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Starting Systems

Subject **Page**

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Starting Systems

Model: All

Production Date: All

Objectives

After completing this module you should be able to:

- Explain the purpose of the starting system.
- List and identify the components of the starting system.
- Recognize the different types of starters.
- Diagnosis starting system problems.

Starting Systems

Purpose of the Starting System

The purpose of the starting system is to convert chemical energy stored in the battery into electrical energy, then into mechanical energy in the starter motor. This mechanical energy is then transferred through gears and drives from the starter motor to the engine flywheel.

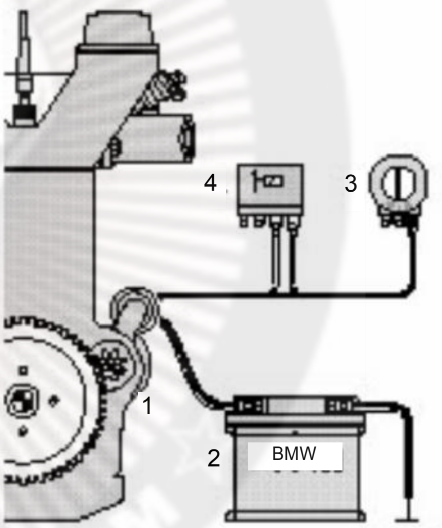
After the transfer and conversion of all this energy the engine flywheel begins to rotate.

The rotation must be of sufficient speed to allow the engine to form the combustible air-fuel mixture required for starting. It must be maintained during initial combustion long enough until the the engine can sustain operation.

To accomplish this a starter or cranking motor is used.

The starting system consists of the following components:

- Battery
- Ignition Switch
- Starter Motor Assembly
- EWS (if equipped)
- Starter Safety Switch
- Cables and Wiring Harness



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1. Starter	2. Battery
3. Ignition	4. Relay

System Components

Battery

The Battery is the primary EMF source in the automobile. The automotive battery is an electro-mechanical device that provides the potential difference (voltage). The battery does not store electrical energy. It stores chemical energy that is converted to electrical energy as it discharges.

All energy for starting the car is drawn from the battery. State-of-charge, and capacity of the battery are important factors in the ability of the engine to start, especially in cold and harsh conditions.

Ignition Switch

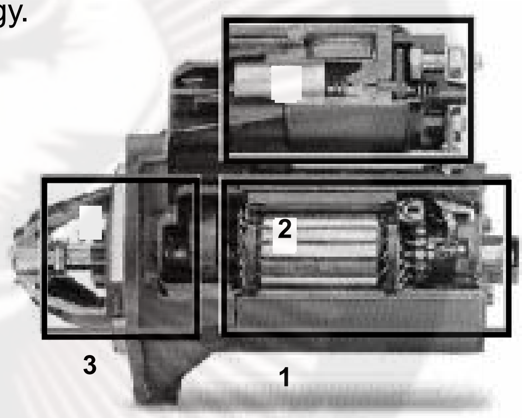
The Ignition Switch provides a request to the starting system to engage the starter motor. This request is handled differently depending on the year of the vehicle and particular sys- tems the vehicle is fitted with.

In non EWS systems the ignition switch provided power directly to the starter solenoid or a starter relay. Beginning with EWS I the start request (KL50) is passed to an Immobilizer control module or an EWS module (EWS II/III).

On vehicles with one touch starting the KL50 signal is passed to the DME.

Starter Motor Assembly

The Starter Motor Assembly is a DC motor which uses the interaction of magnetic fields to convert electrical energy into mechanical energy.



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1. Electric Starter Motor
2. Solenoid Switch
3. Pinion Engaging Drive

The starter motor assembly consists of:

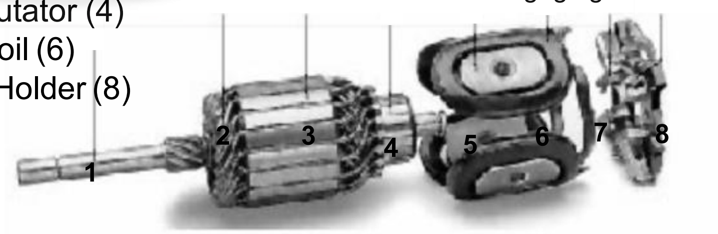
- Electric Starter Motor
- Solenoid
- Pinion Engaging Drive

Electric Starter Motor

The Starter Motor provides the mechanical energy to rotate the engine through a direct or a gear reduction drive.

The major components of the starter motor are:

- Armature Shaft (1)
- Armature Stack (3)
- Poles Shoes (5)
- Carbon Brushes (7)
- Armature Winding (2)
- Commutator (4)
- Field Coil (6)
- Brush Holder (8)



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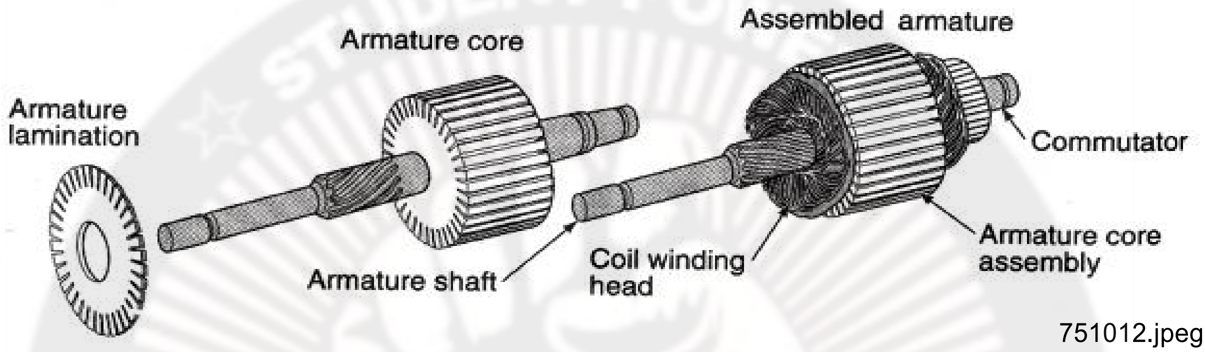
Armature
The Armature assembly is comprised of the armature shaft, armature winding, armature stack and commutator. Thin iron stampings are laminated together to form the stack or core. The slots on the outside of the laminations hold the armature windings. The windings loop around the core and are connected to the commutator. Each commutator segment is insulated from the adjacent segments. The commutator may have up to 30 segments. A steel shaft is insert in the center hole of the laminations with the commutator insulated from the shaft.



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Field Coils

There are two types of field coils:

- Electromagnetic
- Permanent magnet

Electromagnetic
Wire ribbons or coils wrapped around a pole shoe, attached to the inside of the starter housing. The iron pole shoes and the iron starter housing work together to increase and concentrate the strength of the field coils. When current flows thought the field coils strong electromagnetic fields with North and South poles are created.

Permanent
Multiple permanent magnets manufactured from an alloy of boron, neodymium and iron are positioned in the starter housing. Use of permanent magnets allow for the elimination of the field circuit and windings and realize a 50% weight savings.

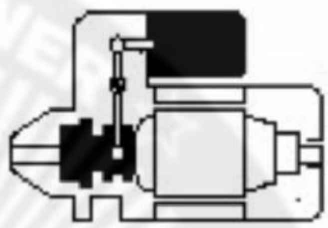
Brushes

Brushes are electrically conductive sliding contacts, usually made of copper and carbon. The brushes make contact with the commutator and as the starter begins to rotate the brushes reverse the flow of current to the armature. Starter brushes carry the full flow of current through the motor.

Solenoid

The Solenoid assembly is an integral part of the starter and is actually a combined relay and engagement solenoid.
The solenoid has two functions:

- Pushing the pinion forward so that it engages in the ring gear of the engine.
- Closing the moving contact, providing the main current path for the starter.



Solenoid switch and pinion engaging drive

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The solenoid has two windings.

- Pull-in winding
- Holding-in winding

Both windings are used to draw in the plunger and engage the pinon, only the hold-in winding is used to hold the plunger in position.

