Commercial Products

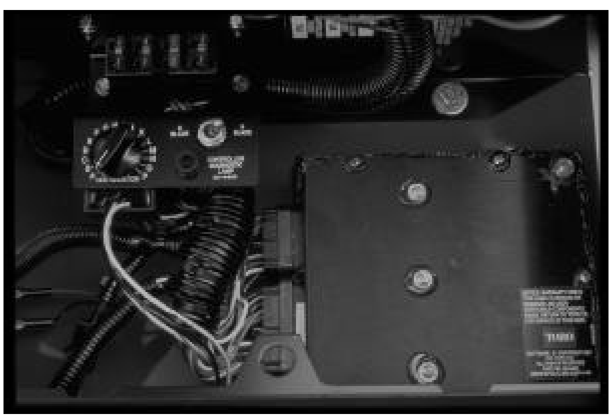
Electrical Systems and Components

Part No. 96885SL, Rev. A

Introduction

Electricity plays an important role in modern turf equipment. Modern 12 volt electrical systems are used almost exclusively in turf equipment.

The demands on the electrical system include: starting, lighting and ignition systems. Electrical circuits control the operation of the machines and monitor certain machine functions. They enhance the overall operation and also improve the operators safety, through various safety circuits. New methods to control the operation and the function of the machine are made possible because of electrical devices.



With the use of microprocessor based controls, the potential of electrical and electronic circuits and controls will greatly change the ease of operation and the reliability of current and future equipment.

These new advances in electrical systems will require a better understanding of electricity and complete electrical systems, to enable technicians to diagnose and repair these systems.

Safety

While the risk of electrical shock is relatively low when working on a 12 volt electrical system, care must be taking when working on equipment electrical systems.

Fumes from battery electrolyte are flammable. Keep all sparks and fires away from the battery. When charging the battery, explosive fumes are produced more rapidly. Be sure the room or area where batteries are being recharged is well ventilated.

Battery acid is harmful on contact with the skin or most materials. If acid contacts the skin, rinse the affected area with running water for 10 to 15 minutes. If acid contacts the eyes, force the eyelids open and flush the eyes with running water for 10 to 15 minutes. Then see a doctor at once.

To avoid injury from sparks or short circuit, **Disconnect the negative battery ground cable** when working on any part of the electrical system.

Remove all Jewelry and watches when working on live circuits.
Injury can result from high temperature caused when jewelry, rings or watches come in contact with powered circuits and ground circuits.

When removing batteries always disconnect the negative battery cable first. When reconnecting the battery wait until last to connect the negative cable.

Do not lay tools or parts across the battery, the metal parts or tools can short across the battery posts and a fire or explosion can result.

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OBJECTIVE: To familiarize the technician with the basic fundamentals of electrical systems and their operation.

2: TEST EQUIPMENT, PAGE 5.
OBJECTIVE: Inform technicians of proper use of electrical test equipment.

3: BASIC CIRCUIT TEST, PAGE 9.
OBJECTIVE: Provide technicians with helpful information on the procedures for testing basic electrical circuits.

4: ELECTRICAL COMPONENTS AND TESTING, PAGE 11.
OBJECTIVE: Explain the operation and function of basic electrical components. Instruct technicians on the proper methods to test various common electrical components.

6: BASIC CIRCUITS, PAGE 21.
OBJECTIVE: Examine various electrical circuits.

7: REVIEW QUESTIONS, PAGE 24.

Review Answers

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Electrical Principles

Electricity

Electricity is a form of energy created by the movement of electrons. Directing these electrons through a circuit, we can perform work. Electricity can produce light, heat, magnetism or mechanical work.

Electricity

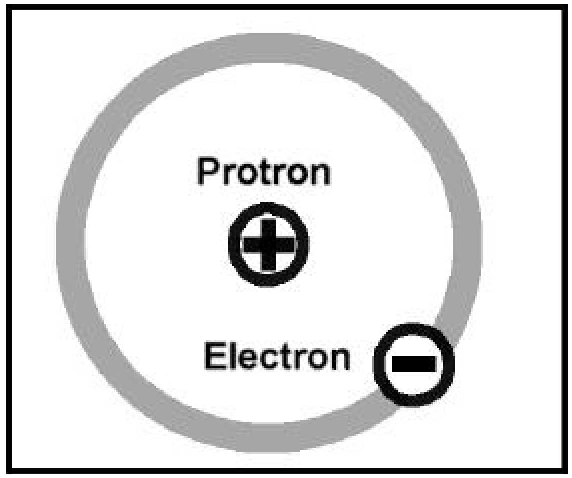


Figure 1

Basic System Requirements

Every electrical system requires 3 basic components and usually 2 accessory components.

1: Power Source
2: Load Device
3: Conductors
"Accessory Components."
4: Switch
5: Fuse

Basic System Requirements

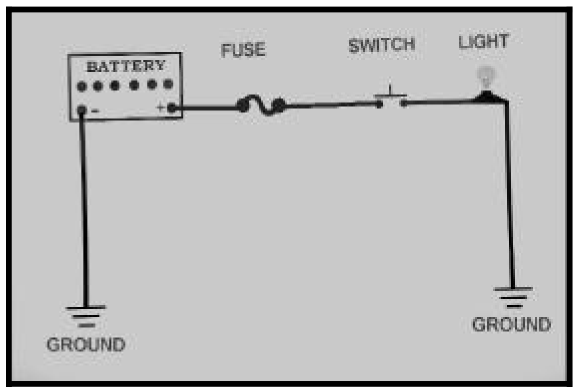


Figure 2

Basic Circuit Types

Series Circuit

A series circuit is a circuit that may include more than one load.

Characteristics of a series circuit:

1: The current is constant through out the circuit.
2: The current must pass through each component in the circuit.
3: The total resistance of the circuit controls the current in the circuit.
4: The total resistance of the circuit is the sum of all the resistance's in the circuit.
5: The sum of the voltage drops across the resistors will equal the applied voltage.

Resistance in a series circuit equals the sum of all resistance's (that is, R = R1+R2+R3+ etc...)

Series Circuit

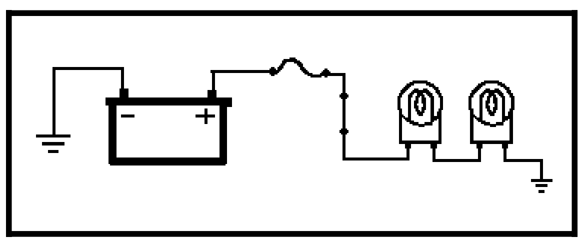


Figure 3

Parallel Circuits

A parallel circuit is a circuit that has two or more loads connected so that current can divide and flow through the load. Most electrical circuits are parallel.

Characteristics of a parallel circuit:

1: The current has many paths.
2: The resistance in each load will determine the current flow for that resistance.
3: The total resistance will always be less than the smallest resistance in the circuit.
4: The voltage drop across all loads will be battery voltage.
The formula for calculating resistance in a parallel circuit is:

$$R = \frac{R1 \times R2}{R1 + R2}$$

Parallel Circuits

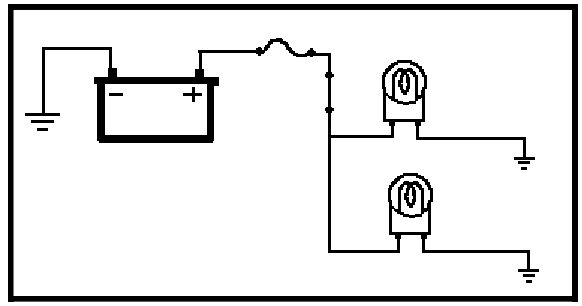


Figure 4

Basic Electrical Elements

Current is the directed flow of electrons through the circuit.
Voltage is the electrical pressure that causes the electrons to flow.
Resistance is a restriction to current flow.

