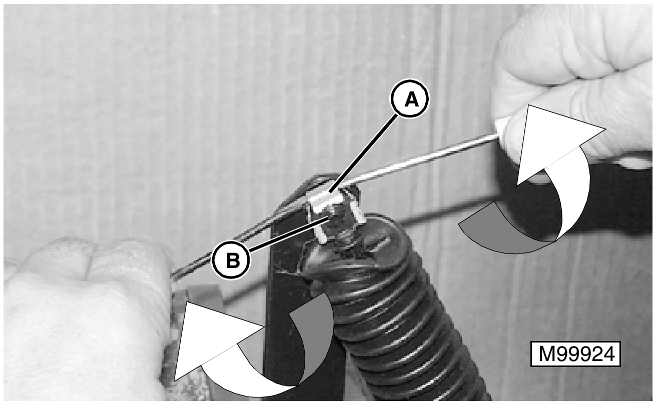
**Installation:**

Installation is the reverse of removal.

# SHOCK ABSORBER REMOVAL AND INSTALLATION

**Removal:**

1. Remove cross shaft assembly. (See “CROSS SHAFT ASSEMBLY” on page 26.)




2. Using two small screwdrivers, gently pry up on end of clip (A) to release clip from groove in pin (B). Remove shock absorber from pin.

*NOTE: Inspect clips that retain shock absorber. If clips are damaged or deformed, replace.*

**Installation:**

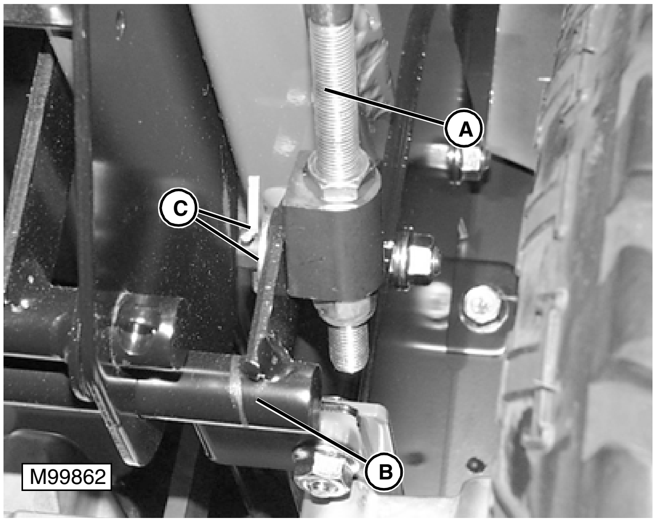
Installation is the reverse of removal.

- If removed, install clips to each end of shock absorber. Install shock absorber onto pins. Using a suitable slip joint or other adjustable pliers, *gently* squeeze clip until flange of clip seats in groove of pin with an audible click. Pull on shock absorber to ensure that clip will firmly retain shock absorber to pin.

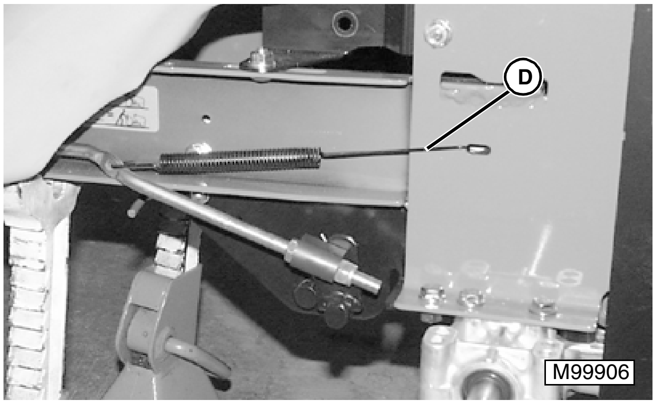
# BRAKE PEDAL AND LINKAGE

**Removal:**

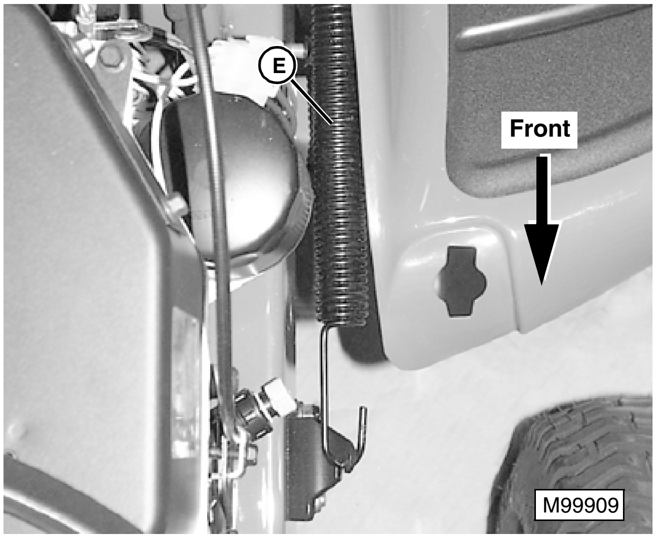
1. Remove mower deck.
2. Remove left rear wheel. (See “REAR WHEEL REMOVAL/INSTALLATION” on page 5 in ‘MISCELLANEOUS” Section.)
3. Remove mower deck lift lever and linkage. (“MOWER DECK LIFT LINKAGE REMOVAL/ INSTALLATION—LTR155/166” on page 30, or “MOWER DECK LIFT LINKAGE REMOVAL/ INSTALLATION—LTR180” on page 33 in “ATTACHMENT” Section.)




4. Near left rear tire, locate brake rod (A) and brake cross shaft (B). Remove cotter pin and washer (C), and disconnect brake rod end from brake cross shaft.




5. Using a suitable spring puller, disconnect brake return spring (D) from frame. Remove brake return spring.
6. Remove battery.
7. If not already done, move lift lever to forward (LOWER) position.

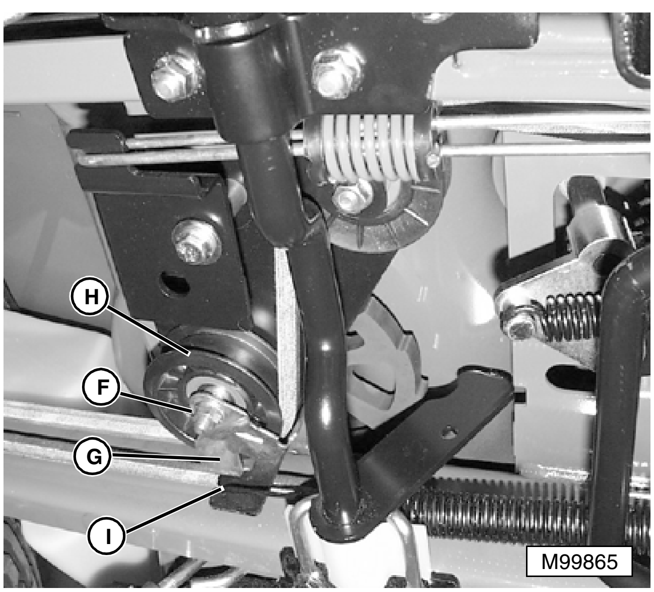



*NOTE: Left closeout panel removed for clarity.*

## ⚠ CAUTION

**TENSIONED SPRING. The mower deck lift assist spring is under high tension when installed. Wear approved eye protection and gloves when removing to minimize the risk of personal injury.**

8. Using a suitable spring puller, disconnect the front of the lift assist spring (E) from bracket on tractor frame. Remove spring from tractor.
9. Engage park brake to relieve tension on traction drive belt.
10. Raise tractor and support on suitable stands to gain easy access to underside of frame.

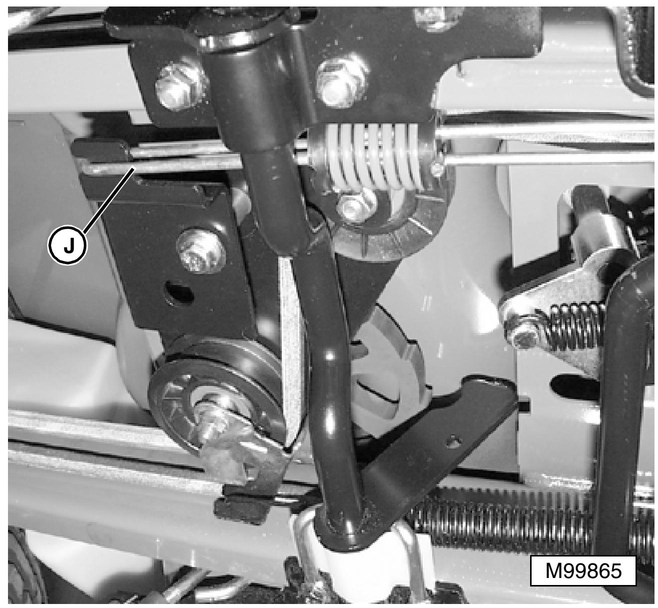



11. Remove nut (F) and belt guide (G).
12. Slip traction drive belt off of flat idler sheave (H).
13. Disengage park brake.

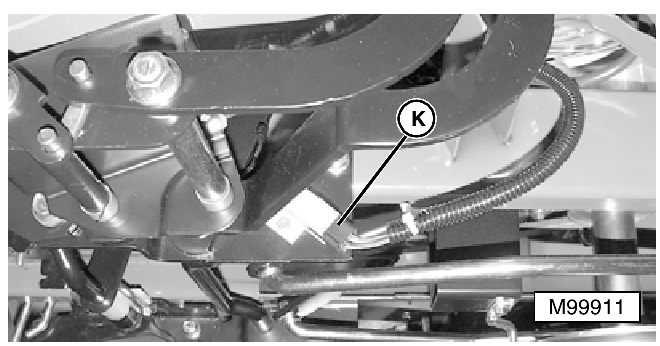
## ⚠ CAUTION

**TENSIONED SPRING. Idler assembly tensioning spring is under high tension when installed. Wear approved eye protection and gloves when removing to minimize the risk of personal injury.**

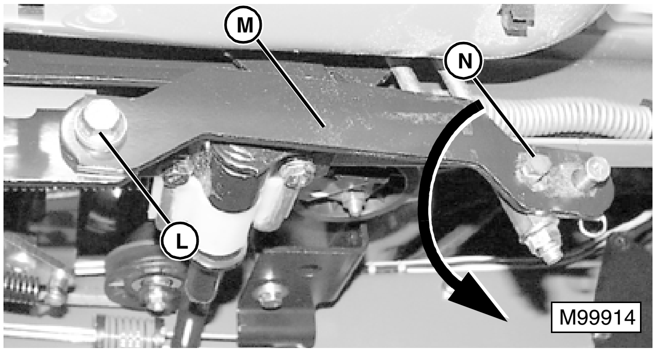
14. Using a suitable spring puller, disconnect idler tensioning spring (I) from idler assembly. Remove spring.



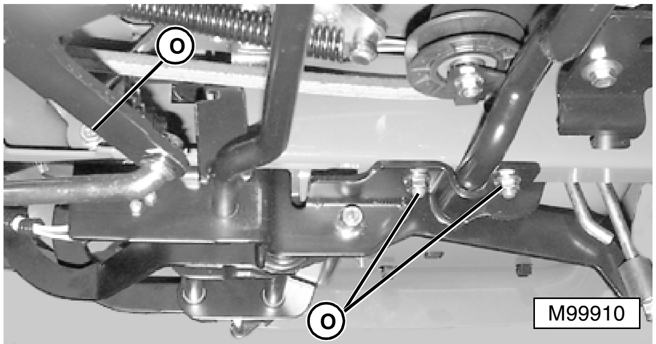

15. Disconnect compression spring assembly (J) from idler assembly and brake pedal arm. Remove spring assembly from tractor.
16. Remove brake pedal pad from brake pedal.



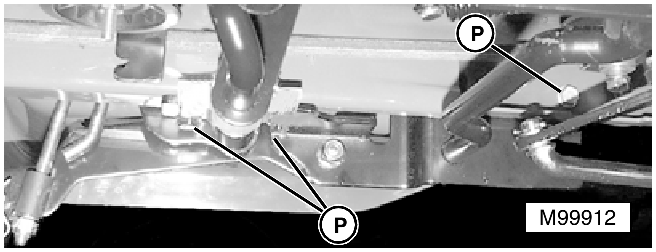

17. Under right foot rest, locate and disconnect brake switch electrical connector (K).




18. Remove cap screw, bushing, and lock nut (L) retaining front of draft arm to lift shaft assembly.
19. Rotate draft arm (M) and remove from lift link (N).
20. Repeat for other side.



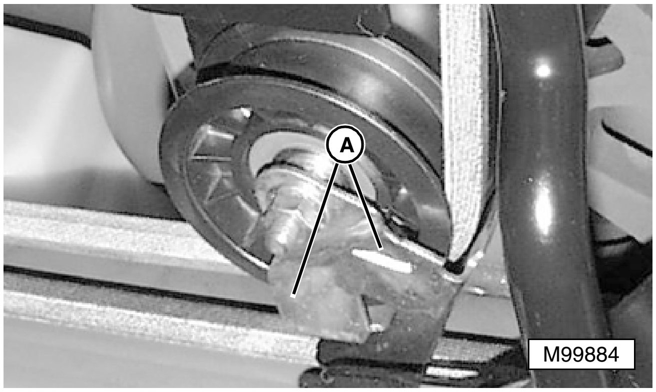

21. Remove three cap screws and nuts (O) retaining right side of brake pedal shaft/lift shaft support to frame.



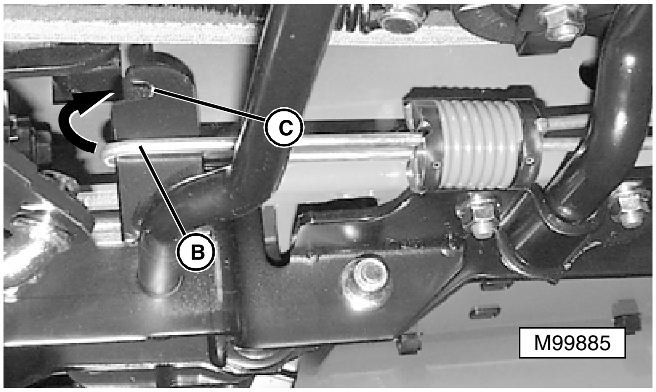

22. Remove two cap screws and nuts (P) retaining left side of brake pedal shaft/lift shaft support to frame.
23. Remove cap screw and nut.
24. Remove brake pedal shaft and lift shaft assembly from the tractor.
25. Inspect components for wear or damage. Replace parts as needed.

**Installation:**

Installation is the reverse of removal.




- Check guides (A) on idler sheaves. Guides should be positioned so that belt is approximately 3 mm (0.125 in.) away on all sides.




- With park brake released, check drive belt tension. If tension is not correct, check compression spring end (B) to make sure that it has not slipped out of slot (C) on brake shaft lever as shown.

# NOTES:

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# SPECIFICATIONS

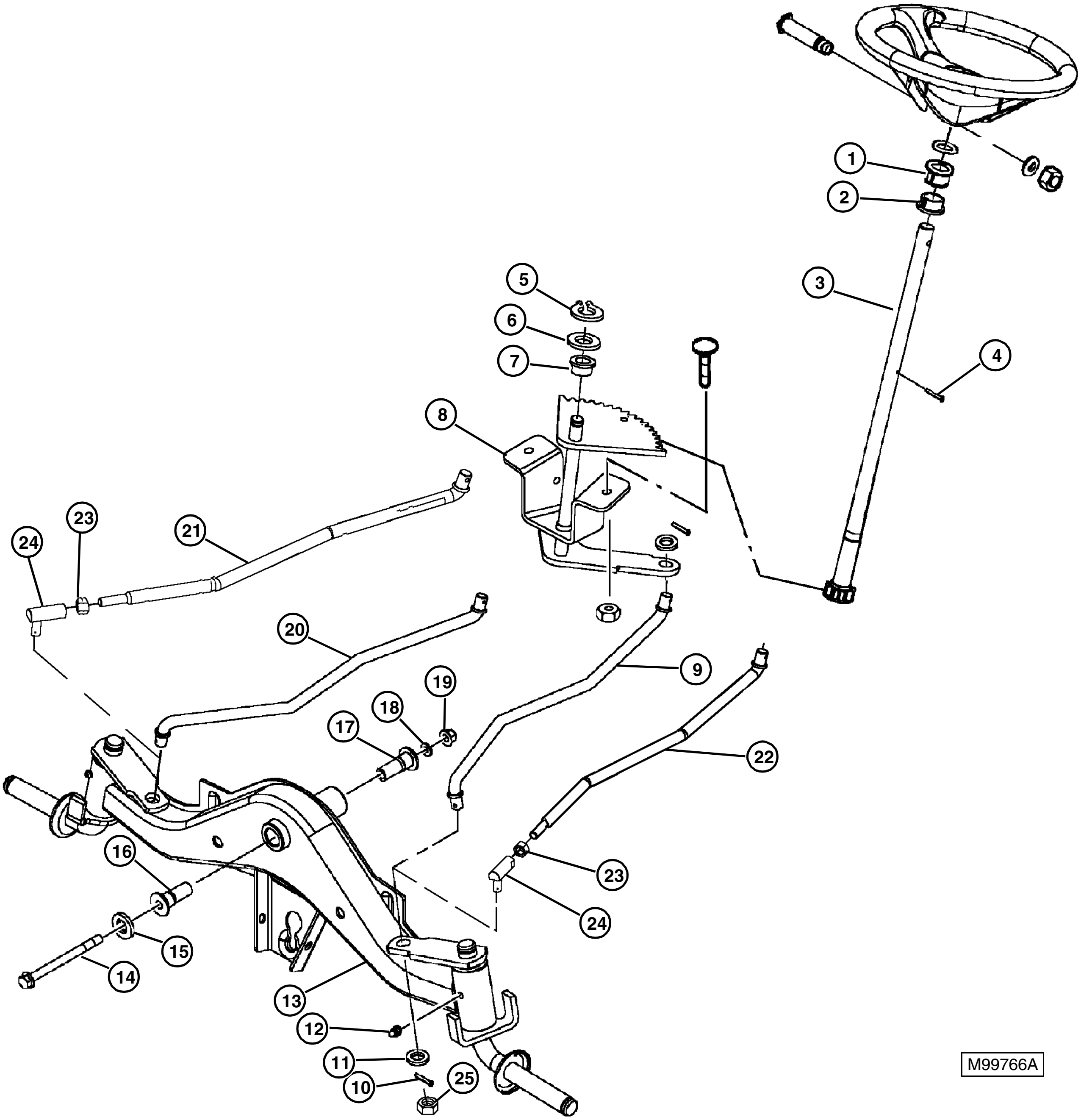
### Steering

Type. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Sector and Pinion
Toe-In . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .20 ± 10 mm (0.79 ± 0.39 in.)

# TORQUE SPECIFICATIONS

Front Axle Pivot . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 68 N•m (50 lb-ft)
Muffler Bracket to Front Frame . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 16 N•m (144 lb-in.)
Muffler to Engine Nuts. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 24 N•m (216 lb-in.)

# COMPONENT LOCATION



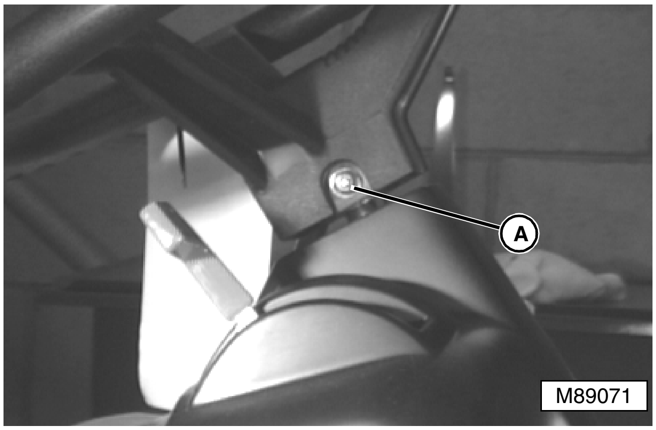

| | | | |
|---|---|---|---|
| 1. Bushing | 2. Bearing | 3. Steering Shaft | 4. Cotter Pin |
| 5. Snap Ring | 6. Washer | 7. Bushing | 8. Sector |
| 9. Tie Rod | 10. Cotter Pin | 11. Washer | 12. Lubrication Fitting |
| 13. Front Axle | 14. Screw | 15. Washer | 16. Spacer |
| 17. Spacer | 18. Washer | 19. Lock Nut | 20. Tie Rod |
| 21. Tie Rod (when used) | 22. Tie Rod (when used) | 23. Nut (when used) M10 | 24. Ball Joint (when used) |
| 25. Lock Nut (when used) 2 used, M10 | | | |

# REPAIR

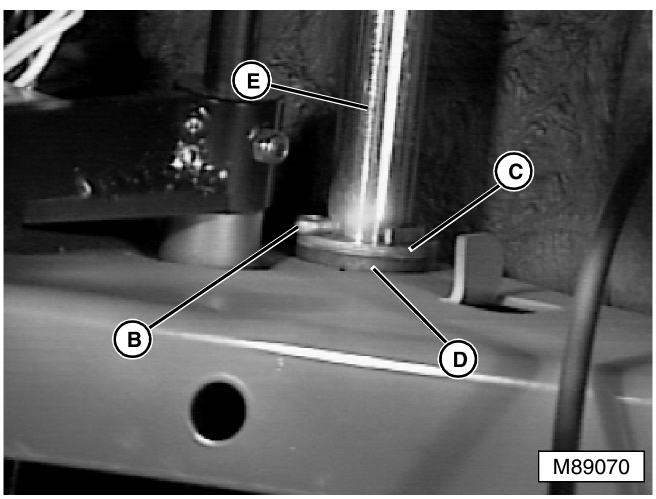
## STEERING GEAR ASSEMBLY REMOVAL AND INSTALLATION

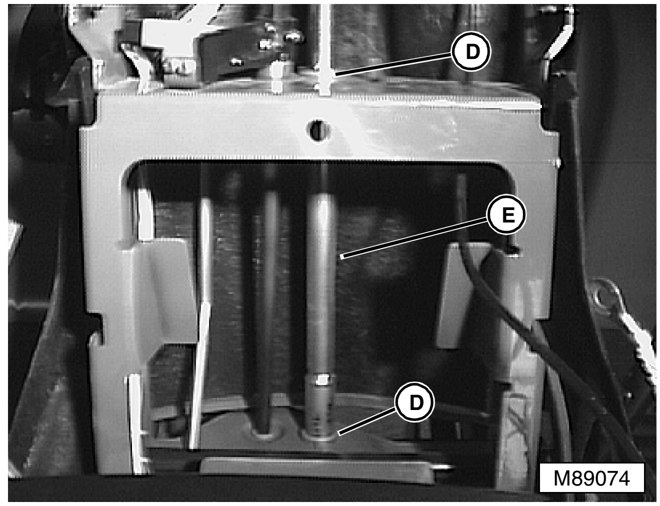
**Procedure:**

1. Disconnect battery and remove.
2. Remove mower deck.
3. Safely raise front and back wheels to a working height.



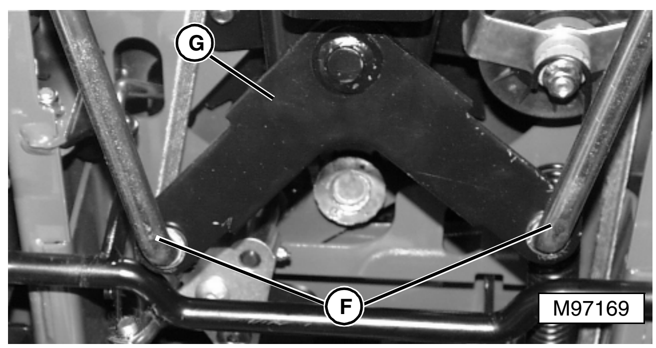

4. Remove steering wheel bolt and nut (A).



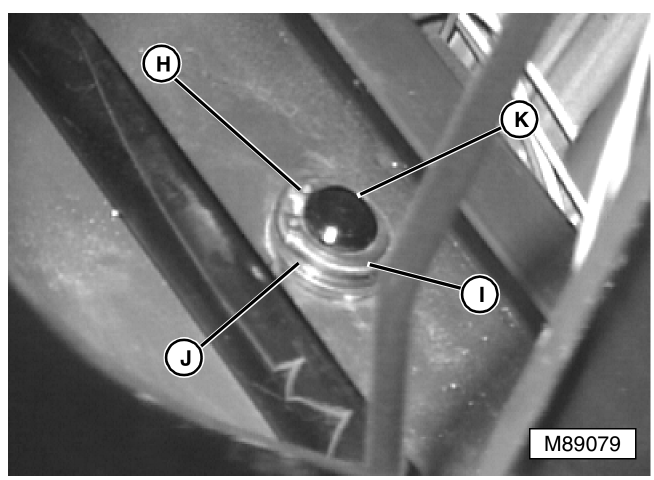




5. Remove cotter pin (B), spacers (C) and bushings (D) from top and center of steering wheel shaft (E).

*NOTE: PTO lever must be ENGAGED and BRAKE must be RELEASED to allow shaft removal from bottom.*



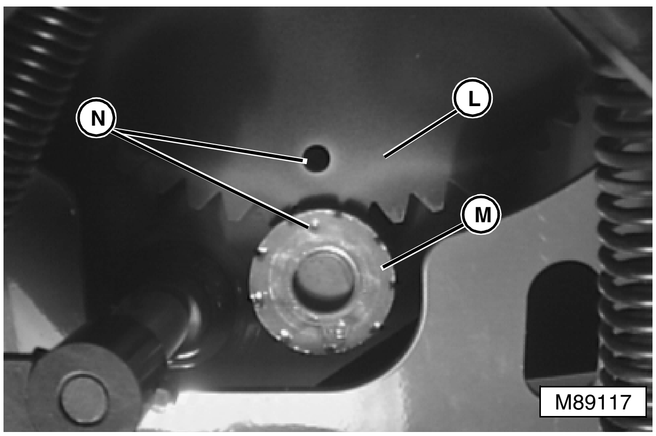

6. Remove cotter pins and washer from tie rods (F) and remove tie rods from steering yoke (G).



7. Remove snap ring (H), washers (I) and bushing (J) from top of sector gear shaft (K).

*NOTE: Write down location and number of washers on pinion and sector gear shafts. If a new shaft is installed, number and placement of washers may need adjustment.*

8. Remove pinion gear assembly from bottom of tractor.
9. Inspect shaft and pinion gear assembly, replace as necessary.



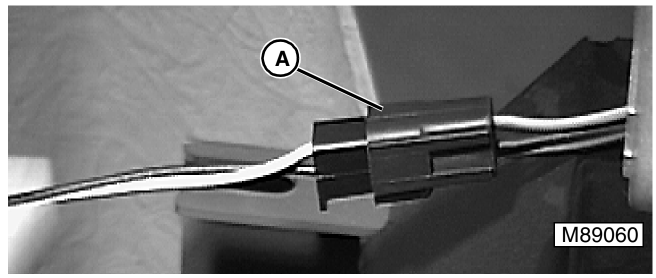

10. Install pinion gear assembly and sector gear making sure pinion gear (L) and sector gear (M) alignment marks (N) are aligned as steering pinion shaft is installed.
11. Install PTO pivot spring on pivot shaft.
12. Install tie rods.
13. Install steering wheel.

