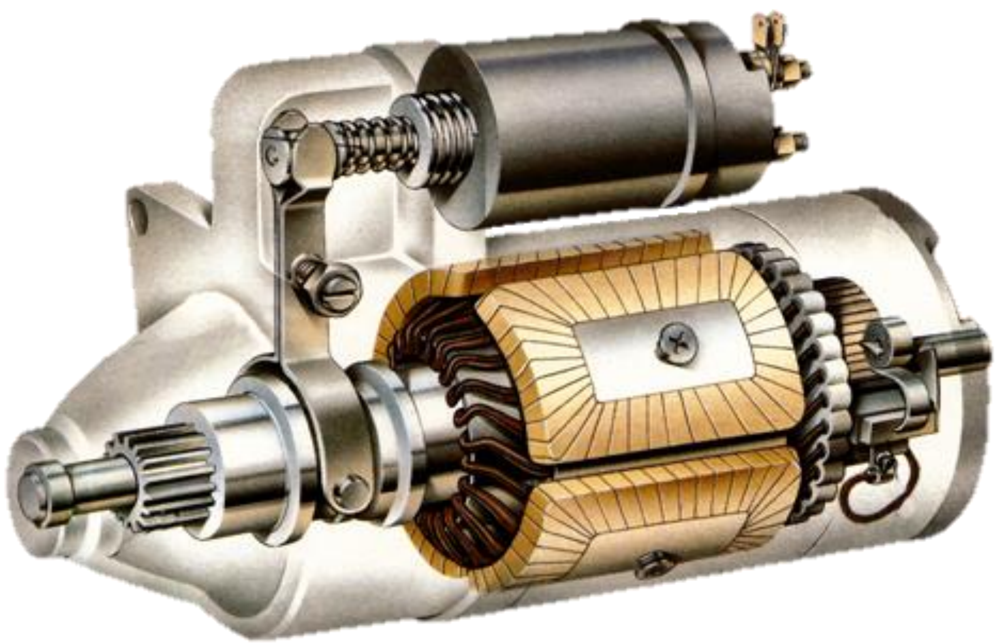
Automotive Mechanics

Level-II

Based on March 2022, Curriculum Version 1



Module Title: - Perform Minor Engine Electrical Systems Service

Module code: EIS AUM2 M04 0322

Nominal duration: 70 Hour

Prepared by: Ministry of Labor and Skill

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Addis Ababa, Ethiopia

Table of Contents

Acknowledgment

Ministry of Labor and Skills wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

Acronym

TDC	Top Dead Center
PCM	Powertrain Control Module
ZD	Zener Diode
TTLM	Teaching, Training And Learning Materials
EMF	Electromotive Force
LAP test"	Learning Activity Performance Test"
Km	Kilo Meter
CEMF	Counter Electromotive Force
KW	Kilo Watt

Introduction to module

In Electrical Systems filed; the service and test Electrical Systems project helps to know the service of work; to Performing Minor Engine Electrical Systems Service of material required; to determine the cost of the work; to estimate the expect project completion time and to know the amount of Electrical Systems Service filed.

This module is designed to meet the industry requirement under the Performing minor Engine Electrical Systems Service occupational standard, particularly for the unit of competency: carry out service and test.

This module covers the units:

- Engine electrical systems
- Minor engine electrical system service
- Clean up work area and maintain equipment

Learning Objective of the Module

- Prepare to test engine electrical systems
- Test engine electrical system
- Perform minor engine electrical system service
- Clean up work area and maintain equipment

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

1. Unit one: Prepare to test engine electrical systems identifying scope of the work

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

• Basic electricity/electronics
• Electromagnetism and transformers
  ✓ Ignition system
  ✓ Starting system
  ✓ Charging system
This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:
• Overviewing of basic electricity/electronics
• Principle of Electromagnetism and transformers
• Operating principles of ignition system
• Operating principles of starting system
• Operating principles of charging system

1.1 Overview of basic electricity/electronics Standardization

Electricity is a form of energy where electrons move from one atom to another. It exists when a voltage source creates current flow by pushing electrons with enough force to overcome the resistance of the circuit. Electricity can also be converted efficiently into other forms of energy, and it can be stored. Electricity provides light, heat, and mechanical power. It makes telephones, computers, televisions, and countless other necessities and luxuries possible.

Almost every system in a modern vehicle uses some type of electric or electronic component. Electric seats and windows, computer controlled ignition and fuel systems, electronic transmissions, anti-lock brakes, active suspensions.

1.1.1 Fundamentals of Electricity

All matter is made up atoms. Atoms have a nucleus with electrons in motion around it.The nucleus is composed of protons and neutrons. Electrons have a negative charge (-), Protons have a positive charge (+) and Neutrons are neutral.

The number of electrons in the outer orbit (valence shell or ring) determines the atom's ability to conduct electricity. Electrons in the inner rings are closer to the core, strongly attracted to the protons, and are called bound electrons. Electrons in the outer ring are further away from the core, less strongly attracted to the protons, and are called free electrons. Electrons can be freed by forces such as friction, heat, light, pressure, chemical action, or magnetic action.

These freed electrons move away from one atom to the next. A stream of free electrons forms an electrical current. To have a continuous flow of electricity, three things must be present: an excess of electrons in one place, a lack of electrons in another place & a path between the two places

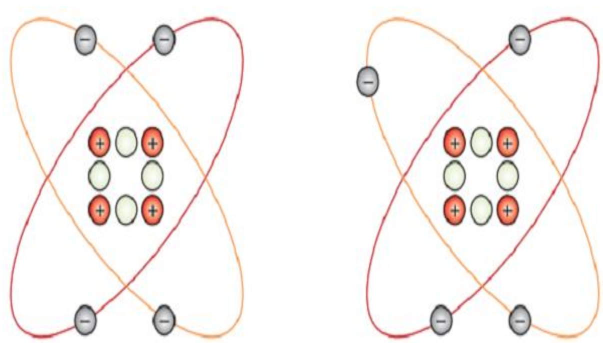


Figure 1-1 Electron on the orbit

Current Flow Theories

Two theories describe current flow.

1. The conventional theory, commonly used for automotive systems, says current flows from (+) to (-).
2. The electron theory, commonly used for electronics, says current flows from (-) to (+)

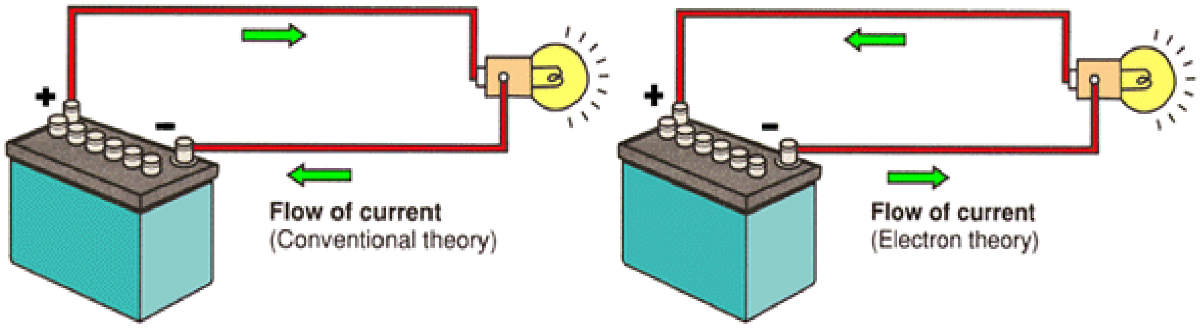


Figure 1-2 Current flow theory

While the direction of current flow makes a difference in the operation of some devices, such as diodes, the direction makes no difference to the three measurable units of electricity: voltage, current and resistance.

Electric current is a flow of electrons and is measured in amperes. The amperes is a measure of how much electrons are flowing per, second. The letter A is the symbol for amperes. A current of one ampere means that in one second about 6.24 x 1018 electrons move through a cross-section of conductor.

The force required to make current flow through a conductor is called a potential difference, electromotive force (EMF), or voltage. Electricity does not flow through a wire unless it is pushed. There has to be an electrical pressure and this pressure is called voltage and is measured in volts. The symbol is V. This pressure can be provided by a battery, or it can be produced by a generator.

Resistance (R) The opposition (resistant) to electrical (current) flow is called resistance. Every electrical component has resistance. Resistance changes electrical energy into another form of energy such as heat, light and motion etc. Resistance is measured in ohms (Ω). The amount of resistance depends upon the composition, length, cross-section and temperature of the resistive material. The resistance of a conductor increases with an increase of length or a decrease of cross-section.

1.1.2 Electromagnetism and transformers

An electric transformer is a device that uses electromagnetic induction to change the voltage of electric current. Electromagnetic induction is the process of generating current with a magnetic field. It occurs when a magnetic field and electric conductor, such as a coil of wire, move relative to one another. A transformer may either increase or decrease voltage.

The transformer in the diagram consists of two wire coils wrapped around an iron core. Each coil is part of a different circuit. When alternating current passes through coil P, it magnetizes the iron core. Because the current is alternating, the magnetic field of the iron core keeps reversing. This is where electromagnetic induction comes in. The changing magnetic field induces alternating current in coil S of the other circuit.

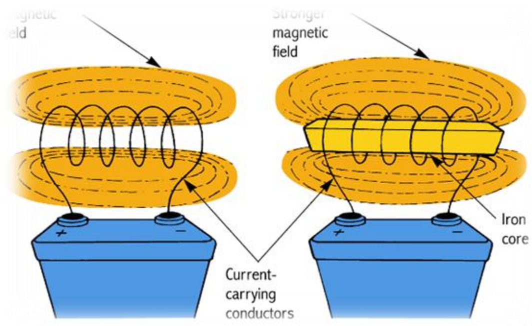


Figure 1-3 Magnetism

1.1.3 Operating principles of ignition system

i. Purpose of the Ignition system

The purpose of the ignition system is to produce the high voltage surges required to ignite the compressed air fuel mixture in the engine combustion chamber at the proper instant under all speed and load conditions. The ignition system is supplied a 12 volt or less battery voltage or charging system voltage and increases to 10,000 to 30,000 volts required to create a spark across the spark plug electrodes in the combustion chamber. There are two types of ignition systems. These are the contact point ignition system and the electronic (transistorized) ignition system.

ii. Requirements of the ignition system

a) A strong spark

The voltage that is supplied to the plugs must be high enough to ensure the generation of the powerful spark across the spark plug gaps. This is because the compressed air fuel mixture has electrical resistance.

b) Proper ignition timing

To obtain optimal combustion of the air fuel mixture, there must be means of varying ignition timing in accordance with the engine RPM and load

c) Sufficient durability

The ignition must have sufficient reliability to endure the vibration and heat of combustion and high voltage of the ignition system itself.

iii. Types of Ignition System

a) Coil ignition system

The figure shows the battery ignition system for a 4 cylinder engine. A battery of 12 volts is generally employed. There are two basic circuits in the system primary and secondary circuits. The first circuit has the battery, primary winding of the ignition coil, condenser, and contact breaker from the primary circuit. Whereas the secondary winding of the ignition coil, distributor, and spark plugs forms the secondary circuits.

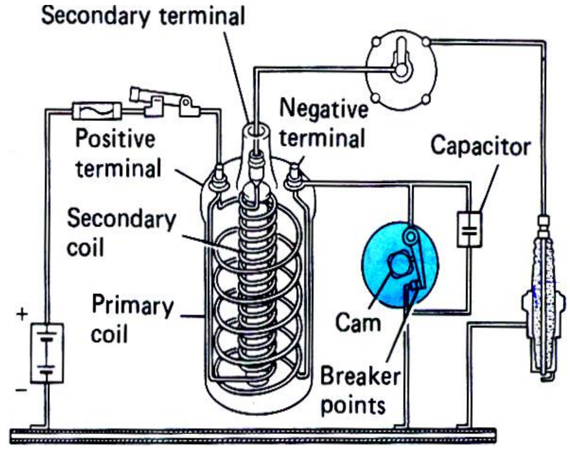


Figure 1-4 Coil ignition system

b) Magneto ignition system

The magneto ignition system has the same principle of working like that of the battery ignition system. In this, no battery is required, as the magneto acts as its own generator.

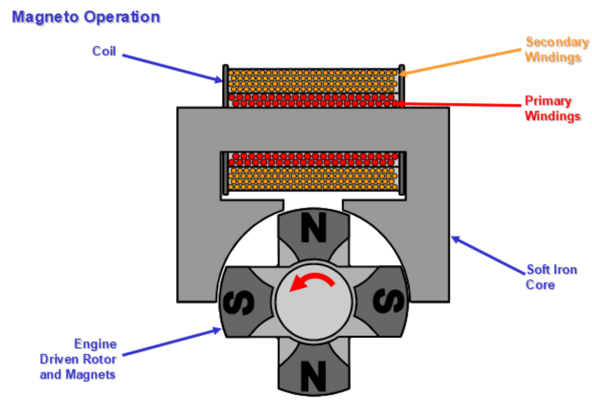


Figure 1-5 Magneto ignition system

c) Electronic Ignition System

The conventional electro-mechanical ignition system uses mechanical contact breakers. Though it is very simple, it suffers from certain limitations as follows.

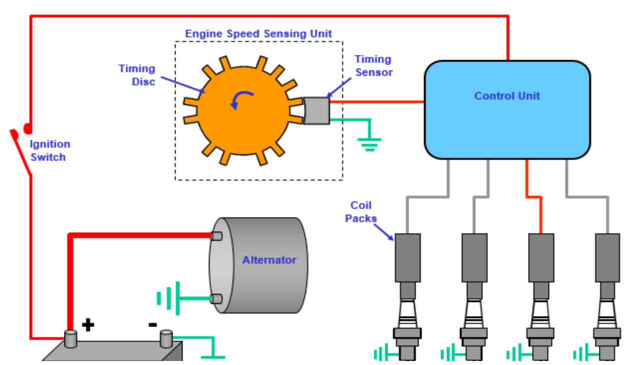


Figure 1-6 Electronic Ignition System

iv. Ignition system components and their function

The contact point ignition system included the battery the ignition coil, the ignition distributor, park plus, the wires and cables that connect them.

a) **Battery:** -It supplies current to the primary circuit of the ignition System.

Figure 1-7 Battery

b) Ignition switch: to open and close the primary circuit of the ignition System

Figure 1-8 Ignition switch

c) Ignition Coil: - It is used to produce high voltage surges by the Principle of induction in the secondary winding.

Construction Ignition Coil

Core: It consists of thin soft iron laminations. The core conducts magnetic lines of force. Hence, it increases the efficiency and output of the coil by promoting faster and more complete coil saturation.

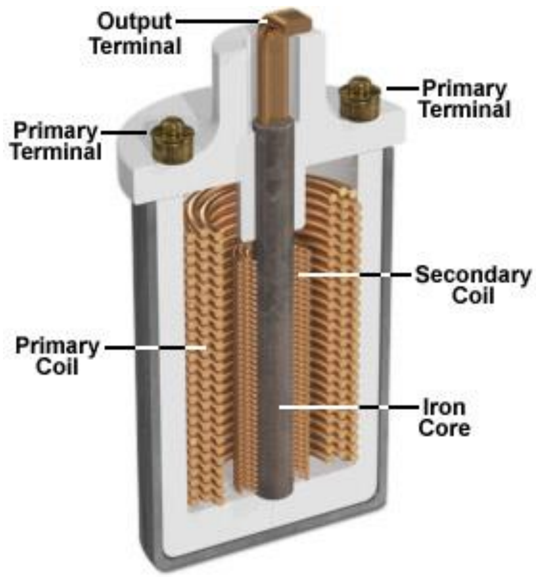


Figure 1-9 Sectional view Ignition Coil

Windings

Primary winding: It consists of approximately 250 turns of relatively heavy wire and wound around the core. It is insulated with special varnish.

Secondary winding: It consists of approximately 20,000 turns of very fine varnished wire. It is wound inside the primary winding around on the same iron core. The layers of the secondary windings are insulated from each other by high dielectric paper.

When the engine is working inside ignition coil heat buildup, this heat reduce by two ways;

By Oil

Oil may be added in the coil to dissipate heat rapidly, additionally to provide greater insulation, in case insulation material failure

By resistor

Resistor is semi-conductor device it used to produce resistance in to circuit reducing heat.

There are two types of resister variable resistor and fixed resistor in ignition system used variable resistor type.

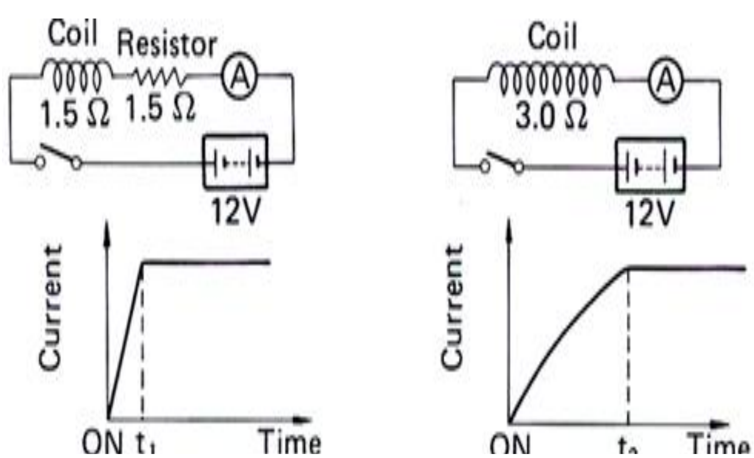


Figure 1-10 Ignition coil resistor

d) Distributor cap and Rotor

The rotor and distributor cap form a rotary switch to distribute the high voltage surges induced in the secondary winding of the ignition coil. Since the rotor sits on top of the distributor shaft. As the shaft rotates, the blade of the cap moves past the terminals which are arranged in a circle around the cap. Each of this outside terminals is connected to a spark plug cable to a spark plug.

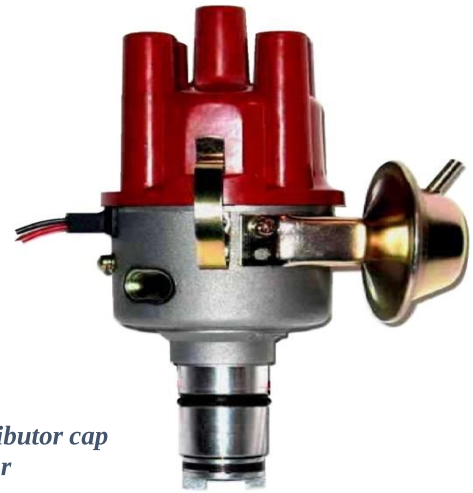


Figure 1-11 Distributor cap and Rotor

e) Contact points

These contact points control the timing of the spark. They periodically interrupt the current flow in the primary winding of the coil so that a high-intensity voltage will be induced into the secondary winding of the coil.

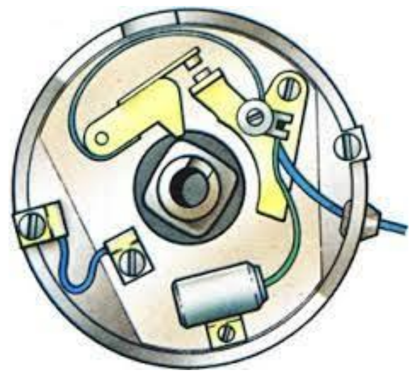


Figure 1-12 Contact points

f) Capacitor

The function of the capacitor or condenser is to reduce the arcing at the contact point. When the points first separate by providing a place where the current can be stored until the points are completely separated. This action also aids in the rapid collapse of the magnetic field with in the ignition coil so necessary for the development of high voltage in the secondary current. The self-induction voltage has also become greater through the rapid collapse of the magnetic field. It can amount to as much as 400 V. The condenser is therefore charged to this voltage.

Figure 1-13 Capacitor

g) High-tension cable

This carry and conducts the high-tension voltage pulses generated in the ignition coil to the individual sparkplugs in the correct order of firing. This cable should be:

Figure 1-14 High-tension cable

- ✓ Insulation to withstand 40,000 V systems
- ✓ Temperature from – 40 0C to + 2600C

- ✓ Radio frequency interference suppression
- ✓ About 160,000 Km product life.
- ✓ 10-year durability

h) Spark plug

It ignites the air-fuel mixture inside the engine cylinder. The spark plug provides a spark gap inside the engine cylinder.

Figure 1-15 Spark plug

When the engine is operating the high voltage current produced by the ignition coil arcs across the gap and creates spark that ignites the air fuel mixture in the cylinder.

- ✓ The sparking performance of the spark plug depends on:
- ✓ The electrode shape
- ✓ The electrode gap
- ✓ The compression pressure
- ✓ The electrode temperature

v. Ignition Coil Working Principle

A. Self-Induction

a magnetic field is generated when a current flow through as result an EMF is generated which created a magnetic flux in a direction which impede the generation of magnetic flux in coil there for current does not flow immediately when it first introduced in the coil but certain period of time is required for the current to rise for the more when current flowing in a coil and that current is cut of suddenly

An EMF generated in the coil in the direction in which the current is tending to flow in direction which hinders the decay of magnetic flux in this way when the current start flow in a coil or when current is cut off the coil generate EMF: which act to impede change in the coil magnetic flux this called the self-induction effect.

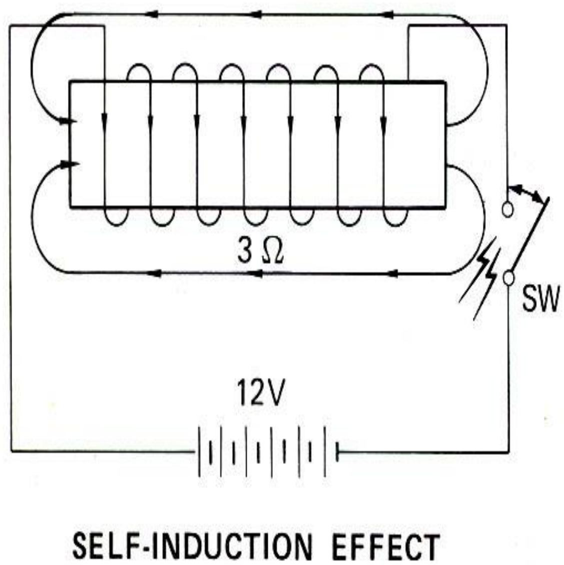


Figure 1-16 Self-Induction

B. Mutual Induction

When to coil are arranged in a line and the amount of current flowing in one of the coil(primary coil)is changed an EMF generated in other coil (secondary coil) in direction which impedes the change in primary coil magnetic flux this called the mutual induction coil effect when the switch is turned off cutting of the flow of current in primary coil the magnetic flux which has been generated up to this time suddenly disappear so an EMF it generated in the secondary coil in a direction which impedes the decay of magnetic flux .

When the contact point is closed an EMF generated in the secondary coil in a direction which impedes generation of magnetic flux by the primary coil this is opposite of what happen when the current switch off. The ignition coil generate high voltage current by means of mutual induction that takes place between the primary coil and the secondary coil cut off by the opening of the breaker points. Individual cylinders require a single spark every two revolution in case of four stroke engine, so the frequency of firing for a four-cylinder engine say at a maximum speed of 6000 rpm will be :-(6000/2) X 4 = 12 000 sparks per minute or 200 sparks per second. There is thus an extremely short interval between firing.

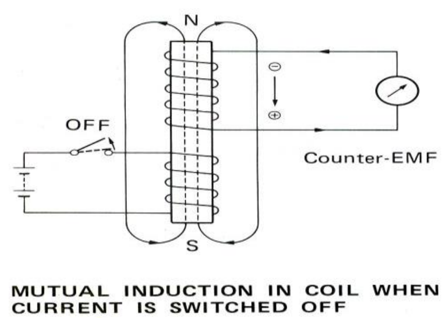


Figure 1-17 Mutual Induction

1. **Amount of magnetic flux:** The more magnetic flux generated in a coil the higher the amount of induction voltage.
2. **Number of coil winding:** the more turn in a coil the higher the induced voltage.
3. **Rate at which magnetic flux changes** the faster the change in the amount of magnetic flux generated in the coil the higher the induced voltage.

vi. Operation of Ignition System

A. Breaker Points Closed

The current from the battery flows through the positive terminal of the primary coil, through the negative terminal and breaker points, and to ground (earth).

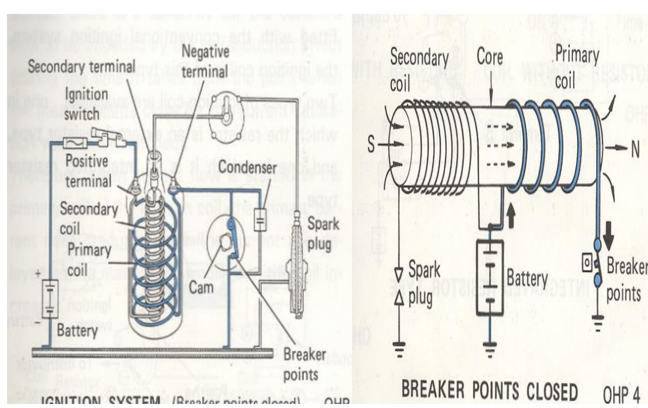


Figure 1-18 Breaker Points Closed

B. Breaker Points Open

As the crankshaft rotates the camshaft, the distributor cam opens the breaker points, causing the current flowing through the primary coil to be suddenly interrupted.