CIRCUIT ELEMENT	DEFINITION	UNIT OF MEASUREMENT	UNIT SYMBOL	MEASURED WITH	FUNCTION SWITCH POSITION	OHM'S LAW
CURRENT	The flow of electrons around a circuit	Amperes (amps)	A	Ammeter	AC amps or DC amps	C=V÷R
VOLTAGE	The force (pressure) which causes current to flow	Volts	V	Voltmeter	ACV or DCV	V=CxR
RESISTANCE	The opposition (restriction) to current flow	Ohms	A	Ohmmeter	Ohms	R=V÷C

Table 1

Ohms Law

The three electrical elements have a direct effect on each other. The formula to calculate this effect is Ohms Law.

The illustration at the right is Ohms law. The letters represent the properties in the system.

V = Voltage,
C = Current,
R = Resistance.
(Hint: remember VCR.)
If you know any two of the values you can apply the proper mathematical formula and find the third.

Lets apply Ohms Law to a circuit

Example 1: A starter motor for a WORKMAN 3200 Gas draws 90 amps when the system is operating correctly.
Since we know the voltage and the current, we find the resistance by taking the voltage and dividing it by the current. (fig.6) 12.5 volts ÷ 90 amps = 0.135Ω.

Example 2: If we increase our system resistance to 0.2Ω, what will happen to our current flow? 12.5 volts ÷ 0.2Ω = 62.5 amps. An increase in our system resistance will decrease the current flow in our circuit. This will result in what symptom? (Answer = slow crank or no start.)
What happens if we decrease our starting system resistance to 0.04Ω? 12.5 volts ÷ 0.04Ω = 312.5 amps. This will result in what symptom? (Answer = slow crank or no start.)

How can higher resistance cause the same symptoms as lower resistance? With higher resistance, the amount of current flowing to the starter is limited by the additional resistance in the circuit. In the case of lower resistance, the only way to lower resistance in a circuit is to provide a shorter path to ground or another path to ground. (That means that a portion of the amperage flow is taking a different path to ground than originally intended. So the result is actually a lower power output from the starter).

Ohms Law

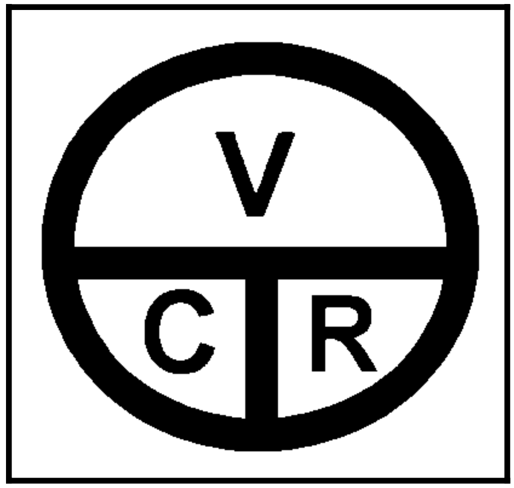


Figure 5

Example 1

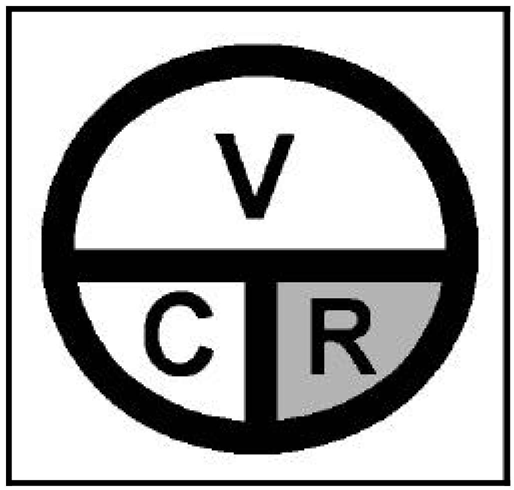


Figure 6

Example 2

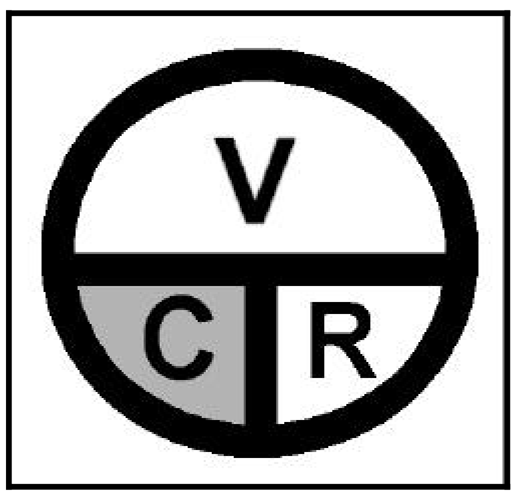


Figure 7

Example 3: A circuit contains a light bulb that measures 4 ohms. The current flow is 3 amps. What is the voltage of the power source? 3 amps X 4A= 12 volts.

Example 3

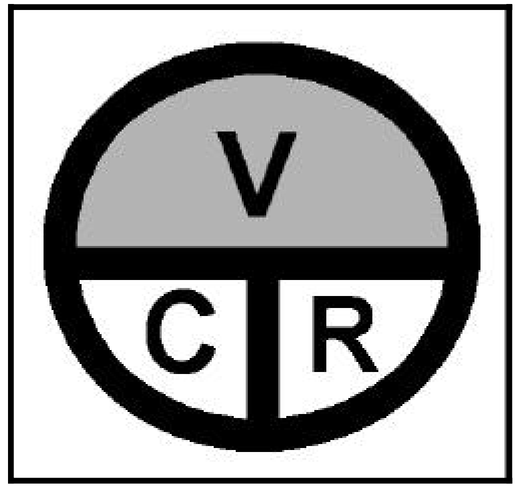


Figure 8

Figure 9 shows some common electrical symbols.