Pinion Engaging Drive

The starter's end shield assembly contains the Pinion Engaging Drive with pinion, overrunning clutch, engagement lever and spring. The drive mechanism is responsible for coordinating the thrust motion of the solenoid switch and the rotary motion of the electric starter motor and transferring them to the pinion.

The starter engages the ring gear on the flywheel by means of the pinion. A high conversion ratio of pinion teeth to flywheel teeth (between 10:1 and 15:1) make it possible to overcome the high cranking resistance of the engine using a relatively small but high speed starter motor.

As soon as the engine starts and accelerates past cranking speed, the pinion must automatically demesh in order to protect the starter. For this reason, the starter incorporates an overrunning clutch.

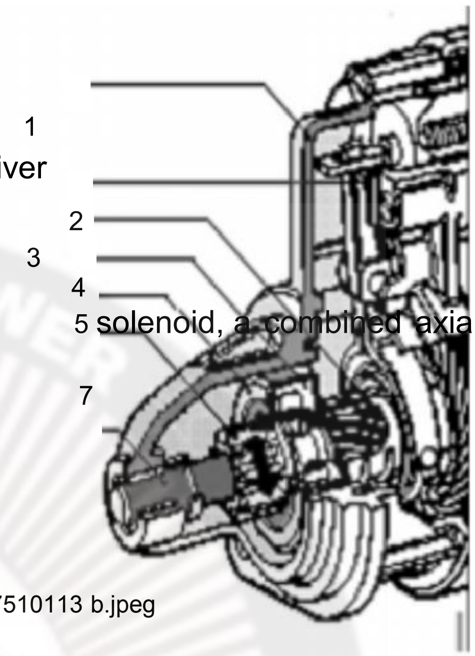
Starter Drives

Conventional Drive

In a Conventional Drive starter the pinion gear is locat- ed directly on the armature shaft.

The pinion and overrunning clutch form the driver assembly.

The driver assembly rides on a helical spline on the armature shaft so that when the driver is thrust by the solenoid, a combined axial and rotar



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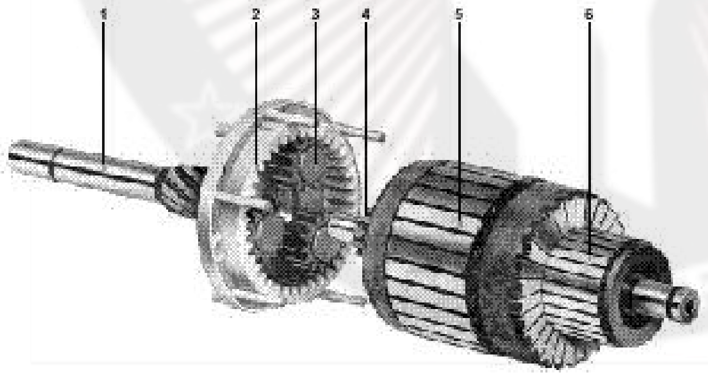
1. Drive End Shield
2. Engaging Lever
3. Meshing Spring
4. Driver
5. Roller Type Overrunning Clutch
6. Pinion
7. Armature Shaft

Gear Reduction Drive

In their design and function, Gear Reduction Drives are much the same as conventional drive starters. The main difference in the gear reduction drive starter is a planetary gear set added between the field frame and the drive end shield. This design allows for the use of smaller and lighter starters.



1. Planetary-Gear Carrier Shaft with Helical Spline.
2. Internal Gear (Ring Gear).
3. Planet Gears
4. Sun Gear on Armature Shaft
5. Armature
6. Commutator

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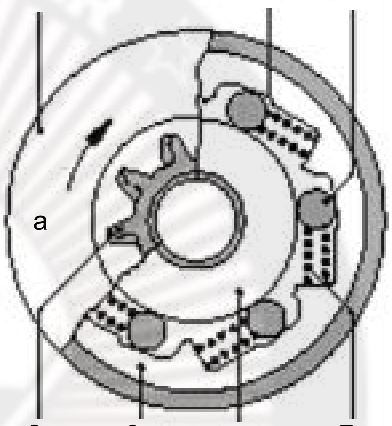
Overrunning
Clutch

In all starter designs the rotary motion is transmitted via an Overrunning Clutch. The over- running clutch allows the pinion to be driven by the armature shaft (or planetary gear set), however it breaks the connection between the pinion and the armature shaft as soon as the accelerating engine spins the pinion faster than the starter.

The overrunning clutch is located between the starter motor and the pinion and prevents the starter motor armature from being accelerated to an excessive speed when the engine starts.

1. Clutch Cover
2. Pinion
3. Driver with Clutch Shell
4. Roller R-ace
5. Roller
6. Pinion Shaft
7. Coil Spring

a Direction of Rotation for Clutch Locking Action



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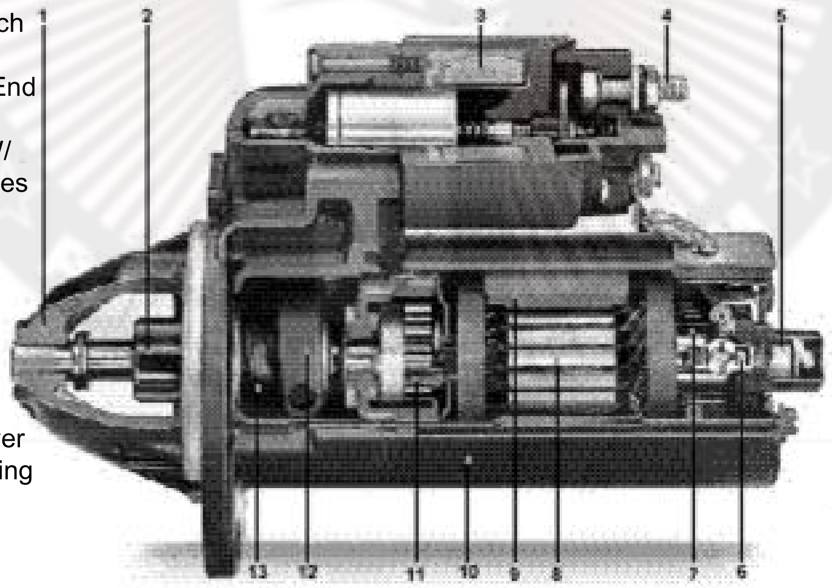
1. Drive End Shield.
2. Pinion
3. Solenoid Switch
4. Terminal
5. Commutator End Shield
6. Brush Plate W/ Carbon Brushes
7. Commutator
8. Armature
9. Permanent Magnet
10. Field Frame
11. Planetary Gear
12. Engaging Lever
13. Pinion Engaging Drive



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Fully assembled permanent magnet gear reduction starter

E
W
S

The EWS system(s) is designed to provide electronic anti-theft protection for the vehicle through the use of coded keys and coded data communication between the EWS and the engine control module. The starter and engine control module are locked out until a prop- erly coded key is recognized and the proper code is established between the EWS and the engine control modules.

Starter Safety Switch

The Starter Safety Switch is part of the transmission range switch on automatic transmis- sion vehicles and a clutch switch on manual transmission vehicles (beginning MY 1997). The purpose of the switch is to prevent engine start-up with the vehicle in gear or the clutch not depressed. On vehicles with EWS, this signal is sent directly to the EWS module for processing.

Cable and Wiring Harness

Cables to the starter from the battery must carry large amounts of current. The wiring har- ness from the ignition switch and/or EWS carry little current as they are control signals to a relay or starter solenoid. Minimum voltage drop in starter cables is necessary to ensure suf- ficient starter speed and torque.

Starting System Principle of Operation

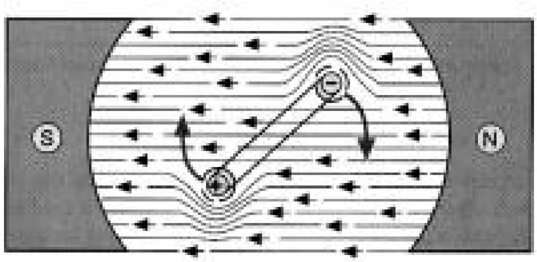
Electric Starter Motor

The Electric Starter Motor converts electrical current into rotary motion. In doing so it con- verts electrical energy into mechanical energy. The interaction of two magnetic fields pro- duce this rotational force.