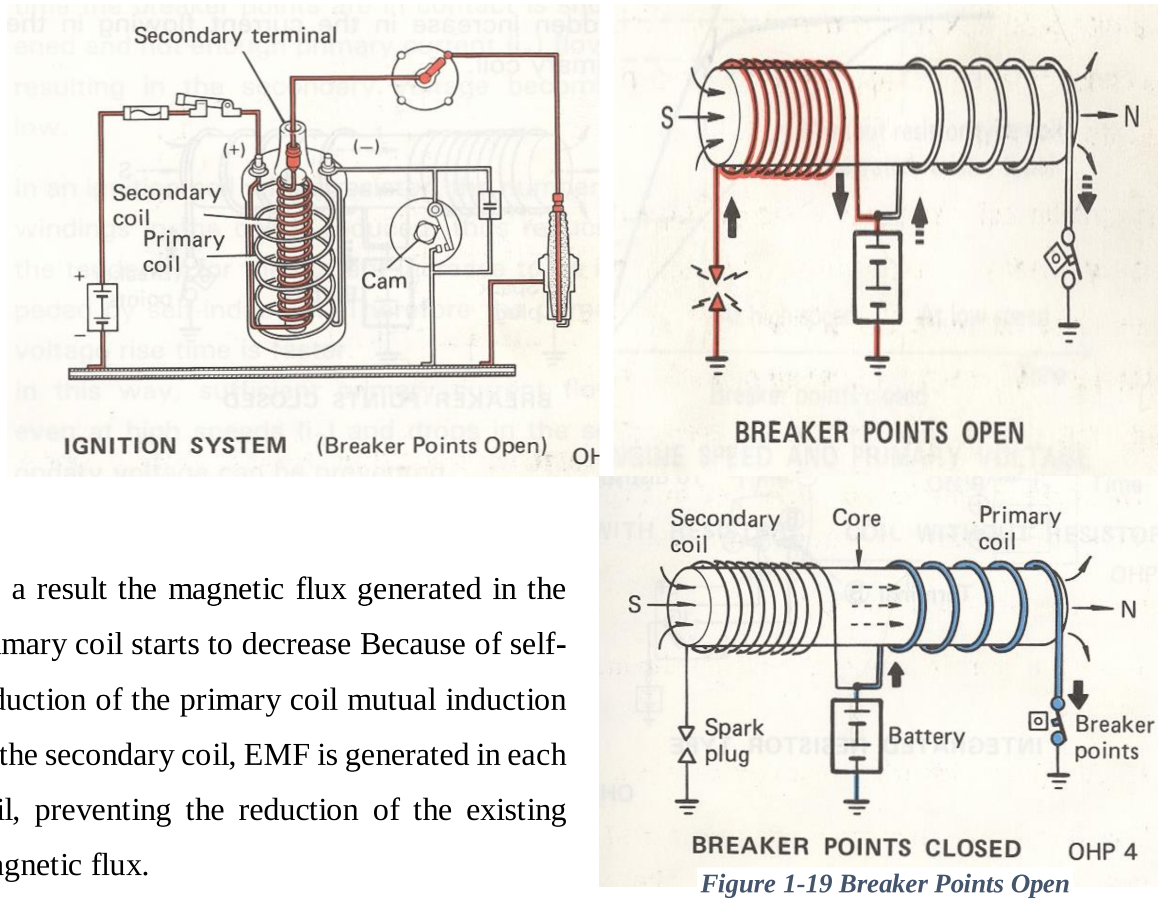


Figure 1-19 Breaker Points Open

As a result the magnetic flux generated in the primary coil starts to decrease Because of self-induction of the primary coil mutual induction of the secondary coil, EMF is generated in each coil, preventing the reduction of the existing magnetic flux.

When the breaker points close again, current starts to flow the primary coil and the magnetic flux of the primary coil starts to increase because of the self-induction of the primary coil, a CEMF is generated preventing a sudden increase in the flowing in the primary coil. As a result, the current does not increase suddenly and only a negligible mutually induced EMF is generated in the secondary coil.

vii. Dwell angle

The dwell angle refer to the angle of distributor shaft cam rotation between the time that the breaker point are closed by the breaker arm spring and the time that they are opened by the next lobe. In the point gap of the four cylinder engine has been adjusted correctly to the standard value the point should remain while the cam rotate 52 degree

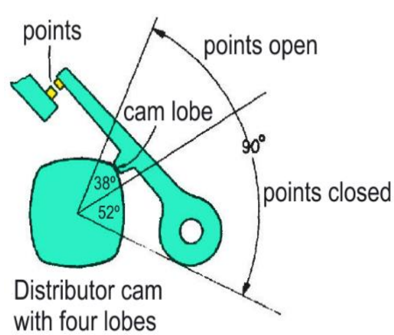


Figure 1-20 Dwell angle

Furthermore the point should open until the cam rotate another 36 degree. Since the combination of the point closing angle and opening angle is 90 degree.

viii. Advance mechanism

Need for timing advance

For the given air-fuel mixture and engine design, the time required for mixture to burn remains constant (approximately 0.002-0.003 seconds). As engine speed increase, the spark must occur earlier to assure complete burning of air –fuel mixture.

Depending on the engine design, the air-fuel mixture burning should be completed between 80-120 A TDC of the piston on the power stroke. This constant burning speed requires that the spark occur earlier with increase engine speed.

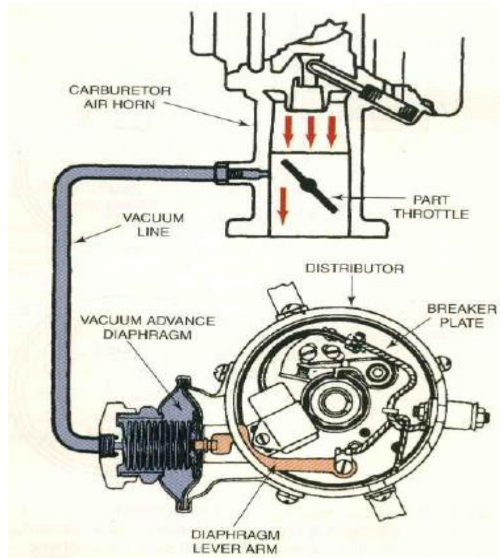


Figure 1-21 Vacuum advance Mechanism

A. Vacuum advance Mechanism

As shown on figure 1-22 this device, situated in the side of the distributor body, senses any variation of manifold vacuum, which is a measure of engine load, and automatically alters the point of firing with respect to the crankshaft angular position to suit the load.

B. Centrifugal advance mechanism

This device, situated in the base of the distributor body, senses any change in engine speed and automatically advances or retards the point of firing relative to the crankshaft angular position to suit the engine speed.

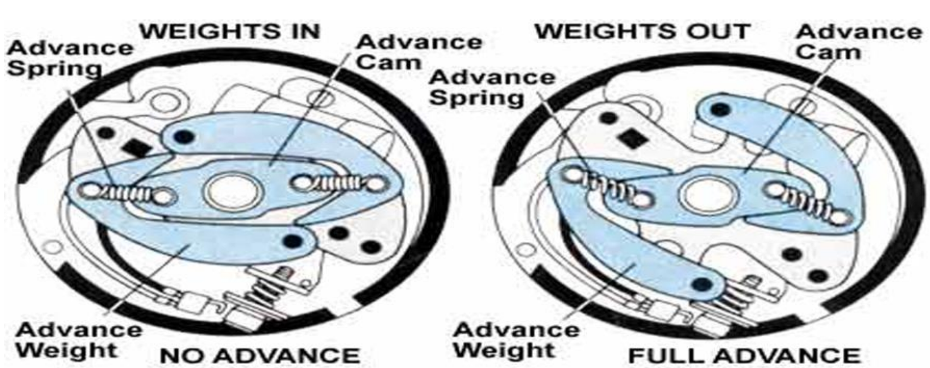


Figure 1-22 Centrifugal advance mechanism

ix. Ignition timing

The position of the point of firing relative to TDC is known as the ignition timing and is expressed in degrees of crank-angle movement. It is set by positioning the distributor body relative to one of the cam lobes so that the contact points have just opened.

- ✓ The situation which
- ✓ The spark plug fires.
- ✓ The flame travels through the combustion chamber, igniting the air/fuel mixture.
- ✓ The burning gases expand, building pressure in the cylinder.
- ✓ The pressure is maximized just as the piston hits top dead center (TDC).
- ✓ The pressure pushes down as hard as possible on the piston, creating maximum power.

Different cylinder head and piston designs change how fast the flame travels. So, the spark needs to fire at different times, to create maximum pressure at the right time. The solution is to advance or retard the timing.

Ignition Advance

Advancing the timing means the plug fires earlier in the compression stroke (farther from TDC). Advance is required because the air/fuel mixture does not burn instantly. It takes time for the flame to ignite the all the mixture. However, if the timing is advanced too far, it will because an Engine Knock. Engine speed (rpm) and load will determine how much total advance is required.

Ignition Retard

Retarding the timing means the plug fires later in the compression stroke (closer to TDC). Retarding the timing can help reduce Detonation. However, if the spark happens too late, you will lose power. This is because the cylinder pressure won't reach its max until the piston is already headed back down on the Power Stroke. Engine damage and overheating can also be a problem.

Factors affecting Ignition timing

Engine load: - For less load, engine combustion is slower and hence requires more ignition advance. But with more load on the engine, faster combustion and hence lesser advance is required.

Engine speed: - For high speed, engine needs more time for complete combustion and hence requires more ignition advance. For low speed, engine needs less time for complete combustion and hence requires lesser ignition advance.

Engine temperature: - Combustion is slower and requires more ignition advance when the engine is cold. But combustion will be faster requiring lesser ignition advance if the engine is hot.

Compression pressure: - combustion will be slower and ignition advance is required for low compression pressure whereas, for high compression pressure the combustion is faster with lesser ignition advance required.

Types of timing

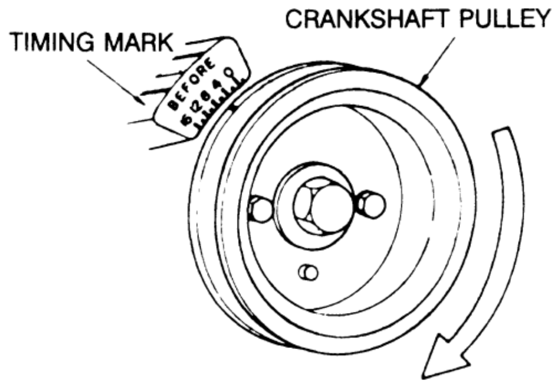


Figure 1-23 Timing mark

Static ignition timing

Static ignition timing is the setting of the distributor contact points so that they open when one piston is almost at the end of its compression stroke at some crankshaft relative angular position before TDC as specified by the engine manufacturer.

At the same time, the distributor camshaft drive must be positioned such that the rotor arm points to the cap electrode and high-tension cable corresponding to the cylinder which is about to begin its power stroke.

Dynamic timing

Figure 1-24 Timing gun

Dynamic timing is setting the ignition timing with the engine running and requires a more expensive piece of equipment called a "timing light".

All timing starts from the same place. You are going to set the timing to a point where the spark in induced at a specified number of degrees just before the number one cylinder reaches top dead center on the compression stroke.

1.1.4 Operating principles of starting system

The starting or cranking system is one of the circuits in an automobile that is responsible to crank the engine at the minimum rotational speed that is required to induce initial engine combustion to produce engine power.

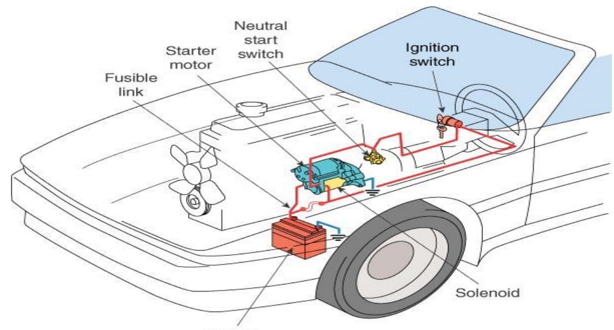


Figure 1-25 the exact location of the starting system

The minimum cranking speed required for starting an engine differs depending on the engine's construction and operating conditions, but generally it is 40 to 60 rpm for a gasoline engine and 80 to 100 rpm for a diesel engine.

A. Motor Principles

When current flows through a conductor a magnetic field is generated around the conductor. The strength of the field depends on the amount of current flowing. The direction in which the field moves depends on the direction of current. If the conductor is placed between the north and south poles of the permanent magnet the lines of magnetic forces from the permanent magnet interfere with each other causing the magnetic field to increase on one side and the conductor rotates to the weaker side. The strength of the electromagnetic force is given by the relation.

$$F = BIL$$

Where F = Force in Newton

B = Magnetic flux

L = Length of the conductor

I = Current flow through the conductor

B. Types of direct current motors

There are several types of direct current motors which differ in the method used to connect the field coil and armature coil.

a) *Series Wound motors*

In series wound motors the excitation and armature windings are connected in series. The excitation current is not tapped off, rather the armature current also passes through the excitation winding. The armature current in this type of motor generates a strong magnetic field because it is usually high when the motor starts under load.

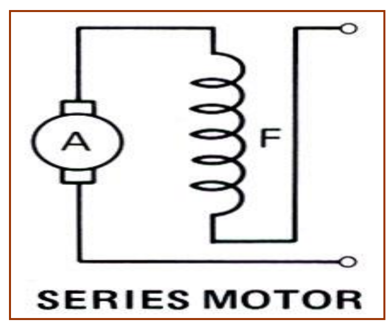


Figure 1-26 Series Wound motors

b) Shunt wound motors

In shunt wound motors the excitation winding is connected in parallel with the armature. When energized with constant voltage, excitation and speed are therefore practically independent of torque this would not be desirable for starter operation. However the drop in battery voltage caused by the

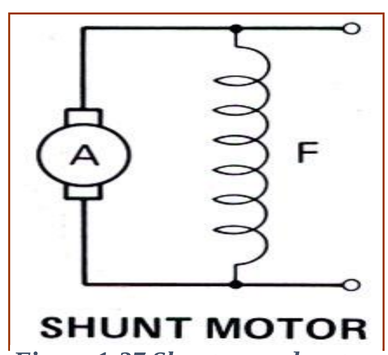


Figure 1-27 Shunt wound motors

starter current yield a beneficially characteristics similar to that of series wound motors.

c) Compound wound motors

Large starters used compound wound motor which have a shunt winding and a series winding which act in to two stages. In the first stage, the armature current is limited because the shunt winding connected in series with the armature and acts as a dropping resistance. This keeps the meshing torque of the armature low. In the second stage the full current is applied to the starter motor which then develops its full torque.

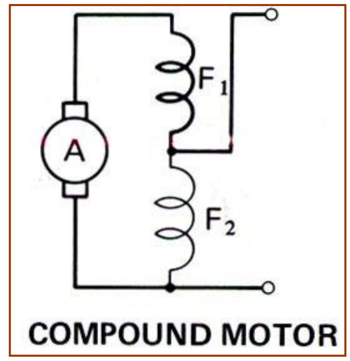


Figure 1-28 Compound wound motors

C. Components Parts of Starting System

a) **Magnetic switch**

It consists of a hold in and pull in coil, a return spring a plunger and other components. It is activated by the magnetic forces generated the coil and carries the following functions:

- ✓ It pushes the pinion gear to mesh with the ring gear
- ✓ It serves as a relay allowing heavy current to pass from the battery to the starter motor

Figure 1-29 Magnetic switch terminals

b) Starter Housing

It is a heavy cylinder machined case that holds the starting motor assembly. Steel pole shoes are securely attached to the inner surface by screws the pole shoes hold the field coils in place inside the housing. The field coils are connected to a terminal and are insulated from the housing.

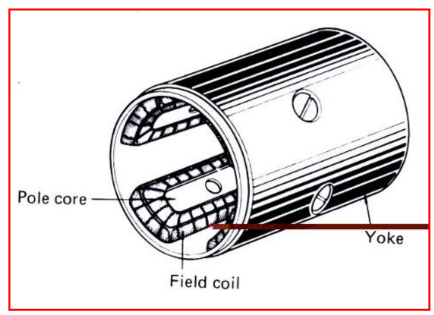


Figure 1-30 Starter Housing

c) Field Coils

The electrical current from the magnetic switch flows thoroughly the field coils which generates the magnetic field required to rotate the armature.

d) Brushes

The brushes are pressed against the segments of the armature commentator by the brush springs and allow the current to pass from the field coils to the armature.

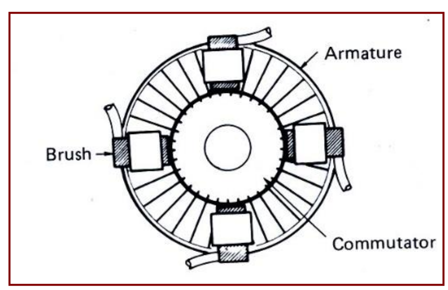


Figure 1-31 Brush and field coil

e) Armature

The armature which is the revolving component of the motor, consists of armature core armature coils, commutator, etc. It revolves as a result of the interaction between the magnetic fields generated by the armature coils and field coils.

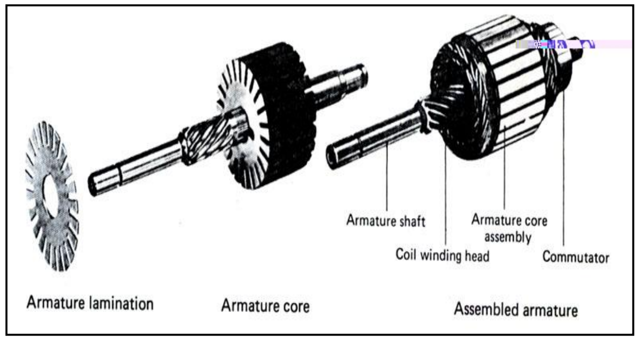


Figure 1-32 Dismantled armature

f) Commentator end frame

The commentator end frame consists of metal plate that bolts to the commentator end of the housing and supports the commentator end of the armature in a bushing. In many starter motors the commentator end frame also supports the brushes. The end frame is positioned on the starter housing by a dowel pin to insure proper alignment.

g) **Drive Housing**

The drive housing supports the driving end of the armature shaft and also contains the mounting flange by which the starting motor is attached to the engine. It is also positioned on the starter housing by a dowel to ensure correct alignment.

h) Overrunning/one way clutch

The starter motor must crank the engine until the engine fires and runs on its own. Once the engine has started, it would rotate at higher speed which could damage the starter motor. The starter clutch is a protective device for the starter motor.

Figure 1-33 Overrunning clutch

A. Starter clutch during cranking

The rotating armature tires to force the clutch housing to which it is splined to rotate faster than the inner race which is combined with the pinion gear.

The clutch rollers are forced to roll towards the narrow section between the clutch housing and the inner race until they jam as a result the rollers transfer the rotational moment of the clutch housing to the inner race and to the pinion gear.

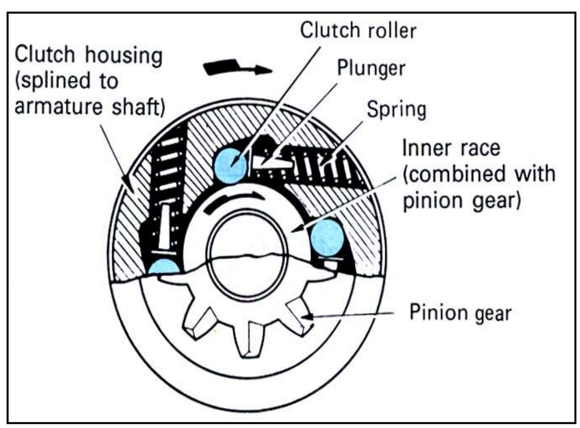


Figure 1-34 Starter clutch during cranking

B. Starter clutch after the engine is started

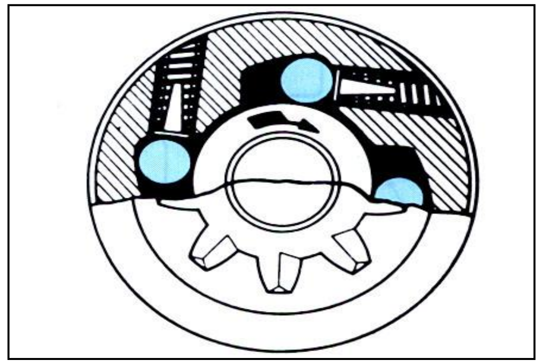


Figure 1-35 Starter clutch after the engine is started

Once 'the engine has started, its torque tires to force the inner race to rotate faster than the clutch housing. The rollers move against the spring towards the wider section inside the housing. As a result the clutch housing and the inner race disengages to prevent the starter clutch from transmitting the engine torque from the pinion gear to the starter motor.

i) Park/Neutral Position Switch

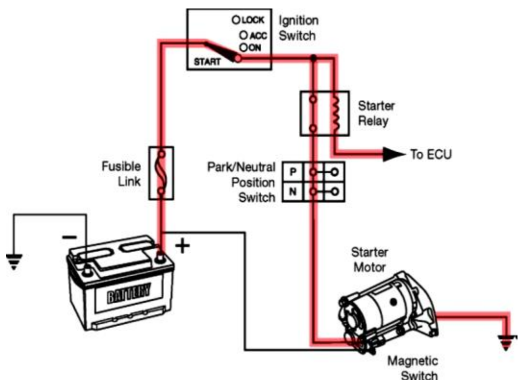


Figure 1-36 Neutral Position Switch

Cars with automatic transmissions had a special switch that prevented starting while the car was in gear. The switch (neutral safety switch) is connected between the ignition switch and the solenoid.

This switch is open at all transmission-lever positions except PARK or NEUTRAL. Late-model cars with the ignition switch and selector lever on the steering column do not need a safety switch.

j) Clutch Safety Switch

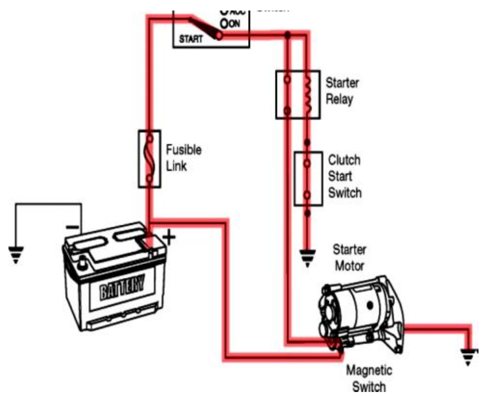


Figure 1-37 Clutch Safety Switch

For manual transmission the clutch start switch perform the same function as the park/neutral position switch.

The clutch start switch opens the starter control circuit unless the clutch is engaged.

k) Computer Controlled Starting

Some key-operated ignition systems and most push-button-to-start systems use the computer to crank the engine. The ignition switch start position on the push-to-start button is used as an input signal to the powertrain control module (PCM).

Figure 1-38 Electronic IG key

Before the PCM cranks the engine, the following conditions must be met.

- ✓ The brake pedal is depressed.
- ✓ The gear selector is in park or neutral.
- ✓ The correct key fob (code) is present in the vehicle.

A typical push-button start system includes the following sequence. Computer-controlled starting is almost always part of the system if a push-button start is used. The ignition key can be turned to the start position, released, and the PCM cranks the engine until it senses that the engine has started. The PCM can detect that the engine has started by looking at the engine speed signal.

Figure 1-39 Push stating button

Normal cranking speed can vary between 100 and 250 RPM. If the engine speed exceeds 400 RPM, the PCM determines that the engine started and opens the circuit to the “S” (start) terminal of the starter solenoid that stops the starter motor.

D. Types of starter motor

a) Conventional Starter Motor

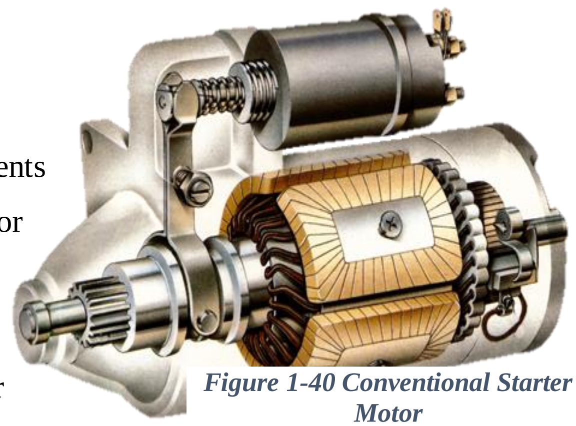


Figure 1-40 Conventional Starter Motor

The conventional starter motor contains the components shown, The pinion gear is on the same shaft as the motor armature and rotates at the same speed. A plunger in the magnetic switch (solenoid) is connected to a shift lever. When activated by the plunger, the shift lever pushes the pinion gear and causes it to mesh with the flywheel ring gear. When the engine starts, an over-running clutch disengages the pinion gear to prevent engine torque from ruining the starting motor.

This type of starter was used on most 1975 and older Toyota vehicles. It is currently used on certain Tercel models. Typical output ratings are 0.8, 0.9, and 1.0KW. In most cases, replacement starters for these older motors are gear-reduction motors.

b) Gear-Reduction Starter Motor

The gear-reduction starter motor contains the components shown. This type of starter has a compact, high-speed motor end a set of reduction gears. While the motor is smaller and weighs less than conventional starting motors, it operates at higher speed. The reduction gears transfer this torque to the pinion gear at 1/4 to 1/3 the motor speed. The pinion gear still rotates faster than the gear

Figure 1-41 Gear-Reduction Starter Motor

on a conventional starter and with much greater torque (cranking power).

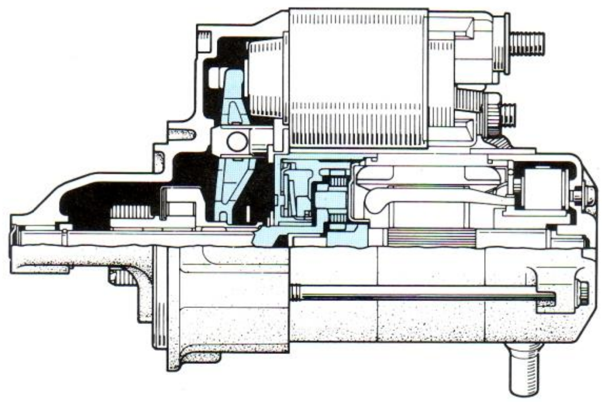


Figure 1-42 Planetary-type starter motor

c) Planetary-type starter motor

The planetary type starter uses a planetary gear to reduce the rotational speed of the armature, as with the reduction type, and the pinion gear meshes with the ring gear via a drive lever, as with the conventional type.

1. Speed Reduction Mechanism

Reduction of the armature shaft's speed is accomplished by three planetary gears and 1 internal gear. When the armature shaft turns, the planetary gears turn in the opposite direction, which attempts to cause the internal gear to turn.

However, since the internal gear is fixed, the planetary gears themselves are forced to rotate inside the internal gear.

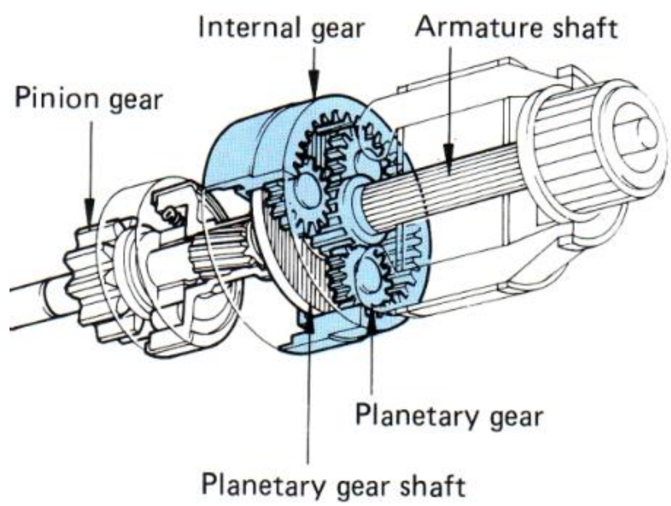


Figure 1-43 Speed Reduction Mechanism

2. Damping Device

The internal gear is normally fixed, but if too much torque is applied to the starter, the internal gear is caused to rotate, allowing the excess torque to escape and preventing damage to the armature and other parts. The internal gear is engaged with a clutch plate and the clutch plate is pushed by a spring washer. If excess torque is brought to bear on the internal gear, the clutch plate overcomes the pushing force of the spring washer and turns, causing the internal gear to rotate. In this way, the excess torque is absorbed.