## FRONT AXLE REMOVAL AND INSTALLATION

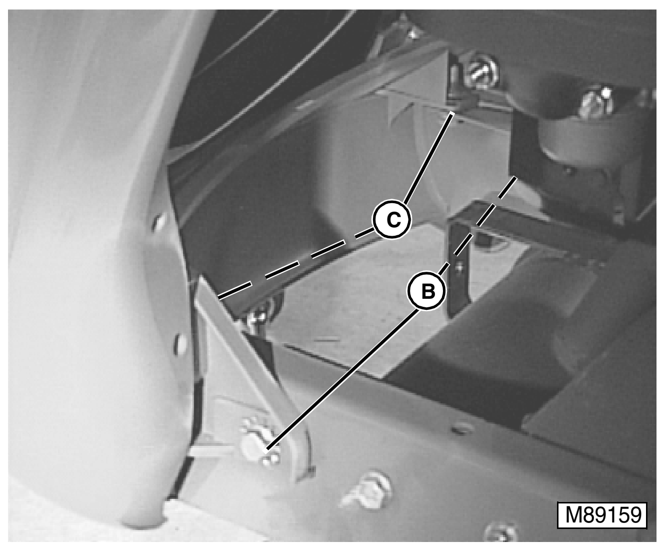
1. Remove mower deck.

*NOTE: When supporting front of tractor frame, allow room to remove front axle.*

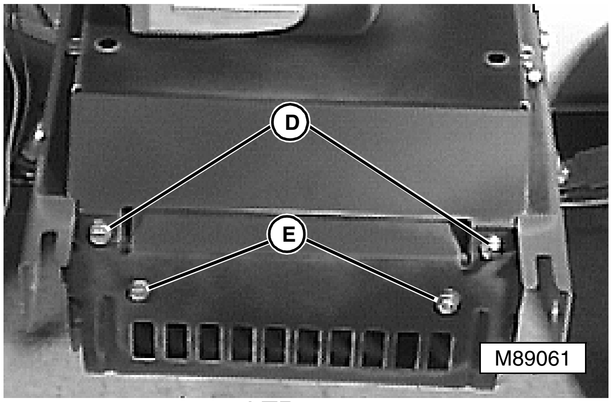
2. Safely support front of tractor frame.
3. Remove front wheels.



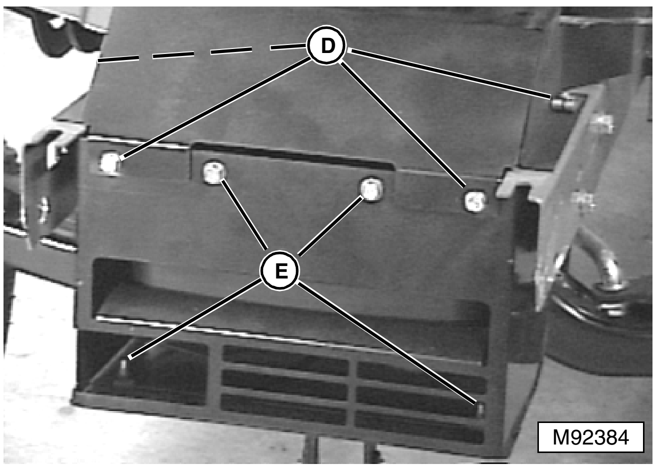

4. Raise hood, disconnect battery negative lead, and headlight connector (A).




5. Remove two bolts (B) securing the hood to the left and right frame side rails. Loosen the two bolts (C) securing the hood to the upper side of the left and right side rails. Remove hood.

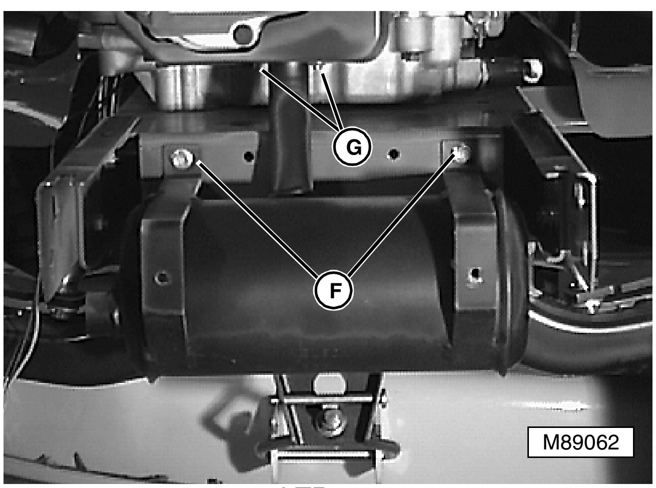



LTR155

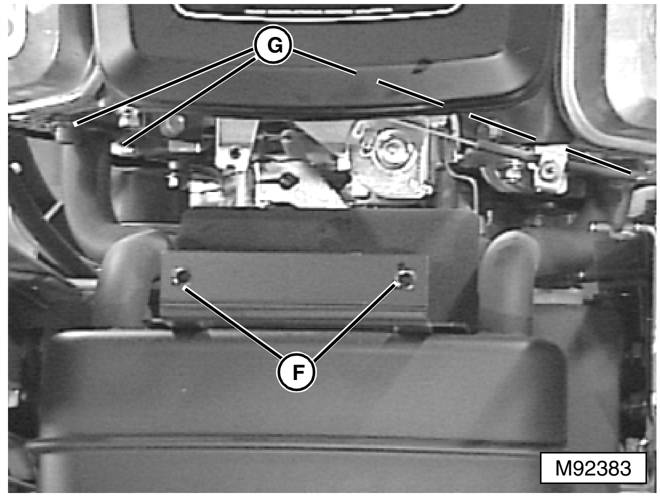



LTR166

6. Remove cap screws (D and E) securing muffler heat shields. Remove muffler shrouds.

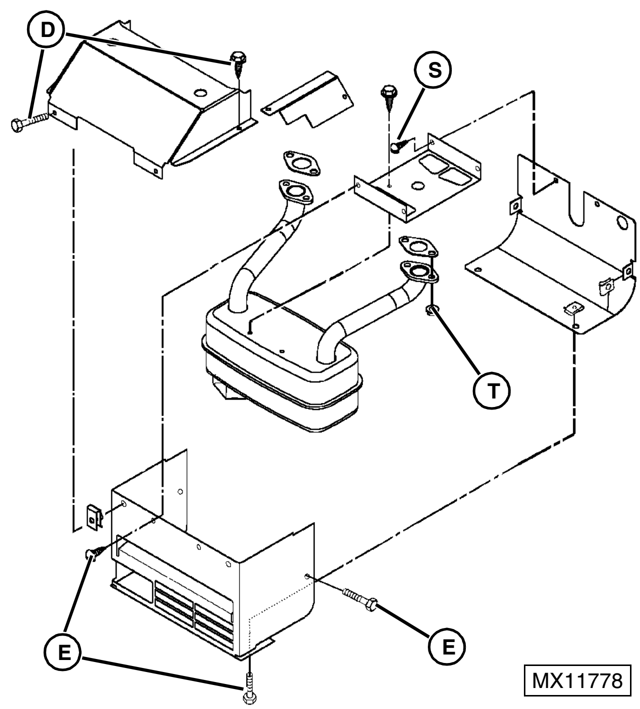



LTR155



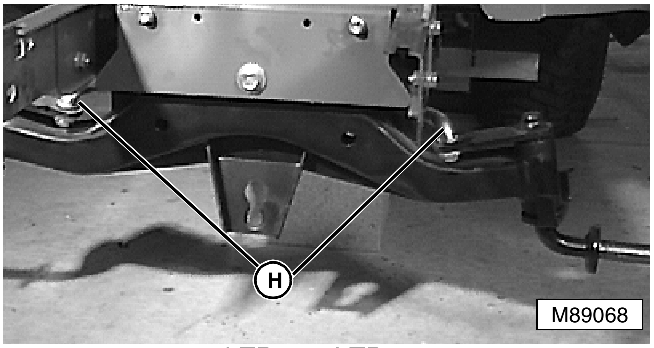

LTR166

7. Remove muffler bracket bolts (F), and muffler to engine bolts (G).
8. Remove muffler.



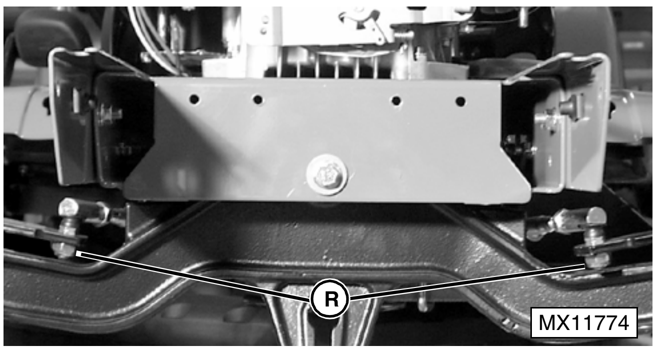

LTR180

9. Remove four upper muffler heat shield cap screws (D), and six front muffler heat shield cap screws (E). Remove the heat shields.
10. Remove two heat deflector cap screws (S).
11. Remove four muffler nuts (T). Remove muffler, gaskets, and heat deflector.



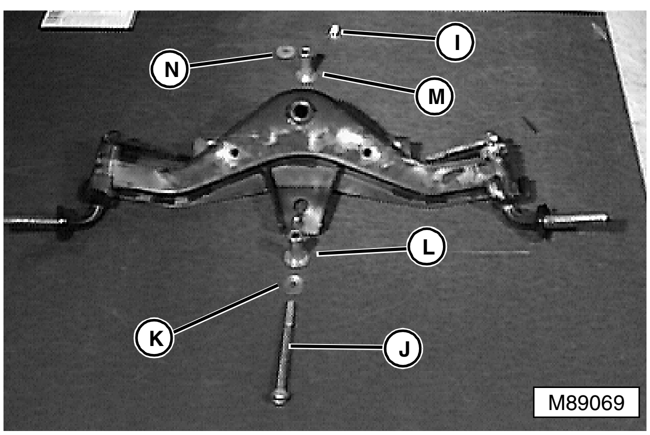

LTR155, LTR166

12. Remove steering rod (H) cotter pins, washers and remove arms from axles.




LTR180

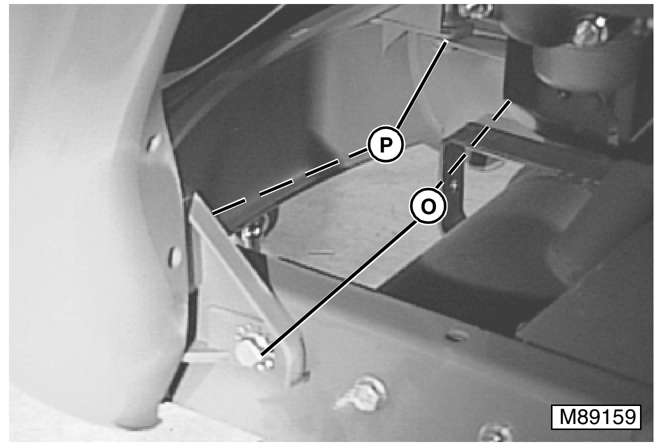
13. Remove lock nuts (R) from tie rod ends. Disconnect tie rod ends from front axles.



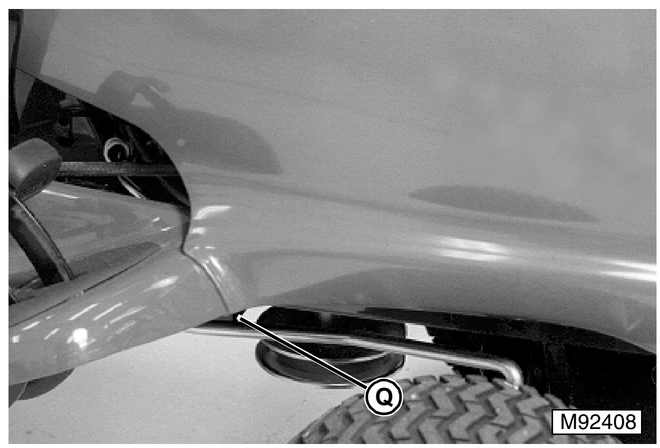

14. Remove axle nut (I), bolt (J), washer (K), bushing (L), rear bushing (M) and washer (N).

*NOTE: If nylon nuts can be tightened by hand, replace.*

15. Remove axle and replace parts as necessary.
16. Grease and install axle. Tighten axle pivot to **68 N•m (50 lb-ft)**.
17. Install tie rods.
18. Install muffler and tighten muffler to engine nuts **24 N•m (216 lb-in.)**.
19. Tighten muffler bracket to frame **16 N•m (144 lb-in.).**
20. Install muffler shrouds.




21. Slide hood into position and install bolts (O). Lightly tighten fasteners so that the hood can be moved forward or backward for alignment.




22. Lower hood into the locked position and align hood as shown (Q), tighten bolts (P), then raise hood and tighten bolts (O).
23. Reconnect electrical headlight connection.

**Torque Specifications:**

| | |
|---|---|
| **Muffler to Engine Nuts. . . . . . . .** | **24 N•m (216 lb-in.)** |
| **Muffler Bracket to Front Frame.** | **16 N•m (144 lb-in.)** |
| **Front Axle Pivot . . . . . . . . . . . . . . .** | **68 N•m (50 lb-ft)** |

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# SPECIFICATIONS

## 42 INCH REAR DISCHARGE MOWER DECK

| | |
|---|---|
| Overall Cutting Width | 107 cm (42 in.) |
| Cutting Height (12 Position) | 19 – 90 mm (0.75 – 3.5 in.) |
| Front to Rear Height Difference (Maximum) | 6 – 9 mm (0.24 – 0.35 in.) |
| Blade Indexing | 90° |
| Sheave Brake Wear Limit (Includes Backing Plate) | 5.0 mm (0.197 in.) |
| Spindle Lubrication | High Temperature EP grease |
| Brake Pad to Spindle Measurement (Mower Deck Set to Lowest Cut Height) | 1.5 – 2 mm (0.06 – 0.08 in.) |

## DRAWBAR LOAD

| | |
|---|---|
| Horizontal | 250 N (56 lb) |
| Vertical | 65 N (15 lb) |

## GRASS COLLECTION SYSTEM

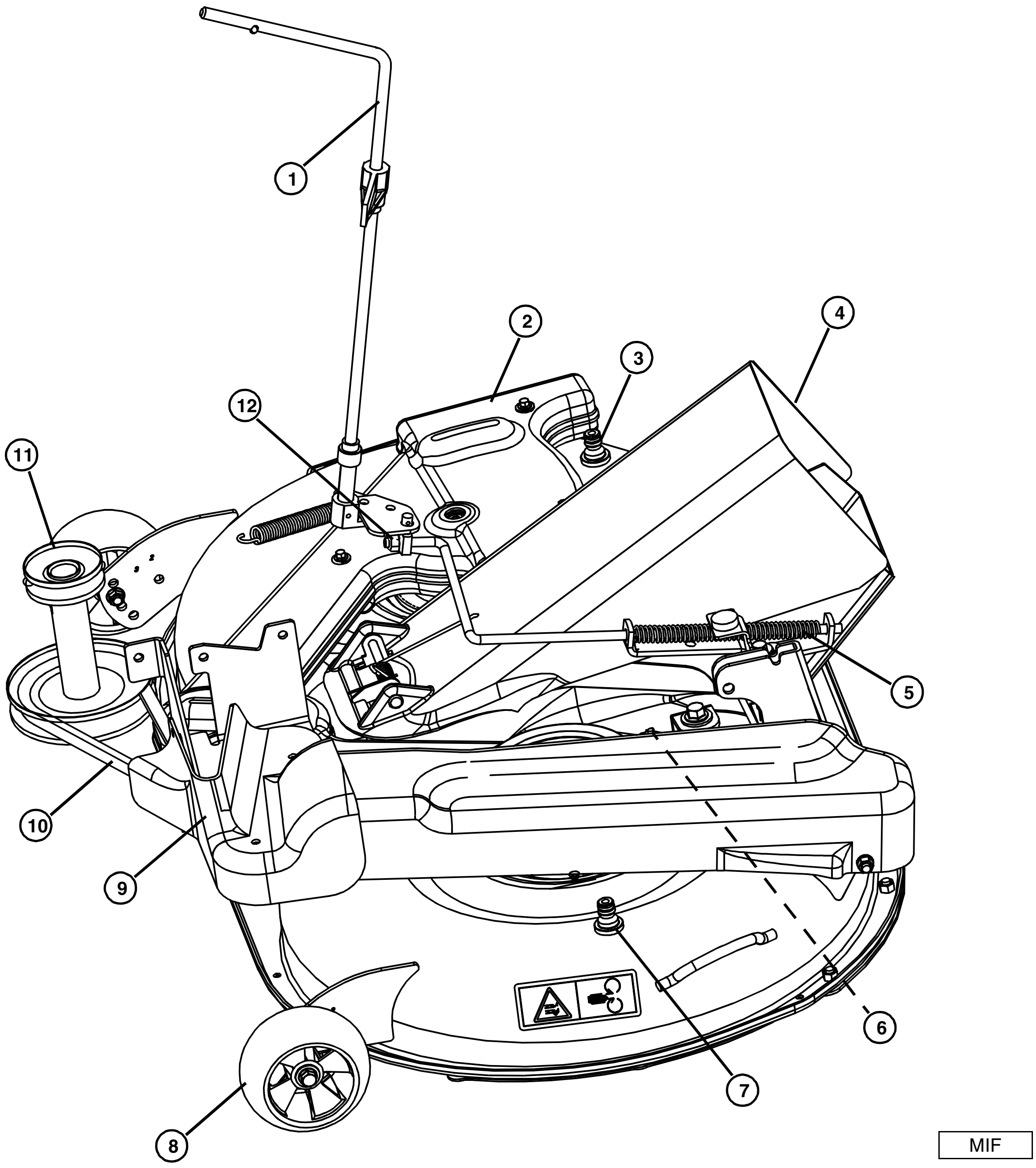
| | |
|---|---|
| Capacity | 0.3 $m^3$ (8.5 bu) |

## TORQUE SPECIFICATIONS (ALPHABETICAL)

| | |
|---|---|
| Blade Bolt Torque | 57 N•m (42 lb-ft) |
| Brake Assembly Lock Nuts | 16 N•m (144 lb-in.) |
| Brake Mounting Nuts | 16 N•m (144 lb-in.) |
| Drive Belt Idler Nuts | 30 N•m (22 lb-ft) |
| Drive Sprocket Nut | 145 N•m (107 lb-ft) |
| Gauge Wheels to Deck | 34 N•m (25 lb-ft) |
| Idler Nuts | 25 N•m (220 lb-in.) |
| Mower Blade Mounting Bolt | 57 N•m (42 lb-ft) |
| PTO Rod Lock Nut | 27 N•m (240 lb-in.) |
| Sheave Mounting Nut | 145 N•m (107 lb-ft) |
| Spindle Mounting Nuts | 27 N•m (240 lb-in.) |
| Spindle Nut | 145 N•m (107 lb-ft) |

# COMPONENT LOCATION

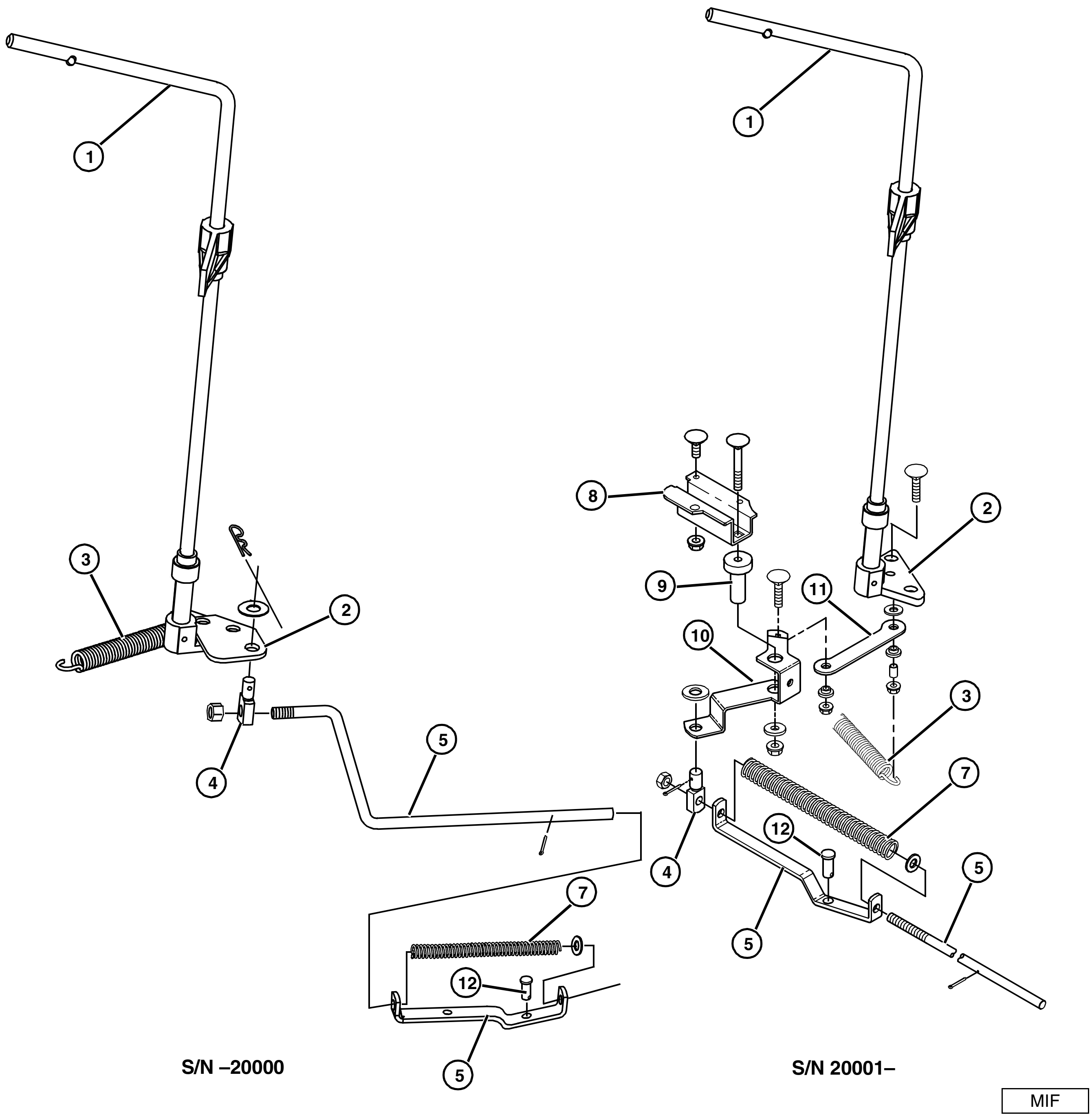
## MOWER DECK (S/N –020000)




| | | | |
|---|---|---|---|
| 1. PTO Lever | 2. Mower Belt Cover | 3. Hose Fitting | 4. Discharge Chute |
| 5. PTO Tension Spring | 6. Brake | 7. Hose Fitting | 8. Gage Wheel |
| 9. Drive Belt Cover | 10. Drive Belt | 11. Input Sheave | 12. PTO Tension Adjustment Nut |

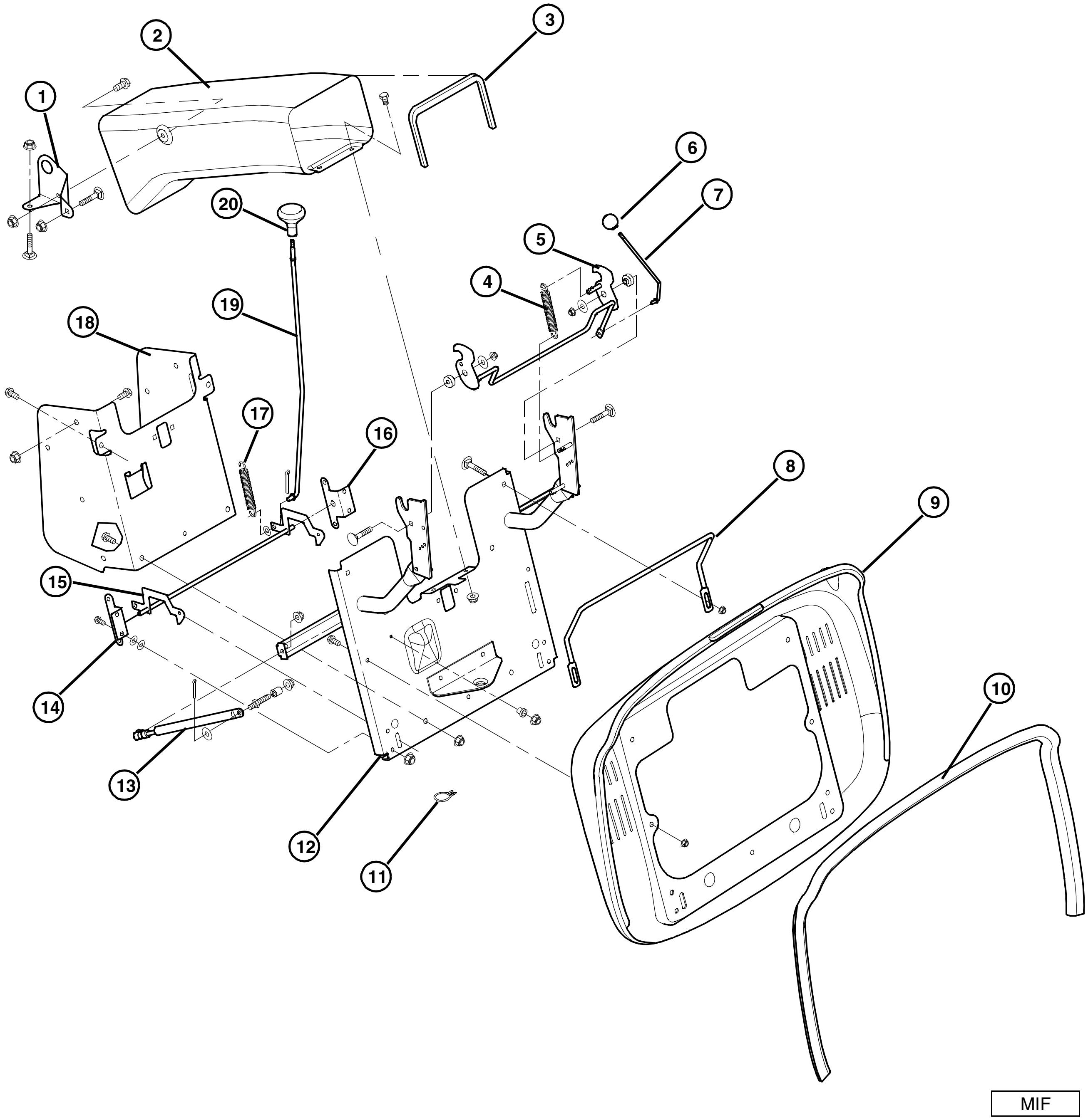
*NOTE: Change in belt tension rod and belt cover for S/N 020001–*