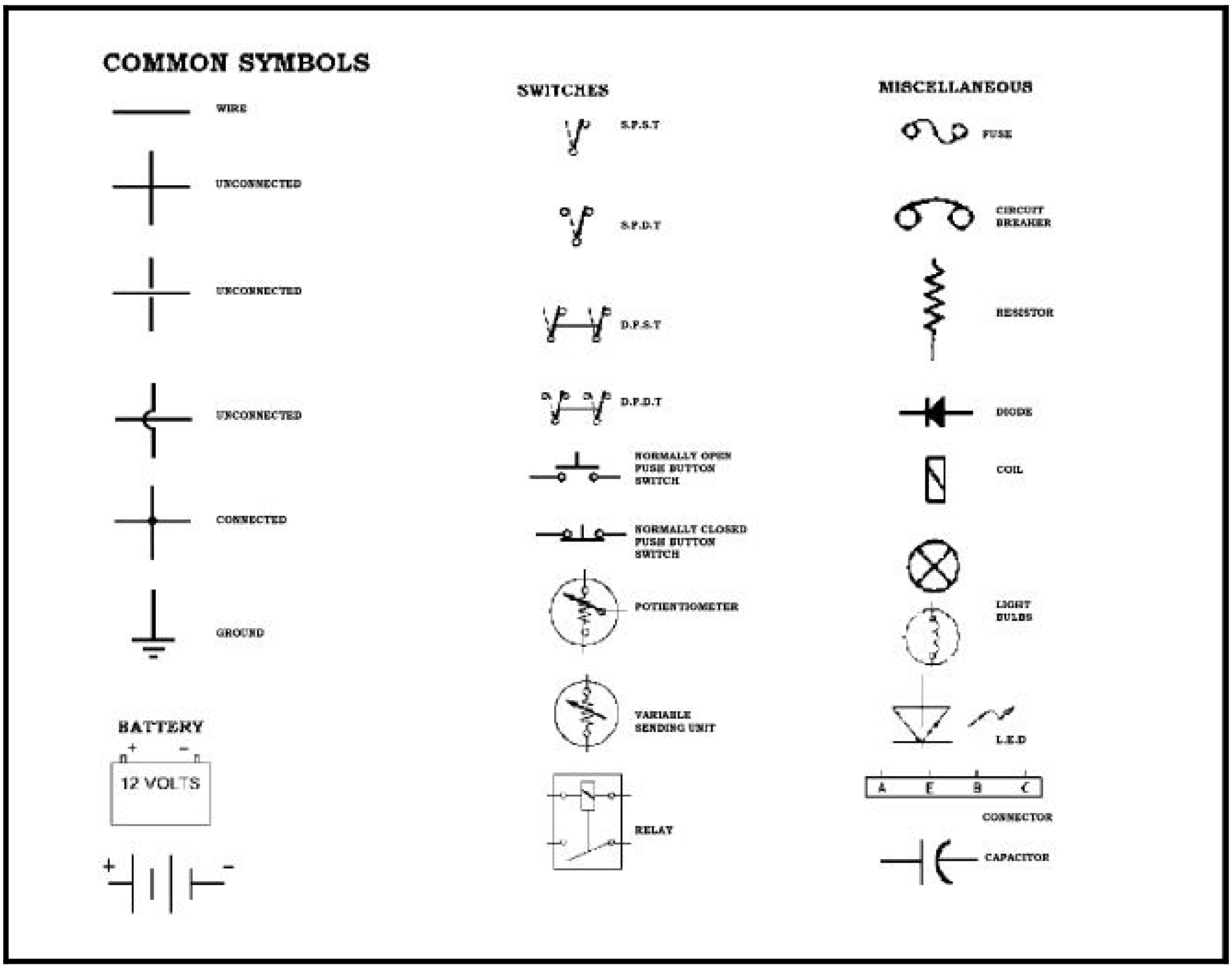


Figure 9

Electrical Testing Equipment

Lets look a some common test equipment

Test lights

Features
1. Used for checking for power in a circuit.
2. Can’t give actual voltage readings.
3. Should not be used on electronic circuits

Test lights

Figure 10

Analog meter

Features
1. Voltage (Pressure) testing.
2. Amperage(Flow) testing.
3. Resistance(Restriction) testing.

Analog meter

Figure 11

Digital-Volt-Ohm meter (DVOM)

Features
1. Voltage (Pressure) testing.
2. Amperage(Flow) testing.
3. Resistance(Restriction) testing.
4. Diode (Check valve) testing.

Digital-Volt-Ohm meter (DVOM)

Figure 12

Advantages of a Digital meter vs. Analog meter

DVOM Advantages:

1: DVOM"s generally are a high impedance (10 Megohm) design.
2: Many DVOM's are "auto-ranging."

NOTE: TORO recommends the use of a DIGITAL mulitmeter when testing electrical circuits.

Advantages of a Digital meter vs. Analog meter

Figure 13

Multimeter Uses

Measuring Current with an Ammeter

1. Open circuit and connect meter in series
2. Close switch and activate circuit
3. Read amperage on meter.

Measuring Current with an Ammeter

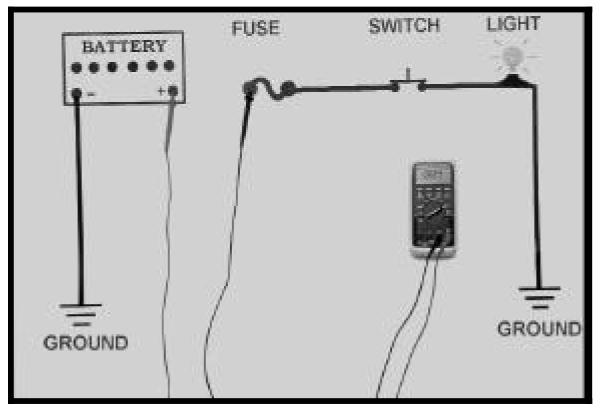


Figure 14

Measuring Voltage with a Voltmeter

1. Connect meter across load
2. Close switch and activate circuit
3. Read voltage on meter.

Measuring Voltage with a Voltmeter

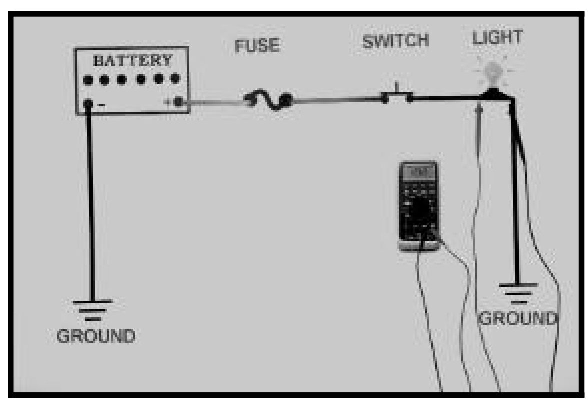


Figure 15

Series connection for voltage readings

Connecting a voltmeter in series checks the complete circuit for continuity. A meter reading of battery voltage, indicates that there is continuity from the battery, to the load and back to the battery. A meter reading of 0.0 volts indicates an open circuit.

Measuring Resistance With an Ohmmeter

1. Isolate the load from the circuit
2. Connect meter across load
4. Read resistance on meter.

High Amperage Circuit Testing

Generally, testing electric circuits over 10 amps will exceed most DVOM's capacity.

Measuring current with AC/DC Current Transducer (Inductive)

1. Clamp meter around wire
2. Activate system
3. Read amperage on meter

Series connection for voltage readings

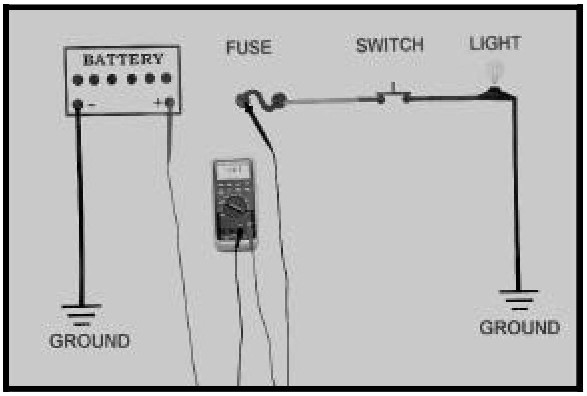


Figure 16

Measuring Resistance With an Ohmmeter

Figure 17

AC/DC Current Transducer (Inductive)

Figure 18

Basic Circuit Testing

Voltmeter testing.

When testing for voltage we connect a voltmeter to the positive and negative post of the battery, we should read 12.6 volts.

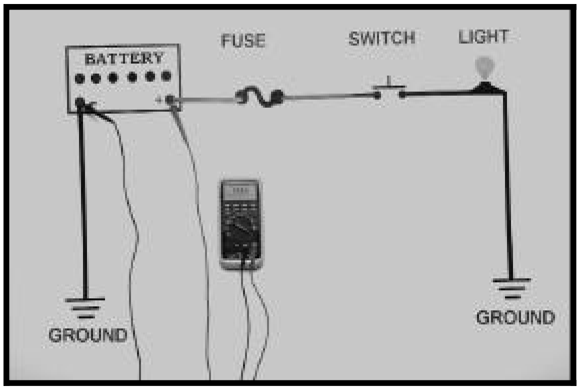


Figure 19

If we connect our voltmeter to the negative post of the battery and to any point up to the switch, we will still measure 12.6 volts. All we are measuring is the voltage available up to the switch. (See fig 20.)

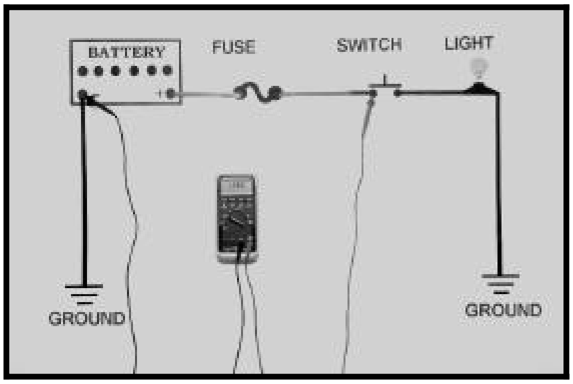


Figure 20

Connecting the voltmeter across the load with the switch open will show a voltage reading of 0.0 volts. Without the switch closed, (no current flowing in the circuit) there is no voltage difference across the load.

