Second module

AEES 2021 syllabus

Charging system

- The function of charging system in an automobile is to generate, regulate and supply the electrical energy for charging the battery and also supply electrical energy when engine is running

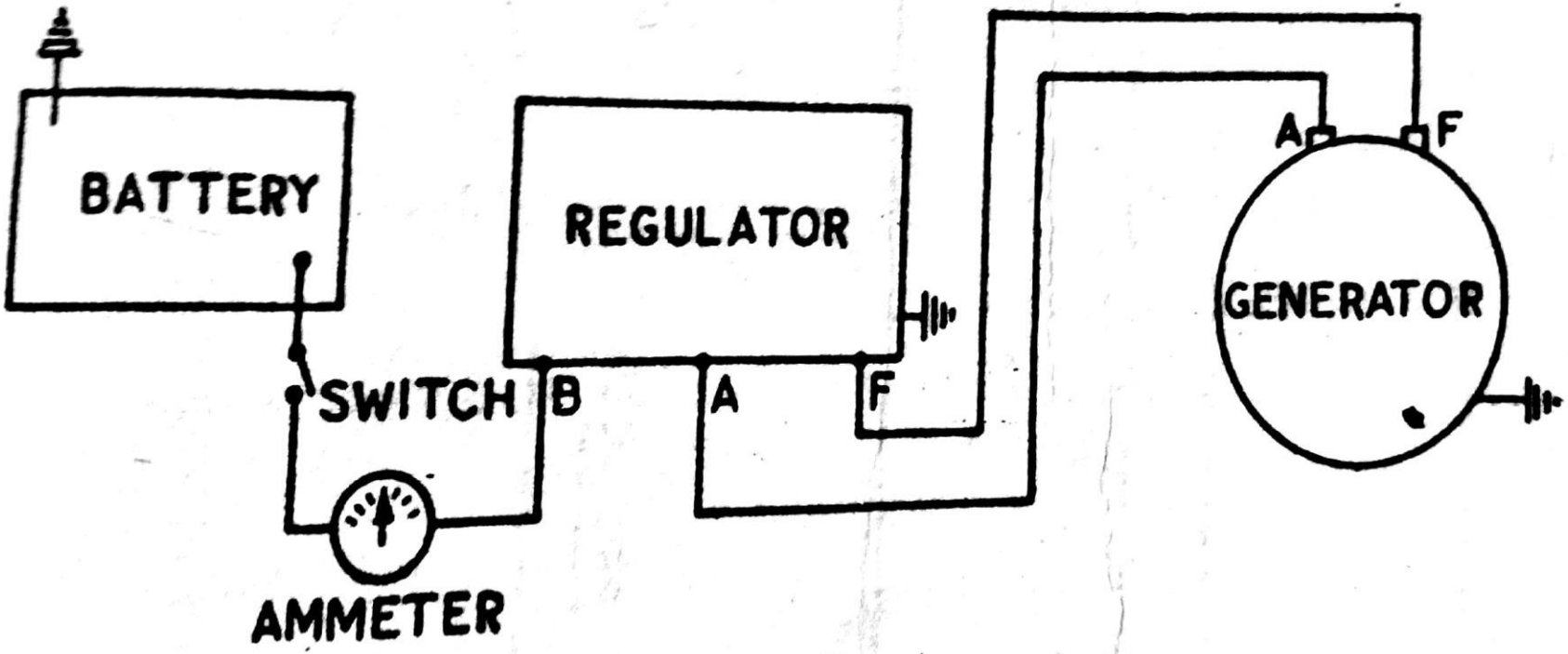


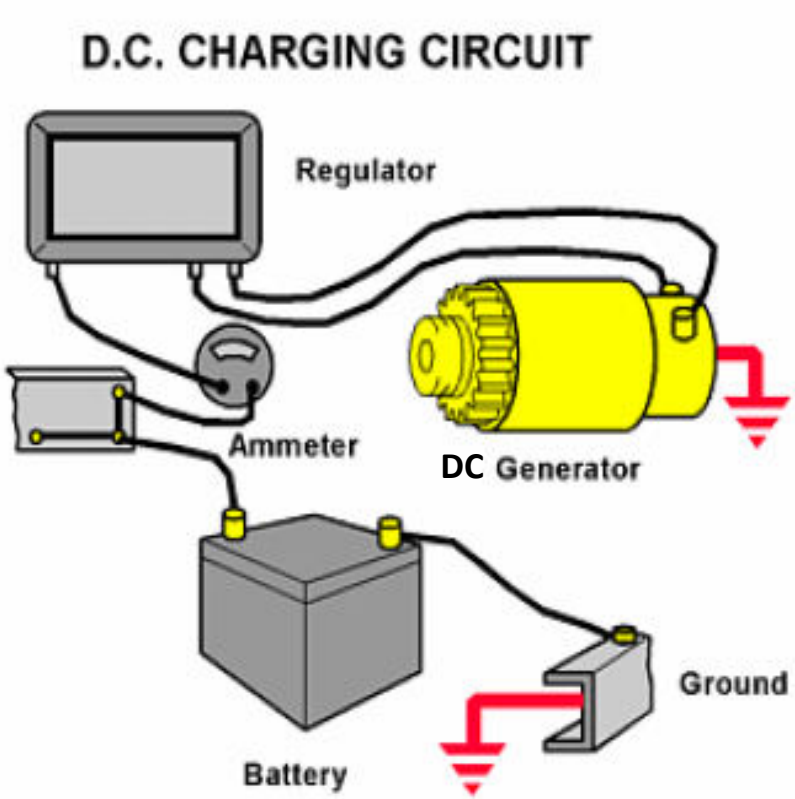
Fig. 16.1. Charging system

Need for charging system

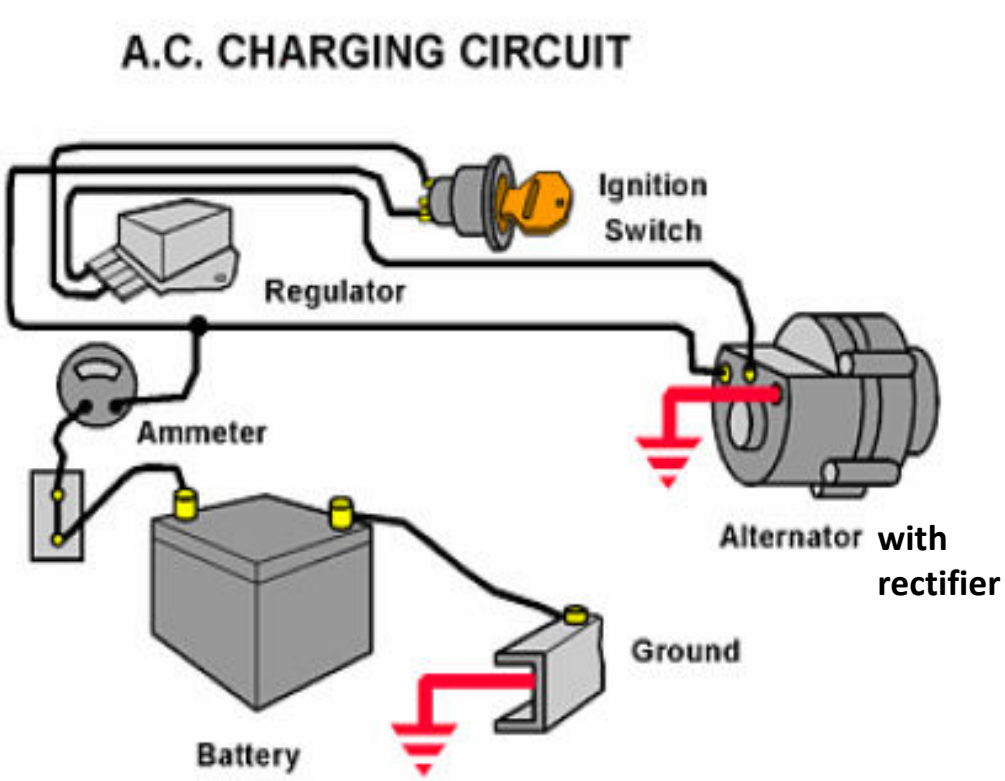
- Motor vehicles need their own efficient and reliable source of energy that is always available to supply power for the-
- – Starter
- – Ignition system
- – Fuel injection system
- – For the ECU to control electronic equipment
- – Lighting system
- – Safety and convenience electronics and so on…
- When the engine is stopped the battery is the source of energy
- When the engine is running the alternator or the Dynamo is the electricity generating device supplying power to all electrical loads.

Types of charging system

1)With Dynamo or DC generator



2)With Alternator or AC generator

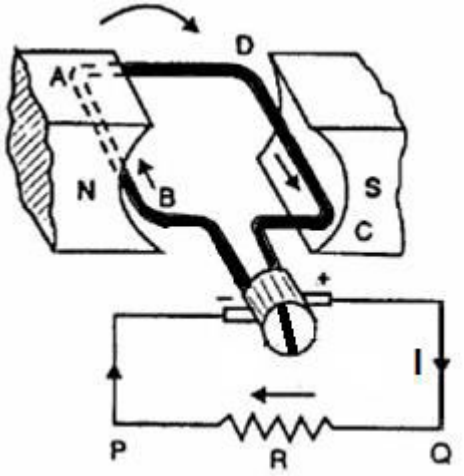


DC generator or Dynamo

- Dynamo is a device used to convert mechanical energy into electrical energy
- When its driven by the engine it produces electricity for running all the electrical circuits of the automobile and keeps the battery in charged condition. This is the function of dynamo

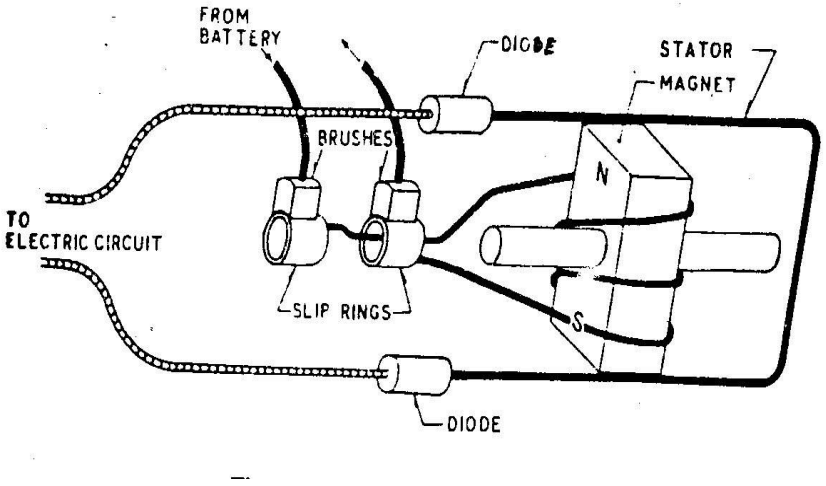
Working principle of a DC Generator

- Consider a single turn rectangular coil ABCD rotating clock wise direction in a magnetic field.
- The e.m.f is induced in the coil is proportional to the rate of change of flux linkage.
- When the plane of the coil is at right angle to the lines of flux, rate of change of flux linkage is maximum , hence e.m.f induced in the coil maximum.
- When the plane of the coil is parallel to the lines of flux, rate of change of flux linkage is minimum hence e.m.f induced in the coil is minimum.
- Emf induced in the armature winding of dc generator is ac , for converting this AC into DC commutators are used.