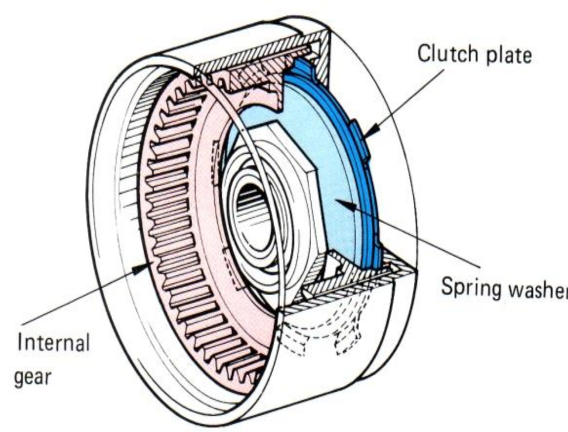


Figure 1-44 Damping Device

E. Operation of starter motor

1. Conventional Starter Motor

Ignition Switch in "ST"

Current flows from the battery through terminal "50" to the hold-in and pull-in coils. Then, from the pull-in coil, current flows through terminal "C" to the field coils and armature coils.

- Voltage drop across the pull-in coil limits the current to the motor, keeping its speed low.
- The solenoid plunger pulls the drive lever to mesh the pinion gear with the ring gear.
- The screw spline and low motor speed help the gears mesh smoothly.

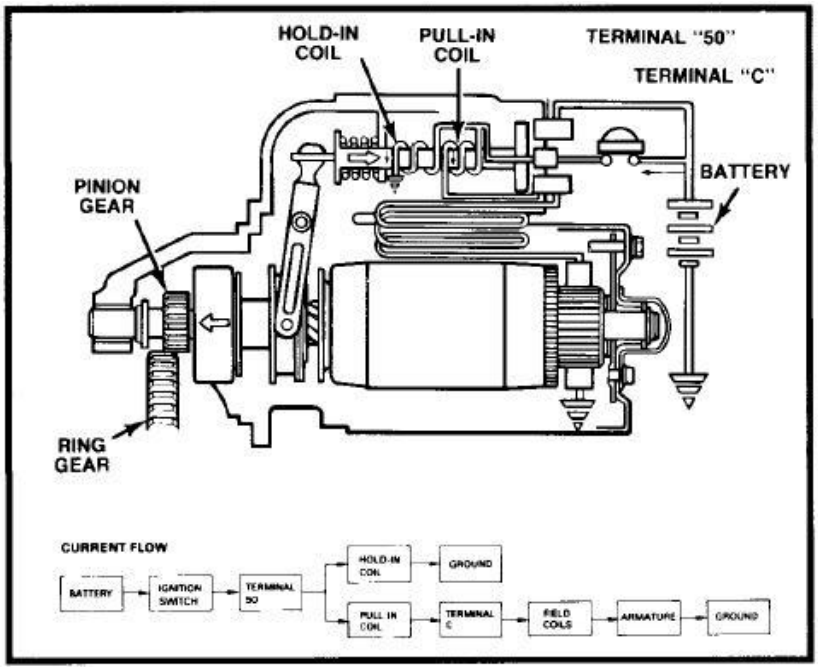


Figure 1-45 Ignition Switch in "ST"

Pinion and Ring Gears Engaged

When the gears are meshed, the contact plate on the plunger turns on the main switch by closing the connection between terminals "30" and "C."

- More current goes to the motor and it rotates with greater torque (cranking power).
- Current no longer flows in the pull-in coil. The plunger is held in position by the hold-in coil's magnetic force.

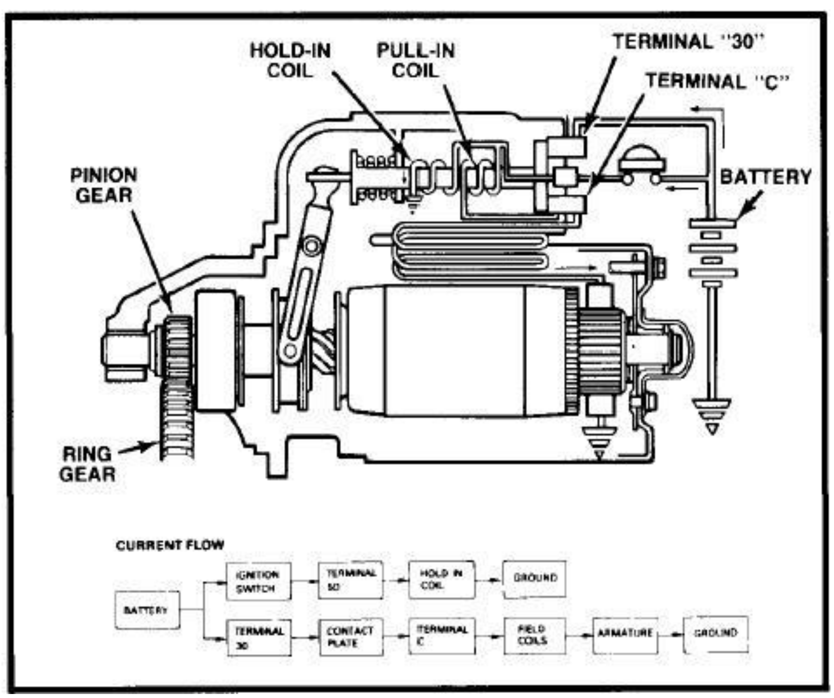


Figure 1-46 Pinion and Ring Gears Engaged

Ignition Switch in "ON"

Current no longer flows to terminal "50," but the main switch remains closed to allow current flow from terminal "C" through the pull-in coil to the hold-in coil.

- The magnetic fields in the two coils cancel each other, and the plunger is pulled back by the return spring.
- The high current to the motor is cut off and the pinion gear disengages from the ring gear.
- A spring-loaded brake stops the armature.

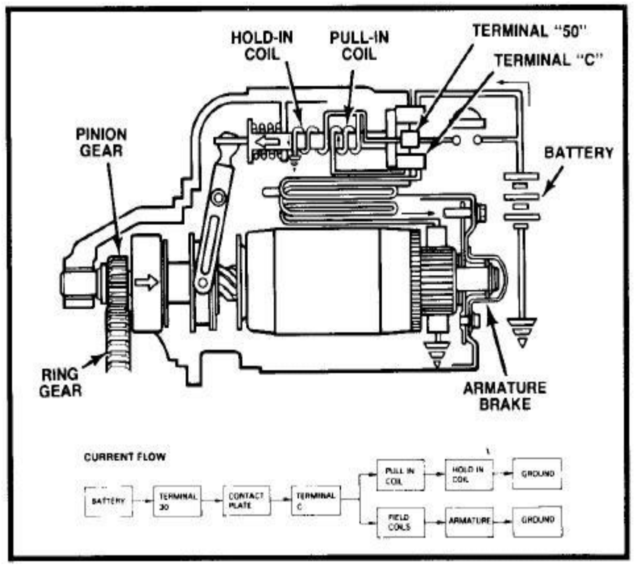


Figure 1-47 Ignition Switch in "ON"

2. **Gear-Reduction Starter Motor**

Ignition Switch in "ST"

Current flows from the battery through terminal "50" to the hold-in and pull-in coils. Then, from the pull-in coil, current flows through terminal "C" to the field coils and armature coils.

- Voltage drop across the pull-in coil limits the current to the motor, keeping its speed low.
  - The magnetic switch plunger pushes the pinion gear to mesh with the ring gear.
  - The screw and low motor speed help the gears mesh smoothly.

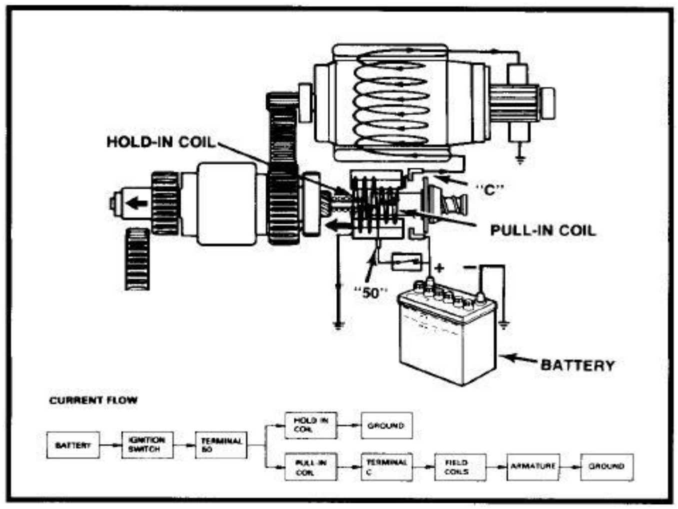


Figure 1-48 1.Gear-Reduction Starter Motor-Ignition Switch in "ST"

Pinion and Ring Gears Engaged

- When the gears are meshed, the contact plate on the plunger turns on the main switch by closing the connection between terminals "30" and "C."
- More current goes to the motor and it rotates with greater torque.

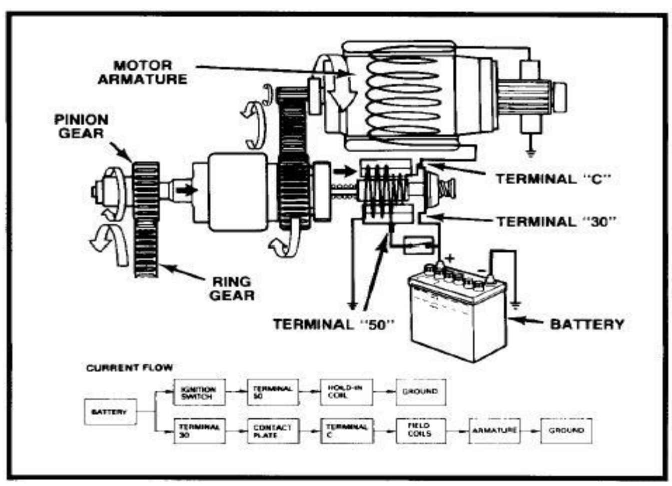


Figure 1-49 Pinion and Ring Gears Engaged

- Current no longer flows in the puff-in coil. The plunger is held in position by the hold-in coil's magnetic force.

Ignition Switch in "On"

- Current no longer flows to terminal "50," but the main switch remains closed to allow current flow from terminal "C" through the pull-in coil to the hold-in coil.
- The magnetic fields in the two coils cancel each other, and the plunger is pulled back by the return spring.
- The high current to the motor is cut off and the pinion gear disengages from the ring gear.

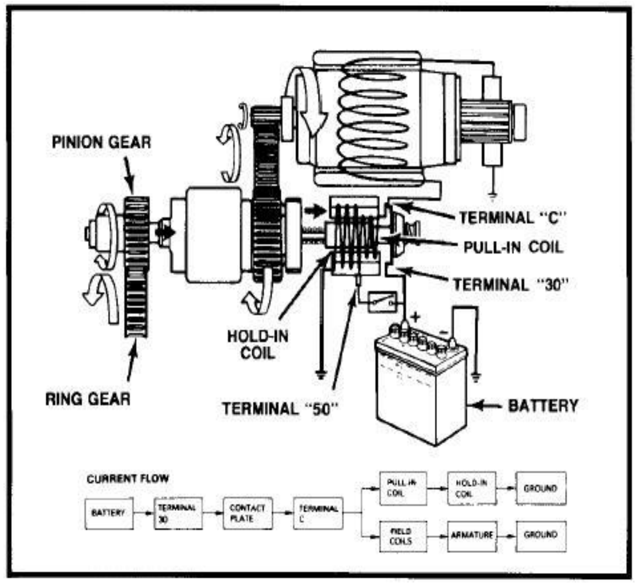


Figure 1-50Ignition Switch in "On"

- The armature has less inertia than the one in a conventional starter. Friction stops it, so a brake is not needed.

1.1.5 Operating principles of charging system

The charging system converts mechanical energy into electrical energy when the engine is running. This energy is needed to operate the loads in the vehicle's electrical system. When the charging system's output is greater than that needed by the vehicle, it sends current into the battery to maintain the battery's state of charge. Proper diagnosis of charging system problems requires a thorough understanding of the system components and their operation.

A. Operation of charging system

When the engine is running, battery power energizes the charging system and engine power drives it. The charging system then generates electricity for the vehicle's electrical systems. At low speeds with some electrical loads "on" (e.g., lights and ventilation), some battery current may still be needed.

But at high speeds, the charging system supplies all the current needed by the vehicle. Once those needs are taken care of, the charging system then sends current into the battery to restore its charge.

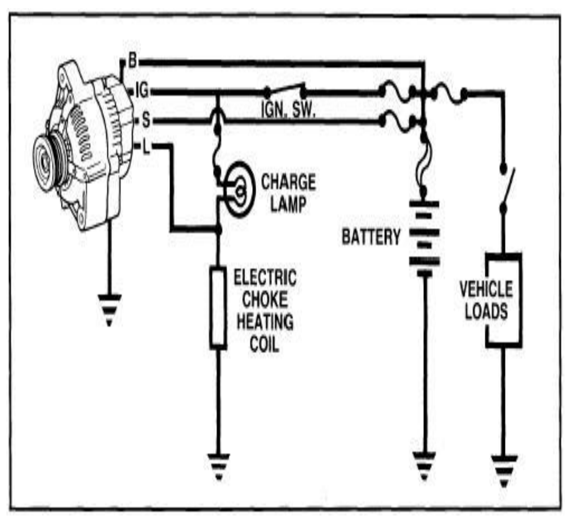


Figure 1-51 Operation of charging system

B. Principles of Alternating Current Generator

An electrical generator is a machine that converts mechanical energy in to electrical energy. This energy conversion is based on the principle of the production of dynamically induced electromotive force.

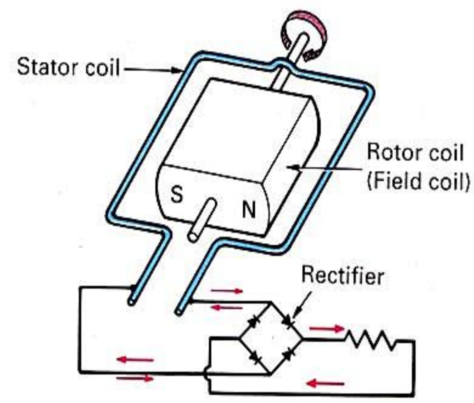


Figure 1-52 Principles of Alternating Current Generator

Whenever a conductor cuts magnetic lines of force dynamically induced EMF is produced in it according to faradays low of electromagnetic induction This EMF will cause a current to flow if the conductor circuit is closed.

Hence the basic essential parts of an electrical generator are:

- ✓ A magnetic field
- ✓ Conductors which can move so as cut the flux.

When the electricity by a coil is supplied through slip rings and brushes, the amount of current flowing to the lamp will change and at the same time so will direction of flow. When the electricity by a coil is supplied through slip rings and brushes, the amount of current flowing to the lamp will change and at the same time so will direction of flow. When the electricity by a coil is supplied through slip rings and brushes, the amount of current flowing to the lamp will change and at the same time so will direction of flow. As the coil rotates the current generated on the first half of the turn will be supplied from the brush on side pass through the lamp then retain to the brush on side B. On the second half turn the current will be reversed. In this fashion, the alternating current generator supplies the current generated by the coil in a magnetic field.

C. Component Parts of Charging System

1. **Ignition Switch** - When the ignition switch is in the ON position, battery current energizes the alternator.
2. **Alternator** - Mechanical energy is transferred from the engine to the alternator by a grooved drive belt on a pulley arrangement. Through electromagnetic induction, the alternator changes this mechanical energy into electrical energy. The alternating current generated is converted into direct current by the rectifier, a set of diodes which allow current to pass in only one direction.

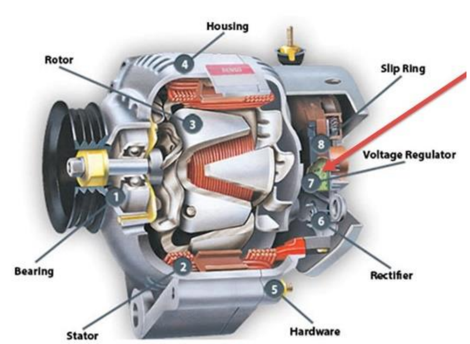


Figure 1-53 Alternator

Alternator Component's

✓ **Fans**

The fans pull air through the slip ring end frame and cools the rectifier and regulator for inbuilt type alternators. The vent holes in both end frames allow the fan to pull ventilating air to the alternator.

✓ **Rotor**

The rotor is composed of two cores, a field coil, slip rings and rotor shaft. The field coil is wound in the same direction as rotation and each end of the coil is connected to a slip ring. The two cores are installed at each end of the coil so as to enclose the field coil.

Magnetic flux is produced as current flows through the coil and one pole becomes the North Pole and the other the South Pole. The slip rings are made of metal with a highly brush contacting

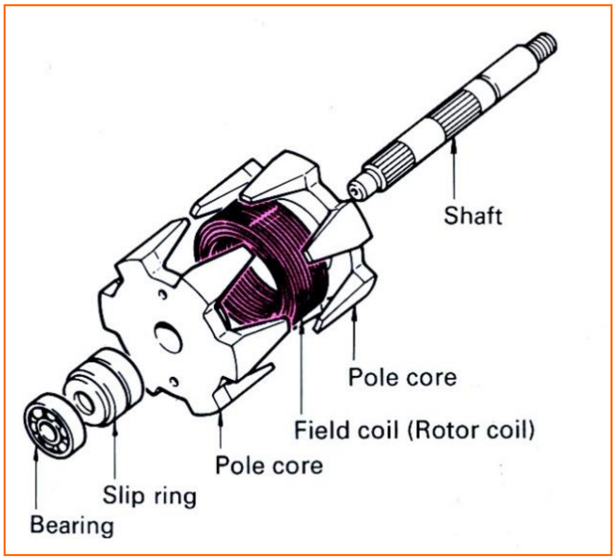


Figure 1-54 Rotor exploded view

✓ **Brushes**

They ride on each slip ring and conduct battery current to the rotor winding to create magnetic field. One is insulated from the frame but the other is grounded

✓ **Stator**

The stator assembly is composed of laminated iron frame and three sets of windings, wound into slots in the frame. The windings make a three phase unit due to the manner of their connection. The type of connection are Star and Delta connections.

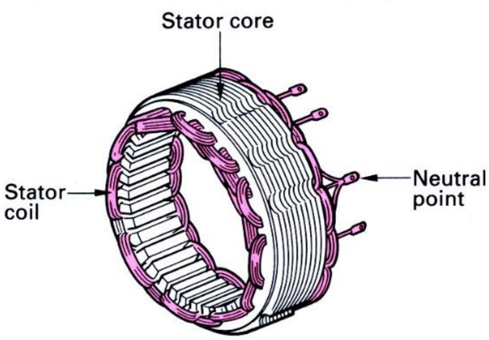


Figure 1-55 Stator components

Star (Y) connection

The first three ends of the windings are connected together to form a common point. The other three ends are connected to the output lines. A fourth cable, called the neutral line, is often brought out from the common point. The availability of the neutral line makes it possible to use all three phase voltages as well as all three line voltages.

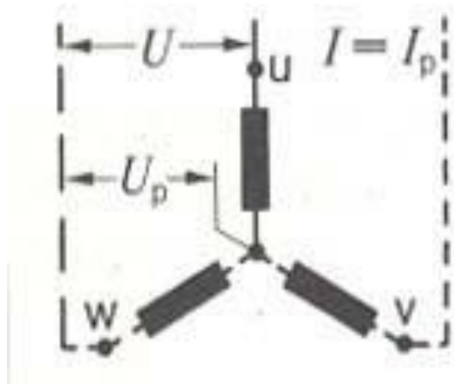


Figure 1-56 Star (Y) connection

Delta_ connection

If the three phase windings are connected in series to form a loop, we would have a Delta connection. There is no common connection for the three phases. Hence, the Delta cannot have a neutral line.

The three lines are taken from the ends of the windings; therefore, the line voltages are also the winding or phase voltages. The current in each line is drawn from the two windings join to feed a single line.

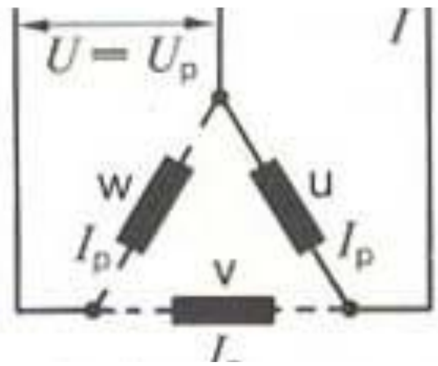


Figure 1-57 Delta_ connection

Diodes

Three positive diodes and three negative diodes are usually mounted in a metal bracket called a heat sink. The heat sink takes heat from the diodes, which gets hot in operation, and transfers the heat into the air.

It has large surfaces. The current generated by the alternator is supplied from the positive side diode holder so it is insulated from the end frames.

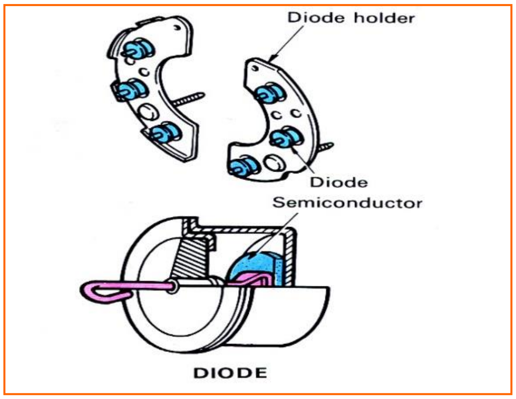


Figure 1-58 Rectifier diode

3. **Voltage Regulator -** Without a regulator, the alternator will always operate at its highest output. This may damage certain components and overcharge the battery. The regulator controls the alternator output to prevent overcharging or undercharging. On older models, this is a separate electromechanical component which uses a coil and contact points to open and close the circuit to the alternator. On most models today, this is a built-in electronic device.
4. **Battery** - The battery supplies current to energize the alternator. During charging, the battery changes electrical energy from the alternator into chemical energy. The battery's active

materials are restored. The battery also acts as a "shock absorber" or voltage stabilizer in the system to prevent damage to sensitive components in the vehicle's electrical system.

5. **Indicator** - The charging indicator device most commonly used on cars today is a simple ON/OFF warning lamp. It is normally off. It lights when the ignition is turned "on" for a check of the lamp circuit. And, it lights when the engine is running if the charging system is undercharging. A voltmeter is used on current models to indicate system voltage. It is connected in parallel with the battery. An ammeter in series with the battery was used on older models.
6. **Fusing** - A fusible link as well as separate fuses are used to protect circuits in the charging system.

D. Circuits of the alternator

There are three standard circuits for the alternator:

- Pre- excitation circuit
- Excitation circuit (self- excitation)
- Generator or main circuit

Pre-excitation circuit

The battery current first flows through the charge indicator lamp and to the excitation winding in the rotor. This is necessary because the remanence in the excitation winding of the iron core is very weak at the instant of starting and at low speeds, and does not suffice to provide the self-excitation needed for building up the magnetic field.

Excitation circuit

The excitation current generates the magnetic field during the operation of the alternator so that the required alternator voltage can be induced in the stator windings. The excitation current comes from the current flowing in the three-phase windings. It comes from the alternator through the

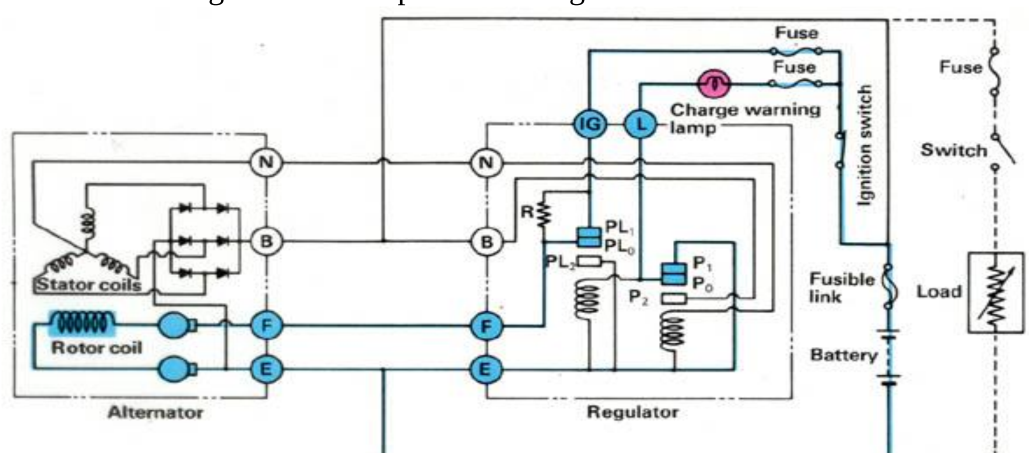


Figure 1-59 Charging excitation circuit

regulator **IG** and **F** terminals or flows through the three exciter diodes if present.. Hence, no external power source is required for self-excitation.

E. Voltage Regulation in charging system

i. Mechanical regulator

It limits the DC output voltage according to external load and state of charge of the battery. If the output is not controlled the battery will be overcharged and the electrical equipment will be damaged. Controlling the electrical flow through the field coil in the rotor does the control.

a) One point type regulator

In this regulator a resistor (R) is connected in series with the field coil (F) of the rotor. This resistance is by passed by the points while the engine is running at low speed. Since the magnetic field in the coil is weak, the points remain closed. When the voltage of the alternator is increased the magnetic field will be strong and the points open. So, current passes through the resistor and the field coil. This decreases the magnetic field strength and the voltage of the alternator reduces and the points close again. In this manner the voltage is stabilized by this type of regulator.

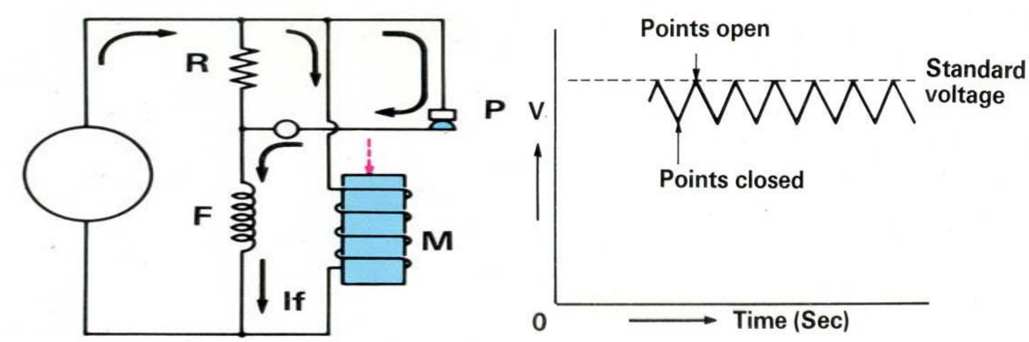


Figure 1-60 One point type regulator

However, one point type regulator is not used very often in present day automobiles because of the following disadvantage.