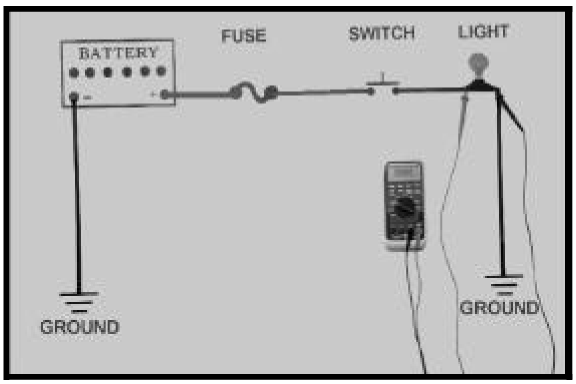


Figure 21

When we close the switch, current flows in the circuit. We will then read a voltage drop (pressure difference) across our load. There must be current flowing in the circuit to measure the voltage difference across the load.

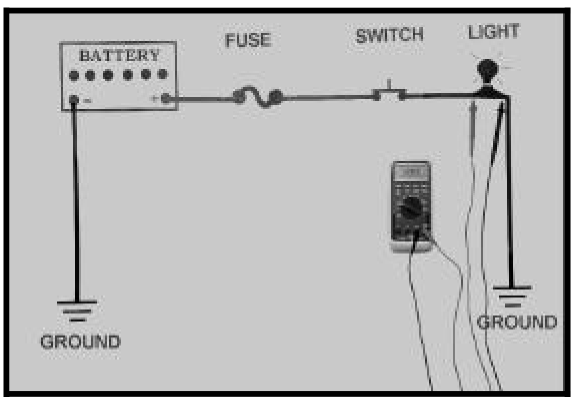
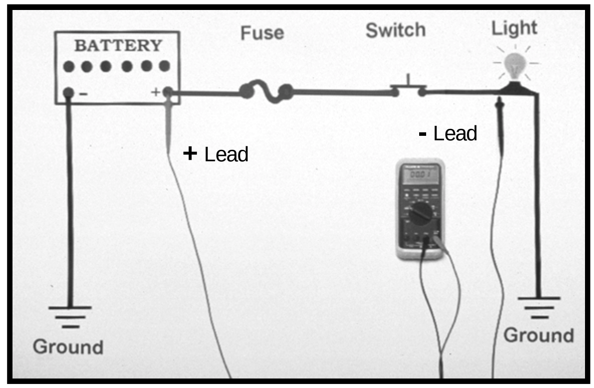


Figure 22

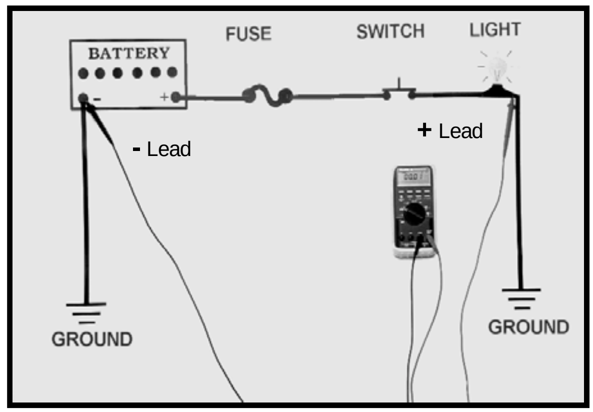
Understanding voltage drop testing.

Testing for voltage drop.

1.) Connect the voltmeter red lead (+) to the power (or "most" positive) side of the component, circuit or connection to be tested.
2.) Connect the voltmeter black lead (-) to the ground (or "least" positive) side of the component, circuit or connection to be tested.
3.) Set the meter scale to exceed the expected test voltage. (Auto-range on digital voltmeters).
4.) Turn "on" the circuit, (remember, current must be flowing through the circuit for resistance to be found) and read the voltage.



Voltage Drop Test - Feed Side of Circuit
Figure 23



Voltage Drop Test - Ground Side of Circuit
Figure 24

Voltage drop testing can isolate areas in a circuit where undesirable resistance is present. It is an important test for both low and high amperage circuits. See table 2 for maximum voltage readings when testing circuits.

When to perform a voltage drop test.

When you encounter poor performance from an electrical component. A test of the circuit indicates that the amperage flow is lower than required to operate the system. The area of excessive resistance must be located and repaired. Performing a voltage drop test will help locate the area of excessive resistance.

Voltage drop specifications (Maximums)

High Amperage Circuits (>20 A)	Low Amperage Circuits (<20 A)
0.4 Volts feed side	0.2 Volts feed side
0.4 Volts ground side	0.2 Volts ground side

Table 2

Electrical Components

Let's look at components and the testing of the components.

Battery

A battery is an electrochemical device that can store electrical energy.

Caution: Gas vapor from a battery is flammable. Keep all sparks and flames away from a battery or an explosion can occur.

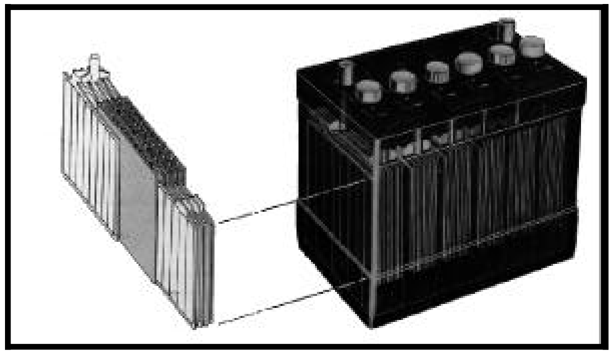


Figure 25

Battery Tests

There are two basic battery tests

Specific Gravity Test (use table 3)

The specific gravity or weight of the battery electrolyte indicates state of the battery charge. A battery hydrometer measures the specific gravity of the electrolyte. Hydrometers are calibrated to measure specific gravity correctly at an electrolyte temperature of 80ºF. To determine the correct specific gravity reading when the temperature of the electrolyte is other than 80ºF: **Add** to the hydrometer reading four gravity points (0.004) for each 10ºF **above** 80ºF. **Subtract** four gravity points (0.004) for each 10ºF **below** 80ºF.

TEST	TEST RESULTS	CONDITION	CORRECTIVE PROCEDURE
SPECIFIC GRAVITY TEST @ 80ºF	GRAVITY BETWEEN 1.250 - 1.280	CHARGED	PERFORM LOAD TEST
	GRAVITY BELOW 1.240	DISCHARGED	RECHARGE PERFORM LOAD TEST
	MORE THAN 50 GRAVITY POINTS (0.050) VARIATION BETWEEN CELLS	(A) SHORTED CELL (B) ACID LOST (C) OLD BATTERY	REPLACE
LOAD test (15 seconds)	MINIMUM TERMINAL VOLTAGE** ** See temperature compensation chart Table 4	(A) DISCHARGED (B) OLD BATTERY	(A) RECHARGE (B) REPLACE

Table 3

* Amperage load should equal one-half the cold cranking amperage of the battery
3 X Amp-Hr rating for 12-volt batteries

Battery Load Test

To test the battery connect the load tester to the battery posts and apply a current load of <u>one-half the cold cranking amperage for 15 seconds.</u> If the cold cranking amperage is not known, use <u>three</u> times the Amp-Hr rating of the battery for 12 volt batteries. (T<u>wo</u> times the Amp-Hr rating for 6 volt batteries). Check the minimum terminal voltage and reference the temperature compensation chart (table 4). If the battery fails this test recharge the battery and test again.

Temperature Compensation Chart

Battery electrolyte temperature	Minimum voltage "under load" @ end of test
70º F (21 deg C)	9.6 VOLTS
60º F (16 deg C)	9.5 VOLTS
50º F (10 deg C)	9.4 VOLTS
40º F (4 deg C)	9.3 VOLTS
30º F (-1 deg C)	9.1 VOLTS
20º F (-7 deg C)	8.9 VOLTS
10º F (-12 deg C)	8.7 VOLTS
0º F (-18 deg C)	8.5 VOLTS

Table 4

Common switches

Description:
Manually operated switches that control current flow in the circuit.

Toggle switches
Push button

Commonly used for Neutral, light, horn and seat switches.

Common switches

Figure 26

Key switch

Used to control unit starting, running, and accessories

Testing
Test Switches with an Ohmmeter. Look for continuity when closed, infinity when open.
When the switch is in the circuit, the switch is tested with a voltmeter.