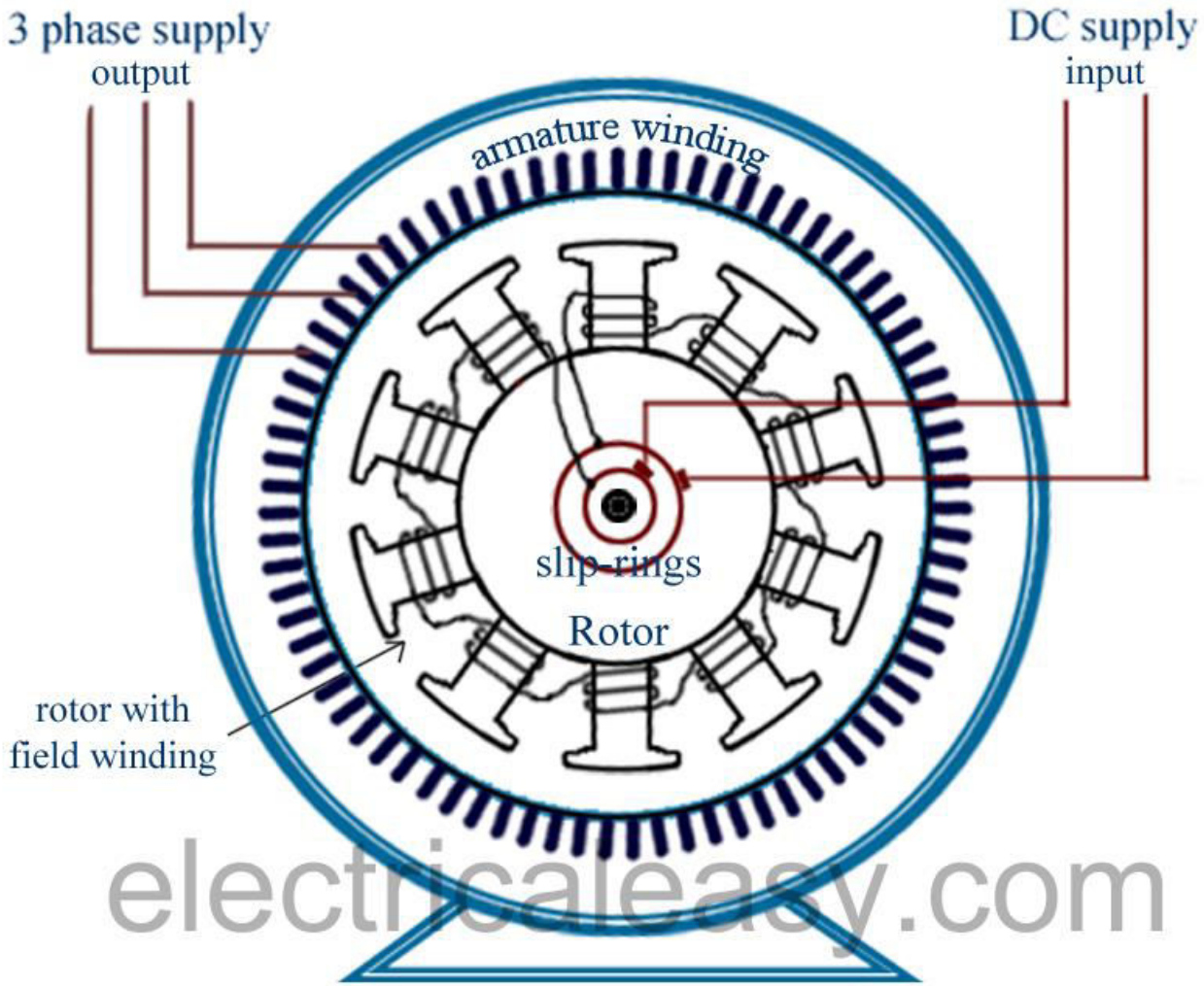


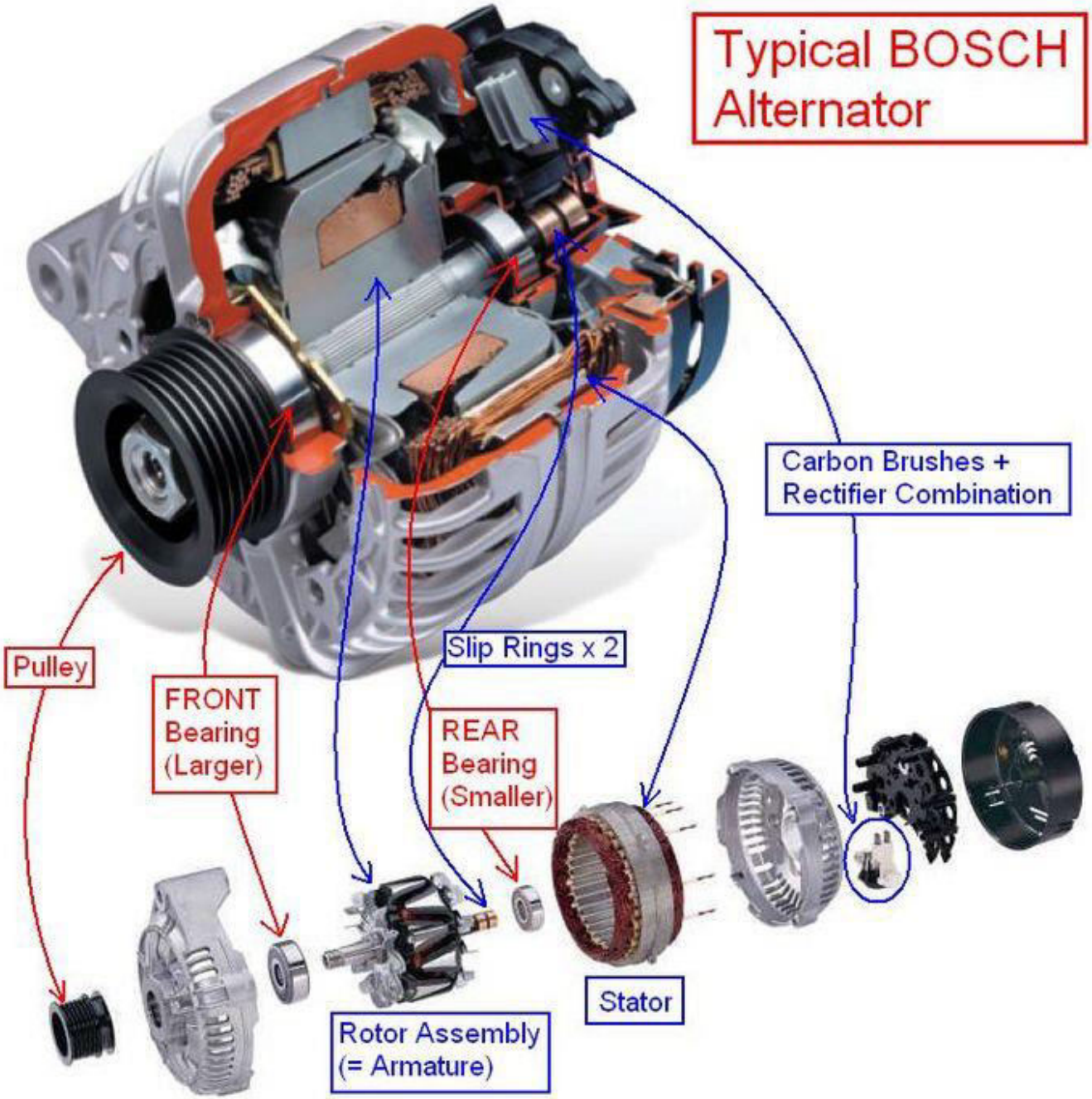
ALTERNATOR /AC GENERATOR

- It operates on the principle of electro magnetic induction
- Modern automobiles which requires more electric loads so we use alternators instead of dynamo
- **Working**
- Alternator is the generator that produces alternating current instead of D.C. as produced by a commutator type generator. It consists of an electromagnet or rotor mounted on a shaft. Current is supplied from a battery for energization of electromagnet through slip rings and the brushes. The rotor is rotated by means of a belt coupled to the engine. The diodes are connected in series with the stator windings, which are further connected to outside electric current. When the electromagnet is rotated, the magnetic lines of force cut the stationary to produce an induced current. The magnet reverses its polarity after every half revolution, due to which the current produced in the stator alternates in sign. To convert this A.C into D.C diodes are employed. Diodes allow the current to pass through them only in one direction. Hence the A.C. is converted to D.C. before it is supplied to electric circuit.



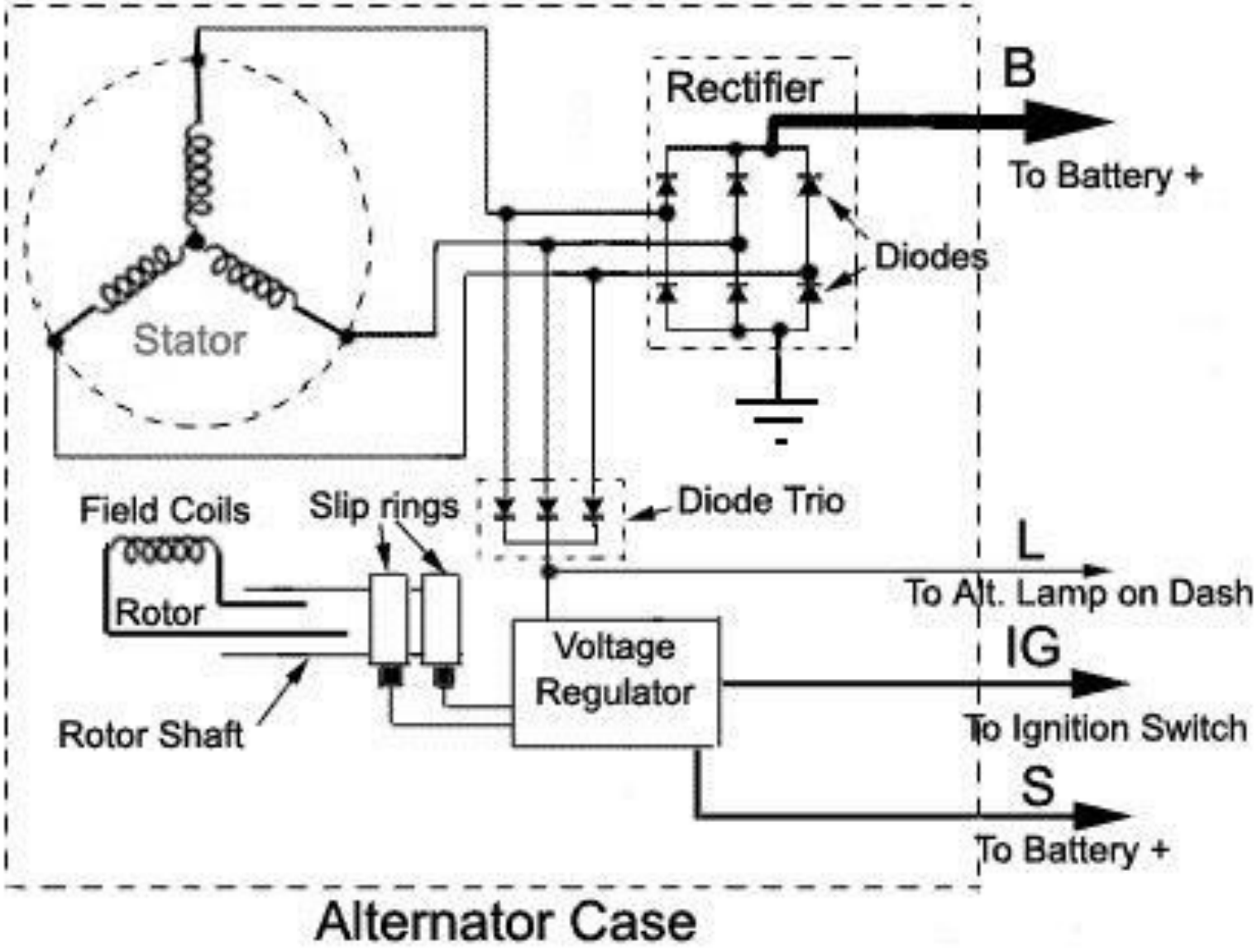
Constructional details of Alternator

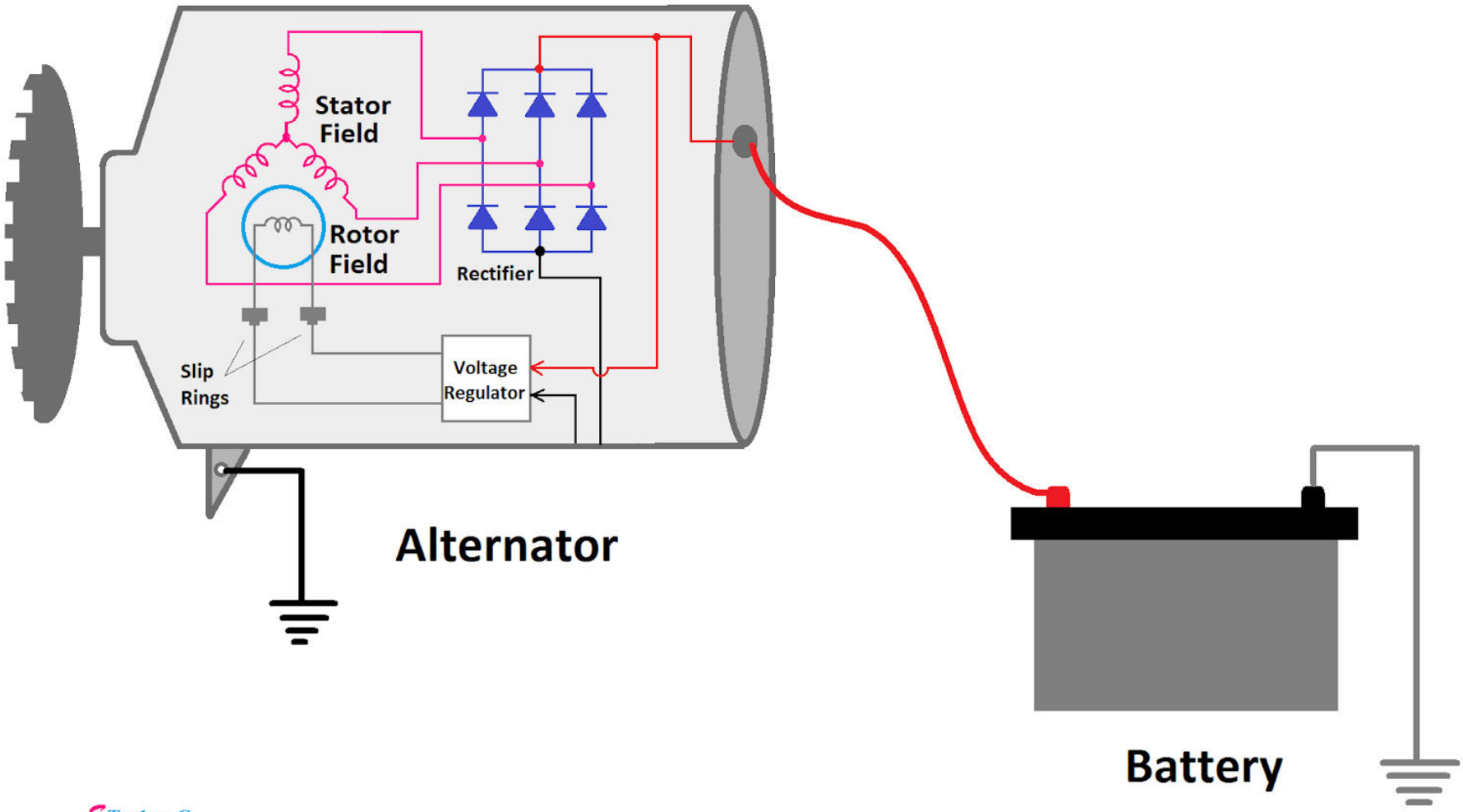



Typical BOSCH Alternator
Carbon Brushes + Rectifier Combination
Slip Rings x 2
Pulley
FRONT Bearing (Larger)
REAR Bearing (Smaller)
Stator
Rotor Assembly (= Armature)

- **Frame or housing**: This encloses the entire alternator made of cast aluminum in two pieces.
- **Rotor :** consists of an iron core around the rotor shaft. Many turns of copper wire coated varnish are wound over the core.
- On both sides of the rotor windings are thick metal plates bent over the winding with triangular fingers called poles. These metal plates are called pole-pieces.
- The pole pieces are placed interlacing each other so that when the current flows through the windings ,these acquire opposite polarity.
- **Slip rings and brushes:** the current to the rotor winding is carried through the copper slip rings and carbon brushes. The brushes ride on the surface of slip rings under spring tension provided by brush holders. As the brushes carry only field current , it has more life.
- **Stator:** 3 phase alternator is commonly used in automobiles. Between two halves of alternator casing the stator is situated which consists of three set of winding wounded over a laminated iron core . All alternators contain at least six diodes, one pair of diode for each winding for full wave rectification.
- The stator winding are usually star connected because with it is able to start charging at lower speeds and has lower maximum out put. Also delta connections are used for getting high out puts.