- ✓ There is great fluctuation of voltage at low speed when the points are opened and closed
- ✓ A large resistance will cause more sparking when the points are open, resulting in shorter life of the points.

b) Two point type regulator

The characteristic of the two-point type regulator is that it has both low speed and high speed operating ranges. At low speed, the moving point opens and closes the low speed point (P1) in the same manner as one point type regulator make and break the contact. At high speed the moving point contacts P2 and field current ceases to flow. The voltage output of the alternator decreases.

This decreases the field strength of the regulator and the moving point closes again with P1 and the cycle is repeated.

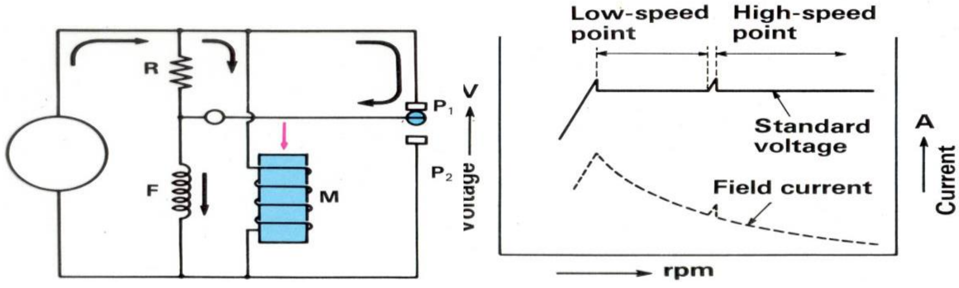


Figure 1-61 Two point regulator

But the disadvantage of this type of regulator is the voltage drop due to the hysteresis effect when changing from the high-speed side to low speed side. Nevertheless. Compared to the one point type, the resistance can be made smaller so there is less sparking so there is a longer life of the points.

Characteristics of the regulators

For the point type regulators, there are various reasons why voltage fluctuates. But the primary causes are due to its hysteresis and temperature characteristics.

a) The hysteresis characteristics

The lowering of voltage when the moving point change from high speed side to the low speed point called hysteresis effect and causes to remain a residual magnetism from the high speed operation in the coil core and continue to pull the moving point for a short time. This phenomena cause to the alternator output to decline. Therefore no attempt should be made to adjust the regulator when the voltage is dropping due to this effect. A 12 volt system will drop from 0.5 to 1 volt.

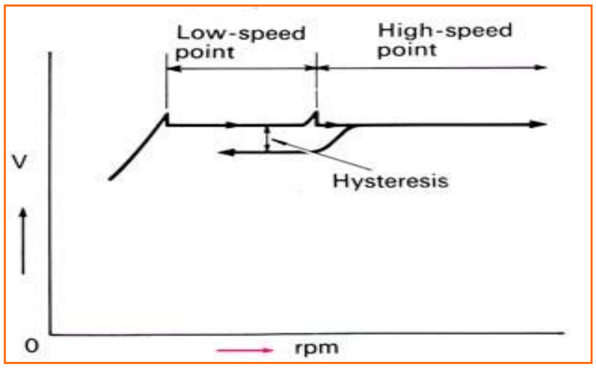


Figure 1-62 Hysteresis characteristics of MR

b) The temperature characteristics

The magnetic coil of the voltage regulator employs copper wiring. If the temperature of this wire rises, the resistance is increased and there will be a reduction of force (electromagnetic force) of the magnetic coil. This results a higher alternator output voltage. To

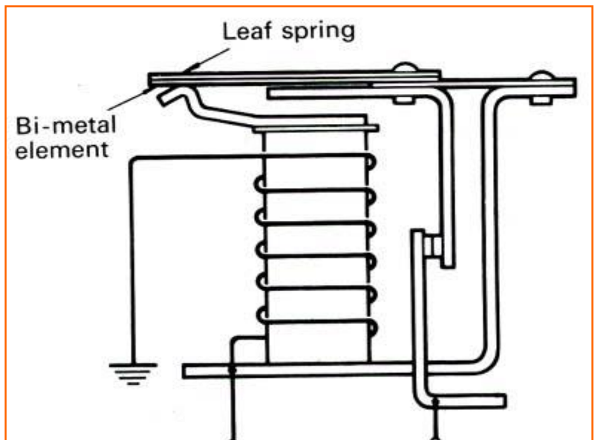


Figure 1-63 Temperature characteristics of MR

prevent such arise in voltage, the regulator utilizes either a resistor or bimetal element for temperature compensation, but some use both.

The resistor reduces the overall resistance in accordance with the temperature fluctuation as a result strong electromagnetic force is developed and the contact point will be pulled sufficiently.

The bimetal element is used together with a spring which supports the moving point. The bimetal element reduces the spring tension as the temperature rises. Therefore, the contact point will be easily opened to prevent the rise of alternator output voltage.

c) Voltage Relay (Charge lamp relay)

A Charging system employs a two-element combination accurate voltage regulation. This is because, the voltage regulator operates in accordance with the voltage generated by the alternator. If there were no voltage relay, there would occur a drop in voltage in the magnetic coil because the voltage is applied to a long circuit via the ignition switch. A reduction of voltage would cause a proportionate decrease in magnetic force of magnetic coil so the moving points would not pulled sufficiently. As a result, alternator voltage would rise to high.

Operation of a regulator with voltage relay

a. When the ignition switch is on engine stepped.

When the ignition switch is turned on field current from the battery flows to the rotor and excites the rotor coil. At the same time, battery current also flows to the charge warning lamp and the lamp comes on.

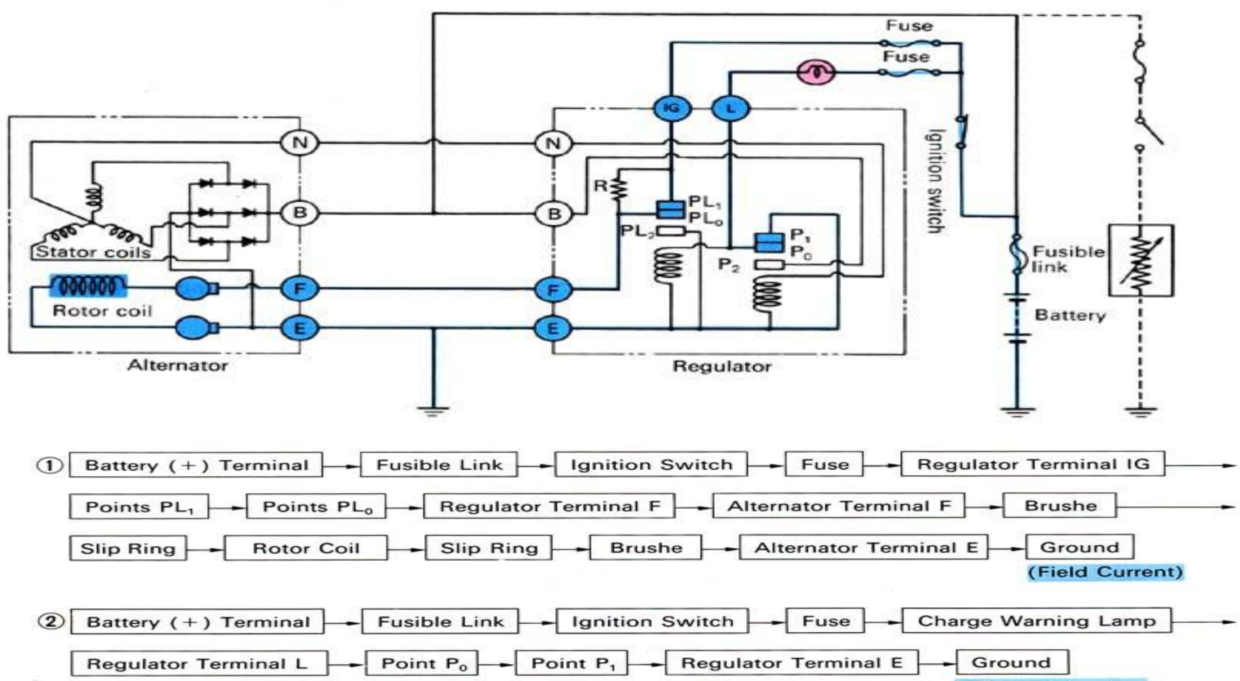


Figure 1-64 When the ignition switch is on engine stepped.

b. Engine operation- (low speed to middle)

After the engine is started and the rotor is turning. Voltage is generated in the stator coil, and neutral voltage is applied to the voltage relay so the charge warning lamp goes out. At the same time; output voltage is acting on the voltage regulator. Field current to the rotor is controlled in accordance with the output voltage acting on the voltage regulator. Thus depending on the condition of point PL_0, the field current either passes through or does not pass through the resistor (R)

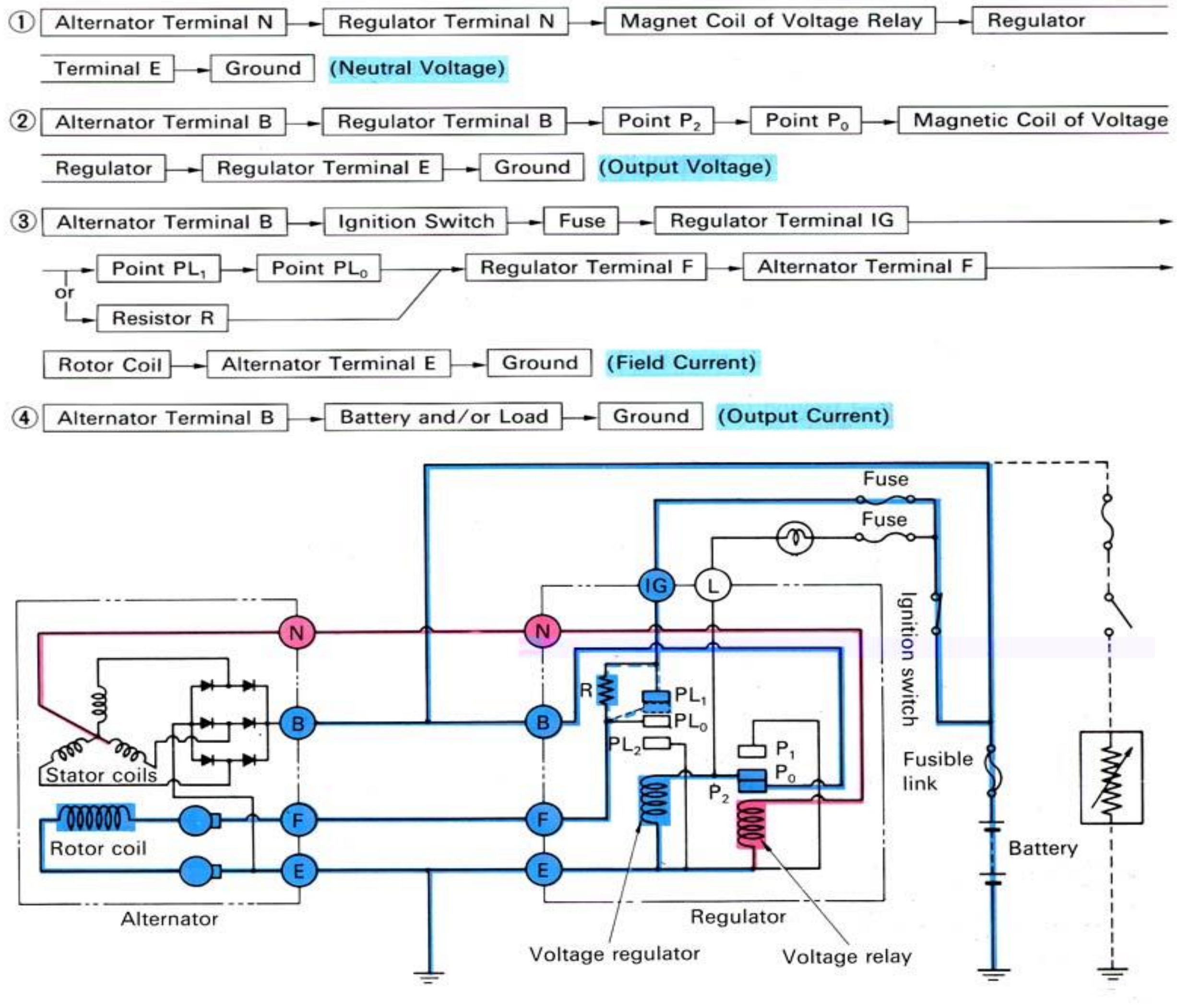
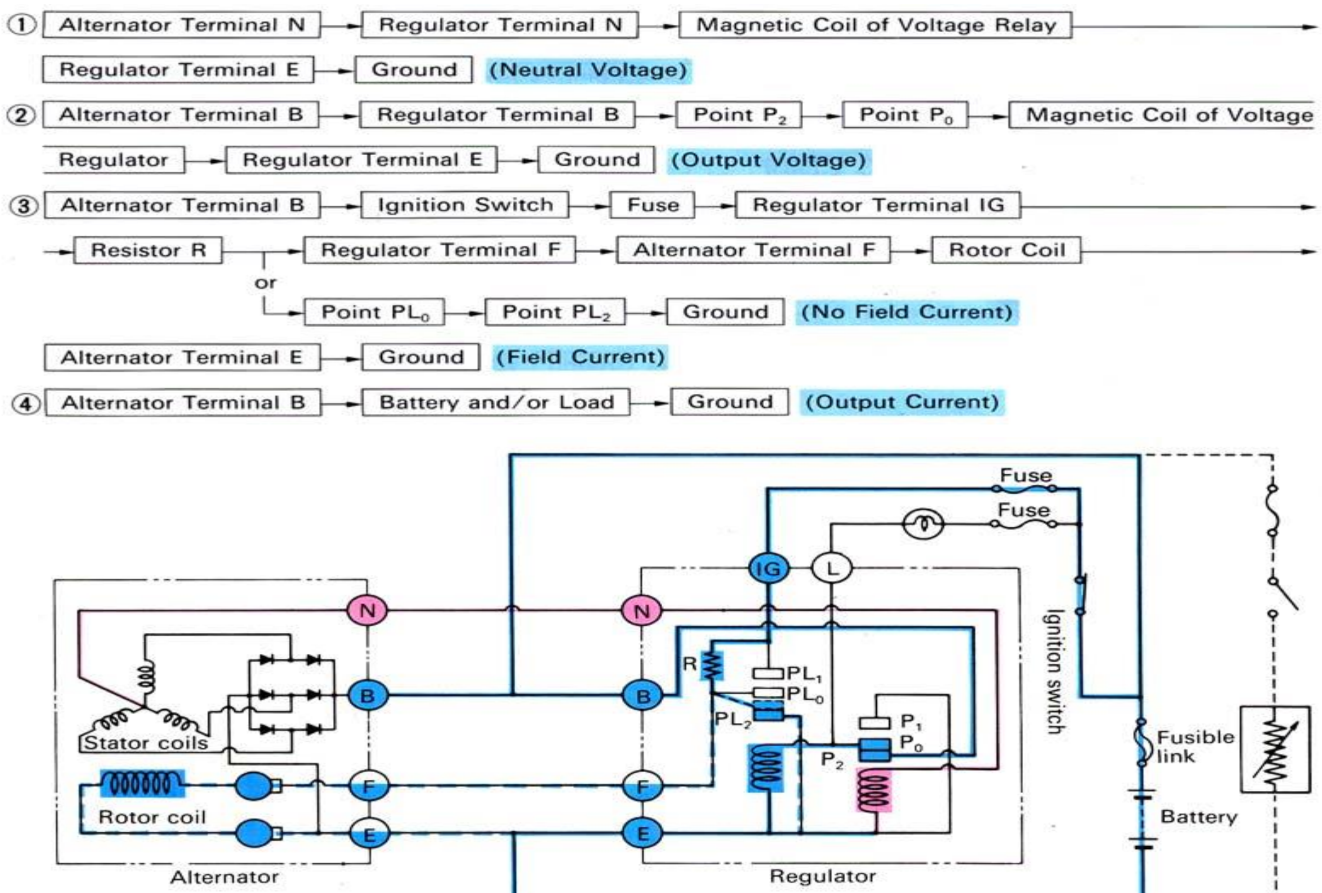


Figure 1-65 Engine operation- (low speed to middle)

C. Engine operating (Middle speed to high speed)

As engine RPM increases, the voltage generated by the stator coil rises and the pulling force of the magnetic coil becomes stronger with a stronger pulling force, field current to the rotor will flow intermittently. In other words moving point PL_0 of the voltage regulator intermittently make contact with point PL_2.



ii. IC-Regulator

The solid state regulator allows battery current to excite alternator field coils, and also controls charging voltage at safe values. It may be separately mounted or inbuilt type.

Advantages over mechanical regulator:

- It is almost foolproof i.e., incapable of error or failure
- It is smaller in size i.e., compact and light
- It can control higher field current with improved durability and reliability (this is due to lack of mechanical points).
- A narrower output voltage range and little or no variation with alternator speed and input voltage i.e., no hysteresis characteristics.
- Voltage variation at the rated load, or at maximum output current of the alternator is between 0.5-1v
- Good resistance to vibration , climatic effects and high durability due to lack of moving parts

- Voltage output becomes lower as its temperature rises, hence proper charging of the battery can be performed. This is because the Zener diode become more conductive as temperature rises
- Spark free switching prevents radio interference

Disadvantage

Susceptible to unusually high voltage and temperatures.

Alternator Terminals

Toyota's high-speed alternator has the following terminals: "B", "G", "S", "U", and "17".

When the ignition switch is "on," battery current is supplied to the regulator through a wire connected between the switch and terminal "IG". When the alternator is charging, the charging current flows through a large wire connected between terminal "B" and the battery. At the same time, battery voltage is monitored for the MIC regulator through terminal "S".

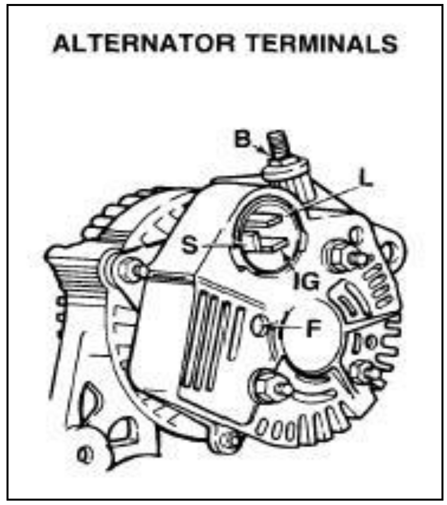


Figure 1-66 Alternator Terminals

The regulator will increase or decrease rotor field strength as needed. The indicator lamp circuit is connected through terminal "U". If there is no output, the lamp will be lit.

The rotor field coil is connected to terminal "P", which is accessible for testing purposes through a hole in the alternator end frame.

Operating principles of IC regulator

The solid state regulator controls the field current using transistors, diodes, and resisters As in the illustration shown below, when the output voltage at terminal B is low, the battery voltage is applied to the base of Tr_1 through resistor R and Tr_1 turns on. At the same time, field current flows from B to rotor coil.

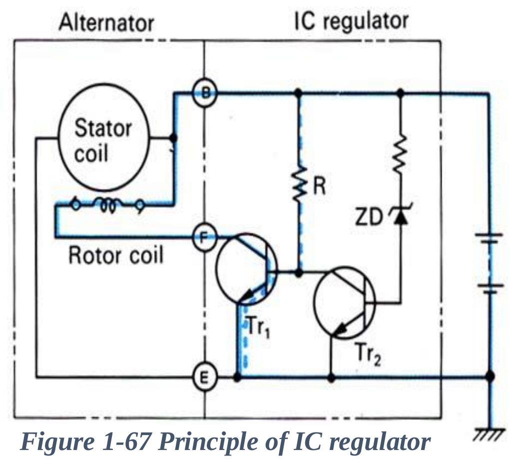


Figure 1-67 Principle of IC regulator

When the output voltage at terminal B is high a higher voltage is applied to the zener diode (ZD) and when this voltage reaches the zener voltages, the zener diode becomes conductive. Accordingly, as Tr_2 turns on Tr_1 turns off. This interrupts the field current. Regulating the output voltage.

Self-check-1

Instruction I: Give answer for the following questions

1. What are the main components of primary & secondary winding?
2. Describing all functions of the different ignition components
3. Identifying parts & terminals of regulator charging system
4. identifying parts & terminals of Starting system
5. Describing all functions of the different Starting components
6. What are the four components of Starting system?

Instruction II. Choose the best answer

1. The alternator brush rides on a

A. slip ring B. Commutator C. Rotor D. Diode

2. The voltage regulator directly controls:

A. field current B. output current C. stator circuit D. Rectification.

3. If a conductor is moved through a magnetic field:

A. heat is created B. voltage is created C. the magnetic field is increased.

D. the magnetic field is decreased.

4. The magnetic field in an alternator is developed in the:

A. stator B. Rotor C. Armature D. None of the above

5. The rotor's field current is controlled to regulate

A. alternator output current B. Diode voltage C. Stator resistance D. none

6. When most of the electrical accessories are turned on, the electrical system will demand (need):

A. lower alternator output B. Higher alternator output C. A and B D. Neither A nor B

7. In an alternator, alternating current is converted to direct current by the:

A. stator B. brushes C. rectifier D. regulator.

8. The purpose of the alternator stator is to:

A. change alternating current to direct current B. have voltage induced in its windings.

C. build up a strong magnetic field D. conduct the field current.

9. When the input voltage to a regulator decreases, the alternator output voltage should normally:

A. increase B. decrease C. Remain the same D. turn ON the charging lamp indicator.

10. A battery that is overcharged can be due to:

A. loose alternator drive belt B. Defective regulator C. High speed driving. D. high resistance

2. Unit Two: Test engine electrical system

This unit to provide you the necessary information regarding the following content coverage and topics:

- Testing instruments and SST
- Common electrical faults
- Engine electrical systems fault: -
  - ✓ Charging system
  - ✓ Ignition System &
  - ✓ Starting System

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Using testing instruments and SST
- Identifying Common electrical faults
- Testing Engine electrical systems faults: -
  - ✓ Charging system
  - ✓ Ignition System &
  - ✓ Starting System

2.2 Common electrical faults

Common electrical problems in cars are varied. While everyone always thinks of the battery first – and it's true that the battery is most often the culprit – your electrical system is much bigger than that. In fact, in newer cars, the electrical system is larger and more complex. This introduces more ways for something to go wrong.

2.2.1 Causes of Electrical Problems

Common Electrical Problems in Cars the reasons for car electrical problems can be many. Your vehicle might have a loose electrical connection. A blown fuse will cause problems. Sometimes, it's that one part of th e system is constantly drawing power, even when the engine is shut off, and it slowly drains the battery.

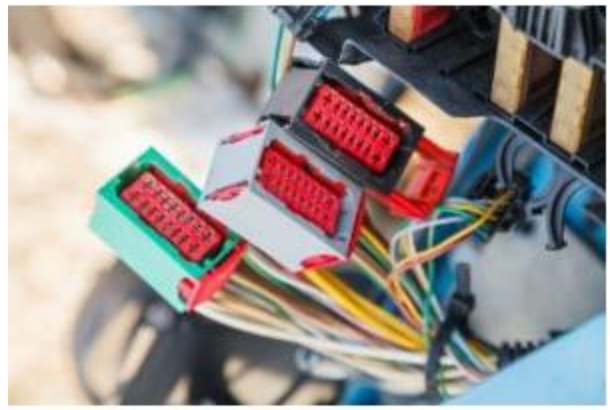


Figure 2-1 Electrical Problems

Perhaps the most common cause of car electrical problems is that the battery is failing. Most car batteries only last about five years. Cold weather can also shorten the life of your battery.

2.2.2 Checking for Electrical System Problems

Many things can indicate you have an electrical problem with your car. Some of the following signs could be caused by other factors, but if you find multiple symptoms it's usually a pretty solid indication your car has electrical issues.

Figure 2-2 Blown fuse

Common Electrical Problems in Cars Blown fuses: When you constantly must replace blown fuses, this indicates something in the electrical system is sending too much current through those fuses.

Dim headlights/taillights/dome lights: If you notice any of the lights on your car are dim as you're driving, this can indicate a problem with the electrical system, usually that the alternator is failing. Ignoring it could leave you stranded somewhere.

Engine struggles to crank: To start, your engine needs electricity flowing to the spark plugs. Without a strong flow, the engine will struggle to get going, or it might not start at all.

Smell of melting plastic: Never ignore this sign, because it can indicate you have wiring that's heating up so much, it's melting the insulation around it. If not taken care of, this could result in a car fire, maybe even as you're driving down the road.

Sputtering engine: If the spark plugs aren't getting enough electrical charge, the fuel won't combust fully in the cylinders. Sometimes, the issue might be with only one or two spark plugs, causing the engine to run rough or sputter.

Lights/horn/radio won't work: These problems can be caused by something as simple as a blown fuse, which is easy to fix. If you have multiple electrical systems failing, however, it might indicate the alternator or another component needs to be replaced.

Many of these common electrical problems in cars are fairly easy to fix. Your local auto supply store will have replacement fuses and spark plugs. For trickier electrical issues, you may need to visit a mechanic to get the problem repaired correctly.

2.2.3 Troubleshooting common electrical problems in cars

Common Electrical Problems in Cars Pop the hood and inspect the battery. If the terminals have any white gunk or other debris on them, clean them thoroughly with a wire brush. Corrosion can bring your car's electrical system to its knees. If that isn't the cause, wiggle the battery cables to see if they're loose.

While you have the hood up, inspect the alternator belt. If it's loose, or you see signs of cracking or fraying, have it replaced immediately. A bad belt can make even the best of alternators run poorly.

Another easy potential cause to diagnose is the spark plugs and wires. Check that the wires are seated firmly at both ends. Using an extension on your socket wrench, ensure the spark plugs are also tightened all the way. When you experience electrical problems while driving, like your headlights dimming, that's usually a sign the alternator is going out.

Figure 2-3 Corroded Terminal post

2.3 Testing Engine electrical systems faults

2.3.1 Starting system

Starting problems can be classified into two broad categories:

- ✓ The engine cranks normally but fails to start.
- ✓ The cranking speed is too low to start the engine.