Key switch

Figure 27

Electromagnetic switches

Description:
Electrically operated switches that control current flow in the circuit.

Types:
1. Relays
2. Solenoids

Relays

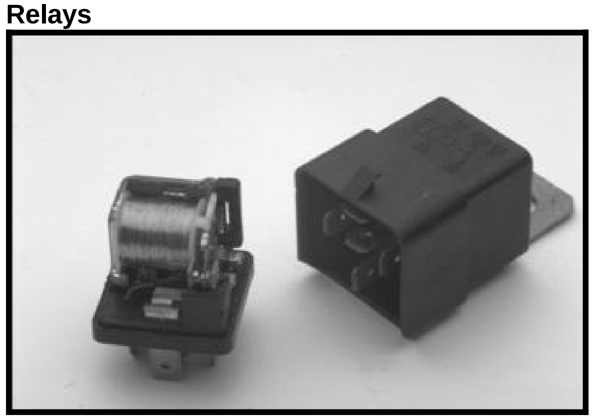


Figure 28

Testing
Relays and solenoids are tested with an Ohmmeter.
Relay test
Terminal 85 to 86 = 76 A or 86 A.
Terminal 30 to 87A = Normally closed
Terminal 30 to 87 = Normally open (until power is applied to terminal 85 & 86).

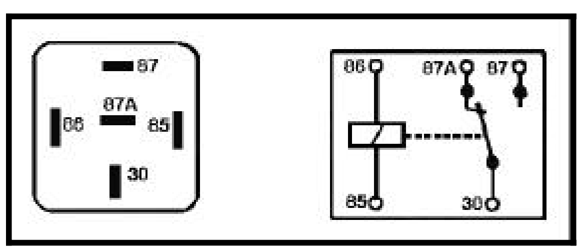


Figure 29

Magnetic switches (Reed Switches)

Description:
Magnetically operated switches that control current flow in the circuit.

Types:
Seat switches

Testing
Magnetic reed switches are tested with an Ohmmeter and using a magnet to close the switch.
1. Magnet away from switch, meter reading O.L. (open)
2. Magnet close to switch, Meter reading 0.2 A (closed)

Pressure switches.

Description:
Pressure operated switches that control current flow for lights and gauges.

Types:
1. Engine oil pressure
2. Hydraulic oil pressure
3. Filter restriction senders

Testing
Pressure switches are tested with an Ohmmeter. Look for continuity when closed, infinity when open. They can be normally open and close at a certain pressure, or normally closed and open at a certain pressure.

Temperature senders and switches

Description:
Temperature controlled switches and senders.

Types:
1. Engine coolant temperature switch and sender
2. Hydraulic system temperature switch and sender

Magnetic switches (Reed Switches)

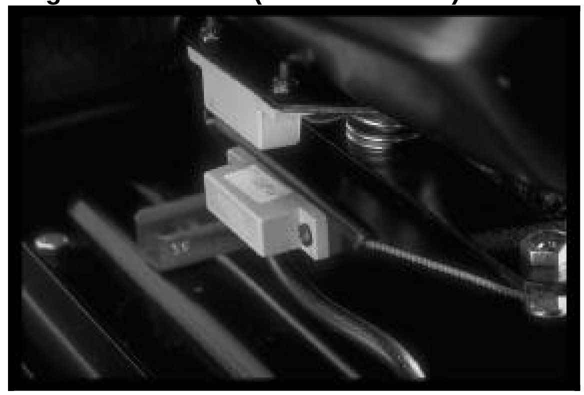


Figure 30

Pressure switches.

Figure 31

Temperature senders and switches

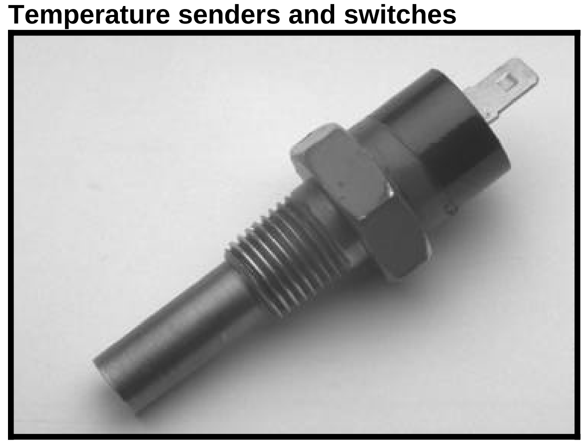


Figure 32

Testing

Temperature switches are tested with an Ohmmeter. With the ohmmeter check if the switch is open or closed. Submerse the sensing bulb in hot water and watch for switch change. (Note: The switch actuation temperature is usually noted on the switch).

Temperature senders are tested with an Ohmmeter.
Measures the resistance of the sender, then submerse the sensing bulb in hot water and watch for resistance change.

Figure 33

Speed sensors

Description:
Switches that sense movement or speed.
Can be operated by a magnet, or sense a moving shaft.

Types:
1. Reel speed sensors
2. Ground speed sensors

Testing
Sensors are tested with an Ohmmeter. Connect the ohmmeter and observe the resistance change when the shaft or gear is moved.

Speed sensors

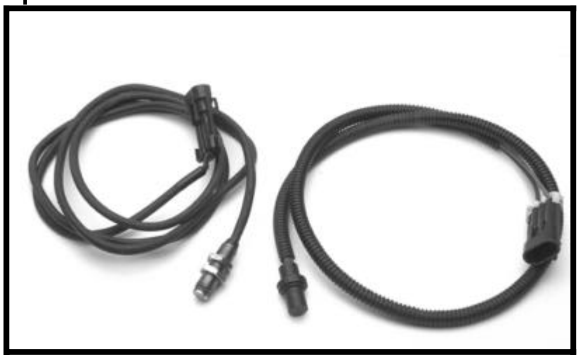


Figure 34

Potentiometers

Description:
Variable resistance switches.
Types
1. Height of cut (H.O.C.)

Potentiometers

Figure 35

Testing
Connecting the Ohmmeter to the two outside terminals will show the total potentiometer resistance. Connecting the Ohmmeter to the center and one outside terminal will show varying resistance when the potentiometer is turned.

Figure 36

Circuit Protection

Description:
Device that interrupts current flow if current flow becomes excessive.

Types:
1. Fuses
2. Circuit Breakers

Testing
Fuses and circuit breakers can be checked with an Ohmmeter if disconnected from the circuit, or checked with a voltmeter while in the circuit.

Load Devices

Description:
Device that converts electrical energy to work.

Types:

Lights

Lights can be tested with an Ohmmeter.

Fuses

Figure 37

Circuit Breakers

Figure 38

Lights

Figure 39

2. Glow Plugs

Glow plugs can be tested with an Ohmmeter and the resistance measured. They can also be removed and connected to a 12 volt battery. If the end glows red the plug is OK.

Another way to test glowplugs is to measure the amperage draw of the glowplug circuit. Normal amperage draw is about 10 amps per glowplug.

Glow Plugs

Figure 40

Figure 41

3. Solenoids

Solenoids are used to control hydraulic valves, fuel injection pumps and some small mechanical functions.

Solenoids

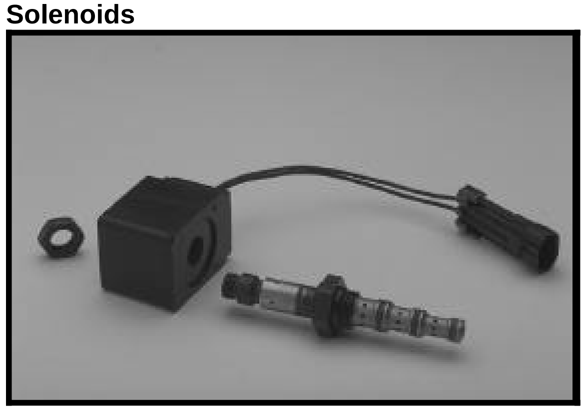


Figure 42

The solenoids can be checked with an ohmmeter or an ammeter. The solenoids currently used come in two different size ratings, 20 and 28 watt. 20 watt solenoids have a resistance of 7.2 A and an amperage draw of 1.66 amps. The 28 watt solenoids have a resistance of 5.1A and a amperage draw of 2.35 amps.

