

UNIT-2

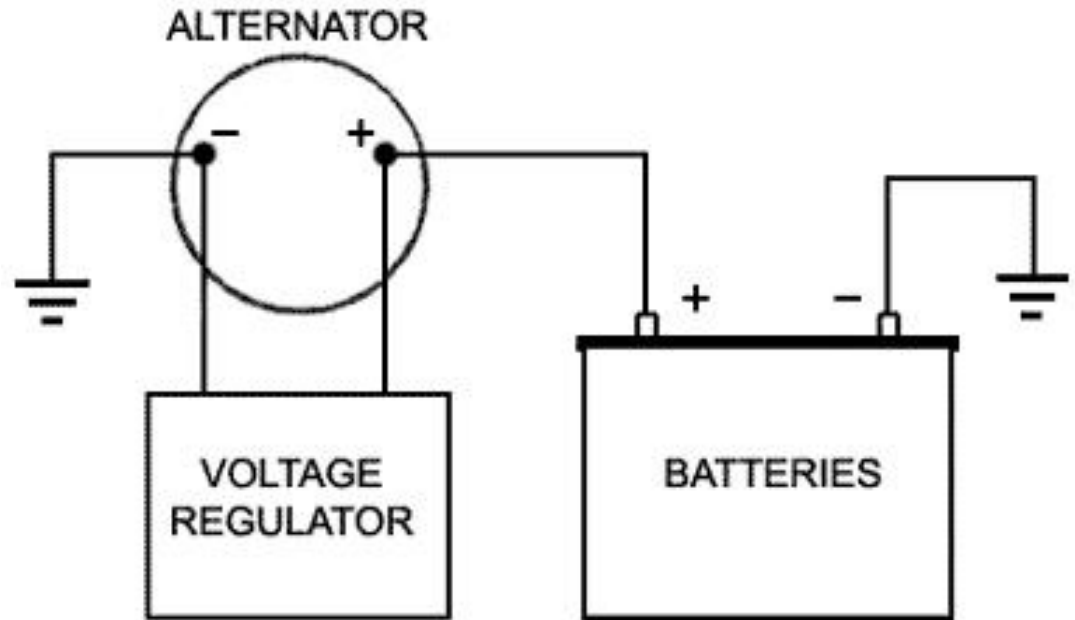
CHARGING SYSTEM

BASIC OF CHARGING CIRCUIT

The Charging system is an important part of the electrical system.

It provides electrical current for the lights, the radio, the heater, the engines electrical systems, and other electrical accessories.

It also maintains the batteries in a charged state, recharging them as necessary.



A typical charging circuit consists of the following:

BATTERY- provides current to energize or excite the alternator and assists in stabilizing initial alternator output.

ALTERNATOR or GENERATOR- uses mechanical (engine) power to produce electricity.

ALTERNATOR BELT- links the engine crankshaft pulley with alternator/ generator pulley to drive the alternator/ generator.

VOLTAGE REGULATOR- ammeter, voltmeter, or warning light to inform the operator of charging system condition.

The generator is a machine that applies the principle of electromagnetic induction to convert mechanical energy, supplied by the engine, into electrical energy.

The generator restores to the battery the energy that has been used up in cranking the engine.

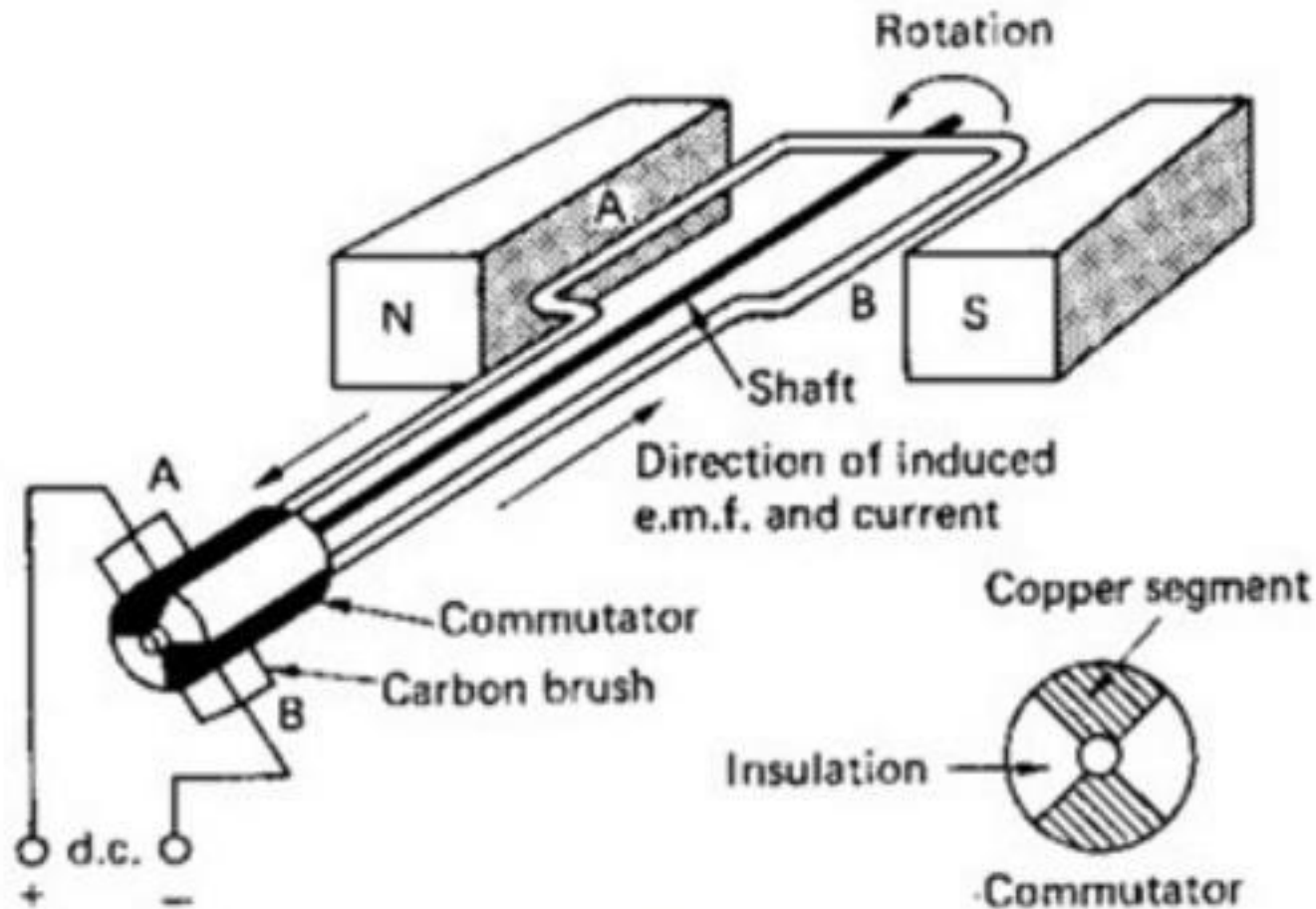
Whether the energy required for the rest of the electrical system is supplied directly by the generator, by the battery, or by a combination of both depends on the conditions under which the generator is operating.

The two types of generators are as follows:

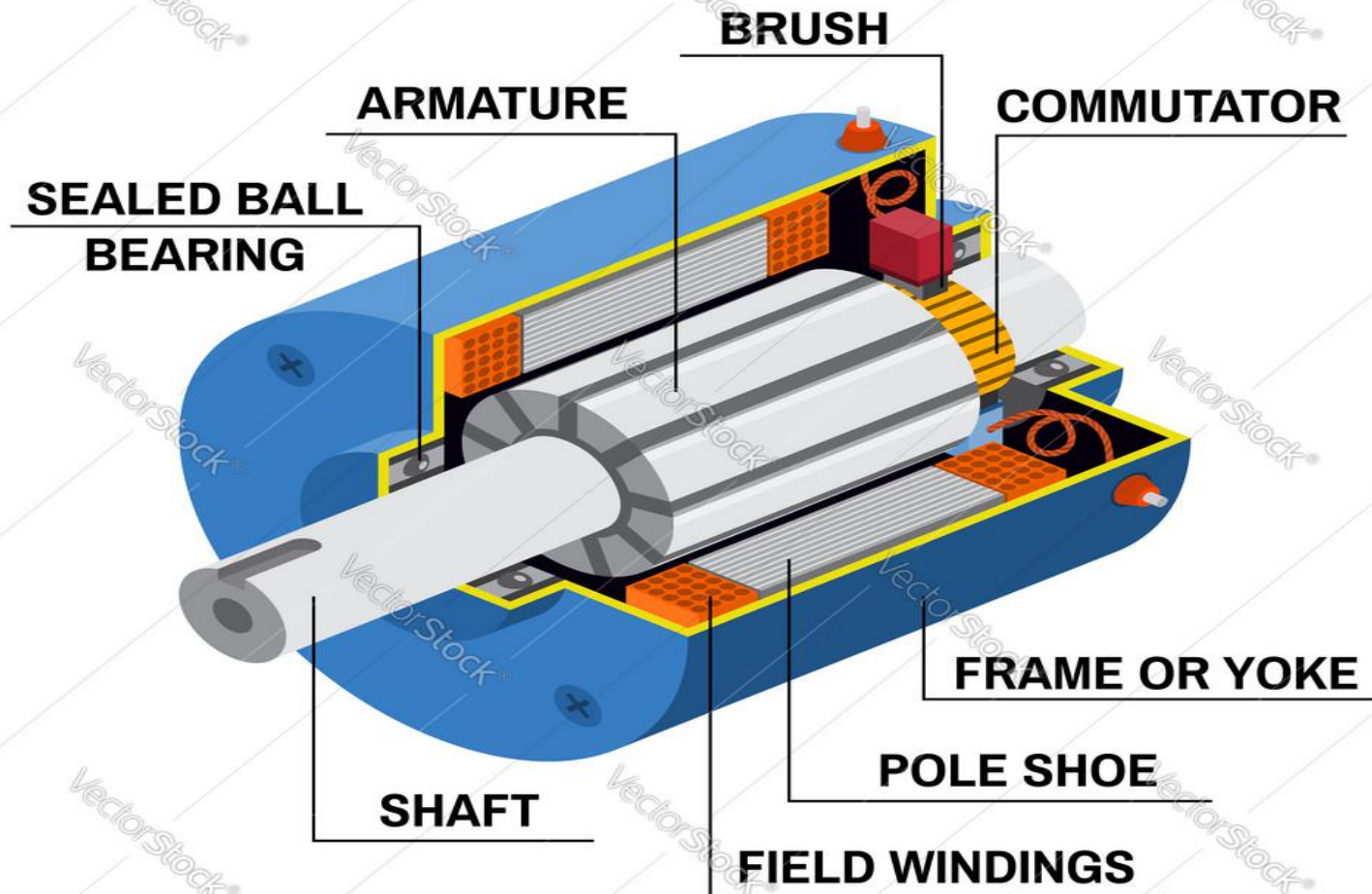
The DC generator supplies electrical energy directly to the battery and or electrical system through various regulating devices.

The AC generator (alternator) has the same function as the dc generator but because only direct current can be used to charge a battery, a component, called a rectifier, must be used to convert from alternating to direct current.

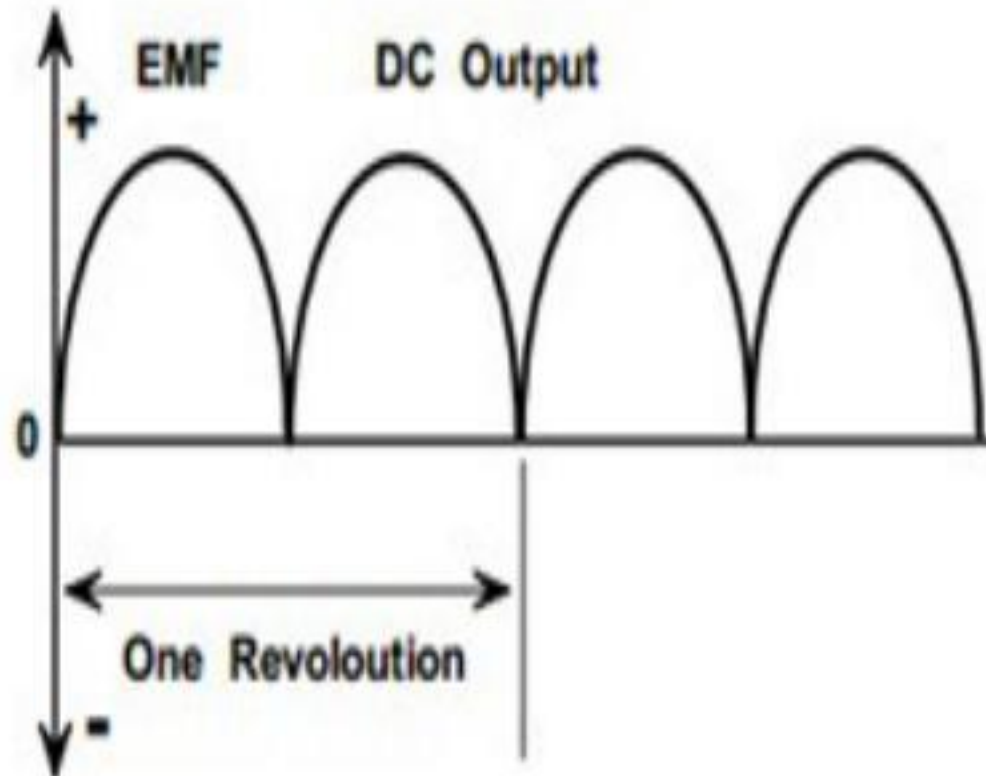
BASIC CONSTRUCTION OF DC GENERATOR



DC GENERATOR



This output from the generator is a pulsating DC voltage as shown in Figure 19.