Typical Alternator Circuit





ETechnoG

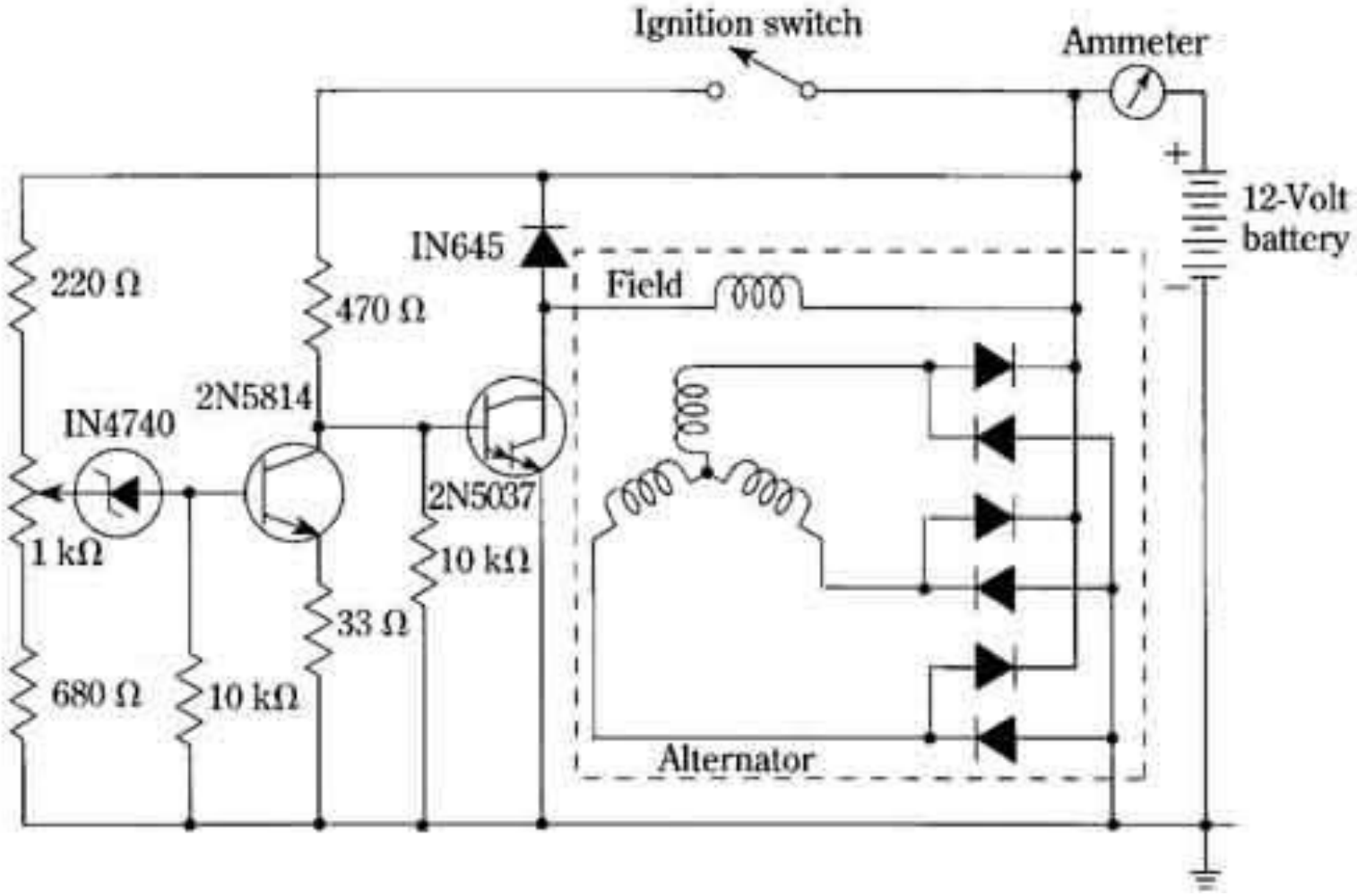
Alternator Wiring in Car

Alternator regulators

- Alternator regulator is of two type

1. Mechanical (the vibrating contact type): similar to that of voltage regulator in DC generator
2. Electronic (transistorized type): This has no vibrating contacts so has more life and is used mostly in modern vehicles

- Modern cars use three-phase alternators with self-contained silicon-diode rectifiers. These machines employ slip rings to conduct current to the rotating field.
- However, a slip ring is a much simpler device than a commutator. Moreover, the field current is a small fraction of the charging current often supplied to the battery. Therefore, the slip rings and brushes require infrequent maintenance compared with the commutator and brush assembly of the old dc generators.
- The electro mechanical voltage regulator did not immediately become obsolete, but the trend is now clearly toward the electronic voltage regulator.


Ignition switch
Ammeter
+
12-Volt battery
−
IN645
Field
220 Ω
470 Ω
2N5814
IN4740
2N5037
1 kΩ
10 kΩ
33 Ω
680 Ω
10 kΩ
Alternator

- A typical electronic voltage regulator is shown in FIG. 23. This circuit senses the battery voltage and causes the alternator to deliver either full charge or none at all. This operating mode simulates that of the electromechanical regulator.
- Whereas the electromechanical regulator might turn the alternator field current off and on at a 100-Hz rate when the charge state of the battery was marginal, the electronic regulator switches on and off at a rate in the vicinity of 1000 Hz.
- This itself is not only the advantage, the important feature is that there is no mechanical wear in the electronic type voltage regulator.
- In the circuit of FIG, the input transistor conducts only when battery voltage becomes high enough to break down the zener diode in its base lead.
- Depending on the battery and its load, the field circuit will be energized and opened at widely varying duty cycles. This type of regulator is more closely related to the switching-type power supply rather than to the “linear” voltage-regulated supply.

Electronic (transistorized) voltage regulators in alternators

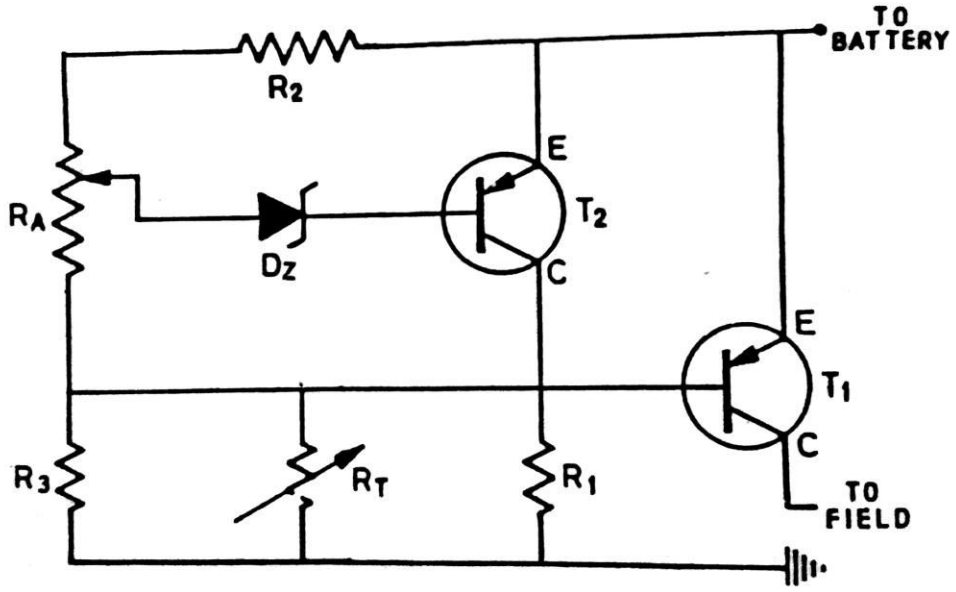


Fig. 16.29. Simplified circuit of a transistorised regulator

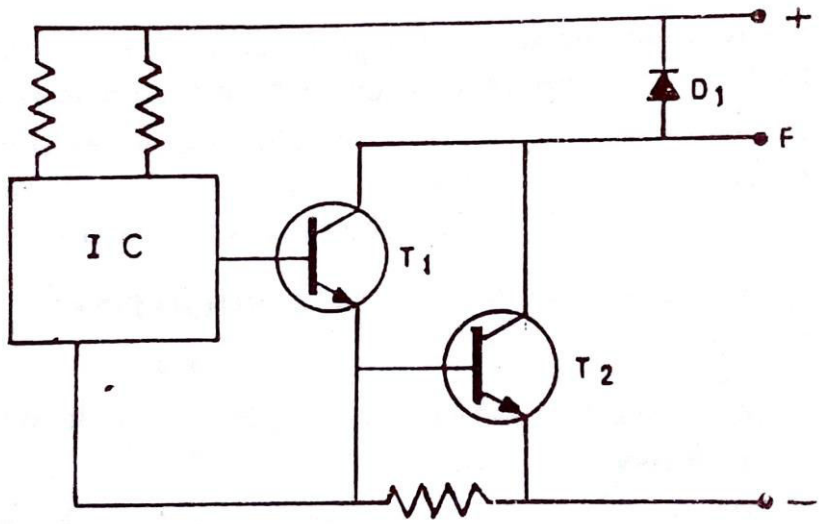


Fig. 16.30. Hybrid IC voltage regulator circuit.

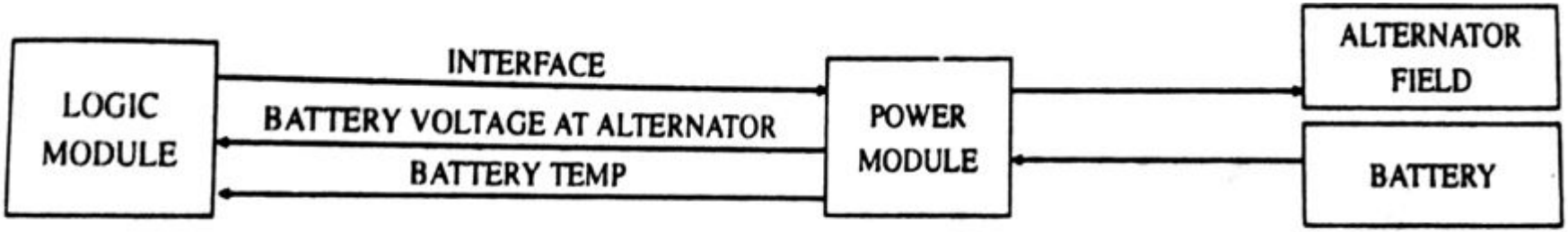


Fig. 16.31. Schematic diagram of computer-controlled charging system.

- Fig 1 shows a basic circuit for transistorized regulator which consists of transistors, Zener diode, fixed resistors and thermister, use these elements to regulate voltage.
- In practice the basic circuit is improved and integrated circuits (ICs) are used as shown in fig 2 where the IC forms main part of regulator
- The latest type as in Fig 3 the charging system control by using computers.
- In such systems the voltage regulator is placed in power module and controlled by the logic module, which also senses battery temperature and battery voltage at alternator and alternator output.
- Simply saying ,the computer switches the rotor (Field) current ON and OFF at fixed frequency of about 400 cycles/second and correct average field current is produced by varying on-off periods, which provides the desired alternator output voltage
- By computerized system diagnosis of charging system is also become easier

Starting system

starting system

- To start an IC engine , the crank shaft has to be rotated at a certain minimum speed , which is about 100 rpm
- For that we use an electric motor that is starting motor

Starting motor

- It is driven by means of the current taken from the battery
- It is mounted on the side of engine, connected to the flywheel when starting
- So it is used for cranking the engine
- It must be power full enough to turn the engine .
- It must have to provide high torque when starting
- For this purpose the starter motor is usually series wound

DC MOTOR

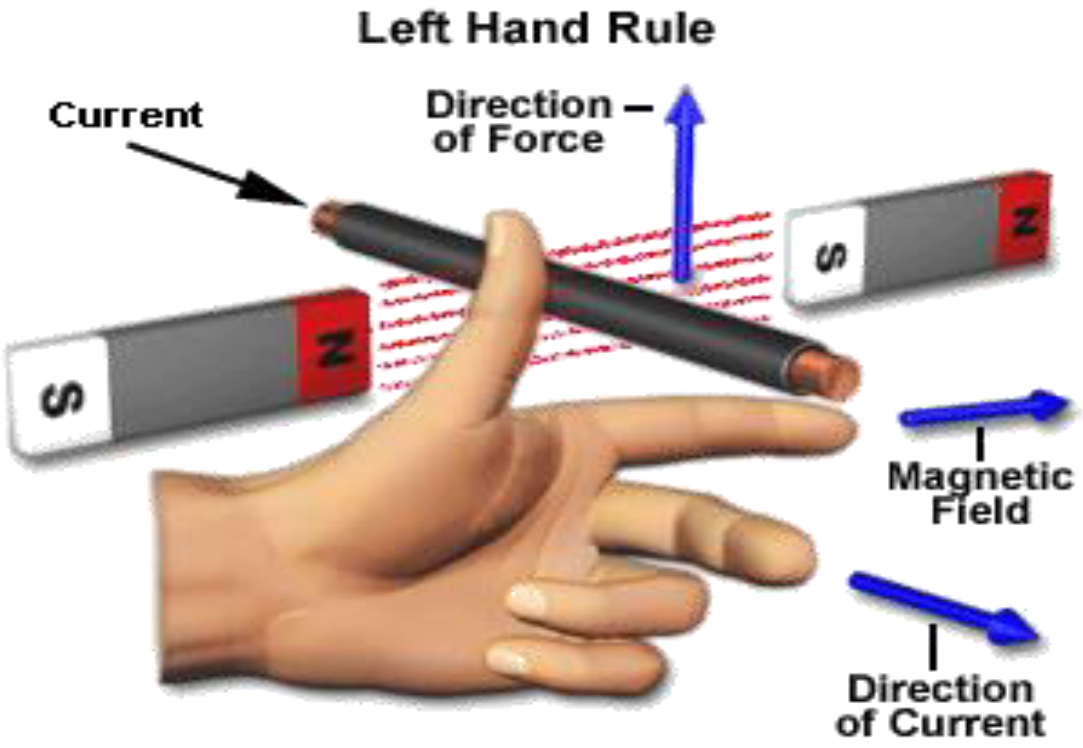
A machine which convert D.C power into mechanical power is known as D.C motor.