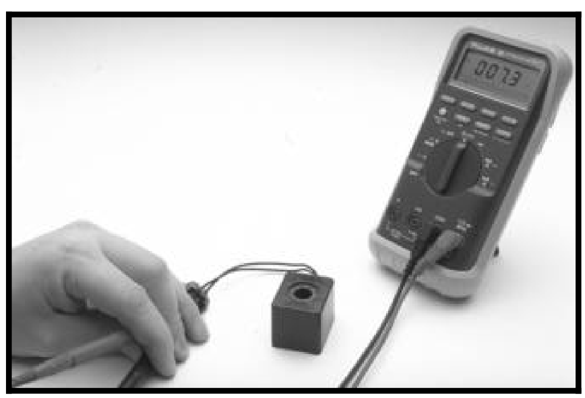


Figure 43

Starter Motors

Description:
Device that converts electrical energy into rotary mechanical energy.

Components:

Drive. Mechanical connection between the starter and the engine.
Armature. Main shaft of the starter that rotates when power is applied to the starter.
Field coil or stationary magnet. Produces the magnetic field to turn the starter.
Starter solenoid (if equipped). Sends the high amperage power to the starter.

Testing

The starter can be tested for current draw using an ammeter.

The field coil is tested with an Ohmmeter checking for shorts and continuity.

The armature is tested with an Ohmmeter to check for shorts between the windings and the armature, and to check for continuity of the windings.

Alternators

Device that produces AC current, then converts this current to DC for equipment functions.

Types:

Stator type, located behind the engine flywheel.

Starter Motors

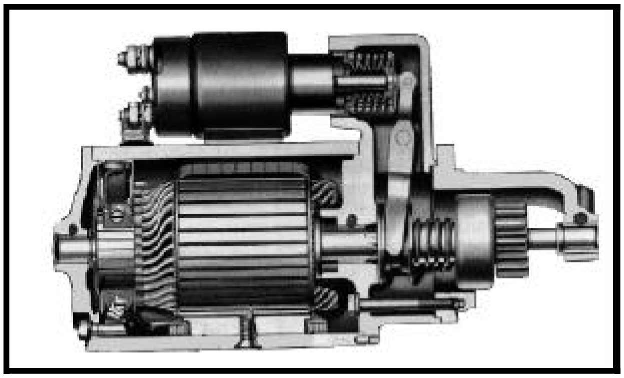


Figure 44

Typical starter draw at 65°F (18°C)	
Groundsmaster 223-D	215 A
Groundsmaster 224	110 A
Groundsmaster 325-D	210 A
Groundsmaster 345	75A
Groundsmaster 455-D	230 A
Greensmasters 3000	85A
Reelmaster 223-D/5100-D	215A
Reelmaster 5300-D	250A
Reelmaster 335-D/3500-D	230A
Reelmaster 450-D/4500-D	300A
Workman 3200	90A
Workman 3200-D	170A
Sand Pro 5000	125A
Multi-Pro 1100	80A
Hydroject 3000	110A

Table 5

Stator type

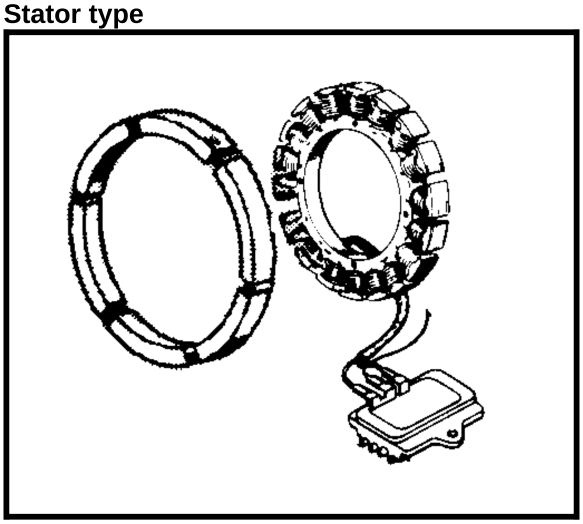


Figure 45

Testing

Refer to the stator type alternator testing table. (Table 6)

Problem	Test	Conclusion
No charge to battery	1. Insert an ammeter in between the battery lead and the B+ terminal. Connect a voltmeter from b+ lead to ground. Run the engine at high idle. If voltage is 13.8 volts or higher, and there is no amperage, place a minimum load of 5 amps on the battery to create a load on the system, observe the ammeter	1. If the charge rate increases when load is applied the charging system is OK and the battery was fully charged. If the charge rate does not increase when a load is applied, test stator and rectifier-regulator. (Test 2 and 3)
	2. Remove the stator wire connector from the rectifier-regulator. With the engine running at high idle, measure AC voltage across the stator leads (lead ac & ac) with an AC voltmeter.	2. If the voltage is equal to the specification in the service manual or greater, the stator is OK. The rectifier-regulator is faulty. Replace the rectifier-regulator. If the voltage is less than specified voltage, the stator is probably faulty and should be replaced. Test the stator further using an ohmmeter (test 3).
	3a. With the engine stopped, measure the resistance across the stator leads (ac & ac) using an ohmmeter.	3a. If the resistance is equal to the specifications, the stator is OK. If the resistance is 0 ohms, the stator is shorted. Replace stator. If the resistance is infinity ohms, the stator is open. Replace the stator.
	3b. With the engine stopped, measure the resistance from each stator lead to ground using an ohmmeter.	3b. If resistance is infinity ohms (no continuity), the stator is OK (not shorted to ground). If resistance or continuity is measured, the stator leads are shorted to ground. Replace the stator.
Battery Continuously charges at high rate	1. With engine running at high idle, measure voltage from B+ lead to ground using a DC voltmeter.	1. If voltage is 14.7 volts or less the charging system is OK. The battery in unable to hold a charge. Service the battery or replace as necessary. If voltage is more than 14.7 volts, the rectifier-regulator is faulty. Replace rectifier-regulator

Table 6

Alternator Assembly

Testing

Alternators can be tested on the machine, on a alternator test bench, or disassembled and the components tested.

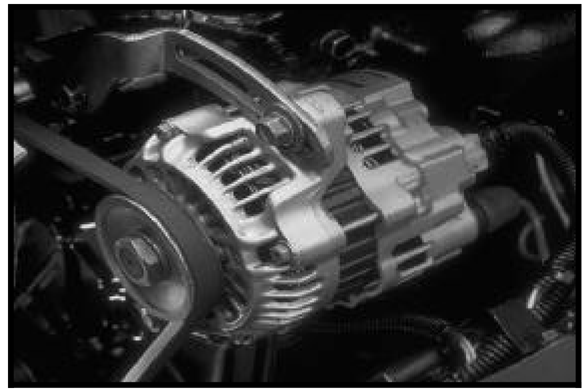


Figure 46

1. Rotor

The rotor windings should be checked for continuity, connect the ohmmeter leads to both slipper rings.

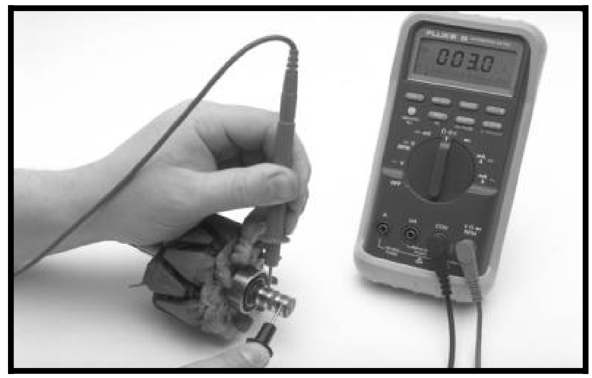


Figure 47

The rotor should be checked for shorts between the windings and the housing. Connect the ohmmeter leads to one slipper ring and the rotor housing.