<https://www.youtube.com/watch?v=-xebh8wU8gY>

The dc generator (fig.) essentially consists of an **armature, a field frame, field coils, and a commutator with brushes** to establish electrical contact with the rotating element. The magnetic field of the generator usually is produced by the electromagnets or poles magnetized by current flowing through the field coils. Soft iron pole pieces (or pole shoes) are contained in the field frame that forms the magnetic circuit between the poles. Although generators may be designed to have any even number of poles, **two-and four-pole** frames are the most common.

The field coils are connected in series.

In the two-pole type frame, the magnetic circuit flows through only a part of the armature core; therefore, the armature must be constructed according to the number of field poles because current is generated when the coil (winding on the armature) moves across each magnetic circuit.

REGULATION OF GENERATOR OUTPUT

The fields of the generator depend upon the **current** from the armature of the generator for magnetization. Because the current developed by the generator increases in direct proportion to its **speed**, the fields become stronger as the speed increases and, correspondingly, the armature generates more current.

The extreme variations in speed of the automotive engine make it necessary to regulate output of the generator **to prevent** excessive current or voltage overload.

On the average unit of a charging current in excess of **12 to 15 amperes** is harmful to a fully charged battery if continued for too long.

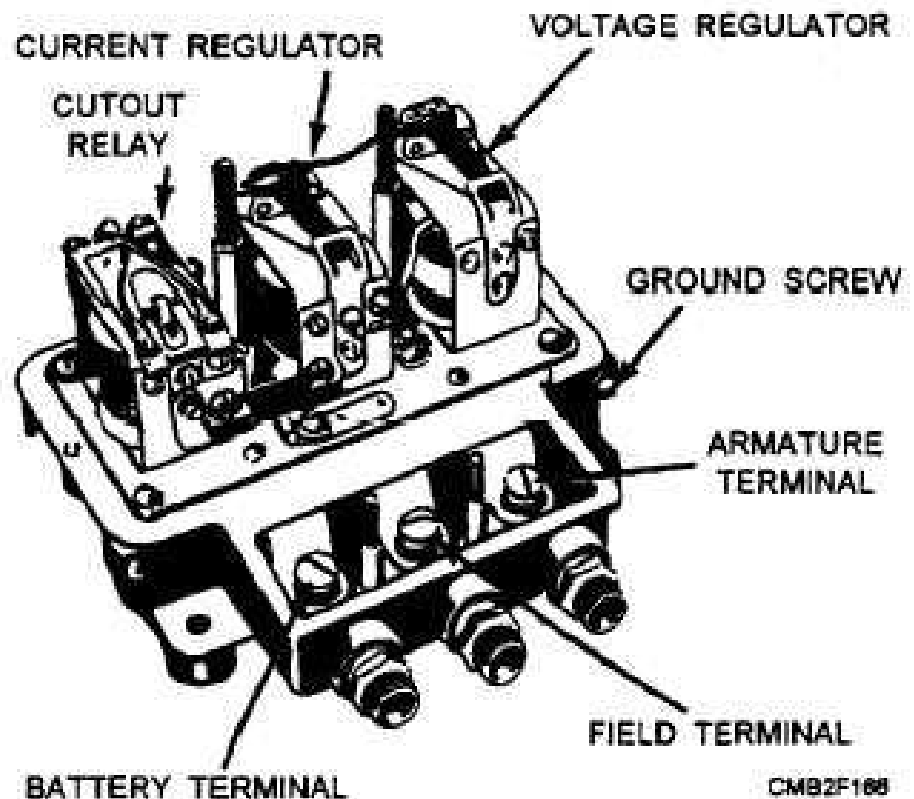
Regulators are of two types, functioning to regulate either voltage or current.

The voltage regulator regulates the voltage in the electric system and prevents excessive voltage, which can cause damage to the **electric units and overcharge the battery.**

The current regulator is a current limiter; it prevents the generator output from increasing beyond the **rated output** of the generator.

Regulation of voltage only might be satisfactory from the standpoint of the battery; however, if the battery were badly discharged or if a heavy electrical load were connected, the heavy current might overload itself to supply the heavy current demand. Therefore, **both current and voltage controls are used in a charging system**

In most applications, a regulator assembly consists of a **cutout relay, current regulator, and voltage regulator** fig.. Each unit contains a separate core, coil, and set of contacts. The regulator assembly provides full control of the shunt-type generator under all conditions. Either the current regulator or the voltage regulator may be operating **at any one time, but in no case do they both operate at the same time.**



When the electric load requirements are high and the battery is low, **the current regulator** will operate to prevent the generator output from exceeding its safe maximum.

In this case, the voltage is not sufficient to cause the voltage regulator to operate.

But if the load requirements are reduced or the battery begins to come up to charge, the line voltage will increase to a value sufficient to cause **the voltage regulator** to operate.

When this happens, the generator output is reduced; it is no longer sufficiently high to cause the current regulator to operate. All regulation is then dependent on the voltage regulator.

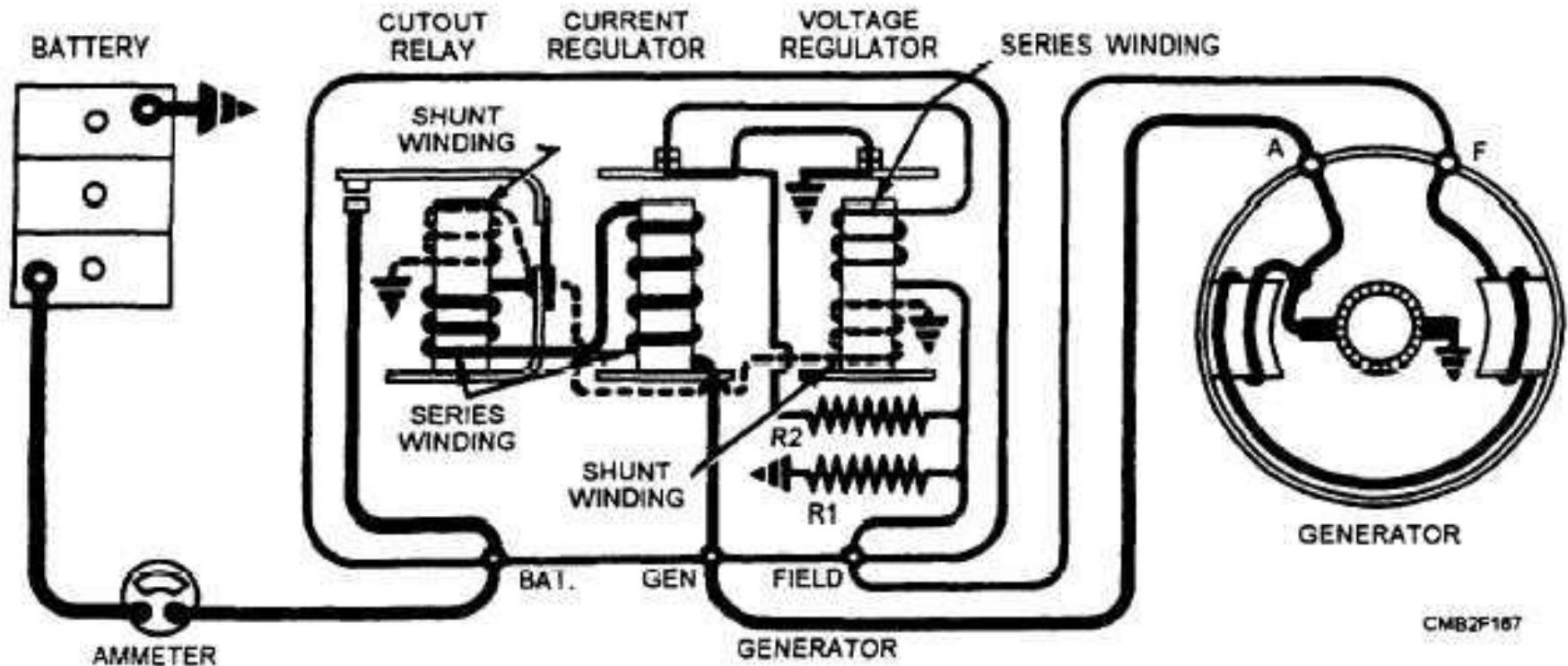


Figure shows a schematic wiring diagram of a typical dc charging circuit

In this circuit, two resistances are connected in parallel into the generator field circuit

when **the current regulator points open**. This provides a low value of resistance, which is sufficient to prevent the generator output from exceeding its safe maximum.

When **the voltage regulator contact points open**, only one resistance is inserted into the generator field circuit, and this provides a higher value of resistance.

The voltage regulator must employ a higher resistance because it must reduce the generator output as it operates, and it requires more resistance to reduce the output than merely to prevent the output from going beyond the safe maximum of the generator.

ALTERNATORS

The alternator fig. has replaced the dc generator because of its **improved efficiency.**

It is smaller, lighter, and more dependable than the dc generator.

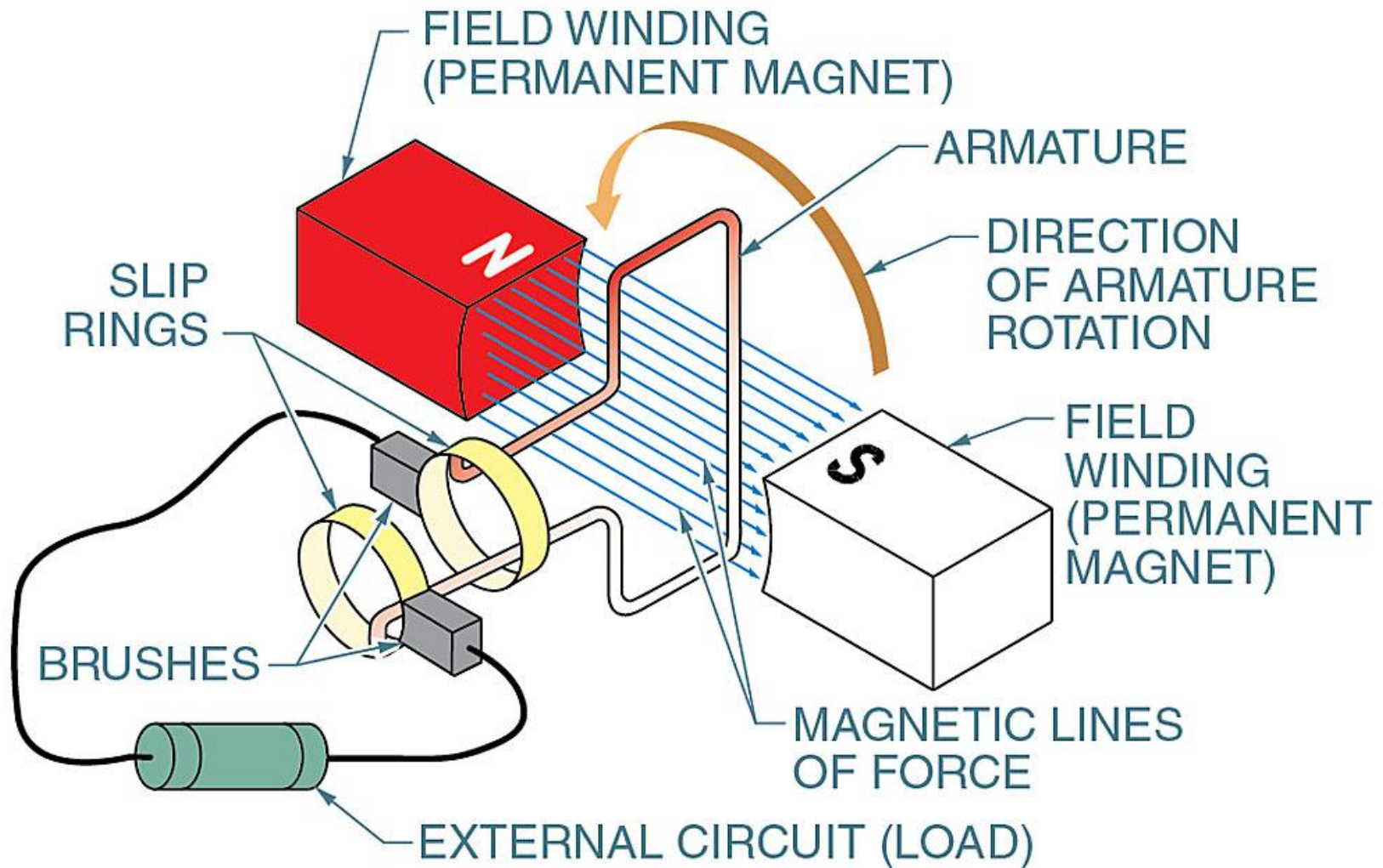
The alternator also produces **more output during idle** which makes it ideal for late model vehicles.