The field coils (either electromagnetic or permanent) located in the housing produce mag- netic flux lines. Within the stationary field coils is the armature, a loop of wire (a conductor) with one end connected to B+, the other to B-. When current is applied to the armature flux lines circle the loop in one direction on one side and in the opposite direction on the other side. The interaction of the flux lines on the armature and the flux lines from the field coil cause the armature to rotate.

The armature will only rotate to the point where the magnetic force is equal on both sides. (Armature 90° to magnetic flux lines of field)

For the armature to continue to rotate, the polarity or direction of current flow must be reversed.



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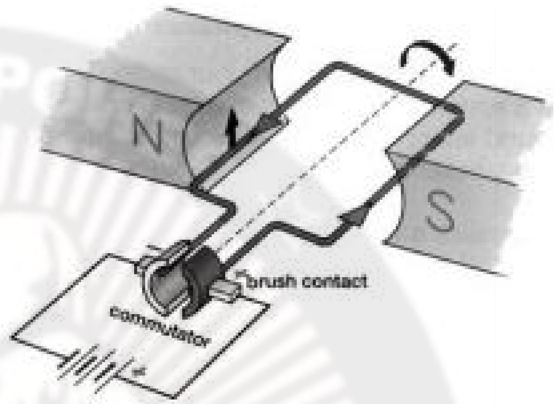
Through the brushes and the commutator, the current flow is reversed as the magnetic forces become equal, causing the armature to continue to rotate.

This constant reversal of current flow in the armature provides continual rotation.



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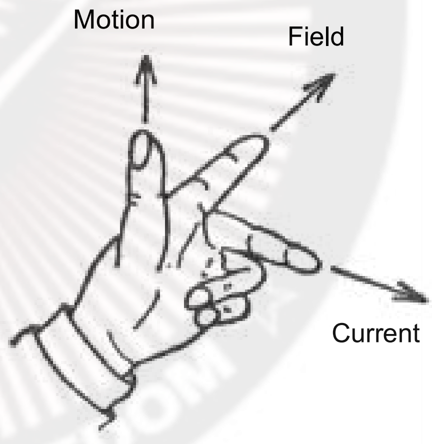
Loopisbeingforceoutofmagneticfield

Direction of rotation is determined using **Flemings Left Hand Rule**.

- Point your First finger in the direction of the magnetic Field (from N to S).

- Rotate your hand about that finger until your second finger points in the direction of the Current (conventional current, from + to -).

- Then your thumb points in the direction of the Movement of the wire.



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Flemings left hand rule
The basic law of motors, the direction of force on a wire that is carrying current when it is in a magnetic field.

To increase the force on the wire (armature) do one of the following:

- Use a larger current.
- Use a stronger magnetic field.
- Use a greater length of wire in the field.

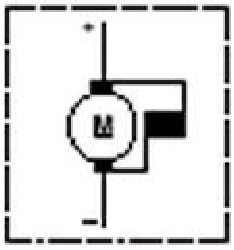
To increase torque and speed in the starter motor, more windings in the armature are added, and the field has more pairs of magnets (either permanent or electromagnetic).

Torque and speed of the starter motor is dependent on the wiring of the field coils. (electromagnetic coils)

- Shunt Wound
- Series Wound
- Compound

Shunt Wound Motors

In Shunt Wound Motors, the field coil is connected in parallel with the armature. The shunt motor does not decrease its torque as speed increases. Shunt motors do not produce high torque.



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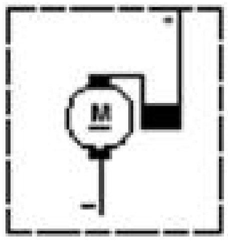
Series Wound Motors

In Series Wound Motors, the field coil is in series with the armature.
The current flows to the field windings, then to the brushes, commutator, and armature back again to the ground side brush. A series wound motor will develop maximum torque output at the time of initial start, then as motor speed increases, torque falls off rapidly due to the CEMF.



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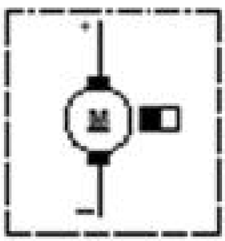
Compound Wound Motors

Compound Wound Motors have some of the field coils wired in series to the armature and some in parallel. This configuration allows the compound motor to develop good starting torque and constant operating speed.

CEMF
Counter Electromotive Force
The voltage produced in the starter motor itself through electromagnetic induction.
This voltage acts against the supply voltage from the battery.
Motors must be designed to control the CEMF for optimum operation.

Permanent Magnet Motors

Permanent Magnet Motors eliminate all wiring to the field coils. The magnetic field is generated by the permanent magnet without the need for winding and pole shoes. The magnets use flux-concentrating pieces to direct the magnetic field.



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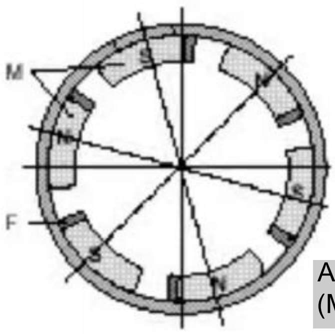

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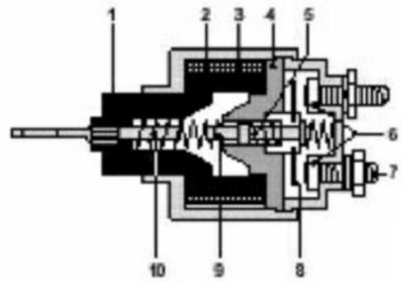
Arrangement of permanent magnets (M) with flux concentrating pieces (F).

Solenoid

The Solenoid performs the following functions:

- Pull the pinion to engage the flywheel
- Hold the pinion engaged with the flywheel during starting rotation.
- Complete the electrical circuit from the battery to the brushes of the starter.
- Cause the pinion to retract from the flywheel.



1. Armature (relay)	2. Pull-in winding
3. Hold-in winding	4. Solenoid armature
5. Contact spring	6. Contacts
7. Terminal	8. Moving contact
9. Switching pin	10.Return spring

Two windings are used to pull and hold the pinion engaged to the flywheel.

Pull-In Winding- The stronger of the two windings, used to pull the pinion into engagement. This winding is released when the starter circuit is completed.

Hold-In Winding- Used to help the pull-in winding move the pinion initially, then holds the pinion engaged to the flywheel.

Signal 50 is received at the solenoid, energizing both windings. The windings cause the armature to be drawn into the coils, pressing on a spring, causing the moving contacts to close. The pull-in winding is released, the starter begins to turn. When signal 50 is released, the power is lost to the hold-in winding, spring pressure forces the armature out of the coil, the moving contacts are opened and the pinion returns to the rest position.

Workshop Hint

The starter motor does not begin to spin until after the pinion is engaged in the flywheel.
This aids in the meshing of the pinion and flywheel

Workshop Hint

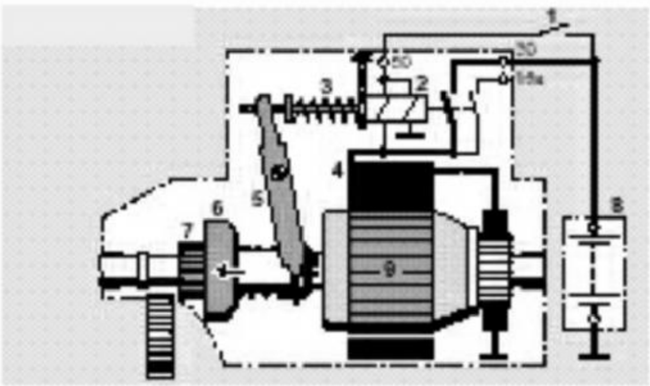
Battery voltage is critical.
The combination of the pull-in winding and the hold-in winding may have sufficient power to engage the pinion. When the moving contacts are completed and the increased load of the starter motor is added to the system, low voltage will cause the hold-in winding to release the pinion. If signal 50 is still present the pull-in winding will again assist in pulling the pinion into engagement and the cycle starts over again. This gives the “clicking” noise from the starter.