# MOWER DECK PTO LINKAGE



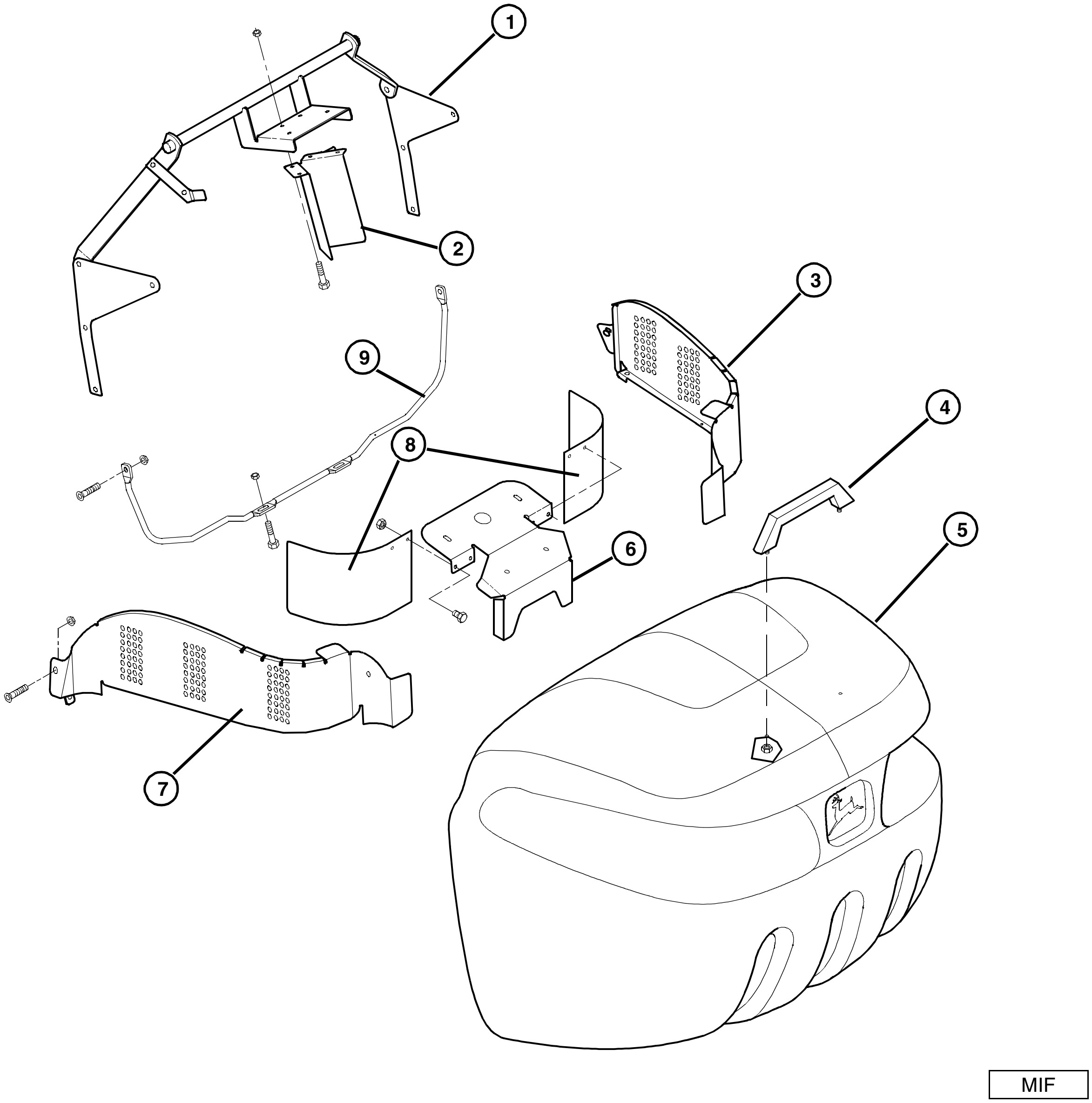

| | | | |
|---|---|---|---|
| 1. PTO Lever | 2. Arm | 3. Return Spring | 4. Rod End |
| 5. Strap | 6. Engagement Rod | 7. Tension Spring | 8. Bracket |
| 9. Bushing | 10. Bracket | 11. Connecting Strap | 12. Pin |

# GRASS COLLECTOR MOUNTING HARDWARE



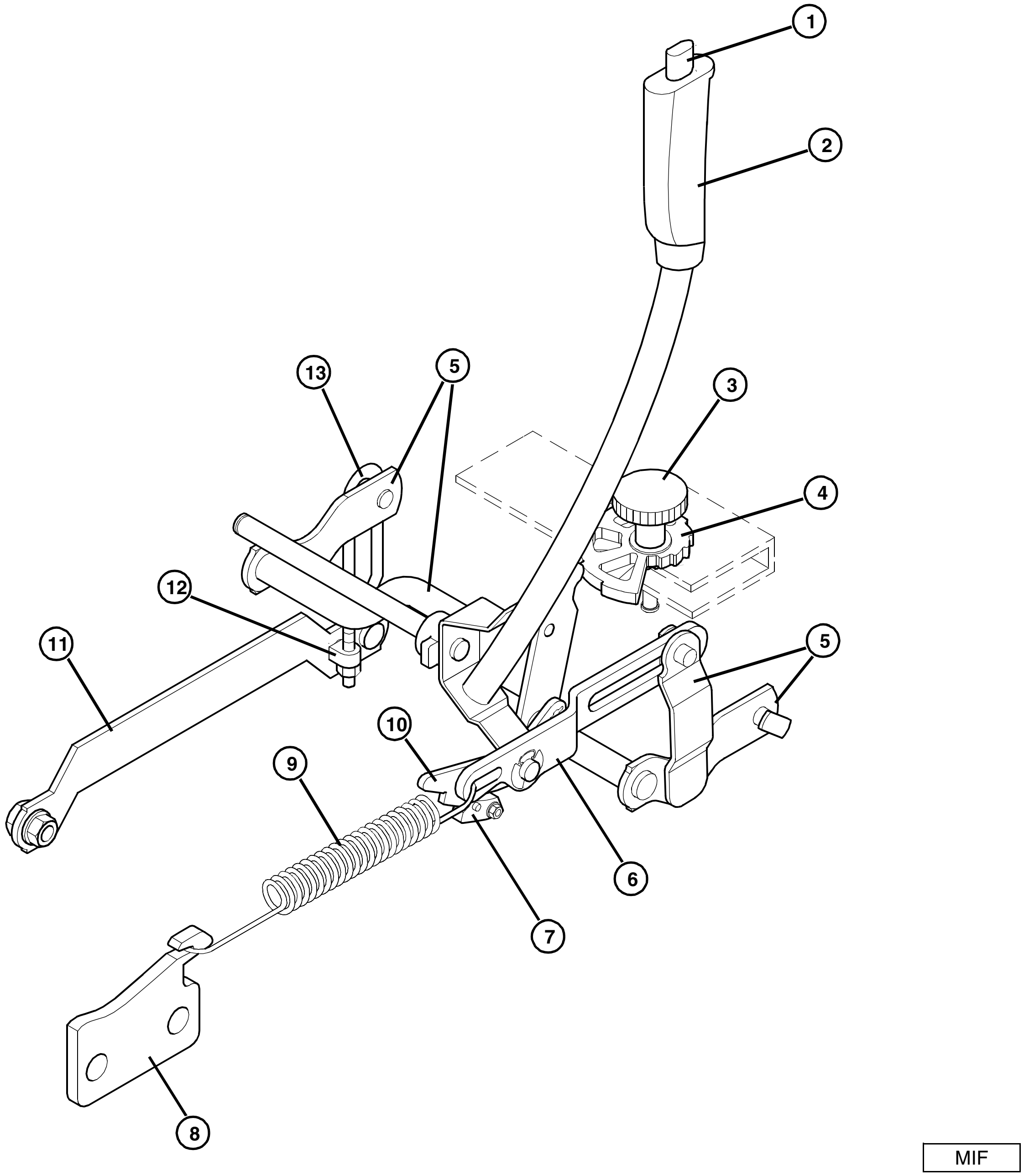

| | | | |
|---|---|---|---|
| 1. Bracket | 2. Chute | 3. Gasket | 4. Spring |
| 5. Latch | 6. Knob | 7. Rod | 8. Brace |
| 9. Front Cover | 10. Gasket | 11. Tie band | 12. Back plate assembly |
| 13. Gas cylinder (lift assembly) | 14. Bracket | 15. Latch | 16. Bracket |
| 17. Spring | 18. Bracket | 19. Rod | 20. Knob |

# GRASS COLLECTOR BUCKET



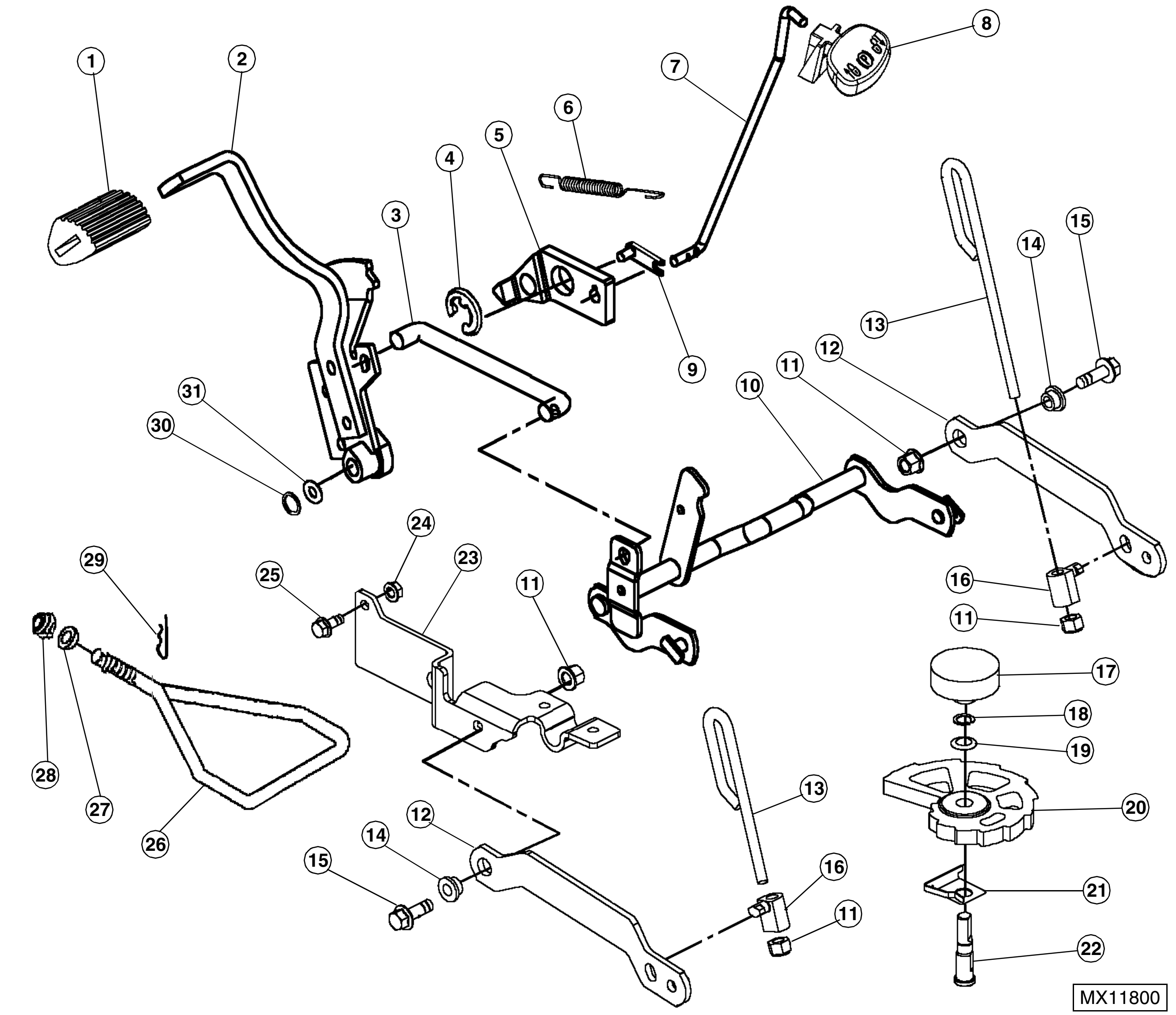

1. Bucket support
2. Flow divider
3. Vent screen
4. Lift handle
5. Bucket
6. Handle support
7. Vent screen
8. Guards
9. Lower support

# MOWER DECK LIFT LINKAGE—LTR155/166




1. Latch Release Button
2. Lift Handle
3. Depth Stop Knob
4. Depth Stop Cam
5. Lift Shaft Assembly
6. Lift Strap
7. Striker
8. Spring Anchor
9. Lift Assist Spring
10. Latch
11. Draft Arm (RH and LH)
12. Lift Link
13. Lift Rod

# MOWER DECK LIFT LINKAGE—LTR180




1. Pad
2. Lift Pedal
3. Lift Link
4. Snap Ring
5. Latch
6. Spring
7. Lift Lock Lever
8. Knob
9. Retainer
10. Lift Shaft
11. Lock Nut, M10
12. Rear Draft Arm
13. Adjustable Lift Rod
14. Bushing
15. Cap Screw, M10X30
16. Link
17. Lift Stop Knob
18. Snap Ring
19. Spring Washer
20. Cam
21. Spring
22. Pin
23. Bracket
24. Flange Nut (2 used)
25. Screw (2 used)
26. Front Draft Arm
27. Ball
28. Lock Nut
29. Pin
30. Snap Ring
31. Washer

# TROUBLESHOOTING

| Check or Solution / Problem or Symptom | Blades Will Not Drive | Belt slips | Belt Jumps Off Sheaves | Vibration | Blades Will Not Stop | Cutting Uneven or Striping | Right Blade Turns Left Blade Does Not |
|---|---|---|---|---|---|---|---|
| Engine Sheave | ● | ● | ● | ● | ● | | |
| Mower Drive Belt | ● | ● | ● | ● | ● | ● | |
| Pivot Idler | ● | ● | ● | ● | ● | | |
| Idlers | ● | ● | ● | ● | ● | | |
| Drive Sheave Brake Linkage | ● | ● | | ● | ● | | |
| Drive Sheave Brake | | | | | ● | | |
| PTO Linkage/Spring | ● | ● | ● | ● | ● | | |
| Spindle Sheaves | ● | ● | ● | ● | ● | ● | |
| Spindles | ● | ● | ● | ● | ● | ● | |
| Blades | | | | ● | | ● | |
| Mower Deck | | | | ● | | ● | |
| Engine | | | | ● | | ● | |
| Damaged Timing Belt | | | | | | | ● |

# DIAGNOSTICS

## BLADES WILL NOT ROTATE

**Test Conditions:**

- Machine Parked On Level Surface
- PTO Disengaged
- Park Brake Engaged
- Ignition Switch OFF

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Engine Sheave | Tight on crankshaft, key not damaged or sheared.<br>Belt guides in place, properly adjusted.<br>Belt on sheave.<br>Sheave angle matches belt angle/ sheave does not wobble when rotating. | Replace key and sheave assembly, tighten cap screw.<br>Replace/adjust as needed.<br>Install belt correctly.<br>Replace engine sheave. |
| 2. Mower Drive Belt | Not damaged, worn or broken.<br>Routed correctly. | Replace belt. (See “MOWER DRIVE BELT REMOVAL AND INSTALLATION—LTR155/166” on page 23.)<br>Reroute belt. |
| 3. Pivot Idler | Not damaged or binding.<br>Belt in place. | Repair or replace and adjust as needed. (See “MOWER DRIVE BELT REMOVAL AND INSTALLATION—LTR155/166” on page 23.) |
| 4. Fixed Idlers | Not damaged or binding.<br>Belt in place. | Repair or replace and adjust as needed. (See “MOWER DRIVE BELT REMOVAL AND INSTALLATION—LTR155/166” on page 23.) |
| 5. Brake Linkage | Not damaged, bent or binding.<br>Properly adjusted. | Replace brake linkage.<br>Adjust linkage. (See “BLADE BRAKE ADJUSTMENT” on page 19.) |
| 6. PTO Linkage/Spring | Not damaged, bent or binding.<br>Properly adjusted. | Replace PTO linkage/spring.<br>Adjust linkage. (See “MOWER DRIVE BELT TENSION ADJUSTMENT” on page 20.) |
| 7. Spindle Sprockets | Not damaged or binding.<br>Belt in place. | Replace spindle sprocket.<br>Install belt correctly. (See “MOWER DRIVE BELT REMOVAL AND INSTALLATION—LTR155/166” on page 23.) |
| 8. Spindles | Not damaged or binding.<br>Both blades turn. | Replace spindle(s). (See “SPINDLES REMOVAL AND INSTALLATION” on page 24.)<br>Replace timing belt. (See “MOWER BLADE TIMING BELT REMOVAL AND INSTALLATION” on page 26.) |

# DRIVE BELT SLIPS

**Test Conditions:**

- Machine Parked On Level Surface
- PTO Disengaged
- Park Brake Engaged
- Ignition Switch OFF

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Engine Sheave | Belt guides in place, properly adjusted.<br>Sheave angle matches belt angle/ sheave does not wobble when rotating. | Repair/adjust as needed.<br>Replace engine sheave. |
| 2. Mower Drive Belt | Not damaged, worn or broken.<br>Routed correctly. | Replace belt. (See “MOWER DRIVE BELT REMOVAL AND INSTALLATION—LTR155/166” on page 23.)<br>Reroute belt. |
| 3. Pivot Idler | Not damaged or binding.<br>Brakes release when PTO is engaged. | Repair or replace as needed.<br>Adjust as needed. Adjust PTO linkage. (See “BLADE BRAKE ADJUSTMENT” on page 19, and “MOWER DRIVE BELT TENSION ADJUSTMENT” on page 20.) |
| 4. Idlers | Not damaged or binding.<br>Belt in place. | Repair or replace as needed.<br>Reroute belt. |
| 5. Brake Linkage | Not damaged, bent or binding.<br>Properly adjusted. | Replace brake linkage.<br>Adjust brake linkage. (See “BLADE BRAKE ADJUSTMENT” on page 19.) |
| 6. PTO Linkage/Spring | Not damaged, bent or binding.<br>Properly adjusted.<br>PTO spring not weak. | Replace PTO linkage/spring.<br>Adjust PTO linkage. (See “MOWER DRIVE BELT TENSION ADJUSTMENT” on page 20.)<br>Replace spring. |
| 7. Spindle Sheaves | Not damaged or binding.<br>Belt in place. | Replace spindle sheaves.<br>Install belt correctly. |
| 8. Spindles | Not damaged or binding. | Replace spindles. (See “SPINDLES REMOVAL AND INSTALLATION” on page 24.) |
| 9. Mower Blades | Turn freely. | Remove obstruction (wire, lodged stick etc.). |

# DRIVE BELT WILL NOT STAY ON SHEAVES

**Test Conditions:**

- Machine Parked On Level Surface
- PTO Disengaged
- Park Brake Engaged
- Ignition Switch OFF

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Engine Sheave | Belt guides in place, properly adjusted.<br>Sheave angle matches belt angle/ sheave does not wobble when rotating. | Repair/adjust as needed.<br>Replace engine sheave. |
| 2. Mower Drive Belt | Not damaged, worn or broken.<br>Routed correctly. | Replace belt. (See “MOWER DRIVE BELT REMOVAL AND INSTALLATION—LTR155/166” on page 23.)<br>Reroute belt. |
| 3. Pivot Idler | Not damaged or binding.<br>Brakes release when PTO is engaged. | Repair or replace as needed.<br>Replace/adjust as needed. Adjust brake or primary drive belt tension. (See “BLADE BRAKE ADJUSTMENT” on page 19, and “MOWER DRIVE BELT TENSION ADJUSTMENT” on page 20.) |
| 4. Idlers | Not damaged or binding.<br>Belt in place. | Repair or replace as needed.<br>Reroute belt. |
| 5. PTO Linkage/Spring | Not damaged, bent or binding.<br>PTO spring not weak. | Replace PTO linkage as needed.<br>Replace spring. |
| 6. Spindle Sprockets/Sheaves | Not damaged or binding.<br>Belt in place. | Replace sprockets/sheaves/spindle as needed.<br>Install belt correctly. |
| 7. Spindles | Not damaged or binding. | Replace spindle. (See “SPINDLES REMOVAL AND INSTALLATION” on page 24.) |
| 8. Deck Height | 19 – 90 mm (.75 – 3.5 in.) cut height. | Adjust height to match depth stop on tractor. (See “DECK LEVELING” on page 16.) |

# VIBRATION

**Test Conditions:**

- Machine Parked On Level Surface
- PTO Disengaged
- Park Brake Engaged
- Ignition Switch OFF

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Engine Sheave | Belt guides in place, properly adjusted.<br>Sheave angle matches belt angle/ sheave does not wobble when rotating. | Repair/adjust belt guides as needed.<br>Replace engine sheave. |
| 2. Mower Drive Belt | Not damaged, worn or broken.<br>Routed correctly. | Replace belt.<br>Reroute belt. |
| 3. Pivot Idler | Not damaged or binding.<br>Brakes release when PTO is engaged. | Repair or replace as needed.<br>Replace/adjust as needed.<br>Adjust PTO linkage. |
| 4. Idlers | Not damaged or binding.<br>Belt in place. | Repair/replace as needed.<br>Reroute belt. |
| 5. Brake Linkage | Not damaged, bent or binding.<br>Properly adjusted. | Repair or replace and adjust brake.<br>Adjust brake. |
| 6. PTO Linkage/Spring | Not damaged, bent or binding.<br>Properly adjusted.<br>PTO spring not weak. | Repair/replace parts as needed.<br>Adjust PTO linkage (See “MOWER DRIVE BELT TENSION ADJUSTMENT” on page 20.).<br>Replace spring. |
| 7. Spindles/Sprockets | Not damaged or binding.<br>Belt in place. | Replace spindles and/or sprockets. (See “SPINDLES REMOVAL AND INSTALLATION” on page 24.)<br>Install belt correctly. |
| 8. Spindles | Not damaged or binding. | Replace. (See “SPINDLES REMOVAL AND INSTALLATION” on page 24.) |
| 9. Blades | Not damaged or bent.<br>Correctly sharpened.<br>Indexed properly. | Replace blades. (See “MOWER BLADE REMOVAL AND INSTALLATION” on page 30.)<br>Sharpen and balance.<br>Re-index. (See “MOWER BLADE TIMING BELT ADJUSTMENT” on page 17.) |
| 10. Mower Deck | Not damaged or bent. | Repair or replace as needed. |
| 11. Engine | Engine running at correct rpm. | Check engine adjustments and condition.<br>Inform operator that engine should be run at full throttle when mowing. |
| 12. Deck Timing Belt | Belt intact (no missing teeth). | Replace timing belt. (See “MOWER BLADE TIMING BELT REMOVAL AND INSTALLATION” on page 26.) |

# UNEVEN CUTTING OR STRIPING

**Test Conditions:**

- Machine Parked On Level Surface
- Park Brake Engaged
- PTO Disengaged
- Ignition Switch OFF

| Test/Check Point | Normal | If Not Normal |
|---|---|---|
| 1. Mower Drive Belt | Not slipping.<br>Installed properly.<br>Properly tensioned. | Check for correct belt.<br>Install belt correctly.<br>Inspect drive belt, replace as needed. Adjust PTO linkage. (See “MOWER DRIVE BELT TENSION ADJUSTMENT” on page 20.)<br><br>Check for worn, damaged, or loose engine sheave.<br>Check that blade brake is releasing. |
| 2. Engine Sheave | Sheave angle matches belt angle/ sheave does not wobble when rotating. | Replace engine sheave. |
| 3. PTO Linkage | In good condition, not worn, damaged, or binding.<br>PTO spring not weak or broken. | Repair/replace parts as needed.<br><br>Replace PTO spring. |
| 4. Spindle Sheaves | Not damaged or binding.<br>Belt in place. | Replace. (See “SPINDLES REMOVAL AND INSTALLATION” on page 24.)<br>Install belt correctly. |
| 5. Spindles | Not damaged or binding. | Replace. (See “SPINDLES REMOVAL AND INSTALLATION” on page 24.) |
| 6. Blades | Not damaged or bent.<br>Correctly sharpened. | Replace blades.<br>Sharpen and balance. |
| 7. Mower Deck | Not damaged or bent, mounting hardware tight.<br>Properly adjusted. | Replace or repair<br><br>Adjust as needed. (See “DECK LEVELING” on page 16.) |
| 8. Engine | Engine running at correct rpm. | Check engine adjustments and condition.<br>Inform operator that engine should be run at full throttle when mowing. |
| 9. Mowing Travel Speed | 1/2—2/3 transport speed. | Reduce mowing speed. |
| 10. Lawn Conditions | 15.24 cm (6 in.) tall grass or less. | Mow more frequently. |

# TESTS AND ADJUSTMENTS

## DECK LEVELING

**IMPORTANT: Always perform Primary Drive Belt Tension Adjustment after leveling deck.**

**Conditions:**

- PTO Disengaged
- Cutting Height Set to **64 mm (2.5 in.)**
- Tire Pressures Correct

**CAUTION**

**STOP engine, remove ignition key and wait for all moving parts to stop rotating.**

### Side-to-Side Leveling

**Procedure:**

1. Position machine on level surface.
2. Stop engine. Remove key. Wait for all moving parts to stop.
3. Check and set tire pressures to **83 kPa (12 psi)** front tires and **55 kPa (8 psi)** rear tires.