The alternator **has a spinning magnetic field.**

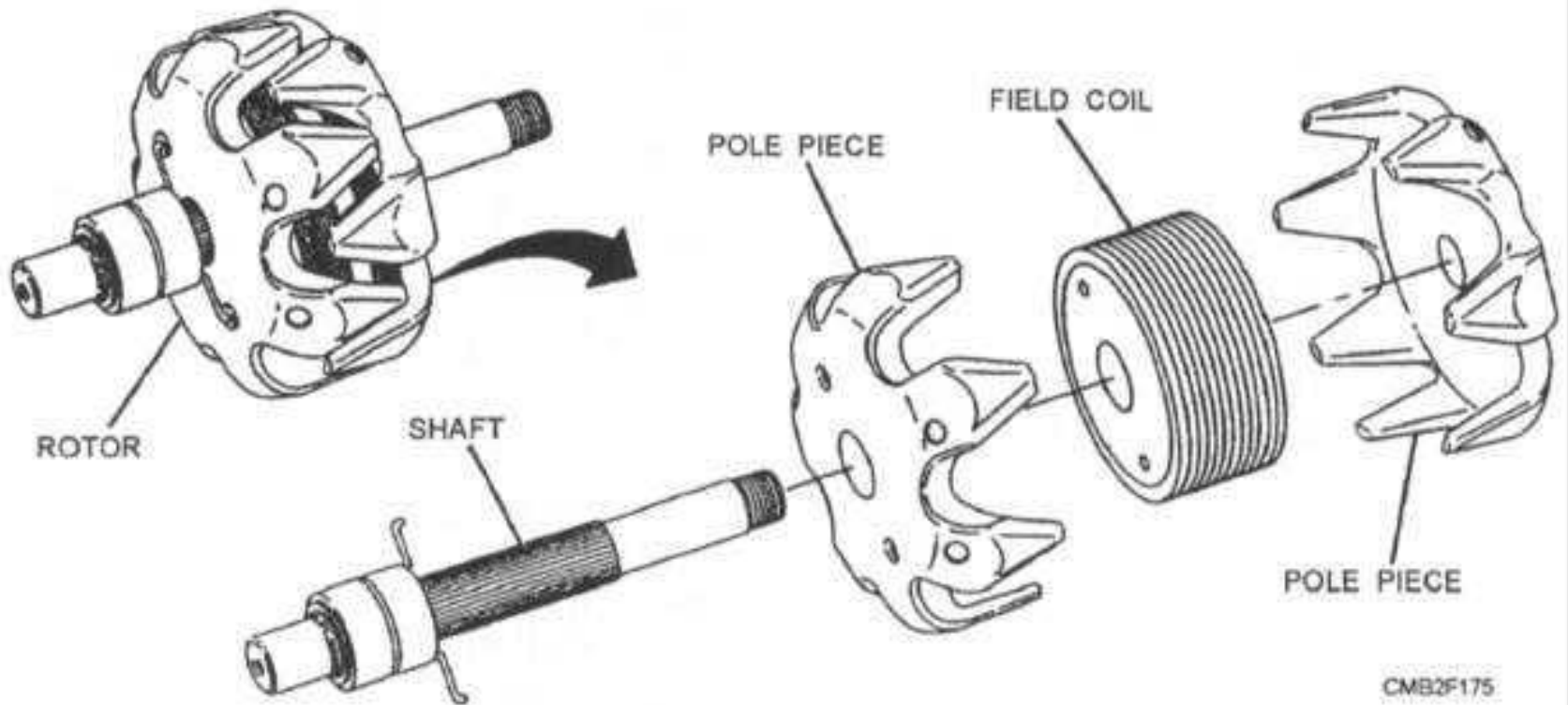
The **output windings (stator) are stationary.**

As the **magnetic field rotates**, it induces current in the output windings.

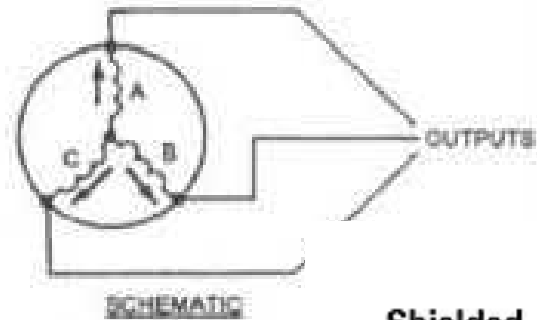
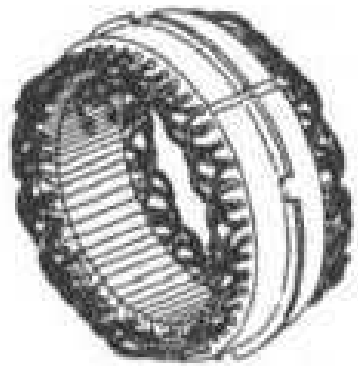
AC GENERATORS



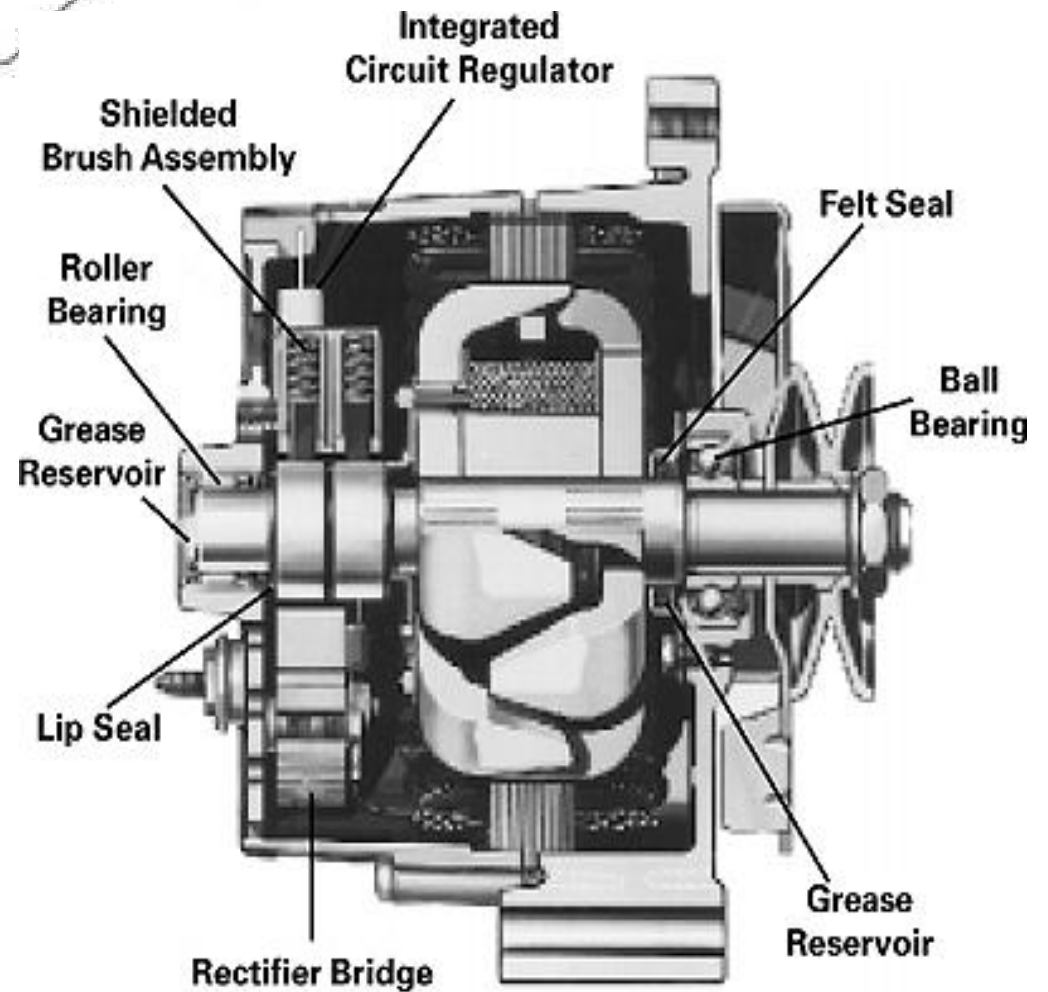
Construction of alternator parts



Rotor assembly

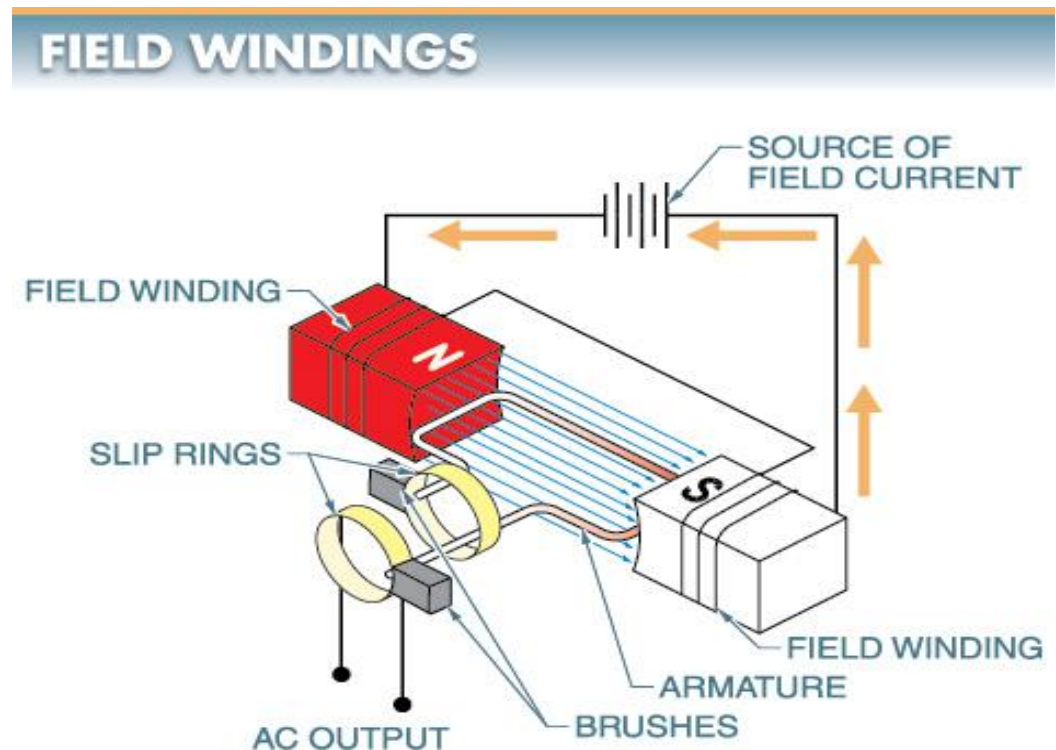


Stator assembly



Field Windings

A field winding is an electromagnet used to produce the stationary magnetic field in a generator. The magnetic field in a generator can be produced by permanent magnets or electromagnets. However, most generators use electromagnets, which must be supplied with current. **See Figure .**



Armature

An armature is the movable coil of wire in a generator that rotates through the magnetic field. The armature may consist of many coils. The ends of the coils are connected to slip rings.

Slip Rings

Slip rings are metallic rings connected to the ends of the armature and are used to connect the induced voltage to the brushes. When the armature is rotated in the magnetic field, a voltage is generated in each half of the armature coil.

Brushes

A brush is the sliding contact that rides against the commutator segments or slip rings and is used to connect the armature to the external circuit.

AC generators are similar in construction and operation to DC generators.

The **major difference** between AC and DC Generator is that DC generators contain a **commutator** that reverses the connections to the brushes every half cycle. This maintains a constant polarity of output voltage produced by the generator.

AC generators use **slip rings** to connect the armature to the external circuit (load). The slip rings do not reverse the polarity of the output voltage produced by the generator. The result is an alternating sine wave output.

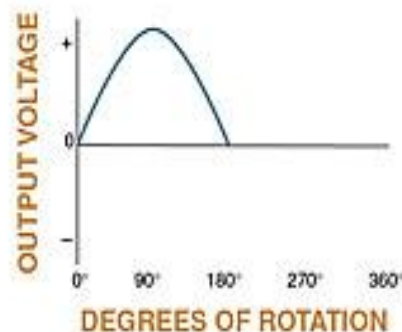
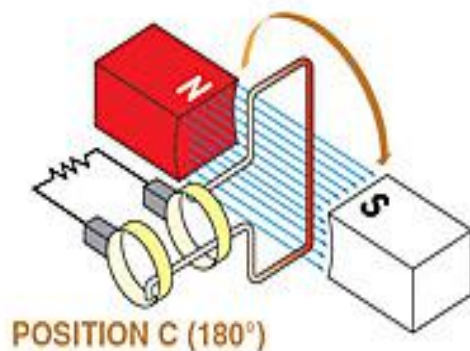
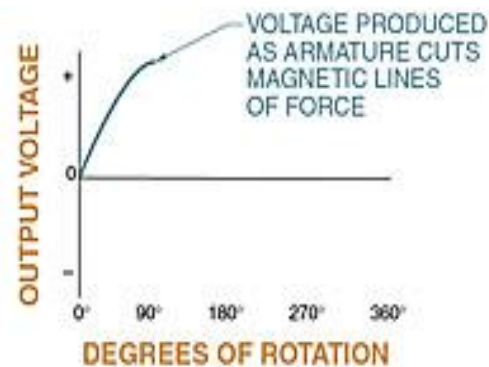
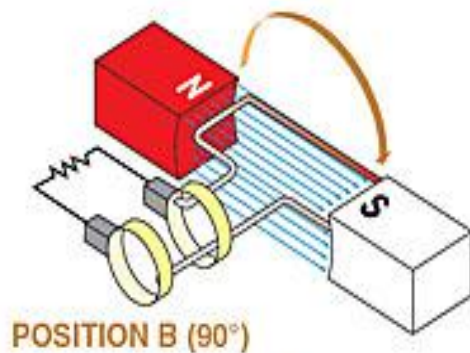
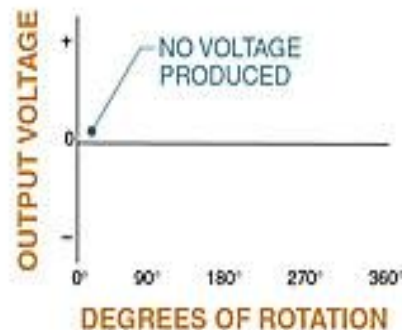
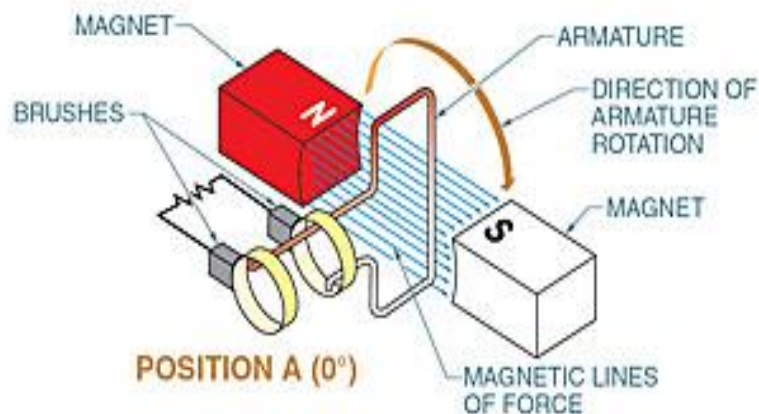
ARMATURE FUNCTION