Pinion Drive

The Pinion Drive gear is attached to the roller-type overrunning clutch which is splined via a helical shaft to the starter armature. At rest the spring pressure in the overrunning clutch wedge rollers between the pinion shaft and the clutch hub race. This locks the pinion to the clutch. During start-up the clutch and pinion rotate as one.

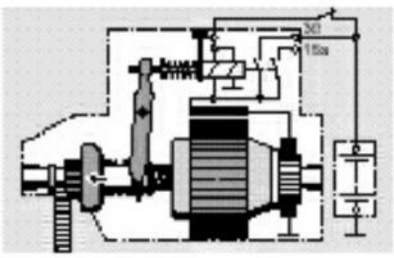
As the engine speed exceeds starter speed, the pinion pushes the rollers, against the spring pressure, into a wider area. This movement of the rollers allow the pinion to turn independently of the starter armature, not causing the armature to overspeed.
When the solenoid windings are released the clutch assembly is pulled away from the fly-wheel through spring pressure.

Phases of Starter Operation



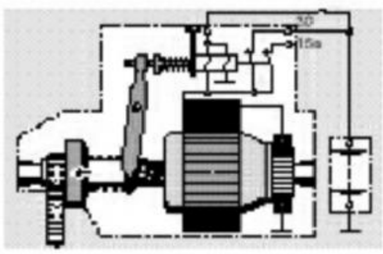
Starter At Rest
No Current Supplied

1. Start Request Signal (KL50)
2. Solenoid Switch
3. Return Spring
4. Field Windings
5. Engaging Lever
6. Overrunning Clutch
7. Pinion
8. Battery
9. Armature



Starter Position Just Before Main Current Is Switched On

Pull-in and hold-in winding energized.
Pinion tooth meets gap in ring gear and meshes.



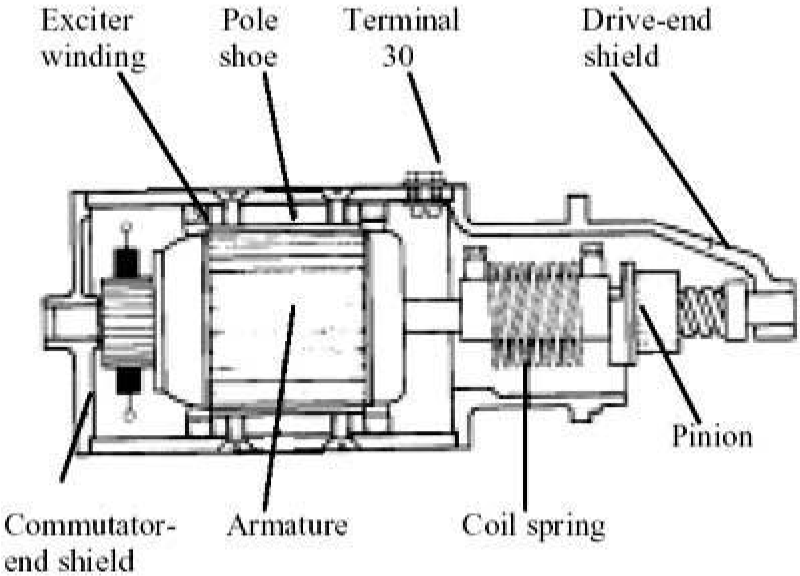
Engine Is Cranked

Engaging lever in end position.
Pull-in winding released.
Pinion meshed.
Main current flows.
Engine is rotated.

Inertia drive starter motor (Bendix Drive)

Inertia drive starter motors use the rapidly accelerated energy in the armature. This goes on before the engagement of the pinion takes place. The starter motors pinion is carried by a steeply pitched screw thread on the armature shaft. This kind of starter motor works **without a solenoid** and therefore the starter switch has strong contact points (operated by hand or by foot) to connect the current flow from the battery to the starter.
When the starter motor operates and runs rapidly up to full speed; the inertia drive (bendix drive) **is forced by action of the thread on the armature shaft.** So the drive get propelled in the direction of the ring gear into engagement with the flywheel. A **damping spring is arranged** between shaft and pinion hub **to ensure that the power flow to the flywheel starts not too violently**.

After engine has started and runs faster then the engaged pinion get ejected from the flywheel by moving backwards on the spiral thread. Because of the violent engagement of the pinion into the flywheel damages can easy appear. That is the reason to use in modern cars instead of these types the **pre–engaged starter motors**.



TESTING OF STARTING SYSTEM

(I) CURRENT DRAW TEST :-

Current draw test measures the amount of current the starter motor can draw when it is actuated. It determines the electrical & mechanical condition of the starting system.

The following procedure is carried out using a BOSCH Auto electric test bench.

1) Connect the test leads of the tester to the battery observing the polarity.
2) Connect the starter motor to the test bench.
3) The motor selected is of 1.4KW capacity.
4) Crank the motor by pushing the starter switch on the test bench. for 5 sec.
5) At no load condition the current drawn from the starter motor will be less than or equal to 75 amp.
6) The voltage will be 12V & the current draw will be less than or equal to 75 amp.

(II) INSULATED CIRCUIT RESISTANCE TEST :-
(VOLTAGE DROP TEST)

This test is used to located high resistance in the starter circuit. Voltage is dropped when current flows through resistance.

Voltage drops are measured by connecting a voltmeter in parallel with the circuit section being tested.

The following test is carried out by using a BOSCH Auto Electric Test bench.

1) Connect the test leads of the test bench to the battery observing polarity.
2) Connect the starter motor to the test bench.
3) Observe the battery voltage on the test bench meter.
4) Connect the voltmeter across the starter motor.
5) At no load condition crank the motor by pushing the starter switch.
6) The difference in the voltage should be within 0.4 volts of the battery voltage.

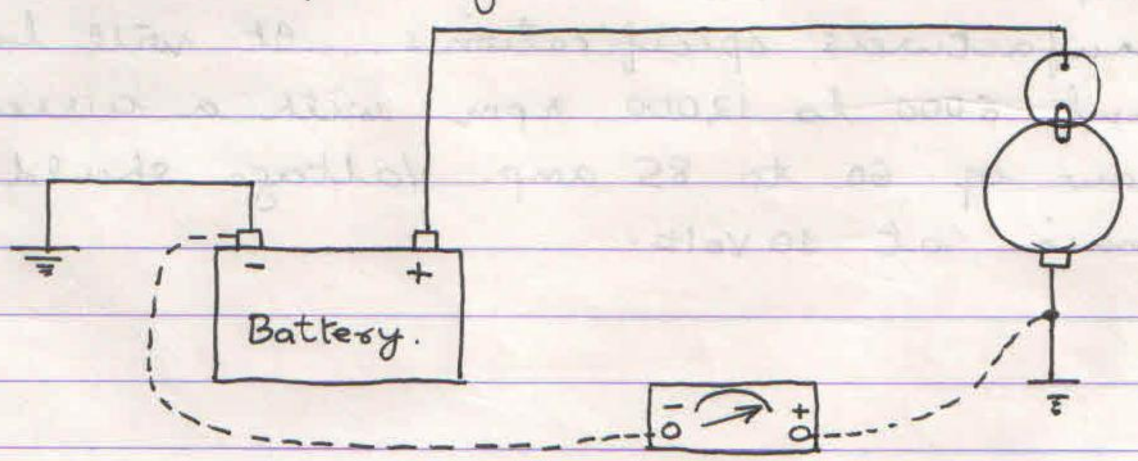
(Ref Fig 10.6)

(III) GROUND CIRCUIT TEST :-

A ground circuit test is performed to measure the voltage drop in the ground side of the circuit.

The following test is carried out by using a BOSCH Auto electric test bench.

1) Connect the test leads of the tester to the battery observing polarity.
2) Connect the starter motor to the test bench.
3) Connect the positive voltmeter test lead to the starter motor case & the negative test lead to the ground battery terminal
4) At no load condition crank the motor by pushing the starter switch.
5) Observe the voltmeter, less than 0.2 Volts indicates the ground circuit is good. If more than 0.2 Volts is observed, then there is a poor ground connection.