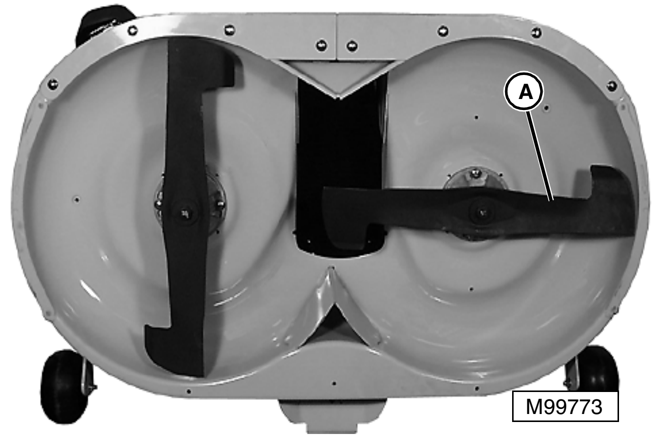
*NOTE: Mowing performance is acceptable when operating deck at extreme limits of tolerance. However, for optimum performance, operate deck at ideal setting specified.*

4. Adjust mower cutting height to **51mm (2 in.)**.
5. Shake deck slightly to ensure deck has settled out on hangers.

**CAUTION**

**Blades are sharp and could cause personal injury. Wear gloves or wrap blade with rag when removing/installing blades. DO NOT hold blade with bare hands.**

6. Turn left blade parallel to axle to measure left outside blade tip.
7. Using a TY15272 Blade Height Gauge or other suitable measuring tool, measure height of outside tip of left blade.



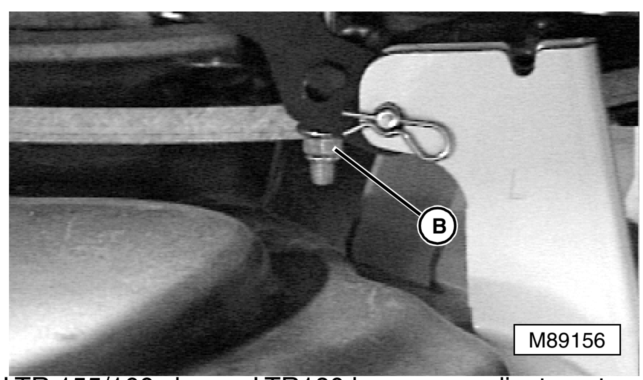

8. Rotate blades **90°** so that right blade (A) is parallel to axle as shown. Then measure right outer blade tip. The difference between measurements must be within specification.

**Specifications:**

**Side-to-side height difference (maximum) . . . . . . . . . . . . . . . . . . . . . . . . . . . 3.0 mm (0.12 in.)**

**Results:**

If the difference in measurements exceeds the specification, turn adjusting nut(s).




LTR 155/166 shown; LTR180 has same adjustment nut

**Adjustment:**

1. Lower or raise one side of the deck by turning adjusting nut (B) at rear hanger.

*NOTE: Adjustable lift links are on both sides of the mower. Cutting height can be made to closely match knob setting by adjusting these lift links. DO NOT adjust deck too high or it will not lock in the full up (TRANSPORT) position.*

2. Turn lock nuts (on both sides of mower deck) until blade tip heights closely match set mower cutting height.

**Front-to-Rear Leveling**

1. Rotate right blade so blade tip faces straight forward.
2. Measure height of blade tips at front and rear of blade.

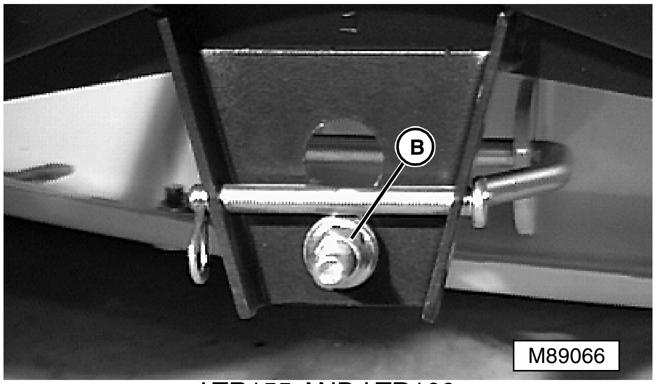
**Results:**

If the difference in measurements does not meet specification, adjust lock nut on front draft rod.

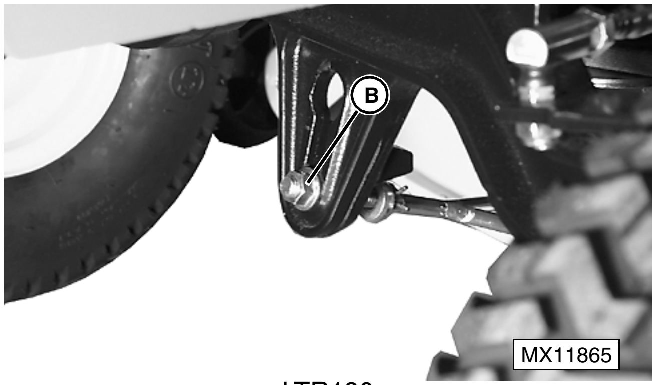
**Specification:**

**Rear blade tip higher than front blade tip . . . . . . . . . . . . . . . . . . . . 6 – 9 mm (0.24 – 0.35 in.)**

**Adjustment:**




LTR155 AND LTR166




LTR180

1. Adjust the height by tightening or loosening the front draft rod nut (C) until blade tip measurement difference meets specification.

*NOTE: DO NOT adjust deck too high or it will not lock in the transport (RAISED) position.*

2. Drive belt tension may be affected by adjusting front draft rod. (See “MOWER DRIVE BELT TENSION ADJUSTMENT” on page 20.)

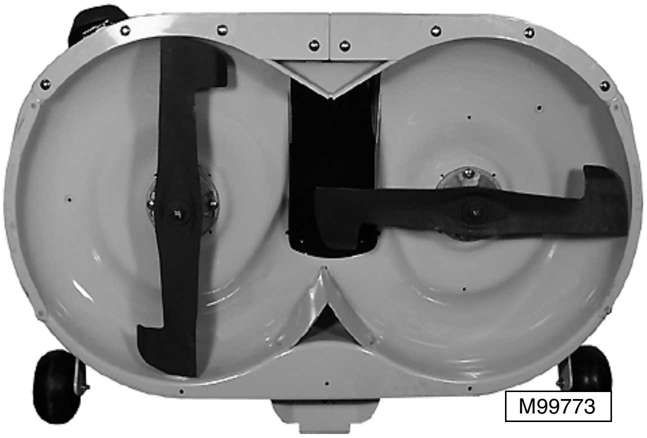
## MOWER BLADE TIMING BELT ADJUSTMENT

**Procedure:**

1. Park vehicle safely.

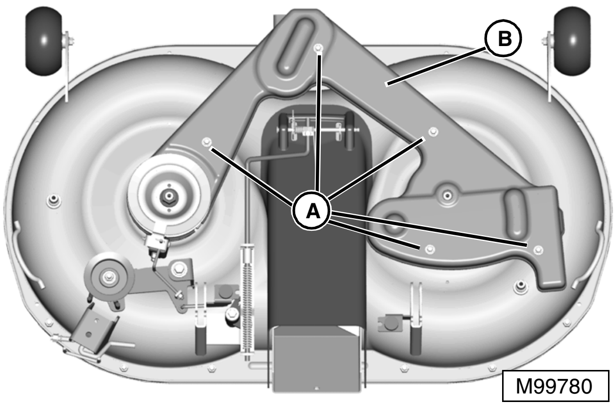
**IMPORTANT: Tension on the timing belt should be adjusted after a major blade impact to avoid belt or blade damage.**

2. Remove mower deck.

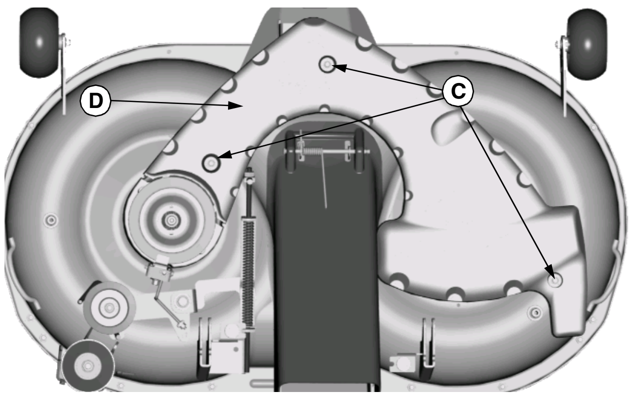



**IMPORTANT: If blades are not 90° apart as shown, belt damage may have occurred. Replace timing belt. (See “MOWER BLADE TIMING BELT REMOVAL AND INSTALLATION” on page 26.)**

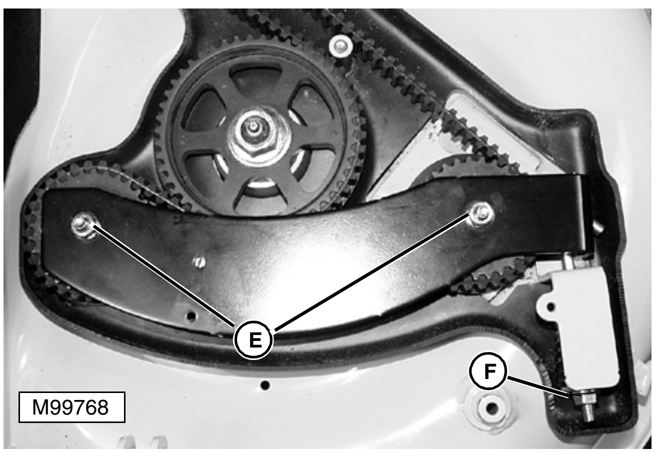
3. Position mower blades 90° from each other as shown.



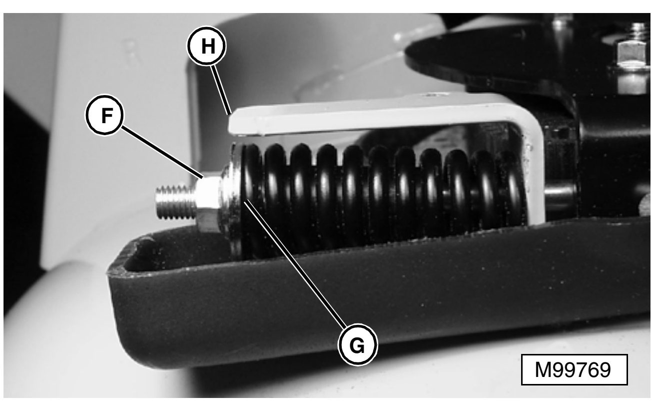

4. (S/N –020000) Remove five cap screws and washers (A) and move cover (B) aside to gain access for adjustment.



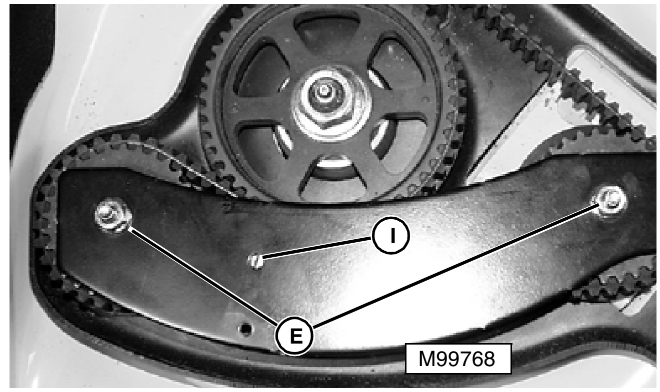

5. (S/N 020001– ) Remove three cap screws (C) and washers and remove cover (D).



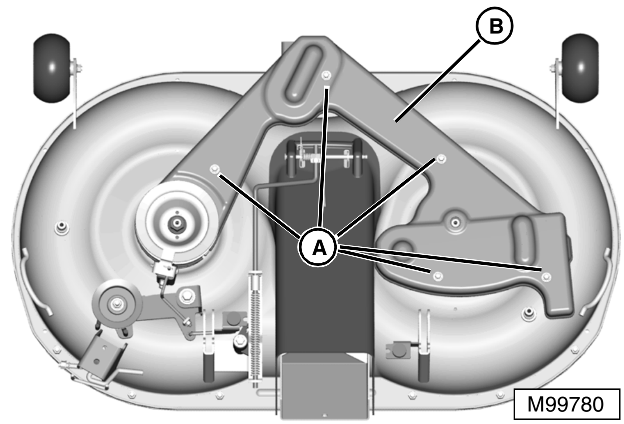

6. Loosen two idler nuts (E) and finger tighten.

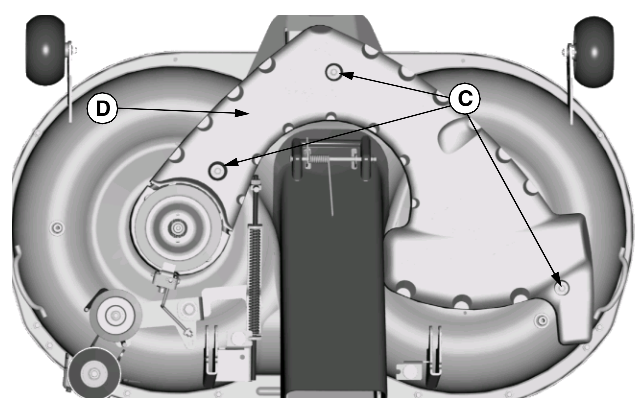



7. Rotate adjusting nut (F) clockwise until end of tensioning spring (G) aligns with end of tensioner assembly bracket (H).
8. Turn blades several rotations and observe that belt is riding properly in sprockets and idlers.




9. Place a screwdriver in slot (I) in top of belt guide, and rotate belt guide clockwise until guide contacts belt. Rotate belt guide counterclockwise 1/8 turn (45°).
10. Tighten idler nuts (E) to **25 N•m (220 lb-in.)**.




11. Move cover (B or D) over timing belt and fasten with five cap screws.
12. Install mower deck.
13. Check that PTO rod properly engages and disengages mower drive. Adjust as needed. (See "MOWER DRIVE BELT TENSION ADJUSTMENT" on page 20.)

# BLADE BRAKE ADJUSTMENT

**Reason:**

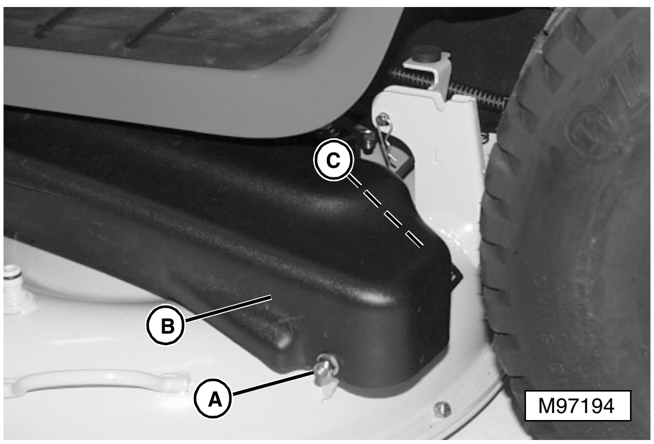
To ensure that brake pad engages and stops mower blades when the PTO is disengaged, and that brake pad does not contact sheave (drag) with PTO engaged.

**Procedure:**

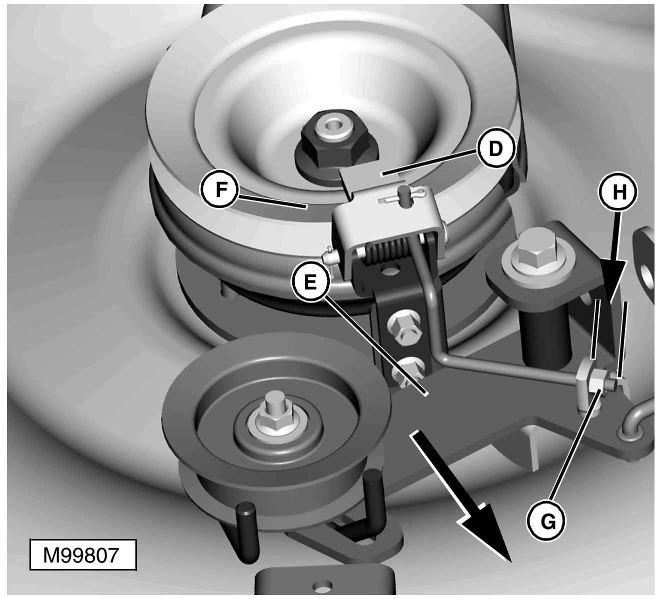
## ⚠ CAUTION

**Sheave brake engagement must be checked and adjusted every time the belt tension is adjusted. Belt tension should be adjusted before brake adjustment is performed.**

1. Park machine safely.
2. Raise mower deck to full UP (transport) position.
3. Set cutting height control to lowest setting (19 mm).
4. Lower mower deck.




5. Remove lock nut and washer (A). Spread cover and remove drive belt cover (B) from pin and stud (C). Slide belt cover rearward and remove from left side of mower deck.
6. Place PTO lever in ON (engaged) position.
7. Check that mower drive belt tension is adjusted correctly. (See “MOWER DRIVE BELT TENSION ADJUSTMENT” on page 20.)




8. Inspect brake pad (D). Thickness of the pad (including the backing plate) should measure **5.0 mm (0.197 in.)** minimum. If less than specification, replace brake. (See “BLADE BRAKE REMOVAL AND INSTALLATION” on page 29.)
9. Manually pull idler arm (E) rearward (arrow) to properly tension drive belt.
10. Measure the minimum distance from brake pad to spindle sheave (F). Set gap to specification:
   - Turn adjusting nut (G) clockwise to move brake pad away from spindle (H).
   - Turn adjusting nut counterclockwise to move brake pad toward spindle.

**Specification:**

**Brake Pad to Spindle Sheave Gap**
**. . . . . . . . . . . . . . . . . 1.5 – 2.0 mm (0.06 – 0.08 in.)**

11. Raise mower deck to full UP (transport) position.
12. Check to ensure that brake pad does not contact sheave. Adjust as needed.

# MOWER DRIVE BELT TENSION ADJUSTMENT

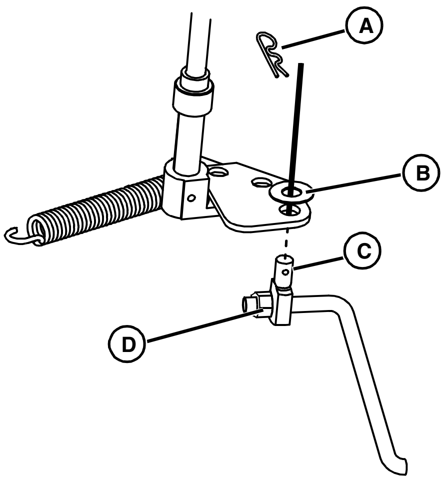
**IMPORTANT: Blade brake adjustment must be checked every time the belt tension is adjusted. Perform brake adjustment after belt tension adjustment.**

**Conditions:**

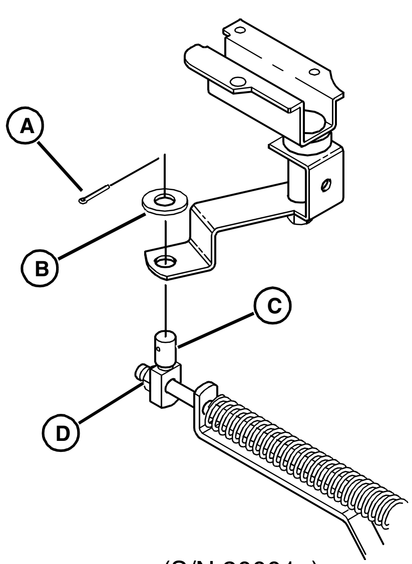
- PTO Disengaged
- Drive Belt in Good Condition
- Cutting Height Set to **19 mm (0.75 in.)**
- Deck Lowered to MOW Position

**Procedure:**

1. Park machine safely.
2. Place PTO lever in OFF (Disengaged) position.




(S/N –20000)

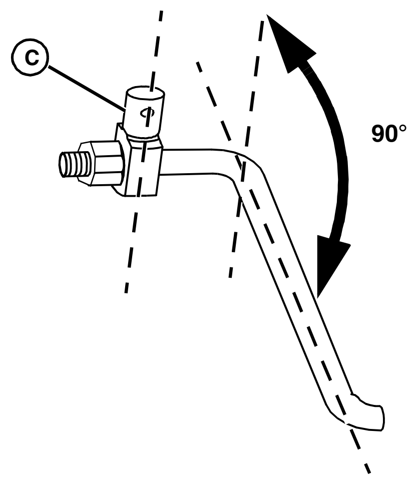



(S/N 20001–)

3. Remove locking pin (A) and washer (B) from rod end (C).
4. Disconnect PTO rod from linkage.
5. Check to see if rod end (C) lines up with hole in PTO arm. If rod end lines up perfectly with hole: Skip to Step 9.

**IMPORTANT: Do not attempt to loosen jam nut (D) on PTO rod without using a suitable wrench to hold link (C).**

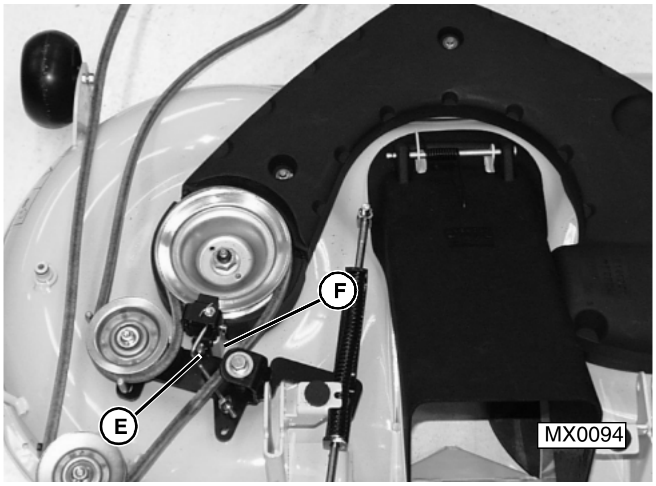
6. Loosen jam nut (D) and rotate rod end until pin slides into PTO lever hole easily.




7. (S/N –20000 Only): Adjust rod end (C) so that pin (E) is 90° to bend in rod.

**IMPORTANT: DO NOT tighten jam nut with PTO rod attached to tractor. Damage to machine may occur.**

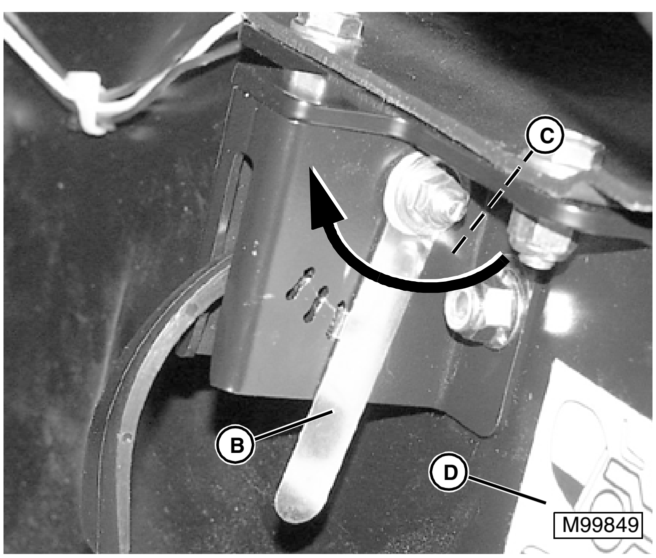
8. Securely hold rod end and tighten jam nut (D) to **27 N•m (20 lb–ft)**.
9. Install link pin (C) into hole in PTO arm. Retain with washer (B) and locking pin (A).

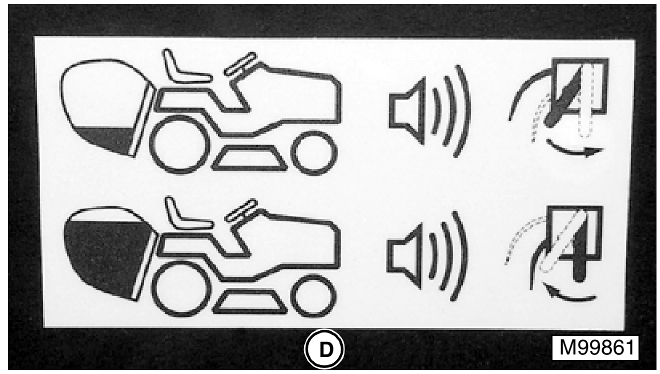


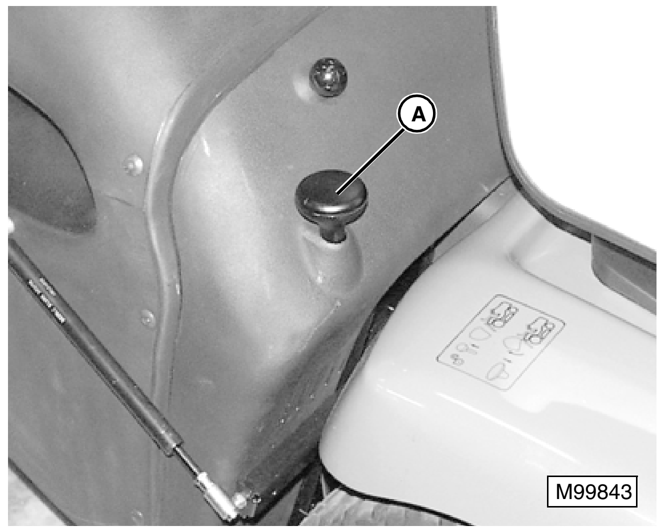

10. Make sure that the arm of the flat idler tensioning bellcrank assembly (E) is up against its stop (F).
   - If it is against the stop, adjustment is correct.
   - If it is not against the stop, disconnect engagement rod, loosen jam nut (D) and turn rod end (C) counterclockwise, looking from the end of the rod, one revolution at a time until it does contact the stop.
11. Perform blade brake adjustment. (See “BLADE BRAKE ADJUSTMENT” on page 19.)

## FILL SENSOR ADJUSTMENT

1. Park tractor on a hard, smooth surface. Stop engine, remove key, wait for all moving parts to STOP.




2. Push down on knob (A) to open grass collector bucket.
3. Pull out and turn adjuster handle (B) to adjust fill sensor switch (C):
   - Move handle clockwise (arrow) to LOWER the level of grass required to turn alarm ON.
   - Move handle counter-clockwise to RAISE the level of grass required to turn alarm ON.

Use label (D) on inside of bucket to aid in adjustment.

**Results:**

Alarm should sound when bucket is filled to optimal level. Discharge chute should not become clogged.