Working principle of DC motor

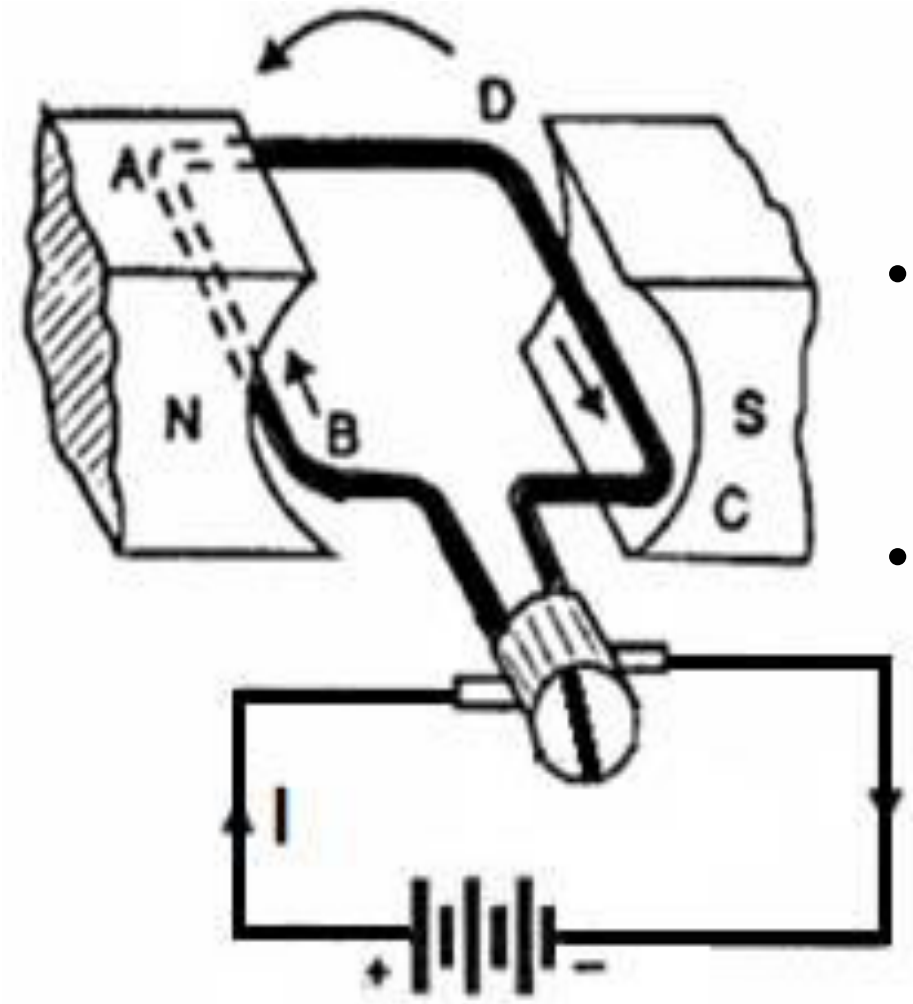
- **Its operation is based on the principle that when a current carrying conductor is placed in a magnetic field, the conductor experience a mechanical force.**
- **The direction of this force is given by Fleming's left hand rule.**

FLEMINGS LEFT HAND RULE

- **Hold out your left hand with forefinger, middle finger and thumb at right angle to one another. If the fore finger represents the direction of the field and the middle finger that of the current, then thumb gives the direction of the force.**

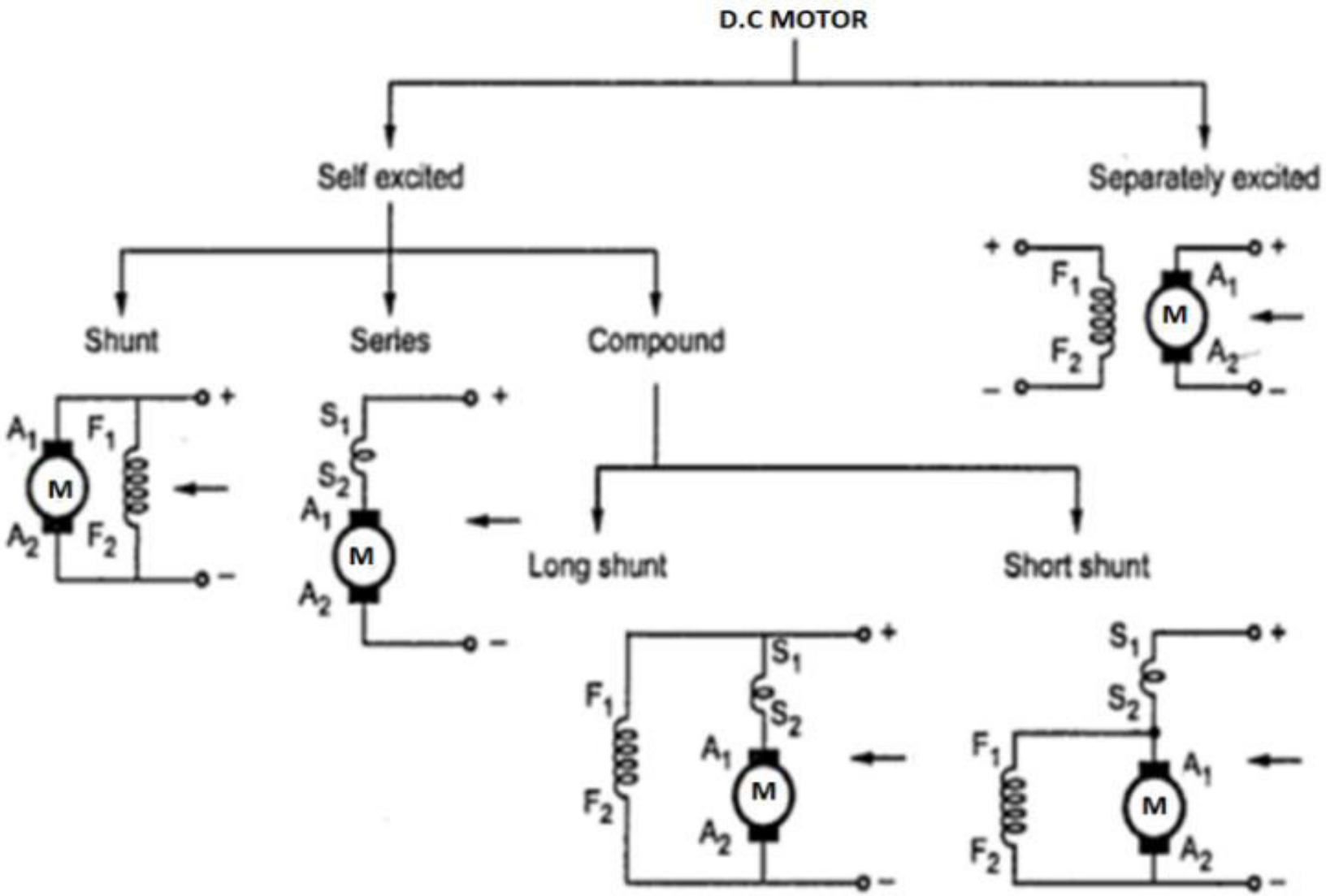


Working of DC motor



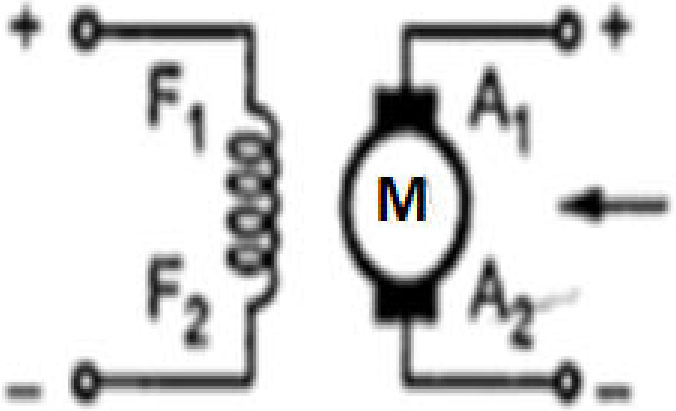
- Figure shows a single loop DC motor. It consist of a rectangular coil ABCD carrying current which is placed in a magnetic field.
- In side AB current flows from B to A and in coil side CD current flows from D to C .
- According to Fleming's left hand rule force act on coil AB to down ward and Coil side CD to upward. Hence the coil rotates in anticlock wise direction.

Classification of D.C Motor Based on field connection



- ***Separately excited dc motor***

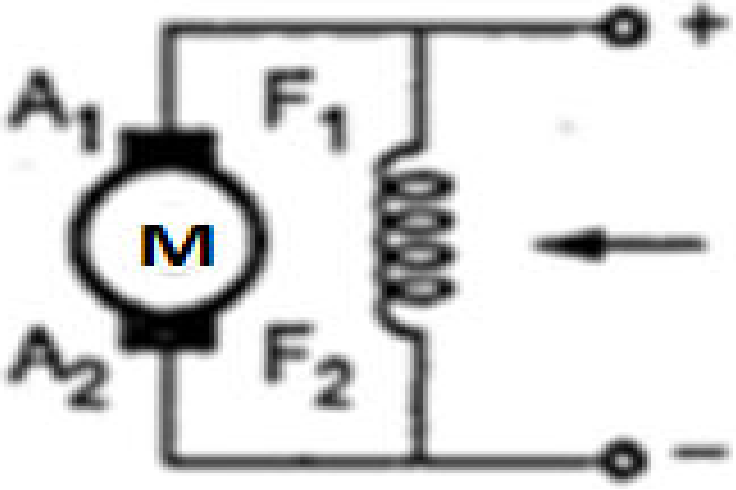
  In this Field winding is supplied from an independent external d.c. source.



Self excited DC Motor

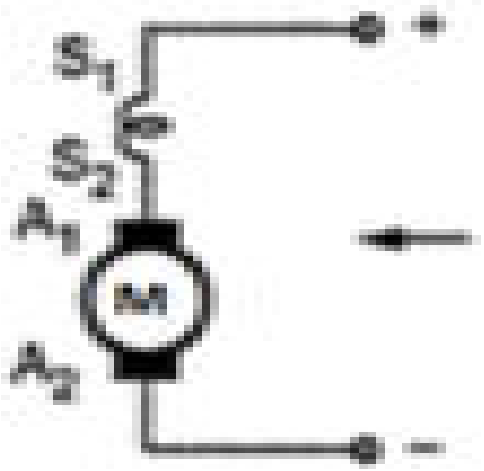
1. Shunt DC Motor

- **In this Field winding is connected in parallel with the armature winding.**



2.Series DC Motor

In this Field winding is connected series with armature winding.

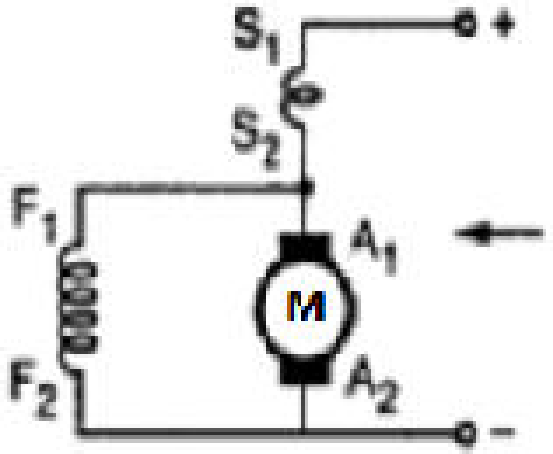


3.Compound wound DC generator

- **In a compound wound motor there are two sets of field windings on each pole –one is in series and other in parallel with the armature.**
- **Compound wound DC generators are two types**

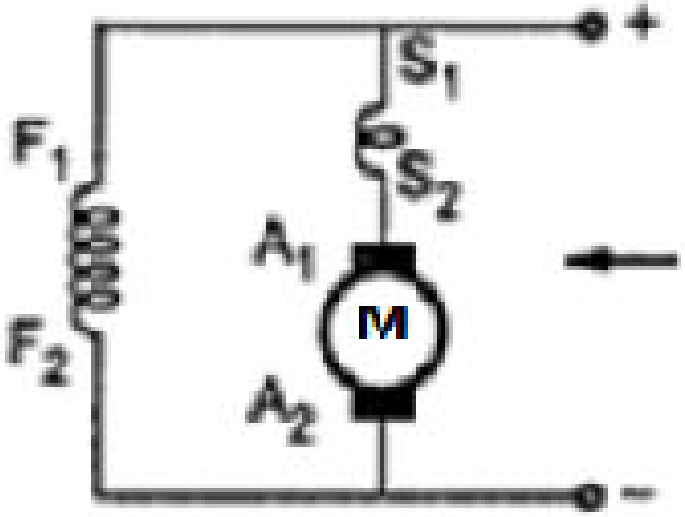
1.Short shunt compounded DC MOtor

- **In short compounded shunt field winding is connected in parallel with the armature winding only**



2.Long shunt compounded DC Motor

- **In long shunt compounded shunt field winding is connected in parallel with both armature winding and series field.**



Permanent Magnet DC Motor (PMDC Motor)

- A **Permanent Magnet DC motor** (**PMDC motor**) is a type of DC motor that uses a permanent magnet to create the magnetic field required for the operation of a DC motor.