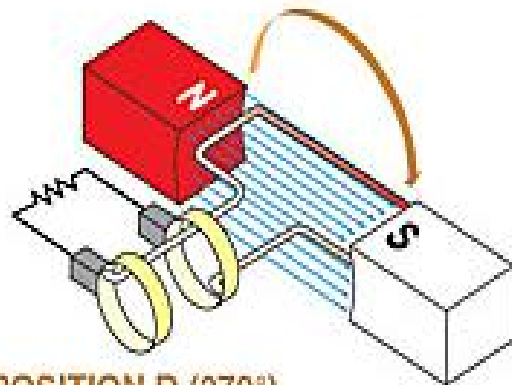
As the armature rotates, each half cuts across the magnetic lines of force at the same speed. Thus, the strength of the voltage induced in one side of the armature is always the same as the strength of the voltage induced in the other side of the armature.

Each half of the armature cuts the magnetic lines of force in a different direction. For example, as the armature rotates in the clockwise direction, the lower half of the coil cuts the magnetic lines of force from the bottom up to the left, while the top half of the coil cuts the magnetic lines of force from the top down to the right. **Therefore**, the voltage induced in one side of the coil is opposite to the voltage induced in the other side of the coil. The voltage in the lower half of the coil enables current flow in one direction, and the voltage in the upper half enables current flow in the opposite direction.

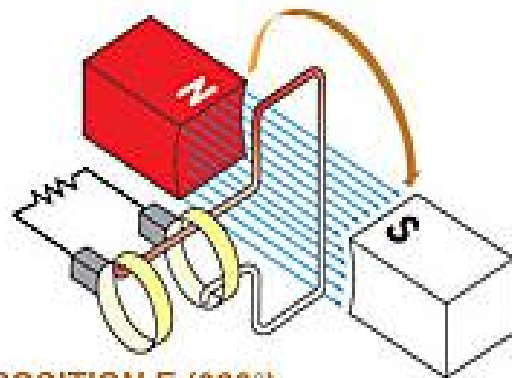
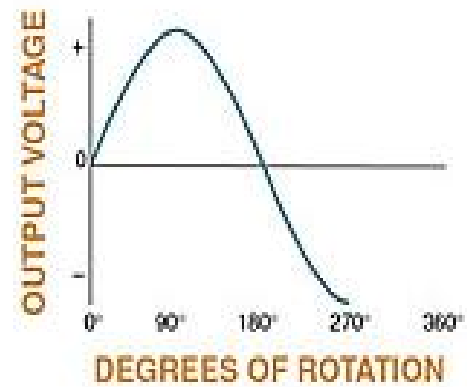
However, since the two halves of the coil are connected in a closed loop, the voltages add to each other. The result is that the total voltage of a full rotation of the armature is twice the voltage of each coil half. This total voltage is obtained at the brushes connected to the slip rings and may be applied to an external circuit.

SINGLE-PHASE AC GENERATORS

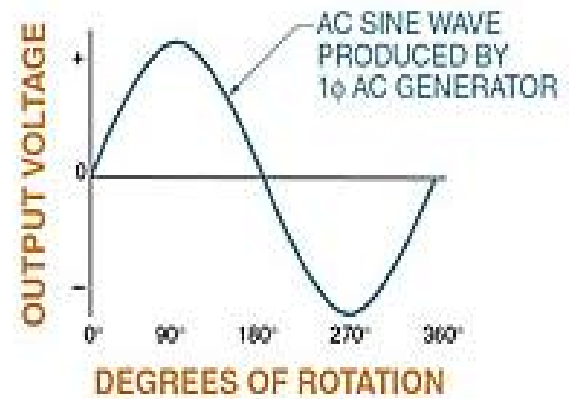




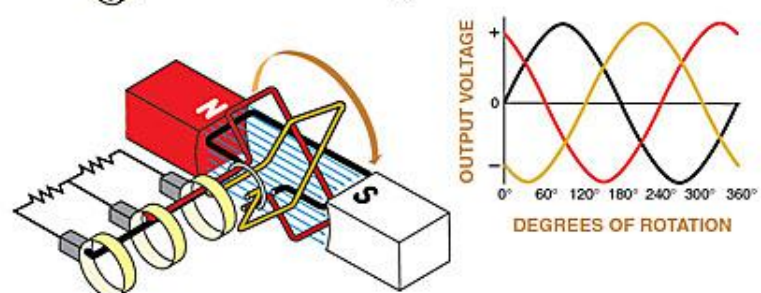
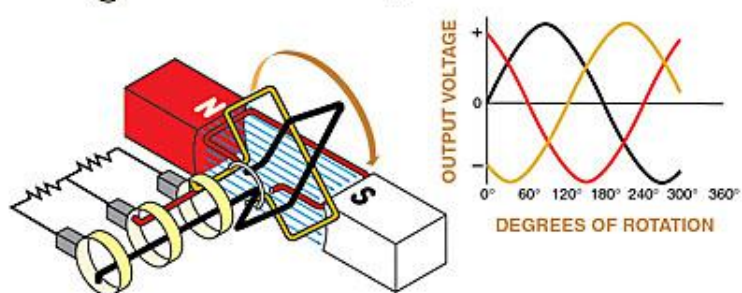
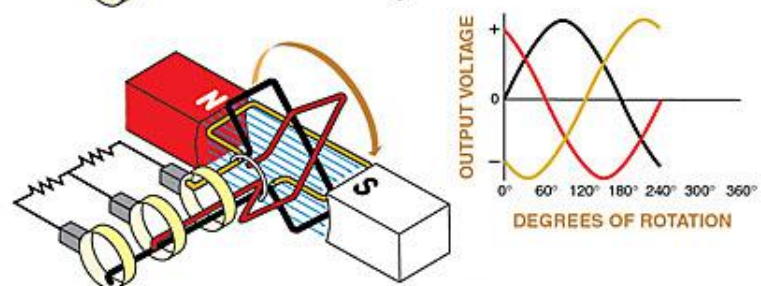
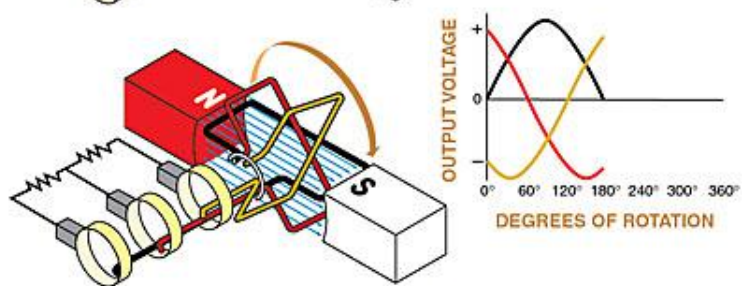
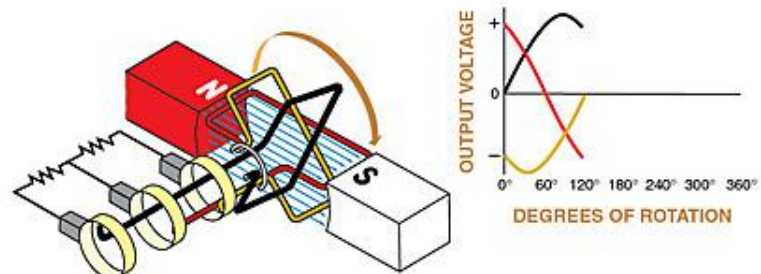
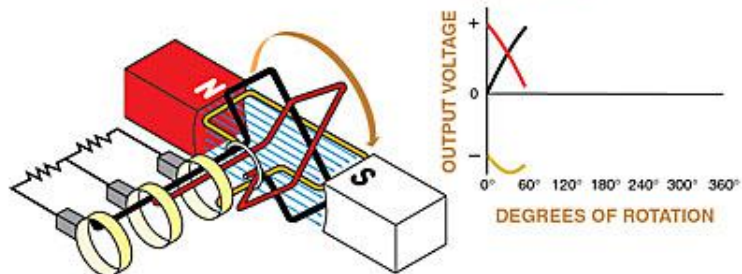
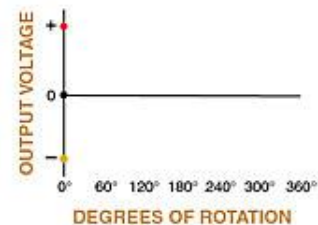
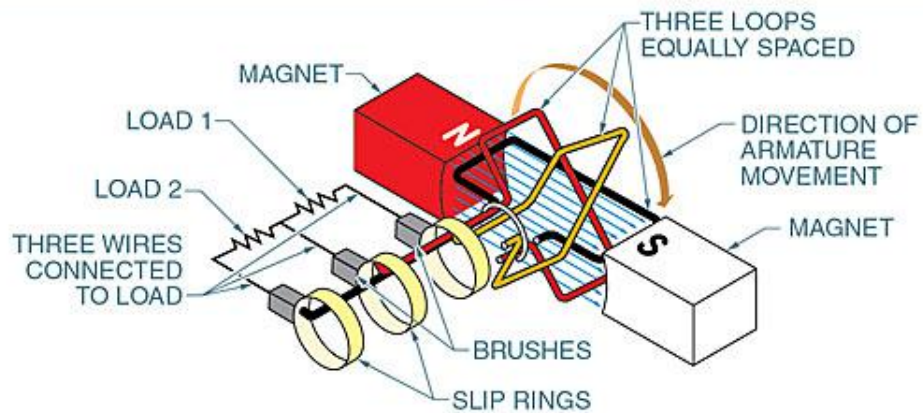
POSITION D (270°)



POSITION E (360°)



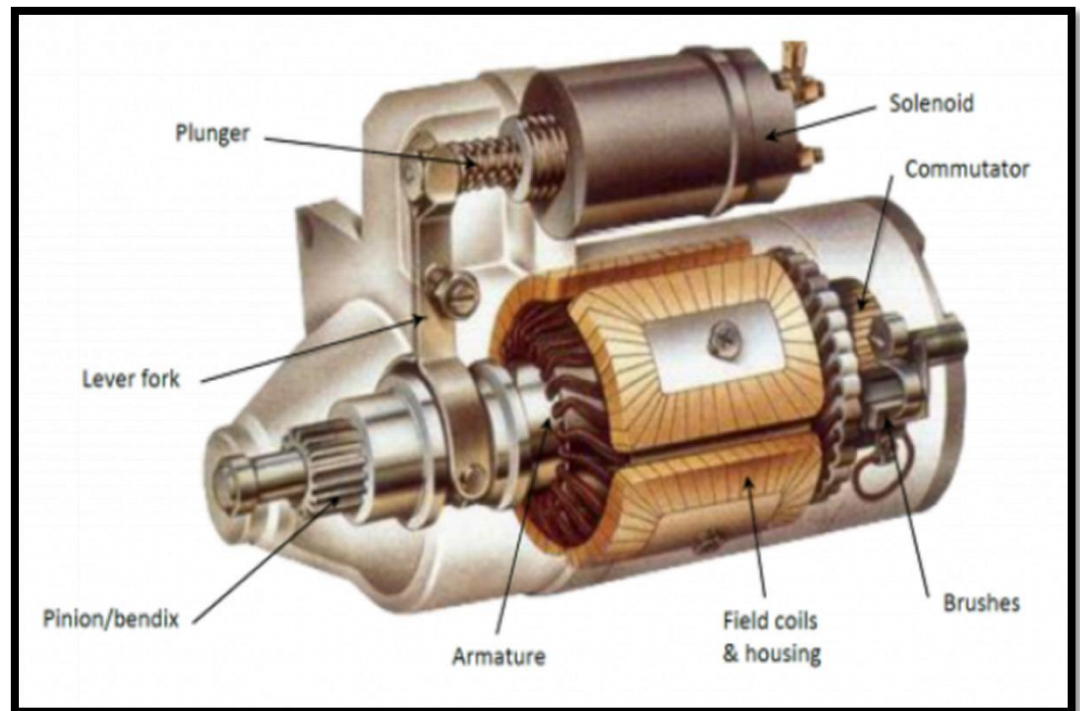
THREE-PHASE AC GENERATORS



Thank You...