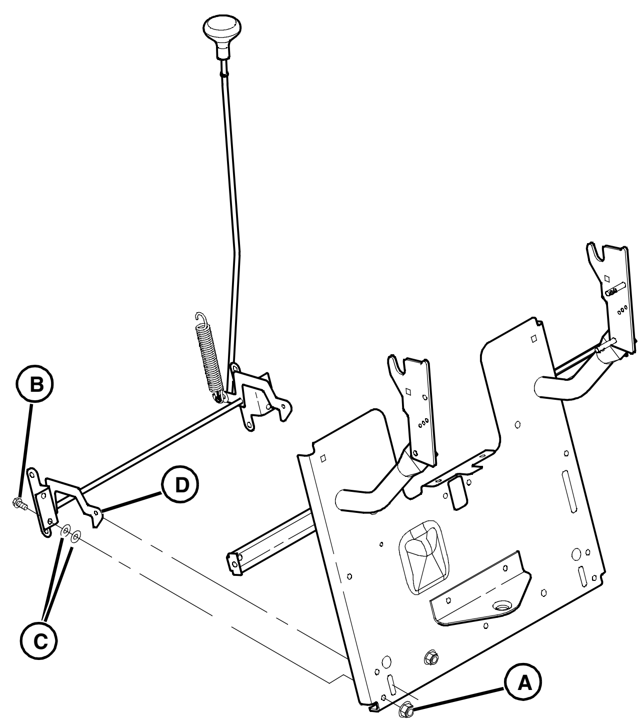
# GRASS COLLECTOR LATCHING ADJUSTMENT

**Purpose:**

To set correct gap at bottom of grass collector to ensure grass catcher closes and latches securely.

**Procedure:**

1. Park tractor on a hard, smooth surface. Stop engine, remove key, wait for all moving parts to STOP.
2. Open grass collector bucket.




3. Remove nut (A) and cap screw (B).

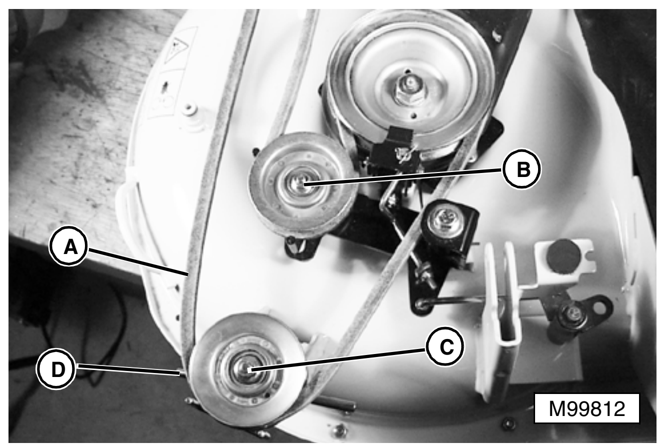
NOTE: *If grass collector bucket is hard to latch, latching arm (D) needs to be extended past plate to catch bucket front cover more easily.*

4. To adjust latching:
 • Add washer(s) (C) to pull in latching arm (D) and tighten latch and sealing capability.
 • Remove washer(s) (C) to extend latching arm (D) and loosen latch and sealing capability.

# REPAIR

## MOWER DECK REMOVAL AND INSTALLATION—LTR155/166

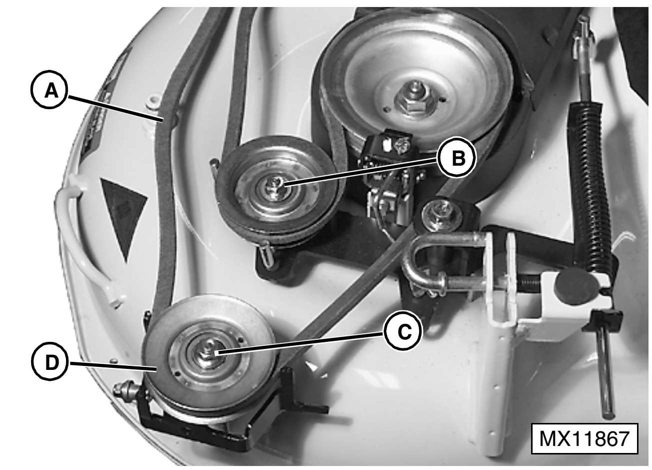
1. Park tractor on a hard, smooth surface. Stop engine, remove key, wait for all moving parts to STOP.
2. Adjust the mower cutting height to **25 mm (1.0 in.)**.
3. Place wood blocks under each side of the mower deck. Lower deck to the MOWING position, resting the deck on the wood blocks.
4. Remove the spring pin from the front draft arm. Remove the front draft arm from the mower deck.
5. Remove the spring pin and washer from the adjustment pin on the end of the mower engagement rod. Separate the adjustment pin from the mower engagement bracket.
6. Pull and rotate the J-pin fasteners on each side of the mower deck. Release the rear draft arms from the deck brackets.
7. Remove the drive belt cover from the left side of the mower deck.



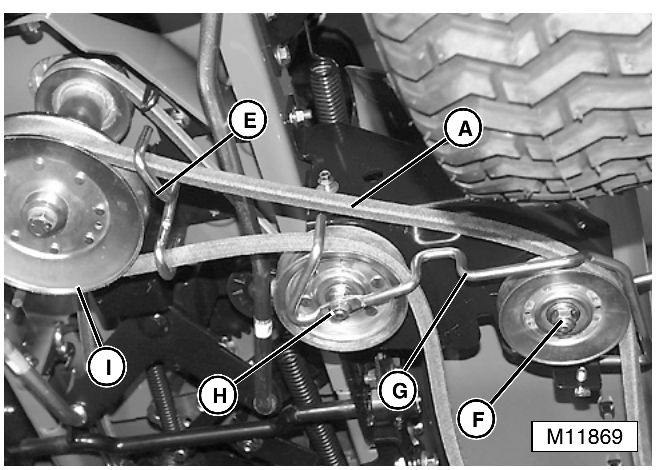

8. Loosen nut (C) on idler sheave and nut (B) on flat idler.
9. Remove mower drive belt (A) from the mower deck.
10. Push the deck forward slightly to disconnect the mower discharge chute from the rear of the machine. Press down on the discharge chute. Remove mower deck.
11. Inspect belt for wear or damage. Replace as necessary.
12. Install belt in reverse order. Use photo to ensure proper belt routing.
13. Rotate belt guide on sheave (D) until edge of rod is aligned with edges of bracket.
14. Tighten nuts (A) and (B).
15. Install mower deck.
16. Adjust mower engagement if necessary. (See “MOWER DRIVE BELT TENSION ADJUSTMENT” on page 20.)

# MOWER DECK REMOVAL AND INSTALLATION—LTR180

1. Park tractor on a hard, smooth surface. Stop engine, remove key, wait for all moving parts to STOP.
2. Adjust the mower cutting height to **25 mm (1.0 in.)**.
3. Place wood blocks under each side of the mower deck. Lower deck to the MOWING position, resting the deck on the wood blocks.
4. Remove the spring pin from the front draft arm. Remove the front draft arm from the mower deck.
5. Remove the spring pin and washer from the adjustment pin on the end of the mower engagement rod. Separate the adjustment pin from the mower engagement bracket.
6. Pull and rotate the J-pin fasteners on each side of the mower deck. Release the rear draft arms from the deck brackets.
7. Remove the drive belt cover from the left side of the mower deck.



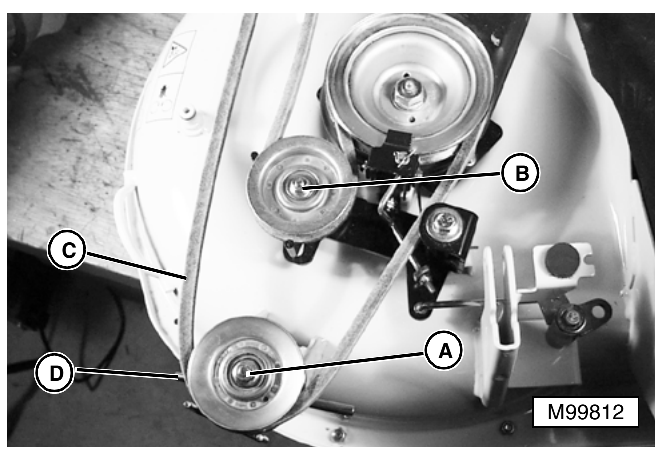

8. Loosen nut (C) on idler sheave and nut (B) on flat idler.
9. Remove mower drive belt (A) from around the belt guides, idlers and drive sheave of mower deck.




10. Loosen nut (F) on V-idler and nut (H) on flat idler, and remove belt (A) from around idlers and belt guide (G).
11. Remove belt from around belt guide (E) and engine drive sheave (I).
12. Push the deck forward slightly to disconnect the mower discharge chute from the rear of the machine. Press down on the discharge chute. Remove mower deck.
13. Inspect belt for wear or damage. Replace as necessary.
14. Install belt in reverse order. Use photo to ensure proper belt routing.
15. Guide belt (A) around engine sheave (I) and belt guide (E).
16. Guide belt around belt guide (G) and idlers and tighten nuts (H and F).
17. Rotate belt guide on sheave (D) until edge of rod is aligned with edges of bracket.
18. Tighten nuts (B) and (C).
19. Attach front draft arm to mower deck and install spring pin to end of draft arm.
20. Install the drive belt cover to the left side of the mower deck.
21. Install the adjustment pin to the mower engagement bracket and secure with washer and spring pin.
22. Pull and rotate the J-pin fasteners on each side of the mower deck. Raise mower deck and allow the J-Pin fasteners to release into position into the deck brackets.
23. Install mower deck.
24. Adjust mower engagement if necessary. (See “MOWER DRIVE BELT TENSION ADJUSTMENT” on page 20.)

# MOWER DRIVE BELT REMOVAL AND INSTALLATION—LTR155/166

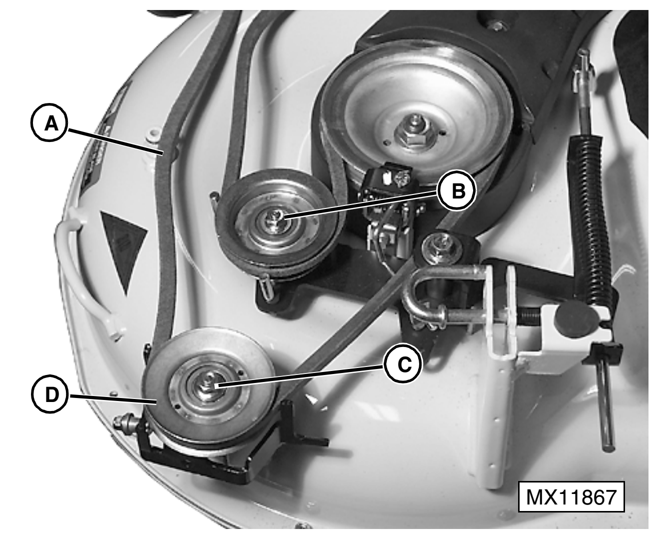
1. Park tractor on a hard, smooth surface. Stop engine, remove key, wait for all moving parts to STOP.
2. Remove mower deck.



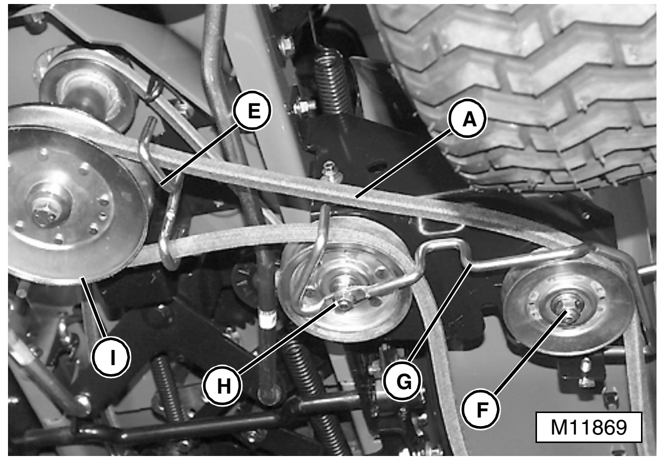
3. Loosen nut (A) on idler sheave and nut (B) on flat idler.
4. Remove mower drive belt (C).
5. Inspect belt for wear or damage and replace as necessary.
6. Install belt in reverse order. Use photo to ensure proper belt routing.
7. Rotate belt guide on sheave (D) until edge of rod is aligned with edges of bracket.
8. Tighten nuts (A) and (B).
9. Install mower deck.
10. Adjust mower engagement if necessary. (See “MOWER DRIVE BELT TENSION ADJUSTMENT” on page 20.)

## MOWER DRIVE BELT REMOVAL AND INSTALLATION—LTR180

1. Park tractor on a hard, smooth surface. Stop engine, remove key, wait for all moving parts to STOP.
2. Remove mower deck.
3. Remove the drive belt cover from the left side of the mower deck.




4. Loosen nut (C) on idler sheave and nut (B) on flat idler.
5. Remove mower drive belt (A) from around the belt guides, idlers and drive sheave of mower deck.

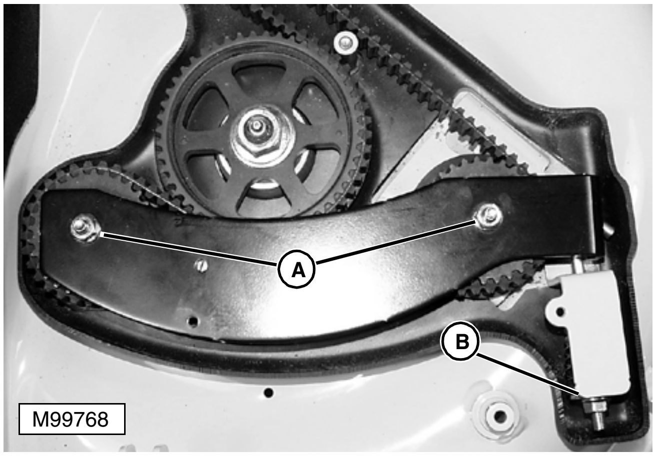



6. Loosen nut (F) on V-idler and nut (H) on flat idler, and remove belt (A) from around idlers and belt guide (G).
7. Remove belt from around belt guide (E) and engine drive sheave (I).
8. Push the deck forward slightly to disconnect the mower discharge chute from the rear of the machine. Press down on the discharge chute. Remove mower deck.
9. Inspect belt for wear or damage. Replace as necessary.
10. Install belt in reverse order. Use photo to ensure proper belt routing.
11. Guide belt (A) around engine sheave (I) and belt guide (E).
12. Guide belt around belt guide (G) and idlers and tighten nuts (H and F).
13. Rotate belt guide on sheave (D) until edge of rod is aligned with edges of bracket.
14. Tighten nuts (B) and (C).
15. Install mower deck.
16. Adjust mower engagement if necessary. (See “MOWER DRIVE BELT TENSION ADJUSTMENT” on page 20.)

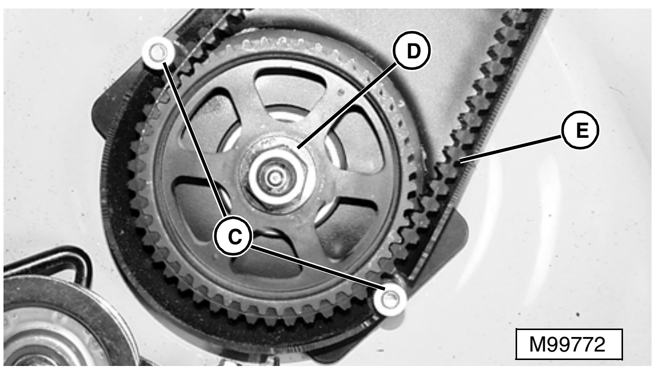
## SPINDLES REMOVAL AND INSTALLATION

**Removal:**

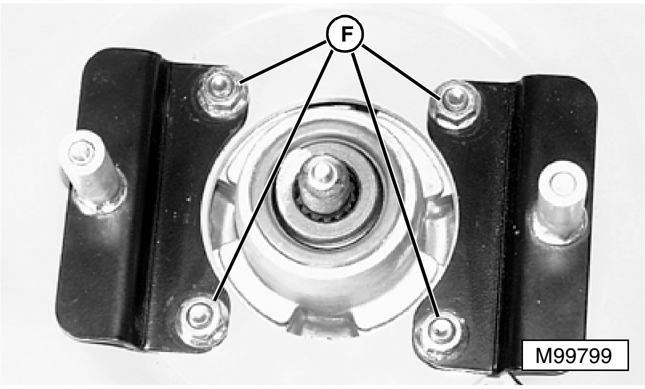
1. Remove mower deck.
2. Support blade for spindle being repaired.
3. Remove brake, drive sheave and top cover.



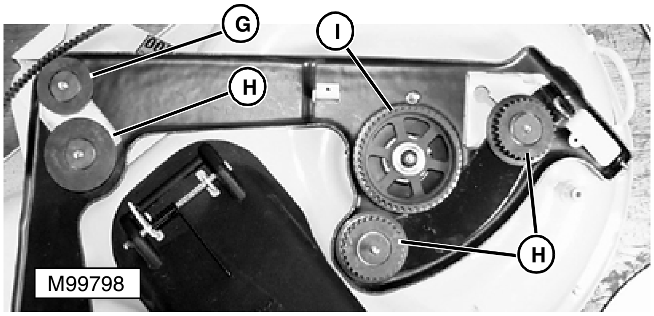

4. To access right spindle loosen idler nuts (A), and remove tensioning nut and washer (B).




5. With tension released, remove belt keepers (C).
6. Remove right drive sprocket nut (D), drive sprocket and timing belt (E).

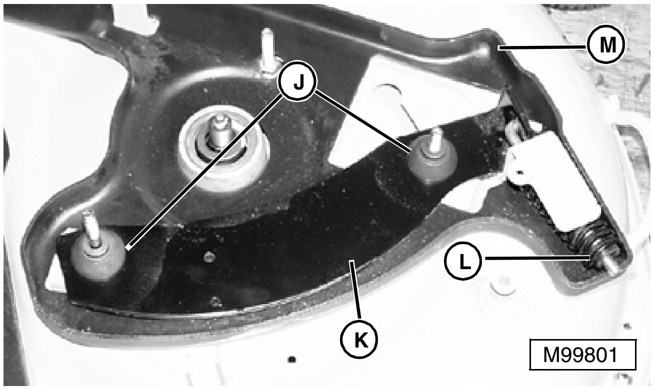



7. Lift and rotate bottom cover to access spindle mounting cap screws and nuts (F).
8. Remove timing belt to access right spindle. (See "MOWER BLADE TIMING BELT REMOVAL AND INSTALLATION" on page 26.)

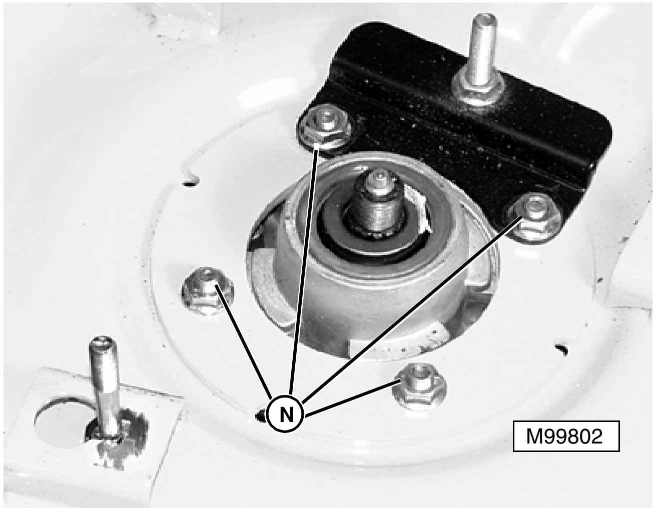



9. Remove pulley with bushing (G), sprockets with bushings (H and right drive sprocket (I).

*NOTE: Spindle shaft may fall out when sprocket is removed.*

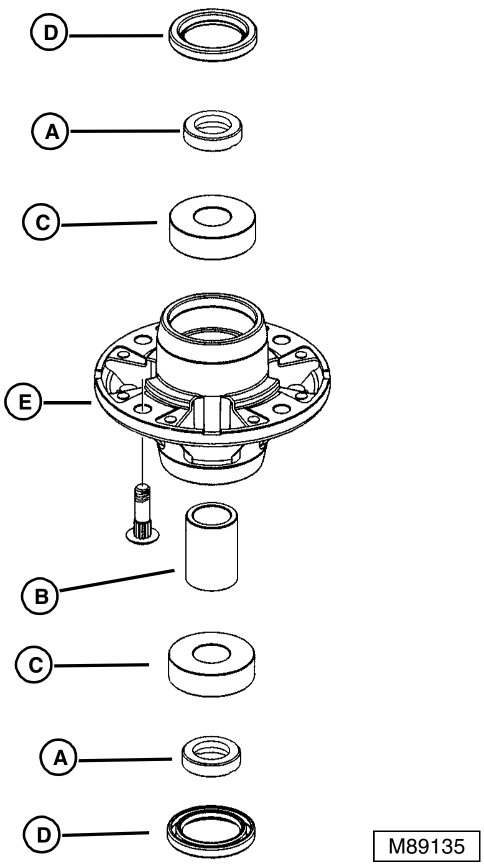



10. Remove bushings (J), lower idler arm (K), tension control spring assembly (L) and bottom of belt cover (M).




11. Remove four spindle mounting cap screws and nuts (N). Remove spindle.

**Spindle Disassembly and Assembly:**




1. Remove both seal bushings (A). Note that the notch is on the bottom side of the bushing.
2. Use a screwdriver to push the spacer (B) to one side and use a drift punch and a hammer to tap out the bearings (C) and seals (D) evenly.
3. Clean spindle housing (E) with a suitable solvent and inspect housing for damage.
4. Fill spindle cavity and pack new bearings with GREASE-GARD® or equivalent.
5. Press upper bearing in against shoulder first.
6. Install spacer and press in bottom bearing.
7. Lubricate seal lips with grease. Install seals with seal lips facing bearings.
8. Install seal bushings ensuring **notch is down**.

**Installation:**

Installation is the reverse order of removal.

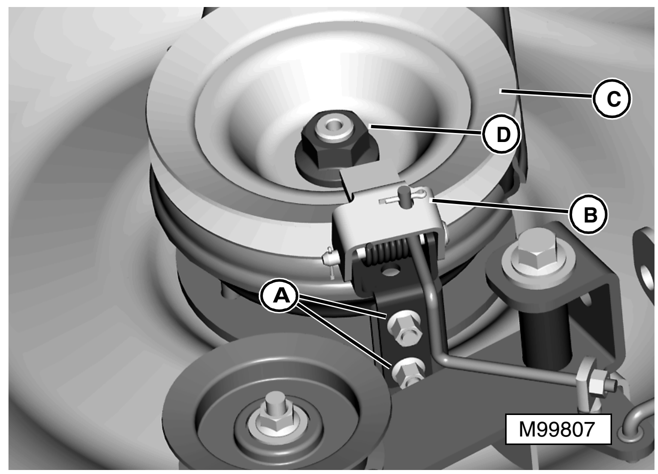
**IMPORTANT: If the threads on a mounting bolt have been damaged, it can be replaced with a nut and bolt. Ensure that the area around the bolt to be pressed out is supported from underneath to prevent the spindle mounting flange from being damaged.**

- Align inside diameter of all components to allow spindle shaft installation.
- Tighten spindle attaching nuts to **27 N•m (20 lb-ft)**.
- Tighten drive sprocket nut to **145 N•m (107 lb-ft)**.

## MOWER BLADE TIMING BELT REMOVAL AND INSTALLATION

**Procedure:**

1. Remove mower deck.
2. Remove drive belt. (See “MOWER DRIVE BELT REMOVAL AND INSTALLATION—LTR155/166” on page 23.)

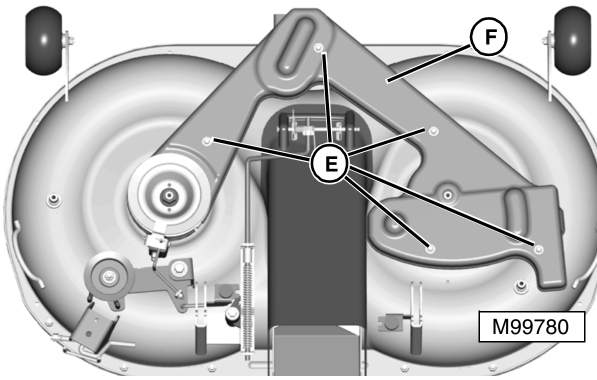



3. Remove two bolts and locknuts (A), and remove brake (B) from drive sheave (C).

**CAUTION**

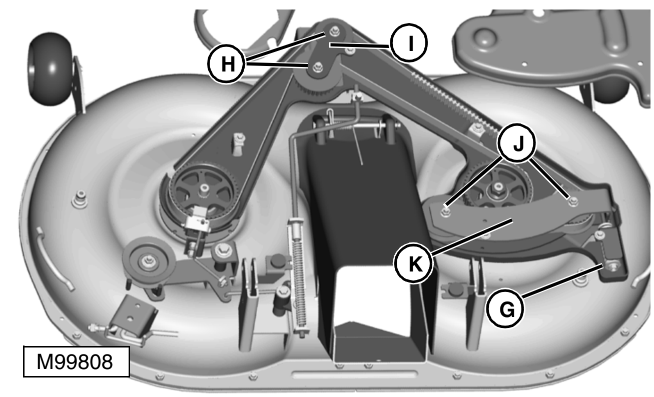
**SHARP EDGES. Wear gloves or wrap blade with a rag when removing/installing blades to reduce the risk of personal injury. DO NOT hold blade with bare hands.**

4. Using a wood block to prevent mower blades from turning, remove nut (D) and drive sheave (C).
5. Place nut (D) back on spindle after sheave is removed and hand tighten to prevent spindle shaft from falling to floor.

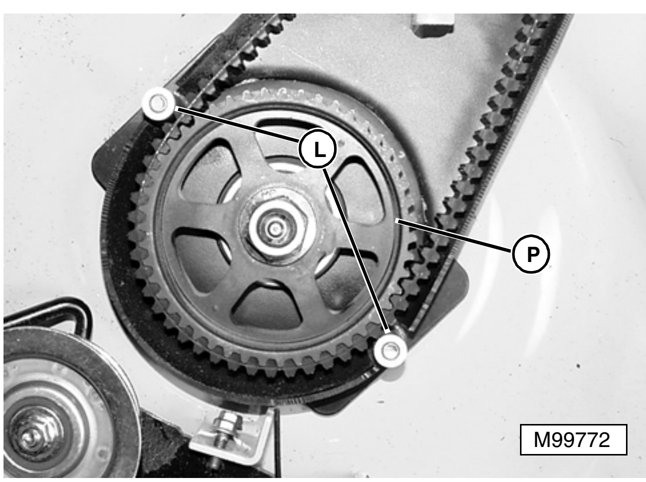



NOTE: (S/N –020000) shown; (S/N 020001 –) has only three (3) cap screws (E) to remove cover (F).