Construction of starting motor

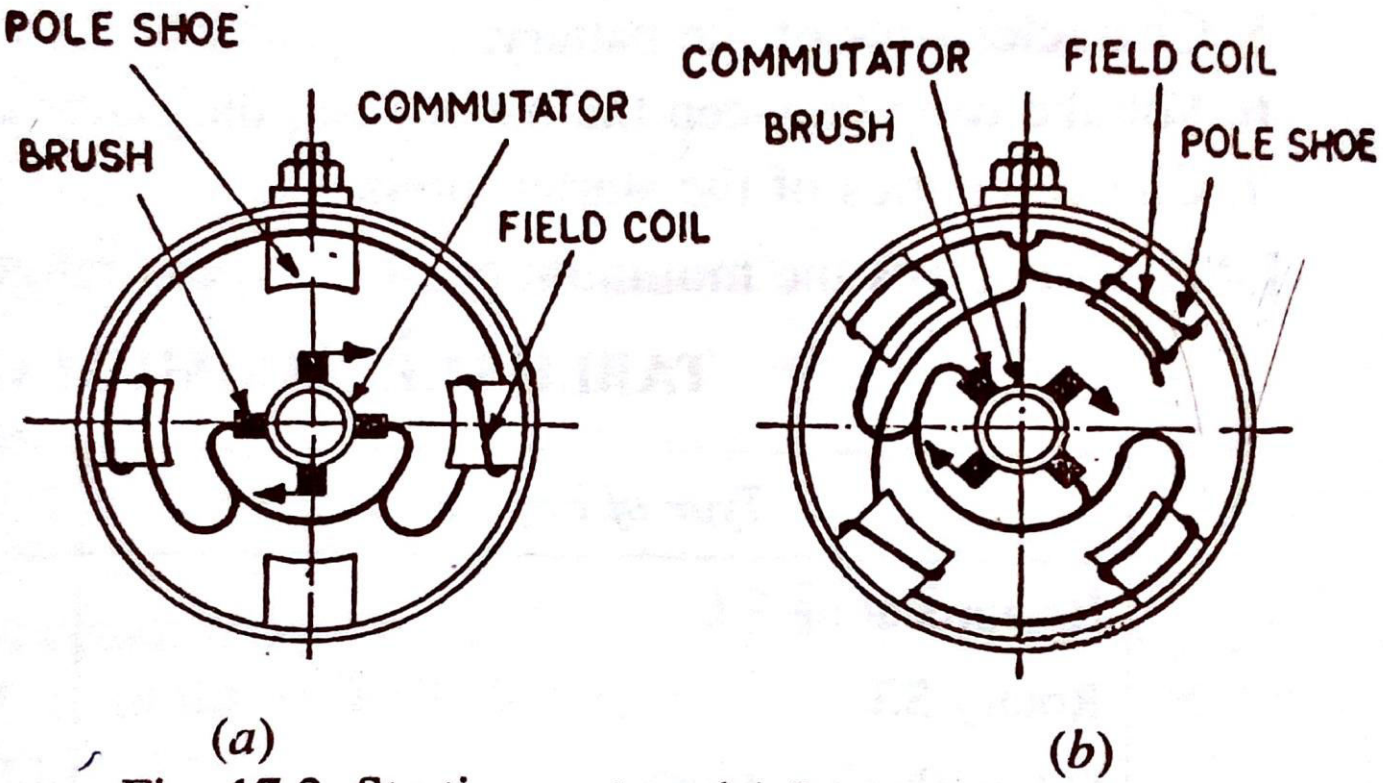
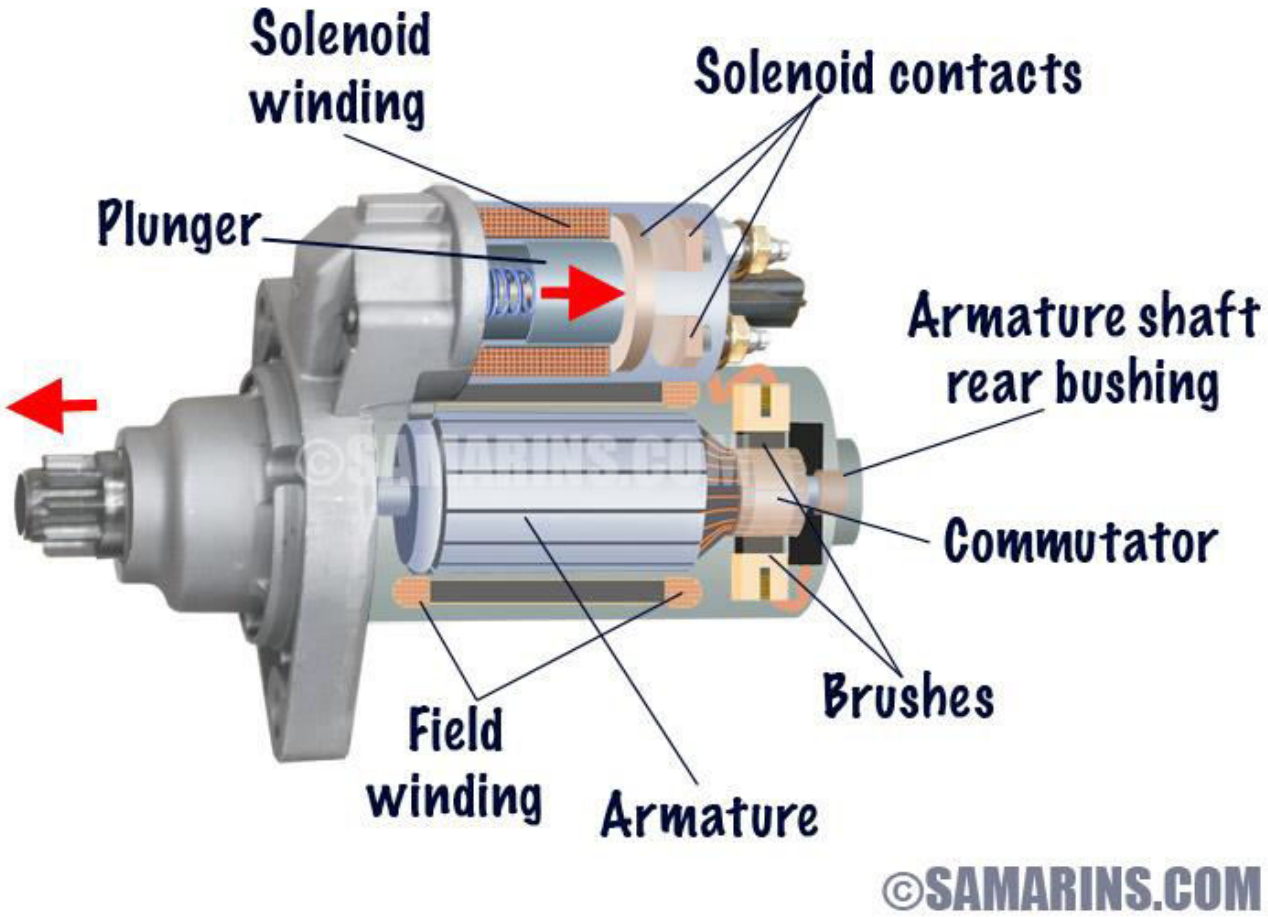


Fig. 17.2. Starting motors (*a*) 2-pole, (*b*) 4-pole.


Solenoid winding
Solenoid contacts
Plunger
Armature shaft rear bushing
Commutator
Brushes
Field winding
Armature
©SAMARINS.COM

- The mains components are the body, the armature, the commutator and brushes and the field windings
- Most automobile starting motors have four poles and four brushes
- At the end of the armature shaft, there is some forms of drive mechanism by means the motor starts the engine
- For light and medium cars starting motors of starting torque 10 to 30 Nm are used
- Large cars and heavy vehicles have starting torque 50 to 150 Nm are required
- Fig below shows schematic diagram of 2-pole and 4-pole stating motors

Starting motor drives

- At the end of the armature shaft of a starting motor, there is some forms of drive mechanism by means the motor starts the engine
- Types of starting motor drives

1) Inertia drives
2) Pre engaged drives

- Out of these Bendix drives are the inertia drives, whereas the other two are pre-engaged.
- In case of inertia drives the starter motor is allowed to attain sufficient speed and hence power before it engages with the engine flywheel starter-ring gear.
- Inertia type drives are commonly used for cars, whereas for heavy vehicles, particularly with the diesel engine, the pre-engaged drives are employed.
- Inertia type drives have excessive wear of the pinion and the ring gear due the aggressive nature of the engagement.

Inertia drives

a) Bendix drive (inboard type)

b) Bendix drive (out board type)

c) Flo- thru Bendix drive (inboard type)

d) Compression spring type bendix drive (inboard type)

Pre engaged drive

a) Over running clutch

b) Dyer drive

a) Standard bendix drive (inboard type)

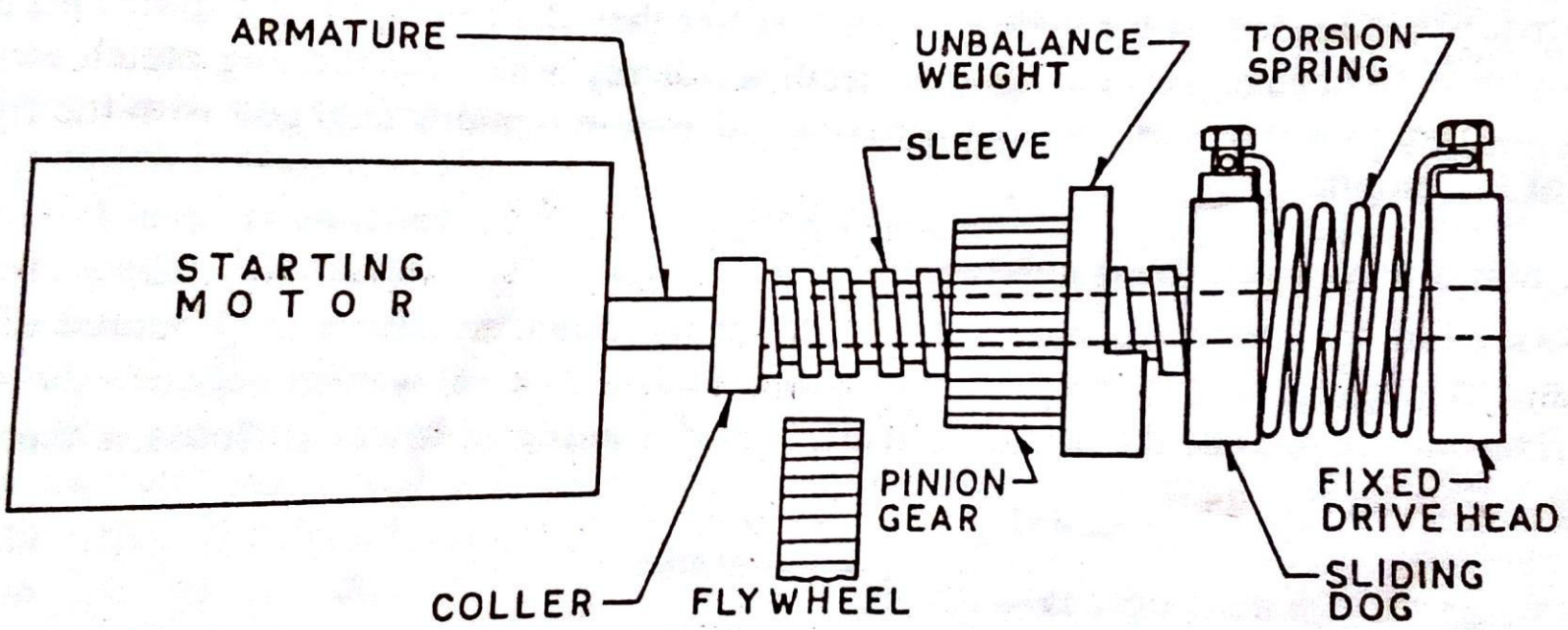


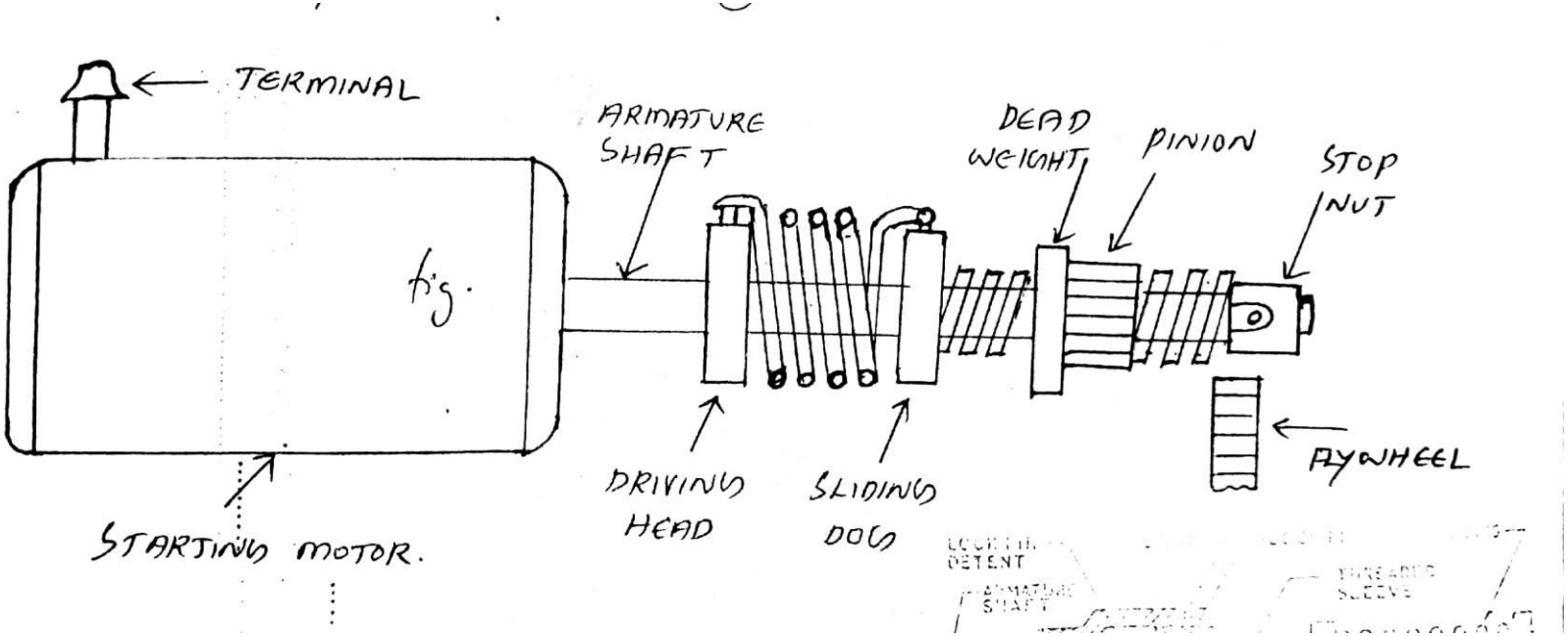
Fig. 17.9. Standard Bendix Drive (inboard type)

- Bendix dries are the inertia drives in which the starter motor pinion is made to engage or disengage with the toothed ring on the periphery of the engine flywheel.
- These may be cither the outboard type or the inboard type.