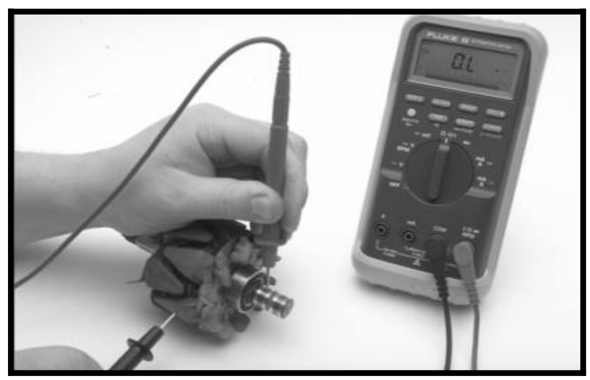


Figure 48

Stator

The stator should be checked for continuity, connect the ohmmeter to the stator windings.

Figure 49

The stator should be checked for shorts, connect the ohmmeter to the stator windings and the housing.

Figure 50

Ignition coils

Description
Device that increases battery voltage to the level required to fire the spark plugs.

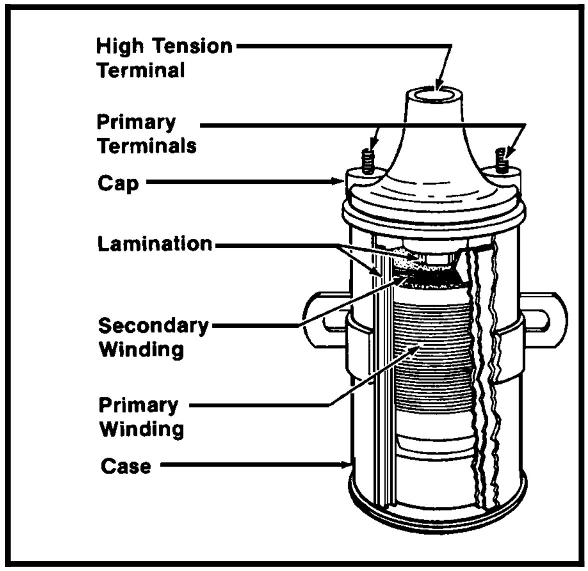


Figure 51

Testing

The coils can be tested with an Ohmmeter. You should have continuity between the + and the - posts and also between the center post and the
+ & - posts

Diodes

Description
Electrical device that allows current to flow in one direction but not the other.

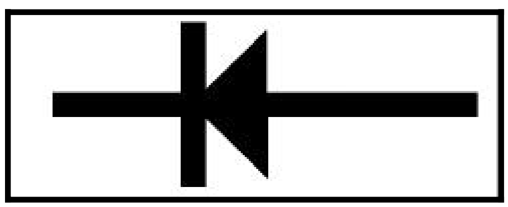


Figure 52

Testing

Diodes can be checked with an Ohmmeter. The meter should show continuity in one direction and open in the other direction. Diodes should be checked with a DVOM with a diode test function.

Basic Circuits

Ignition Systems

Lets look at various types of ignition systems used to operate most gasoline engines.

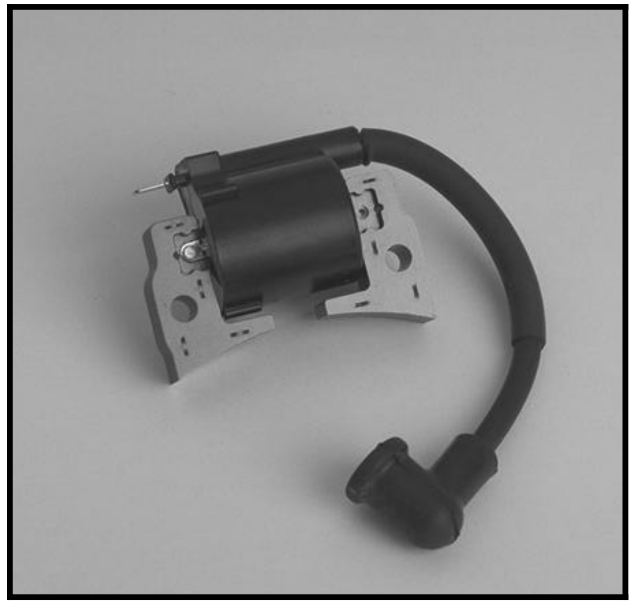


Figure 53

Magneto Ignition

There is two basic types of magneto ignition systems. The first type uses a primary and secondary coil assembly, a set of breaker points, a condenser and the spark plug. In this type of a system the magnets induce current in the coil, the breaker points are opened and the spark is produced.

The second and later type is a solid state magneto. This type of system uses a solid state module instead of the breaker points. There is a triggering coil within the module, and when the magnets reach a certain point, the triggering coil causes the circuit board to stop the current flow in the primary coil and the high voltage discharge is produced in the secondary coil.

The only basic difference between the two types of magneto systems is the way the current flow in the primary coil is interrupted.

Engines equipped with magneto ignitions are stopped by grounding out the primary coil. This is done through a key switch or a kill switch.

Battery Ignition

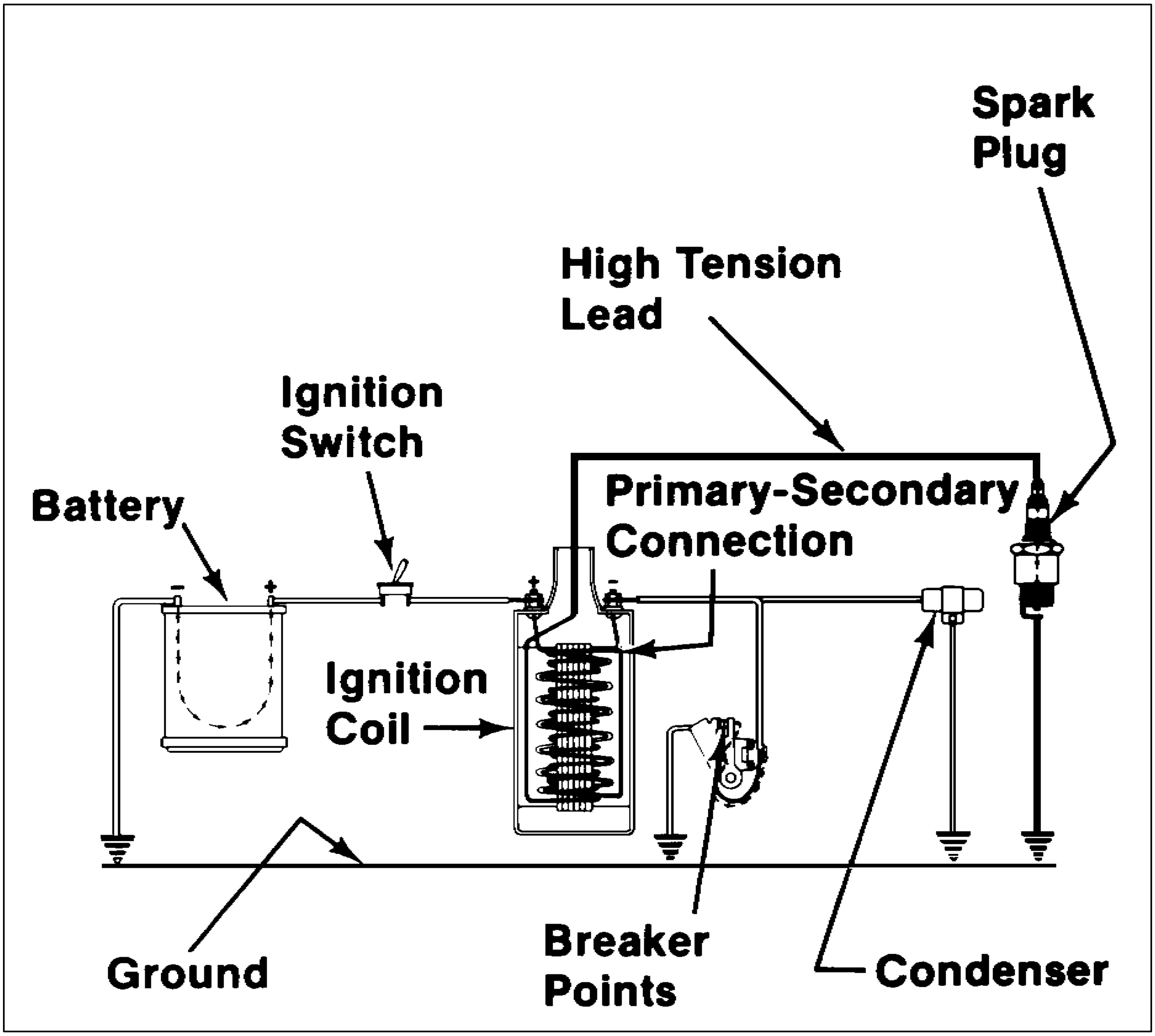


Figure 54

Battery ignition systems use power from the battery to operate the system. This current flows from the battery, through the ignition coil, then through the breaker points to ground. As the engine runs the breaker points open and this interrupts the current flowing through the primary coil of the ignition coil. The collapsing field in the coil induces a high voltage discharge in the secondary windings which is sent to the spark plug. The ignition timing is controlled by the point where the breaker points open.