If the engine cranks normally but fails to start, the defect lies in the engine ignition, fuel, or compression system. If the cranking speed is too low to start the engine, on the other hand, the problem usually lies in the starting system though it could also lie in the engine itself. At extremely low temperatures, for example, a much greater torque is necessary to crank the engine because of higher oil viscosity.

In troubleshooting, careful observation of the conditions under which the trouble arises will aid you greatly in accurately locating the source of the problem.

1. Outline Of on-Vehicle Inspection

If it is thought that the cause of the trouble is not in the engine, but in the starting system, first check to see whether normal voltage is being applied to the starter motor with the starter motor mounted in the vehicle.

Although the starter circuits used on actual automobiles vary in configuration from one model to another, they may be roughly broken down into two types: those having a starter relay and those without one. As the diagrams illustrate, however, in both cases, Terminal 30 always remains connected to the battery while Terminal 50 is connected only when the ignition switch is in the START position. The starter circuit for automatic transmission vehicles also has a neutral start switch, which prevents the circuit from closing, thus activating the starter motor, unless the shift lever is in the neutral (N) or park (P) position.

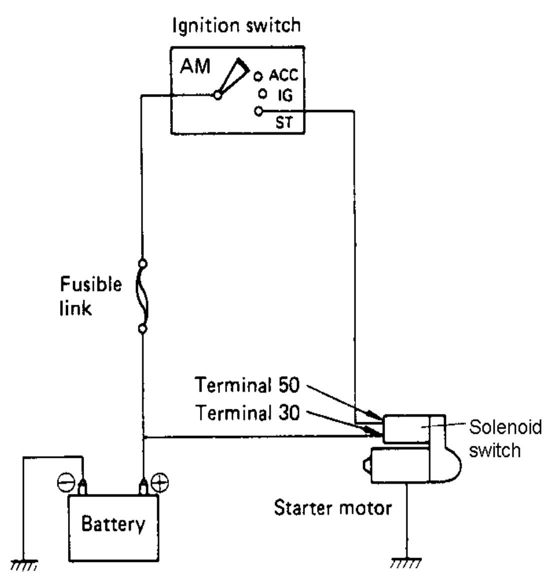


Figure 2-4 Outline Of on-Vehicle Inspection

In the case of vehicles with a clutch start system (manual transmission), a clutch starter relay and clutch start switch are installed to prevent starting if the clutch pedal is not depressed.

2. Turning the ignition switch to the START position causes the pinion gear to move outward with a click, but the starter motor remains deactivated or does not speed up. The problem in this case probably lies in the starter motor, the engine itself, or in the electrical system up to terminal 30.

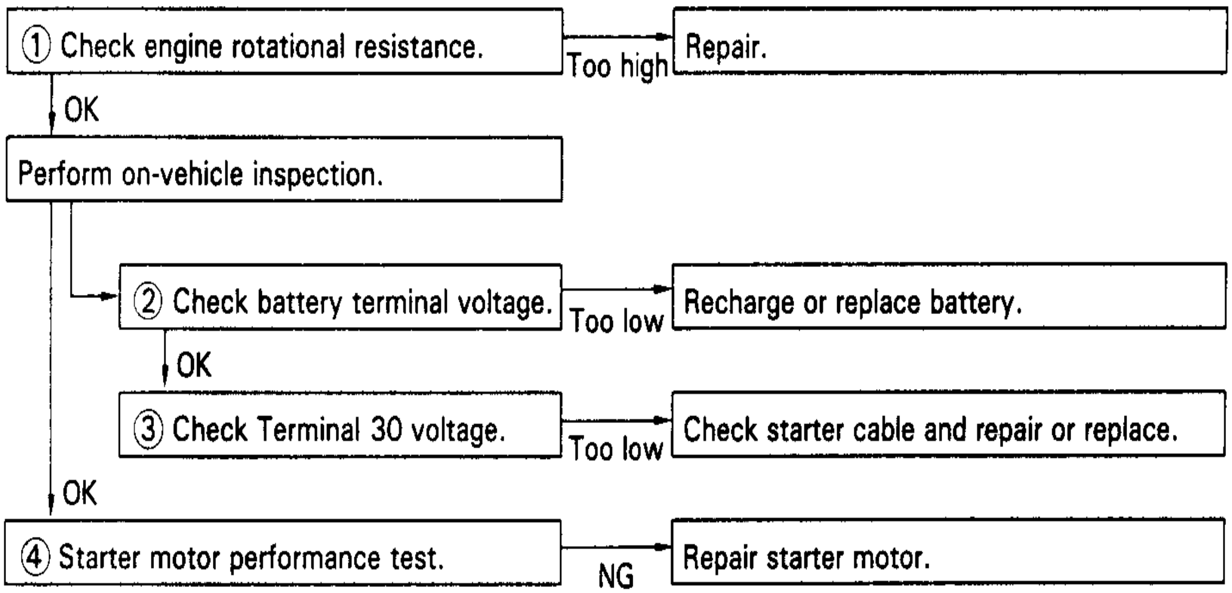


Figure 2-5 Checking flow chart

a. Check the engine rotational resistance. Check to see if unusually large torque is required to crank the engine by rotating the crankshaft manually using a box-end wrench, etc.

b. Measure the battery terminal voltage. When the ignition switch is in the START position, the terminal voltage should be 9.6 V or higher.

c. If the measured value falls below this level, recharge or replace the battery. Check for stains or corrosion on the battery terminals as well.

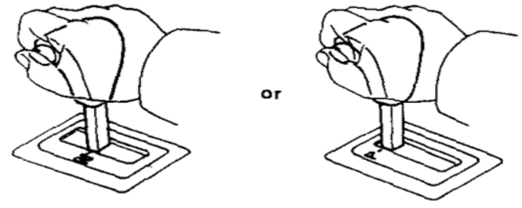
d. Measure the voltage between Terminal 30 of the starter motor and ground.

e. When the ignition switch is in the START position, the voltage should be 8 V or higher. If the measured value falls below this level, check the starter cable between the battery and Terminal 30 and repair or replace it if necessary.

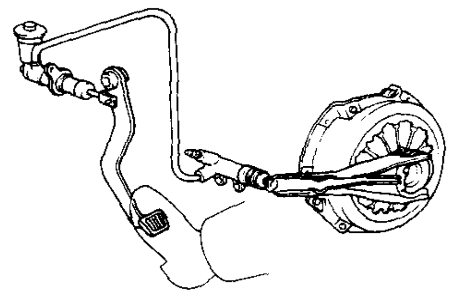
f. Before disassembling the starter motor, roughly pinpoint the source of the problem so that the job may proceed more smoothly. (In this case, the trouble may originate with poor main switch contact, excessively large electrical resistance between the brushes and the commutator, slipping of the starter clutch, etc.)

3. On-Vehicle Inspection

Make sure to put the shift lever in either the neutral (N) or the park (P) position when checking an automatic transmission vehicle.



In the case of vehicles with a clutch start system, check with the clutch pedal depressed.

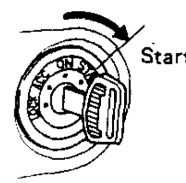


Check Battery Terminal Voltage

1. Turn the ignition switch to the START position and measure the voltage at the battery terminals.

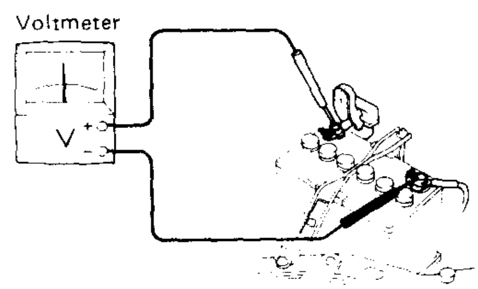
Standard 9.6 V or higher

Replace the battery if the voltage is lower than 9.6 V.



Important:

- If the starter does not operate, or if it turns slowly, be sure to check first to see whether the battery is normal or not.
- Even if the measured terminal voltage is at the normal level, stained or corroded terminals may cause poor starting due to increased resistance, leading to a decrease in the voltage when the ignition switch is turned to START position.



Check Terminal 30 Voltage

1. Turn the ignition switch to the START position and measure the voltage between starter terminal 30 and the body.

Standard: 8.0 V or higher

2. Check the starter cable and repair or replace it if necessary if the voltage is lower than 8.0 V.

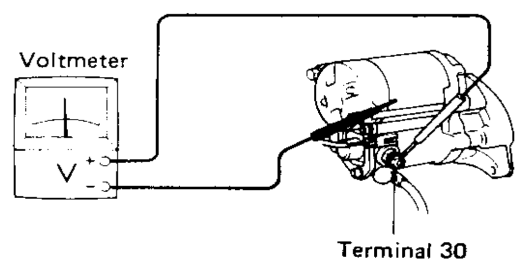
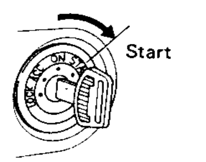


Figure 2-6 On-Vehicle Inspection

IMPORTANT!

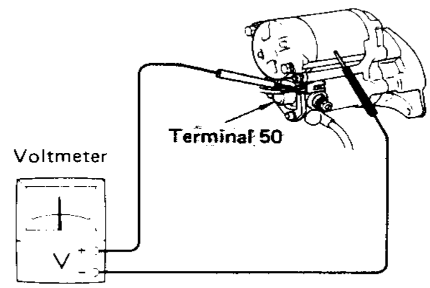
Since the location and appearance of Terminal 30 may differ depending on the type of starter motor, make sure of these by checking the repair manual.

Check Terminal 50 Voltage



1. Turn the ignition switch to START and measure the voltage between starter terminal 50 and the body.

   Standard: 8.0 V or higher

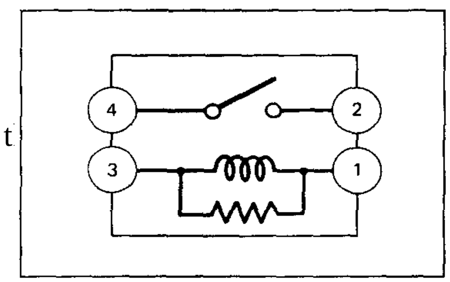


2. If the voltage is lower than 8.0 V, check the fusible link, ignition switch, neutral start switch, starter relay clutch starter switch, etc., one at a time, referring to the wiring diagram. Repair or replace any parts which are faulty.

   IMPORTANT:

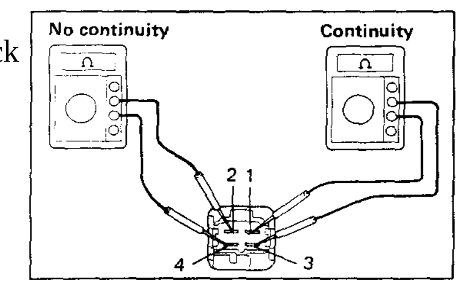
   Since the location and appearance of terminal 50 may differ depending on the type of starter motor, make sure of these by checking the repair manual.

Clutch Starter Relay



If the clutch start system is abnormal, carry out t following checks and adjustments.

Inspection of Starter Relay

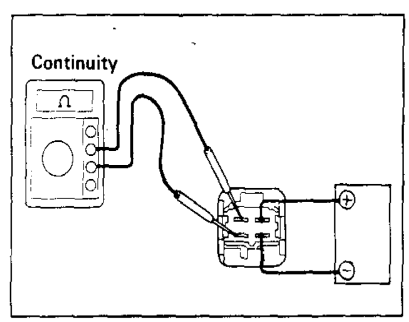


NOTE: The relay is located in the No. 1 junction block the left cowl side.

Inspect Relay Continuity

a) Using an ohmmeter, check that there is continuity between terminals 1 and 3.

b) Check that there is no continuity between terminals 2 and 4.



If continuity is not as specified, replace the relay.

Inspect Relay Operation

a) Apply battery voltage across terminals 1 and 3.

b) Check that there is continuity between terminals 2 and 4.

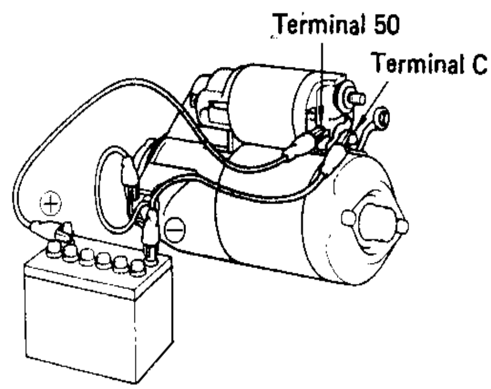
Starter Motor Tests

- Before beginning to disassemble the starter motor first roughly pinpoint the source of the problem by the performance test is recommended since it helps speed up the overhaul, also perform this test after assembly is completed to make sure that the starter motor is operating correctly.
- The test procedures for the conventional and reduction type starter motors are essentially the same. This section, therefore, discusses the conventional type only.
- Complete each test as quickly as possible (within approximately 3-5 seconds). Otherwise, the coil in the starter motor may burnout.

1. Pull-in Test

(a) Disconnect the field coil lead from Terminal C.

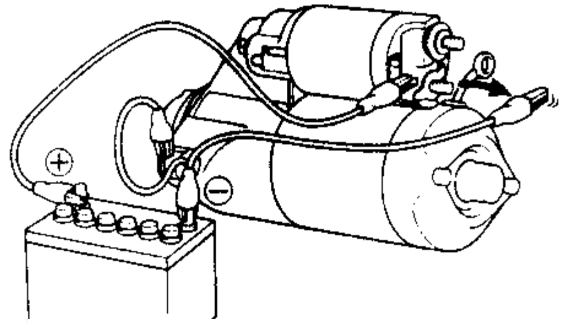
(b) Connect the battery to the magnetic switch as shown. Check that the pinion moves outward.



If the pinion gear does not move outward, check for damage to the pub-in coil, sticking of the plunger, and other possible causes.

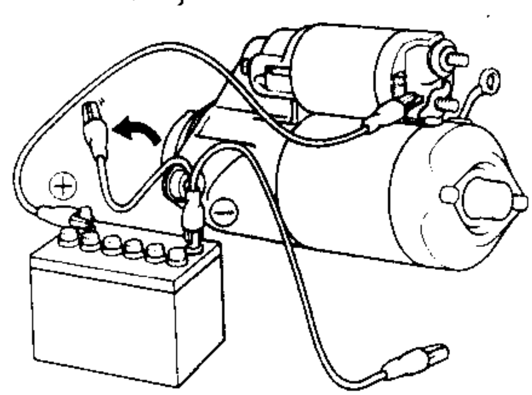
2. Hold-in Test

With the battery connected as above and with the pinion out, disconnect the negative lead from Terminal C. Check that the pinion remains out. If the pinion gear retracts, check for damage to the hold-in coil, improper grounding of the hold-in coil, and other possible causes.



3. Pinion Return Test

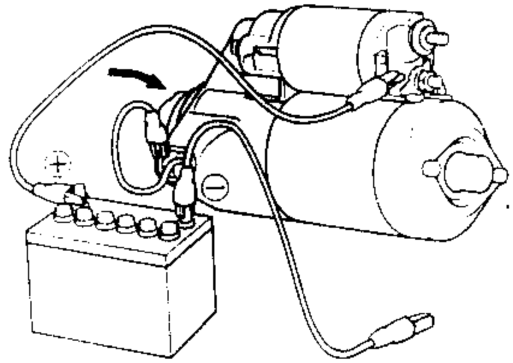
Disconnect the negative lead from the switch body. Check that the pinion retracts. If the pinion gear does not immediately retract, check for fatigue of the return spring, sticking of the plunger, and other

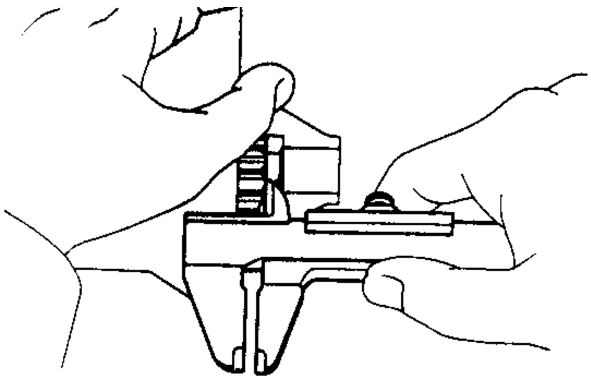


possible causes.

4. Check Pinion Clearance (Except Reduction Type)

(a) Connect the battery to the magnetic switch as shown.





(b)Move the pinion gear toward the armature to remove slack, then measure the clearance between the pinion end and stop collar.

Standard clearance: 0.1 - 0.4 mm

(0.004 -- 0.016 in.)

5. No-Load Test

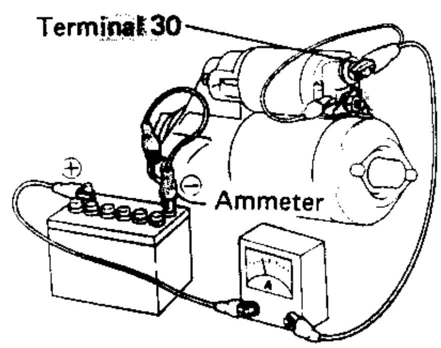
(a) Securely fix the starter motor with a vise, etc.

(b) Connect the field coil lead to Terminal C. Make sure the lead is not grounded.

(c) Connect the battery and ammeter to the starter as shown.

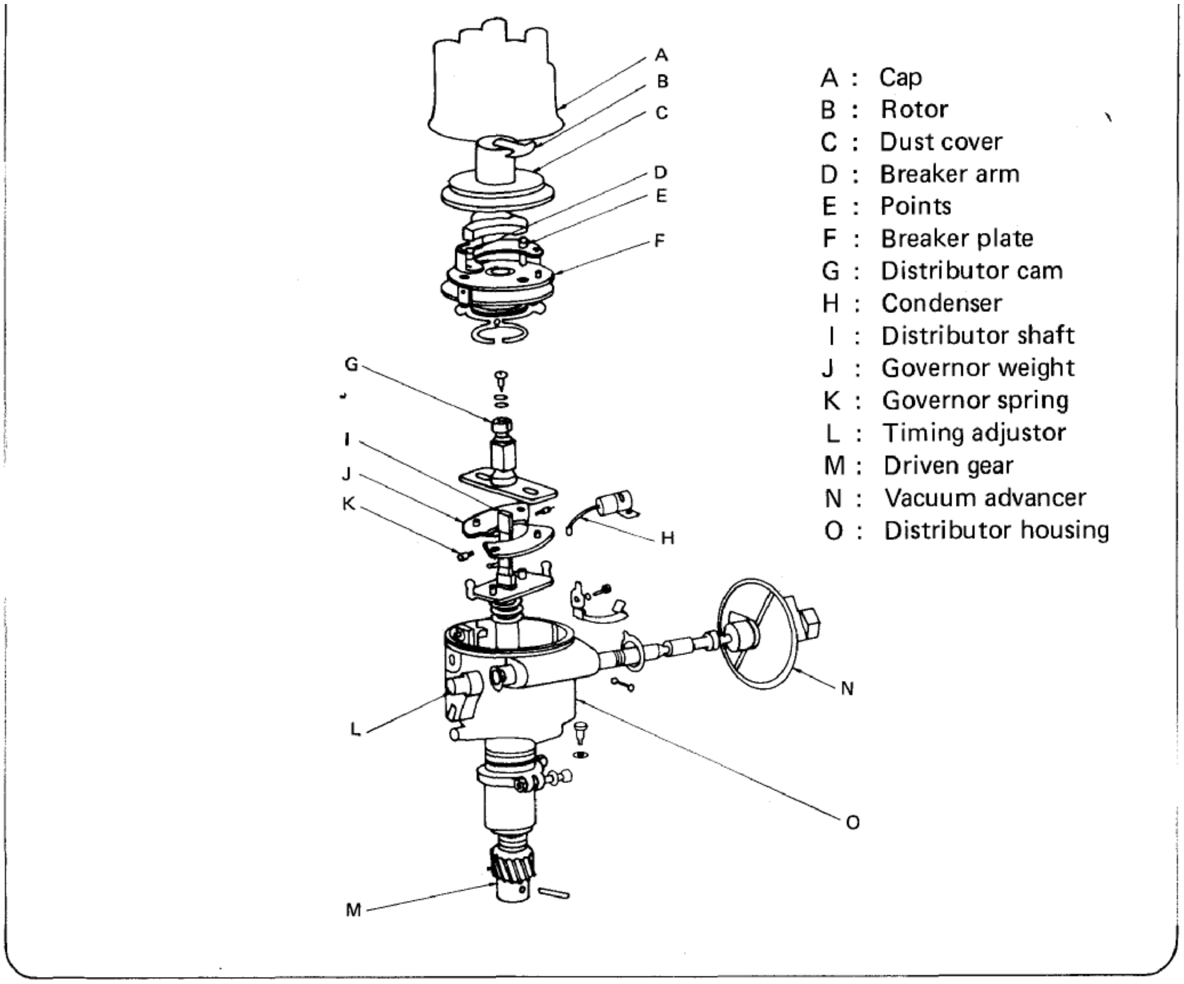
(d) Check that the starter rotates smoothly and steadily, and that the pinion moves out.

(e) Check that the ammeter reads the specified current. Specified current: Less than 50 A at 11 V

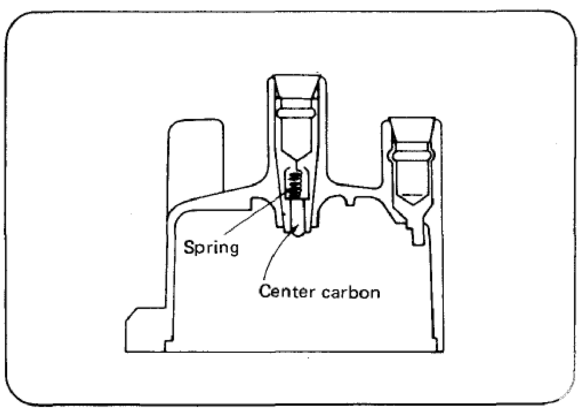


2.3.2 Ignition system

A. Inspection of distrubtor

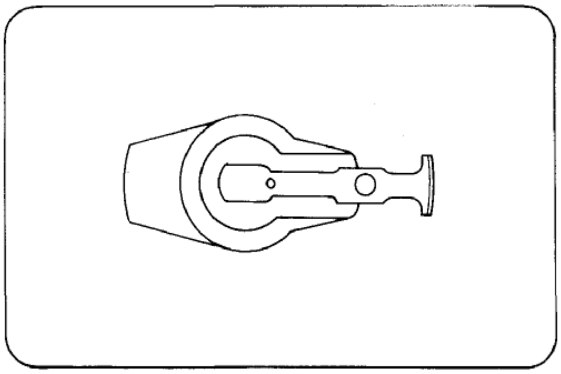


1. Check the distributor cap.



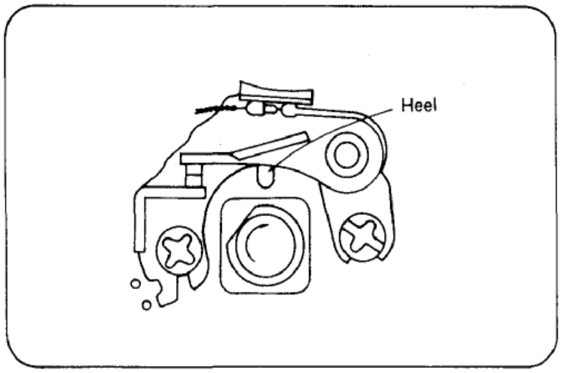
(1) Check the following points:
  a. Cap for cracks or damage
  b. Center carbon and spring for operation and wear

2. Check the rotor.

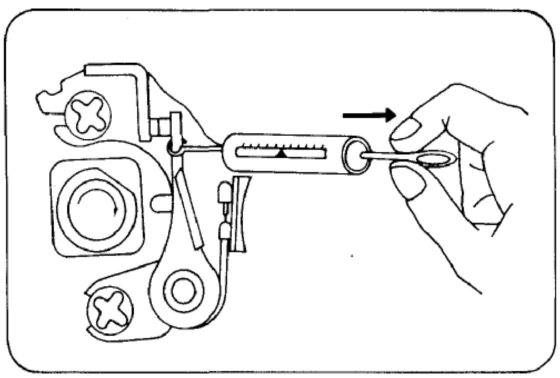


(1) Check the rotor for cracks or damage.
a. If faulty, replace the rotor.

3. Check the breaker arm and points.

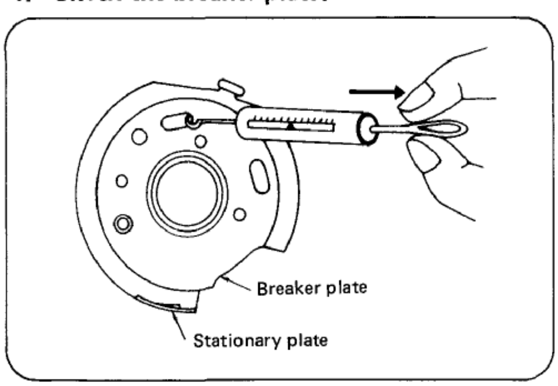


(1) Check the points for burning or contamination, and the heel for wear.
a. If faulty, replace the points.



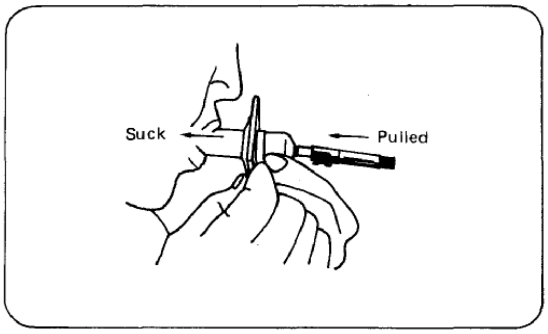
(2) Measure the contact pressure of the points.
a. Replace the points if the pressure is smaller than the specified value.

4. Check the breaker plate.



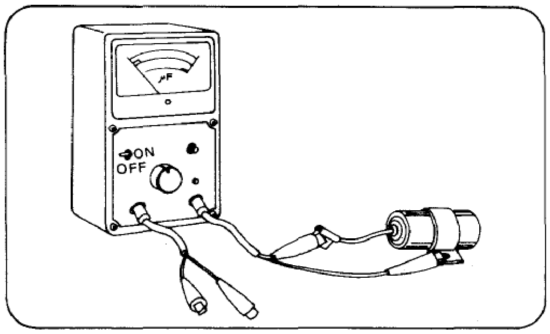
(1) Measure the sliding resistance between the breaker plate and stationary plate.
a. Adjust or replace if the resistance does not meet the specified value.