BENDIX DRIVES

- Fig shows a standard Bendix drive (inboard type) for the starter motor.
- There is a threaded sleeve on the armature shaft. The sleeve can slide or turn freely over the shaft. The shaft is keyed to the fixed drive head which is connected torsionally to the sleeve through a coil spring (which takes up the shock of engagement) and the sliding dog.
- On the sleeve there is a pinion to which an unbalance weight is attached, the purpose of the weight being to prevent the rotation of the pinion on the sleeve threads. When the motor starts, the armature shaft rotates causing the sleeve to rotate and because the pinion cannot rotate due to the unbalance weight, it moves axially towards the motor till it is engaged with flywheel.
- Further movement of the pinion is prevented by the collar attached on the sleeve and because of this pinion has to start rotating. As it is also in mesh with the engine flywheel, the flywheel is rotated and the engine starts.
- When the engine starts, the flywheel that rotates the pinion and because of its bigger size, the flywheel rotates the pinion much faster than the armature (which by now, has slowed down due to releasing of the self-starter switch) with the result that the pinion is backed out of mesh with the flywheel.

b) Bendix drive (out board type)



• In the outboard type pinion moves away from the starting motor to engage the flywheel whereas in the inboard it moves towards the starting motor.
•The working s same as that of inboard type.

c)Flo- thru Bendix drive (inboard type)

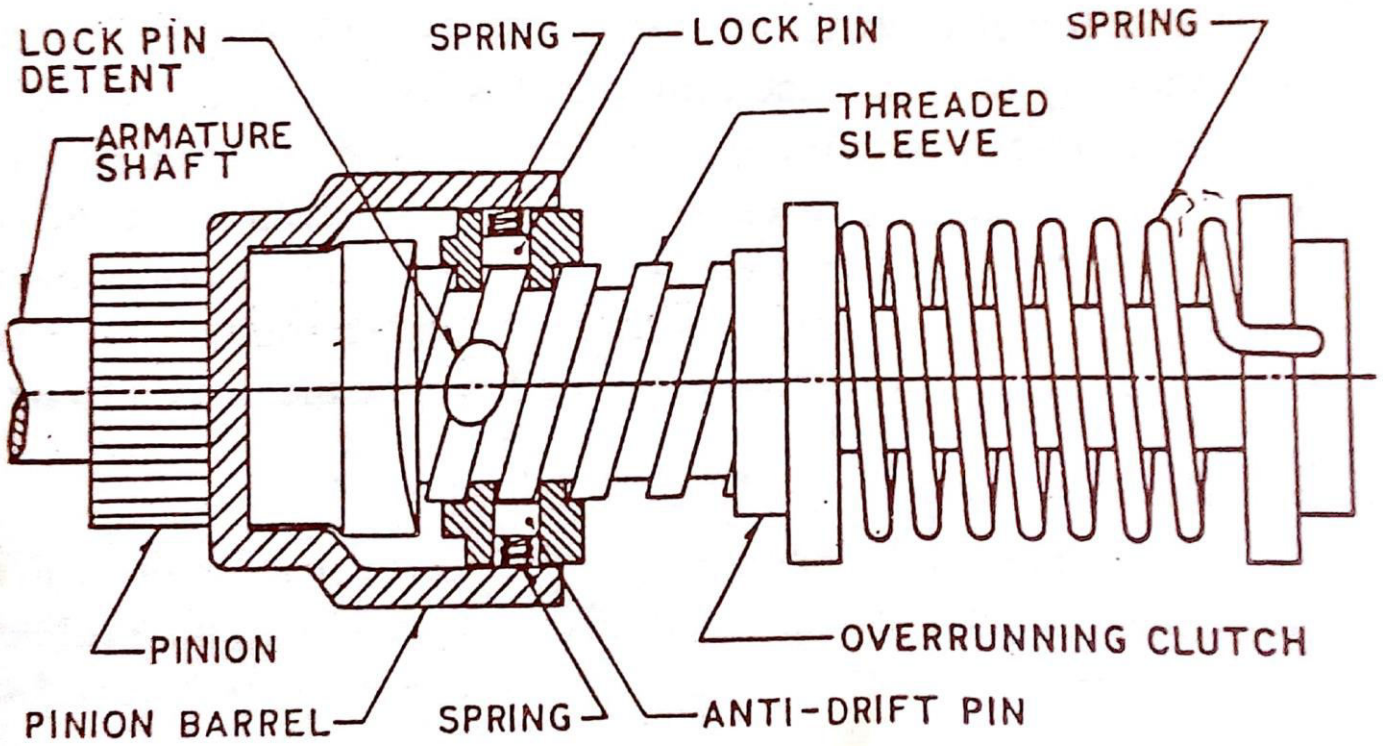


Fig. 17.10. 'Folo-thru' starting drive.

- Folo-thru' drive is similar in construction to the standard Bendix drive.
- The armature shaft is connected to the threaded sleeve through a spring and overrunning clutch. The inside of the pinion barrel fits into the sleeve threads. Towards the end of the sleeve is provided a detent .Two spring-loaded pins, viz., the lock pin and the anti-drift pin are also provided.
- The anti-drift pin provides only a frictional contact with the sleeve teeth, whereas the lock pin action is in connection with the detent.
- The engagement of the pinion with the flywheel takes place in the similar manner as in case of standard Bendix drive. However, towards the end of the pinion travel, the lock pin drops into the detent and would not let the pinion disengage prematurely due to false start
- The pinion thus continues driving the flywheel till the engine really gets stated and attains a speed of about 400 r.p.m, when the lock pin comes out of the detent due to the centrifugal force which overcomes the spring force The pinion then gets disengaged as in case of the standard Bendix drive.
- The anti-drift pin is loaded with a spring which is stiffer than the spring of lock-pin. This prevents the drifting of the pinion to engage with the flywheel teeth accidently.
- The over-running clutch serves to avoid damage to the starting motor in case due to any reason, the pinion remains engaged with the flywheel even after starting of the engine.

d) Compression spring type bendix drive (inboard type)

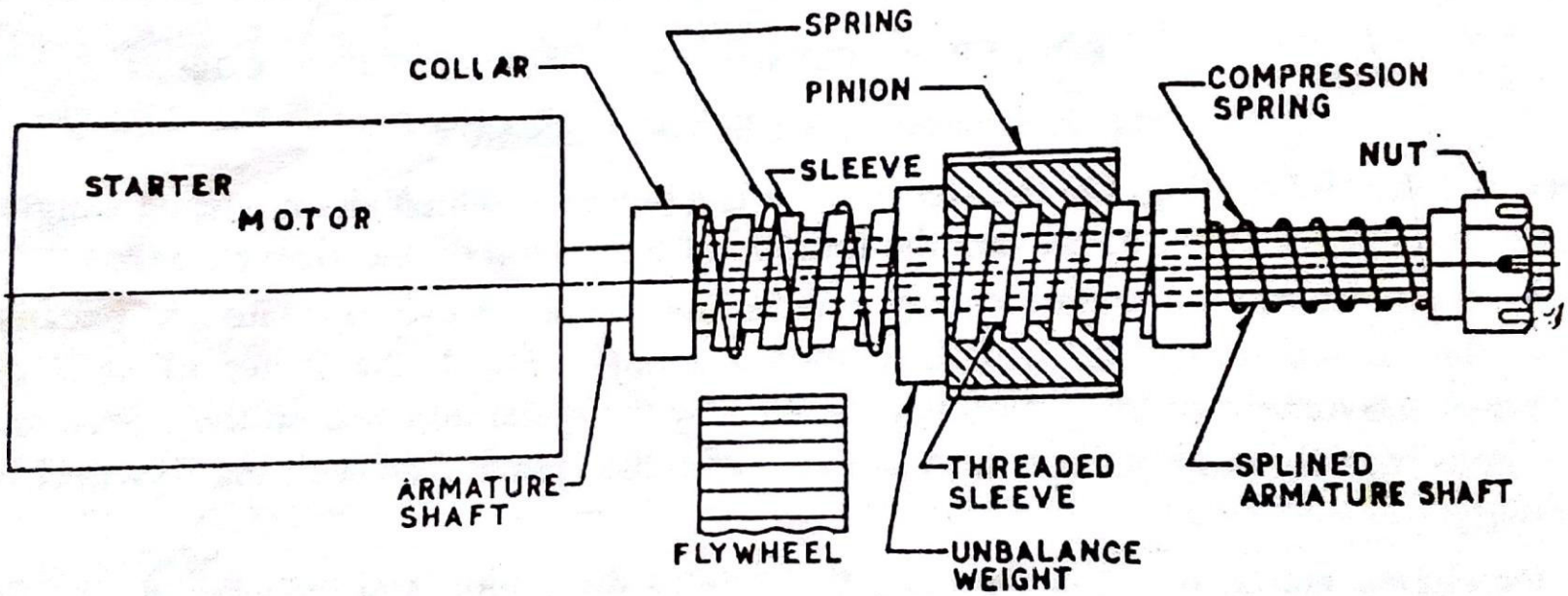


Fig. 17.11. Compression type Bendix drive.

- This differs from the standard Bendix drive in that the threaded sleeve is mounted directly on the splined armature shaft
- A spring under compression is employed in between the sleeve and the nut which is fixed on the end of the armature shaft.
- Another spring of lower stiffness is there between the pinion and the collar on the shaft.
- When the motor is started, the sleeve starts rotating along with the armature shaft. This causes the pinion to travel towards the motor till its teeth engage completely with the teeth on the periphery of the flywheel. By this time the pinion also strikes against the collar which stop its travel further (the spring on the sleeve over which the pinion moves, serves to avoid shock due to striking of the pinion with the collar).
- The pinion, therefore, tries to rotate but is offered initial resistance by the flywheel which is stationary by now.
- The torque of the shaft then has a tendency to force the threaded sleeve further out against the spring tension, till the flywheel starts rotating. The spring tension is consequently relieved.
- When the engine starts, the flywheel rotating at a faster speed causes the pinion to be hacked out of mesh

Over running clutch

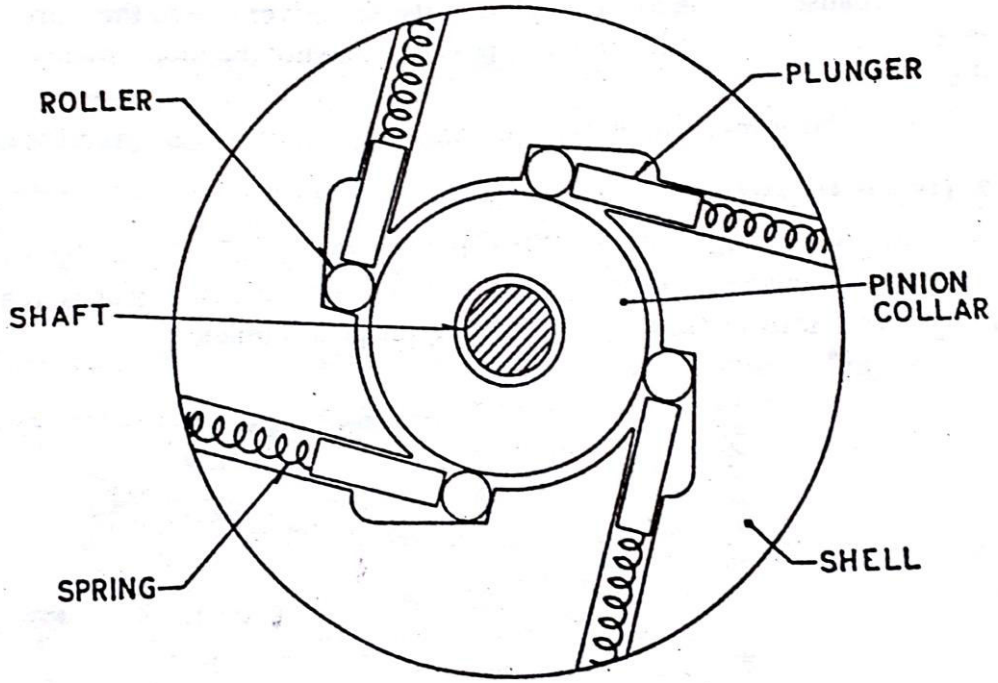


Fig. 17.12. Overrunning clutch for starting drive.

- It consists of a shell and a pinion collar connected in such a way that when the shell is rotating at a speed greater than that of the pinion collar, the former will drive the later.
- However, whenever the speed of the collar becomes more than the speed of the shell, there is no more any connection between the two.
- Such a connection is provided by the spring-loaded rollers, the shell is connected with the armature shaft through splines, whereas the collar is attached to the pinion.