UNIT - II

STARTING SYSTEM



Working Principle

DC starter motors (Figure 1) work on the principle of **magnetic repulsion**.

This principle states that magnetic repulsion occurs when a straight rod conductor composed of the armature, commutator, and brushes is located in a magnetic field (field windings) and current is flowing through the rod.

This situation creates two separate magnetic fields:
one produced by the magnet (pole shoes of the magnetic field winding) and
another produced by the current flowing through the conductor (armature/commutator/brushes).

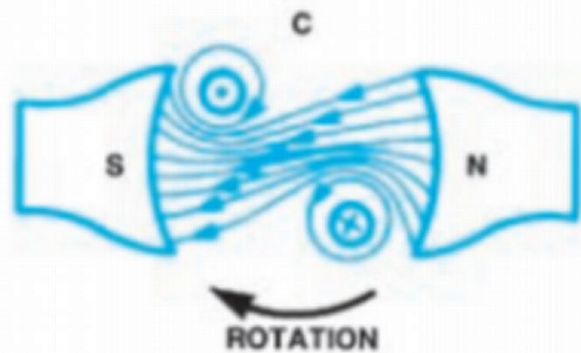
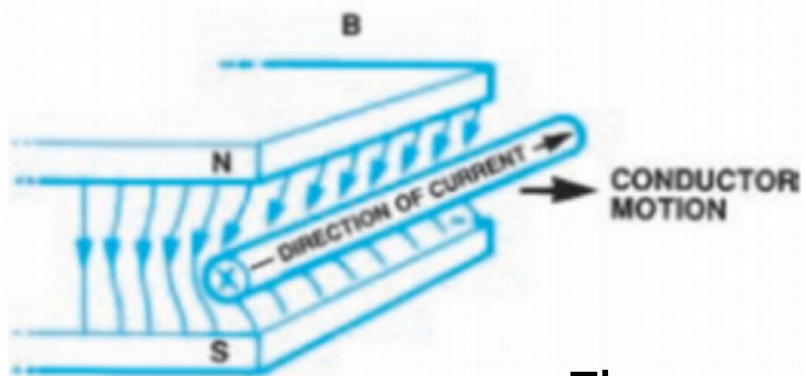
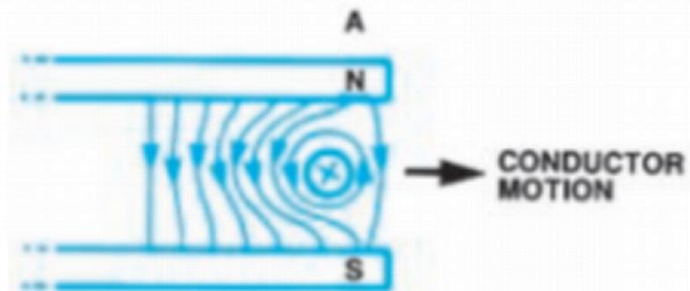


Fig.
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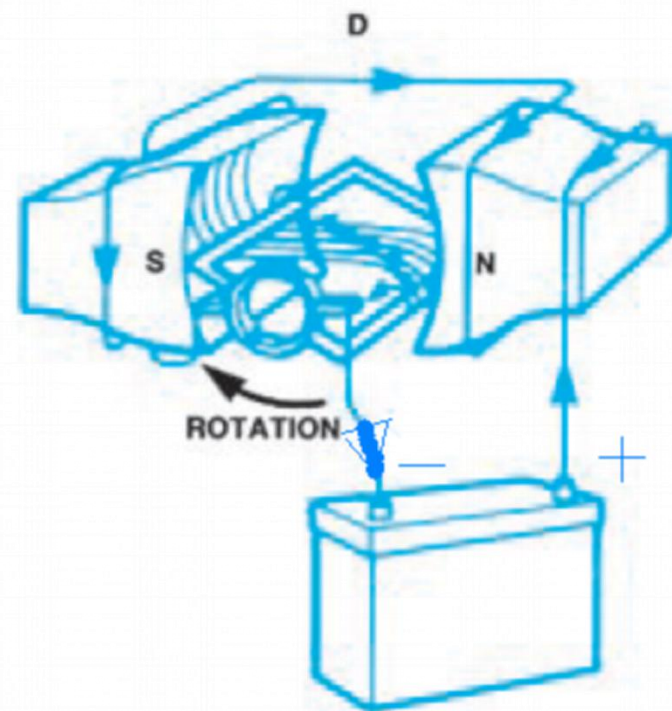
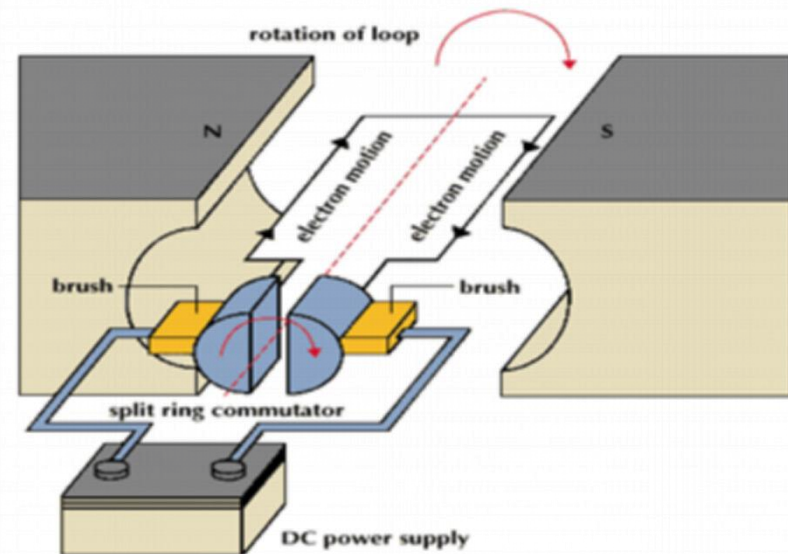


Figure 1 shows the magnet's magnetic field moving from the N pole to the S pole and the conductor's magnetic field flowing around the conductor

Figure 1 shows a stronger magnetic field on one side of the rod conductor (armature/ commutator/brushes) and a weak magnetic field on the other side.

Under these conditions,
the conductor (armature) will tend to be repulsed by the strong magnetic field (pole shoes and field winding) and move toward the weak magnetic field.

Current flows from the positive (+) battery terminal through the brush and copper ring nearer the N pole, through the conductor (armature) to the copper ring and brush nearer the S pole and back to the negative (-) battery terminal. This electrical flow causes the portion of the loop near the S pole to push downward and the N pole to push upward. With a strong field on one side of the conductor and a weak field on the other side, the conductor will move from the strong to the weak.

Put another way, the weaker magnetic field between the S and N poles on one side of the conductor is repulsed by the stronger magnetic field on the other side of the conductor. The commutator then rotates. As it turns, the two sides of the conductor loop reverse positions and the two halves of the split copper ring alternately make contact with the opposite stationary brushes. This causes the flow direction of electrical current to reverse (alternating current) through the commutator and the commutator to continue to rotate in the same direction.

Starting Torque

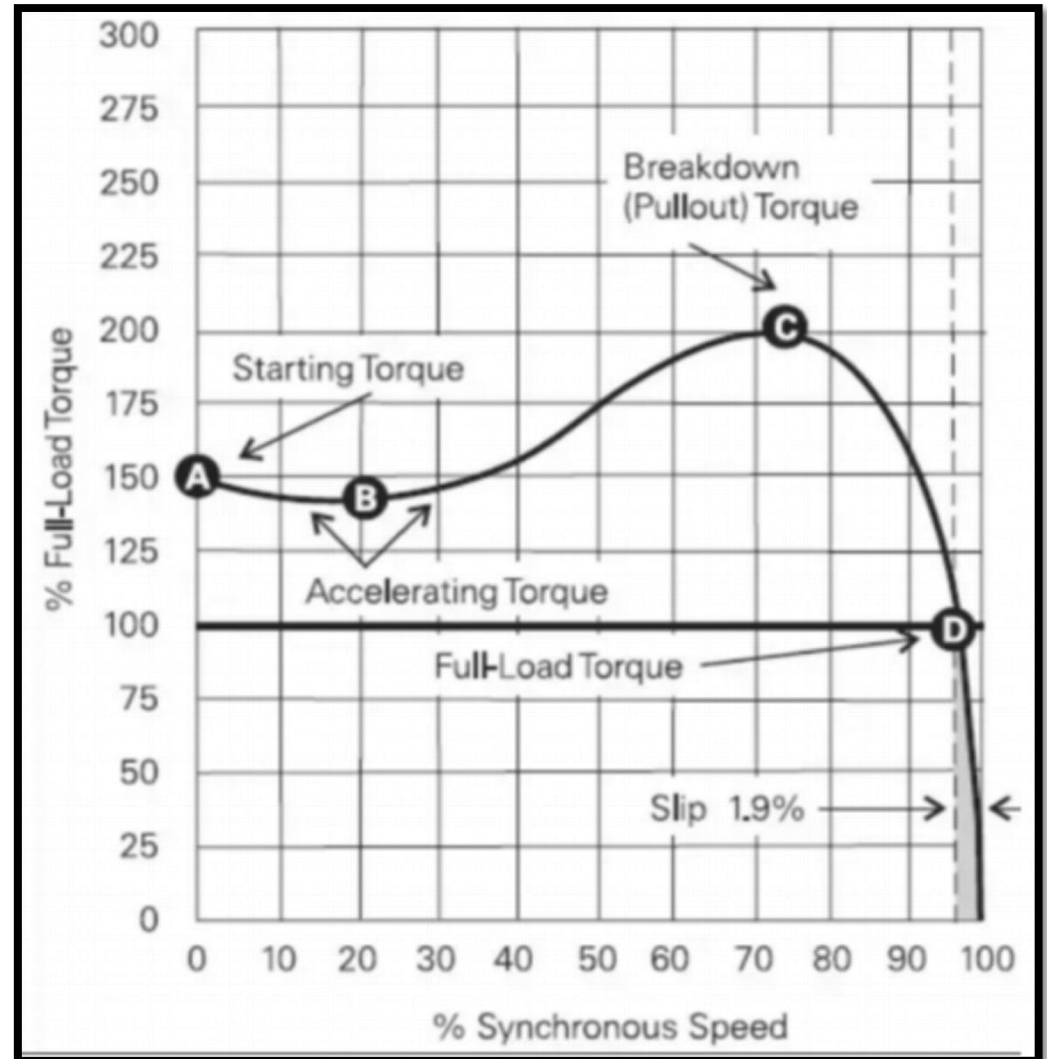
The Starting torque is the maximum torque that a motor can deliver to the mechanical load for its rotation. DC motor is capable to deliver high starting torque, and the motor is suitable for driving the high inertia loads like I.C. engine which demands high starting torque at the time of starting. The DC motor is capable to produce

6 times more torque than its [rated torque](#) at the time of starting of the motor.

If the load demands higher torque than the maximum torque delivering of the motor, The motor will get stalled and will get overload tripped.

The **stall torque** is the maximum torque at which the speed of the motor is zero. When the torque demanded by the load is more than the maximum torque delivering capacity, the speed of the motor will become zero or we can say the motor is not capable to rotate the mechanical load.

A good **starter** will normally draw 60 to 150 amps with no load on it, and up to 250 amps under load (while cranking the **engine**). The no-load amp draw will vary depending on the type of **starter motor**.



Starter Motor And Its Circuit

The three general types of motor internal circuitry, as follows:

- **Series**
- **Shunt (parallel)**
- **Compound (series-parallel)**

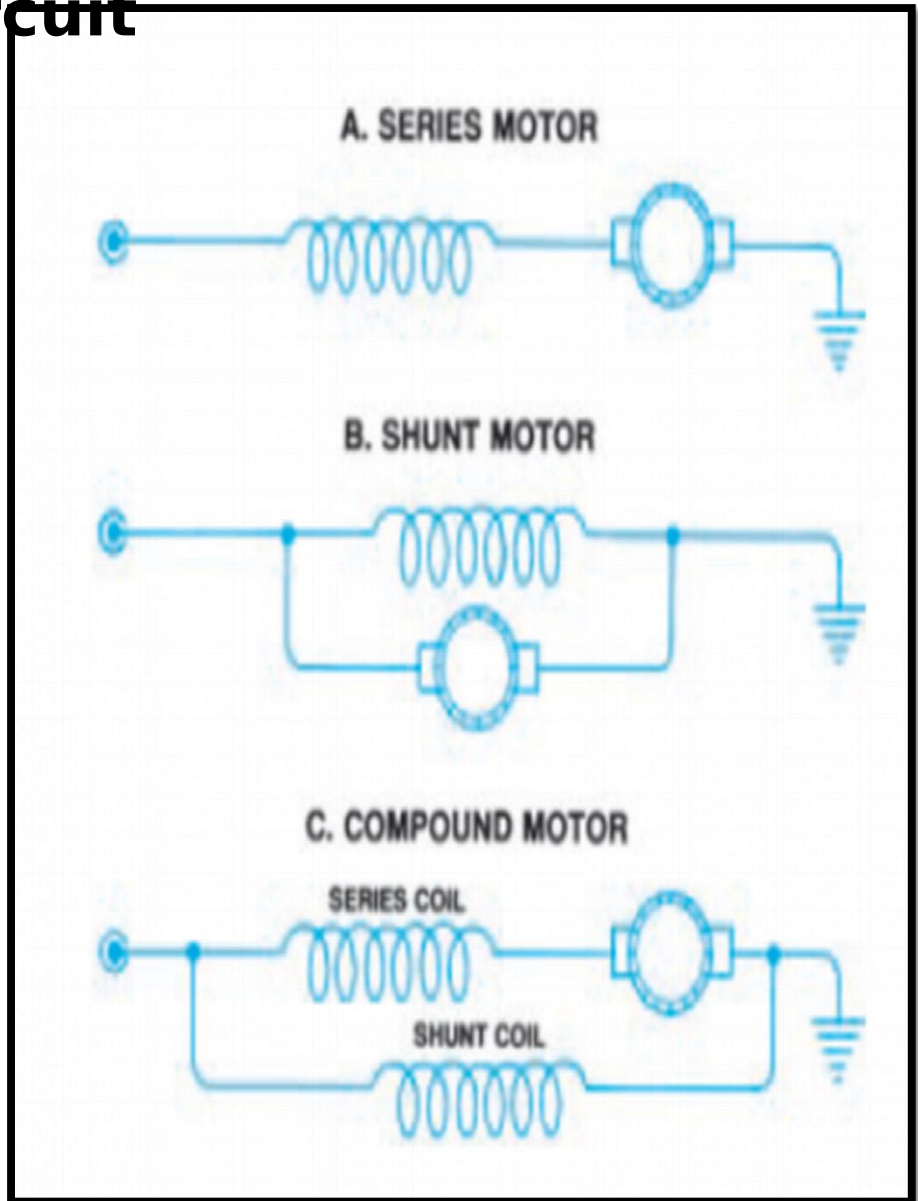
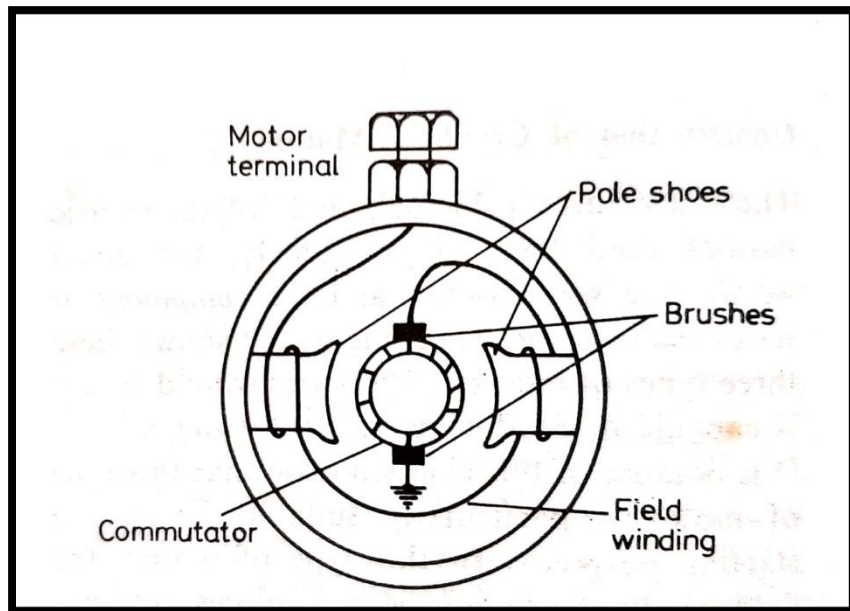


Fig. 1

All automotive starter motors in use today are the series type or the compound type.

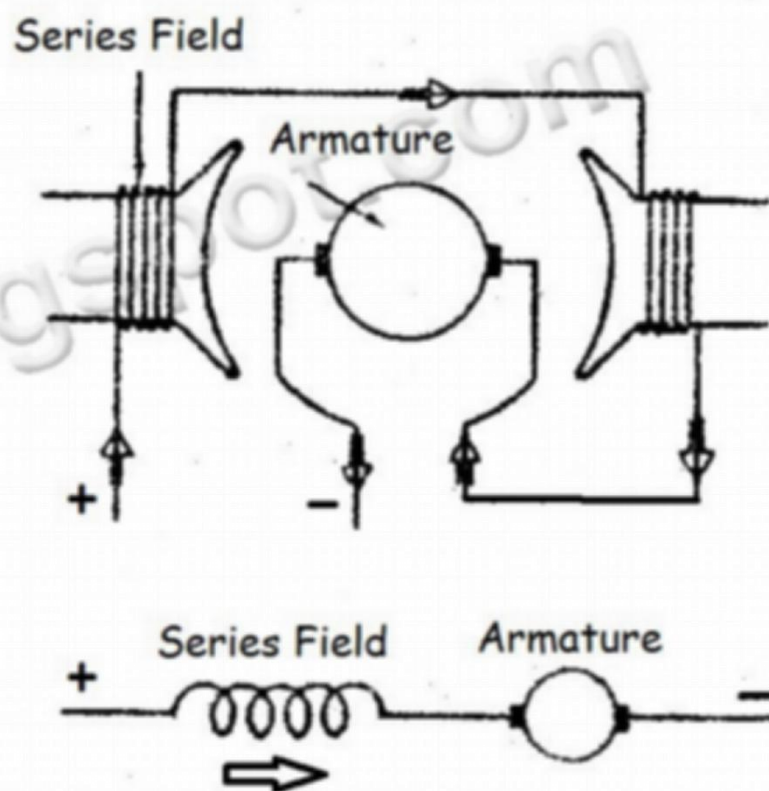
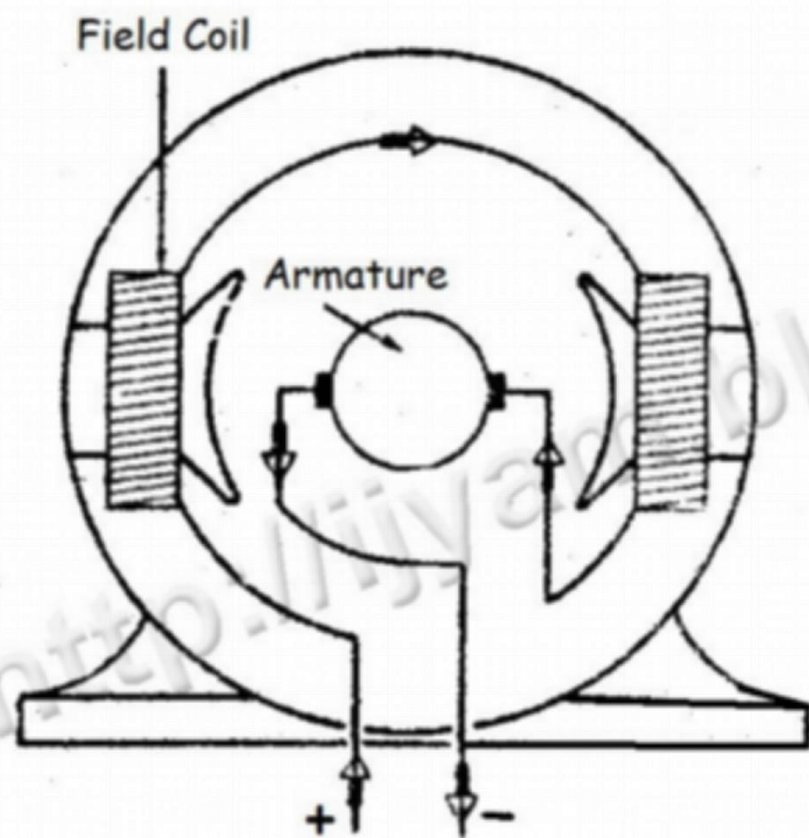
The **series motor (Figure 1 A)** has only one path for current.

As the armature rotates, its conductors cut magnetic flux lines.

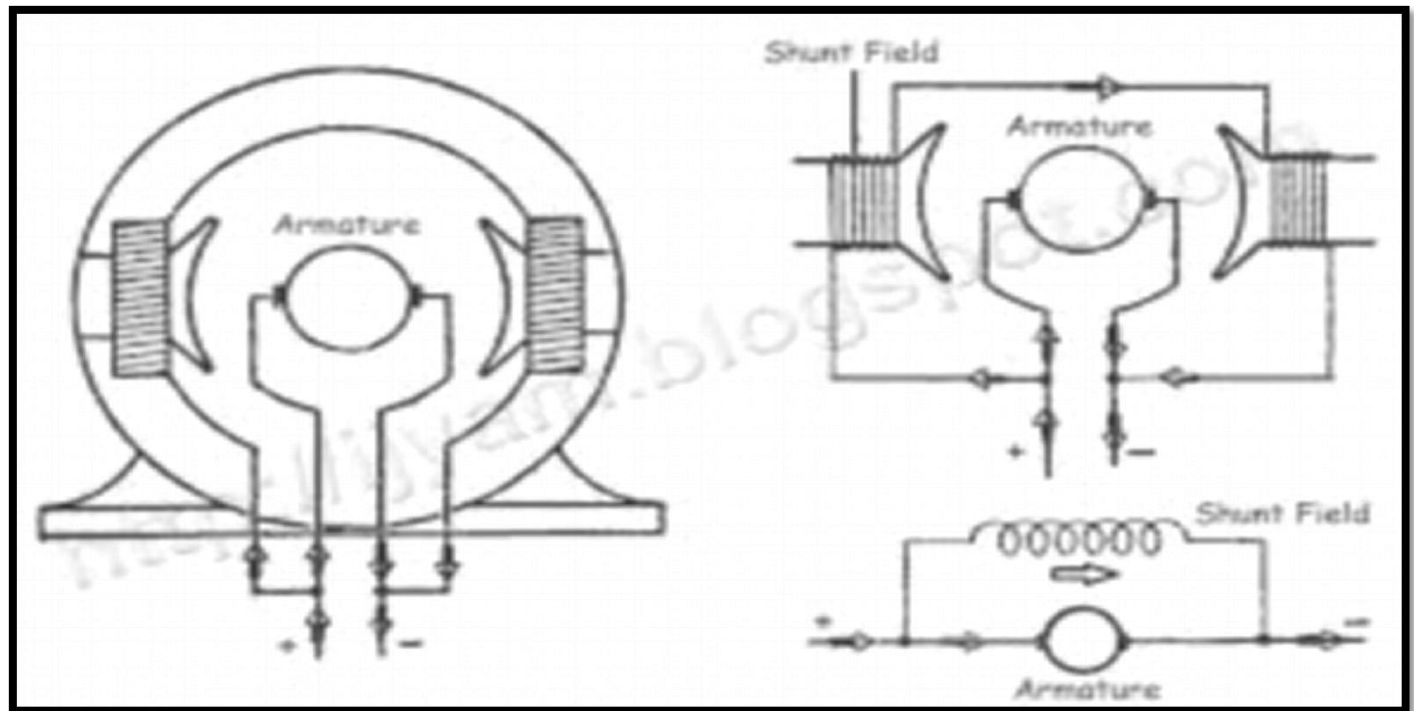
A [counter-voltage](#) is induced in the armature windings, opposing the original current through them. The counter voltage decreases the total current through both the field and the armature windings, because they are connected in series. This reduction of current also reduces the magnetic field strength and motor torque.

Series motors produce a great amount of torque when they first begin to operate, but torque decreases as the engine begins to turn .

Series motors work well as automotive starters because cranking an engine requires a great amount of torque at first, and less torque as cranking continues.



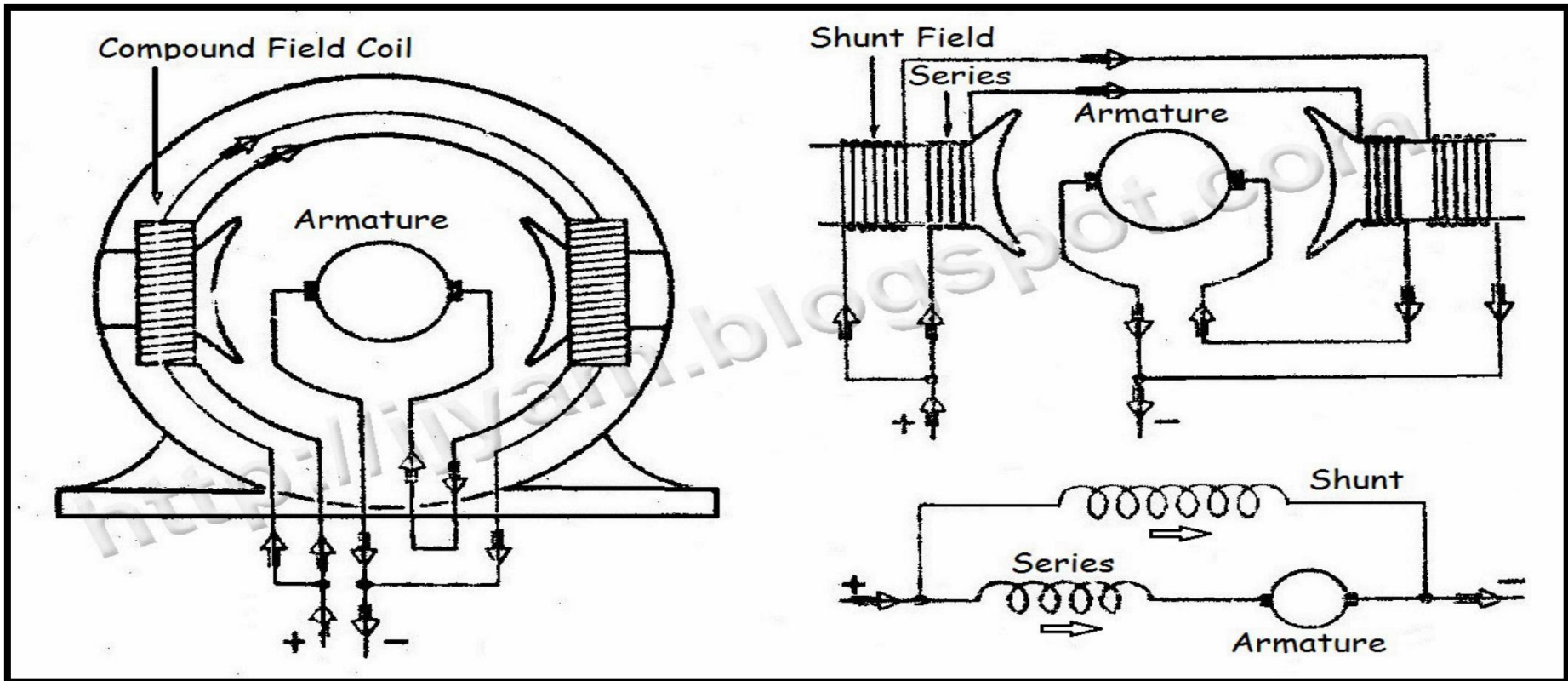
The **shunt motor (Figure 1 B)** does not follow the increasing-speed/decreasing-torque relationship just described. The counter-voltage within the armature does not affect field current, because field current travels through a separate circuit path. A shunt motor, in effect, adjusts its torque output to the imposed load and operates at a constant speed. Shunt motors are not used as automotive starters because of their low initial torque (Figure 2), but are used to power other automotive accessories.