5. Check the vacuum advancer.



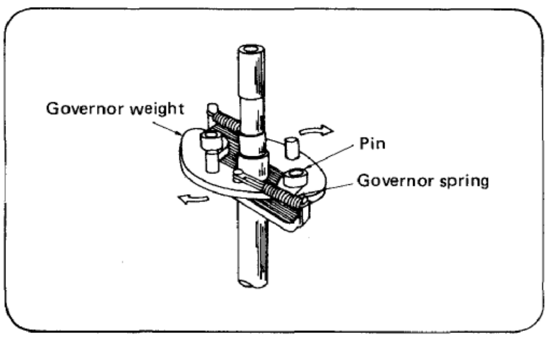
(1) Apply vacuum, and check for leaks or improper operation.

6. Check the condenser.



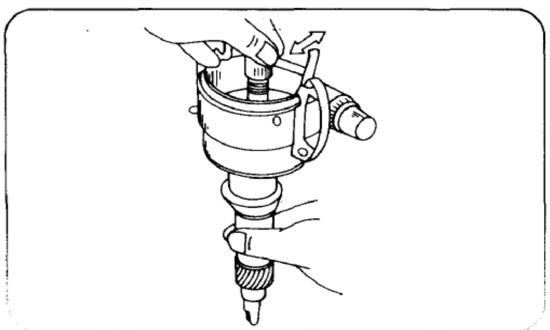
(1) Using the condenser tester, check the following points:
   a. Insulation resistance.
   b. Capacitance
      (Generally 0.20 to 0.24 μF)

7. Check the governor shaft.



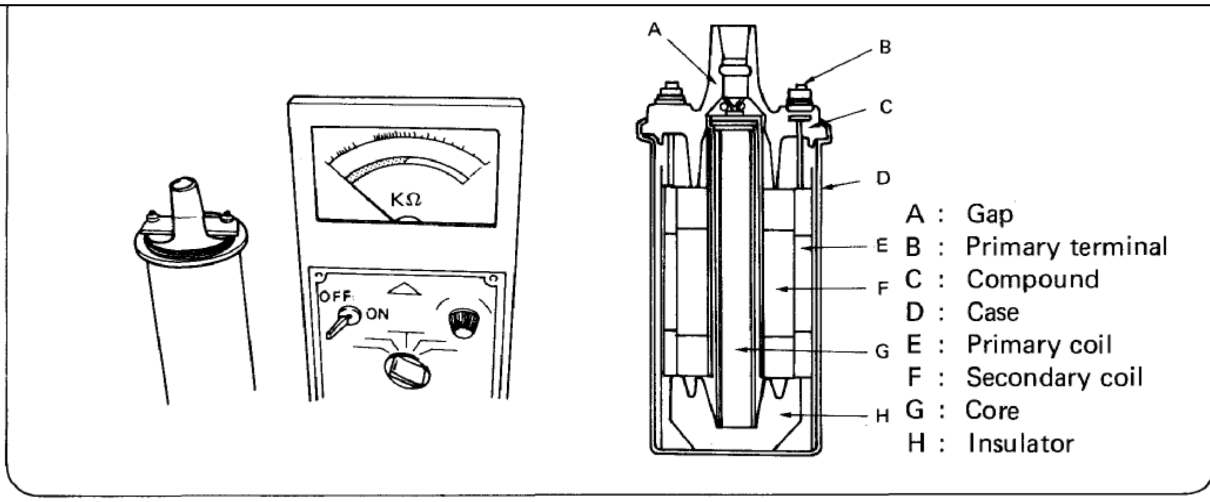
(1) Check the shaft for wear or damage.

(2) Check the governor for normal operation.
   a. If faulty, check the clearance between the governor weight and pin, and check the governor spring.

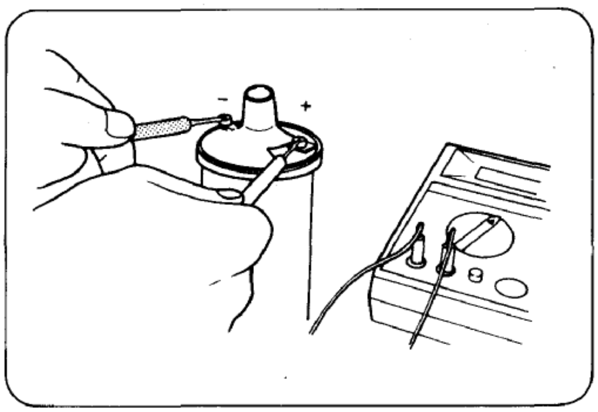


(3) Check the radial play of the shaft.

B. Inspection of ignition coil

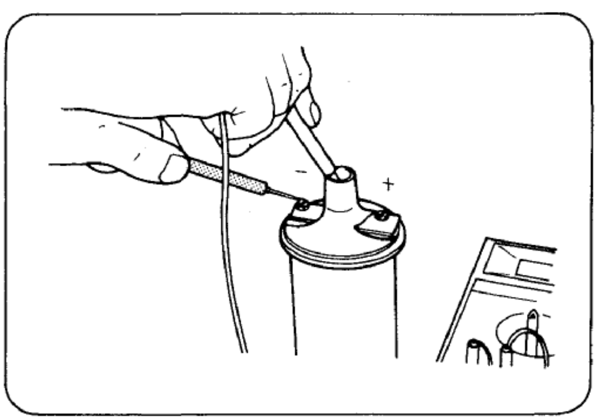


1. Measure the resistance of the primary coil.



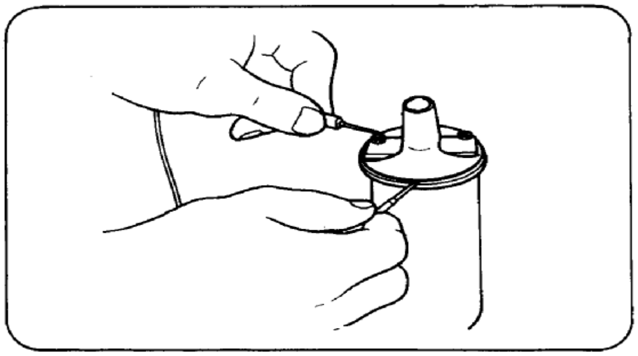
(1) The coil is normal if the resistance is within the specified range. If meter indication is 0 ohm, the coil is shorted; if infinity, the coil has open circuit.

2. Measure the resistance of the secondary coil.



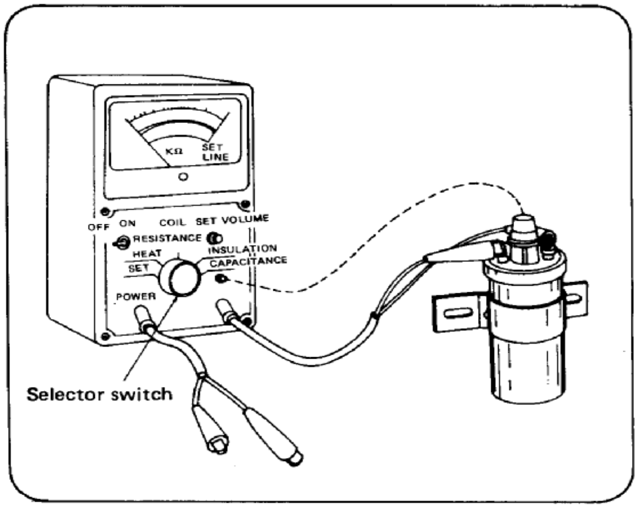
(1) The coil is normal if the resistance is within the specified range. If meter indication is 0 ohm, the coil is shorted; if infinity, the coil has open circuit.

3. Measure the insulation resistance of the coil.



(1) The coil is normal if the resistance is within the specified range. If continuity is indicated, replace the coil.

4. Check the coil, using the coil tester.



(1) Connect the tester and the coil as shown in the Figure on the left.

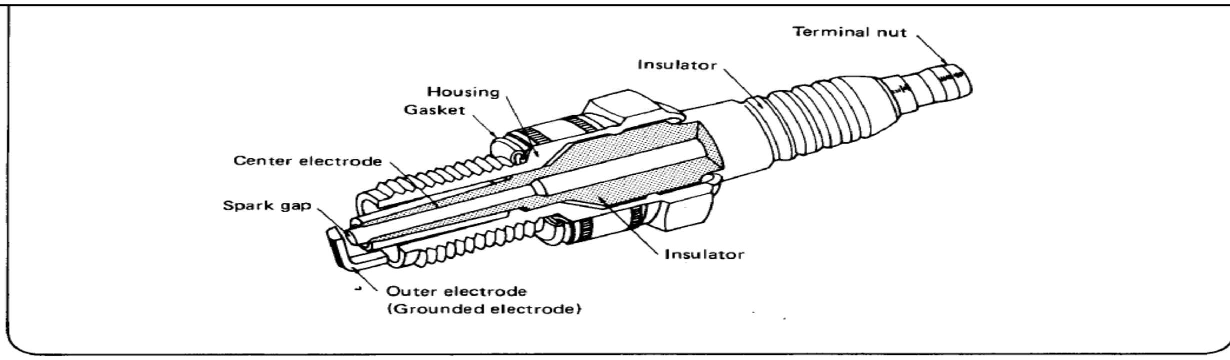
(2) Set the selector switch to the "SET" position, and align the needle with the Set Line.

(3) Set the selector switch to the "COIL RESISTANCE" position, and measure the resistance of the coil.
   a. The coil is normal if the resistance is within the specified range. If the resistance is smaller than the spedification, the coil is shorted; if larger, the coil has open circuit.

(4) Set the selector switch to the "INSULATION" position, and pull off the high tension cord (illustrated by the broken line — — —).
   a. The coil is normal if the insulation is within the specified range. If not, the coil is faulty.

(5) Set the selector switch to the "CAPACITANCE" position.
   a. The coil is normal if the capacitance is within the specified range. If not, the coil is faulty.

C. Inspection of spark plug



1. Check the insulator for burning.

(1) The plug is normal if it is dry and light brown in color.

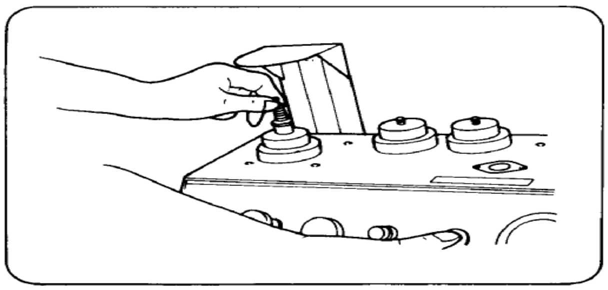
(2) Clean or replace the plug if:
  a. It is stained with black carbon, or
  b. It is burned white, or the electrode is worn.

2. Check the insulator and gasket.

(1) Replace the plug if the insulator is damaged.

(2) Replace the plug if the gasket is damaged or worn.

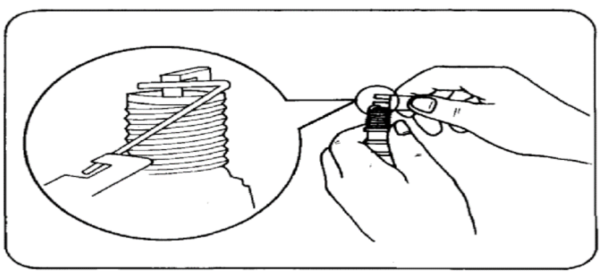
3. Clean the plug.



(1) Use the plug cleaner.

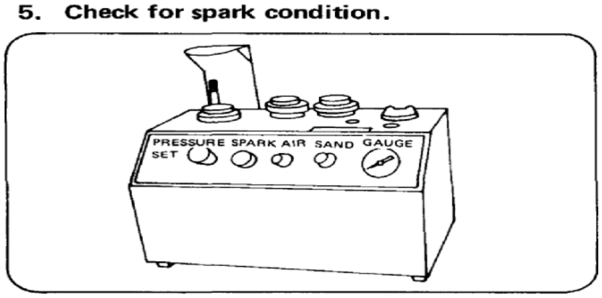
(2) Clean the plug with sand, and then with air.

4. Adjust the plug gap.



(1) Using the plug gap gauge, adjust the gap to the specified value.

5. Check for spark condition.



(1) Using the pressure set valve, set the air pressure to the specified level.

(2) Turn ON the tester switch, and check the spark condition from the access window.
  a. Replace the plug if no spark is produced, or if the spark is irregular.

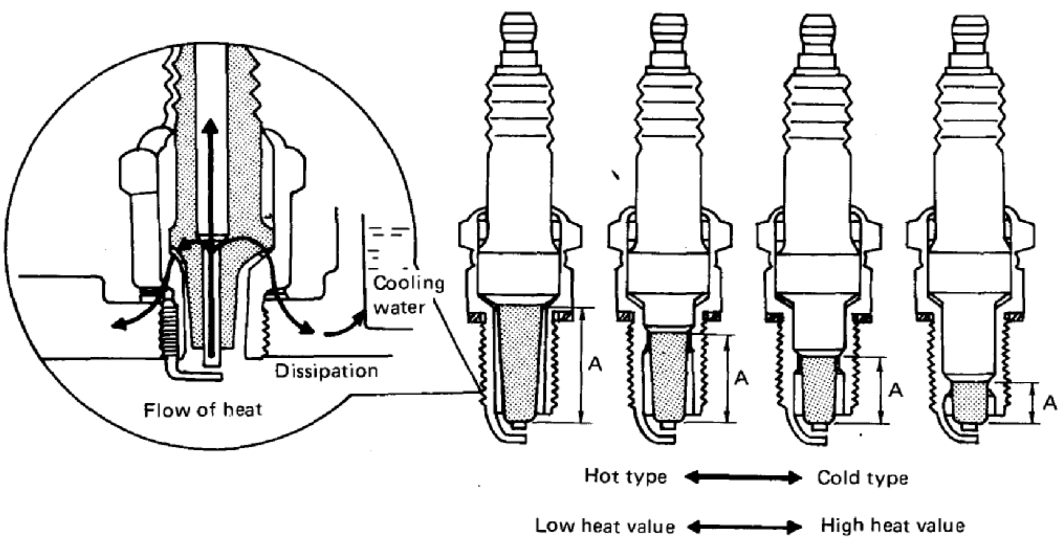
1. Self-cleaning action

Carbon and other contamination can be cleaned by the high temperature of the plug itself. This is called self-cleaning action. The self-cleaning temperature is generally about 400 to 800°C.

2. Heat value

(1) The temperature to which the spark plug can rise is referred to as the heat range. The heat value is a numerical representation of this heat range.

(2) The heat value and the flow of heat inside the spark plug are shown below.



a. Cold type: The length (A) of the insulator is short, and heat dissipation is good.
b. Hot type: The length (A) of the insulator is long, and high temperatures are generated.

3. Plug types

Refer to the manufacturer's specifications.

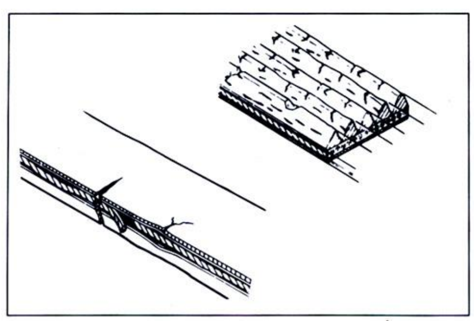
2.3.3 Charging System

General alternator testing and precautions:

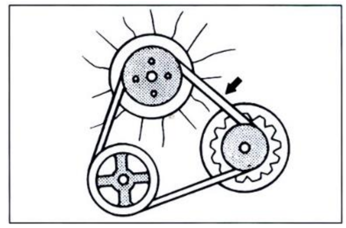
1. To avoid a possible spark or arc that could cause damage, always disconnect the negative battery terminal before performing any service on any electrical components.
2. Be careful of the polarity of the battery. Do not connect the battery with poles reversed.
3. Since battery voltage is always applied on B terminal of the alternator, the B terminal must never be grounded.
4. If battery is charged rapidly using a quick charger, it could be damaged the diodes. Be sure to disconnect the battery cables when using fast charger.
5. Be careful not to get water on the alternator or other electrical components when washing the vehicle
6. The engine should never be cranked with the B terminal of the alternator disconnected. This is because voltage regulation is not occurring at such a time, so the neutral terminal voltage (the voltage at the N terminal) could raise and burn and burn out the relay coil. If the B terminal is disconnected, the wire connected to the F terminal (alternator connector) should always disconnected too.
7. The alternator and regulator should be securely grounded. If they are not securely ground it could cause overcharge, flickering of the light, oscillating of the ammeter needle, etc.
8. The F and IG terminal should not be connected in the reverse for any reason. If they are connected in reverse, it could cause the weir harness to burn up.
9. Never disconnect a battery cable when the engine is running. If the engine continued to run, the alternator could produce 250v when disconnected from the battery and can cause damage the electrical component that is ON at the time of the procedure. Also, this high voltage could cause battery damage or battery explosion if the battery cable was reconnected to the battery with the engine running.

✓ **Inspect drive belt**

Visually check the belt for separation of the adhesive rubber above and below the core, separation of the ribs from the adhesive rubber, cracking or separation of the ribs, torn or worn ribs or cracks in the inner ridges of the ribs.



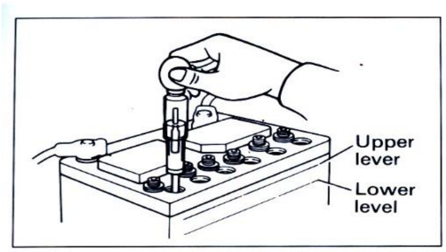
If necessary, replace the drive belt.



b) Check the drive belt tension. If necessary adjust the drive belt tension.

- ✓ **Check battery terminals, fusible links and fuses**

a) Check that the battery terminals are not loosen or corroded

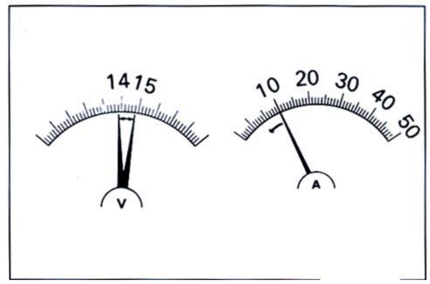


b) Check the fusible links and fuses for continuity

3) Check battery specific gravity

a) Check the specific gravity of each cells

b) Check the amount of the electrolyte in each cell

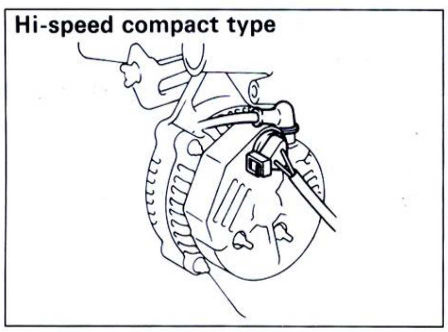


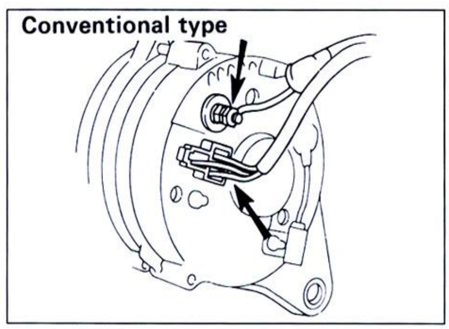
If necessary, refill with distilled water

- ✓ **Visually check alternator wiring and listen for abnormal noises**

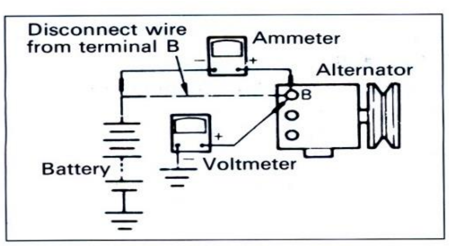
a) Check that the wiring is in good condition

b) Check that there are no abnormal noises from the alternator while the engine is running.





- ✓ **Inspect charge warning lamp circuit**



a) Warm up the engine and then turn it off

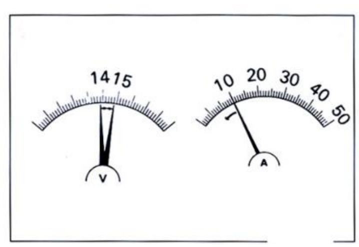
b) Turn off all accessories

c) Turn the ignition switch to the ON. Check that the charge warning lamp is on

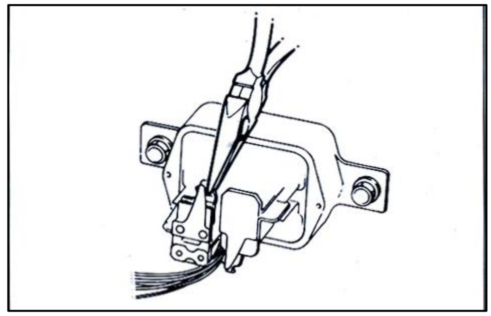
d) Start the engine. Check that the light goes out.

If the light does not operate as specified, troubleshoot the charge warning lamp circuit.

6) Check charging circuit without load



a) Connect a voltmeter and ammeter to the charging circuit as follows:



- Disconnect the wire from terminal B of the alternator and connect it to the negative probe of the ammeter.
- Connect the test probe from the positive terminal of the ammeter to terminal B of the alternator.
- Connect the negative probe of the voltmeter to ground and positive to the B terminal of the alternator.

If the voltage reading is not within standard, adjust regulator or replace it.

7) Check the charging circuit with load

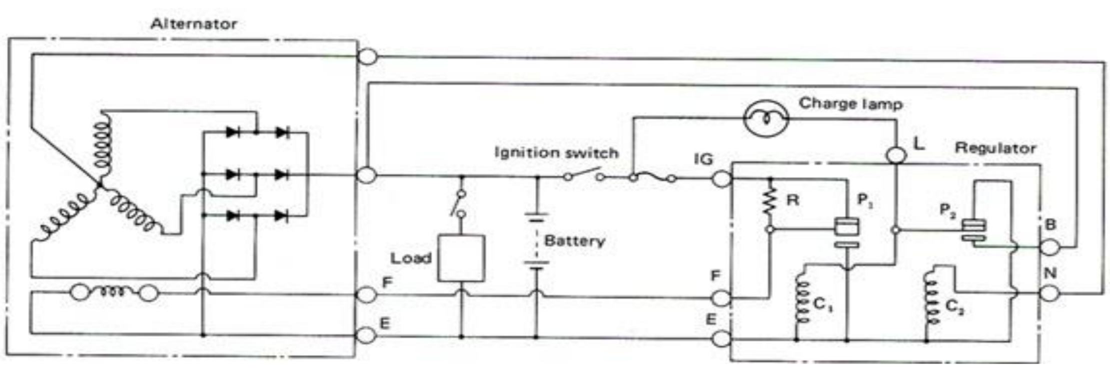
a) With engine running at 2000rpm, turn on the high-beam head lights and place the heater fan control switch to Hi.

b) Check the reading on the ammeter. Standard amperage = more than 30A

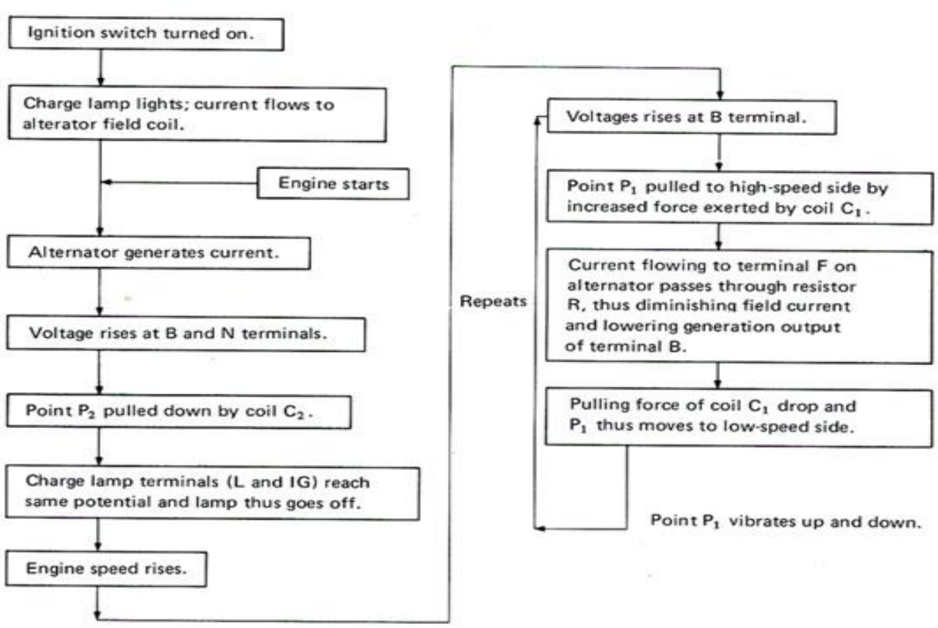
If the ammeter reading is less than 30A repair

Regulator operation

(1) Shown below is a circuit of the 2-element type regulator.



(2) The regulator operation sequence diagram is shown below.



3. **Unit Three: Perform minor engine electrical system service**

This unit to provide you the necessary information regarding the following content coverage and topics:
• Service technique • Engine electrical circuit faults • Post service test This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Following Proper service technique • Repairing engine electrical circuit faults • Carrying out post service test

3.1 Applying proper service technique

3.1.1 Electrical System Diagnostics guide

A vehicle's electrical system is responsible for a whole host of vital functions within a vehicle. The battery, alternator and electrical wiring system enable a vehicle to turn on and off, supply power for accessories like lighting systems, car radios, security systems, and more. If you're seeking a career as an automotive technician, not only will you be responsible for maintaining these systems, you'll also be utilizing your extensive knowledge of vehicle electronics to diagnose and repair them. Thus, when a customer comes in suspecting an issue with their vehicle's electrical system, it's important to be aware of how to conduct diagnostics on this system. Below, discover an introductory guide to this process, which you can use throughout your career as an automotive technician!

A. Obtain Customer Information When Diagnosing Electrical Issues

When it comes to diagnosing electrical system issues, the first step is often the most important one. Before even looking under the hood, make sure to spend some time speaking to the customer in order to obtain information about the nature of their complaint, and their observations related to the problem. Since a customer will be the one with the most experience driving their vehicle, their input will be invaluable to the process of diagnosing the electrical system issue. Once you become an automotive worker, make sure to ask them when the problem occurred, the frequency with which it occurred, the conditions where it occurred, and what symptoms they observed with their vehicle.

B. Be Aware of These Common Electrical System Issues

After listening to the customer's description of the problem, it's helpful to have a few ideas in mind surrounding the issue the electrical system might be experiencing. Knowing a few common electrical system issues may help you to get to the root cause faster and make a diagnosis. One of the most common electrical system issues to look out for is frequently blown fuses, which indicate an electrical fault or short-circuit within the system.

Another common issue is dimming headlights, which could indicate low voltage within the system. Low system voltage could be due to a faulty alternator belt, a dying battery, or loose wires and cables. Battery problems are some of the most prevalent electrical system issues, as a faulty battery can affect the entire system's ability to function.