Pre engaged drive / Over running clutch drive with mechanical shift lever

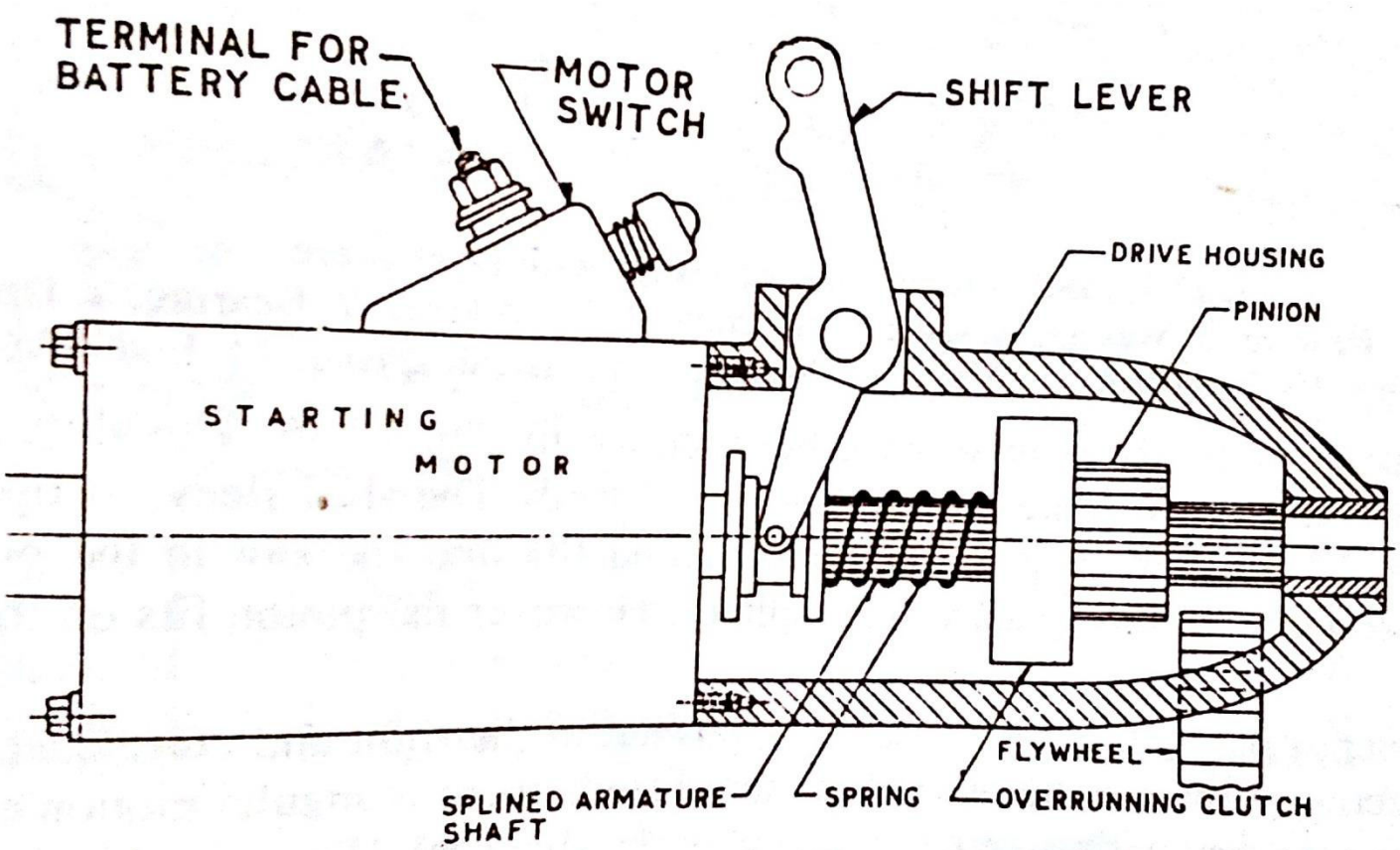
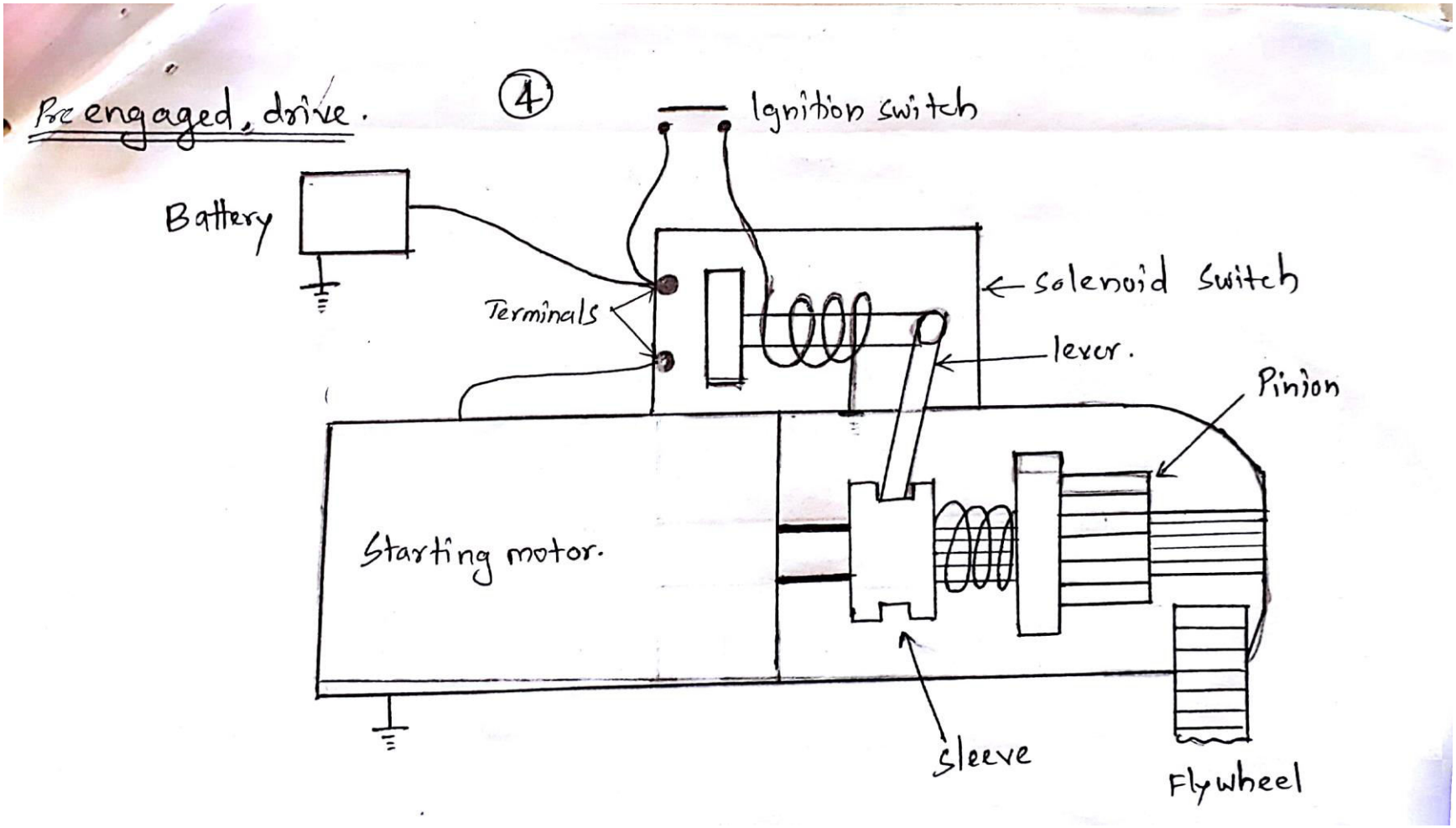


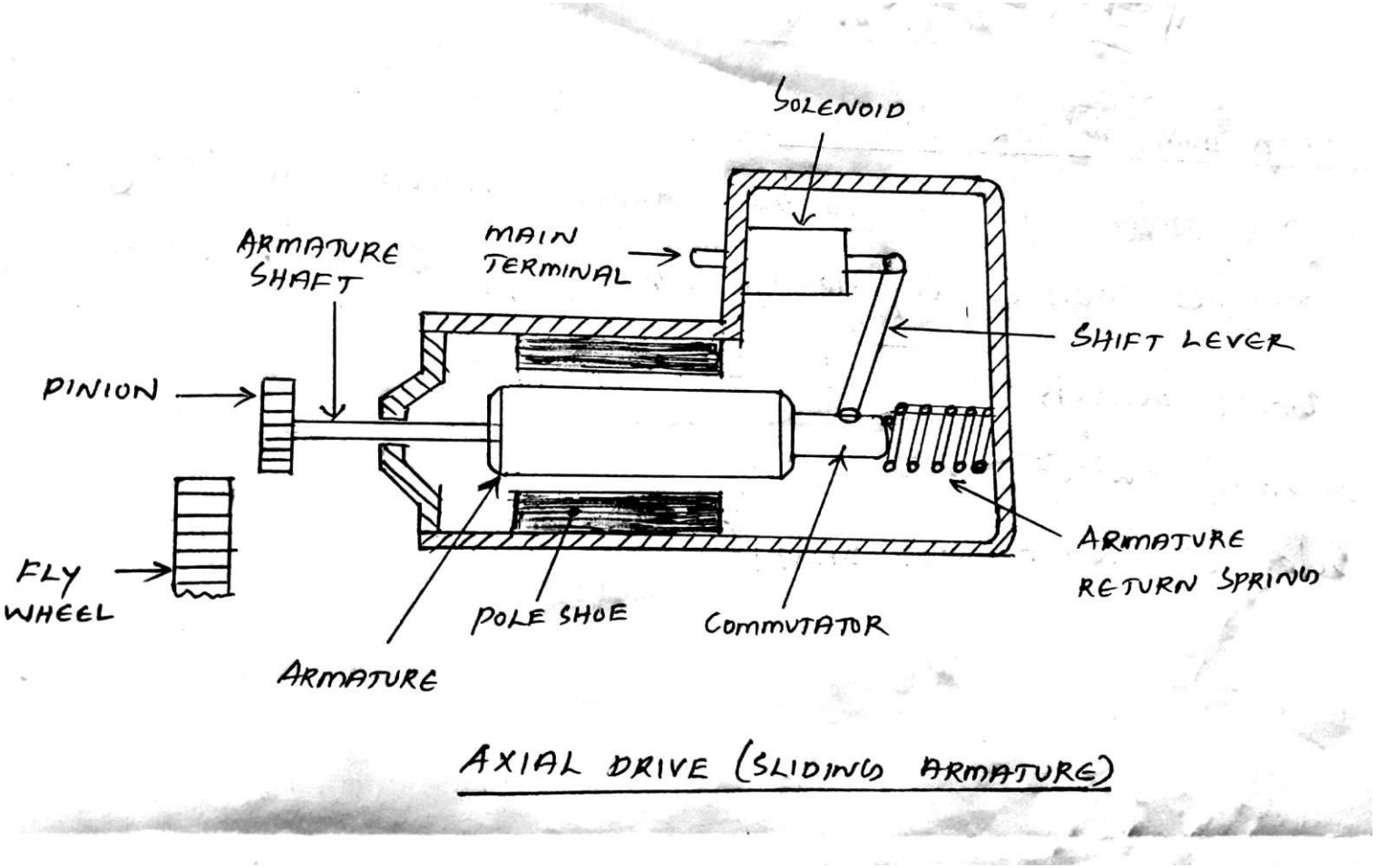
Fig. 17.13. Overrunning clutch type starting drive.

Pre engaged drive / Over running clutch drive with solenoid shift lever



- A starting drive employing the overrunning clutch have shift lever is attached to the starting pedal in case of mechanical starters as shown, or may be operated by means of solenoid switches.
- When the starting pedal is pressed by the driver, the shift lever moves about its pivot, thereby pushing the switch of starting motor and moving the overrunning clutch and the pinion assembly through the spring simultaneously.
- This causes the pinion to get engaged with teeth on the flywheel and also get the armature shaft and therefore the pinion to rotate, which starts the engine.
- However, as soon as the engine gets started, the flywheel and hence the pinion rotates at much faster speed, causing the overrunning clutch to disconnect the pinion side from the motor side.
- Further the motor also stops because as soon as the engine starts, the driver leaves the starting pedal or key which causes the shift lever to come back to its previous position, leaving the motor switch open and disengaging the pinion from the flywheel

Axial drive


SOLENOID
ARMATURE SHAFT
MAIN TERMINAL
SHIFT LEVER
PINION
FLY WHEEL
ARMATURE RETURN SPRING
POLE SHOE
COMMUTATOR
ARMATURE
AXIAL DRIVE (SLIDING ARMATURE)

- In axial drive the complete armature assembly slides axially through the motor casing along with opinion towards flywheel.
- The armature is held by a spring, when the driver switch on the ignition the solenoid coil is energized, then it puts the shift Lever which pushes the armature towards the flywheel against the spring force
- Now the pinion engages the flywheel and engine starts when the engine start, the driver de-energizes the solenoid then the armature is return back to initial position by spring force which disengages the pinion with the flywheel
- it is simple and robust construction

Dyer drive

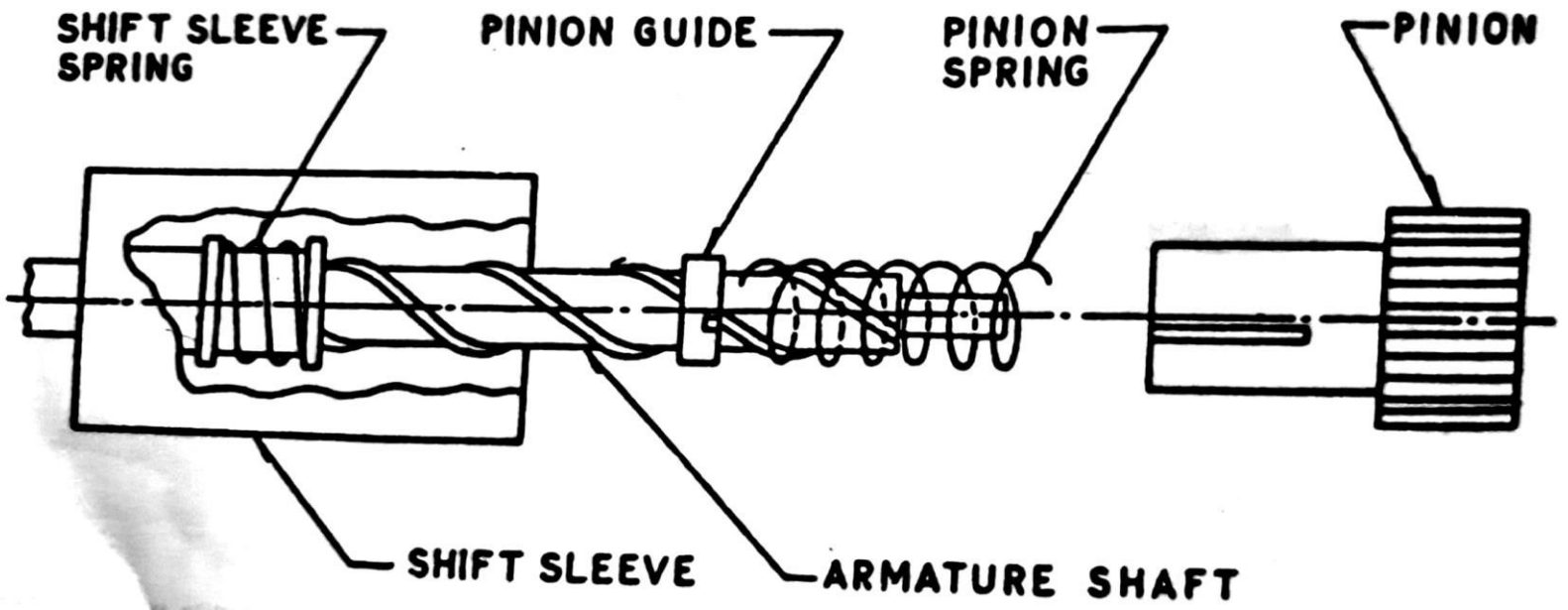


Fig. 17.16. Components of Dyer drive.