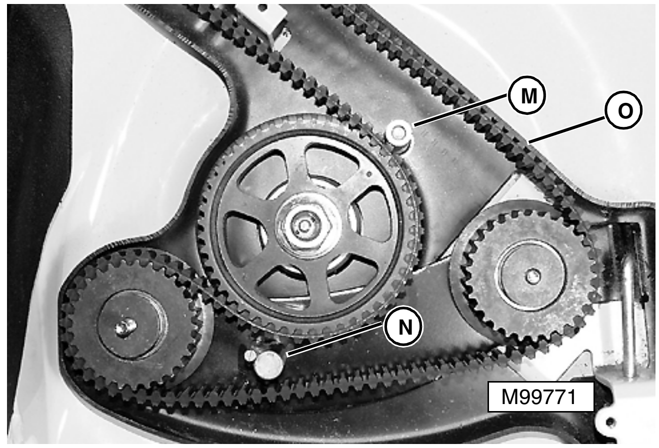
6. Remove five cap screws and washers (E) and remove cover (F).




7. Remove adjusting nut (G).
8. Remove two nuts (H) and bracket (I).
9. Remove two idler nuts (J) and upper idler arm (K).



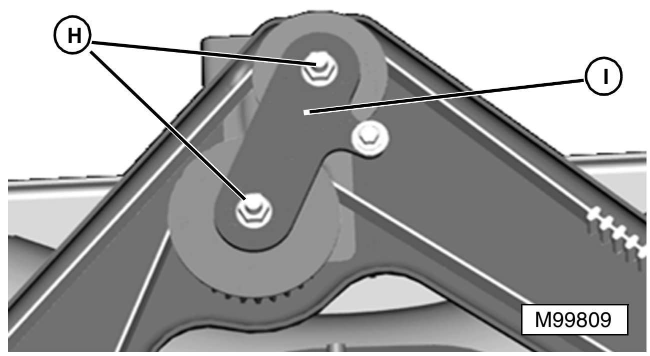

10. Remove two belt keepers (L) from left sprocket (P).



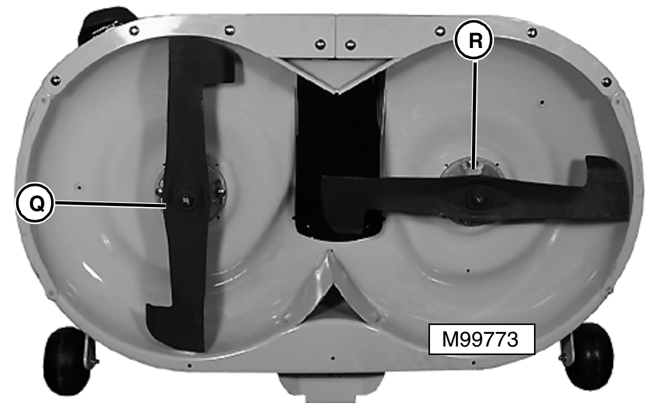

11. Remove belt keeper (M) and belt guide (N) from right sprocket.
12. Remove mower timing belt (O).

**IMPORTANT: HANDLE TIMING BELTS WITH CARE. To avoid belt damage, DO NOT crimp, fold, or twist belt.**

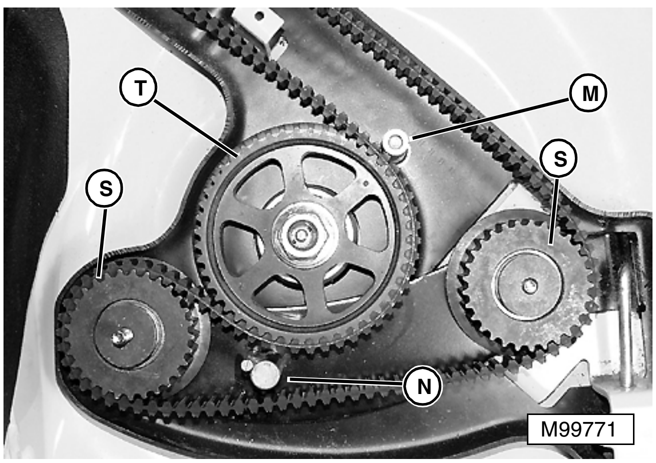
13. Place timing belt around left sprocket (P) making sure teeth of belt are fully engaged in teeth of sprocket.
14. Hold belt in position and install two belt keepers (L), one on each side of left sprocket.




15. Route belt around center idlers as shown, install center bracket (H) and fasten with two nuts (I). Tighten nuts.

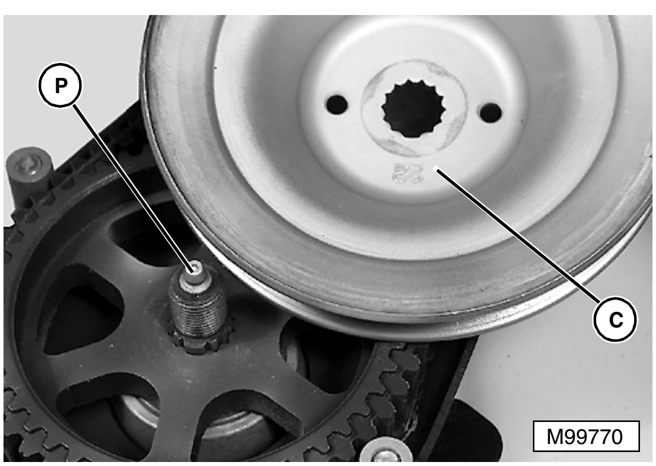



16. Position mower blades (Q) and (R) 90° from each other as shown in picture above.

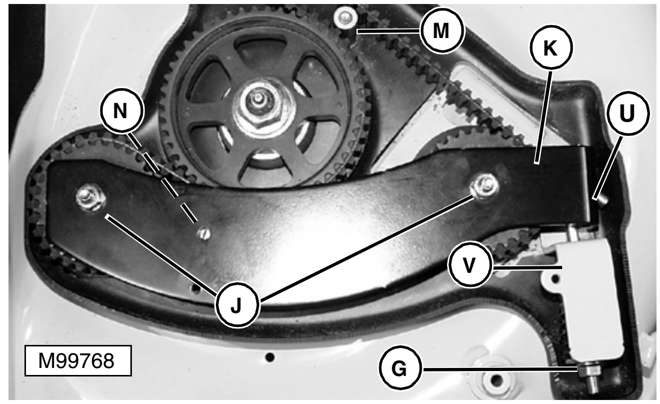



17. Route belt around right idlers (S), right sprocket (T) as shown making sure teeth of belt are fully engaged in teeth of sprockets.
18. Install belt keeper (M) and belt guide (N).

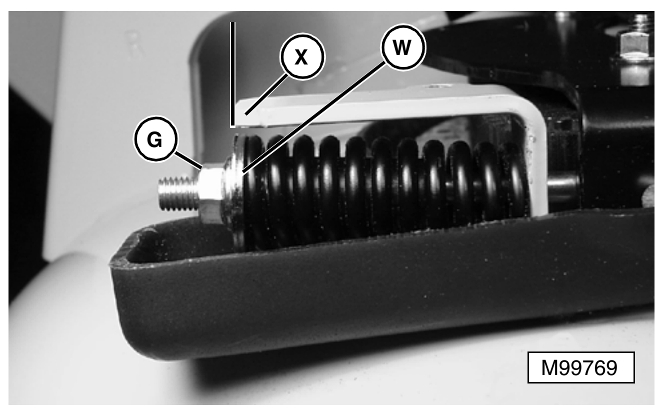
*NOTE: The belt guide will be adjusted later.*



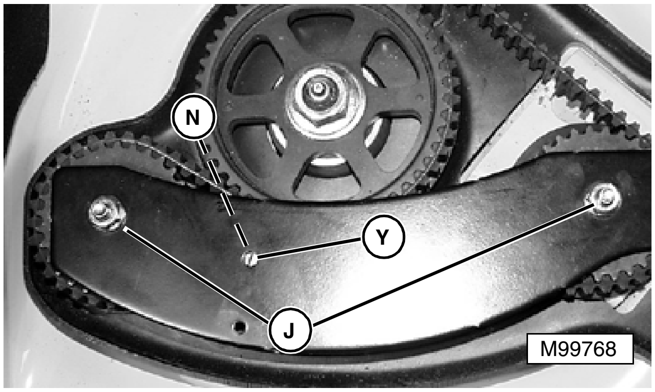

19. Install drive sheave (C) on left sprocket (P). Install nut by hand to hold blade and belt in position. Do not tighten nut.



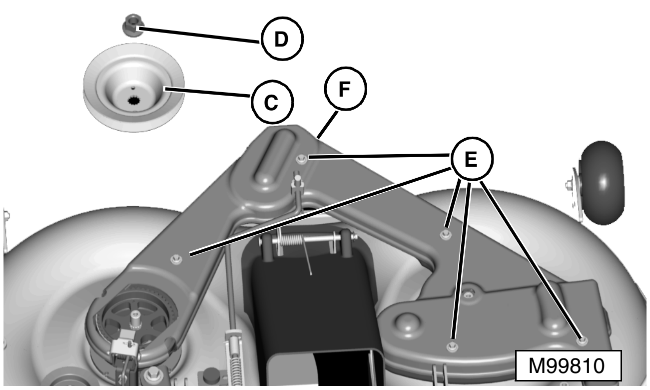

20. Install end of idler arm (K) over hook of tensioning rod (U) and fasten to right idlers with two nuts (J). Make sure belt guide (N) is engaged in hole of idler arm. Do not tighten nuts.
21. Check that blades are still timed (90° from each other). If necessary remove belt keeper (M), jump belt timing and reinstall belt keeper.
22. Using a clamp, compress idler arm (K) against tension rod strap (V) to allow installation of adjusting nut (G).
23. With tensioning spring compressed install adjusting nut (G) on end of tensioning rod.



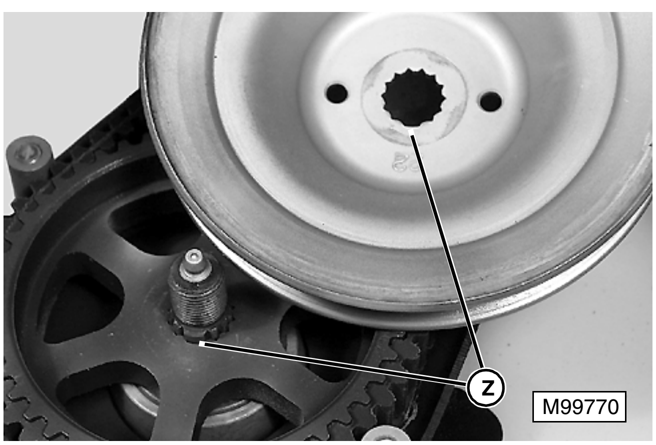

24. Adjust tension on timing belt by rotating adjusting nut (G) clockwise until end of tensioning spring (W) aligns with end of tensioner assembly bracket (X). Turn blades several rotations and observe that belt is riding properly in sprockets and idlers.




25. Place a screwdriver in slot (Y) and rotate belt guide (N) clockwise until guide contacts belt and then counterclockwise 1/8 turn (45°).
26. Tighten idler nuts (J) to **25 N•m (220 lb-in.)**.
27. Check that blades are still timed properly (90° from each other).

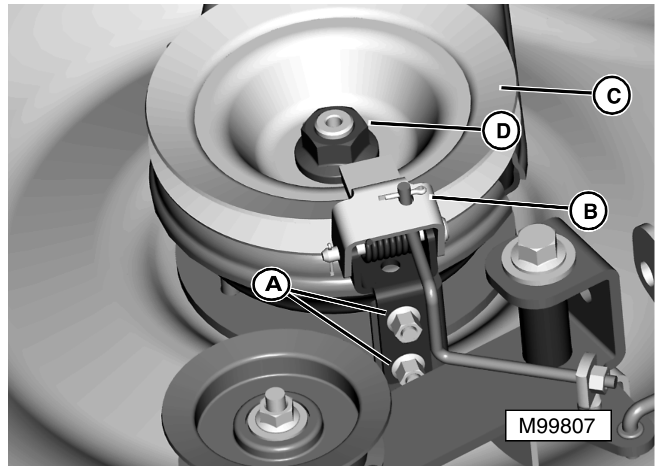



28. Remove nut (D), and, if installed, sheave (C).
29. Install cover (F) using five cap screws and washers (E).




**IMPORTANT: To avoid damage to belt and blades, make sure that drive sheave is properly aligned with blade spindle (Z).**

30. Align groove in drive sheave with flat on left blade spindle and install drive sheave.

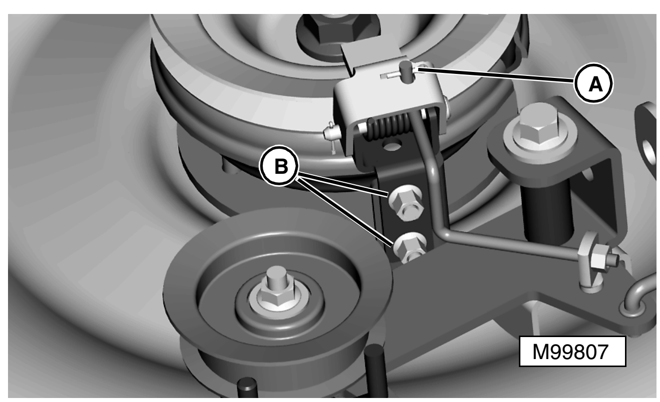



31. Fasten spindle with nut (D) and tighten nut to **145 N•m (107 lb-ft)**.
32. Align brake assembly (B) with sheave (C) and retain with two bolts and lock nuts (A). Tighten nuts to **16 N•m (144 lb-in.)**. Brake pad must seat against sheave face.
33. Install mower deck.
34. Perform primary drive belt tension adjustment. (See “MOWER DRIVE BELT TENSION ADJUSTMENT” on page 20.)
35. Perform brake adjustment. (See “BLADE BRAKE ADJUSTMENT” on page 19.)

## BLADE BRAKE REMOVAL AND INSTALLATION

**Procedure:**

1. Remove mower deck from tractor.
2. Measure the thickness of the pad (including the backing plate). If thickness is **5.0 mm (0.20 in.)** or less, replace brake.




3. If brake must be replaced, remove cotter pin and washer (A) from sheave brake arm.

4. Remove nuts (B) that secure brake to deck and remove sheave brake assembly.
5. Disassemble sheave brake assembly. Replace sheave brake and reassemble sheave brake assembly.

*NOTE: Clean sheave with brake cleaner to ensure surface is free of dirt or grease.*

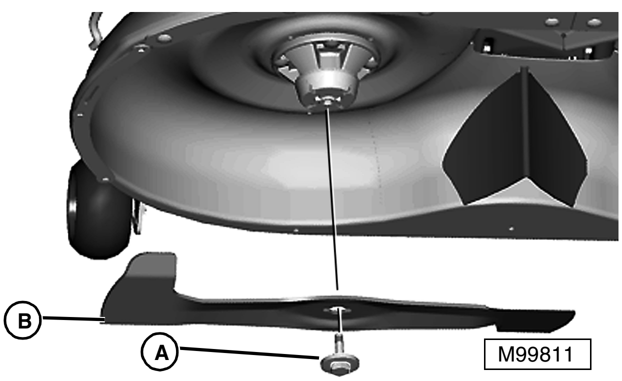
6. Install sheave brake assembly on mower deck.
7. Tighten nuts to **16 N•m (144 lb-in.)**.
8. Adjust brake. (See "BLADE BRAKE ADJUSTMENT" on page 19.)

## MOWER BLADE REMOVAL AND INSTALLATION

**⚠ CAUTION**

**Blades are sharp and could cause personal injury. Wear gloves or wrap blade with rag to remove or install blades. DO NOT hold blades with bare hands.**

1. Remove mower deck.
2. Hold mower blade with glove to prevent spindle from spinning.




3. Remove cap screw with washer (A) and blade (B).
4. Inspect blades; sharpen/balance or replace as necessary.

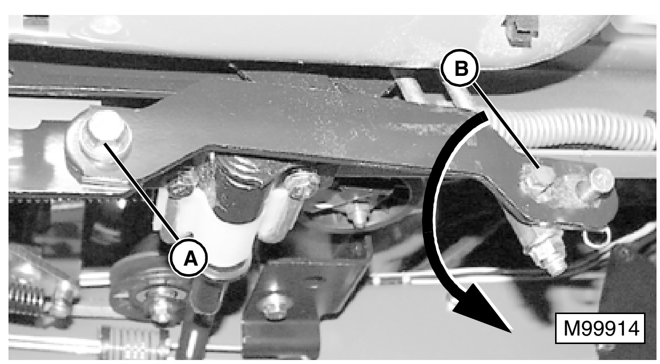
*NOTE: The RIGHT and LEFT sides are marked on the rear draft brackets of the tractor. There are directional marks on the outside edge of the mower. The blades are also marked for identification.*


5. Using gloves, position mower blade (B) with the cutting edge toward the ground onto the mower spindle and align key on bottom of spindle with slot in blade.
6. Install and tighten cap screw with washer (A) by hand until mower blade is in full contact (fully seated) with spindle.
7. With mower blade blocked, to prevent spinning, tighten bolts to **57 N•m (42 lb-ft)**.
8. Ensure blade timing is correct. Blades should be indexed **90**° apart; if not, see "MOWER BLADE TIMING BELT REMOVAL AND INSTALLATION" on page 26.
9. Install mower deck.

## MOWER DECK LIFT LINKAGE REMOVAL/INSTALLATION—LTR155/166

### DRAFT ARMS

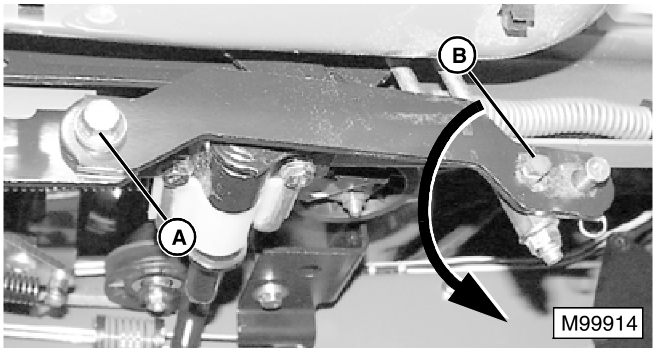
1. Remove mower deck.
2. If not already done, move lift lever to full up (TRANSPORT) position.




3. Remove cap screw, bushing, and lock nut (A) retaining front of draft arm to lift shaft assembly.
4. Rotate draft arm and remove from lift link (B).

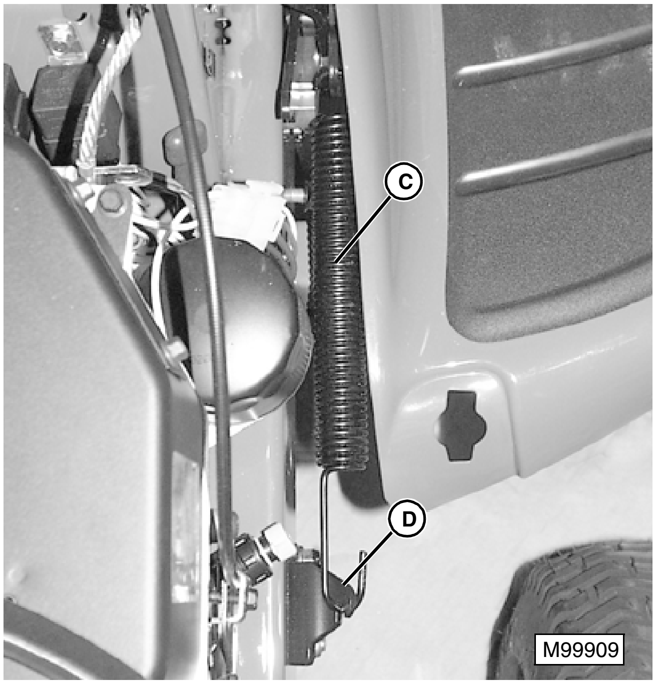
**LIFT SHAFT**

1. Remove mower deck.
2. If not already done, move lift lever to full up (TRANSPORT) position.



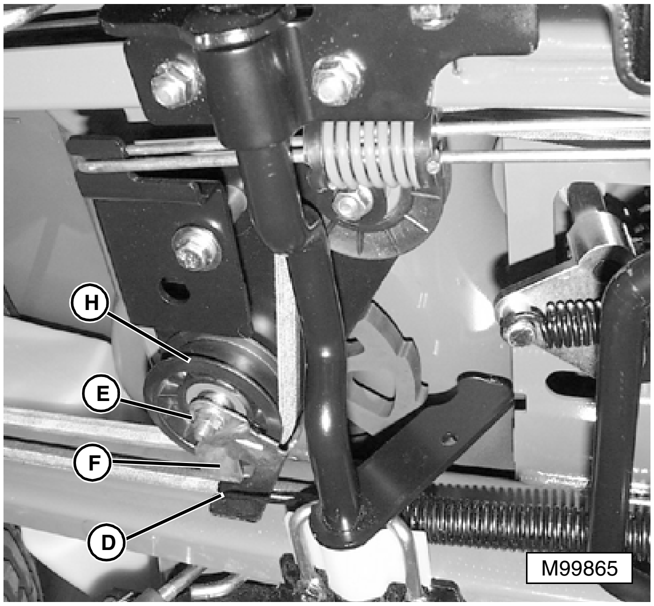

3. Remove cap screw, bushing, and lock nut (A) retaining front of draft arm to lift shaft assembly.
4. Rotate draft arm and remove from lift link (B).

> **CAUTION**
>
> **TENSIONED SPRING. The mower deck lift assist spring is under high tension when installed. Wear approved eye protection and gloves when removing to minimize the risk of personal injury.**




*NOTE: Left side closeout panel removed for clarity.*

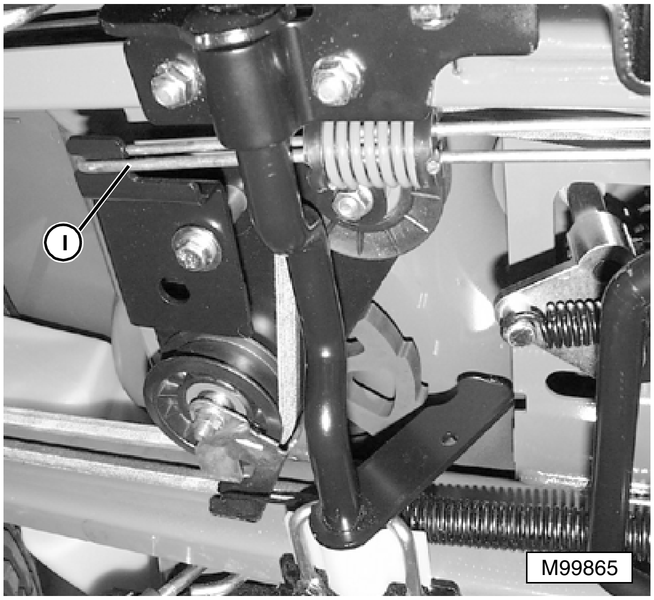
5. Using a suitable spring puller, disconnect the front of the lift assist spring (C) from bracket (D) on tractor frame. Remove spring from tractor.
6. Engage park brake to relieve tension on traction drive belt.
7. Raise tractor and support on suitable stands to gain easy access to underside of frame.



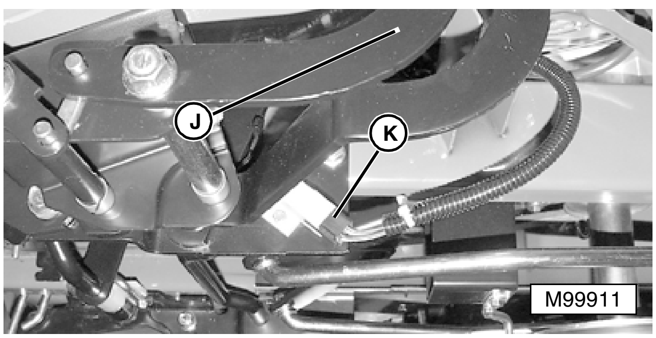

8. Remove nut (E) and belt guide (F).
9. Slip traction drive belt off of flat idler sheave (G).
10. Disengage park brake.

> **CAUTION**
>
> **TENSIONED SPRING. Idler assembly tensioning spring is under high tension. Wear approved eye protection and gloves when removing spring to minimize the risk of personal injury.**

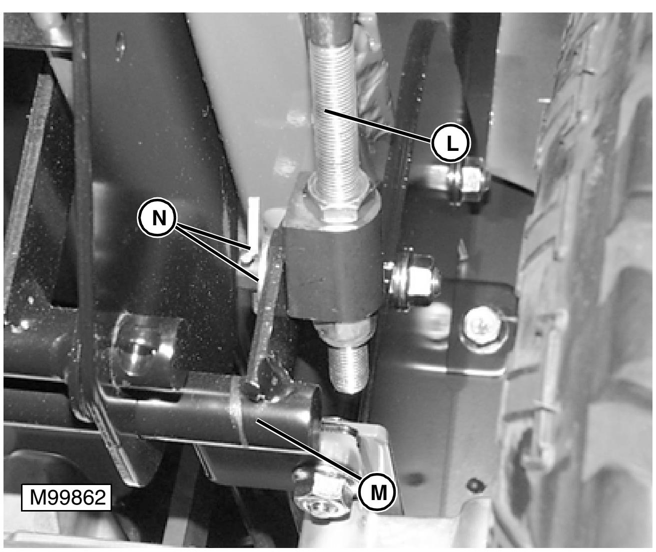
11. Using a suitable spring puller, disconnect idler tensioning spring (H) from idler assembly. Remove spring.



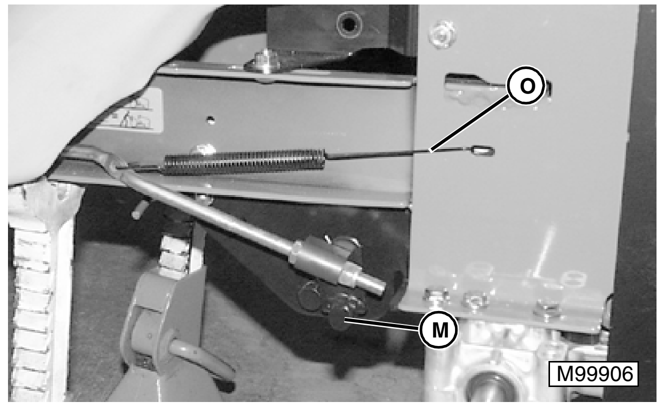

12. Disconnect compression spring (I) from idler assembly and brake pedal arm. Remove spring from tractor.
13. Remove brake pedal pad from brake pedal (J).