C. Perform a Road Test as an Automotive Worker

After identifying a few possible problems, you'll want to take the vehicle in question for a road test. Seeing how the vehicle drives will allow you to identify any problems the customer might have missed, and gain a better understanding of how the electrical system is operating. Those with auto repair training backgrounds have the skills to spot an electrical issue when they see one, helping them to run diagnostic tests and come to a solution.

D. Conduct a Visual Inspection of the System

Once the test drive is over, take a closer look at the electrical system. During the visual inspection, you'll want to check for loose or corroded battery cables, damaged wires, a worn alternator belt, and other potentially faulty components. Identifying damage within the system will help you to determine which circuit could be faulty, as well as the components that are contributing to the problem.

E. Perform Additional Tests as Needed

By now, you've hopefully identified the potential source of the electrical system issue. However, there are still some additional tests which can be performed if you're unsure. In order to determine whether there's a short in the circuit, you can perform a resistance test with a multi meter. To test for an open circuit, you can perform a continuity test, in which the battery is disconnected and the multi meter is used to test for resistance. If a lack of power is suspected within the system, a voltage test can also be performed.

3.1.2 Repairing engine electrical circuit faults

Modern vehicles have complicated electrical systems. They provide power for basic operations like starting the engine, operation of spark plugs, lights, wipers, mirrors, power windows and accessories like the music system. They also power the computers monitoring the control and operation of the engine and other critical systems. All parts of the electrical system must function correctly for your car to work normally. Unlike most mechanical issues, electrical problems are difficult to pinpoint and are best done at a good garage. Get your car checked if you notice any of the symptoms below.

A. Starting Problems

It's frustrating when your car refuses to start or you have to make multiple attempts to get the engine running. A battery problem is the prime suspect. That said, there are other problems that can result in the same symptoms. A bad alternator or starter can also cause starting difficulties. Even when a discharged battery is the culprit, there are several ways in which it can happen.

Leaving your car parked with the headlights, music system or some other accessory accidentally turned on is the most common cause of a discharged battery. In this case, all you need to do is to jumpstart the car and drive it for a while until the battery is sufficiently charged. To do this, you will need a jumpstart cable and another vehicle to supply the power.

B. Dim Lights When the Engine Is Running

If the headlights or the dashboard lights seem to dim when you are idling or driving at low speeds, it points to a problem with the voltage regulator or the alternator. It can also be caused by dying battery that has trouble charging and is overloading the system. If you notice this symptom, get your car checked and fixed as soon as possible or you may get stranded on the road.

C. Some Lights or Accessories Are Not Working

If lights or accessories don't switch on, check for obvious reasons like loose cables or fused lamps. If that's not the issue, it could be a blown fuse. You can fix this easily. You will find the information on replacing fuses in your owner's manual. Anything beyond this needs to be checked by a mechanic. It could be a wiring fault within the system.

If a fuse or set of fuses blows frequently, get it checked as soon as possible. You probably have an intermittent short circuit, a wiring fault or a faulty component that is drawing excess current.

D. Smell of Burning Plastic

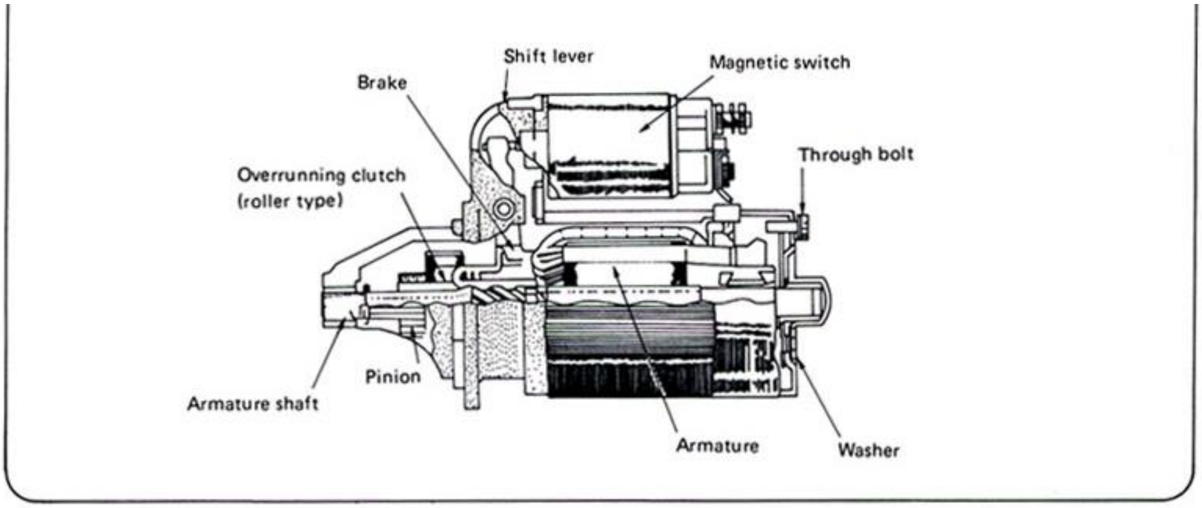
Any kind of odd smell in a car is a cause for concern. You cannot always tell what is burning or how serious the issue is. If you detect a smell of burning plastic, it's likely that some wires or insulation of a wire is burning. Normally, wires will not heat to a point where it burns or damages the insulation. If you notice a burning smell, stop the car and call a mechanic because there is a risk of fire. The fumes are likely to be toxic. So, open the windows to ventilate the cabin.

E. Rough Idling Or Sputtering Engine

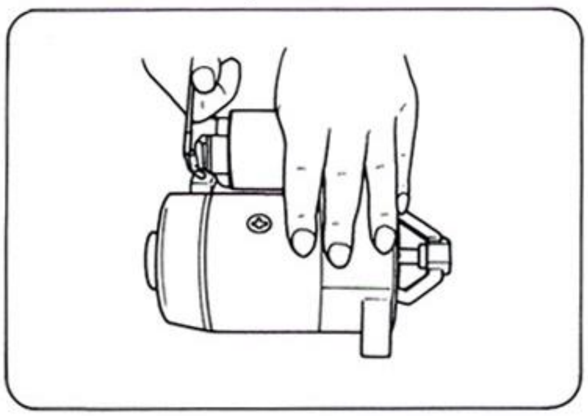
You will be familiar with the sound of your engine. If you notice any rattling or knocking sounds while idling, you probably have a spark plug problem. It could just be a spark plug that just needs cleaning or replacement. It could also be an electrical issue. If you suspect electrical problems, take your car to a good garage.

3.1.3 Repairing engine electrical systems

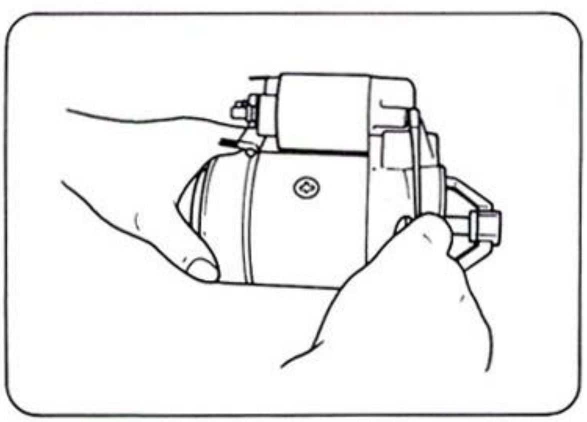
A. Disassembling and inspection of starter motor



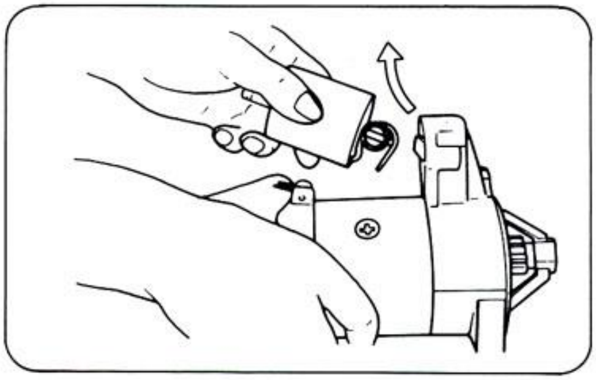
1. Remove the magnetic switch.



(1) Remove the leads from the magnetic switch.

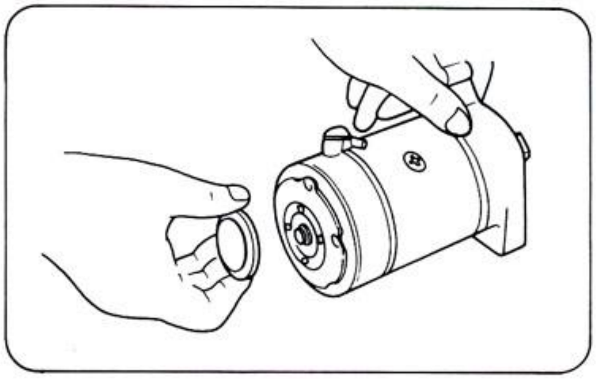


(2) Remove the magnetic switch mounting nut.

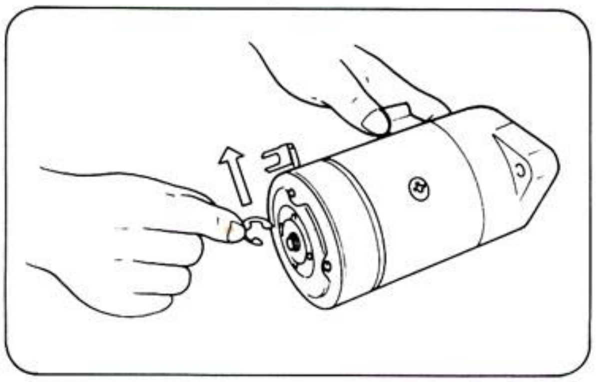


(3) Remove the magnetic switch by lifting it in the direction of the arrow.

2. **Remove the end cover.**

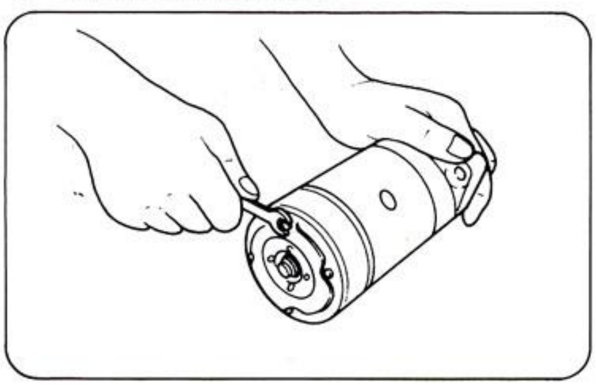


3. **Remove the lock plate.**

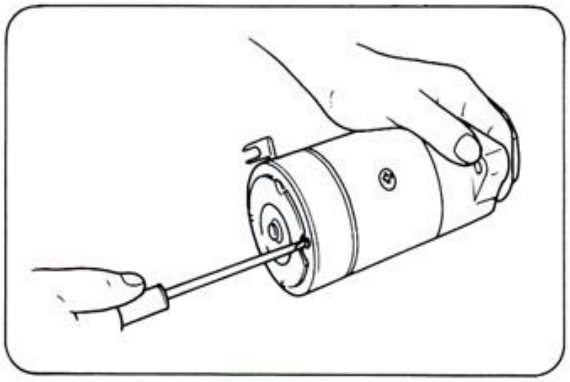


(1) Remove in the direction of the arrow, using a screwdriver.

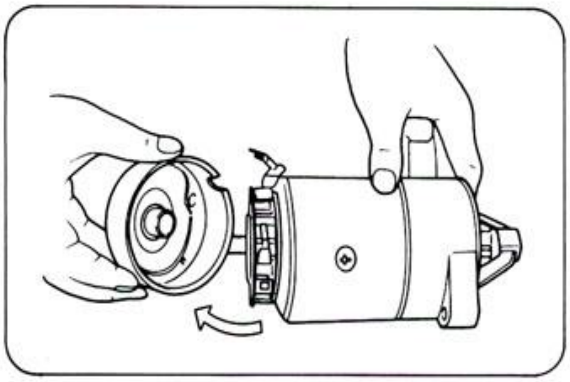
4. **Remove the end frame.**



(1) Remove the through bolt.

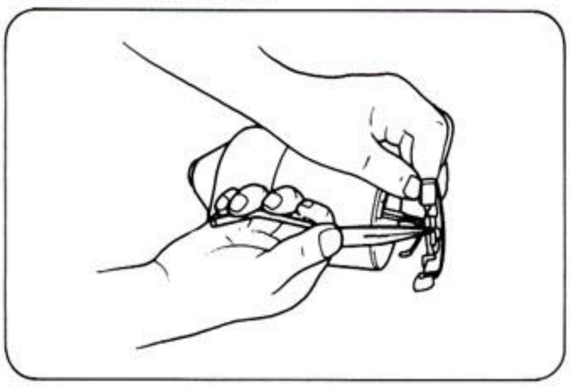


(2) Remove the brush holder mounting bolts.

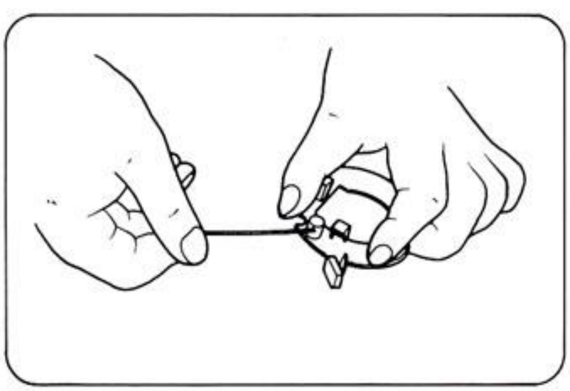


(3) Remove the end frame in the direction of the arrow.

5. **Remove the brush.**

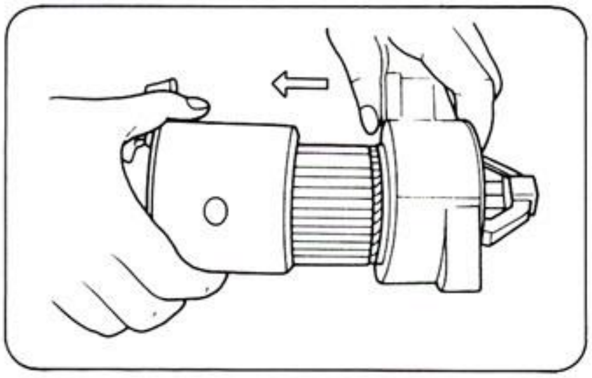


(1) Remove the brush by lifting the brush spring with long nose pliers.



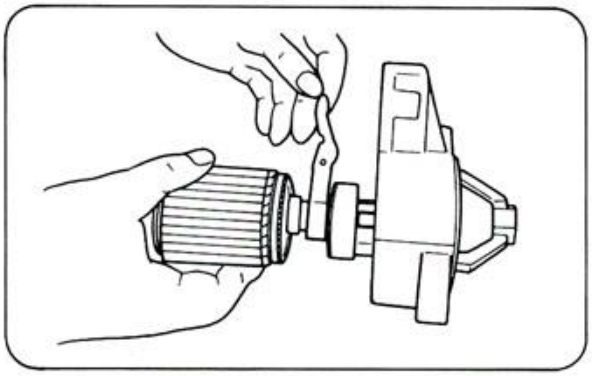
(2) The brush may also be removed as shown on the figure on the left.

6. Remove the yoke.



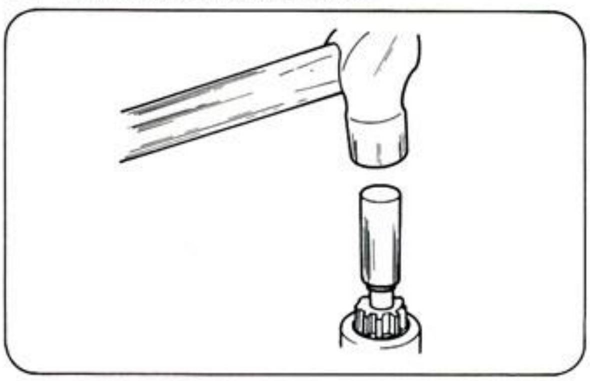
(1) Remove the yoke in the direction of the arrow while oscillating it.

7. Remove the drive lever and armature.

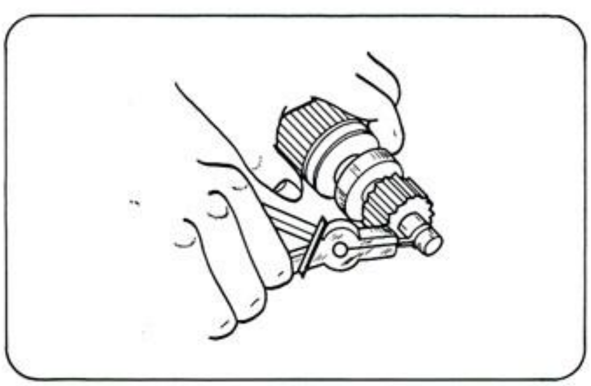


(1) Pay attention to the direction of the drive lever.

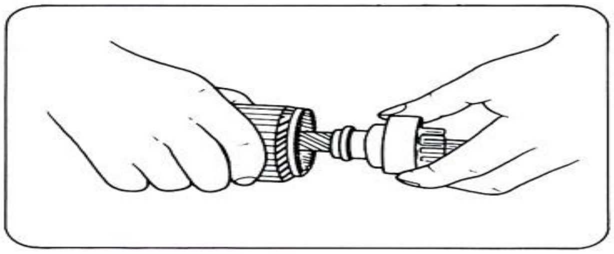
8. Remove the starter clutch.



(1) Using the special tool, remove the pinion stop collar toward the clutch.



(2) Remove the snap ring.



(3) Remove the stop collar clutch.

9. Assemble the removed parts.

(1) To reassemble, reverse the removal procedure.

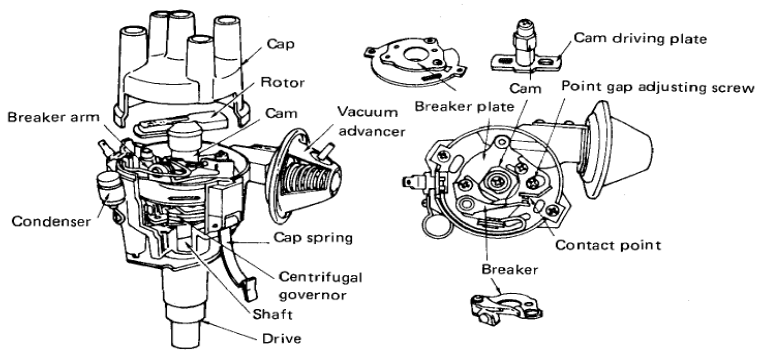
(2) Pay attention to the following points:
a. Ensure the shift lever is positioned in the correct direction.
b. Apply grease to each sliding surface.

B. Disassemble and reassemble Ignition distributor

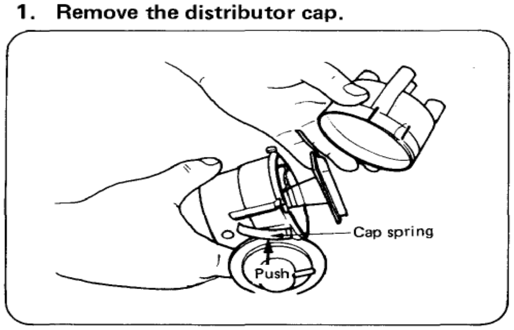
Objectives : Learning to disassemble and reassemble the distributor.

Materials : Distributor

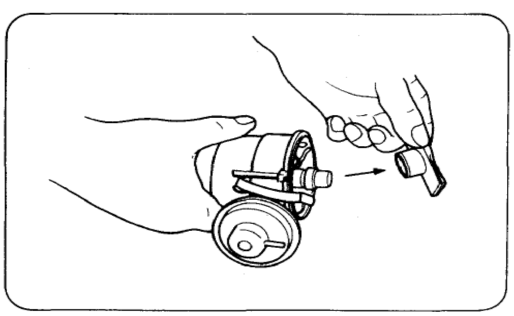
Equipment and tools : 1. Punch 2. Thickness gauge



1. **Remove the distributor cap.**

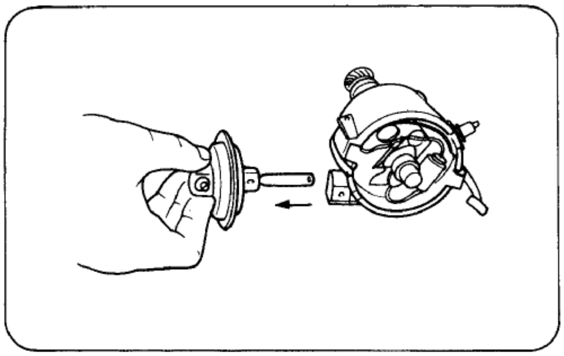


2. **Remove the rotor.**



(1) Pull off the rotor by hand.

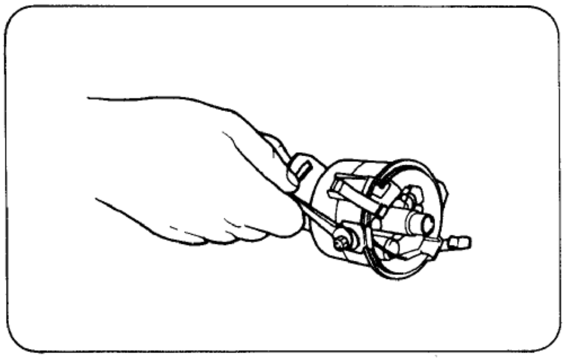
3. Remove the vacuum advancer.



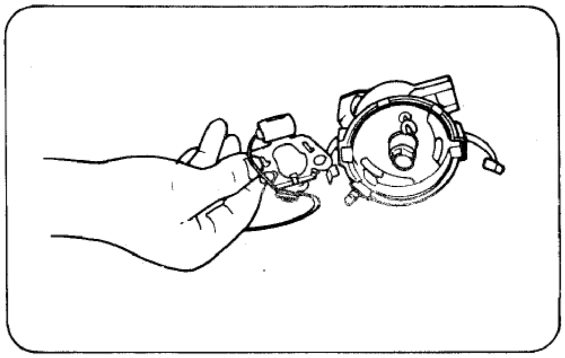
(1) Remove the vacuum advancer mounting screws and breaker plate mounting screws.

(2) Pull off the vacuum advancer.

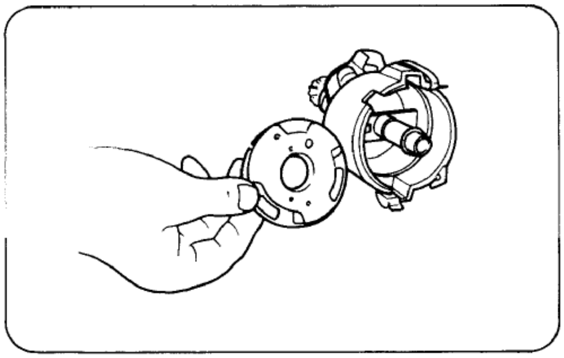
4. Remove the terminal.



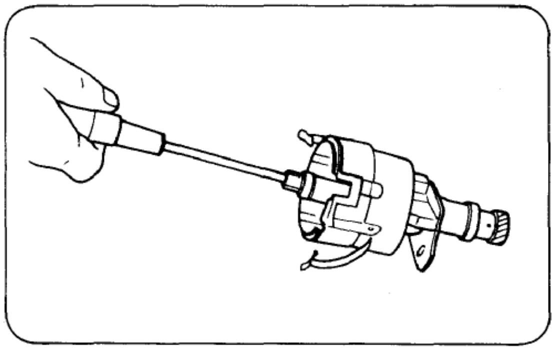
5. Remove the contact point assembly.



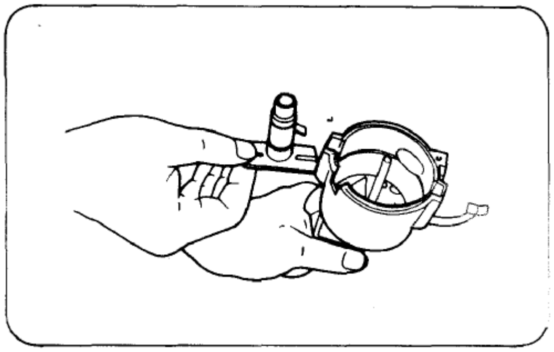
6. Remove the breaker plate.



7. Remove the distributor cam.

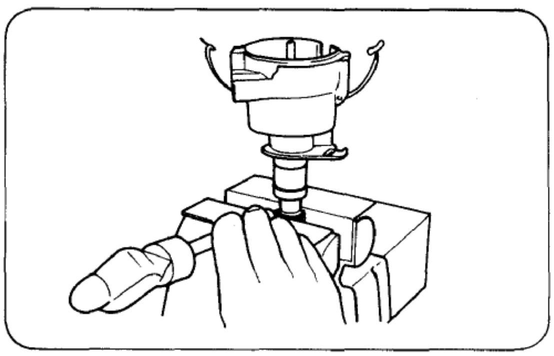


(1) Remove the screw from the end of the governor shaft.

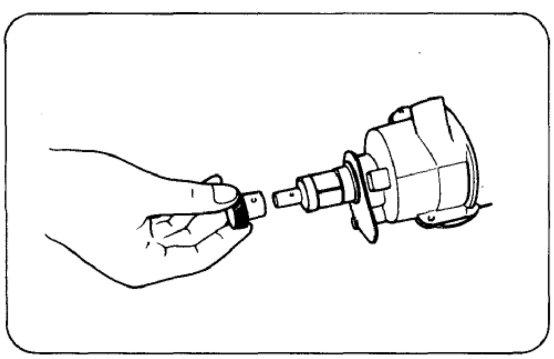


(2) Pull off the distributor cam.

8. Remove the governor shaft.

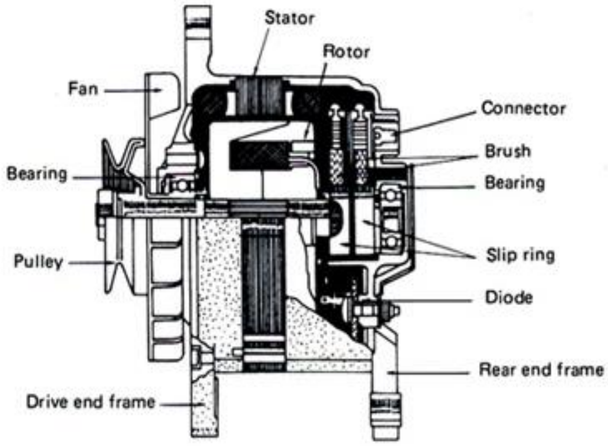


(1) Using a pin punch, remove the pin from the governor shaft.