- The main components of the Dyer drive have been shown in Fig. The shift sleeve is free to move on the armature shaft, in which are provided the spiral teeth.
- The shift sleeve is operated by means of the shift lever. The snug on the pinion guide fits into the slot in the pinion, which ha internal splines corresponding to the armature shaft splines. However the pinion fits on the armature shaft rather loosely.
- When the shift lever is pressed, the shift sleeve is pushed to the right and consequently the pinion is also moved in that direction.
- However, because of the spiral teeth, there is angular motion also. With farther pushing of the shift lever the pinion thus gets engaged with the flywheel.
- However, the chances are that the teeth in the pinion and the flywheel may not align for engagement when the pinion is moved adjacent to the flywheel. In such a case the shift sleeve continues to move the pinion guide along the armature shaft

Starting motor switches
1. Manual switch

8.1. Manual Switch (Fig. 17.18)

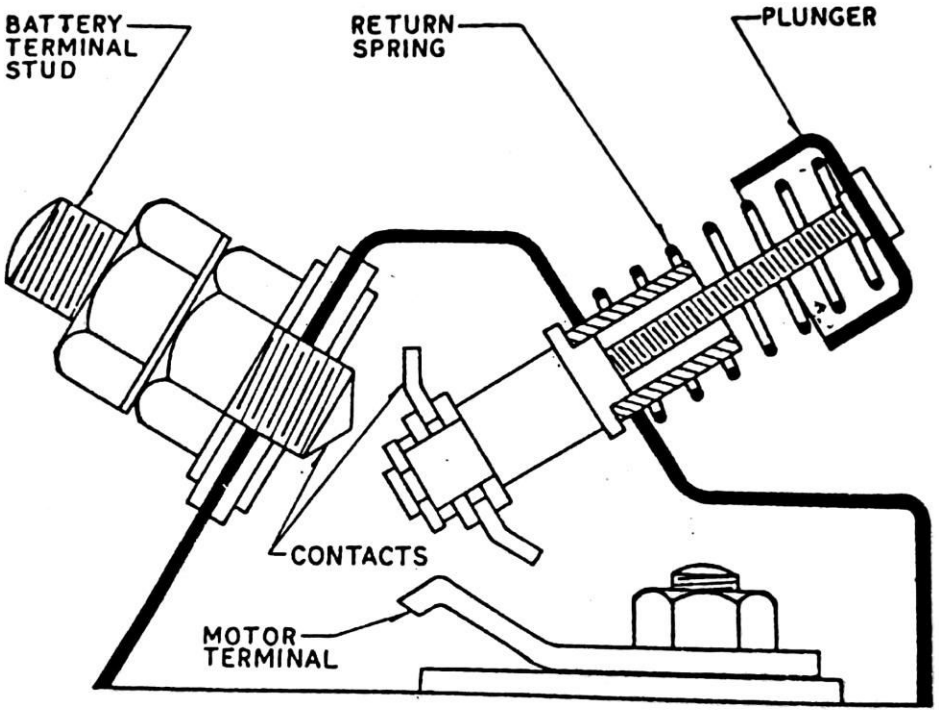


Fig. 17.18. Manual switch.

The construction is very simple. As the plunger is pressed the contacts are made. It may be operated either with hand or with foot.

2. Solenoid switch

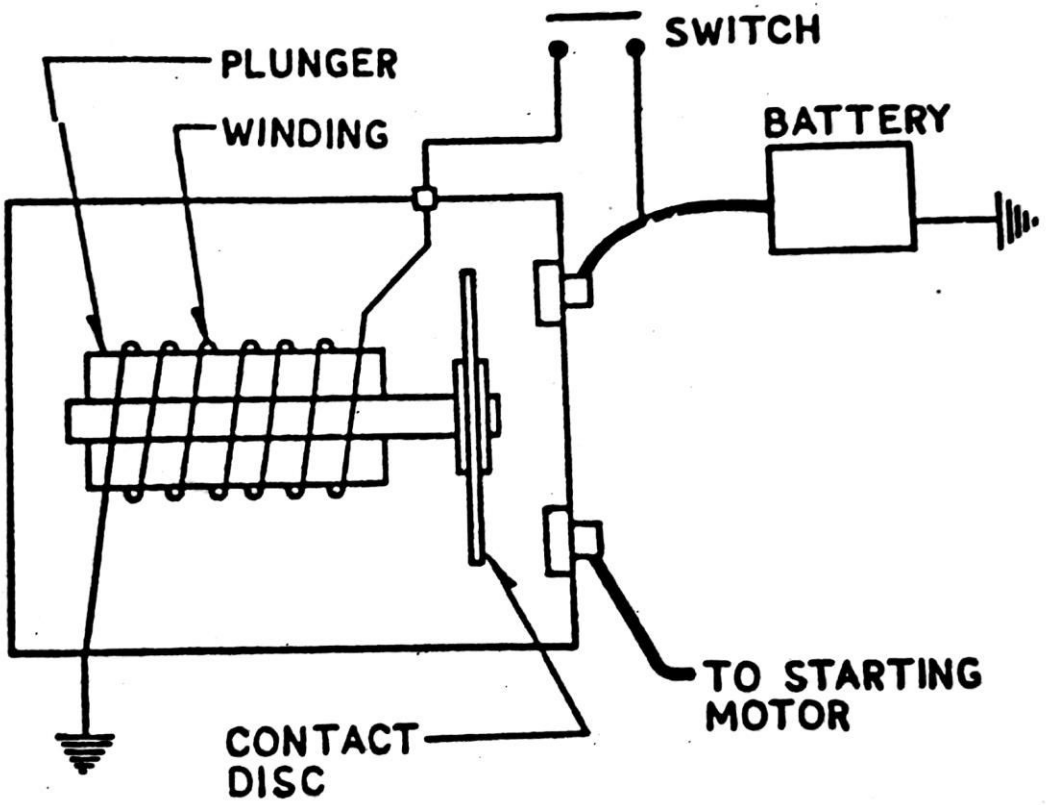


Fig. 17.19. Solenoid switch.

- It is also called magnetic switch.
- As the button is pressed, the current flows from the battery to the winding which produces a magnetic field, resulting in the movement of the plunger to close the switch connecting the battery and the starting motor.
- The advantage of solenoid switch compared to the manual is that the heavy current wiring length is reduced which reduces the voltage drop in the starter circuit and the driver has to operate only a push button or key switch at the dashboard which carries a nominal amount of current only.
- This driver's switch is only of light duty type and its wiring is also thin and light.
- The solenoid switch here has got one winding only. Some solenoid switches have two windings also, the pull-in winding and the hold-in winding.
- Both the windings exert combined force to pull the armature so as to make the contacts of the switch when the pull-in winding is short-circuited and only hold-in winding remains to hold the contacts closed.
- The advantage of this type is that less current is drawn from the battery during the period of hold-in.

3.Solenoid switch cum shift

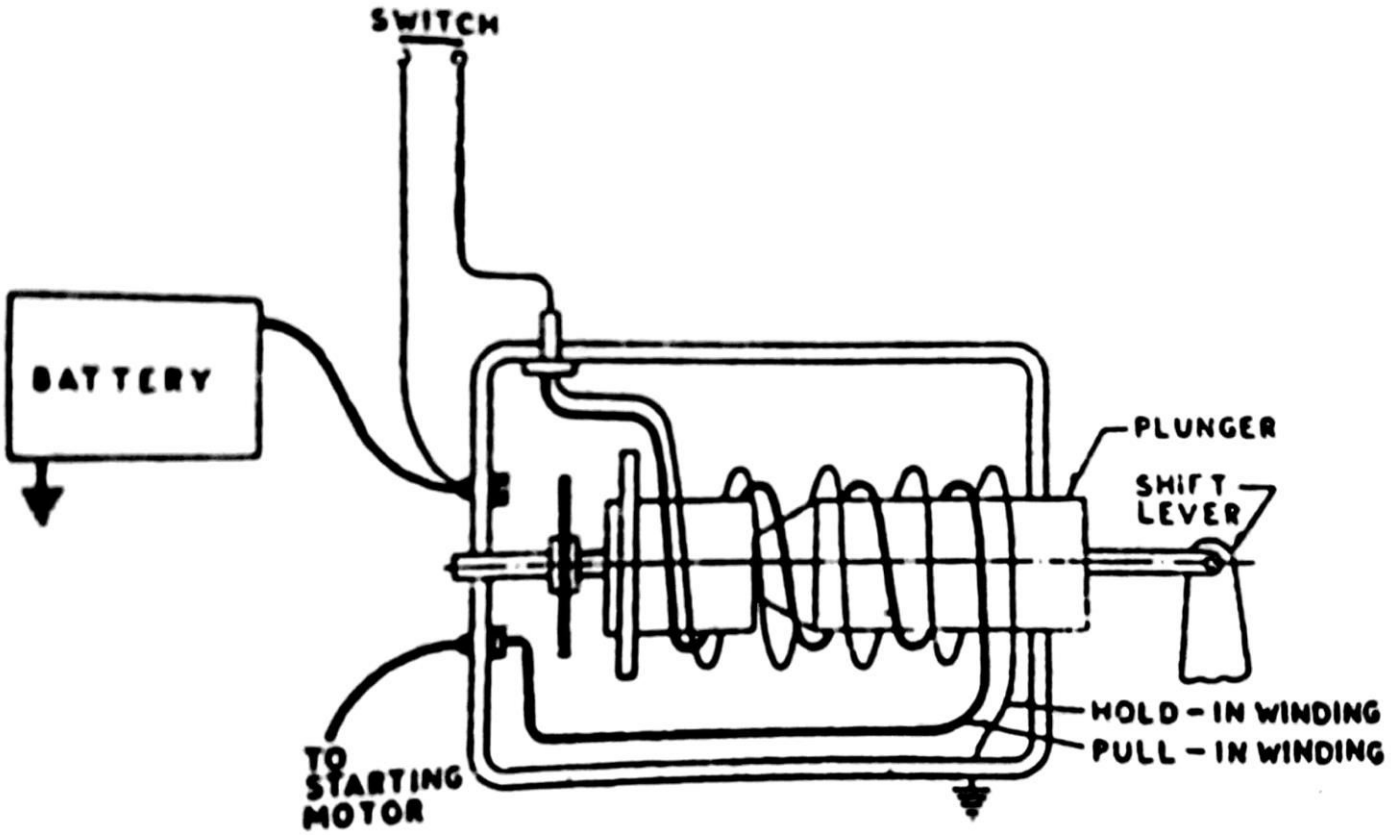


Fig. 17.20. Solenoid switch-cum-shift.

- Solenoid switch cum-shift consists of a solenoid switch which also performs the function of actuating the shift lever in an overrunning clutch type of Dyer's drive.
- The solenoid shift is similar in construction to the solenoid switch except that it has got a different plunger construction suited for operating the shift lever. Further this is of two-winding type.
- It is not necessary, however, that a solenoid shift must have always two windings.

4.Solenoid switch with relay

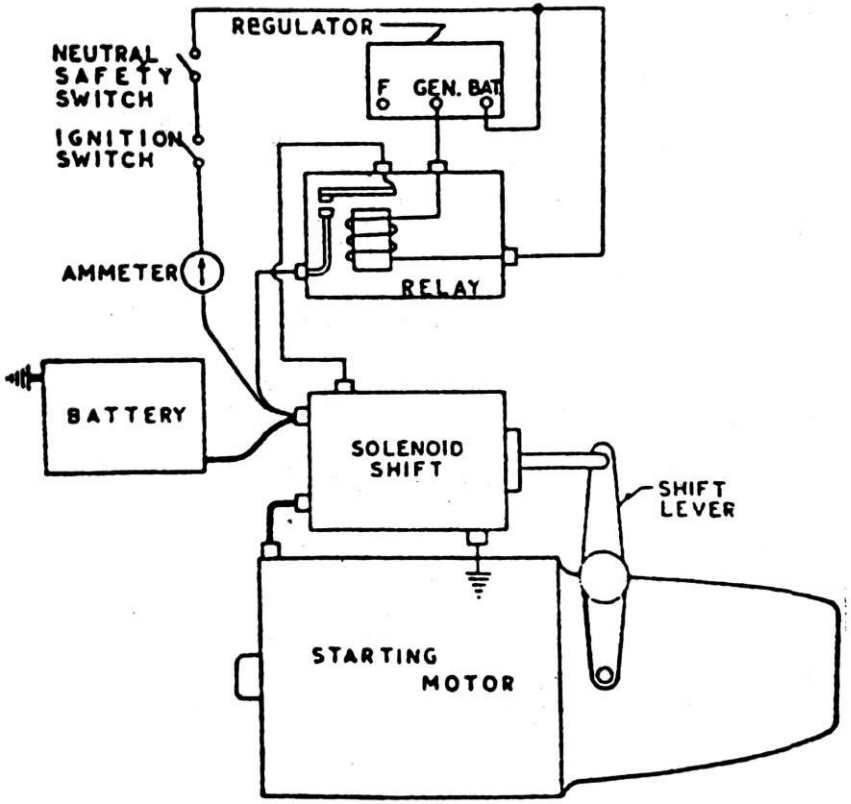


Fig. 17.21. Starting motor wiring circuit using a solenoid shift with relay.

- The wiring diagram shown in Fig for fully automatic circuit for the starting motor.
- The relay used serves to control the solenoid currents.
- Further, completing the relay circuit through the generator provides protection against operating of the starter while the engine is running, because then the generator voltage is approximately equal to the battery voltage.
- As such no voltage applied through the relay even when the switch contacts are closed.
- A vacuum switch is also sometimes employed in the circuit, which provides added protection against starting of the cranking motor while the engine is running.
- Another safeguard has also been provided in the circuit. The neutral safety switch ensures that the circuit will not close unless the transmission of the vehicle is in neutral.
- The ignition switch is operated by the driver with the help of a key so that the starting motor circuit is closed.