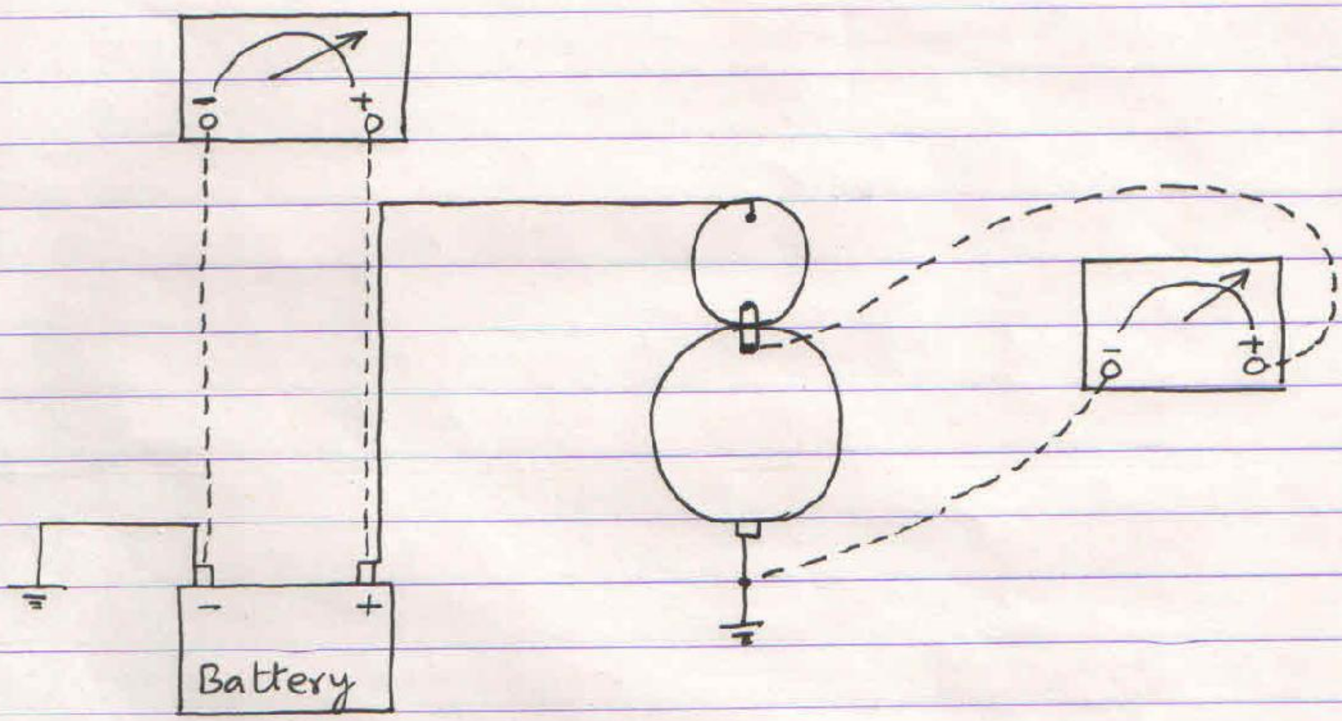
(IV) FREE SPEED TEST :-

The free speed test determines the free rotational speed of the armature. This test is also called as no load test.

With the starter removed from the vehicle, perform the test using a BOSCH Auto electric test bench,

1) Place the starter motor into a secure vice on the test bench
2) Connect the test leads of the tester to the battery.
3) Observe the battery voltage, it should be full charged.
4) Connect the starter motor to the test bench.
5) Push the starter switch on the test bench for 5 sec.
6) Observe the free speed of the armature.
7) Compare the test results with the manufacturers specifications. It will be about 6000 to 12,000 rpm with a current draw of 60 to 85 amp. Voltage should remain at 10 Volts.

INSULATED CIRCUIT RESISTANCE TEST
(VOLTAGE DROP TEST)

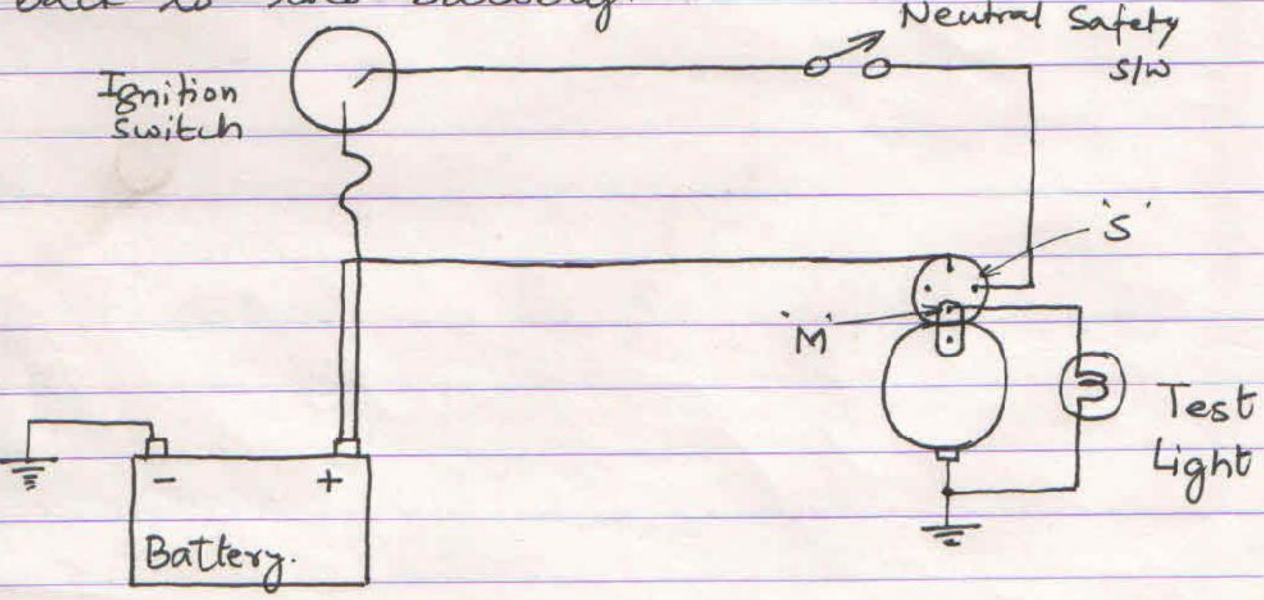


(V) NO-CRANK TEST :-

The no-crank test is performed to locate any opens in the starter or control circuits.

The simple way to diagnose this problem is with the use of a test light

1. Connect the positive lead of the test light to the 'M' terminal and the negative lead to the ground.
2. If the light comes 'ON', then the complete circuit is operating properly.
3. If the test light comes 'ON' very dim, then there is a very high resistance in the circuit.
4. If the test light did not come ON, then try to find the open in the circuit by working the test light through the circuit back to the battery.



VI QUICK TEST :-

→ If the starter does not turn the engine at all, and the engine is in good mechanical condition, the quick test can be performed to locate the problem area.

→ To perform this test,

1. Make sure the transmission is in neutral and set the parking brake
2. Turn on the headlights.
3. Next, turn the ignition switch to the start position while observing the headlights.

Three things that can happen to the headlights during this test :-

a. They will go out
b. They will dim.
c. They will remain at the same brightness level.

1. If the lights go out completely, the most likely cause is a poor connection at one of the battery terminals.
Check the battery terminals, cables for tightness and clean connections

2. If the headlights dim, the battery may be discharged. Check the battery condition. If the battery is good, then there may be a mechanical damage in the engine. If the engine is good, then the starter motor may have internal damage.

3. If the lights stay bright, and the starter does not operate, listen for a deep clicking noise, there is an open in the circuit. The fault is in either the solenoid or the control circuit.

* CONSTRUCTION AND OPERATION OF ALTERNATOR :-

→ The entire charging system consists of the following components :-

1. Battery
2. AC or DC generator
3. Drive belt
4. Voltage regulator
5. Charge indicator lamp.
6. Ignition switch
7. Cables and wiring harness.
8.