The **compound motor, shown in Figure 1 C**, has both series and shunt field windings. It combines both the good starting torque of the series type and the relatively constant operating speed of the shunt-type motor (Figure 1 C).

A compound motor is often used as an automotive starter.

Figure shows the actual relationships of field and armature windings in different types of motors.



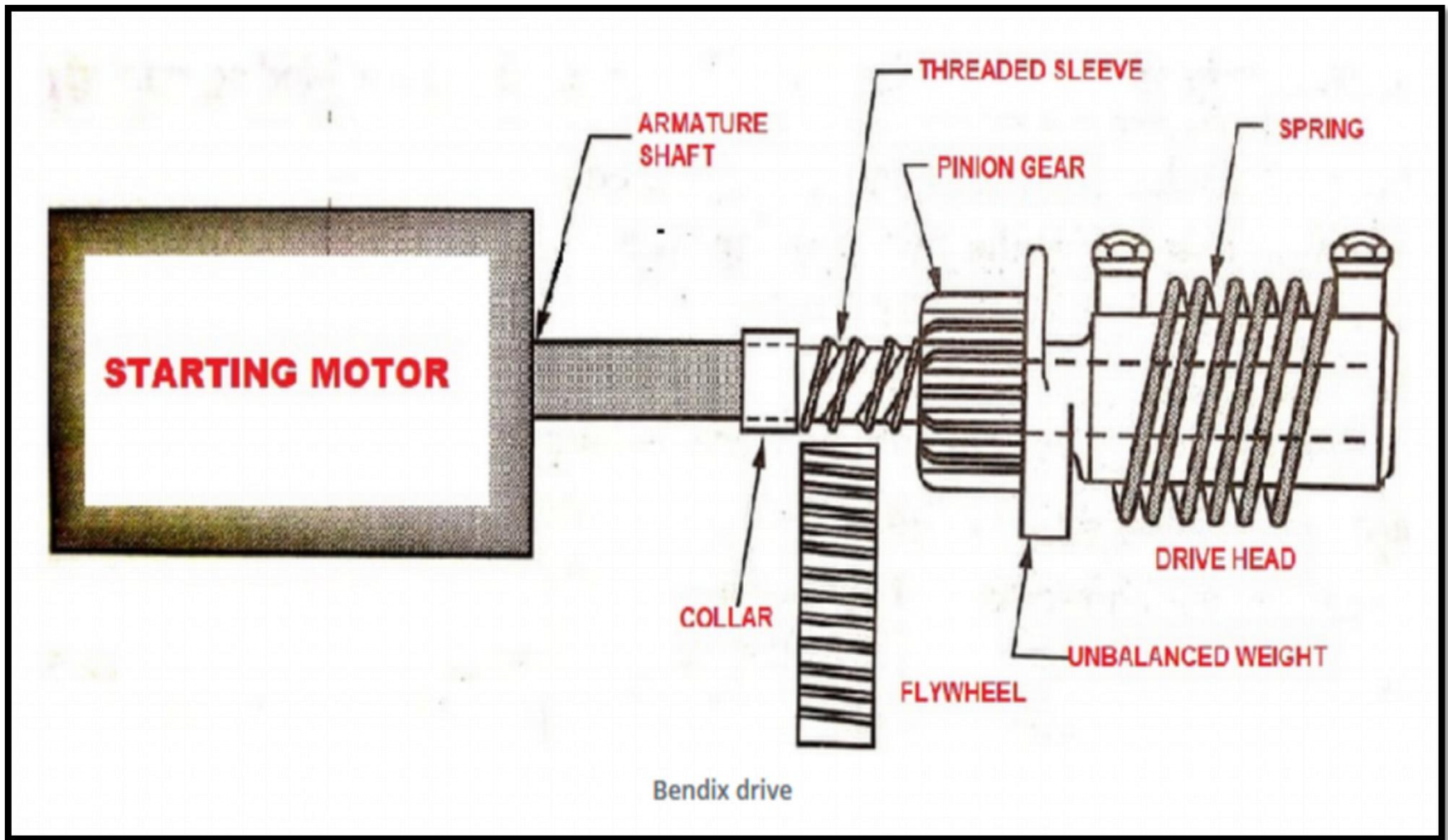
Types of drive mechanisms

Inertia types

- 1) Bendix drive
- 2) Folo-thru drive
- 3) Barrel type drive
- 4) Rubber compression drive
- 5) Friction clutch drive

- 1) Overrunning clutch
- 2) Axial or sliding armature

1) Bendix drive



A Bendix drive is a type of engagement mechanism used in starter motors of internal combustion engines. The device allows the pinion gear of the starter motor to engage or disengage the flywheel of the engine automatically when the starter is powered or when the engine fires, respectively. It is named after its inventor, Vincent Hugo Bendix.

Operation

The Bendix system places the starter drive pinion on a helical drive spring. When the starter motor begins turning, the inertia of the drive pinion assembly causes it to wind the spring forcing the length of the spring to change, and allowing the pinion to engage with the ring gear. When the engine starts, back drive from the ring gear causes the drive pinion to exceed the relative speed of the starter, at which point the drive pinion is forced back and out of mesh with the ring gear.

The main drawback to the Bendix drive is that it relies on a certain amount of "clash" between the teeth of the pinion and the ring gears before they slip into place and mate completely;

the teeth of the pinion are already spinning when they come into contact with the static ring gear, and unless they happen to align perfectly at the moment they engage, the pinion teeth will strike the teeth of the ring gear side-to-side rather than face-to-face,

And continue to rotate until both align.

This increases wear on both sets of teeth. For this reason the Bendix drive has been largely superseded in starter motor design by the pre-engagement system using a solenoid.

<https://www.vehicletech.org/what-is-bendix-and-folo-thru-drive-construction-and-operation-of-bendix-and-folo-thru-drive/>

2) Overrunning Clutch

The overrunning clutch consists of rollers that ride between a collar on the pinion gear and an outer shell. The outer shell has tapered slots for the rollers so that the rollers either ride freely or wedge tightly between the collar and the shell. Figure 9-53 shows the operation of an overrunning clutch.

In Figure 9-53A, the armature is turning, cranking the engine. The rollers are wedged against spring force into their slots.

In Figure 9-53B, the engine has started and is turning faster than the motor armature. Spring force pushes the rollers so that they float freely.

The engine's motion is not transferred to the motor armature. These devices are sometimes called one-way clutches because they transmit motion in one direction only.

Figure 9-53

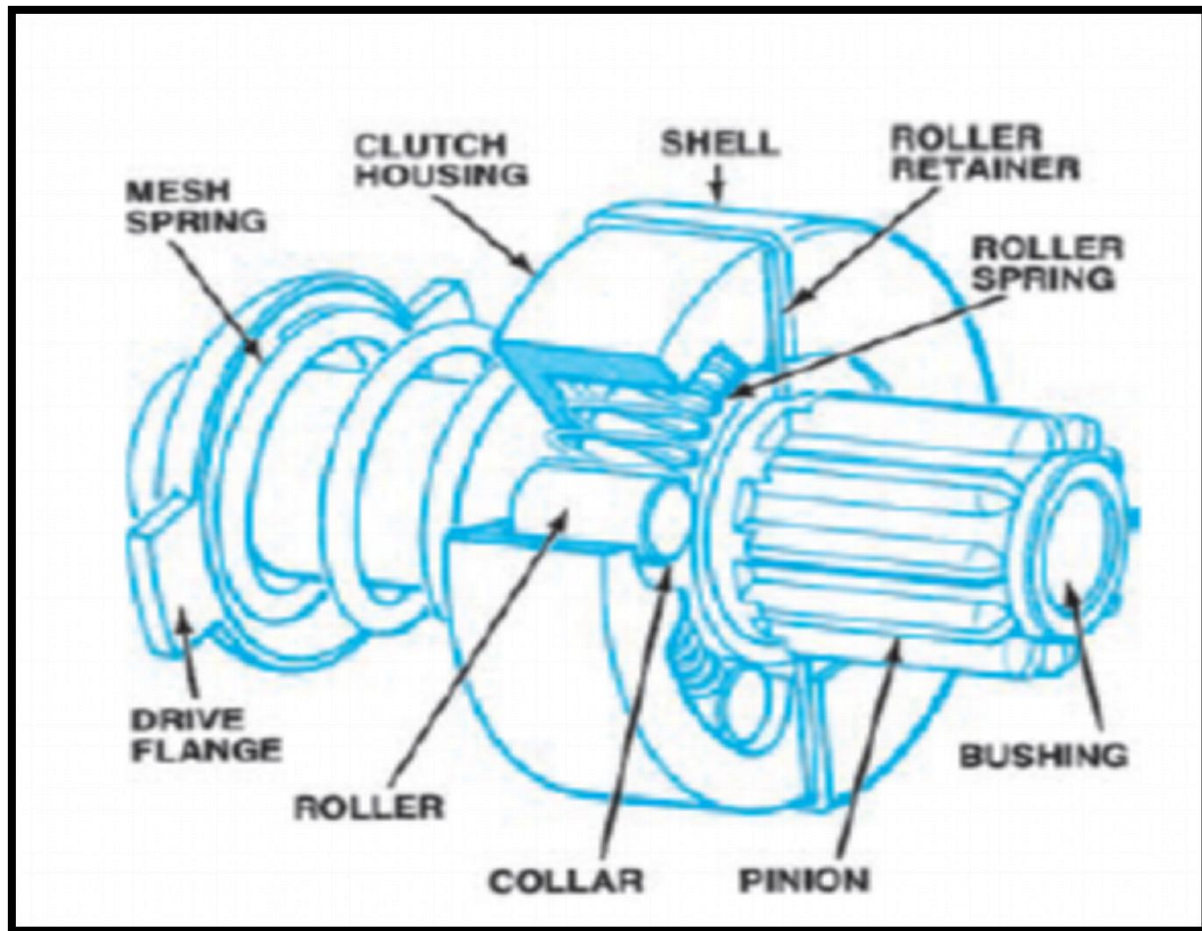
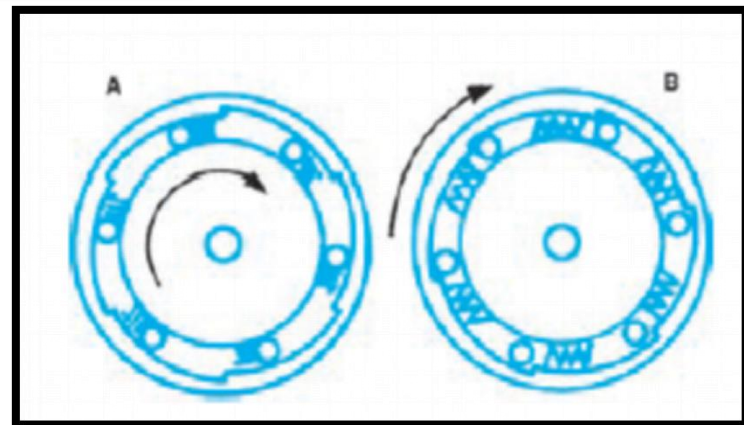