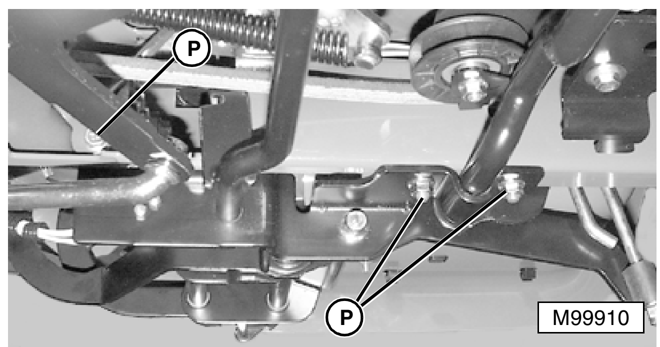

14. Under right side footrest, locate and disconnect brake switch electrical connector (K).



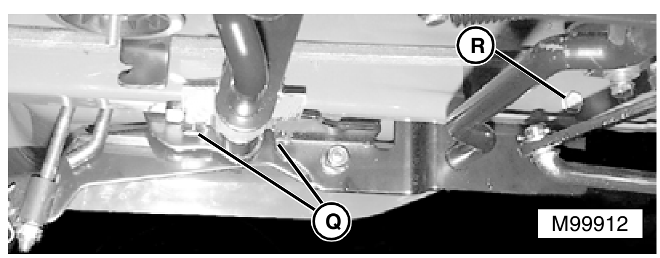

15. Remove left side rear wheel. (See “REAR WHEEL REMOVAL/INSTALLATION” on page 5 in “MISCELLANEOUS” section.)
16. Near left side rear wheel, locate brake rod (L) and brake cross shaft (M).
17. Remove cotter pin and washer (N), and disconnect link from brake cross shaft.




18. Using a suitable spring puller, disconnect brake return spring (O) from frame. Remove brake return spring.



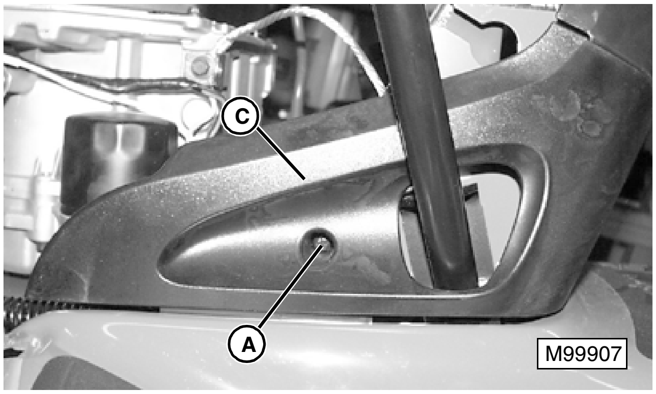

19. Remove three cap screws and nuts (P) retaining right side of brake pedal shaft/lift shaft support to frame.

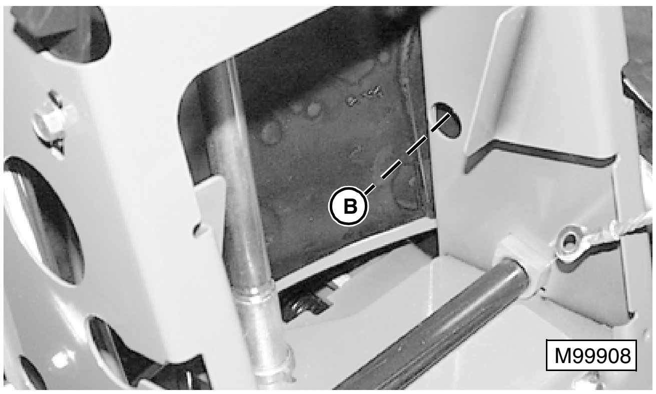



20. Remove two cap screws and nuts (Q) retaining left side of brake pedal shaft/lift shaft support to frame.
21. Remove remaining cap screw and nut (R).
22. Remove lift shaft assembly and brake pedal shaft from the tractor.

### LIFT LEVER

1. Remove battery and mower deck.

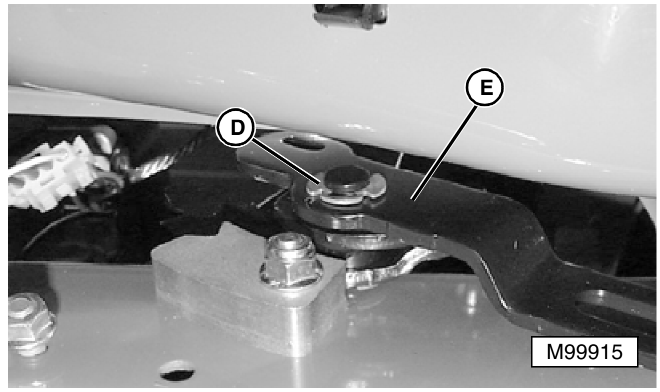


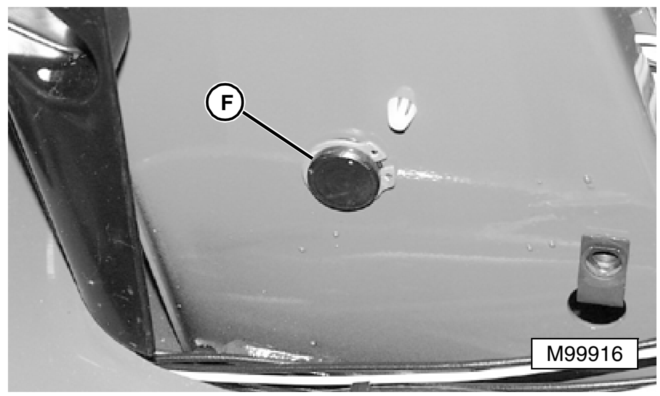

2. Remove screw and washer (A). Remove cap screw and washer (B), and side closeout panel (C). Repeat for other side.
3. If not already done, move lift lever to forward (LOWER) position.

> **CAUTION**
>
> **TENSIONED SPRING. The mower deck lift assist spring is under high tension when installed. Wear approved eye protection and gloves when removing to minimize the risk of personal injury.**

4. Remove lift shaft assembly. (See preceding procedure.)




5. Underneath the tractor, on the left side between the foot rest and frame, locate the E-clip (D) retaining the lift strap (E) to the lever assembly. Remove E-clip and lift strap.




6. On right side of tractor, remove snap ring (F) from end of lift lever shaft.
7. Rotate lift lever handle toward front of tractor and slide lift lever assembly out left side.
8. Inspect components for wear or damage. Replace parts as needed.

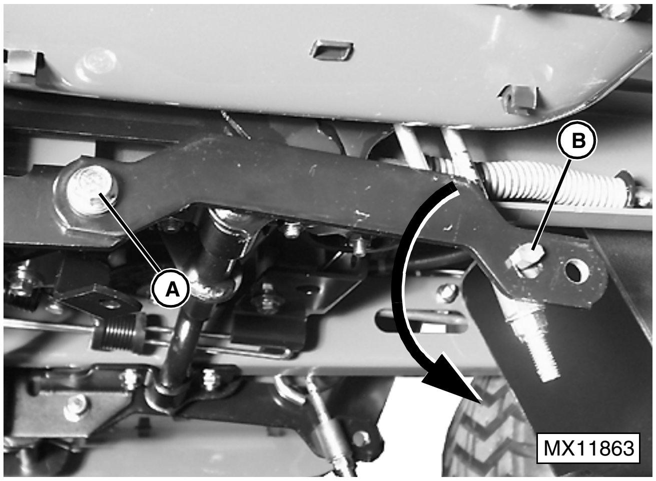
**Installation:**

Installation is the reverse order of removal.

## MOWER DECK LIFT LINKAGE REMOVAL/INSTALLATION—LTR180

### DRAFT ARMS

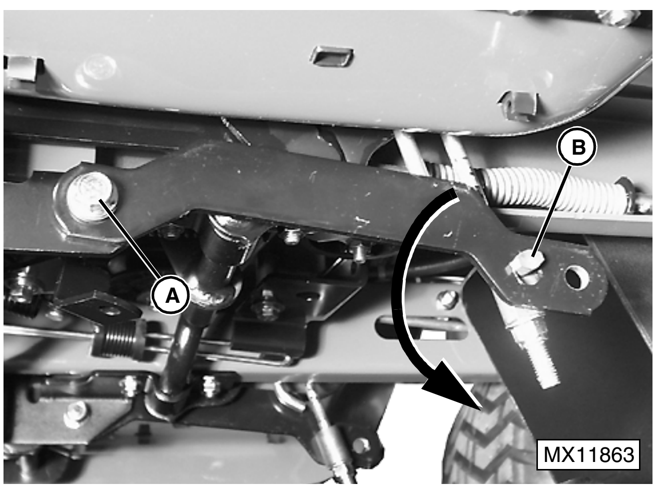
1. Remove mower deck.
2. If not already done, move lift pedal to full up (TRANSPORT) position.



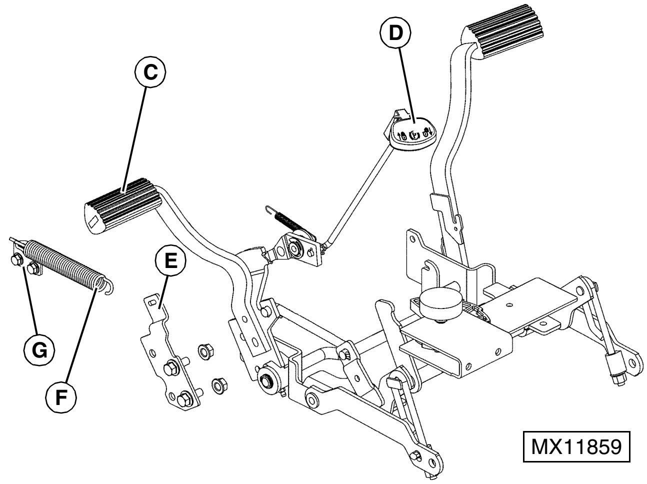

3. Remove cap screw, bushing, and lock nut (A) retaining front of draft arm to lift shaft assembly.
4. Rotate draft arm and remove from lift link (B).

**LIFT SHAFT AND LIFT PEDAL**

1. Remove mower deck.
2. If not already done, move lift pedal to full up (TRANSPORT) position.



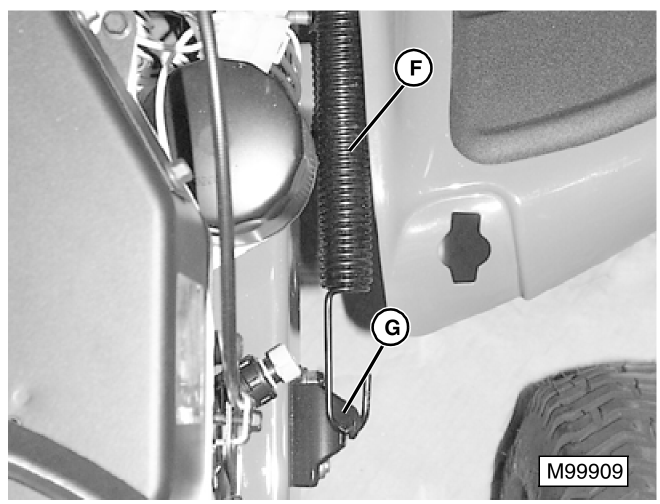

3. Remove cap screw, bushing, and lock nut (A) retaining front of draft arm to lift shaft assembly.
4. Rotate draft arm and remove from lift link (B).




**CAUTION**

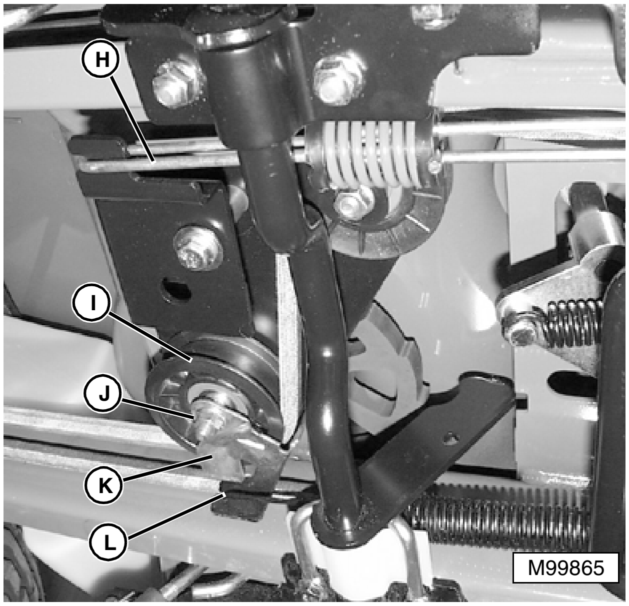
**TENSIONED SPRING. The mower deck lift assist spring is under high tension when installed. Wear approved eye protection and gloves when removing to minimize the risk of personal injury.**

5. Push lift pedal (C) down to remove tension on spring, and pull lift lever (D) up to lock into position.




*NOTE: Left side closeout panel removed for clarity.*

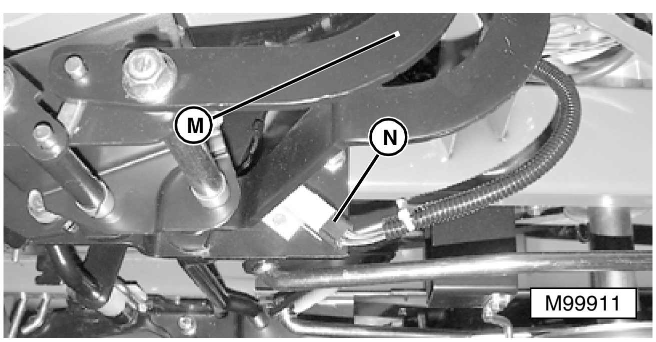
6. Remove spring (F) from front bracket (G) and hole in bracket (E) (exploded on graphic) attached to lift pedal.
7. Engage park brake to relieve tension on traction drive belt.
8. Raise tractor and support on suitable stands to gain easy access to underside of frame.



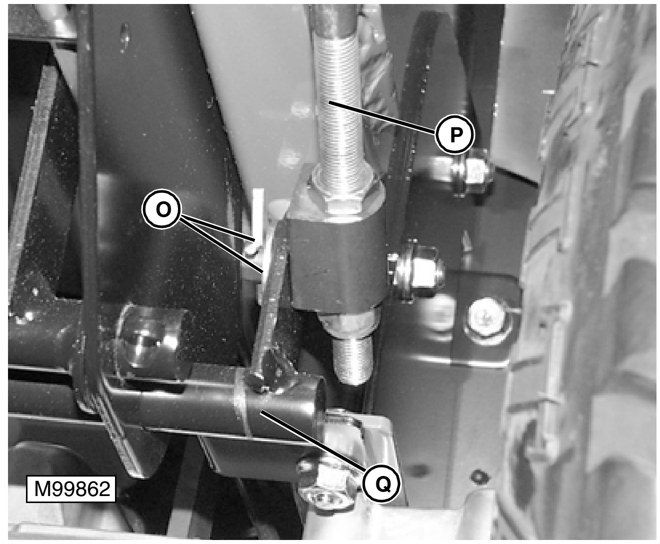

9. Remove nut (J) and belt guide (K).
10. Slip traction drive belt off of flat idler sheave (I).
11. Disengage park brake.

> **⚠ CAUTION**
>
> **TENSIONED SPRING. Idler assembly tensioning spring is under high tension. Wear approved eye protection and gloves when removing spring to minimize the risk of personal injury.**

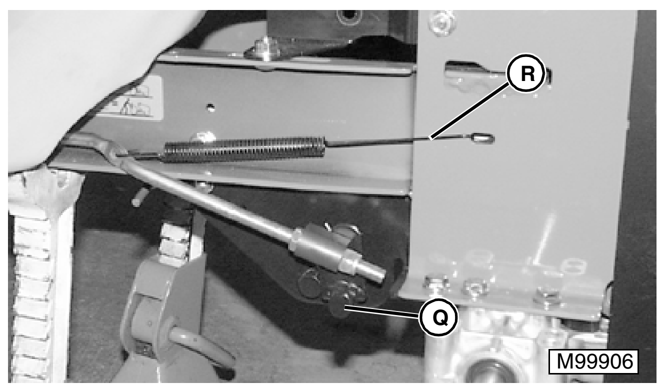
12. Using a suitable spring puller, disconnect idler tensioning spring (L) from idler assembly. Remove spring.
13. Disconnect compression spring (H) from idler assembly and brake pedal arm. Remove spring from tractor.



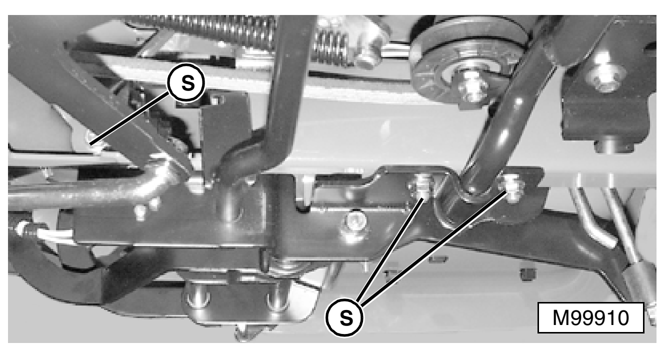

14. Remove brake pedal pad from brake pedal (M).
15. Under right side footrest, locate and disconnect brake switch electrical connector (N).



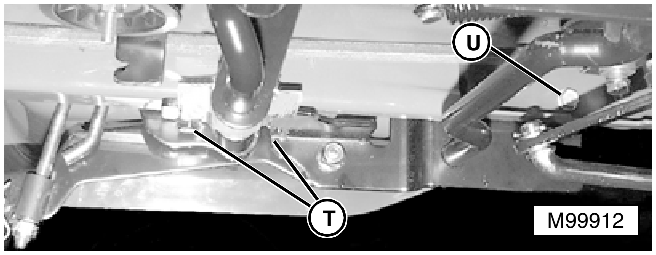

16. Remove left side rear wheel. (See “REAR WHEEL REMOVAL/INSTALLATION” on page 5 in “MISCELLANEOUS” section.)
17. Near left side rear wheel, locate brake rod (P) and brake cross shaft (Q).
18. Remove cotter pin and washer (O), and disconnect link from brake cross shaft.




19. Using a suitable spring puller, disconnect brake return spring (R) from frame. Remove brake return spring.




20. Remove three cap screws and nuts (S) retaining right side of brake pedal shaft/lift shaft support to frame.




21. Remove two cap screws and nuts (T) retaining left side of brake pedal shaft/lift shaft support to frame.
22. Remove remaining cap screw and nut (U).
23. Remove lift shaft assembly and brake pedal shaft from the tractor.

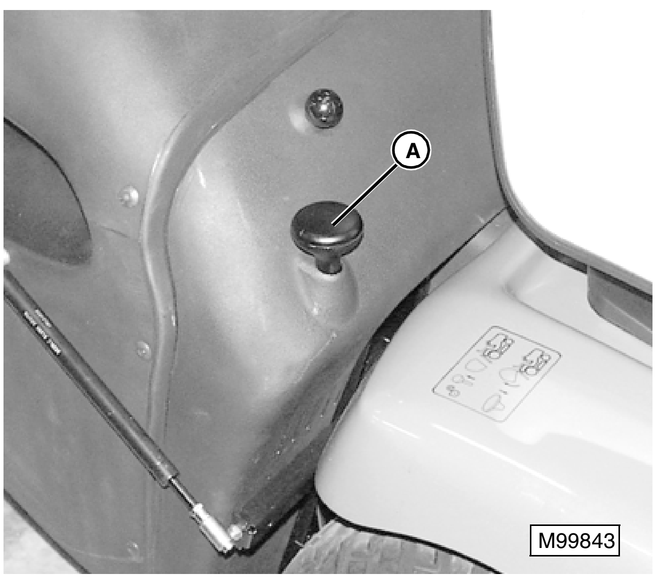
### Installation:

Installation is the reverse order of removal.

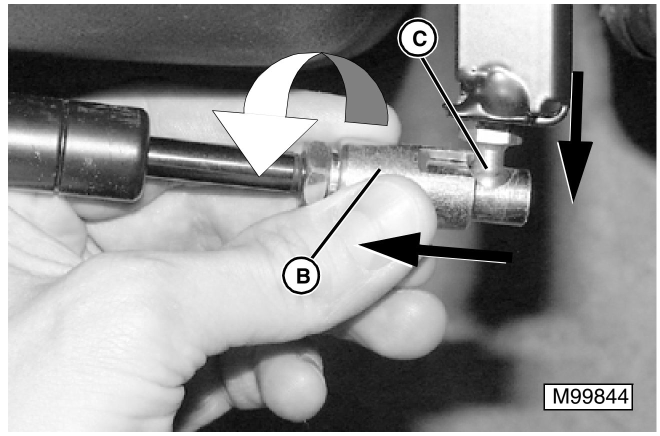
## GRASS COLLECTOR REMOVAL AND INSTALLATION

### Grass Collector Hopper:

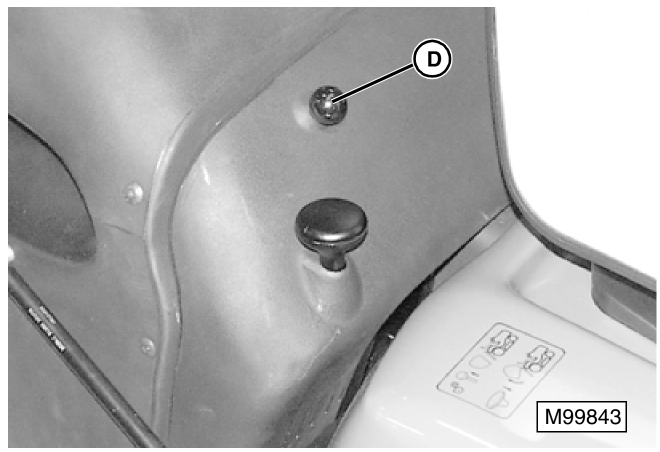
1. Park tractor on a hard, smooth surface. Stop engine, remove key, wait for all moving parts to STOP.




2. Push down on knob (A) to open grass collector hopper.




3. Remove end of gas lift assist cylinder from tractor by pulling back on locking collar (B), and turning. Pull end of cylinder off of ball stud (C).
4. Support grass collector hopper, and repeat for other side.



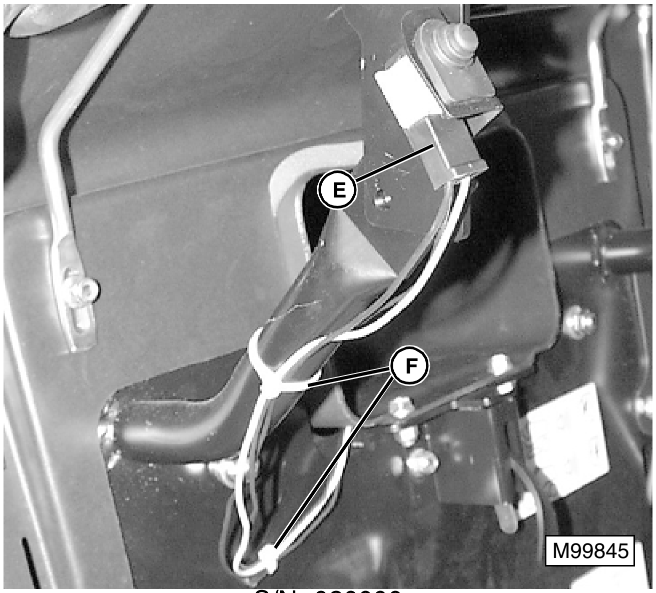

5. Pull up on release handle (D) to unlock hopper support brackets.
6. Lift grass collector hopper off of rear of tractor.

### Installation:

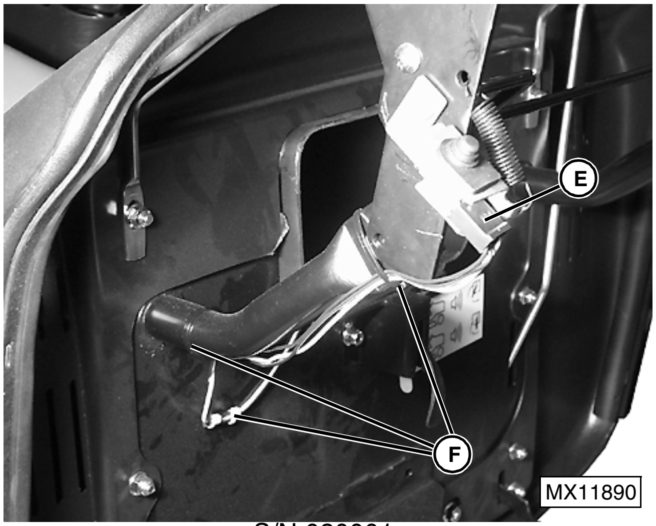
Installation is the reverse order of removal.

### Back Plate Assembly:

1. Park tractor on a hard, smooth surface. Stop engine, remove key, wait for all moving parts to STOP.
2. Remove grass collector hopper (see above.)