AC Generators :- The main components of the AC generator are :-

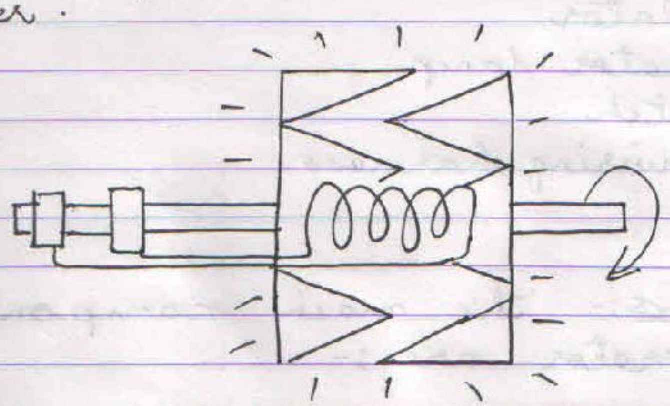
1. The rotor
2. Brushe
3. The stator
4. The rectifier bridge
5. The housing
6. Cooling Fan.

(I) ROTOR :-

_ The rotor in the alternator is an electromagnet.

_ The rotor creates the rotating magnetic field of the AC generator.

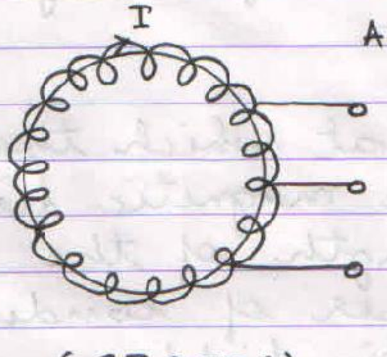
- It is rotated by the drive belt.
- The rotor is constructed of many turn of copper wire around an iron core.
- There are metal plates bent over the windings at both ends of the rotor windings.
- The metal plates are called fingers or poles.
- The poles do not contact with each other.



ROTOR.

(II) STATOR :-

- The stator is the stationary coil in which electrical voltage is produced.
- The stator contains three main sets of windings wrapped in slots around a laminated, circular iron frame.
- Each of the three windings has the same number of coils.
- The coils of each winding are evenly spaced around the core.

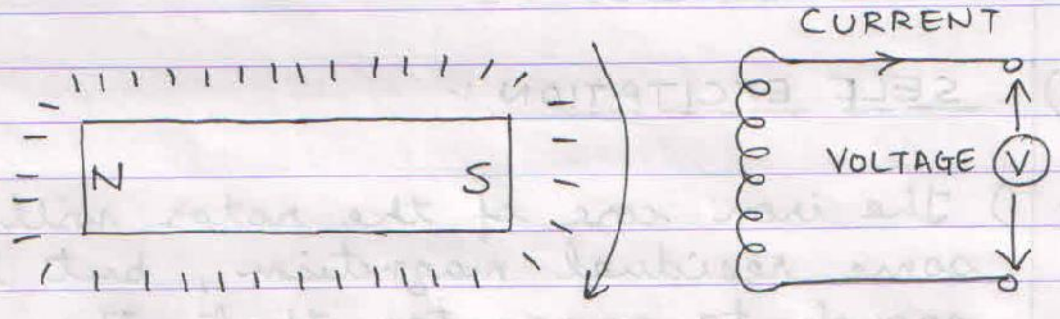


(STATOR)

* PRINCIPLE OF OPERATION :-

→ All charging systems use the principle of electromagnetic induction to generate electrical power.

→ Electromagnetic principle states that a voltage will be produced if motion between a conductor and a magnetic field occurs.



MAGNET COIL

- The amount of voltage produced is affected by :-

a) The speed at which the conductor passes through the magnetic field.
b) The strength of the magnetic field
c) The number of conductors passing thro' the magnetic field.

* FIELD EXCITATION :-

Excitation means to provide magnetic field to the rotor.
Note that the rotor must be supplied with 'dc' through brushes and slip rings in order to produce the magnetic field.

There are two methods of feeding the direct current i.e.

1) SELF EXCITATION :-

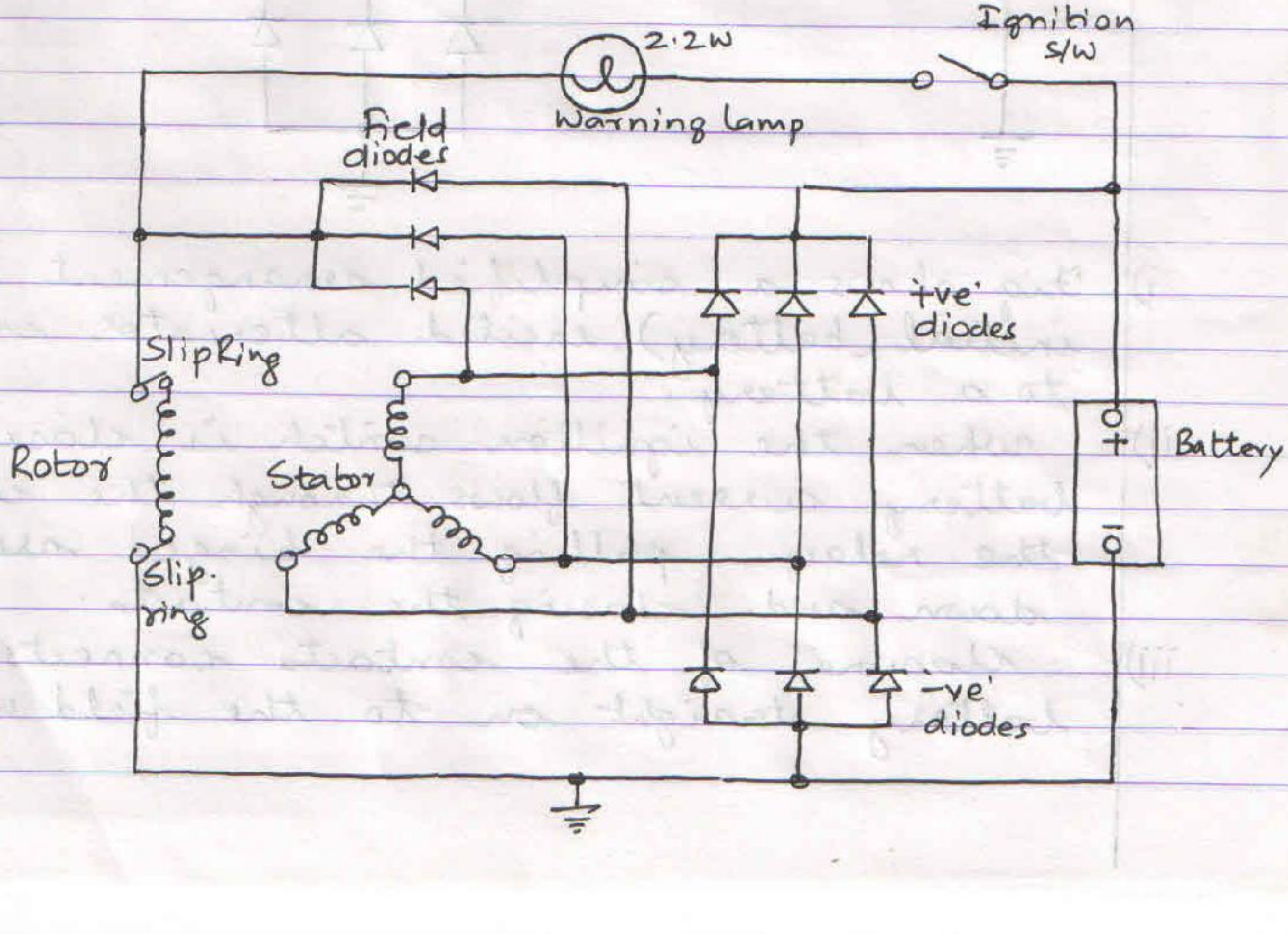
i) The iron core of the rotor will possess some residual magnetism, but it is not enough to guarantee that the alternator will start to generate current when it is rotated.

ii) In order to excite the rotor, a 2.2W charge warning lamp is connected from the battery to the rotor through the ignition switch, which gives sufficient rotor current to set up a magnetic field strong enough to give the generation.