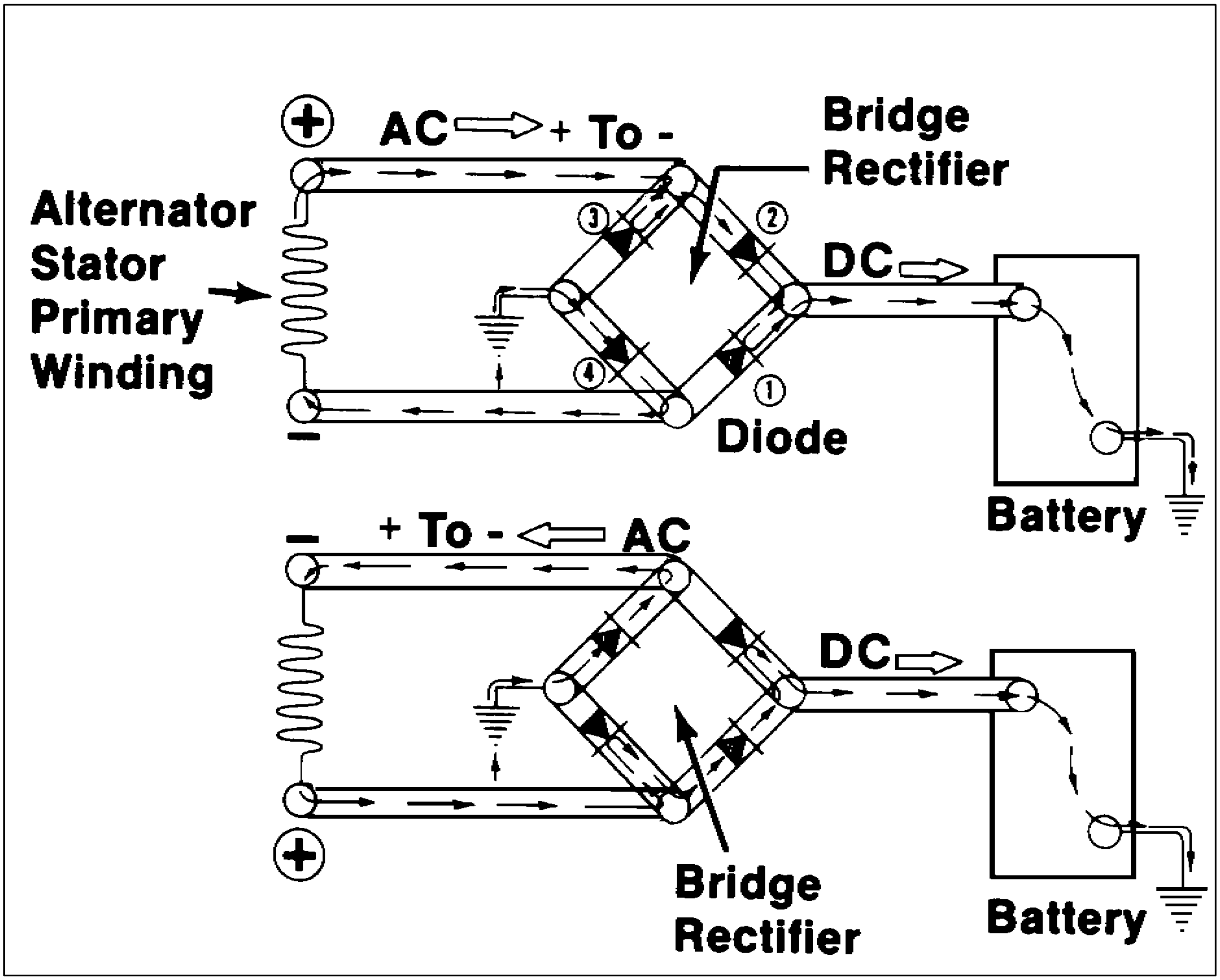


Figure 55

Stator type charging systems operate by producing alternating current in the stator coils and converting this current (AC) to direct current(DC). This is done by the bridge rectifier. The alternating current is allowed to flow out of the rectifier to the battery in only one direction. Figure 55 shows a full wave rectifier. The current produced in both directions is converted to DC.

Review Questions

Answer the following review questions.

1: Current is measured in?

A: Volts.
B: Amps.
C: Ohms.

2: Voltage is?

A: Current flow in a circuit.
B: Electrical pressure.
C: Resistance to current flow.

3: Ohms is the measurement of:

A: Electrical pressure
B: Resistance to electrical flow.
C: Unit of electrical work.
D: All of the above.

4: Which in **not** a Ohms law formula?

A: Current = Voltage ÷ Resistance
B: Voltage = Current x Resistance
C: Voltage = Resistance ÷ Current
D: Resistance = Voltage ÷ Current

5: Resistance is measured with a?

A: Voltmeter.
B: Ohmmeter.
C: Ammeter.

6: Which is true about an ohmmeter?

A: It is connected in series with the circuit.
B: It has its own voltage source.
C: It can be used to measure voltage.
D: It measures current flow in amperes.

7: To measure voltage you:

A: Connect meter in parallel.
B: Set meter to voltage scale.
C: Observe proper polarity.
D: All of the above.

8: The proper load to use when checking a battery with a cold cranking amperage rating of 400 amps is:

A: 400 Amps
B: 40 Amps
C: 200 Amps
D: 800 Amps

9: Voltage drop is?

A: Voltage difference across the battery.
B: Voltage difference across an open switch.
C: Voltage difference across a resistance.

10: Relays are?

A: Manually operated switches.
B: Electrically operated switches.
C: Circuit breakers.
D: Impossible to test.

11: Load testing a battery at 60ºF (16 deg C), What is the minimum voltage under load:

A: 9.1 Volts
B: 9.5 Volts
C: 9.6 Volts
D: 8.5 Volts

12: A component in a 12 volt system has a resistance of 4 ohms. How many amps will it draw?

A: 6 amps
B: 3 amps
C: 8 amps
D: 12 amps

13: Potentiometers are?

A: Variable speed sensors
B: Temperature sensitive switches.
C: Voltage meters.
D: Variable resistance switches.

14: Ignitions coils produce high voltage discharges.

A: True
B: False

15: The battery load test will show:

A: Water level in the battery.
B: Long term low amperage battery output.
C: Ability to deliver current under load.

16: Magneto ignition systems need?

A: Battery power to operate.
B: Engine kill terminal grounded to run.
C: Rotational movement to produce spark.
D: None of the above.

17: High voltage is produced in a ignition coil when.

A: Current flows through the coil.
B: Secondary coil is grounded.
C: Current through primary coil is interrupted.
D: When the points close.

18: Maximum voltage drop in a high amperage circuit is?

A: .4 Volts feed side & .4 volts ground side.
B: 1 volt feed side & 1 volt ground side.
C: .4 Volts feed side & 1 volt ground side.
D: None of the above.

19: Gas from a charging battery is flammable

A: True
B: False.

20: Relays use?

A: Low amperage to control high amperage circuits.
B: High amperage to control low amperage circuits.
C: Push button to control high amperage circuits.
D: None of the above

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