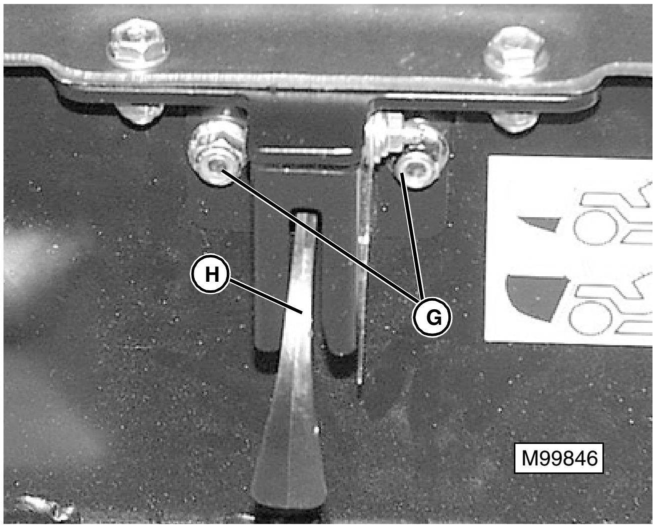



S/N -020000

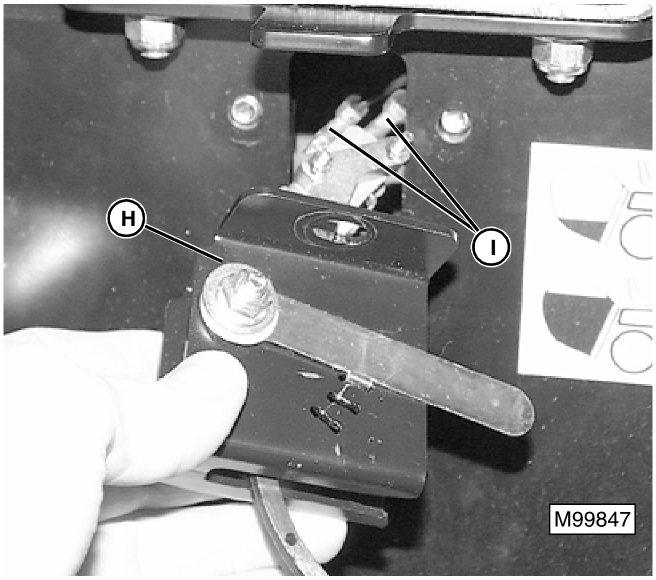



S/N 020001-

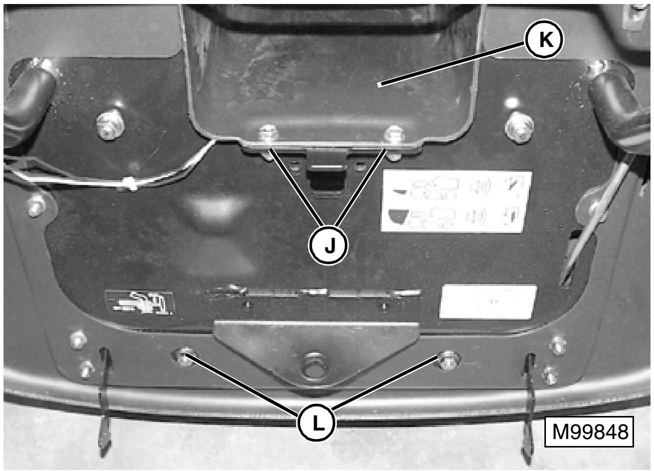
3. Disconnect grass collector fill switch electrical connector (E).
4. Remove tie bands (F) attaching wiring harness to left side support bracket and back plate assembly.



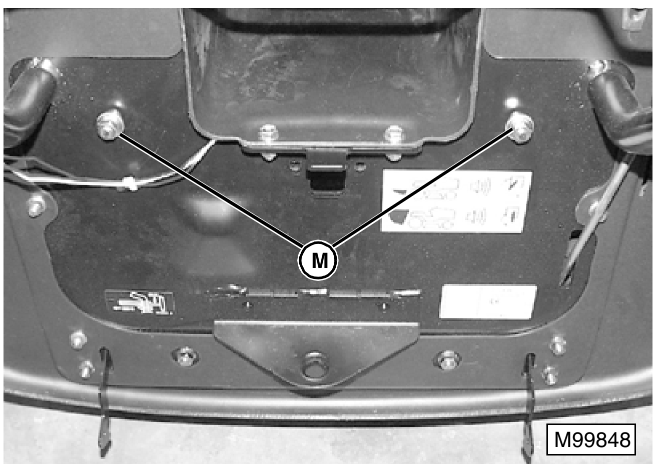

5. Remove two lock nuts and carriage bolts (G) attaching collector fill switch (H) to back plate assembly.




6. Rotate collector fill switch 90° and remove slowly from back plate until wires (I) are visible.
7. Disconnect two wires from switch. Remove switch.




8. Remove two lock nuts and cap screws (J) attaching chute (K) to back plate assembly.
9. Remove two cap screws and nuts (L) from bottom of back plate.




**IMPORTANT: Use care when removing back plate assembly from tractor to avoid damaging wiring harness.**

10. Support back plate assembly, and remove two cap screws, spacers, and nuts (M) from top of back plate. Remove back plate assembly from the tractor.

**Installation:**

Installation is the reverse order of removal.

*NOTE: Grass collector fill switch assembly must be pushed fully upward before tightening.*

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M

# SPECIFICATIONS

**Front Tires**

Size . . . . . . . . . . 15 x 6.00 - 6
Tire pressure . . . . . . . . . . 83 kPa (12 psi)

**Rear Tires**

Size . . . . . . . . . . 20 x 10.00 - 8
Tire pressure . . . . . . . . . . 55 kPa (8 psi)

**Fuel Tank**

Capacity . . . . . . . . . . 6.0 L (1.6 U.S. gal)

# TESTS AND ADJUSTMENTS

## TIRE PRESSURE ADJUSTMENT

**CAUTION**

**Explosive separation of a tire and rim parts can cause serious injury or death:**

- **Do not attempt to mount a tire without the proper equipment and experience to perform the job**
- **Always maintain the correct tire pressure. Do not inflate the tires above the recommended pressure. Never weld or heat a wheel and tire assembly. The heat can cause an increase in air pressure resulting in a tire explosion. Welding can structurally weaken or deform the wheel**
- **When inflating tires, use a clip-on chuck and extension hose long enough to allow you to stand to one side and NOT in front of or over the tire assembly**
- **Check tires for low pressure, cuts or missing lug bolts and nuts**

*NOTE: Front tires are installed with stems to the inside.*
*Rear tires are installed with stems to the outside.*

**Procedure:**

1. Check tire and rim for damage.
2. Using a air pressure gauge, check air pressure.
3. Add or remove air as needed.

**Specifications:**

**Front tire pressure . . . . . . . . . . . . . . . . 83 kPa (12 psi)**
**Rear tire pressure . . . . . . . . . . . . . . . . . 55 kPa (8 psi)**

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# REPAIR

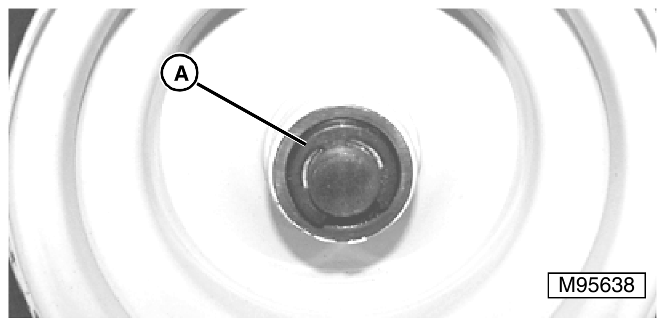
## FRONT WHEEL REMOVAL AND INSTALLATION

**Procedure:**

**CAUTION**

**TRACTOR MAY SHIFT SUDDENLY. When supporting tractor, be sure to place stands so that tractor cannot tilt on front axle pivot.**

1. Raise front of tractor, and support both sides of front axle beam using suitable stands.
2. Remove plastic cap from wheel hub.



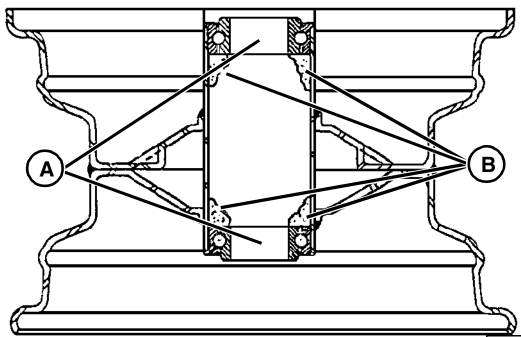

3. Remove E-ring (A) from end of axle.
4. Remove wheel.

**Installation:**

Installation is the reverse of removal.

## FRONT WHEEL BEARING REPAIR

**Procedure:**



M52004

1. Remove bearings (A) using slide hammer puller.
2. Install new bearings using suitable driver on outside race of bearing.

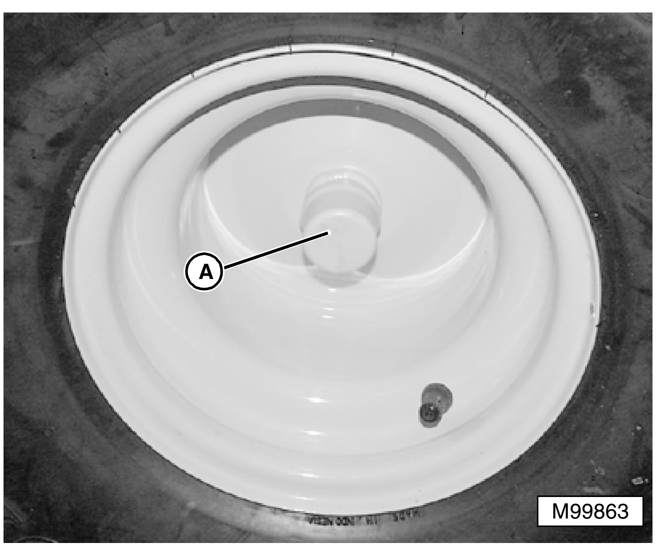
**IMPORTANT: If new bearings are loose in wheel hub, replace wheel.**

3. Pack area behind bearing with specified grease (B).
4. Install wheel.

## REAR WHEEL REMOVAL/ INSTALLATION

**Removal:**

1. Safely lift and support tractor.



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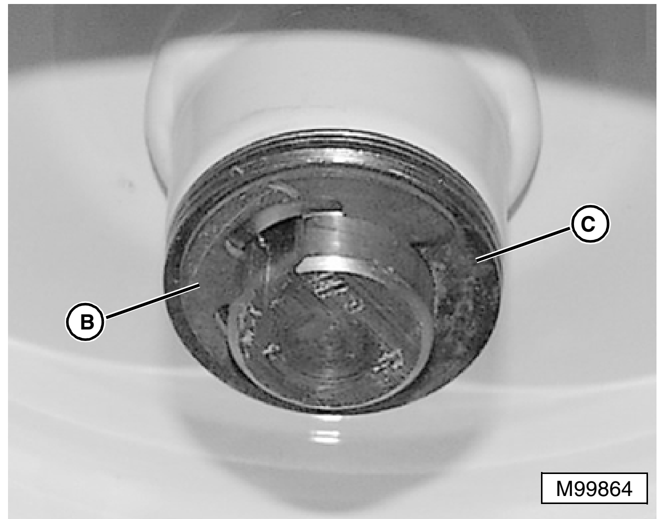
2. Remove plastic cap (A).



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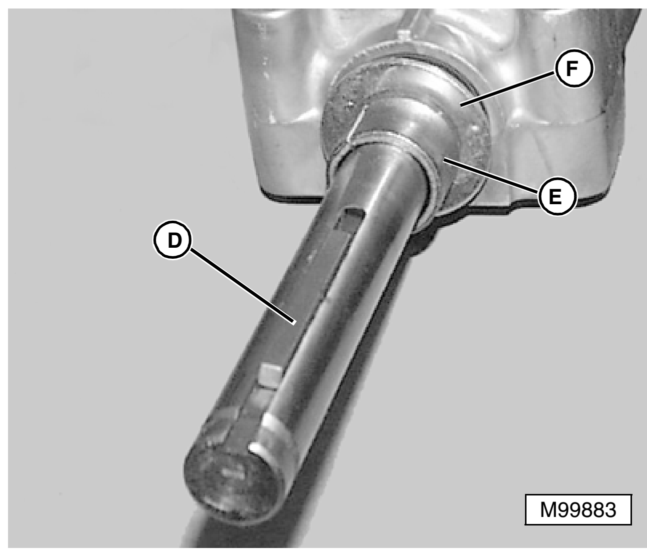
3. Remove E-clip (B), and washer(s) (C).
4. Remove wheel.



M99883

5. Remove key (D), spacer (E) and thrust washer (F).

*NOTE: Rear wheels are installed with valve stems to the outside.*

**Installation:**

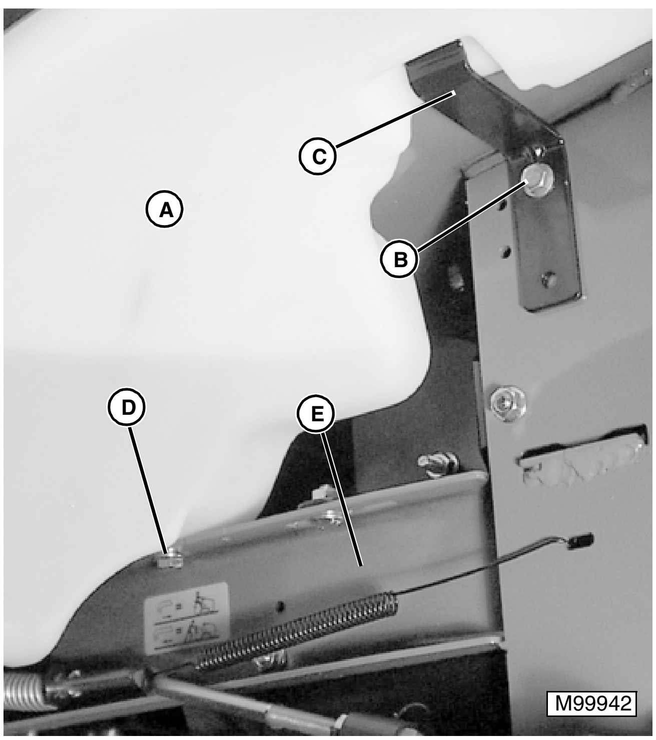
Installation is the reverse of removal.

## FUEL TANK REMOVAL AND INSTALLATION

**Procedure:**

> ⚠ **CAUTION**
>
> **Gasoline is extremely flammable. Do not smoke. Always work in a ventilated area away from open flame or spark producing equipment; including equipment that utilizes pilot lights. Wipe-up any spills IMMEDIATELY.**

1. Disconnect (–) **NEGATIVE** battery cable.
2. Disconnect fuel line at engine fuel pump and drain fuel from tank into an approved fuel storage container.
3. Raise rear of tractor and support on suitable stands.
4. Remove left rear wheel.




5. Support fuel tank (A) and remove cap screw and nut (B) retaining bracket (C) to tractor frame.
6. Remove cap screw (D) retaining fuel tank to frame rail (E).
7. Remove fuel fill cap from tank. Lower tank out of fender and remove from rear of tractor.
8. Install fuel fill cap back onto fuel tank.
9. Disconnect fuel line from fuel pickup on tank. Plug end of fuel line to prevent spillage.

**Installation:**

1. Connect fuel line to fuel pickup on tank.

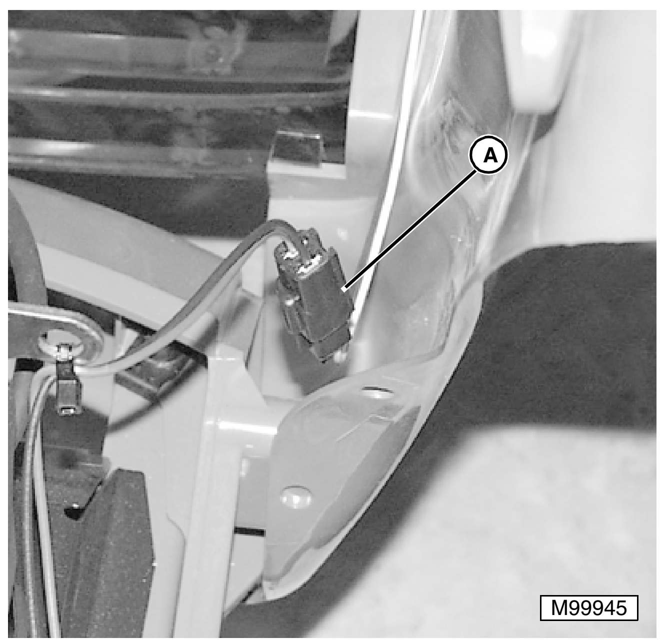
**IMPORTANT: Insure that fuel line is free and clear of all moving parts from fuel tank to engine.**

2. Remove fuel fill cap from tank and install fuel tank onto tractor; insert tank fill neck through hole in fender.
3. Install fuel fill cap to tank.
4. Install two brackets retaining fuel tank to tractor frame. Secure with screws and nuts.
5. Connect fuel line to engine fuel pump.
6. Install left rear wheel.
7. Raise rear of tractor, remove stands, and lower tractor to the ground.
8. Connect **NEGATIVE** (–) battery cable.
9. Fill fuel tank.

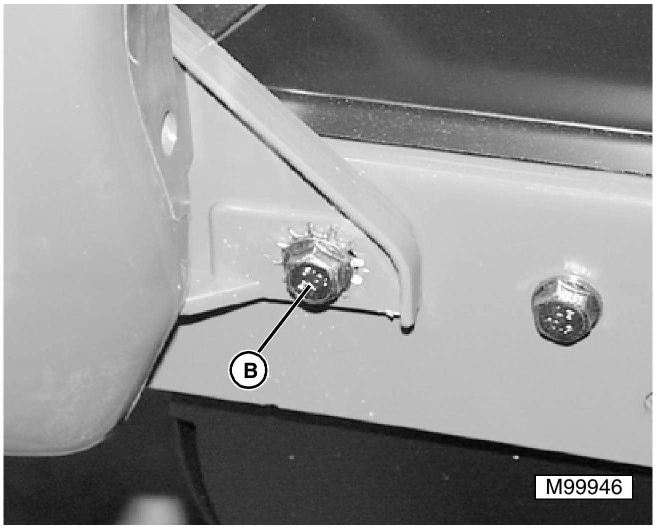
## HOOD REMOVAL AND INSTALLATION

**Removal:**

1. Open the hood.



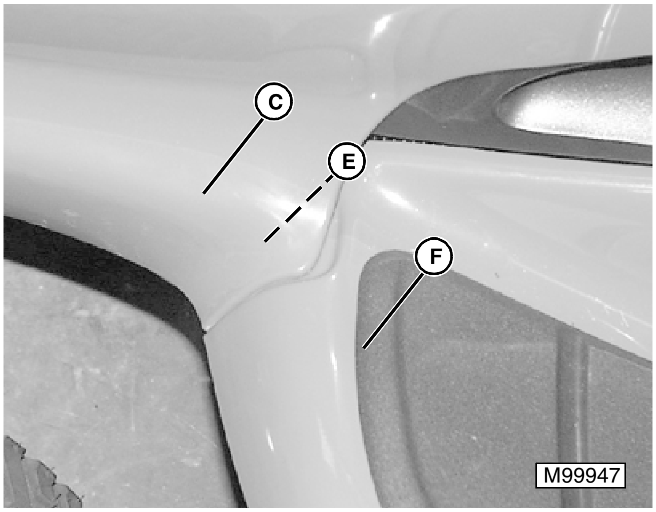

2. On right side of the vehicle frame, near the right front pivot, disconnect electrical connector (A) for headlights.

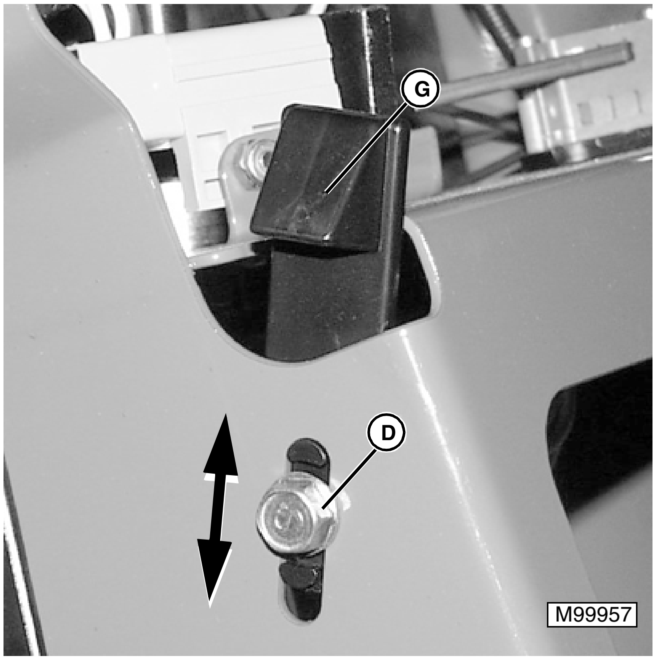



3. Support the hood, and remove two cap screws and external tooth lock washers (B) retaining bumper and hood to tractor frame.
4. Remove hood and bumper from the tractor as an assembly.

**Installation:**

Installation is the reverse order of removal.

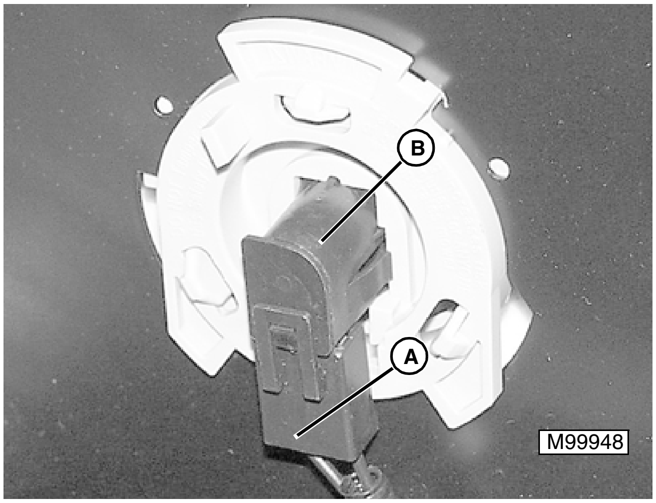


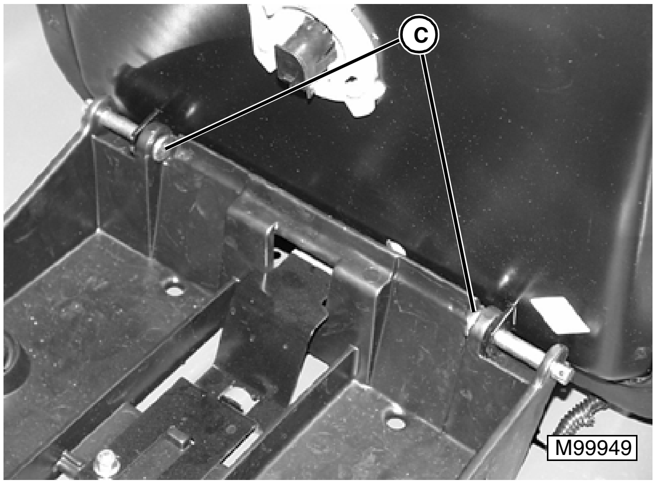

*NOTE: When installing, check hood (C) for proper fit before tightening cap screws (D). Tabs (E) on hood should seat properly in holes in foot rest (F), and there should be no gaps between foot rest and hood edge as shown.*
*After installing hood, check to ensure that hood latches properly. Adjust height of hood latch (G) as needed.*

## SEAT AND SUPPORT REMOVAL AND INSTALLATION

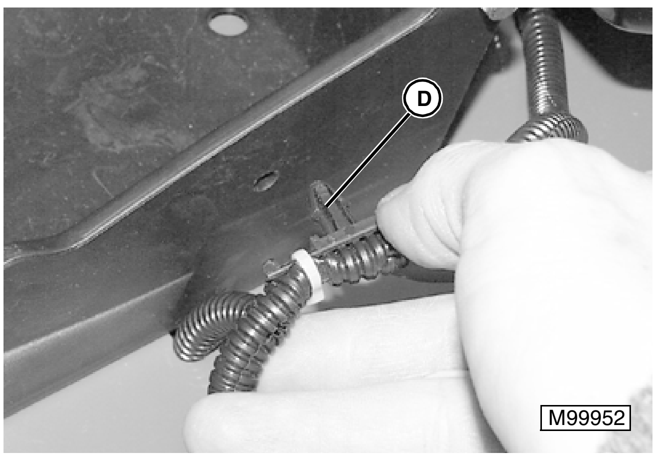
**Removal:**



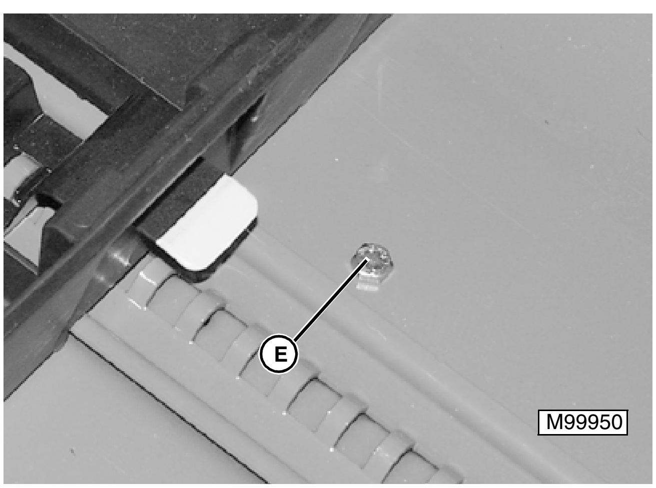

1. Tilt seat forward and disconnect wiring harness (A) from seat switch (B).



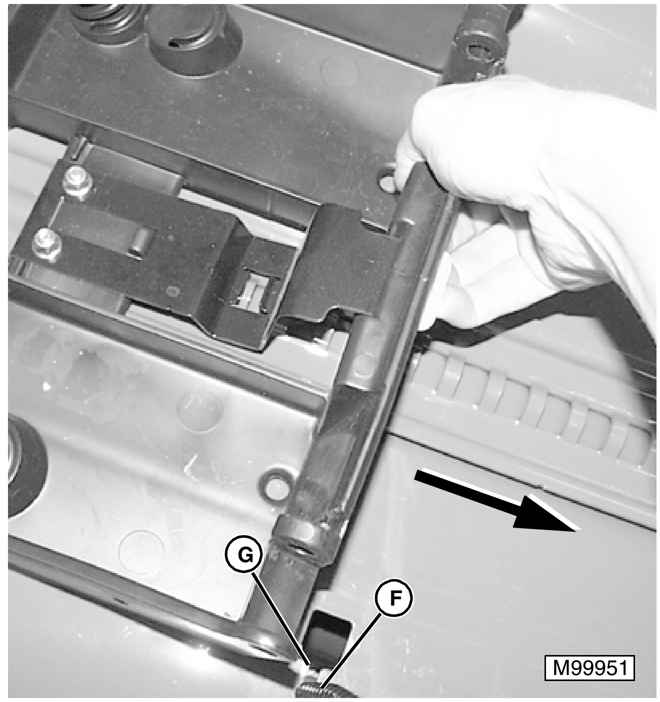

2. Remove two pins (C) retaining seat to seat base. Remove seat.




3. Disconnect wiring harness tie down clip (D) from seat base.




4. Move seat base to rear of tractor. Locate cap screw and nut (E) in front of seat base, and remove.




**IMPORTANT: Use care to prevent damage to seat switch wiring harness (F) when removing seat base. Check to ensure that harness is properly located in key hole (G) to right of seat base as shown.**

5. Lift up on latch, and slide seat base forward and off of track. Remove seat base.

### Installation:

Installation is the reverse order of removal.

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