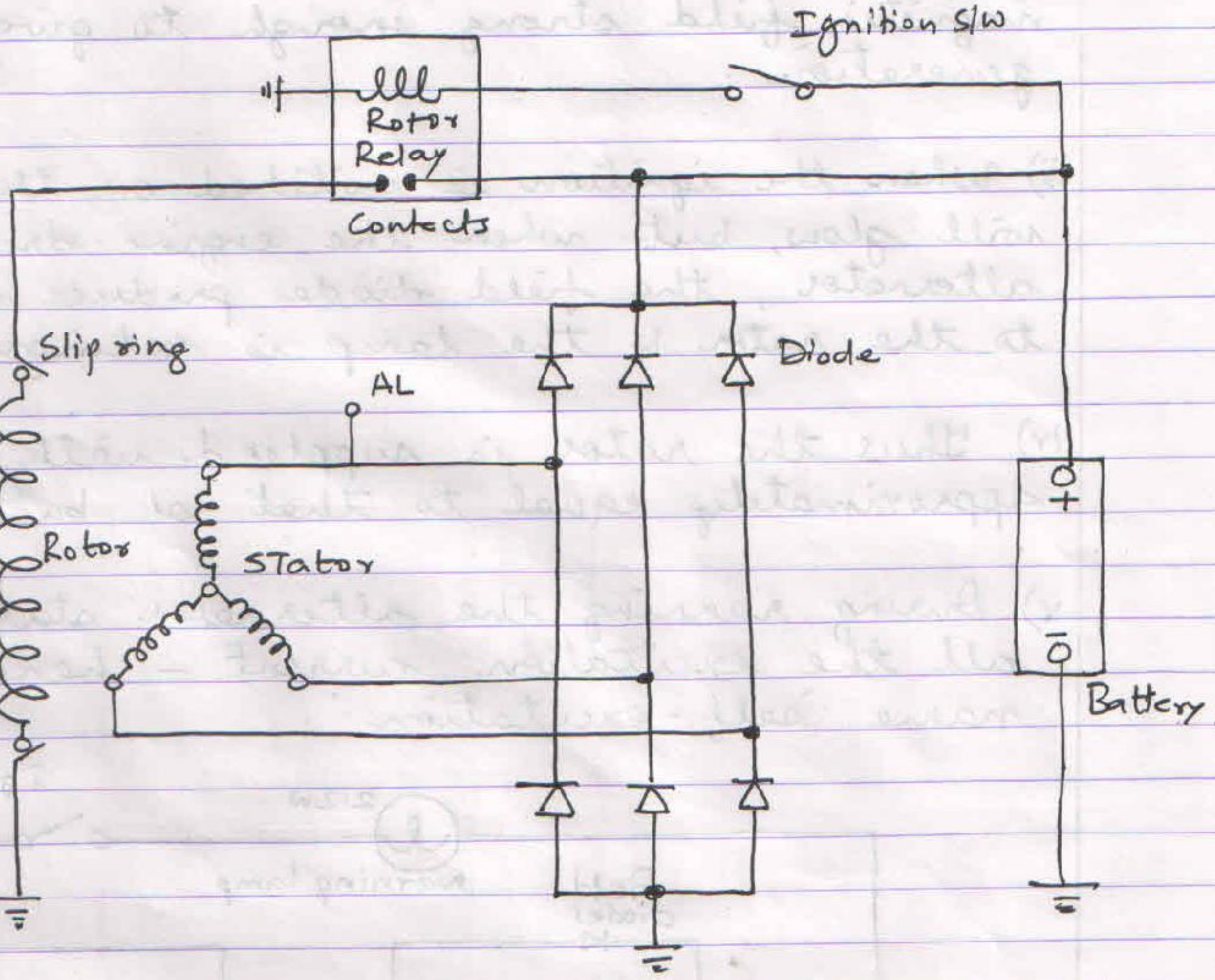
iii) When the ignition is switched ON the bulb will glow, but when the engine drives the alternator, the field diodes produce a supply to the rotor & the lamp is extinguished.

iv) Thus the rotor is supplied with a voltage approximately equal to that of battery.

v) During running the alternator stator provides all the excitation current – hence the name 'self-excitation'.



2) INITIAL EXCITATION (BATTERY EXCITATION)



i) Fig shows a simplified arrangement of a initial (battery) excited alternator connected to a battery.

ii) When the ignition switch is closed, battery current flows through the coil of the relay., pulling the hinged armature down and closing the contacts.

iii) Closure of the contacts connects the battery straight on to the field winding of the rotor.

iv) The flow of the direct current creates the necessary magnetic field to generate AC power in the stator windings.

v) Thus in this method the vehicle battery supplies the required current to the rotor.

* VOLTAGE REGULATION :-

→ The alternator is a variable speed machine.

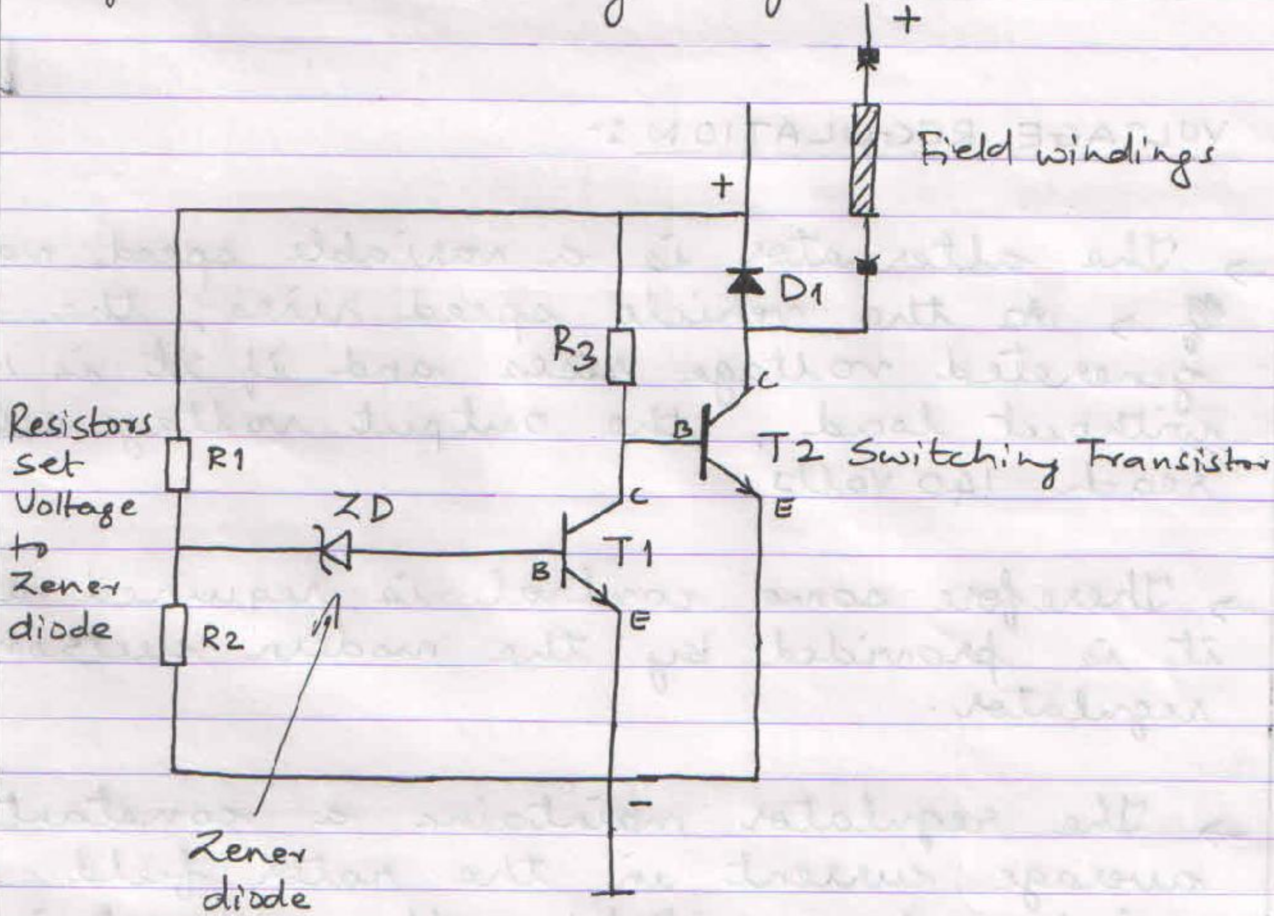
→ As the vehicle speed rises, the generated voltage rises and if it is run without load, the output voltage could reach 140 Volts.