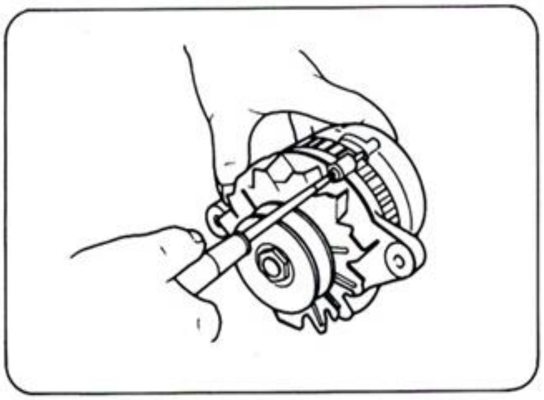


(2) Remove the drive gear.

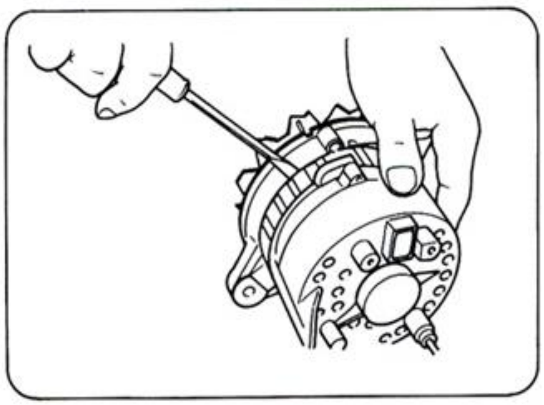
C. Disassembly and Reassembly of Alternator



1. Remove the drive end frame.

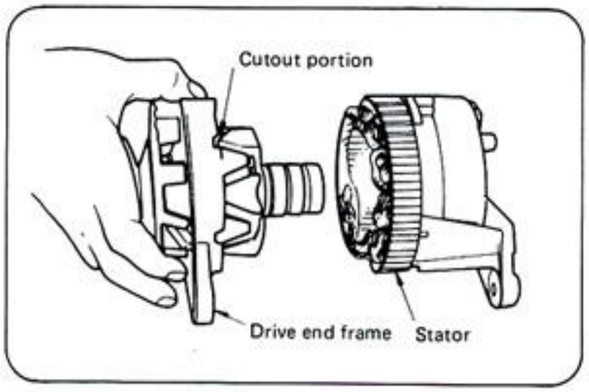


(1) Remove the through bolt.

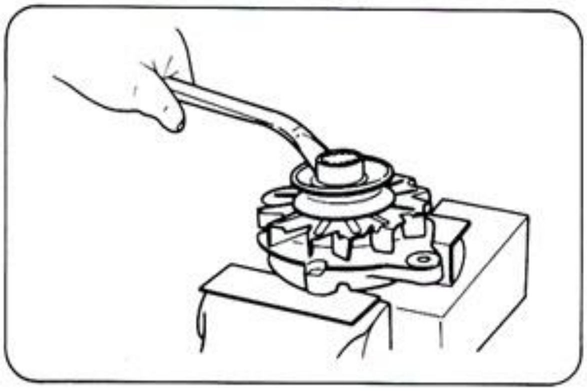


(2) Insert the screwdriver tip into the cutout portion of the drive end frame, and pry up the frame.

(3) Separate the drive end frame from the stator.

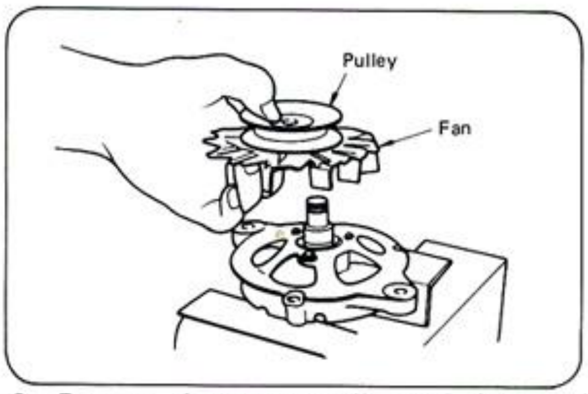


2. **Remove the pulley and fan.**



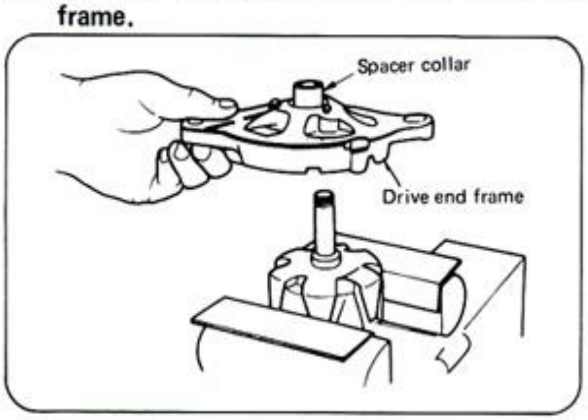
(1) Clamp the rotor core in a vise. Insert cushion plates.

(2) Remove the pulley lock nut.

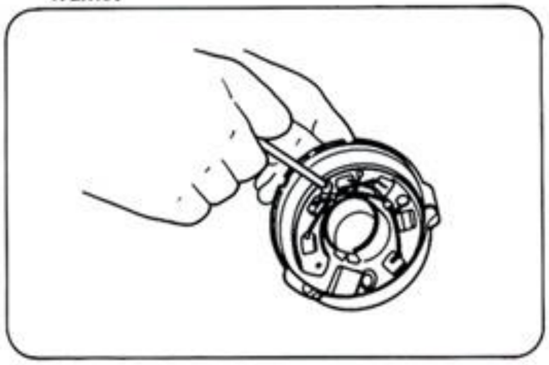


(3) Remove the pulley and fan.

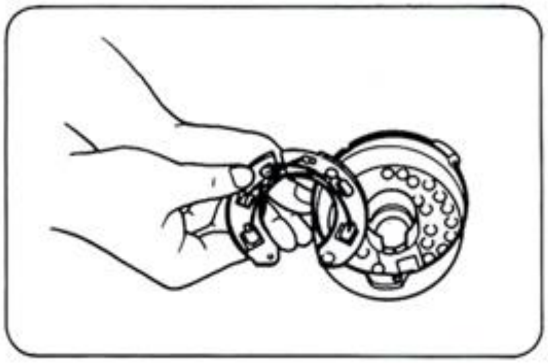
3. **Remove the spacer collar and drive end frame.**



6. Remove the holder fin from the rear end frame.

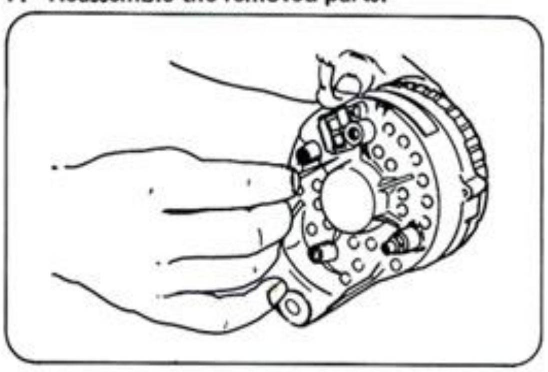


(1) Remove the holder fin mounting bolts.



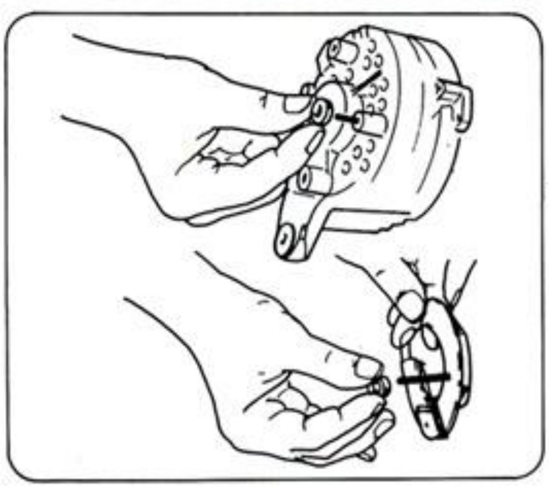
(2) Remove the holder fin from the rear end frame.

7. Reassemble the removed parts.



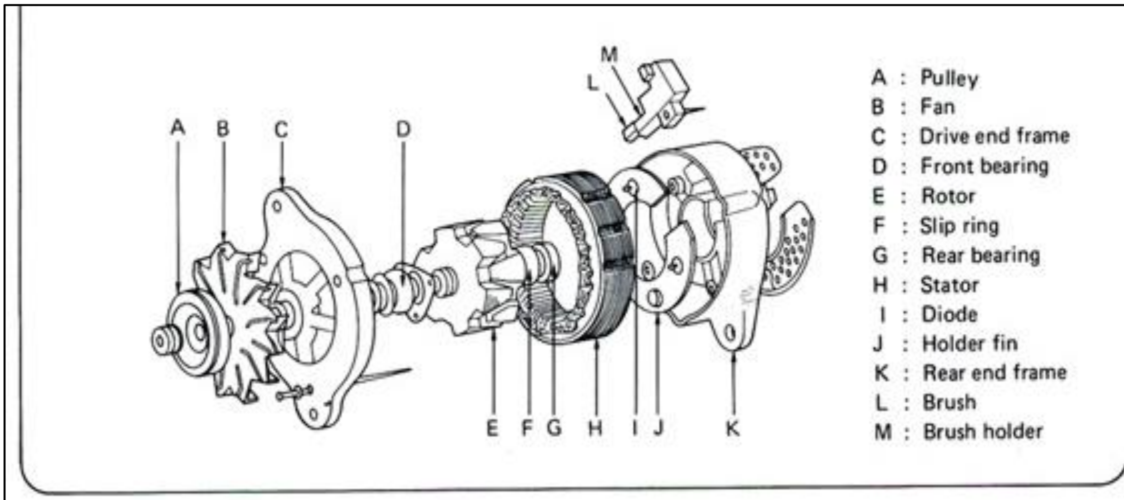
(1) To reassemble, reverse the removal procedure.

(2) Pay attention to the following points:
   a. Tighten the pulley lock nut to the specified torque.
   b. When assembling the rotor, support the brush with the brush holder as shown in the figure on the left.

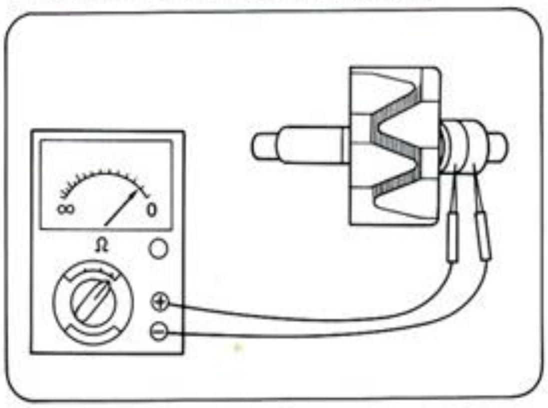


   c. Do not fail to install insulators to the terminal "B" and to the positive side of diode holder.

D. Inspection of Alternator



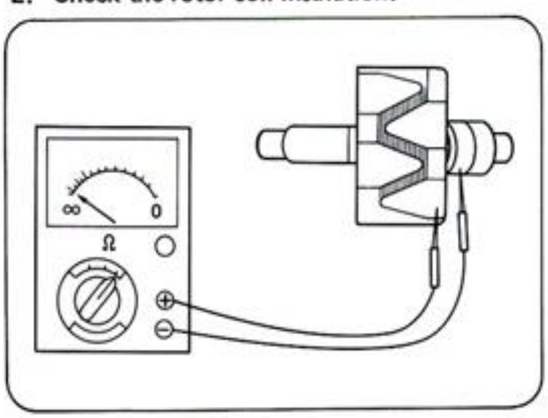
1. Check the rotor coil for continuity.



(1) Measure the resistance between the two slip rings.

(2) The rotor coil is normal if the resistance is within the specified range; if the tester shows no continuity, the coil has open circuit.

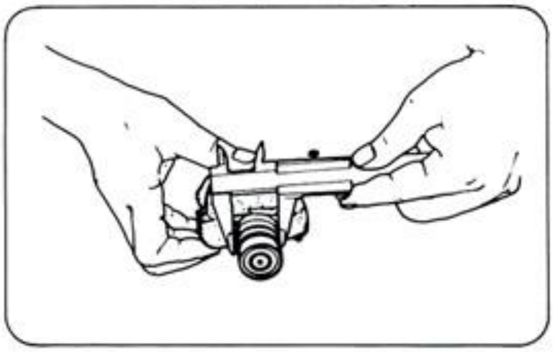
2. Check the rotor coil insulation.



(1) Measure the insulation resistance between the slip ring and rotor core.

(2) The rotor coil is normal if there is no continuity. Replace the coil if continuity is indicated.

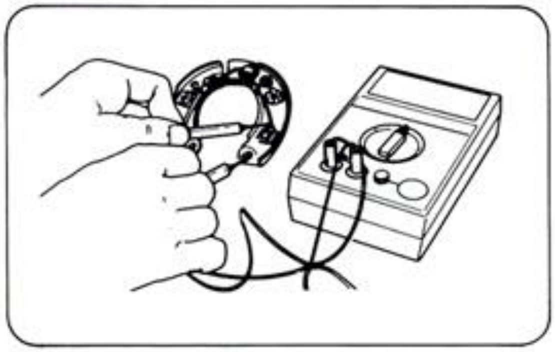
3. **Check the slip ring.**



(1) Measure the slip ring O.D. using vernier calipers.

(2) If the O.D. is within the limit, the slip ring is normal; if it exceeds the limit, replace the slip ring.

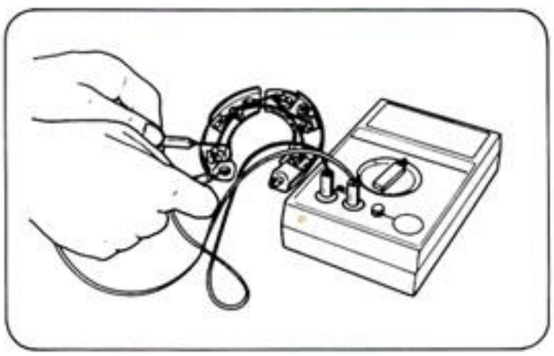
4. **Check the diode.**



(1) Check the positive (+) side diodes (three).

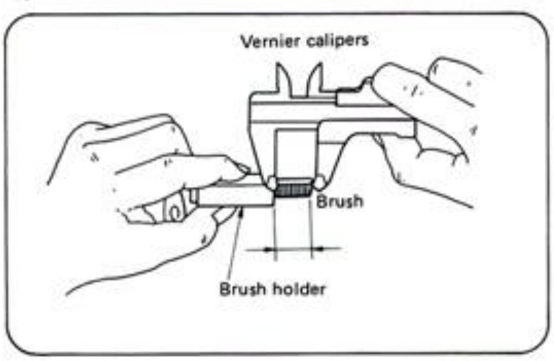
(2) Use the circuit tester ("kilo-ohm" range).

(3) If the diode conducts in one direction but does not conduct in the opposite direction when the tester lead polarity is changed, the diode is normal. If the diode is shorted (resistance of almost zero ohm), or open (resistance of infinity), replace as a unit.



(4) Check the negative (–) side diodes in a similar manner.

5. **Check the brush and brush holder.**



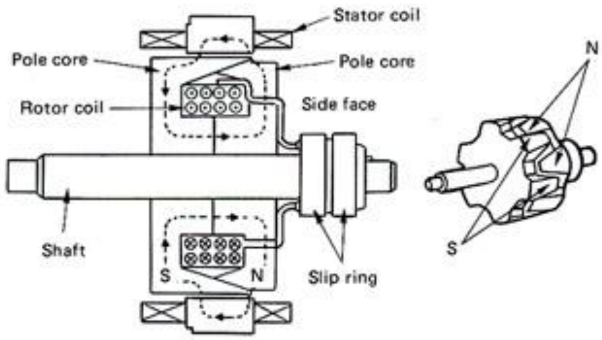
(1) Measure the length of the brush projecting from the brush holder, using vernier calipers.

(2) Replace if the length is less than the limit.

1. Construction of parts

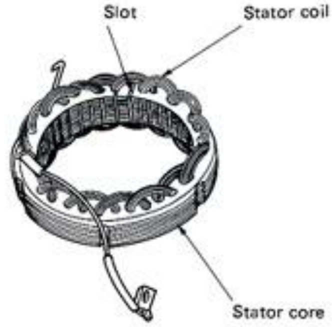
(1) Rotor

a. The rotor is composed of a pole core, coils, slip rings and a shaft.
b. The rotor core is magnetized when current flows through the rotor coil.



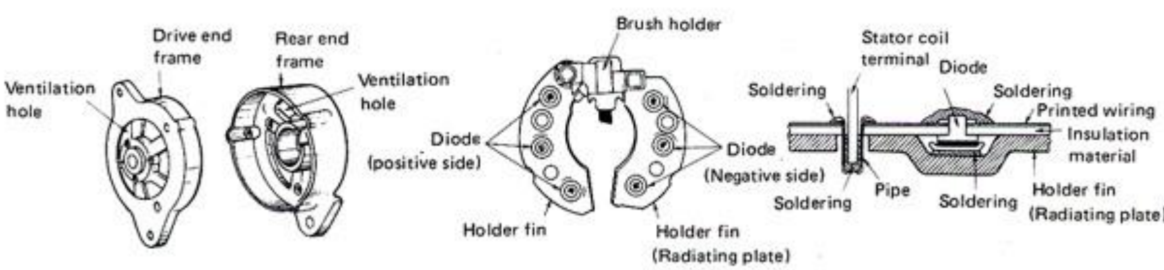
(2) Stator

a. The stator is composed of a stator core and stator coil.
b. The stator core is made by stacking a number of thin iron plates. This forms the passage of magnetic flux in combination with the rotor core.



(3) End frame

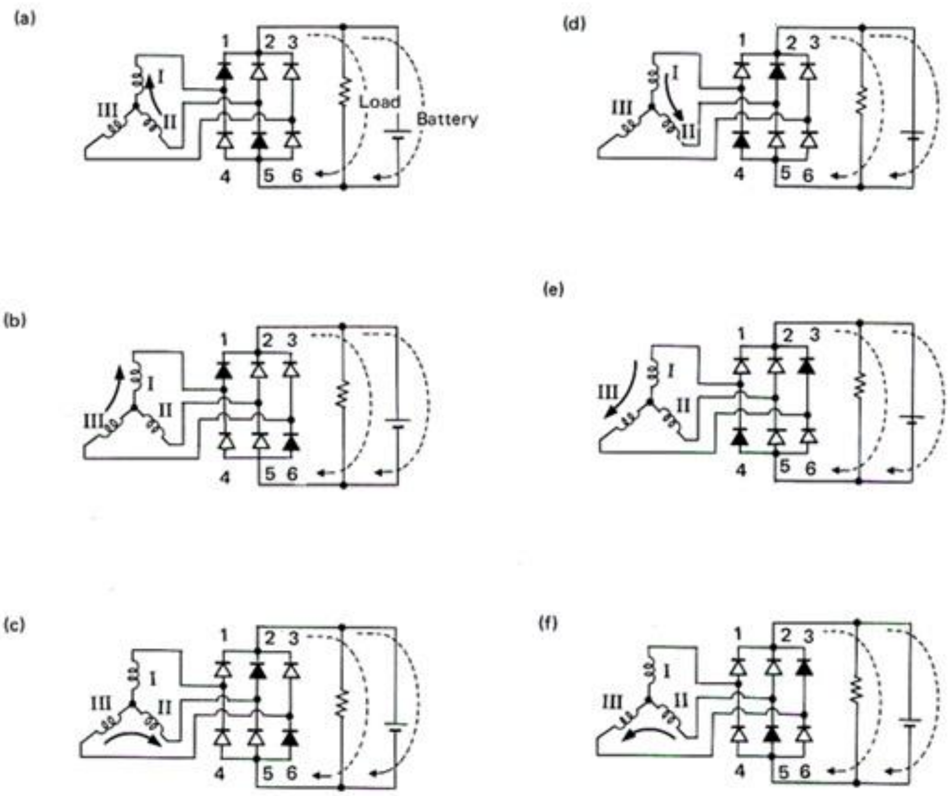
a. The end frame supports the stator and rotor, and also provides the mounting to the engine.



b. The diode, brush and output terminal are mounted to the rear end frame.

2. Rectification

The alternator generates three-phase alternating current, which is fully rectified by six built-in diodes.



4. Unit 4: Cleanup work area and maintain equipment

This unit to provide you the necessary information regarding the following content coverage and topics:
• Clean work area • Waste and scrap materials • Maintain tools and equipment • Faulty equipment This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Cleaning work area • Reusing waste and scrap materials • Maintaining tools and equipment • Tagging and isolate faulty equipment

4.1 Cleaning work area

A contact cleaner (also called electrical cleaner, switch cleaner, electrical contact cleaner, and, specific to automotive repair, battery terminal cleaner) is a solvent cleaner designed to remove contamination from electrical contacts, the conductive surfaces of connectors, switches and other electrical and electronics.

Methods of Cleaning Electrical Apparatus. Never attempt to clean electrical power equipment while it’s energized. Remember to observe all safe work practices and lockout/tag out procedures prior to cleaning. Personnel should be properly qualified before cleaning electrical equipment.

Keeping electrical equipment clean is an important part of any electrical preventive maintenance program, but using the wrong cleaning methods could be costly.

Determine the cleaning method by observing the type of contamination to be removed and the time allowed until the equipment needs to be returned to service.

Sufficient dry time is required when using liquid solvents or water to clean electrical equipment. Insulation should be tested to determine whether it has been properly reconditioned before re-energizing equipment.

Methods of Cleaning Electrical System

1. Rags and Brushes

Wiping off dirt with a clean, dry, lint-free cloth or soft brush is usually satisfactory if the apparatus is small, the surfaces to be cleaned are accessible, and only dry dirt is to be removed.

Don't use waste rags when cleaning electrical equipment because lint will adhere to the insulation, acting as a further dirt-collecting agent, which can cause tracking. Cloth rags should be clean and free of oil, grease, and metallic deposits.

Use care to avoid damage to delicate parts. Rags can easily catch on edges other and sharp objects, which could damage small plastic or moving parts.

2. Liquid Solvents and Water

Accumulated dirt, oil, or grease might require a solvent to be removed. A rag barely moistened (not wet) with a nonflammable solvent can be used for wiping. Solvents used for cleaning of electrical equipment should be selected carefully to ensure compatibility with materials being cleaned. Accumulated dirt, oil, or grease might require a solvent to remove it.

3. Vacuum Cleaning

Loose dust, dirt, and particles can be removed using a vacuum-type cleaner with non-metallic attachments and hoses. Blowing equipment out with compressed air is likely to spread contamination and damage insulation.

4. Sweeping and Moping

If the sweeping of a substation room is required, use a sweeping compound to limit the amount of dirt and dust becoming airborne. When mopping, keep the mop bucket as far as practical from the switchgear to prevent damage from spillage.

4.2 Reusing waste and scrap materials

The idea of being wasteful makes many people uncomfortable. Yet most of us continue to waste because we can't think of anything better to do with last year's phone book, draperies that are too short, or a closet door that was scratched by a favorite pet. We are conditioned to think of things that are old, empty, worn, broken, ugly, or marred as useless, so we throw them away without much thought about the consequences. Most Americans buy far more than they can use effectively, as evidenced by bulging attics and garages.

Carry a reusable tote bag or take bags to the store when you go shopping. There are attractive nylon mesh bags available that can be stored easily in the glove compartment of your car. Durable canvas bags, which take very little space to tuck away when not in use, can also be used.

4.3 Maintaining tools and equipment

Tools and equipment require proper care and maintenance, not only for longevity but also to remain useful and safe for the task at hand. Here are some care and maintenance practices for tools and equipment.

A. Proper storage

Proper storage entails shielding tools from harsh weather conditions, damage and theft. It is particularly crucial for metallic tools to be kept away from moisture to avoid rusting.

Having a cabinet where these tools and equipment are stored will be vital to ensuring a secure storage area. Also, greasing, lubricating or oiling metallic tools and equipment is essential to prevent rust from forming while keeping the tools in the best condition for future tasks.

B. Using tools and equipment for their right task

Using a tool for the task it is intended helps to keep it in its best shape. This reduces unnecessary damage and protects the user. It is also important to check whether the tools are in the right condition before using them.

C. Cleaning after use

Storing dirty tools without cleaning them can cause them to deteriorate. Routine cleaning reduces the chances of rust and can reduce the rate of wear and tear.

D. Inspect tools regularly

Regular inspection of tools is beneficial since it provides an opportunity to see if tools may need repair or replacing. Inspections can help to prevent a situation where a last minute trip to the store to purchase a new tool or spare parts delays a project.

E. Read and follow manuals

The manuals that come with equipment, especially power tools, have important and useful guidelines. They instruct and advise on the best way to keep equipment in optimal condition.

4.4 Tagging and isolate faulty equipment

The Workplace Manager and/or Management OHS Nominee is responsible for ensuring equipment identified as being unsafe or requiring maintenance work, is switched off and disconnected from any source.

If an employee operating or inspecting equipment identifies any equipment that is unsafe or in need of maintenance or repair, they are to take corrective steps, as above and notify the Workplace Manager and/or Management OHS Nominee. Unsafe electrical equipment must be isolated from energy sources, for example by using some of the following methods:

- Removal of fuses
- Isolation of the motor
- Isolation of the control panel
- complete removal of power cable/plug from equipment
- locking out the power supply

For equipment that has been isolated, a tag indicating that the item is "Out of Service" should then be placed onto all on/off switches and power leads. The "Out of Service" tag must be left on faulty items until the fault has been rectified or the tag is replaced with a 'Danger – Do Not Operate' tag and/or lock by a contractor or other person authorized to rectify the fault. The tag is to indicate the reason for the equipment being isolated, who the tag was completed by and the date it was completed. The workplace should have 'Out of Service' and 'Danger Do Not Operate' tags available in an accessible location, when required.

Self-check

Answer the following answer

1. What is electrical cleaning?
2. What is isolation?
3. Why is it important to maintain equipment and tools?
4. What are the steps for isolation?
5. What are the 10 ways of maintaining tools and equipment?

Reference

- ✓ *Recommended Practice for Electrical Equipment Maintenance*
- ✓ *Auto motive mechanics William H.Crouse 10th edition*
- ✓ *Light & heavy vehicle technology   Fourth Edition*
- ✓ *Automotive technology A Systems Approach   7th ed. Jack Erjavec Rob Thompson*

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