Figure 9-53 A & B



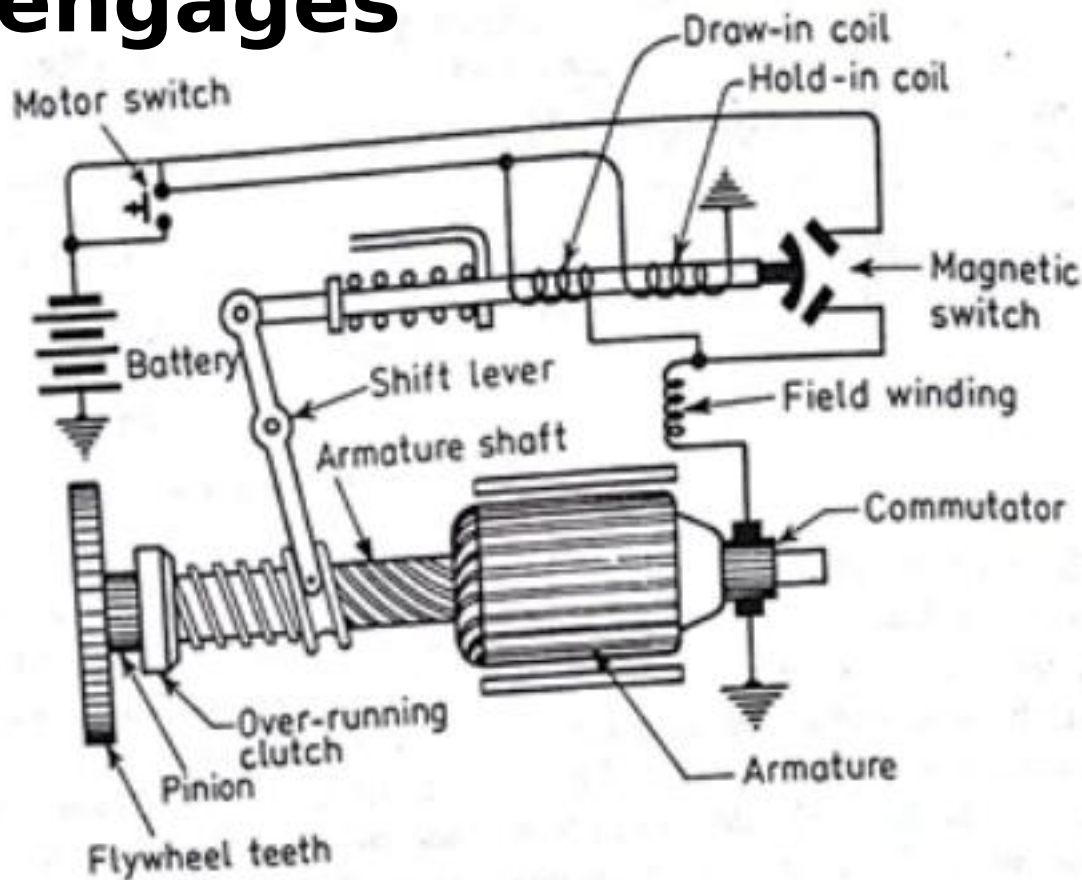
The most common type of starter drive is the overrunning clutch. The overrunning clutch is a roller-type clutch that transmits torque in one direction only and freewheels in the other direction. This allows the starter motor to transmit torque to the ring gear, but prevents the ring gear from transferring torque to the starter motor.

In a typical overrunning-type clutch, the clutch housing is internally splined to the starter armature shaft. The drive pinion turns freely on the armature shaft within the clutch housing.

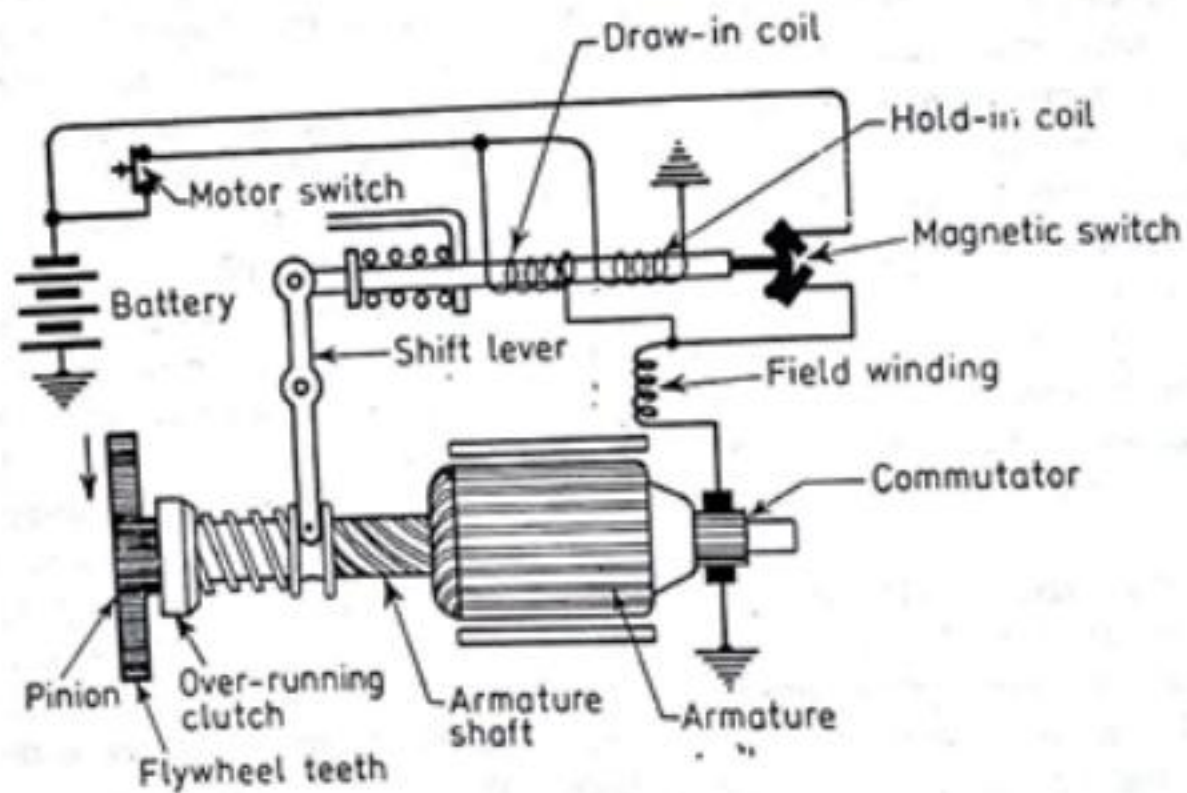
When torque is transmitted through the armature to the clutch housing, the spring-loaded rollers are forced into the small ends of their tapered slots. They are then wedged tightly against the pinion barrel. The pinion barrel and clutch housing are now locked together; torque is transferred through the starter motor to the ring gear and engine.

When the engine starts and is running under its own power, the ring gear attempts to drive the pinion gear faster than the starter motor. This unloads the clutch rollers and releases the pinion gear to rotate freely around the armature shaft.

Fig. (a) And (b) Action of solenoid and overrunning clutch as the pinion engages



(a) Disengaged position



(b) Pinion engaged and motor cranking

Cold Starting Devices: Glow Plug & Choke

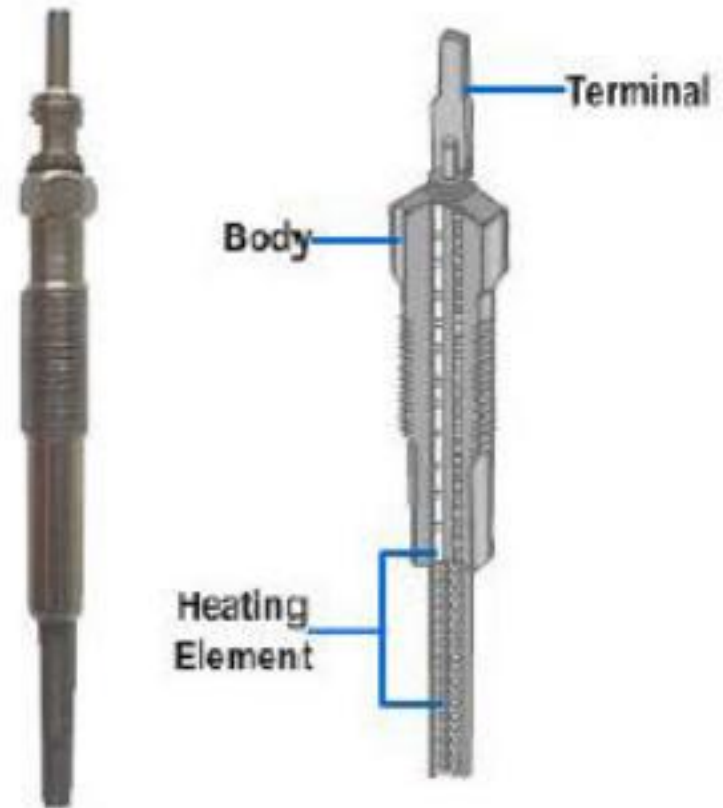
Glow Plugs

The purpose of a glow plug is to **heat up the air** that is drawn into the pre combustion chamber to assist starting, especially in cold weather. Operating temperatures of 1500°F can be reached in a matter of seconds.

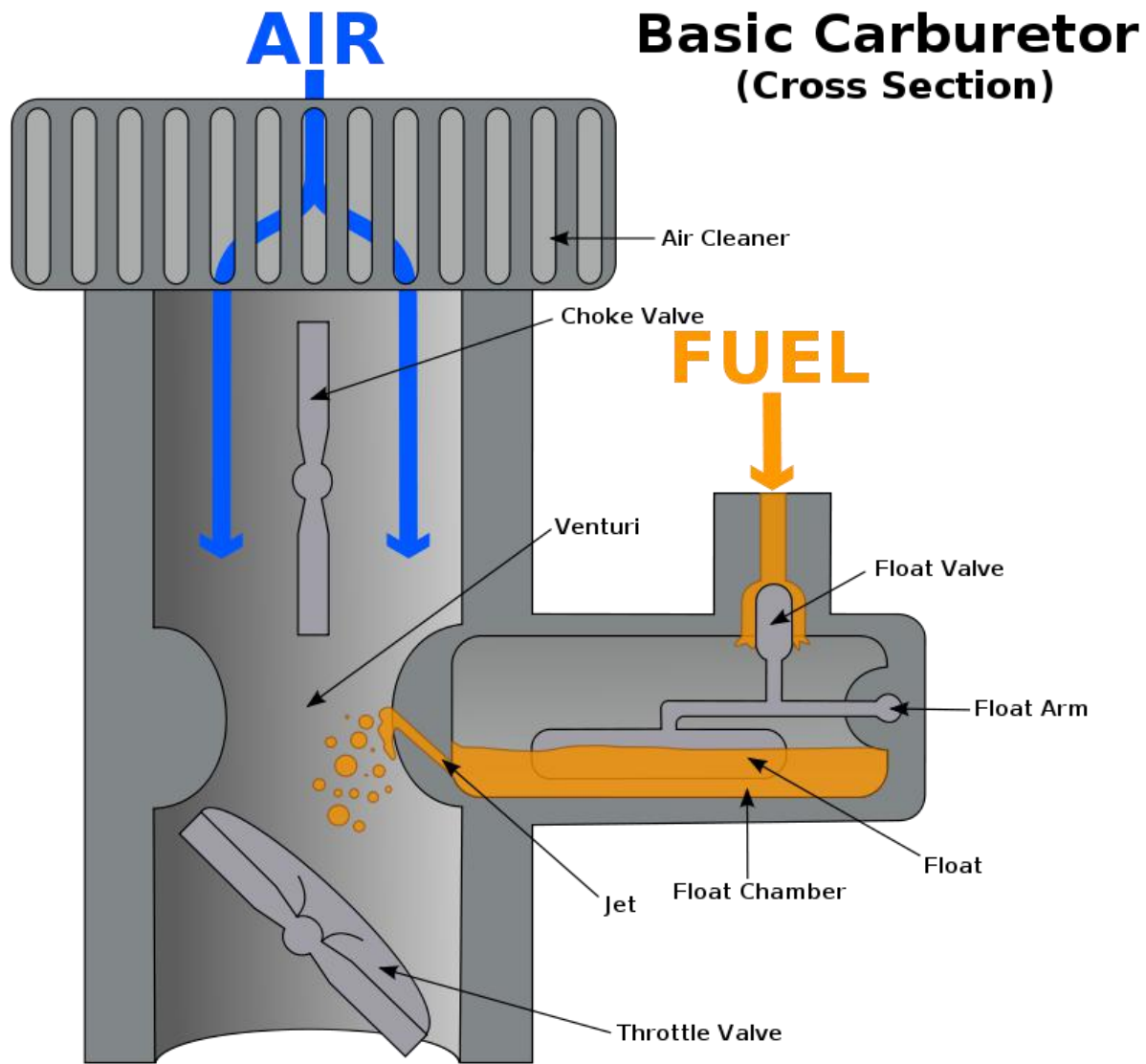
Glow plugs are common on pre combustion chamber engines, but not on direct injection diesels because they use shaped piston crowns that produce a very effective turbulence to the air in the cylinder.

A glow plug is used for each cylinder located just below the injection nozzle and threaded into the cylinder head (Figure 1). The inner tip of the glow plug extends into the precombustion chamber. The glow plugs may be turned on using the ignition switch with the length of time being controlled from an electronic module.

Direct injection engines also have less immediate heat loss to the surrounding cylinder area than in a pre combustion engine and generally have a higher injection spray-in pressure.



Choke



A choke valve is sometimes installed in the carburetor of internal combustion engines. Its purpose is to **restrict the flow of air**, thereby enriching the fuel-air mixture while starting the engine.

Depending on engine design and application, the valve can be activated manually by the operator of the engine (via a lever or pull handle) or

automatically by a temperature-sensitive mechanism called an autochoke.

Choke valves are important for naturally-aspirated gasoline engines because small droplets of gasoline do not evaporate well within a cold engine.

By restricting the flow of air into the throat of the carburetor, the choke valve reduces the pressure inside the throat, which causes a proportionally-greater amount of fuel to be pushed from the main jet into the combustion chamber during cold-running operation.

Once the engine is warm (from combustion), opening the choke valve restores the carburetor to normal operation, supplying fuel and air in the correct stoichiometric ratio for clean, efficient combustion.

**Thank
You...**

Rated torque is the maximum continuous torque available at the design speed that allows the motor to do the work without overheating

The reverse voltage that appears across an inductor when current through the inductor is shut off.