→ Therefore some control is required and it is provided by the modern electronic regulator.

→ The regulator maintains a constant average current in the rotor field winding by switching the current 'on' & 'off', and the result will be an alternator output voltage of about 14.2V.

* ELECTRONIC VOLTAGE REGULATOR :-

- The main component of the electronic voltage regulator is the Zener diode.
- It acts as a sensing element in an electronic regulator
- Fig shows a simplified circuit diagram of electronic voltage regulator.



- This regulator operates as follows :-

i) When the alternator first increases in speed the output will be below the pre-set level.

ii) Under these conditions transistor 'T2' will be switched on by a feed to its base thro' resistor R3.

iii) This allows full field current to flow, thus increasing voltage output.

iv) When the pre-set voltage is reached, the Zener diode will conduct.

v) Resistors R1 and R2 are a simple series circuit to set the voltage appropriate to the value of the 'ZD' say 14.2V.

vi) Once ZD conducts, transistor T1 will switch on and pull the base of T2 down to ground.

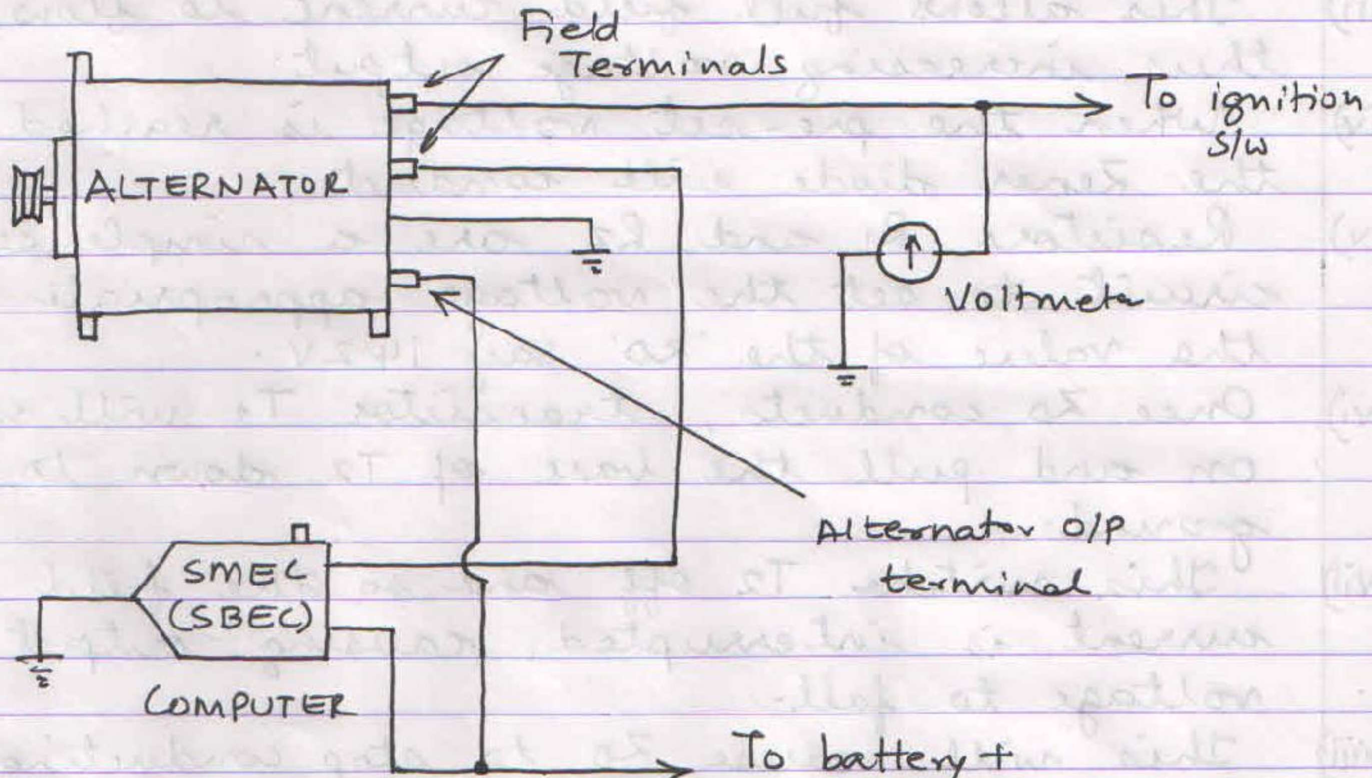
vii) This switche T2 off and so the field current is interrupted, causing output voltage to fall.

viii) This will cause ZD to stop conducting, T1 will switch off, allowing T2 to switch back on and so the cycle will continue.

* COMPUTER-CONTROLLED VOLTAGE REGULATION :-

- In this type the voltage is controlled by the body computer.
- The voltage regulator switches the field voltage 'on' and 'off' at a fixed frequency of about 400 times per second.
- The voltage is controlled by varying the 'on' and 'off' time of the field current.

- Fig shows a simplified block/ckt dig. of a computer-controlled voltage regulator



TESTING OF ALTERNATOR :-

(I) CURRENT OUTPUT TEST :-

Current output test will determine the maximum output of the AC generator.

The following test is carried out on a BOSCH Auto Electric Test Bench.

1) The alternator taken for the test is of 14V 16/35A.
2) Place the alternator on a secure vice on the test bench
3) Connect the test pulley on the alternator
4) Connect the belt of the motor to the test pulley.
5) Start the motor, the alternator will run at 6000 rpm.
6) Turn 'on' the load switch one by one 5A, 20A, 30A to 40A.
7) The alternator will show the maximum current output i.e ≥ 33 amps at 13.5V.

(II) FIELD CURRENT DRAW TEST :-

As the field current is required to create a magnetic field, it is necessary to determine if current is flowing to the field coil. The field current draw test determines if there is current available to the field windings.

The following steps are followed by using a voltmeter :-

1) Connect the negative voltmeter lead to the housing of the alternator.
2) With the ignition switch in the OFF position, connect the positive voltmeter lead to the 'F' terminal screw of the regulator.
3) Check the voltmeter reading. It should indicate the battery voltage. If the voltmeter reads battery voltage, the field circuit is normal.
4) If the voltmeter reading is less than the battery voltage, disconnect the ~~the~~ wiring plug from the regulator & check it.

(III) REGULATOR OUTPUT TEST :-

The regulator test is used to determine if the regulator is maintaining the correct voltage output under different load demands.

The test is conducted on a multifunction test unit. Follow the steps given below :-

1) A BOSCH MR3 type regulator is selected for the test.
2) Switch on the unit & ensure that the power supply is ON.
3) Connect the HCL connector of the regulator connecting cable to the regulator test socket of the unit.
4) Connect the crocodile clip of the cable to the regulator as follows:-
   i) B +ve terminal to the upper carbon brush of the regulator
   ii) B -ve to the earth pt. of the regulator
   iii) DF terminal to the lower carbon brush of the regulator.
5) Press the 'select' push button of the tester unit, MR3 regulator is selected.
6) Press the 'test' push button & start the test
7) The test sequence will be carried out

automatically as programmed & the LCD will indicate Test 'OK' or Not 'OK' with corresponding Green / Red light indication.

8) The test will be carried out at 13.5 V for 5 sec & 15.5 volts for 5 sec.

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NOTE :- FOR ALTERNATOR COMPONENT TESTING REFER JOURNAL

* STATOR
* ROTOR
} FOR OPEN, SHORT & GROUND.